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7

Writing Systems, Reading Processes, and Cross-Linguistic Influences

Reflections from the Chinese, Japanese and Korean Languages

EDITED BY

Hye K. Pae

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Reflections from the Chinese, Japanese and Korean Languages

Edited by

Hye K. Pae
University of Cincinnati

John Benjamins Publishing Company
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Foreword

Catherine McBride
The Chinese University of Hong Kong

This volume represents a comprehensive and critical analysis of script learning in three of the most prominent East Asian scripts. Although there have been previously published books on reading and writing of Chinese, Japanese, and Korean before (Goodman, Wang, Iventosch, & Goodman, 2012; Li, Tan, Bates, & Tzeng, 2006; Lee, Kim, & Simpson, 2009; Nakayama, Mazuka, & Shirai, 2006), the focus of this volume is timely in its specific interests in features of all three writing systems, including some overlaps and differences among them, particularly at the word level, and also on its explicit bilingual/biscriptal focus. In particular, several chapters target the increasingly important issue of learning to read in two or more (sometimes multiple, see Joyce & Matsuda, this volume) scripts. In Japanese, this is simply required. *Kanji*, which has been adopted from the Chinese script, and *kana*, which is a syllabic, sound-based system, must both be learned and routinely used by Japanese readers, and these have varying degrees of difficulty. Some Korean readers also still make use of both *Hangul*, the Korean script, which is sound based, and *Hanja*, the adopted Chinese script. Chinese children and adults typically learn only one Chinese script (Chinese characters – simplified in Mainland China and Singapore; traditional in Taiwan, Hong Kong, and Macau), but most also learn a simple phonological coding system such as Pinyin, taught in Mainland Chinese, or Zhuyin-Fuhao, taught in Taiwan, to serve as an aid to pronouncing Chinese characters. Moreover, in many places in which Chinese, Japanese, and Korean script(s) are learned as native scripts, English is routinely taught as a foreign language and script to be learned. There are ongoing debates about the extent to which there is transfer or various cross-linguistic influences on learning to read across orthographies. At the word level, such transfer has been explored in relation to phonological processing, morphological processing, and even orthographic processing (e.g., McBride, 2016).

The scholarship in this volume should be of great interest to a large segment of the world's population because of the sheer numbers of learners it represents. In my perusals of several Wikipedia, Explorapedia, and other internet sites on language-/script-learning, I gleaned some very rough statistics on worldwide percentages of readers of Chinese, Japanese, and Korean. Most sites do not focus on scripts per se but on languages. This is especially important to underscore for Chinese, because there are several prominent, distinct Chinese languages (including, but not limited to Mandarin, Wu, Yue, Min, Xiang, Hakka, and Gan) that are all in the top fifty or so languages spoken worldwide. With the most prominent Chinese languages combined together, I calculated that approximately 18.9% of the world speaks and probably reads Chinese, 1.9% speak and read Japanese, and 1.1% speak and read Korean as a native language and script. In addition, one site estimated that approximately 40 million people were learning Chinese as a foreign language at the end of 2008, and its popularity keeps growing. Interest in learning either Japanese or Korean as a foreign language has also grown, both in Asia, where Japanese and Korean restaurants, products, K-pop (music), and dramas (including soap operas) are hugely popular, and worldwide.

Apart from the focus on learning to read in Chinese, Japanese, or Korean, as a native or foreign script/language, several chapters in this book also target script learning in English as a foreign or second language. Again, estimates vary, but approximately 5.5% of the world's population speaks English as a native language, with an additional 14.5% or so speaking English as a second or foreign language with varying degrees of fluency. Indeed, governments have adopted the learning of English as a foreign language as part of their basic curriculum for primary or secondary school students in large parts of Africa, Europe, South America, and of course Asia.

Until relatively recently, models and theories of reading development and impairment were based primarily upon findings from monolingual English speakers, usually from the United States of America, Canada, or the United Kingdom (Share, 2008). Such models have been based on rich and varied data, representing careful and often creative research. At the same time, however, with only 5.5% of the world's population speaking English as a native language, such over-attention to monolingual English speaker models of reading has also in some ways misled researchers on what constitutes typical and atypical literacy development. English is a notoriously difficult alphabetic orthography to learn to read and to spell. However, learning to read in Chinese, or *Kanji* in Japan, or *Hanja* in Korea, requires at least an estimated two years more in terms of effortful learning than does English to get to the same level of word recognition skill. In addition, more than 50% of children learn to read first in a language that is not their native language (McBride, 2016). These facts about trends in the world's population should have an impact on models of literacy development, expertise, and impairment.

Perhaps of equal importance is the fact that the majority of the world's children are learning to read in at least two languages and often in two or more scripts. Models of monolingual English speakers cannot capture what it means to be a biscriptal reader, which most school children in Chinese societies, Korea, and Japan are today. The complexities of learning to read in such different systems are not yet well understood. For example, one fundamental aspect of Chinese (Kanji in Japanese; Hanja in Korean) characters is that they are typically comprised of at least two components, a phonetic radical, which rather unsystematically gives some cue to the sound of the character, and a semantic radical, which cues in some way its meaning. There is no clear analogy to the semantic radical in alphabetic orthographies. Semantic information is indeed represented in alphabetic orthographies (e.g., *walked* is spelled with *ed* instead of as *walkt*, the way it sounds, because *ed* is a morpheme indicating the past tense of *walk* as well as the unvoiced sound of the last phoneme of *walk* – not merely the sound of /*t*/). However, within characters, the semantic radicals represent separate information about them; they have no independent pronunciations but merely serve as indicators of meaning. This is a different system from English or other languages represented by the Roman alphabet or indeed any other alphabets. Readers must adapt to these demands in reading Chinese characters but learn other idiosyncracies, including numerous exception words, when learning to read in English. We simply do not yet have a clear and systematic understanding of how and why biscriptal, or multi-scriptal reading, impacts children and adult learners' learning processes.

This volume represents state-of-the art innovations in literacy research across Chinese, Japanese, and Korean. One important feature of this collection is that it contains chapters on both children and adults, and focuses on comparisons of both native script learning and foreign script learning. Understanding both developing and expert readers and writers is the ultimate goal of this research. These researchers collectively seek to understand what the universals and specifics of learning to read and to write are in each script. These ideas are clearly theoretically essential for understanding reading and writing development, impairment, and expertise worldwide. They are also very practical. How best to teach both children and adults learning in a given script is dictated in large part by the features of the language represented by the script and also by the features of the script itself. The importance of phonological awareness and phonics, touted as key for learning to read English, for example, is less obvious for learning to read Chinese for many reasons. As another example, a greater focus on semantics, as communicated by morphological information, or on visual-orthographic information, may be required for optimally reading in Japanese, Korean, or Chinese, as compared to English. Researchers have much more to learn about these scripts and languages before reading processes can be clearly described. The chapters in this book contribute forcefully to this effort.

In the area of reading research, as it pertains to expert reading, reading development, and reading impairment, there is an ongoing debate about universals and specifics of the process. New data often swings the debate to one side or the other. Yet the volume of data on Korean, Chinese, and Japanese remains sparse relative to what is known about alphabetic orthographies, and few models routinely incorporate the typical phenomenon of biscriptal reading. Now is the time for increasing recognition of what earlier models of monolingual speakers of English have left out. The debate about universals and specifics of reading cannot be settled until we fully understand all the dimensions included across typical Chinese, Japanese, and Korean readers. Language features, such as suprasegmental processing and the extent of lexical compounding of word structures, and script features, including amount of visual information to be processed, structuring of various kinds of orthographic information (including the unit of reading – e.g., character vs. word), and even positioning of script on a page, have not typically been incorporated into past models of reading. More radically, it is important not only to use current models of reading in some languages and scripts to extend to others but also to go directly from scripts that have not been researched all that much thus far and identify what the important features of these scripts are and how they can be incorporated into future models of reading expertise, development, and impairment.

The current volume represents an excellent exploration of these complex issues. The division across languages is helpful, but the integration of these three major languages and corresponding scripts in one volume allows the reader to compare in ways that have not been easy in the past. This state-of-the-art research should serve to stimulate more innovative thinking about the process of learning to read and to write in Korean, Japanese, and Chinese, both individually but also cross-linguistically and in relation to English as a foreign language.

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CHAPTER 1

Written languages, East-Asian scripts, and cross-linguistic influences

An introduction

Hye K. Pae
University of Cincinnati, U.S.A.

This chapter describes the realm of writing systems, scripts, and orthographies focusing on three East-Asian languages – Chinese, Japanese, and Korean. With the operational definitions of basic terms, it identifies the visual resemblances in square blocks as the essential feature underlying commonalities among the three scripts as well as the internal structures of words and linguistic units as the crucial features behind dissimilarities. Next, it describes the scope and breadth of cross-linguistic influences and how models and theories of word processing can be established through cross-linguistic research. The chapter closes with the book's objectives, intended audiences, and organization.

Keywords: writing systems, East-Asian scripts, orthography, Chinese, Japanese, Korean

Language is not only a biological property, but also a sociocultural enterprise of human beings. Through constant evolution over time, language has served as a cognitive and cultural tool for meaning-making and communication. Unlike spoken language, writing emerged as a relatively recent human invention that dates back only some 5,000 or 6,000 years in comparison to other inventions that emerged well over 10,000 years ago.[1] Moreover, written language was not seriously considered a part of linguistics until the 20th century due in part to preoccupation with the

1. It is claimed that controlled use of fire dates back to Wonderwerk Cave, Northern Cape province, South Africa during the early Acheulean occupation, approximately 1.0 Ma (Berna et al., 2012). Lipstick was first used in Blombos Cave, South Africa 70,000 years ago; the flute was first invented as a musical instrument in Germany 35,000 years ago; woven clothing was first made about 25,000 years ago; human portraits and fish hooks were first used in Italy 14,000 years ago; rice was first cultivated as a staple crop 10,000 years ago; and beer was first brewed in China about 10,000 years ago (Hall, Smith, & Wicaksono, 2011: 129).

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naturally spoken form of language in linguistics (Sampson, 2015). Although the debate over the source of *spoken-language primacy* is complicated, it is generally regarded that the fixation by and large resulted from the European tradition of linguistics championed by Saussure as well as Bloomfield's influence on American linguistics, as indicated in "the object of linguistic study is not both the written and the spoken forms of words; the spoken forms alone constitute the object" (Saussure, 1966: 23–24, cited Sampson, 2015: 1) as well as "[l]anguage is basically speech, and writing is of no theoretical interest" (Householder, 1969: 886, cited in Sampson, 2015: 1). This *language-is-speech* perspective has resulted in a number of long-standing misconceptions, inconsistencies, and confusions surrounding writing (Joyce, 2016). Through the evolution of linguistic discourse, the *language-is-speech* notion has gone through ebbs and flows. More recent discussions involve not only the division between speech and writing from the theory of signs and symbolism, but also the reverse influence of written language on spoken language. For example, Harris (2009) argues that, although they operate in tandem, speech and writing function differently because they have "quite different semiological foundations" (p. 46). Linell (2005) also points out paradoxical written language bias that has been exerted onto spoken language, ever since written language was considered in the realm of linguistics, because spoken language became dependent upon models and theories derived from written language.[2]

Despite its comparatively short history, the impact of sign systems is essentially incomparable to any other human invention related to communication. It was only through the written word that information was disseminated in ways that transcended *time* and *space* prior to the invention of voice-recording technology. Written language remains as the primary medium of information sharing. Writing has slowly become conventionalized and standardized over time within the realm of writing systems, scripts, and orthographies. Reading comes to the forefront of the written language because sign systems cannot serve their purposes without decoding or reading. Hence, of importance is reading as the ability to comprehend various texts from the primitive form of letters as in early forms of scripts to digital texts, such as pictograms, graffiti, carved or incised initials on treebark, hard-copy texts, emails, text messages and tweets (that are filled with abbreviations and emoticons), and hypermedia digital texts. Although reading is a requisite for successful functioning within modern society, written language is still an understudied, misunderstood, and confusing topic (Joyce, 2016; Powel, 2009).

An understanding of how readers process different forms of scripts can provide insight into overall reading processes in general, and about specific cognitive

2. Given that the focus of this chapter is placed on the three East-Asian scripts, further information on spoken versus written language is not provided here.

mechanisms and constraints in particular. Along this line of inquiry, two particular considerations warrant special attention. First, of the various written languages used in the current era, three East-Asian scripts – Chinese, Japanese, and Korean – stand out visually, linguistically, and theoretically. They have great potential to generate linguistically- and theoretically-informed scientific discourses and theories due to the stark contrasts among these scripts. Second, when these languages are analyzed from the perspectives of bilingualism and dual-language education, our understanding of reading processes can be enriched in more meaningful ways regarding bilingual cognition, as well as cross-language facilitation, inhibition, and interference. To address these two important considerations, this volume has been compiled as a collection of both theoretical and empirical articles written by leading scholars who not only have a wide range of research interests, expertise, and linguistic and cultural backgrounds, but also are from different countries and regions, including the U.S., Canada, China, Japan, Korea, Hong Kong, Singapore, Taiwan, and Australia. This book makes a particularly significant contribution to the field of reading research given that extant research has focused primarily on languages that employ Roman script. As Share (2008) astutely contends, even though English is an outlier in terms of its grapheme-phoneme correspondence and orthography, a great deal of reading research has fostered Anglocentricism in addressing theoretical and research questions that show little relevance to the universal science of reading and literacy. The new wave of cross-linguistic studies involving these three East-Asian languages will greatly facilitate a scientific understanding of different language processes and, in turn, will inform both theories and pedagogical practices.

This general introduction to the volume first provides some operational definitions of related terms that are germane to the book. Second, it tenders brief introductory outlines of the Chinese, Japanese, and Korean languages and writing systems. Third, it reviews some pivotal characteristics and features of the three languages that are involved in word reading. Fourth, it describes the scope and breadth of cross-linguistic influences or cross-language transfer. Finally, this general introduction describes the book's organization and intended audiences.

Writing systems, scripts, and orthographies

Although the categories employed in any classification or typology can be arbitrary in nature, it is imperative to carefully clarify the terminology typically used in the field of reading to meaningfully capture the operating principle represented by each term (Joyce, 2016). The terms *writing system*, *script*, and *orthography* are especially relevant to this volume. On the linguistic continuum, the term *writing system* has the broadest scope, followed by *script*, and then *orthography* which is specific to the language under consideration. According to Coulmas (2013), writing system refers to an "abstract type of graphic system" (p. 17) that generally relates to certain linguistic units. In delineating some key terms associated with word processing, Joshi and Aaron (2006) suggest that a *writing system* refers to written language that is defined on the basis of its linguistic units, such as alphabetic writing systems (e.g., English, Spanish), syllabic writing systems (e.g., Japanese, Chinese), and morphemic writing systems (e.g., Chinese, Japanese *Kanji*). This definition is based on the minimal linguistic unit (i.e., the phoneme, syllable, morpheme levels) represented in the language under discussion. Similarly, the definition provided by Cook and Bassetti (2005) is also along this line, basically following Coulmas' (1999) notion, that a *writing system* refers to the way in which visible signs connect to language in a systematic way (e.g., alphabetic or syllabic writing system) or to the "specific rules for writing used in a particular language" (p. 4; e.g., the English writing system, the Chinese writing system). These definitions of writing system undoubtedly elucidate the indispensable relationship between linguistic units and their corresponding visual signs as well as the abstract operating principle that regulates the narrower concepts of script and orthography. Given that linguistic units are not always clear-cut depending on the linguistic context of a language, however, there are no pure writing systems that are mutually exclusive (DeFrancis & Unger, 1994; Joyce, 2016).

A *script* refers to the "actual physical form" of letters, characters, or other writing conventions (Cook & Bassetti, 2005: 3) or to a "graphic format in which writing is represented" (Joshi & Aaron, 2006: xiii). A particular type of writing system can have multiple scripts. For example, alphabetic writing systems have different physical formats, such as Roman script, Arabic script, and Korean *Hangul* script. Japanese is a good example of how a writing system can include multiple scripts, as it combines Chinese-derived *Kanji*, two authentic Japanese syllabic *Kana* (*Hirakana* and *Katakana*), and Roman alphabet-based *Rōmaji* (see Joyce & Masuda's Chapter 9 in this volume).

The term *orthography* refers to "the set of rules for using a script in a particular language for spelling punctuation, etc." (Cook & Bassetti, 2005: 3) or the "visual representation of language as conditioned by phonological, syntactic, morphological, and semantic features of the language" (Joshi & Aaron, 2006: xiii), as in Chinese orthography or English orthography. Orthography seems to be characterized by users. The difference between British spelling and American spelling indicates that orthographies are culture- and user-specific. Among many differences, the spelling of words in American English often coincides with how those words sound phonetically, while British English tends to preserve the spelling of French-origin words. A similar example can be found in the difference in usage between South Korean and North Korean *Hangul*. South Korean *Hangul* adopts various sound variations to accommodate the ease of articulation, whereas North Korean *Hangul* maintains the rigid printing convention without variations (see Pae's Chapter 16 for various sound variations in *Hangul*). Given that the term *orthography* involves spelling, both English orthography and Korean orthography specifically refer to the graphotactic and conventional rules of the respective language. For example, since officially named *Hangul* in 1910, the Korean orthography has been subject to change on several occasions under various spelling reforms implemented by the Korean government. The most recent Korean spelling reform took place in 1988, but it was also supplemented in 2015 and 2017 by an addendum to the 1988 spelling guidelines along with some punctuation recommendations. Although the Korean orthography has undergone periodic changes, especially in modern times, the underlying principle of the Korean writing system and the forms of the Korean script have never changed since the new writing system was first promulgated in 1443. The basic rule underlying standard written Korean is to write down words as they sound within the parameters of the oral linguistic rule. As a result, the written language *Hangul* corresponds to the oral language, despite certain sound variations found in some word combinations.

Based on the classifications just discussed, the key terms used within this chapter are summarized in Figure 1.[3] It is important to note, however, that, although the terminology is generally consistent across the chapters of this volume, the contributors vary somewhat in how they operationally employ these terms in their own chapters. It should also be noted that this classification can be controversial, but it serves its purpose well with respect to the global view from typology to linguistic units covered in this book. As shown in Figure 1, the basic divisions are made on the basis of linguistic representation; that is, meaning-represented vs. sound-represented. This taxonomy is based on Cook and Bassetti (2005), but it differs from traditional typological classifications due to an inconsistent criterion used within those classifications.[4] Writing systems are classified according to their level of linguistic-unit

3. There are multiple ways of categorizing the world's languages, but, as it would be beyond the scope of this chapter to attempt to cover all languages, the classification mainly focuses on the three East-Asian languages.

4. As Joyce (2016) convincingly argues, the most influential typology of writing systems – namely, Daniels' (1996, 2001) classification that consists of logosyllabary, syllabary, abjad, abugida, alphabet, and featural – uses "undeniably confusing heterogeneous typological criteria" (p. 295). The criteria are heterogeneous and inconsistent because they are a mixture of linguistic levels (i.e., logosyllabary and syllabary), with a set of coined exemplar names for different types of segmentation [i.e., *abjad* (based on the first two letters of the Arabic script), *abugida* (based the first two letters of the Ethiopic script), and *alphabet* (based on the first two letters of the Greek letter, *alpha* + *beta*)], together with a description of grapheme shape (i.e., featural in reference to the Korean *Hangul*).

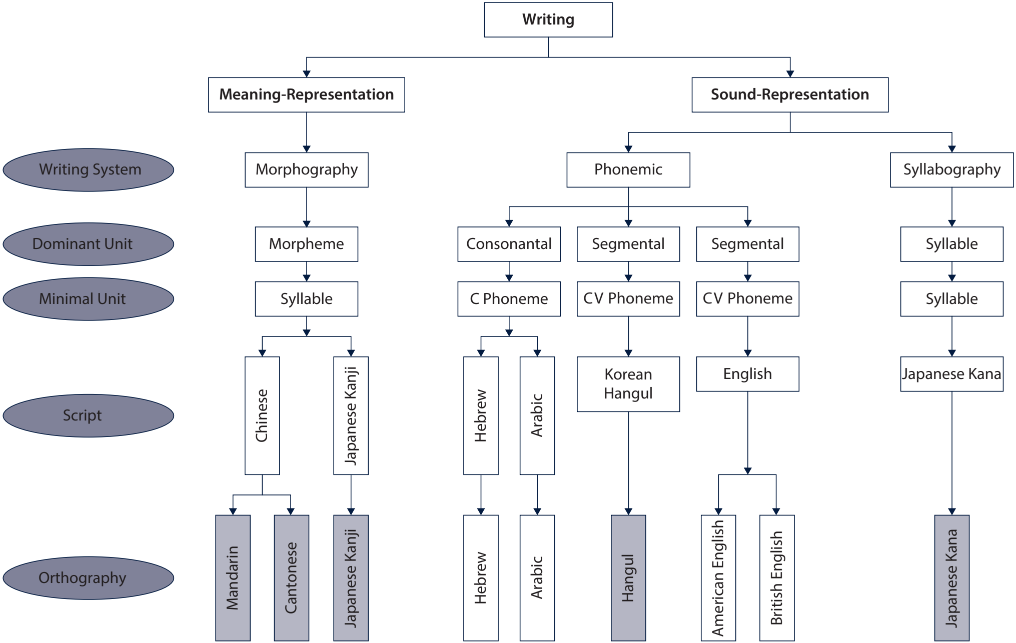

Figure 1. Classification of writing systems, scripts, and orthographies

representation; that is, “morphography” as meaning-representations versus “phonemic” and “syllabography” as sound-representations. Figure 1 also presents the dominant unit and minimal unit, as well as the script of each writing system.

Early written symbols were largely based on pictographs (Sacks, 2003). Pictography includes indigenous and modern pictographs (as well as *petroglyphs*, meaning incised or carved images on rocks). However, pictography has never been regarded as a functional or full writing system (DeFrancis, 1989). Furthermore, Joyce (2016) asserts that there are only three levels of linguistic units--morphemes, syllables, and phonemes--in which writing systems can systematically represent language, because pictographs do not relate to linguistic units in sufficiently systematic ways to underpin a fully functional writing system. Joyce (2016) continues to claim that typologies of writing systems should be based on “typological categories that correspond to these levels and these should be clearly distinguished with terminological labels that are both informative and consistent” (p. 293). Morphography includes morpheme-based Chinese characters and Japanese *Kanji*. Joyce (2016) claims that “… *morphography* is a more precise typological label than logography…” (*italic* original). It should be noted that meaning-based systems can be read by persons who speak different languages. For example, the word “川” (meaning “stream” or “river” is read as /chuan/ in Mandarin, /cyun/ in Cantonese, /sen/ and /kawa/ in Japanese, /chʌn/ in Korean, and /xuyên/ or /xiên/ in Vietnamese. This can be an example that does not support the *language-is-speech* notion, as Joyce (2016) positions himself in opposition to the *language-is-speech* view and encourages the debunking of various misconceptions and confusions in favor of a more scientific discourse.

Phonemic languages have at least three sub-categories, including consonantal (a.k.a., *abjads*), segmental plus, and segmental, which indicate the dominant units. The first subcategory relates to the semitic languages (e.g., Hebrew, Arabic) that represent *consonantal* phonemes in principle. In the consonantal scripts, vowels are only written in a subsidiary, incomplete, and inconsistent manner; vowel notation is available only for emergent readers or special circumstances. The second subcategory involves *segmental plus* reflecting the complementarity of segmentals (i.e., consonants and vowels) and subsyllabic units. This is known as alphasyllabary (e.g., Korean, Kannada) that is characterized, as the name implies, by the duality that the linguistic system subscribes to (i.e., the characteristics of both an alphabet and a syllabary) and corresponds to segmental consonants and vowels (and possibly body-coda units). The third subcategory of *segmental* encompasses alphabets (e.g., English, Spanish) that correspond to segmental consonants and vowels (and possibly onset-rime units). Sacks (2003) remarks that “[a]mazingly, with the sole exception of Korea’s Hangul script…, all of today’s alphabetic scripts have a common origin” (p. 2). He continues to comment that “[o]ur Roman alphabet is a third cousin to the Arabic alphabet, a second cousin to the Cyrillic alphabet, and a grandchild of the Greek alphabet" (p. 2). Although not all alphabets are similar in their appearance, Roman alphabets converge on the general alphabetic principle and the left-to-right linear sequence of graphemes, reflecting their *one* source of origin. The alphabetic principle involves the use of atomic phonemes in combination with other phonemes to construct syllables. The linear sequence of graphemes refers to the way in which letters are blended together. For example, the word *cat* has three phonemes and three graphemes,[5] and the three phonemes are glued together to form a syllable (the alphabetic principle); the three graphemes are blended in the horizontal railway sequence (the linear sequence of graphemes), as opposed to Korean *Hangul*'s grapheme package in a block (see Pae's Chapter 16 for Korean grapheme allocations). These two features of phoneme representation and grapheme sequencing are not possessed by either Chinese or Japanese *Kanji*, as they have the convention of one character corresponding to a syllable in which the blending of phonemes or graphemes does not take place. Moreover, because Japanese has a restricted syllable length (e.g., "/ga, gi, gu, ge, go/"), the word *cat* is rendered as Kana transcription "キャット" /kyatto/, which consists of two syllables with the added vowel to the last consonant "t" due to the syllabic nature of Japanese (for this epenthetic *vowel-addition* feature of Japanese, see Broekhuyse & Taft's Chapter 10 in this volume). Phonemic languages typically use a limited set of symbols--typically 20 to 30--in order to orthographically represent more than 10,000 syllables, of which Chinese and Japanese cannot provide with their inventories of characters or letters.

The last category of syllabography is characterized by syllables. Japanese is known as a syllable-represented language. However, it is more complex than it appears due to the characteristic of *mora* (拍 /haku/), referring to a phonological unit that has equal duration to a syllable. Since *mora* is used as a counting unit as the basis of the sound system, the concept of a syllable is subtle and complex in Japanese. For example, the word for "Japan", "日本" has two syllables but two different pronunciations, one with three morae (*Nihon, Ni-ho-n*, にほん) and the other with four morae (*Nippon, Ni-p-po-n*, にっぽん), in the *Hiragana* orthography. Likewise, the word *Tokyo* has two syllables but have four morae (*to-u-kyo-u* とうきょう). Regardless of the syllable or the mora, of interest is the fact that each Japanese symbol functions as a syllable, which qualifies a "syllabography."

5. In English, the numbers of graphemes and phonemes are not always equal. For example, the word "church" has 6 graphemes but has only 4 phonemes [tʃɜrtʃ].

How Chinese, Japanese, and Korean scripts stand out among written languages

Among 7,000 languages that are currently in use around the world belonging to more than a hundred distinct language families (Hall, Smith, & Wicaksono, 2011), Chinese, Japanese, and Korean are three distinctive languages that are spoken within close geocultural regions. Especially in the written form, each language exhibits uniqueness in terms of its visual configurations and the internal linguistic structures of their lexicons. Despite their visual and linguistic distinctiveness, scientific inquiries into and systematic analyses of these three languages only began about two decades ago. In the relatively exhaustive survey of the world's writing systems in Daniels and Bright's (1996) edited volume, the editors acknowledged their insufficient coverage of these three languages, remarking that "… among modern languages only the Chinese/Japanese/Korean sphere [was] not fully presented here" (p. xxxv). Another edited volume by Taylor and Olson (1996) also provides a relatively thin discussion of these three languages, even though the book is entitled *Scripts and literacy: Reading and learning to read alphabets, syllabaries and characters.*

Chinese is the most commonly spoken language as a first language (L1) in the world, and has gained a reputation as being representative of logography or morphography.[6] Although there is no language that is purely logographic or morphographic (Unger & DeFrancis, 1995), Chinese has been categorized as a morphography in the reading sciences based on the key feature that penetrates its writing system or, at least, captures the overall tendencies of the writing system (Joyce, 2016). The overall tendencies involve a symbol-morpheme correspondence and, at the same time, a syllabary that has a symbol-syllable correspondence, as opposed to phonemic systems that essentially have a symbol-phoneme correspondence. For example, the single-stroke character of "一" /yi1/ (first tone) represents number "one," while the two-stroke character "二" /er4/ (fourth tone or falling tone) represents number "two," such that each character not only represents a morpheme but also indicates the corresponding syllable.

Chinese, which is the oldest among the East Asian scripts, overshadowed an immense influence on Japanese in the script and lexicon. However, the Japanese writing system is interesting in that it employs multiple scripts including morphographic *Kanji*, syllabographic *Kana*, phonemic alphabet *Rōmaji*, and Arabic numerals *Suji* (see Joyce & Masuda's Chapter 9 in this volume). *Kanji* are the

6. Although there are cases in which characters are used merely for their phonetic values in representing a syllable or part of a syllable, the dominant rule is the unit of morphophonetic writing that does not provide phonetic clues.

Chinese-derived morphographic script, which was introduced around the third century through Korea (Smith, 1996). They are used to encode the primary lexical categories, such as nouns, verb stems, adjective stems, and adverbs. *Kana* are another type of syllabic script that functions as a phonographic system. There are two forms of *Kana* which emerged during the 9th century: *Hiragana* (cursive *Kana* typically used for grammatical morphemes) and *Katakana* (simpler incomplete Kana typically used for loan words, foreign words, names of cities, names of persons, new words, and onomatopoeia). The two *Kana* systems, *Hiragana* and *Katakana*, can both be considered complete orthographies for Japanese, as the Japanese spoken language can be written using either of the two *Kana* syllabaries (Smith, 1996). The last type of script used within Japanese is *Rōmaji*, which literally means "Roman letters" and adopts the phonemic system to write the Japanese language, especially for train station names, street highway signs, company names, and acronyms. Lurie (2012) pondered that the use of these multiple scripts in Japanese might have resulted from the need to fill the gap in orthography between Japanese and Chinese that was inevitable at the time of *Kanji* borrowing. Although it has not been scientifically assessed, the multi-script use might also be attributable to the small inventory of syllables and restricted syllable length. Specifically, Japanese has five vowels (i.e., /a/, /i/, /u/, /e/, and /o/) that are the crux of 46 basic syllables. Reflecting the limited number of vowels, the number of syllables (106 *Kana* signs, including 46 basic, 25 secondary, and 35 compound; Taylor & Olsen, 1996), including *Morae* (168 *Mora* signs in total), available in Japanese is much smaller than that of any alphabetic languages (which typically have more than 10,000 syllables) and even less than Chinese (approximately 400 syllables if one ignores tone variations). Despite the small number of syllables, the Japanese orthography fully functions to represent its oral language through multi-scriptal use. This characteristic provides an interesting motivation for investigating the characteristics of the reading processes involved in conjunction with research examining these processes in Chinese and Korean.

Chinese has also exerted an immense influence on the Korean language. Consequently, the Korean language consists of vocabulary from two main sources; one is Chinese words that were adapted to the Korean ways of pronunciation, and the other is authentic Korean words. The former is referred to as "Sino-Korean" words which are Chinese loanwords with Korean pronunciation (about 70% of Korean vocabulary). While Sino-Korean words can be written in either Chinese characters or Korean *Hangul*, native-Korean words cannot be written in Chinese characters. For example, the word "person" can be written in both *Hangul* (인 [in]) and Chinese character (人 [in]), but the equivalent authentic Korean word "사람" [saram] cannot be written in Chinese characters. However, Korean grammar is purely Korean in origin, and, in principle, follows the word order of subject-object-verb, although the subject can be omitted most of the time.

Prior to the emergence of the Korean writing system, the use of Chinese characters on stone inscriptions within Korea can be traced back to 414 C.E. (King, 1996). The linguistically-motivated *Hangul* was independently designed by *King Sejong the Great* (see Pae's Chapter 16 in this volume for the invention of *Hangul*).[7] Due to the systematic blending of a consonant and a vowel and the consistent letter-sound correspondence as well as the featural representation of vocal organs in the segmentals, all of which contributes to effective learnability and usability of *Hangul*, the Korean writing system has earned its reputation as the most scientific writing system in the world (Sampson, 2015).

The phonetic alphabet *Hangul* fundamentally transformed the accessibility of literacy for the whole Korean population, such that the rate of illiteracy within Korea today is less than 2%. This is exactly what *King Sejong the Great* hoped for with his invention in the 15th century. As *King Sejong* mentioned in his declaration of the new writing system in 1443, the Korean spoken language is very different from Chinese, as the two spoken languages belong to entirely different language families. The Korean language is closer to the Japanese language than any other language. While not without contention that Korean is a language isolate (see Pae's Chapter 16 in this volume), Korean has been categorized as belonging to the Altaic family, along with Japanese, with agglutinative features. Agglutinative languages have complex forms of affixes that conjugate from a root word. Unlike the Chinese and Japanese writing systems, however, Korean *Hangul* is basically a phonemic writing system in which a segmental symbol represents a phoneme, and a cluster of graphemes group together to form a syllable. As an example, again consider the single-stroke word "一" (/yi1/ in Chinese; "일" /il/ in Korean) that means number "one." Since this is a Sino-Korean word, it can be written in either *Hangul* or *Hanja* (Chinese character) in Korea. When it is written in Korean, the word "일" /il/ is composed of three graphemes "ㅇㅣㄹ", as opposed to one morphemic syllable in Chinese.[8] This phonemic/graphemic element of Korean is a departure point from the Chinese and Japanese scripts.

7. There have been other views (i.e., command hypothesis and collaboration hypothesis) on the creation of *Hangul*. However, this interpretation is recent and can be more plausible in consideration of the political and diplomatic matters with which the *Chosun* dynasty dealt in the 15th century.

8. Technically speaking, the first grapheme "ㅇ" is a place-holder null phoneme for the vowel of "ㅣ"; hence, the word "일" has two phonemes [ㅣ, /i/] and [ㄹ, /l/] but three graphemes "ㅇ," "ㅣ," and "ㄹ" (see Chapter 16 for more information on this).

Common threads and idiosyncrasies in word recognition in Chinese, Japanese, and Korean

The concurrent coverage of Chinese, Japanese, and Korean within one volume is worthwhile because there are points of discussion that no other three languages can offer in terms of contrasts of their language families, visual configurations, and the internal structures of words. These characteristics provide both commonalities and differences among the three languages and their scripts. Among other features, this introductory chapter underscores visual resemblances as the most fundamental feature underlying the commonalities as well as the internal structure of words as the key feature of the dissimilarities, which, in turn, make word processing either similar or different across these three languages. Visual resemblance involves the graphic elements of the scripts, as the characters of the three languages are essentially confined within square blocks. On the one hand, this permits greater flexibility in terms of writing direction as text can be either horizontally or vertically oriented. On the other hand, the configuration within square blocks means that syllabic boundaries are unambiguous because syllables stand independently and are clearly demarcated from the neighboring syllables. For example, visually clear is the syllabic segmentation of the word "학생" [hɑk-sæŋ] in Korean or "學生" in Chinese character, meaning a "student" in English. The same applies to Chinese (the simplified form of the first character as 学生 [xué3 shēng1]) and to Japanese Kanji (学生 [gaku-sei]). This is different from English words wherein it is difficult to visually differentiate one syllable from adjacent letters within a word. For instance, the word "student" provides no indication of the syllabic demarcation between the two syllables (e.g., <student> vs. <stu·dent>).

Considering the fact that Chinese uses a morphographic script and is a syllabic language and that Japanese partially uses a morphographic script, the similarity in terms of the "equidimensional geometry" of the characters between Chinese and Japanese may not be surprising. What draws linguistic interest in particular lies in the Korean script, which is, unlike Chinese and Japanese, a phonemic and sound-based language.

Despite similarities in visual configurations, differences among the three languages can be found in terms of the language families, morpheme formulation, internal structures of words, and grammar. First, Chinese belongs to the Sino-Tibetan language family, whereas Japanese and Korean belong to the Altaic family,[9] as briefly mentioned earlier. Second, the methods of morphological union are different among the three languages. Many Chinese words correspond to one morpheme or

9. There are contentious debates over the language family of Korean. See Pae's Chapter 16 in this volume.

a monosyllabic root without changes to the root due to inflection. Due to its morphographc and syllabic nature, Chinese has a limited number of syllables, resulting in only 1,277 different syllables with tone variances and only about 400 different syllables without tone variations in Mandarin (Taylor & Taylor, 2014). This yields a large number of homophones in the language.[10] However, Japanese and Korean are agglutinative languages in which affixes or other derivatives are appended to the root word. In Japanese and Korean, affixes "glue together" with stems, and the meanings remain unchanged after their union, yielding a few irregular verbs.

Next, the internal structures of words are clearly different among the three languages. This is obviously related to the syllabic natures of Chinese and Japanese as opposed to the phonemic characteristic of the Korean language. Hence, the minimal unit of language is the syllable for Chinese and Japanese versus the phoneme for Korean. There is empirical evidence that different levels of phonological processing are involved in reading for these different languages, as presented in this book. Since each morpheme of Chinese and Japanese *Kanji* is generally mono-syllabic, it is more likely that reading in Chinese and Japanese *Kanji* involves identification of a word as a visual gestalt (a.k.a., the "look-and-say" method). In contrast, words in Korean are, in principle, more likely to be processed letter by letter (a.k.a., the phonic method of reading). Given that this feature has significant implications for word processing, this volume includes related in-depth discussions in the other chapters within this volume.

Lastly, word order within sentences also differs. Chinese places verbs and prepositions before objects and nouns, respectively, as in English. However, Japanese and Korean place the verb at the end of the sentence, making them "verb-final languages" (e.g., the sentence "She likes apples" is written as "She apple like" without the plural and third-person suffixes in both Korean and Japanese), and both languages place nouns before "postpositions" rather than after prepositions [e.g., the sentence "She went to the store" is written as "(She) (the) store to went" in Japanese and Korean without the definite article, and the subject is most of the time omitted when contextually clear]. Sampson (2015) comments that the Korean language is far more different linguistically from Chinese than is any one language from another among the European languages. While these sentential differences are also worthy of further in-depth scientific discussion, syntax is beyond the scope of this volume.

10. Korean and Japanese have a large number of homophones heavily in Chinese-derived Sino-Korean and Sino-Japanese words.

Cross-linguistic influences or cross-language transfer in word reading

Based on the aforementioned characteristics of Chinese, Japanese, and Korean, there is undoubtedly substantial merit in conducting independent linguistic and/or acquisition studies of each language. However, there are also important implications of undertaking a comparative study in comparison to English as either a first language (L1) or a second language (L2) over any single-language studies, because the treatment of dual languages not only provides a platform for theoretical discussions from multiple angles, but can also yield key insights concerning both linguistic universals and specifics. Following this line of logic, scientific interest has been heightened over the past couple of decades in making comparisons between one or two of these three languages and English as either L1 or L2. When more than one language is involved in reading, facilitation or interference of one or both of the languages is inevitable. Cross-language interactions between two or more languages depend on the degree of transferability and language distance (i.e., typological relatedness).

Jarvis and Pavlenko (2007) summarize various dimensions of cross-linguistic influences, including linguistic skills (phonological, orthographic, semantic, morphological, etc.), directionality (*forward transfer* from L1 to L2, *reverse transfer* from L2 to L1, or *lateral transfer* from L2 to L3), types of knowledge (implicit, explicit), mode (expressive, receptive), channel (aural, visual), and outcome (proactive and negative). Within cross-language transfer research, empirical evidence converges on both cross-language universality and specificity. It is expected that the collection of both theoretical and empirical contributions to this volume will further solidify what we have already identified as language-universal and language-specific factors within bilingualism or multilingualism, as well as address the particular cross-linguistic intricacies involved in reading for the three scripts in both laboratory and natural settings. Although transfer effects are not limited to the lexicon, the scope of coverage for this volume concentrates on script processing. This focused discussion allows us to theorize about the interactions between L1 and L2 lexical properties and among multiple languages under the multicompetence framework formulated by Cook (1991, 1992, 2003). The theory suggests that being multilingual creates a distinct "compound state of mind" that differs from the two monolingual states. Knowledge of two or multiple languages is viewed as an interconnected system rather than each language being an independent system. In capturing the linguistic interdependence in the processing or acquisition of dual or multiple languages, the terms *cross-language influences* and *cross-linguistic transfer* are used. These two terms are used interchangeably throughout this book.

About this book

Objective of the book

The main objective of this volume is to provide a venue to construct a knowledge base and to add a new dimension of understanding as to the processing of words in Chinese, Japanese, and Korean within the context of bilingualism and biliteracy, specifically by offering both descriptive and theoretical accounts of their writing systems. Some chapters provide comprehensive reviews of research on this topic, while others present empirical evidence gained by addressing specific research questions or hypotheses posed a priori. Word reading is a vital stepping stone for sentence comprehension as well as an essential ingredient of reading overall. To fully understand what is entailed in word identification and word reading, a systematic and comprehensive analysis of script effects is imperative. Cook and Bassetti (2005) have lamented that research on L2 writing systems and scripts is scattered with little continuity across various research areas, such as applied linguistics, psycholinguistics, psychology, and education. As indicated earlier, this volume adds a significant discussion beyond the Anglocentric-centered research trend (Share, 2008). Given the usefulness of understanding the processes of these three East-Asian scripts in reading, this book aims to bring together the interdisciplinary research areas for students, researchers, and practitioners in different disciplines. Another aim of this book is to further develop a research agenda for generating a key knowledge base surrounding the word processing of these three East-Asian languages.

The scope of this book does not extend to sentence processing because that involves many variables that are geared more toward individual readers' intrinsic and extrinsic characteristics, such as prior knowledge, motivation, and strategies, that are not easily controlled in empirical analyses. Limiting the chapters to the word or lexical level provides more focused discussions by precluding the potentially spurious variables involved in sentential processing. Some may view this scope as a limitation. However, this (potential) drawback is far underweighed by the exclusively concentrated focus on the given topic with a coverage that is still sufficiently broad in scope and rich in content.

In terms of the notation of transcription, phonemic transcriptions are indicated with the solidus / /, while phonetic transcription is enclosed within square brackets [ ]. Curly brackets { } are used for morphemic transcriptions, and angle brackets < > are used for orthographic transcriptions. Consistency exists throughout the volume, although the contributors employ their own notational conventions as necessary.

Intended audiences

The book is of interest to a wide range of researchers and practitioners in different disciplines of second language acquisition, applied linguistics, psychology, and education. It is also useful for students at the advanced undergraduate and graduate levels. As the contributors have diverse linguistic and cultural backgrounds that allow for building common grounds from many different countries and regions, it also serves students who are interested in the three Asian languages and cross-language influences from all over the world, irrespective of their L1 backgrounds or cultural identities.

Scope of the book

This book serves as an introduction to the field for those who are unfamiliar with the scope, depth, and breadth of achievements that have been made in the fields of reading for Chinese, Japanese, Korean, and beyond, as it provides detailed introductory accounts to each language and their word and reading processes. It can also be used as a reference resource for teaching, research, and technical reports, as the book contains up-to-date literature reviews and empirical reports to the substantive level.

Organization of the book

The book consists of 22 chapters organized into three parts, along with McBride's Foreword that sets the stage for the book. Each part begins with an introductory chapter to the language under discussion. Each chapter stands independently and discusses the fundamental aspects of word or lexical processing for the given language, excluding sentence-level processing.

Part 1 covers the Chinese writing system and script in relation to word recognition or reading. Lin and colleagues (Chapter 2) begin Part 1 by providing a brief survey of the Chinese writing and spoken systems and of core constituents of reading processes in Chinese. They articulate developmental trajectories in learning L1 and L2 among simultaneous and sequential learners of children and adults from the perspective of cross-language and cross-script differences and similarities involved in reading. Chang and Perfetti (Chapter 3) argue that the complexity of graphic forms of scripts hinges upon the unique characteristics of each writing system, which affects perceptual processes involved in reading. Upon using a multidimensional system for quantifying complexity of 131 orthographies (i.e., GraphCom), they elucidate that the use of the complex traditional script of

Chinese requires greater perceptual involvement than the simplified script. Koh and colleagues (Chapter 4) identify different dimensions of within- and cross-language relationships among phonological awareness (PA), morphological awareness (MA), and vocabulary knowledge in reading L1 Chinese and L2 English among Chinese and English monolinguals as well as Chinese-English bilinguals. They have found that PA and MA are consistent predictors of successful reading, whereas vocabulary skills yield conflicting results in the extant literature. They call for further research on the inter-relationships among subcomponents of PA and MA as well as various aspects of vocabulary knowledge involved in word reading. Kalindi et al. (Chapter 5) review the cognitive and linguistic precursors to successful reading versus reading difficulties in Chinese, in addition to reviewing the unique linguistic profiles associated with reading impairments in Chinese. The authors also present evidence-based practices for reading interventions. Jiang (Chapter 6) reviews recent studies with respect to learners' initial understanding of unknown words (semanticization), the acquisition of polysemous words, and learning of new semantic distinctions in Chinese as L2. Cao (Chapter 7) uses a literature review to examine cross-linguistic differences in the brain network, activation, and neural specialization involved in reading, and to uncover how L1 and L2 reciprocally interact with each other in processing. Ma et al. (Chapter 8) presents an fMRI study that examines neural dissociations of semantic and lexical processing in unbalanced Chinese-English bilinguals. They have found that similar activation patterns and neural networks are involved in semantic processing in L1 and L2, but more cognitive resources are engaged in L2 than L1 at the prelexical, sub-lexical, and lexical levels in word processing.

Part 2 deals with the multi-script Japanese writing system, word identification, and reading. Joyce and Masuda (Chapter 9) not only describe the historical development of Japanese and the contemporary multi-script Japanese writing system, they also review psycholinguistic studies of Japanese word processing. Broekhuyse and Taft (Chapter 10) present their research findings of how Japanese-English bilinguals are inclined to recall L2 words based on their native phonological structure (e.g., the pseudo-word "ganics" would be processed in the "Japanized" underlying representation of four morae /ga-ni-ku-su/), suggesting that L2 pronunciation is modulated by L1 linguistic units. Masuda and Joyce (Chapter 11) examine, using the constituent-priming paradigm, the early activation of morphological information in the processing of two-*kanji* compound words to verify the Japanese Lemma-Unit Model proposed by Joyce (2002). They found more complex interactions involved in different forms of morphological information across different word-formation principles. The results are interpreted from orthographic, phonological, and semantic perspectives. Akamatsu (Chapter 12) reports the effects of adult learners' L1 and the length of residence in L2 speaking countries on the mental representation of the concept associated with L2 English polysemous prepositions *at*, *in*, and *on*. Findings suggest that L1 is likely to affect learners' mental representations of L2 prepositions, but significant L2 exposure can mitigate such L1 effects. Yamashita (Chapter 13) presents a longitudinal study that investigates orthographic and phonological processing in L2 English word recognition among EFL learners in grades 9 through 11, suggesting different developmental trajectories involved in word processing between EFL learners and L1-English readers. Koda and Miller (Chapter 14) expound linguistic interactions between L1 and L2 under the crosslingusitic sharing framework proposed by in Koda's earlier work, focusing on morphological awareness, grapheme-morpheme relationships, and L2 word meaning inference. They underscore the importance of taking componential subskills into account in exploring crosslinguistic interactions. Sato's chapter (Chapter 15) identifies translanguaging afforded by scripts and discusses how the multi-scriptal nature of Japanese and the unconventional use of *furigana* (a parallel specification of the pronunciation of *kanji*) influence translation from English to Japanese.

Part 3 focuses on the Korean writing system and its script, *Hangul*, from the history of *Hangul* to data-driven reports of the uniqueness of word processing in *Hangul* as well as L1 effects on processing L2 English. Pae (Chapter 16) begins her chapter with a general introduction to Korean *Hangul* and moves on to linguistic and psycholinguistic accounts of the structure and orthography of *Hangul*. Pae et al. (Chapter 17) examine the impact of the syllabic structure of the Korean script on L2 English word reading using the Korean and English printing conventions (i.e., block formats vs. horizontally linear formats). Results indicate that native Korean readers are likely to take advantage of L1-derived syllabic boundaries when reading L2 English words. Bae et al. (Chapter 18) examines the role of body and rime units in rapid word recognition among Korean natives using a masked priming paradigm. Unlike the dominant claim of the body primacy in Korean, the present evidence is in favor of both body and rime units in processing *Hangul* words. Cho (Chapter 19) examines the respective contributions of orthographic, phonological, and morphological skills and naming speed to reading and writing in Korean *Hangul*, Chinese *Hanja*, and L2 English among Korean children. The findings suggest that morphological awareness is meta-linguistic skills that are transferable across languages regardless of syllabic or phonemic languages, while phonological skills are malleable for cross-language transfer only between phonemic languages. Cho also suggests that orthographic skills are language-specific. Kim and Wang (Chapter 20) summarize the neural mechanisms of reading in Korean as L1 and English and Chinese as L2 to understand whether and how the characteristics of the Korean orthography function in the brain network. They conclude that assimilating networks (i.e., similar to the L1 network) are found for Korean-English bilinguals and accommodating networks (i.e., different from the L1 network) for Korean-Chinese bilinguals. Pae and colleagues (Chapter 21) investigate how native speakers of Korean recover missing information in L2 English texts, compared to native speakers of Chinese and English, when reading mutilated prints (i.e., bottom-half or top-half only text). They find significant differences in reading accuracy and speed among the three L1 groups. Pae et al. suggest that L1 script effects and typological relatedness are the locus of the difference found in the performance of the three L1 groups, especially constituent processing in English for Korean speakers and gestalt processing in English for Chinese speakers.

Bae et al. (Chapter 22) conclude all discussions and reports presented in this volume by underscoring what we know so far concerning reading universals and reading particulars as well as word reading in the three scripts. The conclusion also suggests future directions for theory building, methodological advances, and pedagogical implications for L2 learning.

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PART 1

Chinese

CHAPTER 2

Introduction to script processing in Chinese and cognitive consequences for bilingual reading

Candise Y. Lin[i], Min Wang[ii] and Anisha Singh[ii]
[i]University of Southern California / [ii]University of Maryland, College Park

The Chinese writing system forms the sharpest contrast with the English writing system in terms of its grapheme-phoneme mapping principle. This review paper begins with a description of the characteristics of the Chinese writing and spoken systems, which is followed by the discussion of phonological, morphological, and orthographic processing involved in reading Chinese. We then review the literature central to the question as to how cross-language and cross-script differences and similarities in terms of the three basic processes impact reading English as a second language (L2) by native Chinese readers. We address the question from developmental perspectives targeting both children who are learning to read Chinese and English simultaneously and adult sequential learners of English. The chapter concludes with a discussion of limitations in previous research and future directions.

Keywords: Chinese script, cross-linguistic influence, English as a second language, bilingual reading acquisition

Over 1.3 billion people around the world speak the Chinese language, which consists of seven major dialects, including Mandarin, Yue (e.g., Cantonese), Wu (e.g., Shanghainese), Xiang, Gan, Kejia, and Min (Taylor & Taylor, 2014: 21). All Chinese dialects belong to the Sino-Tibetan language family and they share some similar linguistic features such as having tones, simple syllabic structure, and monosyllabic morphemes. However, most of these dialects are mutually unintelligible. What unifies the speakers of various dialects and facilitates their communication is a common Chinese writing system. Indeed, the Chinese script is used by the largest population in the world (Shu, 2003: 275). Among the several major Chinese dialects, Mandarin has the greatest number of speakers, with 800 million. All examples of Chinese syllables, morpheme, and words used in this chapter are in standard Mandarin (known as *Putonghua*, "common speech").

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This chapter introduces the readers to the writing and spoken systems of Chinese and discusses the phonological, morphological, and orthographic processes involved in reading Chinese. In addition to the literature based on native Chinese readers, studies of Chinese-English bilingual reading related to the phonological, morphological, and orthographic processes are reviewed. We seek to answer the key question as to how cross-language and cross-script differences and similarities impact bilingual reading.

Characteristics of the writing system

The Chinese writing system is often considered logographic in which each basic written unit, the character, maps onto a morpheme. But most researchers prefer the term "morphosyllabic" to emphasize the fact that each character also maps onto a syllable in the spoken language (Leong, 1997: 381). There are considerable differences in how characters are written in the countries and regions that use them. Simplified characters are used in China and Singapore while traditional characters are used in Taiwan, Hong Kong, and Macau. All of the examples of Chinese characters used in this chapter are simplified characters.

Strokes

Chinese characters are composed of strokes, which do not represent any morpheme or sound. Each character is written with a fixed number of strokes arranged in appropriate positions relative to one another. Different configurations of the same stroke form different characters (e.g., 工 'work,' 土 'earth,' 上 'up,' and 士 'solder') (Shu, 2003: 276). Adding, removing, elongating, or shortening a stroke results in a completely different character and hence different meaning and pronunciation. For example, adding a dot to the character 王 'king' makes the character 玉 'jade'; lengthening the vertical stroke in the character 甲 'armor' changes it to 申 'extend'.

There has been a debate regarding whether individual strokes or stroke patterns serve as the functional orthographic unit in Chinese word recognition. Stroke patterns are a fixed set of recurring spatial designs composed of multiple strokes (e.g., 彳, 氵, 日, 宀, 纟, and 皿). Traditionally, the individual strokes are thought to be the principal word constituents in Chinese, analogous to the alphabetic letters in English (Chen, Allport, & Marshall, 1996: 1025). Many studies in Chinese counted the number of strokes as the index of orthographic complexity (e.g., Perfetti & Zhang, 1991: 635, 1995: 30; Wong & Chen, 1999: 465). However, recent evidence suggests that the integral stroke patterns, rather than the individual strokes, should be regarded as the basic orthographic units of Chinese characters. In a same-different character judgment task, Chinese readers were significantly faster to judge pairs of characters with two stroke patterns (i.e. 江 'river' vs. 扛 'carry') than those with three stroke patterns (i.e. 唱 'sing' vs. 喝 'drink') after controlling for the number of individual strokes. In contrast, the total number of strokes in each character had no effect on Chinese readers' speed or accuracy of performance (Chen et al., 1996: 1038). Anderson, Ku, Li, Chen, Wu, and Shu (2013: 53) showed that when school-aged Chinese children were asked to copy unfamiliar or pseudo characters, they were better at reproducing items consisting of familiar stroke patterns (e.g., ) compared to those containing arbitrary stroke configuration (e.g., ). These results suggest that the integral stroke pattern is the important functional unit of Chinese characters for both developing and skilled readers.

Characters

Whether a character has one stroke or twenty strokes, it is written in a square frame occupying a fixed amount of space in print, analogous to the English letter in this respect (Cheung, McBride-Chang, & Chow, 2006: 421). However, unlike the English letter that in many cases represents a phoneme, a character maps onto a morpheme and combining characters results in a word. Each character is equally spaced. For example, 'we are Chinese' is written as 我们是中国人, rather than 我们 是 中国人. As a result of this characteristic of the Chinese text, the character is the most salient unit in Chinese script processing (Chen & Pasquarella, in press) and the idea of a word is rather fuzzy for Chinese readers (Cheung et al., 2006: 421). Research has shown that even educated native Chinese speakers disagree on word boundaries in simple sentences (Hoosain, 1992: 111).

Components

Corpus analysis (Zhou, 1992: 179) of the 新华字典 'New China character dictionary' revealed that 17% of the characters may function independently or as semantic or phonetic components of other characters and these are known as simple characters. On the other hand, 81% of the characters are made up of a phonetic and a semantic component (i.e. radical, 部首 'category header') and these are known as compound or composite characters. Most simple characters are either *pictograms* which are derived from the objects they denote (e.g., 山 'mountain') or *ideograms* which are iconic illustrations of abstract ideas (e.g., 上 'up' and 下 'down') (Taylor & Taylor, 2014: 56). There are two types of compound characters. *Ideographic* *compound* characters combine two pictographic or ideographic characters to suggest a third meaning. For example, combining the characters for 女 ‘daughter’ and 子 ‘son’ makes 好 ‘good’. *Semantic-phonetic compound* characters consist of two components, the semantic radical, which carries information about meaning, and the phonetic radical, which provides information about pronunciation. There are about 200 semantic and 1100 phonetic radicals in the Chinese writing system (Shu, 2003: 275). For example, the character 功 ‘merit’ has the same pronunciation as its phonetic radical 工 ‘work’ and shares similar meaning as its semantic radical 力 ‘strength.’

However, characters like 功 in which both the phonetic and semantic components provide a close indication of meaning or sound are rare (Mair, 1996: 201). In a corpus analysis of more than 6,000 characters, Zhu (1987) found that only 18.5% of the phonetic components have the exact same pronunciation as the characters in which they occurred and these phonetics tended to occur among infrequently used characters. A more recent study (Hsiao & Shillcock, 2006: 417) revealed that among 3,000 most frequent compound characters, about 33% have regular phonetic components which signify the pronunciation of the characters transparently. In another study by Shu, Chen, Anderson, Wu, and Xuan (2003: 35), when only 2,570 characters listed in elementary school textbooks were considered, 39% of the compound characters contained regular phonetic components, including those that had the same syllable segment but different tone as the whole character; e.g., 贡 is pronounced with Tone 4 while its phonetic radical 工 is pronounced with Tone 1. Mandarin Chinese has four lexical tones. The first tone, labeled as 1, is a high-level tone; the second tone, 2, is a high-rising tone; the third tone, 3, is a falling-rising (or dipping) tone, and the fourth tone, 4, is a high-falling tone. An alteration in the lexical tone of a syllable changes its meaning. For example, the syllable [ma[1]] has four possible meanings when different tones are attached to it: [ma1] 妈 ‘mother’, [ma2] 麻 ‘hemp’, [ma3] 马 ‘horse’, and [ma4] 骂 ‘scold’. There is also a wide variability in terms of the transparency of the semantic component in relation to the meaning of the whole character. In Shu et al. (2003: 37), 58% of the compound characters taught in elementary school have transparent semantic components (e.g., 妈 ‘mother’ contains the semantic radical 女 ‘female’).

1. Syllables in brackets are written in Pinyin, an alphabetic scrip that transcribes the pronunciation of Chinese characters.

Characteristics of the spoken language

In Mandarin there are 21 initial consonants, five vowels, three glides, and two final consonants (i.e. /n/ and /ŋ/) (Duanmu, 2007: 23–25, 35). Cantonese has 19 phonemes and six of them occur as both initial and final consonants (i.e. /n, ŋ, p, t, k, m/) (Bauer & Benedict, 1997: 16). Mandarin has no consonant clusters. The maximal syllable structure is CGVX (e.g., [jian]) where C is an onset, G is a glide, V is a vowel, and X is an off-glide of a diphthong[2] or a consonant (Chen & Pasquarella, in press). This simpler syllabic structure and limited coda inventory in Mandarin form an obvious contrast to English. Mandarin only uses about 400 different syllables (not including tones) (DeFrancis, 1984: 42). In contrast, English uses several thousand different syllables and the maximal syllable structure can contain up to three onset consonants, a vowel, and five coda consonants (e.g., *strengths* and *twelfths*).

Mandarin has about 1,300 tone syllables (Taylor & Taylor, 2014: 24) and approximately 7,000 morphemes (Shu, 2003: 275). Therefore, more than five morphemes, or characters, share one syllable. One of the unique features of Chinese is its large number of single-syllable homophones. The tone syllable with the most number of homophones is [yi4], which has 38 different morphemes/characters (DeFrancis, 1984: 46) (e.g., 易 'easy,' 意 'meaning,' 艺 'art,' 益 'benefit,' 翼, 'wing,' and 异 'different'). In comparison, the average homophone density in English is about 1.4, less than a third of that in Mandarin (Chen & Pasquarella, in press).

Several phonetic scripts have been created in modern times to represent the sounds of Chinese characters. Pinyin is used in Mainland China while Zhuyin Fuhao is used in Taiwan as an aid to pronunciation when teaching characters at school. *Pinyin* 拼音 'spell sound' is a Roman alphabet consisting of 26 letters plus ü (similar to 'you' in English) (Taylor & Taylor, 2014: 121–123). Pinyin has the completely transparent letter-sound correspondence. The Pinyin system uses diacritics to mark the four tones in Mandarin (e.g., ˉ, ˊ, ˇ, and ˋ to represent Tones 1, 2, 3, and 4 respectively). *Zhuyin Fuhao* 注音符号 'sound-annotating graphs' is a set of 37 graphs that represent the onset or rime (i.e. vowel plus final consonant) of a Chinese syllable (Taylor & Taylor, 2014: 123). It has the same markers for Tones 2–4 while Tone 1 is not marked.

2. Off-glide is the final, weaker part of a complex vowel such as /ɪ/ of /ɔɪ/ in boy.

Phonological processing in reading Chinese

Most researchers tend to agree that phonology is activated in lexical access when reading alphabetic writing systems, such as English, in which each grapheme maps onto a phoneme (Perfetti, Zhang, & Berent, 1992: 227; Frost, 1998: 76). In contrast, whether phonological information is automatically activated in reading Chinese characters, in which each grapheme maps onto a morpheme and a syllable, remains highly debatable. Due to the characteristics of the Chinese writing system, some researchers have suggested that Chinese readers may completely bypass phonological information and rely on direct visual access to retrieve information in the mental lexicon (Chen, d'Arcais, & Cheung, 1995: 150; Zhou, Shu, Bi, & Shi, 1999: 136; Zhou & Marslen-Wilson, 2009: 1030). On the other hand, Perfetti, Zhang, and Berent's (1992: 231) "universal" phonological principle (UPP) states that, across writing systems, encounters with most printed words automatically lead to phonological activation. Specific differences across writing systems in mapping graphemes to sounds produce differences in the units of phonology that are activated at the earliest stage of word identification (Perfetti, Cao, & Booth, 2013: 9). Particularly, the basic phonological unit activated in alphabetic writing systems is the phoneme whereas such unit in Chinese is the syllable.

Whether phonological information is activated in reading Chinese characters by beginning readers has been examined by Guo, Peng, and Liu (2005: B21). Using the Stroop task, children were asked to name the colors: 红 [hong2] 'red', 黄 [huang2] 'yellow', 蓝 [lan2] 'blue', and 绿 [lü4] 'green.' Critical stimuli were homophones of the color characters: 洪 [hong2] 'flood', 皇 [huang2] 'emperor,' 栏 [lan2] 'fence,' and 虑 [lü4] 'ponder,' respectively. Semantic Stroop interference effects are indicated by longer RTs or higher error rates for trials in which the color name is incongruent with the name of the word (e.g., *red* written in blue ink) while phonological Stroop interference effects are indicated by longer RT or higher error rates for trials in which the homophone of the color name is incongruent with the name of the word (e.g., 洪 [hong2] written in blue ink). Guo et al. (2005: B30) observed both semantic and phonological Stroop interference effects for children. More importantly, there was a negative correlation between reading abilities and the magnitude of the phonological Stroop effect. These results suggest that children with lower reading proficiency have greater phonological activation when reading characters. When children become more skilled readers, they rely less on phonological information during lexical access.

Segmental vs. tonal information

Since Chinese is a tonal language, it is important to investigate the role of tonal information in reading Chinese characters. However, previous research showed mixed results regarding of the importance of tone in lexical access. Using a visual homophone judgment task, Taft and Chen (1992: 151) found that participants had difficulties making "No" responses when a pair of characters had the same syllable segments but different tones (e.g., 举 [ju3] 'lift' and 句 [ju4] 'sentence'). In contrast, it was easier to reject a pair of characters that shared the same tone but differed in vowels (e.g., 举 [ju3] and 挤 [ji3] 'squeeze'). These results suggest that visual character recognition is less influenced by tonal information compared to segmental information.

Spinks, Liu, Perfetti, and Tan (2000: B5) used the Stroop paradigm to examine the activation of tonal information in visual Chinese word recognition The critical stimuli included the color characters (e.g., 红 [hong2] 'red'), homophones of the color characters (same segment same tone S+T+; e.g., 洪 [hong2] 'flood'), homophones that only shared the same syllable segment (S+T−; e.g., 轰 [hong1] 'boom'), and neutral stimuli (S−T−; e.g., 贯 [guan4] 'passing through'). Significant phonological Stroop facilitation effects were found for congruent S+T+ (e.g., 洪 in red) and S+T− characters (e.g., 轰in red) and interference effects were observed for incongruent S+T+ characters (e.g., 洪 in green), although there was no significant effect for incongruent S+T− trials (e.g., 轰 in green). Li, Lin, Wang, and Jiang (2013: 777) extended these results by adding a S-T+ condition in which the homophone had the same tone but a different syllable segment as the color character (e.g., 瓶 [ping2] 'bottle'). Stroop facilitation effects were found for the congruent S-T+ characters, suggesting that both segmental and tonal forms of information constrained lexical access independently and automatically in a color-naming task in which the activation of these constituents was not needed.

Morphological processing in reading Chinese

A Chinese morpheme typically maps onto one syllable in the spoken language and one character in the writing system (e.g., 人 [ren2] 'person') (McBride-Chang, Bialystok, Chong, & Li 2004: 95). Combining two characters together forms a new compound word (e.g. 蜜 'honey' + 蜂 'bee' = 蜜蜂 'honeybee'). Compounding is the major way of word formation in Chinese, as ~80% of the characters in a corpus of 17,430 are constituents of compound words (Kang, Xu, & Sun 2005: 103–122). A fundamental question in the research of compound processing is: 'What is the basic unit of lexical representation, the whole word or individual morphemes'?

(Dronjic, 2011: 10)' In a lexical decision task of Chinese compound words, Zhou and Marslen-Wilson (1995: 597) showed that whole word frequency was the dominant factor in determining RT and this effect did not interact with either syllable or morpheme frequency of either the first or second constituent morpheme.

However, the existence of whole-word representation does not preclude the existence of morphemic representations (Dronjic, 2011: 11). Both auditory and visual priming studies (Zhou & Marslen-Wilson, 1995: 588; Zhou, Marslen-Wilson, Taft, & Shu, 1999: 538) showed that the strongest priming effect was when prime and target shared the same constituent morpheme with the same meaning (e.g., target: 华 [hua2] 贵 'luxurious,' prime: 华丽 'magnificent') compared to when the prime and target shared homographic-homophonic characters (e.g., 华侨 'overseas Chinese') or when the prime and target shared homophonic morphemes (e.g., 滑 [hua2] 翔 'glide'). These results provide evidence for morphological decomposition since the compound words must be decomposed into individual constituents for the priming effects to occur. It appears that both whole word and morpheme representations exist in the mental lexicon and morphological decomposition may be switched on and off during lexical access on the basis of a number of factors including semantic transparency and frequency (Dronjic, 2011: 14).

Taft, Liu, and Zhu (1999: 94–96) proposed the Multilevel Interactive-Activation Framework of reading Chinese that consists of hierarchically organized levels corresponding to words, morphemes, and submorphemic components. The framework includes orthographic, phonological, and meaning units. At the bottom level of the orthographic units is the stroke units which are lines and dots that make up Chinese characters. Strokes units feed their activation to the radical units, which in turn feed their activation to the morphemes that contain these radicals, and finally the morpheme units feed their activation to the whole words (polymorphemic) that contain those morphemes. At the morpheme and whole word levels, there are both orthographic and phonological representations. Both orthographic and phonological units at the radical, morpheme, and whole word levels may be linked to the meaning units.

Orthographical processing in reading Chinese

Despite the visual complexity of the Chinese writing system, there are orthographic rules that can help Chinese speakers extract information when they read and write characters. Most radicals appear in a specific position in a compound character (Shu, 2003: 276). For example, 亻 and 扌 appear only to the left, and 刂 appears only to the right. A character is considered to be consistent if all of the characters in its set of orthographic neighbors share the same phonetic radical and have the same pronunciation (Shu, 2003: 277). For example, 换, 焕, 涣, and 痪, with the phonetic 奂, are pronounced as [huan4]. Regular characters have the same pronunciation as their phonetic radical when it functions as a simple character (e.g., 绘 [hui4] 'draw' with the phonetic 会 [hui4] 'meet') while irregular characters are pronounced differently from their phonetic component (e.g., 租 [zu1] 'rent' with the phonetic 且 [qie3] 'moreover').

Previous research has shown that both adults and children make use of radicals when reading compound characters. Both adults and children name regular characters, especially those with low frequency, faster than frequency-matched irregular ones (Seidenberg, 1985: 14; Shu, Anderson, & Wu, 2000: 61). Radical position also affects speed of lexical access. Taft and Zhu (1997: 769) found that for characters containing radicals with similar radical frequency (e.g., for 斯 and 牺, their radicals 斤 and 西have similar frequency), characters with a radical that frequently occur on the right-hand side (i.e. 斤) were recognized faster than characters with a radical that did not frequently occur on the right-hand side (i.e. 西). These results suggest that positional information is critical for activating radical information during character recognition. In addition, it appears that characters and radicals are represented in separate levels in the mental lexicon and whether a character is decomposed into its radical components during lexical access may be determined by character frequency.

Research showed that developing readers also decomposed compound characters from visual input and the phonological properties of both the phonetic radical and the whole character were activated in parallel. In a primed naming task with third- and sixth-grade children, Wu, Zhou, and Shu (1999: 520) used irregular compound characters (e.g., 海 [hai3] 'ocean' with a phonetic 每 [mei3] 'every') as primes and simple characters (e.g., 美 [mei3] 'beautiful') that were homophonic to the phonetic radical (e.g., 每 [mei3]) as targets. The control characters (e.g., 低 [di1] 'low') shared no orthographic, phonological, or semantic relations with the targets. When the primes were low-frequency words, children named the target faster when the prime was an irregular character than when it was a control character, suggesting that even for young readers radical information was activated in processing low-frequency compound characters and children were able to utilize the radical information to facilitate target character naming.

Besides activating the phonological information of phonetic radicals, readers also segment semantic radicals in compound characters and activate their meaning. Liu, Shu, and Xuan (2002: 6) asked children and adults to judge whether the cue and target characters were semantically related. Two types of cueing preceded the target (e.g., 姐 'sister' with a semantic radical 女 'female'): a semantic opaque character with the same semantic radical as the target (e.g., 始 'begin') and an unrelated character (e.g., 收 'receive'). The correct answer for both types of cues was "No" since they were unrelated to the target at the whole word level. However, both children and adults took longer to reject the pair of words sharing the semantic radical, despite the fact that the prime (e.g., 始 'begin') was not morphologically transparent. Results from the studies reviewed above suggest that radicals are integral to reading Chinese.

Contributions of phonology, morphology and orthography in learning to read Chinese

There have been a large number of studies in the literature that documented the relationships among phonological, morphological, orthographic awareness and reading development among children. Phonological awareness (PA) refers to the ability to perceive, analyze and manipulate the sound units in spoken language (Goswami & Bryant, 1990: 2). Morphological awareness (MA) is generally defined as children's ability to identify, reflect on, and manipulate the morphemic structure of words (Carlisle, 1995: 190). Orthographic awareness (OA) refers to children's understanding of the conventions used in the writing system of their language (Treiman & Cassar, 1997: 70). Research has shown that syllable awareness is an important predictor of character reading in Chinese kindergarten children (e.g., McBride-Chang & Ho, 2000: 54), likely due to the saliency of a syllable in the Chinese spoken language. Tone awareness has also been shown to be essential in the development of reading abilities for school-aged Chinese children, likely as a result of the tonal nature of the Chinese language (e.g., Shu, Peng, McBride-Chang, 2008: 178).

However, an extensive amount of research evidence suggests that MA may play a bigger role in Chinese character recognition than PA. While one syllable usually maps onto several characters, one morpheme maps onto only one character. For example, the syllable [shu1] corresponds to about 20 characters, such as 书 'book', 蔬 'vegetable', and 叔 'uncle', however, each character represents only one morpheme. Therefore, the morpheme-character correspondence is more reliable than the syllable-character correspondence in Chinese. Indeed, some researchers have hypothesized that the role of MA in Chinese is somewhat analogous to the role of phonemic awareness in English (e.g., Nagy et al., 2002: 58) in oral language and reading development.

Morphologically complex words can be formed by inflection, derivation, and compounding. In Chinese, compounding is the most productive way of word formation. Chinese compound words are right-headed, meaning that the right-most constituent determines the semantic and syntactic category of the whole compound word. For example, 书店 is a type of shop (店) that sells books (书). Awareness of this compound structure (hereafter, compound awareness), but not PA, has been shown to be a significant predictor of Chinese character and word recognition for children in Beijing and Hong Kong after controlling for oral vocabulary (e.g., McBride-Chang et al., 2005: 154). In another study, Shu, McBride-Chang, Wu, and Liu (2006: 129) found that awareness of polysemy (a constituent morpheme with multiple meaning in different compound words such as *candy bar* and *bar tender*) had a stronger association to character reading and reading comprehension compared to PA. MA also influenced the acquisition of reading skills longitudinally. Chinese kindergarteners' awareness of compound structure and homophones at Time 1 explained unique variance in Chinese word reading and reading comprehension one year later after taking into account age, vocabulary, PA and OA (Tong, McBride-Chang, Shu, & Wong, 2009: 445).

In addition to MA, OA also played an important role in Chinese literacy acquisition. Children as young as second graders made use of the phonetic component to pronounced unfamiliar characters (Shu et al., 2000: 61). Children with higher reading abilities were better at reproducing novel compound characters with familiar components compared to those with lower reading abilities (Anderson et al., 2013: 52). In another study, children's knowledge of the position and semantic category of semantic radicals correlated significantly with their performance in word reading and sentence comprehension (Ho, Ng, & Ng, 2003: 849). These findings suggest that children's knowledge of radicals is essential in the development of reading skills.

In summary, PA, MA, and OA all contribute to monolingual Chinese children's reading development. Some studies may argue for a bigger role of MA than PA for reading development in Chinese (e.g., McBride-Chang et al., 2005: 155). In the next section, bilingual adults and children's processing of two scripts with Chinese as L1 and English as L2 is examined. We focus on the cognitive consequences of cross-script differences in bilingual reading.

Cross-language phonological and orthographic processing in bilingual reading

Learning to read two scripts is fundamentally different from learning to read only one because learners may bring their existing linguistic knowledge of the first language (L1) to the process of learning to read in the second language (L2) (Koda, 2008: 69). The transfer of spoken or literal knowledge from one language to the other during the learning process is called cross-language transfer. Whether cross-language transfer occurs and what is being transferred are determined by several linguistic factors, such as one's proficiency in L1 and L2, metalinguistic awareness of the learner, print input and exposure in L2, typological similarities and differences between the two languages (Koda, 2008: 70). Transfer from L1 can facilitate literacy development in L2 when the two languages share similar features, such as phonological forms or cognate vocabulary. When learners encounter L2 structures that are different from L1, interference will occur and learners will make errors in L2 (Genesee & Geva, 2006: 178).

A number of studies with Chinese-English bilingual adults have demonstrated the influence of L1 linguistic and orthographic characteristics on the processing of L2 scripts (e.g., Holm & Dodd, 1996: 119; Jackson, Lu, & Ju, 1994: 80; Koda, 1999: 51, 2000: 297; Wang, Koda, & Perfetti, 2003: 143; Wang & Koda, 2005: 89). Specifically, logographic Chinese readers who learn English as L2 (ESL) tend to rely more on orthographic information and less on phonological information for word identification in alphabetic L2. In Wang et al. (2003: 135), Chinese and Korean ESL college students matched for their English proficiency were compared for their relative reliance on phonological and orthographic information using two tasks. In the semantic category judgment task adopted from Van Orden (1987: 182–183), the participants were asked to judge whether the target word was a member of a category (e.g., whether *feet* is a body part and *rose* is a type of flower). Results showed that Chinese ESL learners made more accurate responses to stimuli that were less similar in spelling to category exemplars (e.g., *robs*) than those that were more similar (e.g., *fees*). In the phoneme deletion task adopted from Hart and Perfetti (2000), participants were asked to delete a phoneme in an English word and spell the new word that resulted from the deletion. The uniqueness of this task is that deleting the required phoneme in presented stimulus creates a new word with a different spelling form from the original one (e.g., removing /t/ from 'might' creates the word 'my'). This feature requires the participants not only to manipulate the individual phonemes in the word, but also to accurately access their spelling knowledge of the new word. Results showed that Chinese participants performed more poorly overall than their Korean counterparts and made more errors that were phonologically incorrect but orthographically acceptable. These results suggest that Chinese ESL learners may rely less on phonological information and more on orthographic information in identifying English words than their Korean counterparts. Cross writing system differences in L1 and the transfer of L1 reading skills could be responsible for these ESL performance differences.

The aforementioned studies were focused on English L2 processing while comparing ESL readers of Chinese background to those with alphabetic L1 backgrounds.

Another line of research on cross-language influences on bilingual processing addresses the question of whether the processing of words in English activates the translation equivalents in Chinese. Broadly speaking, a large number of studies have suggested that bilingual word recognition may be language non-selective and automatic across various bilingual language pairs involving similar scripts such as Dutch-English, Spanish-English, or French-English (see Dijkstra, 2005: 182–185 for a review). Zhou, Chen, Yang, and Dunlap (2010: 2062) further showed evidence for cross-script automatic activation. For example, participants' response to an English target word (e.g., bay /beɪ/) was faster when it was preceded by a Chinese character prime that has a similar pronunciation (e.g., 备 [bei4] 'to prepare'). Specifically, phonological information in L1 Mandarin was activated in L2 English automatically regardless of whether the type of task involves phonological information or not (naming or lexical decision) and regardless of the bilingual speakers' level of L2 proficiency. These results suggest that language nonselective access in word recognition and reading is possible even for bilingual speakers whose two scripts are typologically distant.

Cross-language morphological processing in bilingual reading

Ample evidence has been shown to support for fast cross-language morphological activation in L1 Chinese during L2 English reading. For example, Zhang, van Heuven and Conklin (2011: 1239) used a masked priming task, in which Chinese-English bilinguals were shown unrelated English prime-target pairs whose Chinese translations were morphologically related such as 'east–thing' (东-东西) (the Chinese translations consisted of a fully opaque compound word and a monomorphemic word that was either the compound's first or second constituent). Participants responded faster to English word pairs whose Chinese translations repeated the first morpheme than to English word pairs whose Chinese translations did not repeat the first morpheme. This result suggests that there is an automatic cross-language translation from L2 English prime-target pairs to Chinese L1 words and that the morphological constituent in the L1 translated compounds facilitates target word recognition in the L2.

Wang, Lin, and Gao (2011: 132) employed two lexical decision experiments, one with visual stimuli and the other with spoken stimuli, performed only in English to investigate cross-language activation in bilingual compound-word processing. The lexicality of the translated compounds in the non-target language was manipulated. For example, the translated compound of *bathrobe* in Chinese (浴袍) is a real word, whereas the translated compound of *waistline* in Chinese (腰线) is a nonword.

Results from both experiments showed significant lexicality effects, providing evidence for nonselective and automatic cross-language morphological activation in the bilingual mental lexicon. Similar results were replicated in Chinese-English bilingual children (Cheng, Wang, & Perfetti, 2011: 594). Particularly, significant lexical effects were observed when the target language was English but not when it was Chinese, possibly due to the fact that this particular group of bilingual children had higher proficiency in their L2.

Contribution of phonology, morphology, and orthography in bilingual reading development

Along the line of research on Chinese-English bilingual reading development, evidence of the contribution of phonological, morphological, and orthographic processes was obtained via a number of correlational studies. For example, transfer of syllable awareness has been identified in Chinese-English bi-literacy development (Chow, McBride-Chang, & Burgess, 2005: 85; McBride-Chang et al., 2008: 183). Particularly, Chinese syllable awareness uniquely predicted 4.5-year-old bilingual children's English word reading. The transfer of syllable awareness demonstrated that children tended to use their awareness of the prominent phonological unit in their L1 (i.e. syllable) to facilitate their reading in L2. Wang, Yang, and Cheng (2009: 307) found that Chinese onset awareness accounted for a unique variance in both English real word and pseudoword reading. In a one-year longitudinal study, Wang, Lin, and Yang (2014: 208) found that Chinese onset awareness in Grade 1 contributed to English real word reading in Grade 2. Chinese and English share many similar initial consonants, and onset is a shared phonological unit between the two languages. Bilingual children can take advantage of their knowledge of onset in one language and facilitate the development of reading skills in the other language.

Furthermore, Gottardo, Siegel, Yan, and Wade-Woolley (2001: 539) have found that rime awareness in Chinese was a significant predictor for English real word and pseudoword reading. The researchers reasoned that what was being transferred was an underlying process that is not specific to the bilingual children's L1 phonology but is related to the children's ability to reflect on all levels of phonological information regardless of structural differences. Previous studies have reported that Mandarin tone awareness predicts English reading in bilingual children (Tong, He, & Deacon, 2016: 1; Wang, Perfetti, & Liu, 2005: 81; Yeung & Chan, 2013: 11–12). Although English does not have lexical tones, children with better tone awareness may have better general auditory sensitivity, which is a significant predictor of L1 Chinese and L2 English reading in bilingual children (Chung, McBride-Chang, Cheung, & Wong, 2013: 215; Wang, Anderson, Cheng, Park, & Thomson, 2008: 641). Another possibility is that Chinese tone awareness facilitates the development of stress awareness in English since both lexical stress and tone utilize pitch as part of the acoustic realization. Indeed, Tong, He, and Deacon (2016: 1) found that Chinese tone sensitivity predicted English stress sensitivity, which in turn predicted English word reading.

In terms of the contribution of MA, studies with Chinese-English bilingual children have found that compound awareness in L2 English accounted for a unique variance in reading comprehension in L1 Chinese (Pasquarella, Chen, Lam, Luo, & Ramirez, 2011: 36; Wang, Cheng, & Chen, 2006: 550), independent of the influence from age, nonverbal reasoning, Chinese oral vocabulary, and Chinese and English PA. Another study (Luo, Chen & Geva, 2014: 109–110) has found that English compound awareness explained a unique variance in Chinese compound awareness, which in turn contributed to Chinese character reading. However, all of these studies found that L1 Chinese compound awareness had neither direct nor indirect cross-linguistic effect on concurrent or longitudinal L2 English word reading. There are two possible reasons for this finding. First, bilingual children in these studies had higher proficiency in English and cross-language transfer was more likely to occur from the dominant language to the less dominant language. The term *language dominance* is used to describe a situation in which one of the child's language is more proficient and accessible and has better processing abilities (Gertken, Amengual, & Birdsong, 2014: 211). The second reason is that compounding is more productive in Chinese due to the uncommon use of inflection and derivation in the language and the direction of transfer may be determined by the productivity of the target structure (Lin, Wang & Cheng, under review).

Unlike the transfer of PA and MA, the contribution of OA to bi-literacy development was not observed in Chinese-English bilingual children (Gottardo et al., 2001: 539; Wang et al., 2005: 83, 2009: 310). Each grapheme in Chinese is a character that maps onto a syllable and a morpheme. In contrast, each grapheme in English is a letter that maps onto a phoneme. The writing system of Chinese is typologically distant from that of English as Chinese characters have a non-linear visual configuration. Therefore, children's understanding of the writing conventions in Chinese is less likely to be applied when reading English and vice versa. However, Tong and McBride-Chang (2010: 305) showed that Chinese visual-orthographic skills predicted English word reading after accounting for PA and MA in 8- to 11-year-old native Cantonese-speaking children in Hong Kong. The most likely reason for the different pattern of results between Tong and McBride-Chang and Wang et al. may lie in the fact that the bilingual children in the U.S. in Wang et al.'s studies learn to read Chinese via the Pinyin system, whereas children in Hong Kong are taught to read both Chinese and English using a ‘‘look and say’’ approach that makes full use of visual cues for reading and they are not taught any Romanization for Cantonese.

Limitations and future directions

Most of previous research on Chinese-English bilingual reading development has been correlational studies. Specifically, there is a lack of longitudinal and training studies to help establish the causal relationships among PA, MA, and OA to reading in both monolingual Chinese and bilingual children. For example, Ho and Ma (1999: 137–138) showed that five-day intensive training in the use of phonological strategies improved Chinese dyslexic children's character reading skills. Chow, McBride-Chang, Cheung, and Chow (2008: 240) has shown that morphological training at home in which parents guided children to identify morphemes in groups of words led to significant gains in children's word recognition abilities. Training studies like these are not only important for examining the possible causal links among phonological, morphological, and orthographic processing abilities and reading skills, but also critical in bridging the gap between empirical research and educational practices.

There also need to be more studies focusing on the comparison between Chinese and other spoken and writing systems for both adult and developing readers. These cross-linguistic comparisons will reveal how language and script typology influences the differential roles of phonological, morphological and orthographic processing for readers of those languages. For example, McBride-Chang and colleagues (2005: 144–146) compared the contribution of compound awareness to reading development among Mandarin-speaking children in Beijing, Cantonese-speaking children in Hong Kong, Korean-speaking children in South Korea, and English-speaking children in the United States. Results showed that compound awareness, but not PA, was a significant predictor of Chinese character and word recognition for children in Beijing and Hong Kong after controlling for oral vocabulary. Both PA and compound awareness were significant predictors of word recognition in Korean. Finally, PA, but not compound awareness, was significantly associated with word reading in English. These results suggest that the characteristics of the specific language and orthography influence reading acquisition. Clearly, more studies like this are needed to form more systematic comparisons between Chinese and other languages and writing systems.

Most Chinese-English bilingual reading research has focused on English L2 as the target language in behavioral experiments or as the outcome measures of reading development in correlational studies. Recently, there is an increasing interest in the topic of learning Chinese as L2. For example, Tong, Kwan, Wong, Lee, and Yip (2016: 7) showed that L2 Chinese learners with different L1 backgrounds utilized semantic and phonetic radicals differently in a picture-character mapping task. Furthermore, English-speaking learners of Chinese rely more on semantic radicals rather than phonetic radicals when learning new Chinese characters (Zhang, Li, Dong, Xu, & Sholar 2015: 523). More research is needed to better understand how the unique characteristics of the Chinese script, along with the typological distance between L1-L2 orthographies, influence L2 Chinese word recognition.

Conclusion

The Chinese writing system is morphosyllabic; each character maps onto a morpheme and a syllable. There has been debate regarding the automatic activation of phonological information when reading Chinese characters. It appears that phonological activation may be influenced by a number of factors including experimental task demand and reading abilities. For morphological processing, research has shown evidence for both whole word and morphemic representation in lexical access of compound words. For orthographic processing, both children and adults make use of radicals when reading compound characters. Previous studies have found that awareness of phonology, morphology, and orthography all contributes to literacy acquisition in Chinese children. Studies on Chinese-English bilingual readers have shown cross-language transfer of phonological and morphological awareness in bi-literacy development. More studies are needed to compare Chinese with other types of scripts to reveal whether certain processes may be universal in reading while other processes may be shaped by language-specific characteristics.

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CHAPTER 3

Visual factors in writing system variation

Measurement and implications for reading

Li-Yun Chang and Charles A. Perfetti
National Taiwan Normal University, Taiwan / University of Pittsburgh, U.S.A.

We examine the visual properties of graphic forms and the role they play in reading within and across writing systems. We argue that writing-system factors determine the complexity of graphic forms, which affects perceptual processes in reading. We review studies we have carried out on graph complexity, including a description of GraphCom, a multidimensional system for quantifying complexity that we applied to 131 orthographies. We suggest that meeting the challenges of complexity leads to increased perceptual skills and report a comparison of the two scripts of Chinese, the most complex among the world's writing systems. Use of the more complex traditional script is associated with greater perceptual performance compared with the simplified script, lending support to this suggestion.

Keywords: Chinese scripts, cross writing systems, learning to read, visual complexity

Introduction

The manner in which writing systems convey meaning through their mapping to spoken language is highly varied. Many reading studies have involved in-depth discussions on how writing systems vary – their implementation of the phonological principle (Perfetti, Zhang, & Berent, 1992), phonological grain size (Ziegler & Goswami, 2005), orthographic depth (Katz & Frost, 1992), semantic transparency (Wydell, 2012), and how such writing system variation can have an impact on learning to read (e.g., Frost, 2012; Hirshorn & Fiez, 2014; Perfetti & Harris, 2013; Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007; Seidenberg, 2011). Most reading-related writing system research has focused on how reading is influenced by the mapping of graphemes to linguistic units (e.g., Ellis, Natsume et al., 2004; Perfetti, Liu, & Tan, 2005; Perfetti et al., 1992). Little attention has been given to the visual forms of the

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graphs – the basic written units – as factors in learning to read across the world's wide variety of written language.

Although visual graphic form has received slight attention, we should expect it to be a factor in learning how to read and in the development of stable high quality orthographic representations (Perfetti, 2007; Perfetti & Hart, 2002). Visual complexity itself may constrain an efficient development of these orthographic representations, thus contributing to difficulty in learning to read. Moreover, orthographies with visually complex graphs are also likely to contain a larger graph set, providing an additional source of difficulty during learning (e.g., Nag, 2011; Nag, Treiman, & Snowling, 2010). In the context of these observations, we suggest that studying differences in learning to read across writing systems without considering visual properties is likely to result in misleading conclusions.

To put it concretely, in comparing Chinese and English, one may focus on the difference between morpho-syllabic mapping (Chinese) and alphabetic mapping (English) as fundamental. Or one may focus on within a language, comparing the Japanese syllabic script (Kana) with its morphemic script (Kanji). And indeed these comparisons are fundamental, because the core feature of writing is how it represents the spoken language. However, these fundamental systemic differences are associated with differences in the appearance of the graphs. The visual forms and their mapping to language develop side by side. How readily a graphic form leads to a unique encoding in memory that distinguishes it from other graphs needs to be taken into account.

In what follows, we examine how visual complexity plays a role in learning to read. In addition to a general examination of complexity across writing systems and orthographies, we focus on the most visually complex case, written Chinese, to consider whether dealing with complexity might tune the visual skills of a reader. We begin with a general introduction to writing system variations. Next, we review research on visual properties of graphs, and then describe our development of GraphCom, a multidimensional measure for quantifying any graph in any writing systems, and exemplify analyses and applications based on it. Finally, we provide a focus on the graphic complexity of Chinese as measured by GraphCom and apply it to a study of beginning learners of the Chinese. We compare the traditional (more complex) and simplified Chinese scripts, reporting a comparative study of adult, skilled readers of the two scripts. We conclude with a discussion of the issues raised by our analyses.

Writing systems, orthographies, and scripts

To describe writing, we make distinctions among several key terms used in writing scholarship and comparative cross-writing-system research: writing systems, scripts, and orthographies. *Writing systems* are families of written language, characterized by the linguistic units that are most often represented by their graphemes. Because there is some mapping variability within many languages, it is the most typical mapping that defines the system. It has been standard in reading research to refer to the three–way classification described by Gelb (1963) of alphabetic, syllabic, and logographic writing systems; these map graphs to phonemes, syllables, and words, respectively. However, as we explain in the next section, we adopt a five-way system that differentiates among the subsyllabic systems that in the Gelb classification are subsumed (misleadingly) as alphabetic.

Scripts are the visual forms of writing (Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007). A written language can be presented in many scripts; for example, cursive or typeface (e.g., "*font*" and "font" in written English; traditional and simplified in Chinese).

Orthographies, different from scripts, are the implementations of writing systems used by specific languages (Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007). Whereas writing systems are categorized by their most typical level of mapping to linguistic units, orthographies manage the tradeoffs made between the typical mapping of the writing system (the writing system principle) and the actual written forms that have evolved over the history of a specific written language. The terms of orthographic implementation are influenced by many factors that are beyond the scope of our chapter. Most important may be how the orthography manages a morpho-phonological dimension. The morpheme represented by a word and the word's pronunciation might not align well and orthography must manage whether the graphs provide information mainly about pronunciation or mainly about meaning.

Writing systems variations

As we noted above, we adopt a five-way classification of writing system advocated by Daniels and Bright (1996). The practical effect of this system is to expand the category of alphabetic writing to reflect significant differences in their typical mapping; equally important as a matter of writing scholarship, it corrects misleading implications that ancient syllabic systems that preceded alphabets somehow represent alphabetic writing in incomplete form (Share & Daniels, 2016). With this revision, alphabetic systems become only those in which the graphs typically map equally to both consonant and vowel phonemes, rather than only consonants. In true alphabets (e.g., Italian and Korean), each graph maps to a consonant or a vowel and expresses the phonemes equally. Writing systems in which the mapping includes consonant phonemes but either omits vowels or subordinates their forms to consonant graphs are differentiated from alphabets. In abjads (or consonantal writing systems; e.g., Hebrew and Arabic), vowels are omitted in most texts and in others they are marked by secondary diacritics rather than full letter forms. These diacritics are visually less prominent than primary consonant graphs and are configured with the consonant rather than having an independent status. In alphasyllabaries (e.g., Hindi and Kannada), graphs (akshara) map sequences of consonant plus vowel, with reduced vowel forms and diacritics attached to consonants in various ways. The consonant-vowel sequences suggest open syllables, but because they can occur at syllable boundaries (thus breaking up syllables), the writing is not really syllabic. Partially in recognition that the term alpha-syllabary is misleading, Daniels and Bright (1996) refer to this system as Abugida, reflecting the first four graph names of the Ethiopic syllabic alphabet.

In abjad, alphabet, and alphasyllabary writing systems, orthographies rely on grapheme-phoneme correspondence (GPC); in syllabaries or morphosyllabaries, orthographies rely on grapheme-syllable correspondence (Scheerer, 1986). This consistency of the graph-to-phonology correspondence is often described in reading literature as a continuum of "transparent" (or shallow; one-to-one mapping) to "opaque" (or deep; one-to-many, many-to-one, or many-to-many mappings), although the dimension should probably be restricted to alphabetic orthographies. Comparisons across writing systems on a single dimension are questionable given the various mapping choices they make. For the graphs themselves, orthographies can are further delineated by the number their graphs, their graph inventory.

Of systems using higher-level phonological mapping, in which graphs map to full syllables, there are two types: *syllabaries* (e.g., Japanese hiragana and katakana), in which graphs represent whole syllables and *morphosyllabaries* (e.g., Japanese Kanji and Chinese), in which graphs represent syllables and the morphemes associated with the syllable. Thus, in terms of levels of language that are mapped by graphs, Chinese represents the highest level mapping, the morpheme, among the world's writing systems (DeFrancis, 1989).

Generally, the differences among these five writing systems are captured by how their orthographies trade off morphological and phonological information (Frost, 2012; Seidenberg, 2011; Perfetti & Harris, 2013). Another dimension that may capture writing system differences is the visual symbol set (Nag, 2011; 2014; Nag, Caravolas, & Snowling, 2011). Along this dimension, writing systems are placed on a continuum indicating the number of graphs that a given system requires, anchored by "contained" and "extensive" end points. Nag (2011) placed languages along this contained-extensive continuum with estimates of their visual symbol (graph) inventory. On the contained end are alphabets, which require fewer graphs (24–36 for most); on the extensive end are morphosyllabaries, which require large numbers of graphs (Chinese: over 2500); alphasyllabaries (200–500) fall between these two extremes.

These two dimensions of graph inventory and morpho-phonological mapping are not independent. A system that weighs phonological over morphological mapping requires fewer graphs than systems that weigh morphological over phonological. To capture how five major writing systems vary along these multiple dimensions – morpho-phonology and graph inventory – we illustrate their relative positions in Figure 1. Generally, as mapping level increases, the graph inventory also increases.

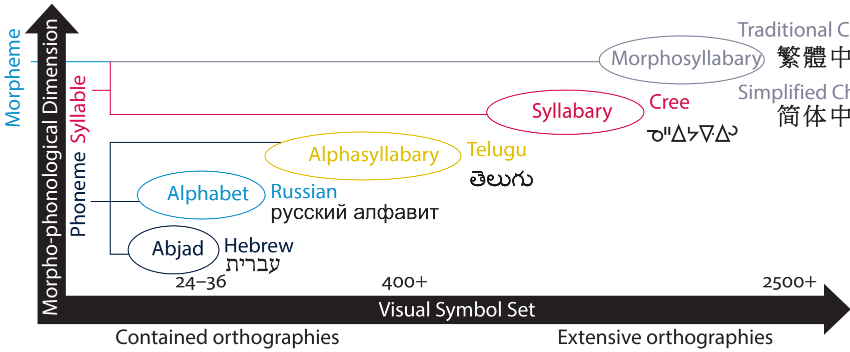

Figure 1. Illustration of a variety across the five world's major writing systems

The graph inventory is not the only relevant difference among writing systems. As the number of graphs increases, so does their complexity. The number of graphs and their complexity present a challenge to learning to read that varies across written languages. To make objective comparisons of complexity, valid and reliable assessments of graph complexity are needed. In the next section, we describe the development of such an assessment and its value in capturing human perceptual performance (Chang, Chen, & Perfetti, 2018).

Graph complexity variation across writing systems

Background

The development of our assessment, GraphCom occurred in the context of a valuable assessment previously developed by Pelli, Bums, Farell, and Moore-Page (2006). This measure is perimetric complexity (PC): the ratio of the square of the sum of inside and outside perimeters to the product of 4π and the area of the foreground (Pelli et al., 2006; Watson, 2012); For example, if upper-case W has a 4,656-pixel perimeter and 136,602-pixel squared area, its perimetric complexity is approximately 13: $4656 \times 4656/\ 136602\ /4\pi = 12.63$) (See Table 1 and Table 2). Thus, perimetric complexity provides an objective, quantitative, measure that is unaffected by font size. Pelli et al. (2006) applied perimetric complexity to a range of graphs and demonstrated that perimetric complexity is inversely proportional to graph identification efficiency; high complexity leads to low identification efficiency. Perimetric complexity has become a useful measure for controlling the complexity of stimuli in studies of learning to read (e.g., Liu, Chen, & Wang, 2016; Wang, McBride-Chang, & Chan, 2014; Yin & McBride, 2015).

However, perimetric complexity does not capture all relevant characteristics of graphs that seem to be important in reading. Two graphs can be equal in PC while differing substantially in other ways. For instance, in Table 1, the graph <w> (an English letter) and the graph <◌ะ> (a Thai letter) both have a PC values of 13; however, the two graphs have salient visual differences in the number of disconnected components (i.e., <w> has one component and <◌ะ> has two components) and thus the number of connected points; <w> has three points, each composed by two lines, and <◌ะ> has two connected points, each composed from one circle and one line.

Table 1. A comparison of two graphs in terms of their visual complexity

	An English graph (alphabet)	A Thai graph (syllabary)
	w	ะ
Perimetric Complexity (PC)	13	13
Number of Disconnected Components (DC)	1	2
Number of Connected Points (CP)	3	2
Number of Simple Features (strokes) (SF)	4	4

Variation along disconnected components is typical for alphasyllabaries and variation along the number of connected points is typical for alphabets. The numbers of connected points in letters of the Roman alphabet used in English (e.g., line terminations in <R>) are the features most critical in letter identification (Fiset et al., 2008). In alphasyllabaries, letters featuring disjointed components (e.g., Thai letter <โ◌ะ>) are highly associated with visual confusion in early literacy (Winskel, 2010). Whether the number of connected points, critical in an alphabet, affects letter identification in an alphasyllabary or whether the number of disconnected components, the salient measure in an alphasyllabary, also plays a role in early literacy in an alphabet, remains to be seen.

Another example of this question is the simple stroke, important in measuring the complexity of Chinese. The number of strokes (usually defined as a one-time movement of pen) has been long used as a complexity index with demonstrated psychological reality. For example, second graders' time to recognize a character increases with the number of strokes (Su & Samuels, 2010). Tamaoka and Kiyama (2013) found that Japanese kanji varying in number of strokes (ranging from 2–20 strokes) interact with kanji frequency in both a lexical decision task and a naming task. Many other studies have manipulated or controlled strokes to study character recognition in simplified (Wu, Zhou, & Shu, 1999) and traditional Chinese (Chen, Allport, & Marshall, 1996). It is interesting that all writing varies in the number of strokes, but that this measure remains unapplied to any writing system other than Chinese.

In this context, Chang et al. (2018) developed a method to assess complexity that takes into account the devices that writing uses to create graphs. This measure, GraphCom, consists of four dimensions: perimetric complexity, number of disconnected components, number of connected points, and number of simple features (strokes). Chang et al. (2018) applied this visual complexity measure to a large number of written languages representing all the five major writing systems, aiming to uncover the variation of visual properties of graphs across writing systems and to demonstrate its value in predicting graph perception.

The graph complexity measure, GraphCom

GraphCom's four dimensions include three added to perimetric complexity: A *simple feature* is a discrete element of an image that can be discriminated independently from other features (Pelli et al., 2006). For example, <T> has two simple features, one vertical and one horizontal segment. A *connected point* (or a junction) is an adjoining of at least two features. For example, <T> has one (the junction of the horizontal line and the vertical line) and <F> has two connected points (the junctions of one vertical line with two horizontal lines). A *disconnected component* is a simple feature that is not linked to other features in a set. For example, disconnected components are shown respectively in <i> (the dot and the vertical line) and <云> (the horizontal line on the top and the integral component at the bottom). With these four dimensions, GraphCom provides a multidimensional assessment of graph complexity that is objective, quantitative, and size-invariant. Table 2 shows how these four dimensions of GraphCom capture different characteristics of five example graphs. For detailed descriptions of these four dimensions, see Chang et al. (2018).

Table 2. Five graphs with complexity values using GraphCom, the measurement system with four dimensions

Writing system	**Abjad**	**Alphabet**	**Syllabary**	**Alphasyllabary**	**Morphosyllabary**
Written language	**Hebrew**	**Russian**	**Cree**	**Telugu**	**Chinese**
Example graph	בּ	з	ᐄ·	ఱః	面
PC	6.02	7.83	12.04	18.06	20.85
DC	2	1	3	3	1
CP	1	1	3	2	14
SF	3	2	6	5	9

Note. PC = Perimetric complexity, *DC* = number of disconnected components, *CP* = number of connected points, *SF* = number of simple features.

Graph complexity for 131 orthographies across writing systems

In applying GraphCom to actual writing, we selected 131 orthographies from five writing systems (Alphabet: 60; Abjad: 16; Alphasyllabary: 41; Syllabary: 11; Morphosyllabary: 3). To assign the number of graphs and writing system categories for these languages, we used Ager's Omniglot (Ager, 1998) for most of the languages, Chen et al. (2011) for the two Chinese scripts, traditional and simplified, and an official list of 1,006 Japanese Kanji by school year (Ministry of Education in Japan, 2015). For these 131 written languages, we generated images of their 21,550 graphs. Using Processing software (Reas & Fry, 2010), graphs were presented in black Arial font against a 500×500-pixel white background. The four dimensions of the GraphCom measure were then applied to each of these 21,550 images (See Chang et al., 2018, for details).

To consider whether GraphCom's four dimensions were related in the same way across all writing systems, we correlated the complexity values separately for each writing system as well as combined across all 21,550 images. As Table 3 shows, the aggregate correlations were high, all at least $r = .82$, expect for the $r = .65$ correlation of DC (number of Disconnected Components) with CP (number of Connected Points). Perimetric complexity showed high correlations with the other dimensions, reflecting PC's ability to capture indirectly much what the other dimensions target specifically. However, the measure showing the greatest shared variance is the number of simple features, the building blocks of the graphs. Finally, the correlations show that the number of disconnected components (DC) is the most distinctive measure, sharing no more than 67% variance with other measures, and only 42% with number of connected points.

Table 3. Correlations of graph complexity across writing systems

	Perimetric complexity (PC)	Number of disconnected component (DC)	Number of connected points (CP)	Number of simple features (SF)
PC	1.00			
DC	.82***	1.00		
CP	.89***	.65***	1.00	
SF	.95***	.83***	.93***	1.00

*** $p < .001$

If GraphCom is useful, it should be able to describe the relative complexity of different written languages. For this, we aggregated data across four dimensions to create a composite GraphCom score and applied it to each written language. (This entailed computing each orthography's mean on each dimension; to put all dimensions on the same scale, these means were converted to within-dimension *Z* scores. The composite GraphCom score is the average of these *Z* scores.)

Figure 2 shows the variation of graph complexity by writing systems; the x-axis reflects the number of graphs, and the y-axis shows writing system categories, ordered roughly by the granularity of mapping units from low (e.g., phoneme; alphabet) to high (e.g., syllable and morpheme; morphosyllabary). Generally, as mapping unit granularity increases, the overall complexity of graphs increases; we noticed that there is no fine-grained separation of mapping principles and overall graph complexity.

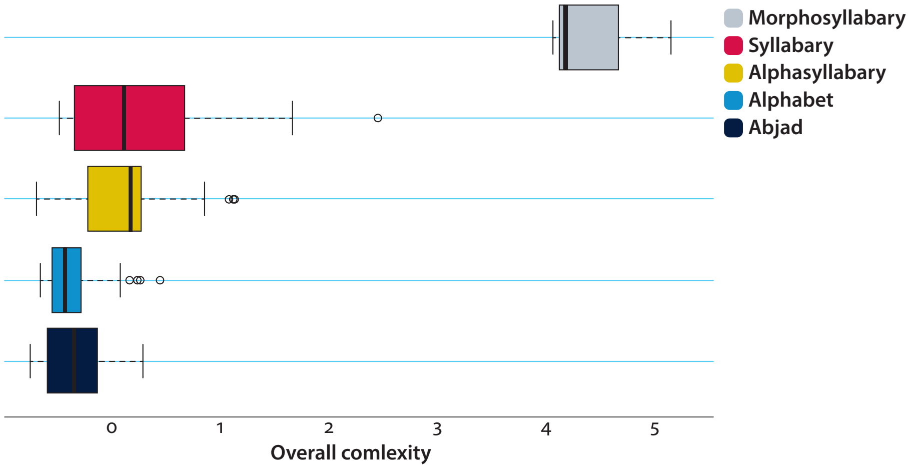

Figure 2. Variation of overall complexity by writing systems – 131 orthographies

To further test the face validity of the measure and to link it to comparative reading research, we applied GraphCom to pairs of orthographies that were commonly investigated in cross-language studies. Table 4 shows the variations of overall complexity of orthography pairs in different writing systems – Abjad: Hebrew vs. Arabic, Alphabet: English vs. Russian, Alphasyllabary: Kannada vs. Thai, Syllabary: Cree and Japanese (Kana), Morphosyllabary: Japanese (Kanji) and Chinese (simplified and traditional). As Table 4 shows, comparisons within as well as between writing systems yield results that one might expect. Thus traditional Chinese is more complex than Simplified Chinese, and both are more complex than Katakana.

Table 4 also resonates with prior observations that more visually complex orthographies tend to map onto higher-level linguistic units (Perfetti & Harris, 2013). It also provides a caution for comparative studies that examine L1 graph complexity effects on reading development, such as the Chinese-Greek comparison in Demetriou, Kui et al. (2005) and the Chinese-Spanish comparison in McBridge-Chang, Zhou et al. (2011). Because graph complexities co-vary with mapping principles (shown in Table 4), it is difficult to assess complexity differences separately from mapping differences across languages. Cultural differences also add complexity to these comparisons.

Table 4. Variation of overall complexity of orthography pairs by writing systems

Mapping unit of a graph (from small to large)	**Variation of visual aspect of orthography** Small ---- overall complexity (in *Z* score; Chang et al., 2018) ------- Large							
Morpheme + syllable								Chinese (traditional) [5.15]
							Japanese (Kanji) [4.05]	Chinese (simplified) [4.17]
Syllable		Cree [−0.38]		Japanese (Katakana) [0.06]				
Akshara					Kannada [0.17]	Thai [1.07]		
Phoneme	English [−0.64]		Russian [−0.39]					
Mainly Consonant	Hebrew [−0.74]			Arabic [−0.11]				

Note. Number in the bracket denotes overall complexity (*Z* score), quantified by GraphCom, of all graphs (expect for Chinese) in that given orthography.

One way to separate graph visual complexity from graph mapping is to examine perceptual performance of speakers of the same language who use the same orthography but with different scripts. This is possible with Chinese, because it employs two scripts – the more visually complex "traditional" script used in Taiwan and Hong Kong and the "simplified" script used in Mainland China. Both Taiwan and China use Mandarin Chinese and the simplified and traditional scripts encode Mandarin at the syllable/morpheme level. The only difference is the visual complexity of the scripts they read; thus differences between Chinese and Taiwanese readers in a perceptual or reading task can be attributed to visual properties of the graphs, assuming other differences between the two groups are not important for the task. The fact that other differences very seldom can be ruled out even in a close cross-cultural comparison is a qualifier on the comparison we report below.

Reading traditional and simplified Chinese scripts

We approach the comparison between traditional and simplified Chinese by measuring script complexities and assessing readers' performance on visual tasks. Because we are particularly interested in investigating how different visual features of two scripts affect visual perception of their skilled readers, we review below a database covering thousands of characters as well as studies focusing on how first-language (L1) reading experiences affect visual perception.

Background

The Chinese Orthography Database Explorer (CODE, Chen et al., 2011; Tseng, Chen et al., 2016), to the best of our knowledge, is the most comprehensive database containing analyses of both traditional and simplified scripts. This database includes 6097 frequent characters, covering 97% of simplified characters summarized by the Committee of National Languages and Scripts in Mainland China (1986); among this character set, 3,930 characters share the same forms in both scripts; 2,167 characters have different forms. To analyze the visual complexity of these 6097 characters in two scripts, the CODE exhaustively calculated the number of strokes and the number of radicals for each character, two widely used complexity indices in Chinese reading research (e.g., simplified Chinese: Wu, Zhou, & Shu, 1999; traditional Chinese: Chen, Allport, & Marshall, 1996; Su & Samuels, 2010). These two indices correspond to two dimensions in GraphCom (Chang et al., 2018): the number of simple features (i.e., number of strokes) and the number of disconnected components (i.e., number of radicals).

We were particularly interested in the complexity difference of 2,167 characters that changed with simplification. For these characters' traditional and simplified forms, we plotted distributions of their number of simple features and the number of disconnected components as shown in Figures 3 and 4. For both figures, the y-axis shows frequency (by type) and the x-axis shows a complexity measure. For the number of simple features (strokes; Figure 3), the traditional forms (in red) are more complex (M = 15.47, SD = 4.07) than the simplified forms (in orange; M = 10.07, SD = 3.37). For the number of disconnected components (radicals; Figure 4) the traditional forms are also slightly more complex (M = 3.66, SD = 1.43) than the simplified forms (M = 3.08, SD = 1.16). Thus, the simplification of 2,167 characters (the Committee of National Languages and Scripts in Mainland China, 1986) led to a decrease in visual complexity along two dimensions of GraphCom. Our next question is whether experience with these different scripts affects visual processing.

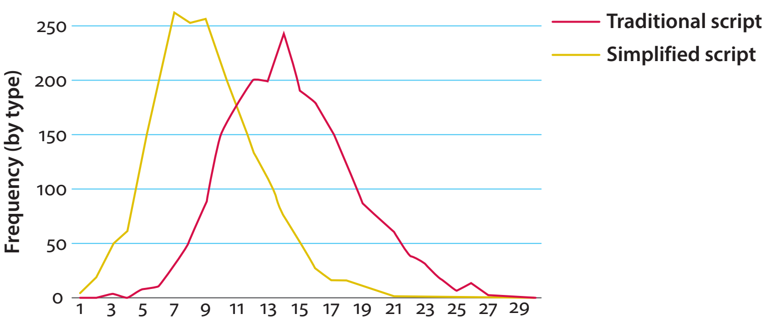

Figure 3. Distribution of number of simple features (i.e., strokes) for both traditional and simplified scripts (2,167 characters)

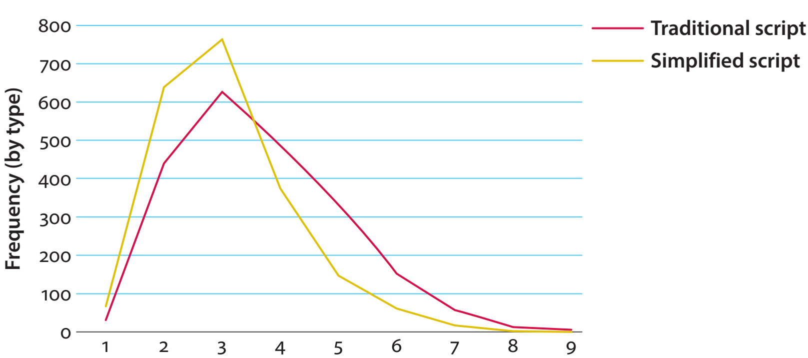

Figure 4. Distribution of number of disconnected components (i.e., radicals) for both traditional and simplified scripts (2,167 characters)

Reading more complex scripts may require stronger visual-spatial skills and may, in turn, strengthen such skills, as suggested by McBride-Chang et al. (2011) in their comparison of Chinese and Spanish children and earlier by Demetriou et al. (2005) in their comparison of 8- to 14-year-old readers of Greek and Chinese. For example, McBride-Chang et al. (2011) found that Hong Kong children, who read the traditional script, outperformed children learning to read Spanish on a standardized visuospatial relationship task. These findings do suggest that learning to read more visually complex first language (L1) fosters visual skills and across a range of experience levels. However, because these comparisons can separate neither the mapping differences between the writing systems nor cross-cultural factors, the stronger conclusion that graph experience causes the perceptual differences requires additional evidence.

There is also the question of age-related experience. On the hypothesis that experience in reading more complex graphs increases visual-spatial abilities, one would expect effects to increase with reading experience, consistent with perceptual learning theory (Fahle & Poggio, 2004). Instead, Demetriou et al. (2005) found that the Chinese-Greek differences were larger at the youngest age (8) than at older ages (up to age 14).

Adding to the puzzle is that the study most directly comparable to the one we describe here found a reverse complexity effect. McBride-Chang, Chow, Burgess, and Hayward (2005) reported that Chinese kindergartners from Xiangtan (i.e., simplified Chinese users; mean average: 5.3 years) outperformed their Hong Kong counterparts (i.e., traditional Chinese users; mean average: 4.9 years) in perceptual performance on line drawing and geometric form tasks. The authors suggested that, in the simplified script, the visual differences among graphs are relatively subtle and thus require more visual attention as compared to the traditional script. This is an important point that needs to be directly addressed eventually. Is it the overall complexity of the graphs that matters? Or is it the discriminability among graphs? One may expect these to be correlated, and although they are overall, the simplification process in Chinese, from an information point of view (Shannon & Weaver, 1949), may have reduced redundant information from the traditional graphs, leaving fewer features to discriminate among similary appearing graphs.

Additional considerations in any comparison of Hong Kong and Mainland China readers are cultural and schooling factors (Zhang & MacBride-Chang, 2011). In contrast to the Mainland practice of introducing reading alphabetically through pinyin, in Hong Kong, characters are learned without a phonological coding system. In contrast, a comparison of Taiwan and Mainland Chinese readers is one in which both groups learn a phoneme-level coding system before beginning character learning (Zhuyin in Taiwan and pinyin in Mainland).

A cross-script adult comparison

Our aim was to provide a comparison between two comparable groups, where the main difference was the script. We also aimed to test perceptual performance on actual writing graphs and on nonlinguistic stimuli that are demanding of visual-spatial processing. Measuring graph perception, rather than performance on line drawings, targets the perceptual process of reading directly. The fact that preliterate preschoolers can differentiate graphs from line drawings (Levin & Bus, 2003; Robins & Treiman, 2009; Treiman, Hompluem, Gordon, Decker, & Markson, 2016) shows that graphic forms quickly become functional perceptual categories, making them an appropriate target for testing perceptual learning. As for nonlinguistic stimuli, the hypothesis that visual-spatial abilities are enhanced through reading implies a test for generalization. Effects limited to graphs suggest training perception of specific visual categories; effects observed on nonlinguistic stimuli suggest a more general training effect.

Our comparison targeted the traditional Chinese script used in Taiwan and the simplified script used in mainland China, measuring performance on a same-different perceptual judgment task using graphs – from a variety of orthographies – that varied in complexity. In addition, for a test of generalization to nonlinguistic stimuli, we chose a pattern recognition task. We hypothesized that the Taiwan group would outperform the China group in both tasks, because Taiwanese learn to read the more complex graphs of the traditional Chinese script. Because of the issues raised by the complexity studies that we cited above, we provide the important details of our study (Chang, 2015) that differentiate it.

Taiwan and China groups responded to a mix of graphs beyond those from the two Chinese scripts. These graphs were sampled from Hebrew, Russian, Cree, and Telugu, as well as simple Chinese characters and complex Chinese characters. Sixty adults (age range: 18–35), whose first language was Mandarin Chinese, participated in this study. All had completed nine-years of formal education in Taiwan or China and were college students at the time of the study. These two groups were matched on age and gender and the number of learned languages beyond the first language.

In the same-different perceptual judgement task, participants decided whether two graphs were the same or different. The stimuli were from six graph groups of increasing complexity selected from five writing systems: Hebrew (abjad), Russian (alphabet), Cree (syllabary), Telugu (alphasyllabary), simple Chinese and complex Chinese (morphosyllabary. In total, 1,440 pairs of graphs were tested. For the "same" pairs, graphs in each orthography (expect for Chinese) were exhaustively used to pair with themselves; for the "different" pairs, individual graphs appear only once during testing. Complexity varied with the six-graph groups. Each participant responded to 360 pairs of graphs. In the experiment, graph pairs were exposed for one second, with one second between trials.

The pattern discrimination task was adapted from a complex working memory span task (Chein & Morrison, 2010), which has been shown to cover a broad range of visual processing difficulty for adults (Morrison & Chein, 2011). We revised this task[1] to tap individuals' capacity for visual form discrimination.

Results

Overall, we observed complexity effects (Taiwan vs. China groups) for both graph and non-graph stimuli. Results from the the graph same-different perceptual judgment task showed that the Taiwan group outperformed the China group on most of the graph groups, particularly on graphs from those languages for which they had less experience. Table 5 shows the mean accuracy, response time, and patterns of responses on graphs across writing systems, respectively. Generally, the Taiwan group showed higher accuracy and faster response times than the China group. For accuracy, performance is a function of graph complexity. The Taiwan group outperformed the China group on less complex graphs (i.e., Hebrew, Russian, Cree, Telugu, and simple Chinese), while both groups performed equally well on complex Chinese graphs. For the response time data, again, performance depended on the graph complexity and participant group. The Taiwan group had significantly faster response times on Hebrew, Russian, Cree, and Telugu graphs while no group differences were found on the simple Chinese or complex Chinese graphs. These results showed that graphs with higher complexity yielded lower judgment efficiency and the patterns of performance differed by participants' script experiences.

For the pattern discrimination task, the critical question was whether a participant group effect (Taiwan vs. China groups) would hold for the non-graph stimuli. Table 6 shows the results. Although the accuracy difference was negligible, the Taiwan group responded faster on accurately-responded items than the China group. These results may suggest that the superior visual perceptual skills of the Taiwan group found in the graph stimuli can be generalized to the non-graph stimuli. In fact, what differentiates the two groups is perception of less experienced forms – the non-Chinese graphs and the checkerboards.

1. In this task, participants were required to compare the symmetry of two complex checkerboard patterns. Each checkerboard pattern measured 1.5 inches square, yielding a visual angle of approximately 4.8°. The task consisted of 100 trials over 5 minutes with breaks between blocks of 20 trials (four total). For each trial, two checkerboard patterns were presented simultaneously side by side (left-and-right) and participants were encouraged to respond as accurately and quickly as possible, within a limit of 2.5 seconds. They were asked to press "1" if the patterns were both symmetrical or both asymmetrical and "2" if only one was symmetrical.

Table 5. Means (*M*) and standard deviations (in parentheses) of mean accuracy (in proportions, top panel) and response time (in millisecond, bottom panel) in examining whether graph complexity differentially affects perceptual variability across writing systems

Participant group	Graph group (ranked complexity from simple to complex)						F	η_p^2	Pairwise comparison (with Bonferroni adjustments)
	1 Hebrew	2 Russian	3 Cree	4 Telugu	5 Simple Chinese	6 Complex Chinese			
Mean accuracy (ACC)									
Simplified Chinese	0.90 (0.06)	0.91 (0.07)	0.89 (0.07)	0.83 (0.08)	0.89 (0.07)	0.77 (0.09)	96.74 **	.621	2> 1,3,5> 4> 6
Traditional Chinese	0.92 (0.04)	0.93 (0.04)	0.92 (0.04)	0.85 (0.07)	0.91 (0.06)	0.76 (0.08)	190.41 **	.650	1,2,3,5> 4> 6
Response time (RT)									
Simplified Chinese	663.48 (45.89)	647.63 (53.84)	656.44 (54.34)	736.78 (51.72)	679.82 (51.76)	762.55 (48.85)	282.28 **	.827	1,2,3 <5 <4 <6
Traditional Chinese	539.88 (42.88)	632.51 (44.44)	735.72 (41.32)	719.42 (49.33)	670.27 (46.30)	752.83 (53.44)	336.85 **	.851	2 <1,3 <5 <4 <6

** $p < .01$; $\alpha = .05$ (one tailed). For the pairwise comparison, all *ps* < .001.

Table 6. Means (*M*) and standard deviations (*SD*) of proportion accurate and response time (RT) of the pattern discrimination task ($n = 60$, respectively)

	Proportion accurate (%)		RT (ms)	
Chinese group	***M***	***SD***	***M***	***SD***
China (Simplified Chinese)	80.41	10.29	1672.45	160.78
Taiwan (Traditional Chinese)	79.33	10.64	1582.45	241.70

To summarize, in the graph and non-graph tasks for accessing participants' visual discrimination ability, the Taiwan group outperformed the China group in several aspects. The Taiwan group was more accurate and faster in discriminating less-experienced, graph stimuli and faster when accurately judging complex, non-graph stimuli, although there was no advantage for accuracy alone in the pattern discrimination task.

General discussion: Measuring complexity and showing that it matters

Writing systems have their own patterns that go beyond the mere transcription of spoken language. In cross-writing-system research, it is important to elucidate the relationships among mapping principles, orthographies, and visual aspects of these orthographies. We reviewed two studies (Chang, 2015; Chang et al., 2018) that examined how variation of writing systems affects graph perception – the initial, visual phase of reading. First, we introduced GraphCom, a multi-dimensional measure of graph complexity, which quantifies the visual properties of real writing and results in an ordering of complexity among the 131 orthographies analyzed. The measure can be applied to any number of orthographies beyond those analyzed. When we applied GraphCom-measured graphs to perceptual judgments, we found that each of its five dimensions were needed to account for these judgments (Chang et al., 2018). Perimetric complexity, a single powerful measure, was less successful than the multi-dimensional measure provided by GraphCom.

Having a measure of complexity allows questions about complexity factors in learning to read as well as perceptual judgments. It also can help test the hypothesis that learning to read a more complex orthography can sharpen visual perceptual skills. To test this, we compared a minimal pair of scripts controlling for language and (only approximately) cultural background. Our comparison of traditional with simplified Chinese, which differ in visual complexity but have the same linguistic properties, provides a fair test of whether exposure to more complex script is associated with higher perceptual performance on both written graphs and unfamiliar, non-linguistic stimuli. The results showed that skilled readers of more complex Chinese script outperformed those of less complex Chinese script in the discrimination tasks involving both kinds of stimuli. These findings underscore the end-state of graph mastery, fine-grain visual discrimination that are important but often ignored in reading research.

The mapping principle of writing systems that determines graph inventory and graph complexity

Beyond our sample of 131 orthographies, the GraphCom can be applied as a research tool to any of the many other orthographies in different writing systems. GraphCom's dimensions capture basic perceptual factors (i.e., the number of simple features, the number of connected points, and discontinuities in the configural form) and exceed a powerful single measure of overall configurational complexity (i.e., perimetric complexity, Pelli et al., 2006) in accounting for graphic complexity effects on graph perception. Thus, the resulting complexity variation of 131 orthographies (Figure 2) represents an objective quantification of complexity among the 131 written languages that aligns with informal observations of these languages. The sampled orthography pairs across writing system (Table 4) provides a clearer picture in explaining how complexity co-varies with the mapping principles.

Thus, abjads (e.g., Hebrew and Arabic) and alphabets (e.g., English and Korean) show similar low levels of complexity because their writing systems use graphs to map to more fine-grained linguistic units (i.e., phonemes). These systems need a relatively small number of graphs, which allows the re-use of a small set of graphs to form large numbers of words, the hallmark of productive writing system (Verhoeven & Perfetti, in press). At the other end of the scale, morphosyllabic writing systems (e.g., traditional Chinese, simplified Chinese, and Japanese Kanji) require a very large number of graphs to code coarse-grain linguistic units (i.e., syllable morphemes). As the needs of the number of graphs increase, these systems need to add graphs by adding more simple features, using more connected points, or creating disconnected components to make a graph that is distinguished from others. Overall, graph complexity is driven by the number of graphs that are needed in an orthography, which in turn, is governed by how it manages the mapping of graphs to linguistic units in spoken language (for discussions, see Perfetti & Harris, 2013; Verhoeven & Perfetti, in press).

Visual perceptual effects of processing traditional and simplified Chinese scripts

The higher language level of the mapping principle, the larger the number of graphs needed for the writing system and thus the more complex the orthographies. Naturally, across writing systems, this causal chain affects the process of learning to read, especially the time required to master the complete set of graphs. In alphabetic orthographies (average number of graphs: 20–30) such as Finnish, children master all graphs during the first grade (Seymour, Aro, & Erskine, 2003; White, Grave, & Slater, 1990); in alphasyllabic orthographies (average number of graphs: 400) such as Kannada, children require three to four years of formal instruction to master all graphs (Nag, 2007); in morphosyllabic orthographies (average number of graphs: > 3000) such as Chinese, children continue to learn novel characters after six years of formal education (Shu, Chen, Anderson, Wu, & Xuan, 2003). Thus, the number of graphs, ranging from quite small in "contained" orthographies to extremely large in "extensive" orthographies (Nag, 2007), has a strong influence on the pace of orthographic learning.

Figure 2, covering a wide range of orthographies, supports this observation – orthographies that have more visually complex graphs are also likely to contain a larger number of graphs, providing an additional challenge during learning. Indeed, these claims are strengthened by a modeling study that simulated graph learning across hundreds of languages (Chang, Plaut, & Perfetti, 2016). The model simulation produced a learning time that was strongly correlated ($r = .80$, $p < .001$) with graph complexity and number of graphs. Although graph complexity is correlated with the number of graphs at $r = .71$ ($p < .001$), both factors accounted for unique variance in predicting pace of learning. Collectively, these findings underscore the role that visual complexity plays in influencing orthographic learning across writing systems.

Graph complexity has an effect on readers' visual perceptual processing. As the Chang (2015) study suggests, reading more complex graphs may use fine visual skills and may, in turn, strengthen such skills. The Taiwan group, whose reading experience is with the more visually complex traditional script, showed better perceptual skills than the China group, whose reading experience is with the less visually complex simplified script. This result does not seem to fit with previous research reporting that children learning to read simplified Chinese show better visual perceptual skills than their age-matched cohort learning to read traditional Chinese (McBride-Chang et al., 2005). A three–way comparison among Hong Kong, Mainland China, and Taiwan readers is needed to align the results. Meanwhile, the Chang (2015) study summarized here provides the stronger test of the complexity hypothesis, which claims that experience in reading complex graphs supports acquisition of perceptual discrimination skills. Our participants were adult, literate, and well-matched college-level Chinese readers who have mastered more Chinese characters and thus were an appropriate sample for an experienced-based hypothesis. Presumably, the growth and decline of readers' visual skills change over time for these Chinese groups with age, cognitive, and education differences.

Moreover, as vision researchers suggest (Fahle & Poggio, 2004), visual perceptual learning involves skill improvement through repeated exposure to visual stimuli. Meeting the demands of graph identification as part of reading can be seen as visual perceptual training through a repeated exposure to graphs. For readers of English, if they read an hour a day for 40 years, they would have read more than one billion letters (Pelli et al., 2006). Certainly, even after 10 years, the letters of the English alphabet would be massively overlearned. For readers of Chinese, a few years of reading hundreds of radicals recurring in thousands of characters as parts of words can lead similarly to perceptual learning that can enhance visual-spatial processes. When the characters are more complex, as they are in the traditional script, such discrimination skill may surpass even that of those who read simplified Chinese, which of course is higher in complexity than all other orthographies.

Conclusion

At its core, learning to read is about learning to map graphic input to linguistic units. This process varies across writing systems, given their mapping principles (see other chapters, this volume). Mapping requires more than association; the form of the graph must be encoded by the reader such that it is distinguished from all the other graphs in the writing system. We underscore the role that visual complexity plays during the mapping process. Although visual complexity – including the number of graphs and overall graph complexity – is a consequence of implementing mapping principles, we emphasize that visual complexity is a factor influencing learning to read in a way that is interdependent with mapping. Our GraphCom measure of the visual properties of graphs is a practical research tool for designing studies of graph perception, graph learning, and cross-linguistic studies of reading and writing. Our experimental results comparing readers of the traditional and simplified Chinese scripts offer a case study concerning scripts: scripts have their own patterns and influences on reading that go beyond the transcription of spoken languages.

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CHAPTER 4

How do phonological awareness, morphological awareness, and vocabulary knowledge relate to word reading within and between English and Chinese?

Poh Wee Koh, Xi Chen and Alexandra Gottardo
Florida State University, USA / Ontario Institute for Studies in Education, University of Toronto, Canada / Wilfrid Laurier University, Waterloo, Canada

We discuss the cross-language relationships of phonological awareness, morphological awareness, and vocabulary in the context of English and Chinese and also how these three constructs are related to word reading within and between the two languages. We focused on a series of studies that have examined Chinese and English monolinguals, as well as Chinese-English bilinguals. Research supports the contributions of phonological awareness and morphological awareness to reading in English and Chinese, as well as across the two languages. Findings pertaining to vocabulary, however, have been mixed. The review of research here suggests the need to further investigate the inter-relations among subcomponents of phonological awareness and morphological awareness as well as how different aspects of vocabulary knowledge relate to word reading.

Keywords: phonological awareness, morphological awareness, vocabulary knowledge, cross-language transfer, word reading, Chinese-English bilinguals

Due to the unique features of the Chinese writing system, learning to read Chinese involves somewhat different processes than learning to read English (McBride-Chang et al., 2005). Thus, findings of research in reading Chinese, coupled with those in reading English and other alphabetic writing systems, shed light on the universal and unique processes involved in learning to read (McBride-Chang & Ho, 2005; Yang, Perfetti, & Liu, 2010; Perfetti, Zhang, & Berent, 1992). Similarly, research on cross-language transfer between Chinese and English enables us to disentangle transfer that is based on common linguistic forms (e.g., cognates) and transfer that is more metalinguistic in nature. In what follows, we first discuss

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the unique characteristics of the Chinese language and writing system. We then examine how phonological awareness, morphological awareness and vocabulary knowledge contribute to word reading in Chinese and English and whether these constructs transfer between the two languages in Chinese-English bilinguals.

Characteristics of the Chinese language and writing system

Chinese is a language with many unique phonological and morphological features. With regard to phonology, Chinese has a relatively simple structure. In Mandarin Chinese, the maximal size of a syllable is CVC. The total number of syllables is roughly 400 when tones are not considered. Cantonese has about 600 syllables. Both Mandarin and Cantonese are tonal languages, with four and six tones, respectively. Even with tones considered, the total number of syllables in Mandarin and Cantonese are limited (Chung, Ho, Chan, Tsang, & Lee, 2010; Wang, Cheng, & Chen, 2006; Zhou & Marslen-Wilson, 1994). Like English, phonological awareness in Chinese consists of syllable awareness, onset-rime awareness, and phonemic awareness. Because each syllable corresponds to a morpheme in the oral language and a character in print, syllable awareness is the most salient aspect of phonological awareness in Chinese (McBride-Chang, Bialystok, Chong, & Li, 2004). Onset and rime pronunciations are taught in Mainland China and Taiwan, using Pinyin and Zhuyinfuhao, respectively, whereas phonological awareness at the phonemic level is not required for learning to read Chinese. In addition, tone awareness is unique to Chinese and other tonal languages.

Morphemes form the building blocks of meaning in words across languages. English has a large number of derived and inflected words, while the majority of words used in modern Chinese are formed through lexical compounding by combining two, and sometimes more, root morphemes, e.g., 冰山 /bing1shan1/ (ice mountain: iceberg) and 电脑 /dian4nao3/ (electric brain: computer) (Duanmu, 1998; Sun, Huang, Sun, Li, & Xing, 1997). These root morphemes can be free morphemes, e.g., 冰 /bing1/ (ice), or bound morphemes that appear together with other morphemes, e.g., 脑 /nao3/ (brain). More than 75% of words in Chinese are formed by lexical compounding. In comparison, the number of inflected and derived words is smaller in Chinese (Ku & Anderson, 2003; Packard, 2000). Thus, studies involving Chinese children have focused primarily on compound awareness. With this focus, most studies have identified two aspects of morphological awareness; (1) the ability to reflect on and manipulate morphological structure, and (2) the ability to identify morpheme meanings (Chen, Hao, Geva, Zhu, & Shu, 2009; Liu & McBride-Chang, 2010; Liu, McBride-Chang, Wong, Shu, & Wong, 2013).

Morphological structure measures typically ask children to construct novel compounds, either by making an analogy to an existing compound (e.g., *Striped horse (Zebra) is a kind of horse with stripes on the body. What should we call a cow with stripes on the body?/striped cow*) or by answering a definition question (*What do we call mist that smells sour?/sour mist*) (Chen et al., 2009; McBride-Chang et al., 2005; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). These tasks tap into children's understanding of common compound structures, which include subordinate [e.g., 黑板 /hei1ban3/ (black board: blackboard)], coordinate [e.g., 宫殿 /gong1dian4/ (palace palace: palace)], subject-predicate [e.g., 地震 /di4zhen4/ (earth shake: earthquake)], verb-object [e.g., 读书 /du2shu1/ (read book: read)], and adverb-verb [e.g., 好看 /hao3kan4/ (e.g., nicely look: good looking)]. Due to the large number of homophones in Chinese, measures that examine morpheme meaning usually require children to differentiate morphemes with similar pronunciations but different meanings [e.g., 袋 /dai4/ in 口袋 /kou3 dai4/ (mouth pocket: pocket) and 带 /dai4/ in 带鱼 /dai4 yu2/ (belt fish: cutlassfish)]. Some tasks require children to differentiate homographs, which are characters that represent homonymous morphemes [e.g., 面 /mian4/ in 面包 (flour bun: bread) and 面孔 (face)].

The Chinese writing system also distinguishes itself in several important ways. It consists of thousands of visually complex characters. While a small number of characters are simple characters without an internal structure, the majority of characters (70%–80%) are semantic-phonetic compound characters [e.g., 妈 /ma1/ (mother)], each of which is comprised of a semantic radical [e.g., 女 (female)] and a phonetic radical [e.g., 马 /ma3/] (Shu, Chen, Anderson, Wu, & Xuan, 2003). The former provides some indication of the meaning of the character, whereas the latter reflects the character's pronunciation. Neither semantic nor phonetic radicals always provide reliable information about the character. According to Shu et al. (2003), among the semantic-phonetic compound characters taught in primary school in Mainland China, 58% have semantic radicals that provide reliable information, whereas only close to 40% have phonetic radicals that have the same pronunciation as the character when tone is not considered.

Phonological awareness

Development of phonological awareness in Chinese

Phonological awareness refers to the ability to manipulate sound units of a language (Mattingly, 1972). Skills underlying or related to phonological awareness include speech perception, verbal short-term memory and reasoning skills (McBride-Chang, 1995). Stanovich (1992) proposed that the development of phonological awareness progresses from the acquisition of larger phonological units such as syllables to that of finer units such as phonemes. This developmental sequence has been supported empirically in English (e.g., Anthony & Francis, 2005; Anthony, Lonigan, Driscoll, Phillips, & Burgess, 2003; Carroll, Snowling, Hulme, & Stevenson, 2003; Treiman & Zukowski, 1991).

In regards to Chinese, on the one hand, there is evidence that children learning Chinese appear to acquire and develop different aspects of phonological awareness in a similar fashion (Ho & Bryant, 1997; Shu, Peng, & McBride-Chang, 2008). Several studies showed that children as young as 3 years performed above chance on a syllable detection task (Shu et al., 2008), whereas only children who were 4 years old or older performed above chance on rime and tone detection measures (Ho & Bryant, 1997; Shu et al., 2008). Furthermore, these studies also showed that only grade 1 children performed above chance on onset awareness measures. Since consonant clusters do not exist in Chinese, onset awareness measures are also measures of initial phonemes. Taken together, these studies suggest Chinese children develop syllable awareness first, followed by rime and tone awareness, and they develop onset/phoneme awareness last.

On the other hand, it has been suggested that the acquisition of phonological awareness in Chinese might differ from that of other languages. This is because children attend to different phonological units based on the phonotactic structure of their language and the grain size of the orthography, or sound-symbol relations (e.g., Caravolas, 2006; Cheung, Chen, Lai, Wong, & Hills, 2001; Durgunoğlu, 2002; Ziegler & Goswami, 2005). Chinese is a "logographic" writing system and its syllables can be further divided into onsets and rimes rather than phonemes in school instruction, Chinese children develop phonological awareness more slowly than their English-speaking peers (Ho & Bryant, 1997). However, exposure to phonetic training has been found to aid in the development of phonological awareness among Chinese children. For instance, as compared to Hong Kong children who learn Chinese using the "look-say" method, Chinese children in the Mainland and Taiwan who learn the language with the help of a phonetic system (Pinyin and Zuyinfuhao, respectively) demonstrate higher levels of phonological awareness (e.g., Huang & Hanley, 1995; McBride-Chang et al., 2004). In another line of research, Chinese children learning English outperformed monolingual Chinese children on phonemic awareness tasks (Bialystok, McBride-Chang, & Luk, 2005; Chen, Xu, Nguyen, Hong, & Wong, 2010), suggesting that exposure to an alphabetic language such as English facilitates phonological awareness in Chinese.

Phonological awareness in reading Chinese

Why is phonological awareness important for Chinese reading? Indeed, the absence of grapheme-phoneme correspondences in Chinese renders the connection between phonological awareness and reading less apparent. Nonetheless, according to the universal phonological principle, reading involves activating phonology at the smallest unit allowed by the writing system (Perfetti et al., 1992). This unit is the syllable in Chinese, which explains the prominent role that syllable awareness plays in Chinese reading. Across several empirical studies, syllable awareness has been shown to be a particularly strong predictor of Chinese reading (e.g., McBride-Chang & Ho, 2005; McBride-Chang & Kail, 2002; McBride-Chang et al., 2008). For example, Shu et al. (2008) observed that syllable awareness was a significant predictor of Chinese character reading in Chinese kindergartners. Both real words and pseudowords were used in the syllable deletion task, thus ruling out the possibility that children were able to delete syllables in real words because they also represented morphemes. A similar finding was reported by McBride-Chang et al. (2008) among 5-year-old Hong Kong kindergarteners. In this concurrent study, syllable awareness was found to predict Chinese reading.

In addition, researchers have proposed a link between suprasegmental phonology and visual word reading (Arciuli, Monaghan, & Seva, 2010; Tong, Tong, & McBride, 2017). Tone is a suprasegmental feature that is unique to Chinese and other tonal languages. A large number of syllables in Chinese have the same onset-rime structure but have different tones [e.g., 峰/feng1/(hill) – 逢/feng2/ (encounter)]; thus, tone awareness enables children to distinguish these syllables and therefore is important for reading Chinese (Shu et al., 2008; Tong, Tong, & McBride-Chang, 2015; Yeung & Ganotice, 2014). In the studies conducted by Shu et al. (2008) and McBride-Chang et al. (2008), tone awareness, in addition to syllable awareness, was found to be a significant predictor of Chinese character recognition among Chinese kindergarteners. Additionally, Tong et al. (2015) demonstrated that the ability to differentiate lexical tones explained unique variance in Chinese character reading, after controlling for syllable and onset awareness and morphological awareness in 6-year-old children in Hong Kong.

Finally, it has also been put forth that awareness of onsets and rimes contribute to reading in Chinese. This is because in Mainland China and Taiwan, where a phonetic coding system is used to indicate pronunciations of characters, children are taught to pronounce characters by combining onset and rime units. However, empirical studies investigating the relation between onset-rime awareness and Chinese word reading have yielded mixed findings. For instance, studies comparing good and poor readers have found that poor readers performed lower on onset and rime awareness as compared to good readers (So & Siegel, 1997; Chung & Ho, 2010), pointing to the importance of onset-rime awareness in reading Chinese. In addition, in a longitudinal study involving Chinese-English bilingual children in the United States, Wang, Lin, and Yang (2014) found that rime awareness measured in grade 1 predicted Chinese character reading in grade 2 after controlling for compound awareness and orthographic processing. However, although Ho and Bryant (1997) also showed that rime awareness was significantly correlated with character and pseudo-character reading in grade 1 Hong Kong Chinese children, the correlation was not significant in the grade 2 group. Notably, the studies described above did not include syllable awareness (e.g., Ho & Bryant, 1997) and consequently their findings cannot be used to compare the relative contributions of different aspects of phonological awareness to Chinese reading.

While it is important to explore the relative contributions of different aspects of phonological awareness to Chinese reading, it is also important to note that these skills tend to be highly correlated. Therefore, future research should explore whether these skills, including tone awareness, are represented by the same underlying construct in Chinese, as is the case in English (Anthony & Lonigan, 2004).

Phonological awareness in reading English in Chinese-English bilinguals

A number of studies have examined the role of English phonological awareness in English reading among Chinese-English bilinguals (e.g., Cheung et al., 2010; Gottardo, Chiappe, Yan, Siegel, & Gu, 2006; Hsu, Ip, Arredondo, Tardiff, & Kovelman, 2016; Wang et al., 2014). Generally speaking, this body of research reveals that despite differences in Chinese and English, commonalities exist in terms of aspects of phonological awareness related to reading across the two languages. Just as is shown in Chinese reading research, syllable awareness has also been found to be related to word reading in English in Chinese-English bilinguals (McBride-Chang et al., 2004; Yeung & Chan, 2013). For example, several studies conducted by McBride-Chang and colleagues (McBride-Chang & Kail, 2002; McBride-Chang et al. 2008) demonstrated that syllable awareness was equally associated with word reading within both Chinese and English in Hong Kong kindergartners.

However, it has been shown that when multiple aspects of phonological awareness are included in the same study and compared to the relationship with word reading between Chinese and English, different patterns can be observed that reflect the phonological and orthographic features of Chinese and English (e.g., McBride-Chang et al., 2008). For instance, in addition to syllable awareness, tone awareness has been found to predict word reading in Chinese, but generally has not been included in studies of English reading (McBride-Chang et al., 2008; Shu et al., 2008). On the other hand, phonemic awareness may be an aspect of phonological awareness that is specialized for learning alphabetic languages, while learning to read Chinese does not require phonological representation at the level of the phoneme. In a comprehensive study including multiple aspects of phonological awareness in both Chinese and English, Yeung and Ganotice (2014) observed that tone awareness explained unique variance in Chinese word reading. Phonemic awareness, but not syllable awareness explained unique variance in English word reading in Hong Kong kindergartners. These findings provide support for the psycholinguistic grain size theory (Ziegler & Goswami, 2005) that the relationships between phonological awareness and word reading differ across languages because children attend to different phonological units based on the phonotactic structure of their language and the grain size of the orthography.

Cross-language transfer of phonological awareness in Chinese-English bilinguals

There is substantial evidence of cross-language transfer of phonological awareness, both at the construct level and in relation to word reading among Chinese-English bilinguals. At the construct level, studies examining patterns of phonological awareness between Chinese and English have shown a general correlation among phonological measures across the languages. This association has been reported in Chinese-English bilinguals in Hong Kong (Keung & Ho, 2009) as well as in North America (e.g., Gottardo et al., 2006; Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Luo, Chen, & Geva, 2014; Lam, Chen, & Cummins, 2016). More direct evidence of transfer of phonological awareness appears in studies assessing the effectiveness of instructional programs. In a two-year longitudinal study involving first grade children in China, Chen et al. (2010) observed that compared to peers who received less intensive English instruction, those who received more intensive English instruction developed higher levels of onset, rime, and phonemic awareness in English. Similar but delayed effects were found for growth in these aspects in Chinese, but not tone awareness. These results suggest that for Chinese speakers, instruction in an alphabetic orthography has positive effects on phonological awareness in Chinese through cross-language transfer, but the transfer may not occur among all of the sublevel skills due to differences in the languages in question.

Furthermore, there is ample evidence that for Chinese-English bilinguals, phonological awareness measured in either the L1 or L2 contributes to word reading in the other language (Chen et al., 2010; Gottardo, Gu, Mueller, Baciu, & Pauchulo, 2010; Gottardo et al., 2001; Keung & Ho, 2009; Wang, Yang, & Cheng, 2009). In their landmark study, Gottardo et al. (2001) reported that Chinese rime awareness explained unique variance in English word and pseudoword reading after controlling for English phonemic awareness in a mixed sample of Chinese-English bilinguals in Canada between the ages of 6 and 13 years old. Gu and Gottardo (2004) also found that Chinese rime awareness was uniquely related to English reading among Chinese-Canadian children in grades 5 and 6. However, no such transfer was found in children who were in grades 1 and 2. The researchers concluded that age was a moderator of the relationship between phonological awareness and word reading in English. Evidence for cross-language transfer of syllable awareness, another aspect of phonological awareness, was also presented in a series of studies conducted by McBride-Chang and colleagues involving Hong Kong kindergartners (McBride-Chang & Ho, 2005; McBride-Chang et al. 2008; Chow, McBride-Chang, & Burgess, 2005). For example, both Chow et al. (2005) and McBride-Chang et al. (2008) found that Chinese syllable awareness was longitudinally related to English word reading after controlling for the autoregressor and other aspects of phonological processing (e.g., speeded naming). However, these studies did not control for phonological awareness in English.

Interestingly, although tone awareness is an aspect of phonological awareness that is specific to Chinese, it has been found to contribute to English word reading (e.g., Tong, He, & Deacon, 2016; Yeung & Ganotice, 2014; Wang, Perfetti, & Liu, 2005). Yeung and Ganotice (2014) showed that tone awareness explained unique variance in English word reading in Hong Kong kindergartners. Tong et al. (2016) extended findings of Yeung and Ganotice (2014), demonstrating that tone awareness measured in grade 2 in Cantonese Chinese predicted English word reading a year later. Two studies by Wang and colleagues (Wang et al., 2005; Wang et al., 2009) also reported that tone awareness explained unique variance in English real word or pseudoword reading after controlling for phonological awareness and other reading-related variables among Chinese-English bilingual children in the United States. Wang et al. (2009) proposed two explanations for the relationship between Chinese tone and English reading. The first one is that the underlying mechanism for tone awareness is general auditory processing, which is related to reading in English (e.g., Reed, 1989; Tallal, 1980). However, Wang et al. (2009) also pointed out that the tone awareness task used in their studies was fundamentally different from the auditory processing tasks used in the studies on English reading. Another, perhaps more plausible explanation is that tone awareness represents sensitivity to prosodic features of a language. Sensitivity to prosodic properties such as stress and rhythm has been shown to predict word reading in English (Clin, Wade-Woolley, & Heggie, 2009; David, Wade-Woolley, Kirby, & Smithrim, 2007). This connection may explain why awareness of Chinese tones is useful for English word reading in Chinese-English bilinguals.

Morphological awareness

Development of morphological awareness in Chinese

Researchers have identified two overlapping yet distinct aspects of morphological awareness: (1) morphological structure awareness, which refers to the ability to reflect on and manipulate morphological structure, and (2) morpheme-level awareness, which in Chinese focuses on the ability to differentiate the meaning of homophonic or homographic morphemes (Chen et al., 2009; Liu & McBride-Chang, 2010; Liu et al., 2013). As compared to the rich research base on the development of morphological awareness in English (Carlisle, 1995; Berninger, Abbot, Nagy, & Carlisle, 2010), relatively little is known about the development of morphological awareness among Chinese children. Ku and Anderson (2003) found that Taiwanese children improved in performance on measures of morpheme meaning and word formation between grade two and grade six. Furthermore, consistent with the fact that there are more compound words than derived words in Chinese, children's performance was higher on compound words than derived words. With respect to morphological structure awareness, Liu and McBride-Chang (2010) showed that it was more difficult for third grade Hong Kong children to produce noun compound words of subject-predicate and verb-object structures than those of subordinate and coordinative structures, because the former two types are less common. Relatedly, across different structures, it was more difficult to produce compounds with verb morphemes than those without, probably because Chinese verbs are highly specific.

To our knowledge, two studies have examined factors that are related to the ability to identify morphemes in Chinese children. Hao et al. (2013) found that both semantic relatedness of words and morpheme status played a role in the development of this ability. When children were asked to judge whether words contained the same morpheme, they were more accurate when words containing the morpheme were closely related in meaning [e.g., 电视 /dian4 shi4/ (electric vision: television) and 电话 /dian4 hua4/ (electric talk: telephone)] and when the morpheme was a free morpheme. Performance at identifying the same morpheme appearing in distantly related words [e.g., 假山/jia3shan1 (artificial mountain: rockery) – 假发 / jia3fa4 (artificial hair: wig)] became better with age. Extending Hao et al. (2013), Li et al. (2016) asked children to judge whether a pair of words shared the same first morpheme in conditions where orthography and phonology were manipulated. There was a homograph condition with the same orthography and phonology [e.g., 面包/mian4 bao1/ (bread) and 面孔/mian4 kong3/ (face)], a condition with the same orthography but different phonology [e.g., 大海/da4 hai3/ (sea) and 大夫/dai4 fu1/ (doctor)], a homophone condition with different orthography but the same phonology [e.g., 高兴/gao1 xing4/ (happy) and 糕点/gao1 dian3/ (cake)], and a baseline condition where both were different. The results demonstrated the effects of both orthography and phonology. Sharing either feature made it more difficult for children to conclude that the two first morphemes were not the same.

Morphological awareness in reading Chinese

There are several reasons why morphological awareness is a skill important for Chinese word reading (e.g., Lei et al., 2011; Li, Shu, McBride-Chang, Liu, & Peng, 2012; McBride-Chang et al., 2003; Liu et al., 2013; Pan et al., 2016). First, Chinese is often labelled a "morpho-syllabic" language, meaning that in most cases, a morpheme corresponds to a syllable in the oral language and a character in print. Thus, morphemes are key units connecting oral language with the writing system. Second, Chinese morphemes can be combined in various ways to form different compound words, where the meanings are transparent (Shu et al., 2006; Yin, 1984; Yuan & Huang, 1998). As such, awareness of compound structure facilitates the production and understanding of compounds. Third, since Chinese has many homophones as well as homographs, homophone/homograph awareness enables the reader to differentiate morphemes that have the same phonological form or the same orthographic form, or both. Given the clear grapheme-morpheme association and less systematic representation of phonological information, compound awareness may be more important for reading Chinese than phonological awareness. Several studies have found that compound awareness was a stronger predictor of Chinese word reading and vocabulary than phonological awareness when both constructs were included (e.g., Chen et al., 2009; Liu et al., 2010; 2013; Tong & McBride-Chang, 2010).

Research has demonstrated that both morphological structure awareness and homophone awareness are related to Chinese word reading (Chen et al., 2009; Liu & McBride-Chang, 2010; Tong & McBride-Chang, 2010; Li et al., 2012). For example, in a study focusing specifically on morphological structure awareness, Chen et al. (2009) found that a compound analogy task explained unique variance in Chinese character reading in first and second graders in China. Two studies (Li et al., 2012; Liu & McBride-Chang, 2010) that tapped morphological structure awareness and homophone awareness found that both aspects were uniquely related to Chinese word reading in primary school children in China. Tong and McBride-Chang (2010) reported similar findings in Hong Kong second graders. A limitation of the study was that it combined the performance on the morphological construction task and homophone production task into a single score. As such, it was not possible to tease apart the effect of each measure.

Notably, there is some evidence that morphological structure awareness was more predictive of Chinese word reading than homophone awareness (e.g., Liu et al., 2013; Zhou et al., 2014). Zhou et al. (2014) found that an intervention involving lexical compounding improved Chinese children's word reading performance but homophone training did not. Liu et al. (2013) found that both lexical compounding and homophone awareness were associated with character reading in 9-year-old Hong Kong children. However, when character reading from a previous time point was controlled for, only structure awareness remained to be a unique predictor. Based on these findings, Liu et al. (2013) hypothesized that structure-level and morpheme-level awareness may have somewhat different relationships with word reading in Chinese (e.g., Liu et al., 2013; Zhou et al., 2014). This hypothesis needs to be substantiated by future studies.

Morphological awareness in reading English in Chinese-English bilinguals

It is well established that both inflectional awareness and derivational awareness contribute to English word reading among English-speaking monolinguals (e.g., Hsu et al., 2016; Marinova-Todd, Siegel, & Mazabel, 2013; McBride-Chang et al., 2005; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). These findings are consistent with the fact that the majority of words in English are inflected or derived words. Studies involving Chinese-English bilinguals have demonstrated similar patterns (e.g., Cheung et al., 2010). For example, Ramírez, Chen, Geva, and Luo (2011) observed that derivational awareness contributed similar amounts of variance to English word reading in Chinese-English and Spanish-English bilinguals as well as in monolingual English-speaking children in grades 4 and 7 in Canada. In the same study, compound awareness was not a unique predictor of English word reading in any of the groups. Similarly, Wang et al. (2006) reported that derivational awareness but not compound awareness was related to English word reading in Chinese-English bilinguals in the United States. In another study, Wang et al. (2009) found that English compound awareness did not account for unique variance in English word reading in Chinese-English bilinguals. Taken together, these findings highlight the commonalities in English reading between English-speaking monolinguals and Chinese-English bilinguals.

Cross-language transfer of morphological awareness in Chinese-English bilinguals

Despite the differences between English and Chinese, two similarities are observed with regard to the morphological structure of the two languages. Firstly, noun-noun compounds in both English and Chinese are right-headed, where the overall meanings of words are contained primarily in the right morpheme (Clark, Gelman, & Lane, 1985). Secondly, compounds in both languages share the feature of semantic transparency (Frisson, Niswander-Klement, & Pollatsek, 2008; Pasquarella, Chen, Lam, Luo, & Ramírez, 2011), although the degree of transparency appears to be greater in Chinese (Hipfner-Boucher, Lam, & Chen, 2014). The existence of morphological similarities between the two languages establishes the foundation for cross-language transfer (Koda, 2005). The fact that these similarities are limited to compounds explains why compound awareness is the focus of cross-language transfer studies.

An emerging body of research has investigated the cross-language association of morphological awareness at the construct level. Evidence for the cross-language association of compound awareness between Chinese and English comes from Luo et al. (2014). In their study, Luo and colleagues (2014) found that after substantive controls, English compound awareness accounted for 21% of variance in a parallel measure in Chinese in Chinese-English bilinguals in Canada. Conversely, 18% of the variance in English compound awareness was accounted for by Chinese compound awareness, providing empirical support for cross-language associations in both directions (English-to-Chinese and Chinese-to-English). Several other studies, however, only observed transfer from Chinese compound awareness to English compound awareness (e.g., Cheung et al., 2010; Zhang et al., 2010). On the other hand, contrary findings of nonsignificant correlations between parallel compound awareness tasks in English and Chinese have also been reported (e.g., Wang et al., 2006; Wang et al., 2009). Therefore, the underlying nature of transfer of morphological awareness needs to be further investigated in Chinese-English bilinguals.

There is strong evidence for transfer of compound awareness to reading outcomes in Chinese-English bilinguals (e.g., Wang et al., 2006; Wang et al., 2009). In their study with Chinese-English bilingual children from grades 1 through 4 in the United States, Wang et al. (2006) found English compound awareness to be a significant predictor of Chinese character reading. Chinese compound awareness, on the other hand, did not predict English word reading. This pattern of results was replicated with a younger sample of Grade 1 children in the study conducted by Wang et al. (2009). While Pasquarella et al. (2011) found that English compound awareness contributed to Chinese vocabulary and reading comprehension in Chinese-English bilinguals in Canada, the cross-linguistic effect was not significant on Chinese word reading. Pasquarella et al. (2011) argued that the direction of transfer is influenced by the structures of the languages and writing systems involved. Since Chinese has a large number of compounds, children need compound awareness from both languages to support Chinese reading development. In contrast, compound awareness is less important for reading English, thus there is little need for cross-language transfer to occur from Chinese compound awareness to English reading outcomes. However, Cheung et al.'s (2010) study with Hong Kong children in kindergarten, grade 2, and grade 4 yielded findings of an opposite trend. Chinese compound awareness predicted English word reading but English compound awareness did not predict Chinese character reading. It appears that the direction of transfer may also depend on the relative proficiencies of the languages involved and the language learning context. Given that Chinese is the stronger language for Hong Kong children whereas English tends to be the stronger language for Chinese-English bilinguals in English-speaking countries, the opposite directions of transfer observed in Hong Kong and North America suggest that transfer occurs from the stronger to weaker language.

Notably, few studies have investigated cross-language transfer of morphological awareness with a longitudinal design. Luo and colleagues (2014) examined both concurrent and longitudinal cross-linguistic relationships between morphological awareness and word reading in Chinese-English bilinguals. The researchers found that English compound awareness made a concurrent, indirect contribution to Chinese word reading mediated by Chinese compound awareness. Longitudinal cross-language contributions, however, were not observed either from English morphological awareness to Chinese word reading, or from Chinese morphological awareness to English word reading. Wang et al. (2014) followed the participants in Wang et al. (2009) for one year and tested them again in grade 2. In this longitudinal study, however, compound awareness in grade 1 was not related to word reading in grade 2 across Chinese and English in either direction. It is not clear why morphological awareness does not transfer to reading longitudinally. Further research is warranted to clarify this issue.

Vocabulary

Development of vocabulary knowledge

Vocabulary knowledge is widely acknowledged as a multi-dimensional construct that consists of at least two dimensions, a breadth dimension and a depth dimension (e.g., Beck & McKeown, 1991; Laufer & Paribakht, 1998; Nagy & Scott, 2000). Vocabulary breadth refers to the number of words one knows and this knowledge could range from having a rudimentary to a deep understanding (Nassaji, 2004; Nation, 2001). Generally, vocabulary depth is thought to be concerned with how much one knows about a word (e.g., multiple meanings, relationships with other words). Some researchers have categorized vocabulary depth as comprising two dimensions of knowledge, paradigmatic knowledge and syntagmatic knowledge (e.g., Haastrup & Henrikson, 2000; Schwartz & Katzir, 2012). Paradigmatic knowledge is defined as the knowledge of hierarchical relationships among words (Schwartz, Moin, & Leikin, 2012). These relationships include antonymic links (e.g., man-woman), synonymic associations (e.g., happy-delighted), as well as superordinate (e.g., transportation – car, train, airplane) and subordinate relations (e.g., orange, apples, bananas) (Henriksen, 1999; Ly & Jung, 2013; Schwartz & Katzir, 2012). Syntagmatic knowledge, on the other hand, refers to the knowledge of how words can be combined across word classes (e.g., small + room = small room) (Schwartz et al., 2012).

In terms of development, it has been found that syntagmatic knowledge develops earlier than paradigmatic knowledge (e.g., Anglin, 1985; Cronin, 2002; Miller & Johnson-Laird, 1976; Palermo, 1971; Snow, 1990; Söderman, 1993; Wolter, 2001). It has been suggested that this trend holds true also with Chinese-English bilingual children (Sheng, McGregor, & Marian, 2006). This developmental shift is attributed to changes in the organization of the mental lexicon (Nelson, 1977), which is hypothesized to be a result of school experience and more exposure to reading (Cronin et al., 1986). As paradigmatic knowledge is associated with the organization of word concepts into meaningful categories, which represents a higher order cognitive skill (Anglin, 1985; Schwartz & Katzir, 2012), the proposed developmental shift from syntagmatic to paradigmatic knowledge reflects increasing language proficiency (Lippman, 1971).

Vocabulary knowledge in reading Chinese

We hypothesize that vocabulary plays an important role in Chinese word reading for two reasons. First, Chinese is a phonologically opaque script where meaning and sound cannot be fully dissociated, thus vocabulary knowledge is important in word identification. Second, the phonetic radical in a compound character does not always correspond to the pronunciation of the character, therefore, vocabulary knowledge would aid in character and word reading when the radicals do not provide accurate information of character pronunciations. Research has supported the relationship between Chinese word reading and vocabulary at both the breadth and depth levels. In a study conducted by Huang and Hanley (1995), vocabulary knowledge was found to be a significant predictor of Chinese word reading in third-grade

Taiwanese children after partialling out the contributions of visual skills, phonological awareness, and IQ. So and Siegel (1997) conducted a cross-sectional study with children in Hong Kong between 6 to 10 years of age and found that vocabulary depth, measured using a sentence meaning task, was not predictive of word reading for children in grades 1 to 3 but emerged as a significant predictor at Grade 4. These findings suggest that the role of vocabulary in word reading increases with age. With increased reading demands, readers encounter compound characters, which are less transparent, and need to use vocabulary knowledge to facilitate reading.

Vocabulary knowledge in reading English in Chinese-English bilinguals

Research examining the relationship between vocabulary and word reading in English has been less common, with even fewer studies on English-Chinese bilinguals. This is possibly because popular reading models such as the simple view of reading model (Hoover & Gough, 1990) consider decoding/word reading and vocabulary to be separate constructs. In the few studies that have been conducted with English-Chinese bilinguals, findings support the role of vocabulary in English word reading (Wang et al., 2006; Wang et al., 2009). For instance, in Wang et al. (2006)'s study with Chinese-English bilingual students in grades 1 through 5, English vocabulary assessed using a breadth measure explained a significant amount of variance in English word reading. In another study, Wang et al. (2009) also found that vocabulary breadth contributed a significant amount of variance to English word reading, although it did not emerge as a unique predictor after controlling for other variables.

Cross-language transfer of vocabulary knowledge in Chinese-English bilinguals

According to the distributed characteristic of bilingual development (Cobo-Lewis, Pearson, Eilers, & Umbel, 2002; Hernandez, Li, & MacWhinney, 2005), there are lexical entries that are only accessible in one language (i.e., language-specific) and others that are available in both languages (common across languages) to a bilingual child (Bedore, Peña, Garcia, & Cortex, 2005). Therefore, there is a need to consider how vocabulary knowledge in both languages interact to gain a better understanding of the vocabulary levels of bilingual children (e.g., Bedore et al., 2005; Pearson, Fernandez, & Oller, 1993). However, there is a dearth of research on the cross-linguistic associations of vocabulary knowledge, especially across typologically different languages. This is possibly due to the view that vocabulary knowledge represents a more complex construct (Gottardo et al., 2001) that renders transfer less likely (e.g., Proctor, August, Carlo, & Snow, 2005).

The limited literature regarding this line of research has been focused on languages with cognates (e.g., English and Spanish), which are words across languages that have similar meanings and share at least some orthographic and phonological properties (e.g., *accident – accidente*) (Holmes & Guerra Ramos, 1995). Findings of different studies converge, showing evidence of cross-language associations of vocabulary breadth (Cunningham & Graham, 2000; Nagy, García, Durgunoğlu, & Hancin-Bhatt, 1993). In comparison, fewer studies have investigated transfer of vocabulary knowledge between languages represented by different writing systems where cognates do not exist, such as English and Chinese. To date, research examining the crossover effect of vocabulary knowledge on word reading in Chinese-English bilinguals has yielded non-significant results (Pan et al., 2016). However, Jiang (2000, 2004) established that transfer at the semantic level can occur across English and Chinese despite the dissimilarities in the two languages. In the model put forth by Jiang (2000), semantic transfer for older learners occurs through three stages. The first stage is the word association stage where the learner encounters a new word in the L2 and associates it with the L1 translation to access conceptual information about the word. In the second stage (i.e., the lemma mediation stage, this translation process facilitates transfer across languages and over time creates a direct link between the L2 word and the concept, thus reducing the reliance on accessing the concept through the L1. In the final stage (i.e., the full integration stage), with increased exposure to the word in the L2, strong links between the L2 word and concept are formed, including information about the word that are contextualized within the L2 (e.g., syntactic properties). Reliance on the L1 is further reduced or no longer necessary.

Jiang (2000)'s three-stage theory is similar to established bilingual processing theories, such as the Revised Hierarchical Model (RHM) of bilingual processing, which suggest that cross-language associations exist at the level of vocabulary depth and that cross-linguistic transfer can occur even across languages that do not share cognates. According to the RHM, the forms that words take differ across languages but they share a common underlying concept. For instance, the words "dog" in English and "狗/gou3/" in Chinese both correspond to the concept of an animal with four legs that barks (Potter, So, von Eckardt, & Feldman, 1984; Snodgrass, 1984). Wolter (2006) puts forth that paradigmatic knowledge constitutes this common concept. Paradigmatic associations among words are formed from the same word class and thus, relations remain stable across languages. For instance, the words "car" and "train" in English, despite being expressed as different forms in Chinese ("车/che1/" & "火车/huo3che1/"), still fall under the concept "transportation". Therefore, a learner who has knowledge of words and their corresponding concepts in one language only needs to learn the forms of these words in the other language without having to acquire the concepts again. In contrast, syntagmatic knowledge is highly contextualized and involves combinations across different word classes. Words go through what Wolter (2006) terms a "conceptual modification" in these cases where combining words often lead to a change in the concept of the resulting word (e.g., blue + moon = blue moon). Therefore, meanings are less consistent across languages (McKeown & Radev, 2000).

Ordóñez, Carlo, McLaughlin and Snow (2002) provided empirical support for Wolter's claim by establishing cross-language associations of vocabulary depth at the paradigmatic level. In their study, Ordóñez and colleagues (2002) asked Spanish-English bilingual children to provide definitions for high frequency nouns in both English and Spanish and their responses were coded for paradigmatic and syntagmatic aspects. They found that children's level of paradigmatic knowledge (measured by the number of paradigmatic responses children made in word definitions) was related between the two languages. Koh (2016) furthered this line of research by showing that a cross-language relationship of paradigmatic knowledge existed for English and Chinese. In this study with eight- and ten-year old Chinese-English bilingual children in Singapore, paradigmatic knowledge was found to be significantly related between English and Chinese, after controlling for the effects of nonverbal reasoning and English vocabulary breadth. In contrast, there was no evidence of a cross-language association of syntagmatic knowledge. The results obtained by Koh (2016), combined with those of Ordóñez et al. (2002), suggest that the cross-language transfer of paradigmatic knowledge occurs in both typologically similar and dissimilar orthographies. These findings also support the proposition of the RHM (Kroll & Stewart, 1994) in that there exists a common concept across languages. The finding that paradigmatic, but not syntagmatic knowledge, was associated across languages is consistent with Wolter's (2006) hypothesis that the vocabulary knowledge shared across languages is paradigmatic in nature. Syntagmatic knowledge, on the other hand, is likely to be contextualized across languages.

Conclusions and future directions

In this chapter, we examined the literature on the contribution of phonological awareness, morphological awareness, and vocabulary to word reading in English and Chinese among Chinese-English bilingual children. We also reviewed research on the cross-language associations of these three constructs and the relationships they share with word reading across English and Chinese. Taken together, the results of this body of research demonstrate many similarities between reading Chinese and English, two typologically different writing systems, pointing to universal processes in reading. At the same time, our review also reveals language specific processes as determined by the unique characteristics of each writing system.

The current state of research in English points to the importance of phonemic awareness in word reading. In contrast, the importance of syllable and tone awareness is highlighted in Chinese word reading. However, findings with regard to the role of onset-rime awareness in Chinese word reading are mixed. Considering the high correlations among the different facets of phonological awareness, future research should explore whether they represent the same underlying construct in Chinese. With respect to cross-language transfer, emerging research provides support for the transfer of syllable, rime and tone awareness between English and Chinese. Interestingly, there is evidence for transfer of tone awareness despite the fact that tone is not a feature of the phonetic system in English. Researchers argue that tone awareness reflects general auditory processing or sensitivity to prosodic properties such as stress and rhythm, which are related to English word reading. Further research is needed to validate these claims.

Our review of the literature also shows evidence for a significant relationship between morphological awareness and word reading within Chinese and English. However, how different aspects of compound awareness are associated with character reading in Chinese needs to be further considered. With respect to cross-linguistic transfer, there is evidence of cross-language relationships of compound awareness, both at the construct level and in terms of reading skill. However, the direction of these relationships is still unclear. Research on factors that influence the direction of cross-language relationships is needed, given that past studies have found that transfer is dependent on factors such as level of language proficiency and language learning environment. Notably, cross-language transfer of compound awareness has only been observed in concurrent studies. More studies with longitudinal designs are needed to clarify the long-term crossover effect of morphological awareness in Chinese-English bilinguals.

Finally, there has been more research in Chinese examining the relationship between vocabulary and word reading as compared to English. The cross-language association of vocabulary and word reading in these two languages has also been under studied. Future research could adopt a more in-depth examination of the different aspects of vocabulary, namely, breadth and depth, in the same study, and their relationships with word reading within and across Chinese and English.

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CHAPTER 5

The complexities of written Chinese and the cognitive-linguistic precursors to reading, with consequent implications for reading interventions

Sylvia Chanda Kalindi[i], Kevin Kien Hoa Chung[ii], Duo Liu[ii] and Li-Chih Wang[ii]
[i]The Mount Saint Vincent University, Canada / [ii]The Education University of Hong Kong

This chapter will review universal and unique cognitive-linguistic precursors to reading acquisition and impairment, such as reading disabilities and dyslexia, in the Chinese language. The chapter will examine research evidence linking phonological awareness, morphological awareness, orthographic awareness, rapid automatized naming (RAN), and visual skills to reading acquisition among children in mainland China, Hong Kong, and Taiwan. Understanding these cognitive-linguistic constructs and their mechanisms underlying reading acquisition is essential in order to explain reading impairment. Compared to dyslexic children of alphabetic languages, Chinese children with dyslexia present different and often multiple profiles of cognitive-linguistic deficits, the most dominant being RAN, orthographic awareness, and morphological awareness and the less dominant being phonological awareness. In particular, the review will examine the causes, characteristics, uniqueness or idiosyncrasies found in speakers of Chinese, and consequences of dyslexia in children in the three Chinese societies. Such a review will offer insight into and lay foundations for developing effective evidence-based interventions for children with reading impairment both inside and outside of school. Implications for current evidence-based practices in interventions are also discussed.

Keywords: Chinese language, reading acquisition and difficulties, interventions, dyslexia

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Introduction

Impairment in reading has been a source of concern to researchers for well over a century. Specifically, in western countries, researchers have for long been intrigued by the prevalence and persistence of reading impairments such as dyslexia, even in instances where the children have sufficient educational opportunity as well as adequate intelligence (Miles & Miles, 1999; Seymour, 1998). It is reported that developmental dyslexia affects approximately 4 to 11 percent school-aged children worldwide (Chan, Ho, Tsang, Lee, & Chung, 2007; Salter & Smythe, 1997) although lately concerns have been raised that across different languages it is likely not the same phenomenon (Ziegler & Goswami, 2005). This is especially true pertaining to the Chinese language which is non-alphabetic and described as a unique logographic writing system with different cognitive and linguistic characteristics from alphabetic languages. Although initially presumed to result from impaired phonological processing (Bradley & Bryant, 1983; Ziegler & Goswami, 2005), there is a growing body of research indicating that in Chinese, dyslexia could be due to multiple cognitive deficits (e.g. Chung & Ho, 2010; Chung, Ho, Chan, Tsang, & Lee, 2010). Chinese therefore provides a good basis for examining issues of linguistic universality and specificity in reading impairment.

In this Chapter, we will first describe features of the Chinese orthography that make it unique including how the various languages, scripts and instruction methods across different Chinese societies provide a backdrop for later highlighting of the cognitive profiles of Chinese dyslexia. We also review, briefly, the different cognitive profiles of dyslexic readers in various Chinese societies, and common support strategies for children identified to be at risk of reading failure before concluding with suggestions for future research.

Features of the Chinese orthography

To start with, we shall describe the characteristics of the Chinese writing system that generally make literacy acquisition a fairly complicated task for the learner. Highlighting these features is cardinal for the remainder of this chapter, in terms of providing a basis for issues such as intervention. Researchers have sometimes described Chinese as a morpho-syllabic writing system because each basic graphic unit of Chinese, a character, is linked with a morpheme (meaning unit) and represents a syllable of spoken Chinese (DeFrancis, 1989; Mattingly, 1984). A character is made up of strokes. A stroke refers to an unbroken line drawn in a single movement and is the smallest single component of a Chinese character. Chinese has eight basic strokes that are produced using different movements, such as, dot, horizontal vertical, slant, press down, hook, curve and raise (McBride, 2016). Strokes are combined to form stroke-patterns referred to as radicals which are then used to form whole characters. As Guo (1995) points out, a whole character can have a lot of detail sometimes consisting of as many as 32 individual strokes. Clearly the number of strokes needed to form a uniformly sized character is relatively high and this may result in obvious visual complexity. Furthermore, more than 80% of the characters are ideophonetic compounds constructed from a meaning component, referred to as the semantic radical, and a pronunciation component called the phonetic radical (Kang, 1993). Also, in some cases a character could have more than two radicals (Zhou, 1978). A typical example illustrating the functional role of radicals in a character would be in "晴" (sunny), where "日" (sun), shows the meaning of the character sunny and "青" (blueness) is the phonetic radical indicating the sound of the compound character (McBride, 2016). Shu and colleagues (2003) have further revealed that there are approximately 200 semantic radicals as well as 800 phonetic radicals. However, for the majority of Chinese characters, the phonetic radical does not provide reliable pronunciation cues, whereas semantic radicals are more reliable and are directly associated with meaning. This association between component radicals and the sound or the meaning of the whole character is neither entirely transparent nor completely reliable because of the variability of semantic and phonological regularity found in characters (Shu & Anderson, 1997; Shu, Anderson, & Wu, 2000). Such features of the radicals not only make Chinese unique but also make it a complex orthography with regards to literacy acquisition. While most alphabetic orthographies greatly depend on phonological awareness in promoting word reading across scripts (e.g. Adams, 1990), Chinese is clearly not a phonologically reliable orthography (e.g. Chung, Ho, Chan, Tsang, & Lee, 2010; Ho, Chan, Lee, Tsang, & Luan, 2004). In this regard, the association of phonological processing skills and word reading in Chinese has been inconsistent (e.g. Chow, McBride-Chang, & Burgess, 2005; McBride-Chang et al., 2011a).

Besides the functional irregularity highlighted above, Shu and Anderson (1997) further point out that the positional regularity of radicals that is at the core of a character's orthographic structure has an important role in its processing. Typically, radicals inhabit certain positions within a character. Most semantic radicals take up the left or top position within the left-right "喝" (drink) or top-bottom "菜" (vegetables) structure. While around 75% of these radicals are on the left side of a character (Feldman & Siok, 1997), there are exceptions to this rule. For example, the semantic radical "攵" is on the right position (such as "放" 'release' and "攻" 'attack'), while the semantic radical "皿" is at the bottom (such as "盆" 'basin' and "盒" 'box'). Such inconsistencies on the positional regularity of radicals led to some researchers pointing out that understanding the legal positions of semantic and phonetic radicals in a character can be complicated (Ho, Yau, & Au, 2003). Despite this complication with the Chinese script, precisely analyzing radical information for character recognition (McBride, 2016) in early literacy is cardinal. Accuracy in radical knowledge is crucial for early learners (e.g. Ho, Ng, & Ng, 2003; Tong & McBride-Chang, 2010) as sensitivity to radicals including orthographic structures is a unique step in the character learning process that influences reading acquisition and failure (Chung, Ho, Chan, Tsang, & Lee 2011).

In addition to this, considering each character is unique in terms of the number of strokes, radicals as well as its spatial configuration, those children with good character knowledge skills have to rely on their excellent memories to store the large numbers of characters in the lexicon. In this sense, speed of processing which here reflects the speed of accessing the lexicon has also been said to be important for Chinese literacy acquisition (Ho, & Lai, 1999).

Also noteworthy is that in Chinese, the majority of words are multisyllabic with about two-thirds being bisyllabic (Taylor & Taylor, 1995). Yuan and Huang (1998) indicate that over 75% of Chinese words are built or compounded from two or more morphemes or meaning units. The majority of words share the same morpheme such as "餐桌" (dining table), "電腦桌" (computer table), "木桌" (wooden table) with the morpheme "桌" (table) and thus are semantically related with the semantic radical providing some indication to its meaning. In fact, a relatively large number of syllables share the same sounds creating an extensive problem of homophony, as a large number of morphemes are represented by a limited number of syllables (Packard, 2000). For example, "氣" (air), "戲" (movie) and "棄" (give up) (Chung & Ho, 2010). In view of this, some researchers have suggested that oral knowledge of whole words as well as how morphemes fit together would both be more strongly associated with word reading in Chinese, because both contribute to children's capability to guess the identities of words in cases where not all individual characters are recognized (McBride, 2016). In any case, given the relatively large number of lexical compounding as well as homophonic morphemes, awareness of this morphological information may facilitate the reading process in Chinese. Research has increasingly shown that morphological awareness makes an important contribution to reading processes, especially reading problems (Chung et al., 2010; 2011; Shu, McBride-Chang, Wu, & Liu, 2006).

Another unique feature about Chinese is that unlike English, it has no inflectional system (e.g. tenses, prepositions, gender, subject-verbal agreements or plurals) and many word boundaries are unclear (Li & Thompson, 1981). In this case, to fulfill the various syntactic functions learners need primarily to depend on the morphosyntax. For example, to express plural form of nouns, singular nouns such as " 球" (ball), "椅子" (chair) and "鞋子" (shoe) may then be combined with quantifiers like "許多" (many), "一些" (some) and "很少" (a few) to indicate plurality. Likewise, to indicate different tenses, function verbs could be added after the main verb to show an action status. For example, "在" (function verb to denote a continuous action) can be used in combination with "飛" (fly), i.e. "在飛" (expressing the action of flying). In addition to this, the word order system in Chinese is rather loose compared to English. In as much as the canonical word order for Chinese sentences is mainly Subject-Verb-Object (SVO), in instances where the topic of a conversation happens to be the object of a sentence, Object-Subject-Verb (OSV) order is also accepted, for purposes of emphasizing the object. For example, the SVO sentence "我打破了花瓶" (I hit break PERF [perfective aspect] vase) can be converted to an OSV sentence "花瓶被我打破了" (Vase bèi I hit break PERF [perfective aspect]" by using the preposition 'bèi', and placing the object "花瓶" (vase) before the subject " 我" (I). Given the lack of inflections and word boundaries, Chinese readers have to monitor the semantic relations of character sequences in a sentence (Wong, Xiao, & Chung, 2013). Hence besides morphosyntax skills, mastering word order is another important aspect of syntax in Chinese. Mastering word order is key for comprehension because grammatical function of words in Chinese sentences is marked by their order rather than their inflection or declension as is the case for English (Chung, 2018). Therefore discourse skills in soliciting syntactic information from the given linguistic constituents and drawing inferences between sentences that together form a meaningful discourse are crucial to understanding Chinese texts.

The Chinese script and literacy instruction

In addition to the distinctive characteristics of Chinese orthography highlighted above, Chinese is spoken and taught differently across various Chinese societies. For example, Putonghua is used by over 70% of the population in Mainland China and is also the national language (Grimes, 2002). Putonghua is also spoken in Taiwan while Cantonese (a dialect of Chinese) is primarily spoken in the south part of Mainland China including Hong Kong. Another striking difference across Chinese societies has to do with the nature of script adopted by different societies. The issue of script type has far reaching effects on the literacy acquisition process as one script may be easier to read than the other and may even affect the process of learning to write considering a particular script could be more laborious and time consuming than the other.

There are two distinct scripts in Chinese, traditional, used in Hong Kong and Taiwan, as well as simplified, used in Mainland China. Simplified characters were adapted from traditional characters and because of this the two scripts have characters that share the same written form (Rohsenow, 2004). Approximately 50% of the most common 2000 characters are identical across scripts, the others differ substantially from one another (Rohsenow, 2001). Comparing the frequency of use of characters across scripts, the traditional script has approximately 4,500–4,900 commonly used characters (Cheung and Bauer, 2002; Liu, Chuang and Wang, 1975) while the simplified script has about 3,000 Chinese characters in daily use (Foreign Languages Press Beijing, 1989). This naturally indicates that the simplified script has much more reduced memory burden for early learners as it has fewer strokes implying children can be faster when writing the simplified characters. On the other hand, some researchers have indicated that this simplification could ignore or delete some visual information cardinal for character recognition (Wong, Xiao, & Chung, 2013). In any case, Chinese characters are generally so visually distinctive and comprise many different parts such that novice writers using the traditional script also have to remember and include 22.5% more strokes (Gao & Kao, 2002). This generally highlights the increased memory burden as well as the importance of visual skills for Chinese literacy acquisition. McBride (2016) further pointed out that for those learning the simplified script which lacks some visual cues, the importance of visual skills could be critical. Difficulty in visual processing has actually been strongly linked with dyslexia among Chinese readers (e.g. Ho, Chan, Lee, Tsang, & Luan, 2004).

Another interesting feature in Chinese societies has to do with the different approaches to early literacy learning that is driven by the presence of an auxiliary phonological coding system in some societies. Research indicates that the methods adopted for learning to read Chinese likely lead to possible effects on reading performance and cognitive abilities (Lee, Hung, & Tzeng, 2006). Both Mainland China and Taiwan use a phonological coding system which notates the sounds of Putonghua and simplified characters. Hanyu Pinyin used in The Mainland China employs Roman letters to represent traditional phonology and the simplified Chinese is leant together with their corresponding pinyin transcriptions (Chung & Ho, 2010; Wong et al., 2013). Thus teachers usually present a new character together with its appropriate Pinyin symbol as a cue to strengthen the association of pronunciation and orthography in the character. The Pinyin system uses consonants, vowels as well as tone to represent the sound of a simplified character (Wong et al., 2013). In Taiwan, children are also introduced to the Zhuyin Fuhao in the first two years of elementary school. The Zhuyin Fuhao comprises a set of three symbols with consistent symbol-sound (grapheme-phoneme) correspondence. On the other hand, Hong Kong does not have a phonological coding system and the traditional characters are taught as a whole unit using the look-and-say method, where teachers emphasize rapid retrieval of the names of Chinese characters (Ho, 2010; Zhang & McBride-Chang, 2011).

The methods of learning Chinese described above are thought to have possible effects on reading performance and cognitive abilities (Lee, Hung, & Tzeng, 2006). Evidence of the impact of the phonetic learning system has been documented in studies that have directly compared the reading performance and also reading-related abilities of children learning with and without a phonetic system. These studies (e.g. Chen et al., 2004) have particularly reported the importance of phonological awareness in literacy development of children that use the phonological coding system. For example, Hong Kong kindergarteners fell behind Mainland kindergarteners who had learned pinyin in both syllable deletion and onset deletion even though their word reading skills were better than those in Mainland China (McBride-Chang, Bialystok, Chong, & Li, 2004). Cheung and colleagues also investigated the phonological awareness of children in Hong Kong and Mainland China before and after learning pinyin and found a difference only in performance of the various phonological awareness tasks after pinyin instruction was introduced (2001). Children from Mainland China out-performed chronologically-age matched Hong Kong children in tasks such as onset awareness and sound matching. Longitudinal studies have also demonstrated the importance of children's early pinyin representation for Chinese reading acquisition, both theoretically and practically (for details see Lin et al., 2010). A study by Shu, Peng, and McBride-Chang (2008) also disclosed that onset phoneme awareness and tone awareness of 3 to 5-year-old kindergartners developed rapidly in the first grade after receiving pinyin instructions, but their syllable and rime awareness increased only gradually across this range of ages.

Cognitive profiles of Chinese dyslexia

Studies into the cognitive-profiles of dyslexia among Chinese individuals have identified several deficit areas, such as orthographic processing skills, rapid automatized naming, morphological and phonological awareness, including visual processing skills (e.g. Chung & Ho, 2010; Chung, Ho, Chan, Tsang, & Lee, 2010; Ho, Chan, Tsang, & Lee, 2002; Shu, McBride-Chan, Wu, & Liu, 2006; Wong, Xiao, & Chung, 2013; Yin & Weekes, 2003). For Chinese dyslexics, these deficit areas are key for the purposes of identification and early intervention. Below we review the cognitive deficits.

Orthographic awareness

As earlier alluded to, Chinese characters are generally visually complicated and require the learner to be aware of the conventional rules in not only structuring the characters but also identifying and/or distinguishing real characters from pseudocharacters (i.e. characters which may be legal yet do not exist orthographically), non-characters (i.e. characters with illegal composition) as well as visual symbols (McBride, 2016). In this regard, orthographic processing skill, defined as "the ability to form, store, and access orthographic representations" (Stanovich & West, 1989: 404), is considered an important factor for facilitating the reading development in Chinese children. In terms of orthography, Chinese characters are composed of strokes presented in a two-dimension space and orthographic processing skill has thus been understood and measured at two levels (Li, Dong, Zhu, Liu, & Wu, 2009; Li, Shu, McBride-Chang, Liu, & Peng, 2012), namely (1) knowledge and function of semantic and phonetic radicals, and (2) knowledge and legal positions of these radicals. Studies indicate that the role of orthographic skill at either of these two levels significantly predicted character reading performance in Chinese children (e.g., Tong et al., 2009; Yeung, Ho, Wong, Chan, Chung, & Lo, 2013). Research has further shown that orthographic deficits could be a prominent problem for Chinese dyslexic readers due to the unreliable grapheme-phoneme correspondence in Chinese characters (Chung & Ho, 2010; Chung et al., 2010; Ho, Chan, Lee, Tsang, & Luan, 2004; Lam & McBride-Chang, 2013; Wong, Xiao, & Chung, 2013).

Rapid Automatic Naming (RAN)

In addition to orthographic skills, rapid automatized naming has also been shown to be associated with reading in both alphabetic and non-alphabetic languages (e.g. Ho & Lai, 1999; Wimmer, Mayringer, & Landerl, 2000). RAN refers to "how quickly children can name continuously, presented and highly familiar visual stimuli" (Georgiou, Parrila, & Kirby, 2006: 199). According to Wolf and Katzir-Cohen (2001) this involves retrieving verbal representations from orthographic patterns in the mental lexicon and mapping arbitrary symbols to spoken language. Manis and colleagues further pointed out that a deficit in rapid naming could also reflect the difficulty of learning arbitrary associations (1999). Considering the mapping of orthography-to-phonology in Chinese is quite arbitrary, rapid automatized naming has been strongly associated with reading performance in Chinese (Ho, Chan, Tsang, & Lee, 2002; Ho & Lai, 1999; McBride-Chang, Lam, Lam, Doo, Wong, & Chow, 2008). Thus, RAN is another skill that has been associated with reading failure in Chinese and suggested as another core cognitive deficit in Chinese dyslexia (Chan et al., 2007). Studies by Ho and colleagues (Ho & Lai, 1999; Ho et al., 2002, 2004) have indicated that Chinese children with dyslexia named an array of stimuli (objects, colors, digits or letters) more slowly than did typically-achieving children.

Morphological awareness

Another skill considered important for reading success or failure in Chinese is morphological awareness (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005; Shu, McBride-Chang, Wu, & Liu, 2006). It refers to the ability to reflect upon and manipulate word formation rules in understanding and creating new complex words (Kuo & Anderson, 2006). Chinese morphological awareness has been understood and measured at two levels, morpheme and morphological structure. At the morpheme level, homophone awareness refers to the awareness that one syllable may correspond to different morphemes. This has demonstrated to be an important component of morphological awareness in Chinese, and could probably be due to the homophony prominence and word compounding issues in Chinese. As a result, studies (e.g. McBride-Chang et al., 2005) have proposed that morphological awareness could be of greater importance in learning to read Chinese than in alphabetic languages. Although the link between morphological awareness and Chinese children's reading development has been proved in various studies (e.g. Li et al., 2012), some researchers have also attempted to tap the underlying mechanisms, as the role of morphological awareness in learning Chinese characters is not so obvious (e.g., Liu & McBride-Chang, 2010). Currently, studies investigating such mechanisms are rather scant although Liu, Li, and Wong (2017) have proposed ways of understanding the association. They posit that the role of morphological awareness in Chinese character reading might be (1) mediated by some factors, such as orthographic awareness and vocabulary; and (2) moderated by morpheme family size. However, more studies are needed to further verify these assertions. In any case, research studies have shown that Chinese dyslexic readers have much poorer morphological awareness skills than typically developing readers (e.g. Chung et al., 2010; Shu et al., 2006).

Phonological awareness

Phonological awareness, the ability to reflect on, analyze and manipulate the sounds of a language has been shown to be predictive of reading ability in English (e.g. Torgesen & Mathes, 2000) but also in Chinese (e.g. McBride-Chang & Kail, 2002). As a morphosyllabic language, Chinese has a relatively simple phonological system. With very few exceptions it has a one-to-one-to-one correspondence between morpheme, syllable, and Chinese character (McBride, 2016). Since word reading in Chinese does not require processing of a complex phonological structure, this characteristic of the Chinese phonological system on the one hand makes it easier for children to grasp, while on the other hand this lessens its influence on Chinese children's literacy development, although its association with reading has been observed in some studies. Same as in alphabetic languages, phonological awareness could be measured at both syllable and phoneme level in Chinese. However, at the phoneme level Chinese focuses mainly on onset and rime, rather than the middle/inner phonemes, because inner phonemes do not commonly exist in the Chinese phonological system. This could partly be due to the lexical compounding nature of Chinese characters. In any case, the predictive effect of phonological awareness on Chinese children's word reading performance has been documented in several studies (e.g. Ho & Bryant, 1997; Siok & Fletcher, 2001). Huang and Hanley (1994, 1997) also found that in both longitudinal studies, the predictive effect of phonological awareness reduced remarkably when variables such as vocabulary and character reading were included in the model. This indicated that phonological awareness could not explain the difference in reading performance across different years.

The role of phonological awareness at the syllable level (i.e., syllable awareness) has recently been investigated in some longitudinal studies (e.g. Pan et al., 2011; Pan et al., 2016) as well as concurrent studies (Shu, Peng, & McBride-Chang, 2008) in Mainland China. Compared to phoneme onset and rime awareness, syllable awareness has been found to be more important in Chinese. Considering the one-to-one correspondence between character and syllable (but not phonemes) in Chinese, it is reasonable according to the psycholinguistic grain size theory (Ziegler & Goswami, 2005) to postulate the importance of syllable awareness for Chinese children's reading development.

Noteworthy is that the observed importance of phonological awareness has mainly been in young Chinese children (i.e., preschoolers or kindergartners) (e.g., Ho & Bryant, 1997; Shu et al., 2008; Pan et al., 2016), compared to primary school children (e.g., McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Pan et al., 2016). It is possible that the relatively simple phonological structure of Chinese makes it easy for young children to grasp, and thus the variance in phonological awareness may only be salient in a small time window. In any case, studies have demonstrated that Chinese dyslexic children also have lower phonological awareness skills when compared with typically developing children (Chan et al., 2007; Ho et al., 2002). Chinese dyslexics have demonstrated deficits in syllable awareness (e.g. Chow, McBride-Chang, & Burgess, 2005), onset and rime detection (Ho, Law, & Ng, 2000) and tend to use fewer phonetic cues in learning characters. However, the importance of phonological awareness across Chinese societies varies owing to the differences in instructional methods and the nature of script adopted for teaching early literacy skills, as will be discussed further in the next section.

Visual skills

Finally, considering the various features of the Chinese writing system highlighted earlier, visual processing skills, in particular visual perceptual and visual memory skills, have been proposed to be important for reading in Chinese. However, studies on this have yielded inconsistent findings (e.g., Ho, Chan, Tsang, & Lee, 2002; Luo, Chen, Deacon, Zhang, & Yin, 2013; McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005; Siok, Spinks, Jin, & Tan, 2009). The cause for the inconsistent findings has been attributed to issues of measurement, suggesting the Gardner sub-test of visual skills may not be ideal for testing Chinese children. This is supported by McBride-Chang and colleagues' findings that Chinese as well as Japanese children are better at the visual skill tasks compared to children who are alphabetic language speakers (2011a).

Another area of visual skills that has been investigated to ascertain its importance for reading or for identifying children with dyslexia in some alphabetic languages is visual spatial attention (e.g. Bosse & Valdois, 2009; Plaza & Cohen, 2007). According to Vecera and Rizzo (2003), visual spatial attention entails attending to the spatial location of visually presented objects. Studies among Hong Kong Chinese third graders suggest that visual spatial attention skills significantly predict Chinese literacy skills (Liu, Chen, & Chung, 2015; Liu, Chen, & Wang, 2016). However, the role of visual spatial attention in Chinese reading development as well as identifying reading failure needs further investigation.

Cognitive profiles of dyslexic readers among various Chinese societies

In spite of the above general outlook of the profile of Chinese dyslexic children, it is important to state here that the prevalence of the said deficits varies across regions. Considering the spoken language differences, type of Chinese script and the distinct instructional methods earlier alluded to between Mainland China and Hong Kong, Luan (2005) investigated the cognitive profiles of Chinese dyslexic children in the two regions. For dyslexic children in Mainland China (Beijing), the most prevalent deficit was morphological awareness (29.6%) followed by phonological awareness (27.6%) and rapid naming deficit (27.6%), whereas among the Hong Kong dyslexic children, the three main deficit areas were rapid naming (52%), morphological awareness (26.5%) and visual orthographic deficit (24%). It was further indicated that the most outstanding difference in the proportion of exhibited cognitive deficits between Beijing and Hong Kong dyslexic children lay in phonological awareness (27.6% vs. 12%) and rapid naming (27.6% vs. 52%). These findings could be due to the differences in the instruction methods employed when teaching early literacy skills, i.e. the look-and-say method for Hong Kong while Beijing emphasizes the grapheme-phoneme correspondence using the Pinyin system. Some researchers have further pointed out that the nature of phonological processing difficulties among Hong Kong dyslexics could be different from that predominant in alphabetic languages (for details see Wong, Kidd, Ho, & Au, 2010). In any case, it has also been observed that the difficulty in visual processing at the basic level is more pronounced among Hong Kong Chinese dyslexics who use the traditional script and have to master the large numbers of visually distinct characters to acquire reading skill. Furthermore, other studies have also reported a fairly high prevalence of orthographic and visual processing deficits among Hong Kong dyslexic children (Ho et al., 2004; Ho et al., 2002). In this regard, the nature of the script plays a key role in determining the instructional methods which ultimately produces varying cognitive profiles of dyslexia across the different Chinese societies.

Supporting children with reading difficulties

Recent intervention studies including case study research, qualitative research, descriptive studies and experiments involving quasi-experiments (e.g. Gersten & Baker, 2000; Ogawa & Malen, 1991) have suggested various approaches and instructions to assist and support children at risk of reading failure. Below we highlight some approaches and instructions that have been used for Chinese children with reading difficulties.

One of the reliable approaches to early identification and intervention for children with reading difficulties has been to use the Response to Intervention (RTI) model as it provides early support and intervention for children at risk of reading failure (Hughes & Dexter, 2011). RTI is an alternative to the IQ-discrepancy model for identifying children with reading difficulties and it also enhances provision of a school-wide strategy that guides instruction according to how the child responds to the intervention. In this regard, the RTI helps to avoid the “wait to fail” model where children are often not identified as eligible for intervention until Grades 3 or 4. For example, although Hong Kong has an estimated prevalence rate 9.7% dyslexic students in the schools, official testing for the presence of dyslexia does not begin until the children are around seven years old. This is in spite of many Hong Kong children beginning formal literacy instruction when they start kindergarten at age three (Chung & Ho, 2010). Nevertheless, the RTI is designed as a multi-tier prevention and intervention system that consists of three tiers linking different levels of intensity and individualization based on the need presented by the child. Under the 3-tier model, all children in Tier 1 are assessed and monitored according to their responses to the regular classroom instruction in reading. In Tier 2, the children (around 20% of the children in the classroom) who fail to respond to Tier 1 are expected to have extra small group reading instruction. However, for children (approximately 3–5% of children in the whole class) with persistent reading difficulties in Tier 2, Tier 3 helps to provide intensive and individualized intervention (Chung, 2018).

Reading interventions for English-speaking children under RTI have included five essential components of cognitive-linguistic skills identified by the National Reading Panel (2000): phonemic awareness, letter knowledge, fluency, vocabulary and comprehension. On the whole, the RTI approach has been demonstrated to be effective in reducing the number of children requiring special education. For example, the Heartland Early Literacy Project (HELP) found that the number of children who were placed in special education at the participating school decreased by 14% in kindergarten, 24% in the first grade, 25% in second grade, and by 19% in third grade (Tilly, 2003). In view of such a success rate, attempts have been made to use the RTI approach to meet the needs of Chinese children with reading difficulties. Recent studies focused on three levels of skills for reading interventions, that is: oral vocabulary and morphological skills (oral language skills), orthographic skills and word recognition strategies (word-level skills), reading fluency, syntactic skills, reading comprehension and writing strategies (text-level skills) (Ho et al., 2014; Ho et al., 2012). For efficient literacy acquisition in Chinese, this approach may be ideal as it enhances training in both word-level and text-level cognitive skills. Considering Chinese early learners at risk of reading failure exhibit a lot of difficulties in morphological as well as orthographic skills when compared to typically developing children (e.g. McBride-Chang et al., 2005; Wong et al., 2013), explicit training in these deficit areas helps alleviate the reading problems. For example, since Chinese has many homophones and homographs it becomes necessary that a learner finds a way of disambiguating a character by considering it in context. As McBride (2016) further clarifies, lexical compounding tasks (through extensive games and exercises on combining different morphemes to form different compound words) exploit children's sense of the way in which morphemes fit together, through awareness of morphosyllabic properties of Chinese characters. Thus, based on the position of the character and the child's sense of the language orally, they eventually know how to make educated guesses as to what the whole word could be. This also highlights the importance of a good sense of oral vocabulary in order to effectively combine morphemes. Instruction in oral language skills such as building oral vocabularies, may be specifically important for Hong Kong early learners whose spoken language, Cantonese, differs extensively from the traditional written Chinese both in vocabularies and syntax (Ho et al., 2012).

Research studies by Ho and colleagues (2012, 2014) reported that the Tier 1 support was effective in improving cognitive-linguistic and reading performance of the children, with positive effects sustained at the end of second grade. They found that children who were initially below the benchmark, that is, around 18–58% of those with reading difficulties in Tier 2 and 7% of those with dyslexia in Tier 3 remedial groups, achieved the benchmark of reading after receiving intervention for up to 2 years (Ho et al., 2014). The reading interventions were effective in word-level as well as text-level skills, and in some cases, reading comprehension. Besides gains in cognitive and literacy areas, the children also showed better skills and motivation in learning (Ho et al., 2014). These results have implications for individual differences and help to highlight the best practices in teaching and learning for children at risk of reading failure at Tier 1 as well as those that may require Tier 2 or 3. Based on their findings, Ho and colleagues proposed the following: (a) using vocabulary as a curriculum anchor across various academic disciplines, (b) using strategies to activate children's prior knowledge about a topic and engage them actively in learning target vocabulary and content and exposing these children to different sources of the content of the text, (c) employing graphic organizers to identify salient details and reduce distracting information, (d) directing children's attention toward the content of the text and building mental representations of the ideas presented through open-ended and meaning-based questions about the text that they have read, (e) using cooperative and peer-tutoring strategies to enhance engagement and articulation of the content and vocabulary knowledge in the text, and (f) applying multisensory approaches incorporating various visual, auditory, tactile and kinesthetic senses (2012, 2014). In addition to this, suggestions have also been made to ensure that an intervention curriculum for children at risk of reading failure builds foundational skills to mastery level and also strives to incorporate complex reading tasks (Chung & Ho, 2010). For such a curriculum, specific components would vary by grade level to reflect the developmental changes at various reading stages.

Evidence from reviews of literature (e.g. Ward-Lonergan and Duthie 2016) has further shown that explicit instruction provided in phonological awareness, sound-symbol correspondence, knowledge of morphology, syntax, semantics, fluency strategies, word meaning strategies, word learning strategies as well as reading comprehension strategies is effective in bringing about improvements in reading performance. Noteworthy however, is that explicit phonological awareness instruction among early learners would not really be beneficial for all Chinese children who may be at risk of reading failure. This is especially true for societies such as Hong Kong which do not have a phonological coding system (e.g. Pinyin or Zhuyin-Fuhao) to map Cantonese onto Chinese characters (e.g. McBride, 2016; Wong et al., 2013; Zhang & McBride-Chang, 2011). However, explicit instruction enhances the scaffolding children require to understand the content of the text and helps to deepen children's understanding of facets such as character writing as will be illustrated in alternate approaches and instructional methods below.

Given that the common deficit Chinese children with dyslexia present is poor orthographic knowledge (30.4% in Ho et al. [2004], 31.3% in Liu et al. [2006], and 33.3% in Wang & Yang [2015]), there has been a focus by researchers to zero in on the best strategies for orthographic knowledge instructions across the various Chinese societies to overcome this common obstacle in the schools (e.g. Ho et al., 2012) and also in the homes (e.g. Lam & McBride-Chang, 2013). Designs of the new instructional methods attempt to address the main weakness of regular instruction for Chinese character, which is teaching new characters by employing unsystematic approaches where many Chinese characters are introduced over a certain period of time (Wan, 1991).

Therefore, with the new instructional approaches, similar Chinese characters are grouped together when teaching and this involves explicit teaching of the functions of semantic radicals as well as the functions and regularity of Chinese characters. We shall describe the Chinese Stem-deriving instruction, which is the most popular among the new instructional methods. As earlier indicated, for the Chinese Stem-deriving instruction Chinese characters are taught in a group, sharing the same stem, and thus called the Stem-family instruction (Lu, 2000). For instance, the teaching design set to teach the stem "包" (/bao1/) and its extending characters with semantic radicals"手" (/shou3/, hand)," 火" (/huo3/, fire), and" 草" (/tsao3/, grass) are" 抱" (/bao4/), "炮"/bao1/ (/pao14), and" 苞"/bao1/ (/bao1/) are all taught in one teaching session. The shapes and sounds of both stem and extending characters are emphasized in the teaching by dictation, and the teachers also use pictures or other media to explain the meaning (Lu, 2000). Chinese stem-deriving instruction is generally regarded to be an effective instruction method and thought to improve the majority of Chinese dyslexic children's Chinese learning at least at character level (Chen et al., 2013; Lu, 2000; Zhang, Wang, Wen, Qin, & Zhong, 2006).

In addition to the above explicit instructional approaches, Chung (in press) has indicated that modulated instruction can also help to meet not only the precise needs of individual children but also offer the children extended opportunities to listen to, talk about, tell and also read stories. These various approaches and instructions may assist and support children with reading difficulties to develop their reading proficiency, an important component of reading comprehension.

Conclusion and future directions

This chapter briefly highlighted general features of the Chinese orthography and how such attributes illustrate the idiosyncrasy of the Chinese writing system. We described the general composition of a Chinese character, its constituents, as well as the high possibility of two or more characters being compounded when making whole words, aspects that are peculiar to yet key for understanding reading impairment and intervention in Chinese literacy acquisition. We also reviewed the existence of two distinct Chinese scripts in one of the most visually complex writing systems as particularly remarkable considering the demand it places on the learner.

Although the notion of reading disability in Chinese is a relatively new phenomenon (Ho et al., 2014), the chapter has reviewed universal and unique cognitive-linguistic precursors to reading acquisition and impairment in Chinese, particularly RAN, orthographic and morphological awareness as core skills. In addition to this, phonological awareness as well as visual skills such as visual spatial attention have been identified as features of Chinese dyslexia. In spite of the generally extensive research into the cognitive linguistic precursors of dyslexia in Chinese, very little research has gone into intervention studies to alleviate the identified reading failure among early learners. We have reviewed the RTI approach as an effective large-scale means of addressing the various deficits exhibited by Chinese dyslexics especially in Hong Kong. Also reviewed are other instructional approaches aimed at alleviating the common orthographic awareness problem experienced by Chinese dyslexics.

Last but not least, several issues and questions are worth addressing in future studies. Considering research on dyslexia is relatively new among Chinese societies, as earlier alluded to, many questions remain. Further research is needed to investigate the various types of cognitive linguistic precursors of dyslexia in Chinese. For example, as visual skills have rightly been identified to be key in Chinese literacy acquisition (e.g. Ho & Bryant, 1999; Huang & Hanley, 1997), different varieties of visual skills such as pure copying are worth exploring. Preliminary evidence indicates that pure copying in dyslexic children is impaired compared to typically developing children (Kalindi et al., 2015; McBride-Chang et al., 2011b). It may also be helpful to further compare the cognitive profiles of dyslexia to examine the effect of diglossia. Given the limited intervention studies obtaining among Asian societies, it would be beneficial to carry out more studies of this nature to help children not only in Hong Kong but also in Taiwan or Mainland China. While RTI has shown to be effective in Hong Kong, the extent to which the findings can be extended to other societies remains unclear. In addition to this, it would also be important to carry out studies to ascertain whether the effect of RTI intervention helps to prevent late-emerging reading difficulties common from middle to senior primary grades (Chung, 2018). Also, it would be commendable for researchers to take advantage of the people's generally high levels of familiarity/skills to information technology related devices in most Asian societies by designing computer-based intervention programs for implementation both in the homes and schools to cater more holistically for the needs of Chinese children with dyslexia.

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CHAPTER 6

Semantic processing and development in Chinese as a second language

Nan Jiang
University of Maryland, College Park

Languages differ in the semantic structures underlying their linguistic forms. Thus, the learning of a new language entails the development of a semantic system that is specific to the target language. This chapter reviews recent studies that examined three topics related to semantic processing and development among learners of Chinese as a second language (CSL). They are the factors that may affect the initial understanding of the meanings of unknown words, the acquisition of multiple meanings of polysemous words, and learning of new meanings and new semantic distinctions. The chapter concludes with some discussion of pedagogical implications of this line of research.

Keywords: Chinese as a second language, semantic development, semanticization, vocabulary acquisition

Every language has a unique semantic system underlying its linguistic form. Thus, languages differ in how meanings are structured and lexicalized. Some meanings may be lexicalized in one language but not in another. *Mooncake* and *jianghu* (a fictional society of kung fu warriors depicted in the movie *Crouching Tiger*) are examples of Chinese-specific meanings. Sometimes, a semantic distinction is made in one language but not in another. For example, a concrete-abstract semantic distinction is made for many words in Chinese but not in English. Hence, for the English word *support*, there are two Chinese words, *zhicheng* (支撑) and *zhichi* (支持), with the former expressing a concrete meaning (e.g., supporting a wall) and the latter conveying an abstract meaning (e.g., supporting a decision). Even when a word is borrowed from one language to another, it can go through semantic changes, resulting in only partial overlap in meaning. For example, the Chinese word *shafa* (沙发) is a direct borrowing from the English word *sofa*, but *shafa* can refer to an upholstered seat for one person while a sofa usually refers to such a seat for two or more people.

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Due to such differences, learning a second language (L2) necessitates the development of a new semantic system that is specific to the target language if learners are going to use L2 words accurately. However, adult L2 learners face two challenges in this endeavor. First, by the time they begin learning an L2, a semantic system has already been established that is closely associated with their first language (L1). This existing system is likely to influence the learning of the new system. Where the two systems differ, semantic development means the restructuring of the existing semantic system which may be harder than the creation of a new one. Second, adult L2 learners often do not have access to sufficient optimal input and interaction that are necessary for semantic restructuring to take place. These two challenges set semantic development in L2 apart from semantic development in L1. While lexical development is typically accompanied by substantial concurrent semantic development in child L1 learning, there may be only limited semantic development in L2 learning. As a result, L2 lexical forms may often be mapped to L1 meanings, as envisioned in models of L2 vocabulary acquisition (e.g., Hall, 2002; Jiang, 2000) and documented in empirical studies (e.g., Giacobbe, 1992; Jiang, 2002).

This raises many questions about semantic development in adult L2 learning. For example, how successful can adult learners be in overcoming their L1 influence and developing nativelike semantic structures in an L2? What factors may affect this success? What semantic processing strategies are L2 learners likely to adopt in learning new words? How does L2 proficiency affect the adoption of such strategies?

These are all legitimate issues to be explored in second language acquisition (SLA) research. There has been, indeed, increasing research on these issues in the past 20 years, both in SLA in general and in the study of the acquisition of Chinese as a second language (CSL) in particular. In this selective review of the latter, research on the following topics are considered: the factors affecting successful semanticization, the acquisition of multiple meanings of polysemous words, and learning new meanings and new semantic distinctions.

Factors affecting successful semanticization

I suggested that for a majority of L2 words, semantic development might occur in two stages: the comprehension stage and the development stage (Jiang, 2004a). The comprehension stage involves the initial familiarization with the meaning of a new word, or semanticization. It can be achieved in multiple ways. In classroom settings, the meaning of a new word can be conveyed directly and explicitly by means of a translation equivalent, a visual aid, a gesture, or a definition. However, under many circumstances, for example, in extensive reading, learners often face the task of understanding the meaning of a new word on their own, (e.g., by means of guessing). Some studies examined factors affecting a learner's success in correctly guessing the meaning of an unknown Chinese word. Several factors were found to affect the outcome.

One of them is semantic transparency. The Chinese language is unique in that most words are compound words consisting of two or more characters (or morphemes). The percentage of such compounds in Chinese is over 70%, according to Feng (2003). Furthermore, each component character or morpheme has its own meaning. Semantic transparency refers to the extent to which the meaning of a compound can be derived from the meaning of its component characters. Chinese words differ in the degree of semantic transparency. Some words are highly transparent such as *huayuan* (花园, garden, *hua* = flower, *yuan* = garden) and *haibian* (海边, beach: *hai* = sea, *bian* = side). A learner who knows the meanings of the component characters will also know the meanings of such words. Others are completely opaque, such as *dongxi* (东西, thing: *dong* = east, *xi* = west) and *xiaoxing* (小心, careful: *xiao* = small, *xing* = heart). Many words lie somewhere between the two ends of the semantic transparency continuum.

Several studies showed that learners were more successful in guessing the meaning of a more transparent word than that of a less transparent one. In one such study, Gan (2008) constructed Chinese sentences that contained compounds unknown to the participants. Each sentence was followed by four Chinese words. The participants were asked to read the sentences, guess the meanings of the unknown words, and indicate their guess by identifying the word with a similar meaning among the four candidates. A total of 90 CSL students were tested (Experiment 1). The target words were 12 transparent and 12 opaque compounds. The participants were found to be more successful in guessing the meanings of the transparent words (mean score 10.3) than opaque words (mean score 5.6). In a study reported by Zhang (2010), a similar finding was obtained. Zhang made a five-way distinction of compound words in terms of semantic transparency following Fu (1985). Two criteria were adopted in the distinction: whether the meaning of a compound can be (a) directly and (b) completely derived from its component morphemes. Thus, Type 1 compounds were those whose meaning is directly and completely derivable from the two components, e.g., *pingfen* (平分, evenly divide: *ping* = even, *fen* = divide). The meaning of a Type 2 word is directly but only partially related to those of both components, e.g., *pingnian* (平年, non-leap year: *ping* = even, *nian* = year). The meaning of a compound may be indirectly related to both components in Type 3 (*tiechuang*, 铁窗, prison: *tie* = iron, *chuang* = window), directly related to one of the two components in Type 4 (*chuanzhi*, 船只, *boat*: *chuan* = boat, *zhi* = particle), or completely unrelated to the meanings of the components in Type 5 (*dongxi*, 东西, thing). Forty intermediate CSL students were tested on four words in each category that were matched on lexical properties other than semantic transparency. These words were given to the participants who were asked to guess their meanings. The mean accuracy scores (maximum: 5) for the five types of words were 3.66, 1.54, 0.56 1.65, and 0.78, respectively. It was clear that it was easiest to guess the meaning of an unknown compound when the component characters directly contribute to their meaning (Type 1), even if it was a single character (Type 4). The role of semantic transparency has been documented in several other studies (e.g., Hong et al., 2017; Zhang & Zeng, 2010).

Context also plays a role in successful semanticization. In another experiment, Gan (2008) asked the participants to read sentences that provided strong, weak, or no context for the guessing of the meaning of unknown words and found that the availability of context had a significant effect on the participants' performance. The same issue was explored by the same author in another study (Gan, 2011) where the participants were asked to read short passages that contained unknown words. The position of the context related to the target words was manipulated such that it came before a target word, after a target word, or both before and after a target word. The passages contained 34 unknown words including 12 with preceding context, 17 with following context, and 5 with context both prior to and following the target words. The participants were asked to read the passages, identify the words unknown to them, complete reading comprehension questions, and then explain (a) the meaning of the unknown words and (b) on what basis they guessed the meaning. The explanation was evaluated in terms of accuracy. The results showed declining accuracy from double contexts to the preceding context to the following context. In another experimental study reported by Jiang and Fang (2012), target words were presented in three conditions: in isolation, in a sentence context but without the target word shown, and in a sentence context with the target word shown. The participants were asked to guess the meanings of the unknown target words. Their accuracy scores showed a similar advantage of the context. The mean scores for the three conditions were 0.96, 1.46, and 2.15, respectively among the L2 learners.

An interesting finding in this context is the interaction between context and semantic transparency. In both Zhang and Zeng (2010) and Hong et al. (2017), for example, they manipulated semantic transparency and context strength. They found that semantic transparency played a role only when the context was weak for indicating the meaning of unknown words. There was no difference between more and less transparent words when the context provided a strong cue for word meaning.

The facilitative role of context could also be seen in studies that examined incidental vocabulary acquisition among CSL learners, where acquisition was measured in terms of correct guessing of the meaning of unknown words. In these studies, the participants were asked to read a passage for comprehension; no explicit teaching of vocabulary was provided. The participants were tested prior to and following the reading activity to determine if there was any gain in vocabulary knowledge as a result of reading. One of the earliest such studies was reported by Qian (2003). She asked a group of 28 Japanese CSL speakers to read a passage for comprehension. Twenty words unknown to the participants were selected as target words. Ten appeared in the passage (Set A) and the other ten did not (Set B). A pretest and two posttests were administered in which the participants were asked to provide the meaning for each word, guessing if necessary. There was an interval of four weeks between the two posttests. The participants' performance was evaluated in terms of accuracy, with 0 for incorrect meaning, 1 for partially correct meaning, and 2 for accurate meaning. The pretest confirmed the unknown nature of these words, as both sets received the score of zero. The first posttest showed a mean score of 0.1929 and 0.0143 for words in Set A and Set B, respectively, which showed measurable learning for those words that appeared in the passage, but the gain for the other words was minimal. The second posttest showed that the knowledge gained through reading declined but was still measurable, but no measurable knowledge was found for words in Set B. These results suggested that CSL learners can develop certain vocabulary knowledge by simply being exposed to words in context, and at least some of this knowledge may be retained for an extended period of time. The findings were replicated by Zhu and Cui (2005) who tested 19 CSL learners with the same test materials and a similar procedure. The results showed a considerable gain between a pretest and a posttest.

Finally, the semantic relationship between the two component characters of a compound was also found to affect success in semanticization, as shown in Yang (2014). Instead of using existing Chinese words, Yang took an innovative approach, following Clark, Gelman, and Lane (1985), by replacing a morpheme in an existing Chinese noun-noun compound with another morpheme to form a new Chinese compound, e.g., turning *maoyi* (毛衣, sweater: *mao* = wool, *yi* = clothes) into *maomao* (毛帽, wool hat: *mao* = hat). This approach offered three advantages for the purpose of the study. First, all words created this way were new to participants. Thus, there was no concern about whether some words were familiar to some participants. Second, because the words were unfamiliar even for native speakers, it became possible to compare native and non-native speakers in how such words were to be understood. Third, by using different new morphemes to replace morphemes in existing words, new words of different semantic relations could be created specifically for examining the role of semantic relation on new word understanding. Related to the last point, three types of new compounds were created, as illustrated in Table 1.

Fifty-seven CSL learners of three proficiency levels (21 low, 24 intermediate, and 12 high) and 25 native speakers of Chinese were tested on 45 new compounds including 15 in each semantic relation. They were asked to write down the meaning of each compound in Chinese or English. A predetermined meaning (see the third column in Table 1 for examples) was used as a criterion for judging the participants'

Table 1. Examples of three types of new compounds differing in semantic relation

Existing compound	New compound	Meaning	Semantic relation
maoyi, 毛衣 (wool sweater)	*maomao* 毛帽	Hat made of fur	*made of*
yusan, 雨伞 (umbrella)	*xuesan* 雪伞	Umbrella for snow	*for*
bingtang 冰糖 (crystal sugar)	*qiutang* 球糖	Ball-shaped candy	*property*

performance. The results showed that native and non-native speakers differed in their accuracy across the three conditions of semantic relations. Native speakers showed the highest accuracy rate on the *made-of* compounds (95%). The *property* compounds produced the lowest results (77%). CSL learners did the best on the *for* compounds (78%), followed by the *made-of* compounds (65%). The *Property* compounds were the least accurate (37%). The mean accuracy rates were 66%, 57%, and 57% for the high-, intermediate-, and low-proficiency groups, respectively. The author attributed the better performance on the *for* compounds by CSL learners to the frequency of such compounds in learner input. She found that *for* compounds accounted for 11.1% of all words in the vocabulary list of the Chinese Proficiency Test (HSK), while *made-of* compounds accounted for only 4.8%.

The findings that semantic transparency and context affected the success in guessing a word's meaning are not surprising. They can serve as the basis for further research into the relationship between semantic transparency and context on the one hand and vocabulary acquisition and teaching on the other. For example, attempts may be made to (a) classify high-frequency disyllabic words into several categories based on their semantic transparency, (b) empirically evaluate the validity of such a classification, and (c) make use of such empirically tested classifications in material development and classroom teaching. One may also explore the relationship between semantic transparency and context and discover what type of context is particularly effective for words of the different degree of semantic transparency. A further topic that can be pursued is what types of errors learners make when they fail to guess a word's meaning correctly and what leads to their incorrect guessing.

The acquisition of multiple meanings of polysemous words

Polysemy, the presence of multiple related meanings in a single word form, is common in human language. The Oxford English Dictionary lists more than 150 meanings for the verb *set*, and its explanation extends to 19 pages, according to O'Grady et al. (2010). The Contemporary Chinese Dictionary (Chinese-English Edition, Foreign Language Teaching and Research Press 2002) lists 25 meanings for the Chinese verb *da* (打), not counting the seven pages of multimorphemic words beginning with the morpheme.

This phenomenon has attracted the attention of some scholars who examined the acquisition of multiple senses of such polysemous words. Among them, Li (2002) attempted to explore the acquisition order of the different senses of two high-frequency polysemous words, *zai* (再) and *you* (又), both of which may be translated into *again* in English. Eighty-eight English-speaking CSL learners of three different proficiency levels served as participants. Five different meanings were differentiated for each word. They were *repetition, continuation, condition, degree*, and *supplement* for *zai*, and *repetition, coordination, change, mood*, and *supplement* for *you*. Further distinctions were made between the use of these senses in different syntactic structures. Two tasks were used to assess the participants' acquisition of these different meanings: a sentence-based fill-in-the-blank task and a cloze test. For the first task, 30 sentences were constructed for each word on the basis of their different meanings. Passages of approximately 200 characters served as materials for the second task. The participants' performance was analyzed in terms of the accuracy in the use of these two words in their different senses. By combining the data from both tasks, an accuracy order was obtained for each word. For the word *zai* (not considering structural differences), they were in the order of *condition* (100%), *supplement* (93.4%), *repetition* (87.7%), *continuation* (77.7%), and *degree* (76.9%). For *you*, they were *coordination* (99.0%), *change* (91.6%), *repetition* (90.7%), and *supplement* (84.4%) (no information was available for *mood*). Little explanation was provided regarding the cause of such developmental sequences, however.

Zhang, Meng, and Liu (2011) reported a case study of another Chinese polysemous verb *da* (打, hit), which has multiple meanings of both literal and figurative senses. The semantic development was assessed in two ways: a pen-and-paper test and a corpus-based analysis. In the former, a total of 61 CSL learners of three different proficiencies were asked to read sentences and select the word 打in its appropriate meaning. Twenty-eight sentences involving 14 different meanings of *da* served as critical stimuli. The participants' performance was analyzed in terms of the accuracy for each of the 14 meanings. A clear difference was found in accuracy across different meanings, with the mean accuracy score ranging from 89% for the meaning of *play* to 7% for the meaning of *compute* (calculated on the assumption that there were two sentences for each meaning, thus a total of 122 points out of the 61 participants). Between these two ends, the top three senses were *open* and *begin* (84%), *hit* (78%), and *buy* (60%) and the bottom three senses were *employ a certain method* (16%), *knit* (19%), and *react with the body part* (29%). There was a clear relationship between the learners' proficiency and their performance, with the mean accuracy scores being 10.8, 13.1, and 17.4 for the low-, intermediate-, and high-proficiency groups, respectively. In the corpus analysis component of the study 10,740 essays written by CSL speakers, totaling approximately four million words, served as the L2 output source. Three hundred thirty-six instances of the word *da* used as a verb were identified. Among the most frequently intended meanings were *hit*, *play*, and *give out*, which together accounted for 79% of all uses. Meanings such as *knit* and *buy* were never intended in the corpus. The authors indicated that the frequency and accuracy in the use of the verb *da* in its different meanings were influenced by two factors: how often a meaning is intended in language use (i.e., in the input available to a learner), and the extent to which a meaning is related to the basic "hit" meaning of the verb.

The acquisition of multiple meanings of polysemous words has only received limited attention. This research showed that frequency and the relation to the core meaning of a word played a role in the process. It is likely that other factors might also be involved. For example, how various meanings are related to the meanings of L1 translations can be one. It is conceivable that a meaning that overlaps with the core meaning of a primary L1 translation may be learned early or with relative ease with while a meaning that is distant from the core meaning is learned with less ease.

Learning new meanings and new semantic distinctions

Due to differences in semantic structures across languages, L2 leaners often face the task of learning new meanings or new semantic distinctions that are not present in their L1. The three examples in the introductory paragraph, the meaning of *mooncake* and *jianghu*, the concrete/abstract distinction of words such as *zhicheng* and *zhichi*, and the difference between *shafa* and *sofa*, represent the new Chinese meanings and distinctions for English-speaking learners. Quite a number of studies have examined whether and to what extend adult CSL learners are able to successfully develop such new meanings or distinctions.

One such study was reported by Hong (2012) who examined the distinction of semantically related words by CSL learners of three different proficiencies and compared semantic development with syntactic development. Two tasks were used. The first was to judge whether the use of an underlined word in a sentence was appropriate. The second was to identify a word from three candidates that was the best for a sentence. In both tasks, the critical manipulation was the inaccuracy involved, which could be semantic or syntactic in nature, as shown in (1) and (2) respectively. In the first pair, the two underlined words, *zhunshi* and *jishi*, share the same in part of speech, but differ in meaning, one being more similar to *on time* and the other to *in time*. The first is more appropriate than the second in this particular sentence context. The two underlined words in the second pair, *gaibian* and *bianhua*, are quite similar in meaning (both meaning *change*), but they differ in argument structure. The first is a transitive verb and thus fits with the sentence better than the second which is intransitive.

(1a) 他每天早上8 点上学,非常<u>准时</u>。
(He goes to school at eight every morning, and is very <u>punctual</u>)

(1b) 他每天早上8 点上学,非常<u>及时</u>。
(He goes to school at eight every morning, and is very <u>in time</u>)

(2a) 我不想<u>改变</u>自己原来的想法。
(I don't want to <u>change</u> my original idea.)

(2b) 我不想<u>变化</u>自己原来的想法。
(I don't want to <u>change</u> my original idea.)

One hundred twenty CSL students participated in the Hong (2012) study. The results from both tasks were similar: the participants did better with sentences with syntactic inaccuracies than those with semantic inaccuracies. For example, the mean accuracy scores for the syntactic and semantic errors were 28.7 and 25.3, respectively, in the first task. Additionally, there was a tendency for the difference to become smaller as the learners' L2 proficiency increased. This was most apparent in the results obtained from the second task, where the beginning learners showed a syntactic advantage over semantic inaccuracies, but the difference disappeared among the intermediate and advanced learners. Hong (2012) attributed the difference to the degree of salience associated with syntactic and semantic errors. Syntactic inaccuracies often appeared more salient to the learners and thus were easier to eradicate, while semantic differences were often subtler and less systematic, and thus more difficult to notice.[1]

Hong and Chen (2013) also explored whether CSL learners could develop fine-tuned semantic details for words that were near-synonyms such as *rongyi-jiandan* (容易-简单, easy-simple), *difang-didian* (地方-地点, place-location). Even though two different English translations may be available for these pairs of words, as shown in these examples, they are by no means in a one-to-one mapping relation. Thus, such semantic distinctions can be both subtle and new to English speakers. The test items consisted of sentences accompanied with three choices, two of which being the pair of related words, and the third being "both are good." The sentences were constructed such that a correct answer could be identified only when the participants knew the subtle semantic differences between the words concerned, as shown below:

(3) 这个句子虽然很长,但结构很________。
(Though this sentence is long, its structure is ______.)
a. 容易
b. 简单
c. 两个都可以

1. It should be noted that the semantic distinction between 准时and 及时 is not the best one to illustrate what is unique to Chinese, as a similar distinction exists in English between "on time" and "in time." A complete list of the target words was provided in the paper.

(4) 春天天气变化大，很_______感冒。
(The weather changes fast in spring, so it is _____ to catch cold.)
a. 容易
b. 简单
c. 两个都可以

Seventy-one participants of three proficiency levels were tested. The three proficiency groups had learned Chinese for half to one year, one year to two years, and more than two years by the time of testing, respectively. Their task was to pick the right answer for each sentence. The results showed a steady increase in accuracy across the three proficiency groups, the accuracy rates being 46%, 64%, and 81%, respectively. Information from posttest interviews suggested that many learners associated these words with their L1 translations and had the tendency to consider them identical in meaning, which was consistent with the findings reported by Jiang (2002, 2004b) involving learners of English as a second language.

Hong and Zhao (2014) compared three different types of semantically related word pairs in their degree of difficulty. They were distinguished in terms of the degree of semantic overlap (similar or synonym) and exchangeability. Thus, Type A pairs were semantically similar words that cannot be used interchangeably (e.g., *jishi-zhunshi*, 及时—准时, in time, on time, respectively), Type B pairs included synonyms that can be sometimes used interchangeably (e.g., *nuzi-nuren*, 女子—女人, woman), and Type C pairs involved semantically similar words that can be sometimes used interchangeably (, e.g., *anquan-pingan*, 安全—平安, safe). Thirty such word pairs, all known to the participants, were used as critical stimuli, along with 26 pairs of other words as fillers. The 56 pairs were divided into five sets of 10–12 pairs to be used in five experimental sessions. For data collection, the differences between these words were first explained to the participants. A week later, the participants were given 10–12 pairs of words, each accompanied by 3–4 sentences each with a blank. Their task was to fill in the blanks with these words. Their accuracy rates were computed for each type of word and used as an indication of their difficulty. The participants were 28 intermediate and advanced CSL learners, including 14 in each proficiency group. It was found that Type A produced the highest accuracy rates (83.6%), followed by Type C (74.1%), and then Type B (70.4%). The advanced learners also produced a higher mean accuracy rate (81.1%) than intermediate learners (70.3%). The results suggested that whether or not two semantically related words can be used interchangeably plays a role in their acquisition. The fact that two words appeared in their distinctive contexts might help differentiate two otherwise very similar words, as the authors alluded to.

Shen and Xu (2015) reported a study of semantic development by English-speaking CSL learners. The materials included two sets of Chinese words known to participants. The first set included 10 Chinese words that were not usually translated into English in the same part of speech: *kexi, gaibian, huiyi, yingxiang, zunjing, baogao, xuyao, buchong, jujue, lanyong* (可惜，改变，回忆，影响，尊敬，报告，需要，补充，拒绝，滥用). The second set included 10 Chinese words that were usually translated into English in the same part of speech: *renshi, yinqi, tiaozheng, shuoming, shiying, chongman, jianli, yikai, zhuiqiu, baoyuan* (认识，引起，调整，说明，适应，充满，建立，移开，追求，抱怨).[2] The participants were asked to perform three tasks: translation, identification of a sentence out of four candidates that a target word could fit the best and provision of justification for their selection (for the second set only), and completion of a word learning survey that consisted of five items. The following example illustrates a test item for the first two tasks:

(5) 可惜 English translation: ____________________
Circle the sentence(s) in which the word fits best.
a. 他这么年轻就死了，真是太 ________ 了。
(He dies at this young age. it is too ________.)
b. 我们不应该 ________ 那些坏人。
(We should not _______ those bad people.)
c. 小王失去了工作，没有收入，但是他要养活一家人，所以我很 ________ 他。
(Xiaowang lost his job, thus his income, but he has to support his family, so wo _______ him very much.)
d. 老徐对这个五岁的小女孩充满了 ________ ，因为她没有父母亲。
(Laoxu felt very ________ toward this five-year-old girl, because she has no father.)

Even though it was not explicitly stated in the report, it is clear from the test materials that the study was designed around some semantic distinctions, e.g., *kexi* (可惜) and *kelian* (可怜) in this example. Fifteen third-year university CSL learners and 15 NS of Chinese served as participants. The level of lexical and semantic development among the CSL learners was assessed by comparing their performance with that of NSs. The results showed a significant difference between CSL learners and NSs. The mean accuracy rate for the NSs was 94%. Except for one item, their mean accuracy for all items was 86% or higher. The mean accuracy rate for the CSL learners was 49%, with the accuracy scores for individual words ranging from 13% to 80%. There were indications that CSL learners continued to rely on their L1 lexical and semantic knowledge in completing the task. For example, the CSL

2. Note that the distinction does not seem to be straightforward as words in the first set can also be translated into English words of the same part of speech, e.g., *gaibian* 改变, and the word in the second set can also be translated into English words of a different part of speech, e.g., *tiaozheng* 调整, due to the fact that many of these Chinese words can be used in different parts of speech.

learners translated the word *zhuiqiu* (追求) into "pursue" and incorrectly chose the sentence that would fit the English translation (*pursue a job*) but not the Chinese word (i.e., 追求工作). Information obtained from their explanations and surveys also confirmed L1 mediation in the task. Many learners revealed the use or the preference for the use of their L1 in performing the task and in vocabulary learning in general. Based on the results, Shen and Xu (2015) reached the conclusions that (a) the development of productive vocabulary was a long and slow process and (b) even advanced CSL learners continued to rely on their L1 meanings, which echoed the findings and conclusions by Jiang (2000, 2002, 2004b) and Zhang (2011).

Finally, Saji and Imai (2013) reported an innovative study of the development of fine semantic distinctions among various Chinese verbs for the meaning of "hold" among both NSs and NNSs of Chinese. There are more than a dozen verbs in Chinese that express the meaning of "hold", depending on the body part involved in holding an object and the position of the object in relation to the body. For example, *na* (拿) is to hold something with one hand, *tuo* (托) is to hold something in one's palm, *ding* (顶) is to hold something on one's head, and *kang* (扛) is to hold or carry something on the shoulder. In contract, Japanese and Korean have fewer such verbs. They both have a general term for the action, *motsu* in Japanese and *teulda* in Korean, plus a smaller set of more specific verbs. To explore how CSL learners could develop semantic distinctions embodied in these Chinese verbs, Saji and Imai (2013) picked thirteen such verbs, and created 26 video clips, two for each verb. Twenty Japanese and 30 Korea CSL learners participated in the study. They were all learning Chinese in China at the time of testing and had a mean length of study of 20 and 39 months for the two groups, respectively. Thus, they could be best characterized as advanced CSL learners. They were asked to view the video clips and then write down the most appropriate Chinese verb for each video, either in character or pinyin. Their performance was compared to that of Chinese speaking three-, five-, and seven-year-old children and adults on the one hand and to that of native speakers of Japanese and Korean who completed the task in their respective language. The first comparison was intended to assess how adult L2 learners compared to L1-speaking children and adults in semantic development, and the second comparison provided a basis for determining how their performance was influenced by their L1. Several findings emerged from the study. First, there was a great deal of similarity between L1 children and L2 adults. Both groups used only a subset of the 13 verbs. The mean number of verbs used by the Japanese and Korean CSL groups was 7.1 and 7.7, compared to 8.5 for seven-year-old L1 children and 11.2 for L1 adults. Both groups used the verb *na* (拿) as a general term to refer to multiple specific actions of *holding/carrying*. For example, the seven-year old group used *na* to refer to five different actions, Japanese CSL seven actions, and Korean CSL nine actions. In comparing CSL learners' performance to that shown by native speakers of Japanese and Korean, there was a clear pattern of L1 influence. Where a native Japanese speaker used the general Japanese word *motsu* to refer to an action in the Japanese task, Japanese CSL learners always used the general verb *na* in the Chinese task. A similar trend was also found in the Korean CSL learners' performance. For all the eight situations where Korean native speakers used the Korean verb *teulda* in the Korean version of the test, Korean CSL speakers used *na*. A closer comparison of the two groups CSL learners' performance revealed a further sign of L1 influence. For example, Japanese has a specific verb for holding something on one's shoulder, *katsugu*, which is similar to the Chinese verb *kang*, but in Korean, the verb *teulda* is a more general word covering the meaning of *kang*. As reflecting this L1 difference and its influence on L2 learning, Japanese CSL learners were found to be able to use the specific Chinese verb *kang*, but more Korean CSL learners used the general term *na*.

Conclusion

Semantic restructuring is a topic related to more general L2 acquisition issues such as language transfer and the impact of maturational constrained on adult L2 learning. It is also a prerequisite for accurate use of a target language. Thus, semantic development is a topic of both theoretical and practical significance. I suggested that for a majority of L2 words, semantic development might occur in two stages: the comprehension stage and the development stage (Jiang, 2004a). In the comprehension stage, an L2 word is likely to be understood in the existing L1 semantic system, the most likely scenario of the mapping of an L2 word to the meaning of its L1 translation. This leads to an L1 influence that is well documented in both experimental settings and in lexical errors produced by L2 speakers in classroom settings (e.g., Ecke, 2015; Ellis, 1997; Giacobbe, 1992; Ijaz, 1986; Jiang, 2002, 2004b; Ringbom, 1983). The development stage is when semantic restructuring occurs which leads to the development of L2-specific meanings. However, successful restructuring faces two obstacles: (1) the established association between L2 word form and L1 meaning and (2) the lack of optimal input to trigger the restructuring process. Related to the first obstacle, even though L1 and L2 meanings are different, the similarity can be enough to allow a learner to use new L2 words without much trouble. For example, an English-speaking CSL learner can use the Chinese word *shafa* in its English meaning for *sofa* without creating any communication problem. This takes away the motivation and need for the development of new meanings. Furthermore, L2 learners often do not have access to input that is clear or powerful enough to indicate how the meanings of two L2 words differ, or how the meaning of an L2 word differs from that of its L1 translation. For example, the two Chinese words, *dong* (洞) and *kong* (孔), are related in meaning and they can be both translated into English as *hole*. However, they cannot be used interchangeably under many circumstances, which means they are not identical in meaning. It is difficult to imagine that a great deal of input is available that can clearly indicate how they differ. To make things worse, it is very difficult to articulate their semantic differences. Where no sufficient input is available to trigger semantic restructuring, the initial mapping of L2 form and L1 meaning becomes further consolidated with every additional exposure to the word. This may lead to semantic fossilization.

We are just beginning to explore whether or to what extent adult L2 learners are able to develop nativelike semantic structures while learning a new language, though. The research reviewed above shows that many factors such as semantic transparency, contexts, and the semantic relationship between the two component characters of a compound word, may affect successful semanticization, and that there can be a great deal of variation in the success in the acquisition of multiple meanings of a polysemous word. More importantly, this research confirms that semantic development can be a long and slow process. Even advanced CSL learners may continue to rely on their L1 semantic structures while using their L2 Chinese.

Several strategies can be taken on the part of instructors and material developers to help combat semantic fossilization. Some explicit explanation will help learners see a semantic distinction made in L2 but not in L1. A good example is the concrete/abstract distinction made in Chinese but not in English. In addition to *zhicheng* (支撑) and *zhichi* (支持) mentioned earlier, this distinction is also made in *sunhuai* (损坏) and *sunhai* (损害), both meaning *damage* in English, *zuowei* (座位) and *xiwei* (席位), both meaning *seat* (in a room vs. on a committee), for example. Such differences can be explained in a few minutes, but may take a considerable amount time and input for learners to discover on their own. Carefully selected input or instructional materials developed to specifically target an L2-specific semantic distinction can also help trigger semantic restructuring. For example, where explicit explanation of the differences between *dong* and *kong* may be difficult and where natural input may not provide a cue to indicate such differences, an instructor can identify, write, and use sentences where the two words cannot be used interchangeably as instructional materials to help learners discover the semantic differences on their own. An intensive exposure to such materials will help accelerate the process of semantic restructuring. Finally, where the basic meaning of a Chinese word is similar to its translation in the learners' L1, there is no need to avoid using L1 translations. Initial semanticization can be quickly achieved with L1 translations so that more time is available for helping learners discover semantic nuances between Chinese words and their L1 translations through specifically developed instructional materials.

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CHAPTER 7

Brain mechanisms of Chinese word reading

Fan Cao
Sun Yat-Sen University, Guangzhou, China & The Chinese University of Hong Kong, Shenzhen, China

Research on Chinese reading provides important insights into the understanding of language-universal and script-specific mechanisms of reading, because Chinese is contrastively different from alphabetic languages. In this chapter, I will first summarize neuroimaging findings of Chinese word reading in adults in comparison to English word reading. Then, I will discuss how the brain adapts to one's language with learning and development. Then, I will focus on the topic of second language learning, including how one brain processes Chinese and English in bilinguals, how first language influences second language learning, and whether there are different optimal learning methods for different second languages. This chapter will address these important questions based on neuroimaging studies.

Keywords: Chinese, fMRI, bilingual, development, learning, specialization

Introduction

Neuroimaging research has provided important insights about brain mechanisms of human cognition and human learning. One significant change in the brain with learning is the transition from a diffused network at the beginning of learning to a more specialized network when the proficiency reaches a high level (Wong, et al., 2007). Neural specialization refers to greater involvement of task relevant regions and less involvement of task irrelevant regions (Johnson, 2011), which increases the efficiency of a neural network. Language learning provides a great context to study neural specialization, because different languages may end up with different neural networks, since different features exist in different languages. Chinese is unique in its logographic nature and contrasts with Western alphabetic languages dramatically. Therefore, studying brain mechanisms involved in Chinese learning using neuroimaging techniques and comparing it to learning alphabetic languages would provide essential evidence for neural specialization and neural

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adaptation. Even though neuroimaging research on Chinese reading started much later than that in English, there has been a decent amount of accumulated evidence to date contributing to the understanding of neural specialization during language learning.

Cross-linguistic differences in the brain network engaged in reading

Word reading is essentially a process of retrieving meaning and sound from print, and this nature of reading is universal across languages (Perfetti & Liu, 2005). However, the specific procedures of mapping print to sound and meaning may vary from one language to another (Perfetti & Liu, 2005). In alphabetic languages, in which visual form represents sound, phonology and orthography have an intimate relationship and the interactivity between them is very robust due to the systematic mapping of grapheme-phoneme-correspondence. However, in logographic languages, such as Chinese, in which the visual form does not represent sound, it is through remote memorization that children learn the sound and meaning of each character. The activation of phonology from orthography is through a "whole-word" procedure. These differences in the mapping between orthography and phonology fit well with the dual-route model of reading (Coltheart, et al., 1993; Coltheart, et al., 2001), in which there are a lexical and a sub-lexical pathway in the mapping between orthography and phonology. The sub-lexical pathway uses the grapheme-phoneme-correspondence rule to assemble phonology in reading while the lexical pathway uses a whole-word-to-whole-syllable mapping to retrieve phonology. Neuroimaging studies have successfully captured the differences between the two pathways by identifying a dorsal sub-lexical pathway, which includes the temporo-parietal regions, and a ventral lexical pathway, which includes the temporo-occipital regions and inferior frontal gyrus (IFG) (Pugh, et al., 2000; Jobard, et al., 2003). Supporting evidence for these two pathways comes from cross-linguistic comparisons and training studies. Cross-linguistic research that focuses on L1 reading has compared opaque languages with transparent languages, such as English and Italian (Paulesu, et al., 2000), Chinese and English (Bolger, et al., 2005; Tan, et al., 2005), Chinese characters and Chinese pinyin (Chen, et al., 2002), and Japanese Kanji and Kana (Tokunaga, et al., 1999), with the former being more opaque and the latter being more transparent in each of these pairs. Transparent languages refer to those with a regular mapping system between grapheme and phoneme. In other words, each grapheme corresponds to only one phoneme and vice versa. Opaque languages refer to those with irregular mapping between grapheme and phoneme, in which one grapheme may correspond to different phonemes in different words and vice versa. Another body of cross-linguistic research has compared L1 and L2 reading in bilinguals with a within-subject design, in which L1 and L2 happen to have different degrees of orthographic transparency, such as Spanish-English (Jamal, et al., 2012), English-Chinese (Nelson, et al., 2009; Cao, et al., 2013), and Hindi-Urdu bilinguals (Kumar, 2014). Research on monolingual and bilingual subjects has provided evidence for the cross-linguistic difference in brain activation – the opaque languages are associated with greater activation in the lexical pathway while the transparent languages are associated with greater activation in the sub-lexical pathway. This pattern fits the framework of dual-route model. Recently, several training studies have manipulated how subjects acquire the mapping from orthography to phonology in learning an artificial language. For example, In one condition, addressed phonology or whole-word mapping was taught, and in the other condition, assembled phonology or sub-lexical mapping was taught (Mei, et al., 2013; Mei, et al., 2014). Results from these studies also show clear dissociation between these two pathways. In summary, when the writing system is transparent, there is greater involvement of the dorsal sub-lexical pathway, whereas when the writing system is opaque, there is greater involvement of the ventral lexical pathway.

With the broader background of language differences in the brain introduced under the framework of dual-route model of reading, we now specifically focus on the differences between Chinese and English. Chinese is unique in comparison to English at both the visual form level and the mapping level: (1) Chinese characters have a more complex visual-spatial configuration than English words that contain letters that have a left-to-right layout. Chinese characters can be top-down (呆 vs 杏), left-right (扣), and inside-outside（困）layout. (2) Chinese characters map to sound at the whole syllable level. No part of a character corresponds to a single phoneme in the syllable. Consistent with the different language properties, the comparison of brain activation between native Chinese speakers and native English speakers has revealed greater involvement of the right middle occipital gyrus (MOG) and fusiform gyrus for Chinese reading than English reading (Bolger, et al., 2005; Tan, et al., 2005; Nelson, et al., 2009; Cao, et al., 2013; Cao, et al., 2013), which is presumably due to the complex holistic visual-orthographic configuration in Chinese. Research has also found greater activation in the left middle frontal gyrus (MFG) for Chinese reading than English while there is greater activation in the left temporo-parietal regions for English than Chinese (Bolger, et al., 2005; Tan, et al., 2005; Cao, et al., 2013). This is because the whole word mapping for Chinese recruits the left MFG to a greater degree while the sub-lexical reading in English recruits the phonological assembly region to a greater degree. The left MFG has been repeatedly found to be more involved in Chinese reading than English reading; however, the interpretation of the exact function of this region has been debated. Hypotheses about its function include addressed phonology (Tan, et al., 2001; Tan, et al., 2001); visual processing (Tan, et al., 2000); lexical selection and integration (Bolger, et al., 2008; Cao, et al., 2011). Taken together, mature readers of native Chinese and English show different brain activations in reading, which is consistent with the expectations of the dual route model: greater involvement of the lexical pathway in Chinese and greater involvement of the sublexical pathway in English.

The cross-linguistic difference in brain activation increases with development

An intriguing question following the finding of the cross-linguistic differences in mature readers is whether the same differences exist in children. In other words, how does the language difference appear and/or change with exposure to reading? In order to answer this question, developmental studies that compare children and adults within each language are essential. In a series of developmental studies within Chinese, it has been found that the right MOG and left MFG show increased activation in adults compared to children, suggesting their crucial roles in Chinese reading (Cao, et al., 2009; Cao, et al., 2010; Cao, et al., 2011). Specifically, in a comparison between Chinese native children and adults, there is increased activation with age in the right MOG in a visual rhyming judgment task (Cao, et al., 2010), a visual spelling task (Cao, et al., 2010), and a visual meaning judgment task (Cao, et al., 2009). There is increased activation in the left MFG with age in a visual rhyming (Cao, et al., 2010), a visual spelling (Cao, et al., 2010), an auditory rhyming, and an auditory spelling task (Cao, et al., 2011). Interestingly, there is decreased activation in the left superior temporal gyrus (STG) with age in the visual rhyming judgment task (Cao, et al., 2010). The developmental changes in the brain suggest that regions that are essentially relevant for Chinese reading (e.g. the right MOG, the left MFG) are more involved in Chinese adults than children while those that are less relevant (e.g. the left STG) tend to show a developmental decrease with age. In English reading development, it has been found that there is increased activation in the left temporo-parietal regions and left fusiform gyrus from children to adults (Booth, et al., 2004; Turkeltaub, et al., 2004), but reduced involvement in the right nonlinguistic visual areas (Turkeltaub, et al., 2003). In summary, developmental research in Chinese and English suggests that brain regions that are essential for reading in one's language show increased involvement over development while regions that are not relevant show decreased involvement. This pattern suggests a developmental increase in the degree of neural specialization of reading to one's writing system, which may be the result of an interaction between neural maturation and linguistic experience.

Even though there is evidence for developmental changes within each language, very few studies have directly compared developmental changes in the two languages. In one recent study, researchers have directly tested how brain network changes with age differently in Chinese and English in a visual rhyming judgment task using a two ages (adults, children) by two languages (Chinese, English) design (Cao, et al., 2015). A significant interaction between age and language was found at the left STG, inferior parietal lobule (IPL) and right MOG. At the left STG and IPL, there was a developmental increase in English but not Chinese; while at the right MOG, there was a developmental increase only in Chinese but not English. These findings suggest that the phonological brain regions play an increasingly important role in English reading from childhood through adulthood, while the visuo-orthographic region plays a more and more important role in Chinese reading over development. This suggests that the brain adapts to one's writing system with experience. Another study based on the same sample of subjects found that in an auditory rhyming judgment task, there was increased activation in the left STG, IPL and IFG from children to adults only in English but not in Chinese, and the increase was more pronounced for words with conflicting orthographic and phonological information (e.g. pint-mint, similar orthography but different phonology; jazz-has, different orthography but similar phonology) (Brennan, et al., 2013). This suggests that English speaking adults are more sensitive to the conflicting orthographic information even when the task does not require access to orthography. During reading acquisition in alphabetic languages, the interactivity between orthography and phonology increases (Ziegler & Ferrand, 1998; Perre & Ziegler, 2008) and this reorganizes and/or enhances the phonological network, whereas this influence of reading acquisition on phonological processing does not take place in non-alphabetic Chinese due to the lack of intimate relationship between orthography and phonology (De Gelder, 1992; Zhou X, 1999). Actually, in another study (Cao, et al., 2011), Chinese adults showed reduced activation in the left fusiform gyrus and left middle occipital gyrus compared to children during the auditory rhyming judgment task, suggesting the interactivity between orthography and phonology could decrease with age in Chinese when it hurts the task performance. Due to the fact that there are extensive homophonic characters corresponding to one syllable in Chinese, activation of orthography may add unnecessary competition for the auditory rhyming task which can be conducted solely relying on phonology. Taken together, all evidence appears to suggest that the language divergence between Chinese and English increases from children to adults with language experience, which implicates that the brain becomes more specialized to one's language with exposure over development.

Reduced neural specialization in children with low reading proficiency

Neural specialization takes place while one learns to read in his/her own writing system, which is reflected as increased involvement of the relevant regions and decreased involvement of the irrelevant regions with increased reading proficiency. Therefore, the level of neural specialization varies according to the individual's reading proficiency level. One study found that higher accuracy on a visual rhyming judgment task is associated with greater activation in the left MFG, and greater accuracy in a semantic judgment task is associated with greater activation in the left fusiform gyrus in native Chinese children (Cao, et al., 2009). Because the left MFG is associated with phonological processing in Chinese reading, presumably responsible for the whole character to whole syllable mapping, and the left fusiform gyrus is involved in verbal semantic processing, greater activation in these two regions with increased accuracy on the task suggesting increased neural specialization for task. In English, it has been found that better performance is correlated with greater activation in the left supramarginal gyrus and angular gyrus in a visual rhyming and an auditory spelling task in a group of children aged 9–15 years, suggesting these two regions play an essential role in the conversion between orthography and phonology, because both of these two tasks require conversion between orthography and phonology (Booth, et al., 2003). In the same study, it was found that better performance is correlated with greater activation in the left fusiform gyrus for a visual spelling task and better performance is correlated with greater activation in the left STG for an auditory rhyming task, suggesting that when the task is intra-modal (i.e. the task can be conducted within either orthographic or phonological representation and without the necessity of converting between them), the representation regions play an essential role (Booth, et al., 2003). Taken together, both research from Chinese and English suggests that high language proficiency is characterized by greater involvement of brain regions that are essential for the task, indicating greater neural specialization.

Developmental dyslexia is one extreme example of low reading proficiency. Developmental dyslexia is defined as reading failure that cannot be explained by general intelligence, sensory acuity, or motivation (Shaywitz, et al., 1998). Due to the contrastive features of Chinese and English, there has been debate about whether developmental dyslexia in Chinese and English is associated with a universal mechanism or not. Research on developmental dyslexia in English and other alphabetic languages has reached a relative consensus that phonological deficit is the core deficit that causes reading disability (Bradley & Bryant, 1983; Rack, et al., 1992; Pennington & Lefly, 2001). The phonological deficit refers to the impairments of processing and/or representing phonemes (Shankweiler, et al., 1992;

Shankweiler, et al., 1995). The underspecified phoneme representations, or the unsuccessful retrieval of the phoneme representations, lead to poor development of the grapheme-phoneme correspondence that is essential to reading (Snowling, 1980; Muter, et al., 1998). A number of neuroimaging studies have investigated brain abnormalities associated with developmental dyslexia in English, and a consistent finding is reduced brain activation in the left temporo-parietal region and temporo-occipital region in participants with developmental dyslexia (Rumsey, et al., 1997; Paulesu, et al., 2001; Schulz, et al., 2009; van der Mark, et al., 2009; Tanaka, et al., 2011; Kita, et al., 2013), which explains the deficient phonological and orthographic processing in developmental dyslexia. Developmental dyslexia has also been found to be associated with increased activation in nonlinguistic areas such as the right pre/postcentral gyrus (Ramus, 2014), implicating compensation mechanisms. Taken together, developmental dyslexia is associated with reduced activation in the key language regions and increased activation in compensation areas, suggesting the opposite pattern of neural specialization. Therefore, developmental dyslexia is characterized by reduced neural specialization in English.

Chinese, on the other hand, does not have a relative consensus about the hypothetic cause of developmental dyslexia yet. There are also much less published neuroimaging studies on Chinese dyslexia, however the handful of studies suggest different patterns than English dyslexia. These studies found reduced brain activation in the left middle frontal gyrus (MFG) in a morphological task (Liu, Tao, et al., 2013), a homophone judgment task (Siok, et al., 2004), a character decision task (Siok, et al., 2004), and an auditory rhyming judgment task (Cao, 2017). None of these studies has reported reduced brain activation in the left temporo-parietal region, which is different than the finding from English dyslexia. Some studies have also reported reduced brain activation in the bilateral temporo-occipital areas (Siok, et al., 2004; Liu, et al., 2012), which is consistent with the finding from English dyslexia. Taken together, the reduction in left MFG in Chinese dyslexia, along with the reduction in left temporo-parietal region in English dyslexia, seems to be consistent with the findings of cross-linguistic differences between Chinese and English in normal reading. The left MFG is the critical region in successful Chinese reading, which is responsible for the nature of addressed phonological processing in Chinese, while the left temporo-parietal region is critical for successful English reading, which is responsible for the nature of grapheme-phoneme-correspondence in English. Therefore, the deficit of dyslexia in both languages is the reduced neural specialization to their own writing system. One study, with a direct comparison of developmental dyslexia between the two languages, found that dyslexic children in the two languages show very similar brain activation patterns in a word semantic task, however, control children showed specialization to their own writing system with greater activation in the left superior temporal sulcus (STS) in English control children and greater activation in the left MFG in Chinese control children (Hu, et al. 2010). Therefore, this study provides direct evidence that the universality of developmental dyslexia across different languages is the inability to adapt to the features of the writing system, implicating reduced neural specialization.

Neural specialization during bilingual processing

In the globalized world, most people know more than one language. English and Chinese are two languages that are used by most of the population, and more and more people become English-Chinese bilingual. Since Chinese and English are associated with different brain networks in native speakers, how do bilinguals process these two languages? Would they develop separate networks for each language or use one universal network for both languages? Research has accumulated evidence for both assimilation and accommodation (Piaget, 1983). Assimilation refers to using existing first language network to process the second language and accommodation refers to engaging an additional network for the new language (Perfetti, et al., 2007). In late Chinese-English bilinguals, a very similar brain network has been found to process both the L1, Chinese and the L2, English on a visual rhyming judgment task (Cao, et al., 2013), semantic task (Luke, et al., 2002), homophonic judgment task (Tan, et al., 2003), and even an English pseudo word rhyming judgment task (Cao, et al., 2014). In early Chinese-English bilinguals, it was also found that there was a great overlap in brain activation for Chinese and English during single word reading (Chee, et al., 1999) and sentence comprehension (Chee, et al., 1999). One study found that the higher the proficiency in the second language the greater the similarity between the first language and the second language processing network in Chinese-English bilinguals (Cao, et al., 2013). At the same time, evidence of accommodation has been observed at the script level and the mapping level. One study found reduced activation in the right MOG for English words and pseudo words (Cao, et al., 2014); the same study suggests that the phonological assembly regions, such as the left STG and IPL, are more connected with orthographic regions during the English pseudo word rhyming task in highly proficient bilinguals. These results suggest that even if a Chinese network is used in reading English pseudo words, the classic grapheme-phoneme-correspondence regions that are important for native English reading are involved in highly proficient bilinguals by connecting with the visuo-orthographic region. Even though there is some evidence of accommodation in Chinese-English bilinguals as well, the Chinese-English bilinguals show less accommodation than English-Chinese bilinguals. English-Chinese bilinguals have been found to show accommodation when they process their relatively low proficiency L2, Chinese. These studies have found that these bilinguals showed greater activation in the STG and IFG for their L1, English, but greater activation in the right MOG and left MFG for their L2, Chinese (Nelson, et al., 2009; Cao, et al., 2013). These findings suggest that the brain can effectively accommodate to the newly learned writing system by recruiting the relevant brain regions.

The accommodation in English-Chinese bilinguals and the assimilation in Chinese-English bilinguals seem to suggest that the relationship between the L1 and L2 plays an important role in the balance of assimilation and accommodation. When L1 is moe opaque than L2, such as in the case of Chinese-English bilinguals, the existing network is sufficient enough to learn the more transparent L2. Whereas when L1 is more transparent than L2, such as in the case of English-Chinese bilinguals, significant adoption of new neural resources is needed to acquire the more arbitrary mapping of L2. Supporting this hypothesis, a recent study on Korean-Chinese-English trilinguals found that when native Korean speakers read Chinse, a network that is more similar to native Chinese speakers is employed; however, when they read English, the native Korean network is recruited (Kim, et al., 2016). This is consistent with the hypothesis, because Chinese is more opaque than Korean which would require additional accommodation while English is very similar to Korean in terms of the mapping between orthography and phonology, both of which are alphabetic, and assimilation is efficient for reading English. One pitfall of this study is that even though Chinese is more opaque than Korean, English is also a little more opaque than Korean. In order to test the hypothesis, an ideal situation would be a group of trilinguals with one L2 more opaque and the other L2 more transparent than L1. Another pitfall of this study is that even though Chinese and English were matched on the proficiency level in the Korean-Chinese-English trilingual subjects, the subjects were recruited in Beijing who were Korean students learning Chinese language and culture; therefore, the language acquisition environment and the amount of usage may be different in Chinese and English.

In a recent training study (Cao 2017), we have successfully overcome these two pitfalls by teaching native English speakers Chinese and Spanish with the learning method and amount of exposure well matched. Chinese is more opaque than English while Spanish is more transparent than English. Subjects showed greater activation in bilateral IFG when reading newly learned Chinese characters than L1. These subjects also showed greater activation in the bilateral STG when reading newly learned Spanish than L1. Chinese reading also produced greater activation than Spanish reading in the left IFG and left inferior temporal gyrus (ITG), while no regions were more activated for Spanish than Chinese. These findings fit well with the dual-route model, in which Chinese engages the lexical pathway to a greater degree while Spanish engages the sublexical pathway to a greater degree. However, these findings do not support our hypothesis about the balance between assimilation and accommodation in L1 and L2, according to which, one should expect no difference between Spanish L2 and English L1 because Spanish is more transparent than L1 and the existing network should be sufficient enough for learning Spanish. In contrast, our results seem to suggest that no matter whether the L2 is more or less transparent than L1, some degree of accommodation happens. Taken together, this study suggests that the brain of adult second language learners can flexibly adapt to the properties of the target second language by engaging the sub-lexical pathway to a greater degree if the L2 is more transparent than L1, and the lexical pathway to a greater degree if the L2 is more opaque than L1.

Consistent with the training study, a meta-analysis study has had similar findings by comparing brain activation of the same L2 languages in two groups of studies (Liu & Cao 2016). In one group of studies, the L2 is more transparent than the L1, while in the other group of studies, the same L2s are more opaque than the L1s. It was found that the same L2 languages evoked different brain activation patterns depending on whether it was more or less transparent than L1 in orthographic transparency. The bilateral auditory cortex and right precentral gyrus were more involved in shallower-than-L1 L2s, suggesting a "sound-out" strategy for a more regular language. In contrast, the left frontal cortex was more involved in the processing of deeper-than-L1 L2s, presumably due to the increased arbitrariness of mapping between orthography and phonology in L2. This meta-analysis study suggests that the brain regions involved in L2 reading does not actually depend on whether the L2 is a transparent or opaque language, but depends on whether the L2 is more or less transparent than L1. This implicates that the existing L1 system has a significant influence/constraint on how the second language is learned. Both the Chinese and Spanish learning study on native English speakers and the meta-analysis study suggest that no matter whether the L2 is more transparent or opaque than L1, there will be accommodation in the brain, which does not support the hypothesis that there will be only accommodation when the L2 is more opaque than L1 and assimilation is efficient when L2 is more transparent than L1, which was developed based on the observation of assimilation in Chinese-English and accommodation in English-Chinse bilinguals. Future research, including computational modelling work, should aim to understand why there is little accommodation in Chinese-English bilinguals when they process their second language. One possibility is that the same brain regions may be involved in different calculations for different languages. Another variable that should be taken into consideration is that the learning method and usage of English in Chinese native speakers are different from other bilingual populations. English is taught as a foreign language in Chinese schools, which is seldom used in daily life. This may make Chinese-English bilinguals so unique that they barely show accommodation.

How native language influences second language learning

A number of behavioral studies have documented that the experience of one's first language will modulate how the second language can be learned (Wang, et al., 2003; Wang, et al., 2005). In the brain, there is also evidence of L1's influence on L2, such as the meta-analysis study mentioned above (Liu & Cao, 2016). Another study compared Chinese-Japanese and Korean-Japanese speakers' brain activation during their common L2 Japanese reading and found that Chinese L1 speakers showed greater involvement of the left MFG than Korean speakers even in Japanese reading (Jeong, et al., 2007). This suggests that the classic Chinese region, the left MFG, is also carried over to process the second language in the Chinese native speakers. The left MFG has been found to be more activated in Chinese reading than alphabetic reading, presumably due to the lack of grapheme-phoneme-correspondence rule in Chinese and the whole character maps to the whole syllable. However, this study did not directly compare brain activation in L1s. Another recent study compared Chinese –English bilinguals and Korean-English bilinguals on the brain activation of both L1 and L2 and found that Korean speakers involve the right IFG to a greater degree both in their L1 and L2 in comparison to Chinese speakers, while Chinese speakers involved the left MFG to a greater degree in both their L1 and L2 (Kim, et al., 2017). Therefore, this study provided more direct evidence that regions that are heavily involved in L1 are also heavily involved in L2. Another training study has examined how L1 influences the learning of addressed phonology and assembled phonology (Mei, et al., 2015). It was found that the left MTG was activated to a greater degree in addressed phonological learning of an artificial language than assembled phonological learning only in native Chinese speakers, while the left supramarginal gyrus was activated to a greater degree in assembled phonological learning than addressed phonological learning only in native English speakers (Mei, et al., 2015). It suggests that the existing L1 phonological network is more ready to be engaged in the new language when the phonological learning method is the same as in L1. When L1 is addressed phonology, the address phonological network is more involved in addressed phonological learning, however, when L1 is assembled phonology, the assembled phonological network is more involved in assembled phonological learning. In one word, the L1 experience modulates the learning processes of the new language.

How learning a second language affects L1 processing

Even though a number of studies have focused on how L1 influences L2, very few studies have examined how L2 influences L1. A behavioral study found that high proficiency in L2, Chinese is associated with low reading fluency in L1 in English-Chinese bilingual adults, while high proficiency in L2, Spanish is associated with high reading fluency in L1 in English-Spanish bilingual adults (Kaushanskaya, 2011). This suggests that second-language experiences influence native-language performance and can facilitate or reduce it depending on the properties of the second-language writing system. One fMRI study found that long-term experience with Chinese made English speakers show increased activation in the right fusiform gyrus when reading English (Mei, et al., 2015). It suggests that not only L1 brain regions can be carried over to L2, but L2 brain regions can also be carried over to L1. The meta-analysis study mentioned above has examined how age of acquisition (AOA) of L2 influences L1. The study found that early bilinguals showed increased activation in the left fusiform gyrus than late bilinguals during L1 processing even though the L1s are the same languages, suggesting that there may be greater co-activation of L1 and L2's orthography in early bilinguals than late bilinguals (Liu & Cao, 2016).

To summarize, the brain can selectively engage appropriate regions to adapt to the properties of the second language. The existing L1 system constrains how second language can be learned, because different brain regions will be involved in learning the same L2 depending on whether L2 is more or less transparent than L1. L2 acquisition and learning also influences how L1 is processed. More research is needed to have a deeper understanding about the dynamics between L1 and L2 in the brain, so that researchers would be better positioned to explain why some bilingual populations have more assimilation than accommodation while other bilingual populations have more accommodation than assimilation.

Appropriate learning methods facilitate neural specialization

Phonological learning helps lexical learning only in alphabetic but not non-alphabetic language

Language learning is characterized by increased brain specialization to the target language, and the learning experience plays an important role in modulating the process of brain specialization. Optimal learning methods may facilitate the process of neural specialization in language learning. Written word learning relies upon the establishment of high-quality, well-connected orthographic, phonological, and semantic representations. For alphabetic languages, orthographic representations are intimately connected with the phonological forms they represent. Success in reading is dependent upon establishing phonological connections to orthography (Rayner, et al., 2001; Vellutino, et al., 2004; Ziegler & Goswami 2005), once phonology is activated by orthography, semantics can be accessed in the spoken-language vocabulary. Accordingly, phonemic awareness has been found to be associated with reading performance and serves as the best predictor of later reading achievement in English (Bradley & Bryant, 1983; Goswami, 1993; Muter, et al., 1997; Anthony, et al., 2003). Phonological processing regions, such as the left IPL and left STG are heavily involved in English word reading and become more so with skill and age (Shaywitz, et al., 1998; Booth, et al., 2003; Turkeltaub, et al., 2003; Booth, et al, 2004; Dehaene, 2010; Brennan, et al., 2013; Cao, et al., 2015). Extensive research shows that explicit phonologically-based instruction emphasizing phonemic awareness and the link between phonemes and written language, helps children achieve decoding and word recognition skills with effects maintained over time in both typical and atypical readers (Vellutino, et al., 1997; Ehri, et al., 2001; Torgesen, et al., 2001; Snowling & Hulme, 2011). Phonologically-based training is accompanied by structural and functional changes in the reading network. For example, increased brain activation was found in the left IFG and the left temporo-parietal region in a number of phonologically-based intervention studies (Simos, et al., 2002; Aylward, et al., 2003; Eden, et al., 2004; Shaywitz, et al., 2004; Simos, et al., 2006). Another study also found increased fractional anisotropy at the left anterior centrum semiovale in children with reading difficulty (Keller & Just, 2009), suggesting increased myelination following intervention. Taken together, phonological methods are effective in alphabetic lexical learning.

For Chinese, the situation is different. Although Chinese characters are also connected to phonological representations, these connections are less intimate (Perfetti, Liu et al., 2005). On the other hand, the visual forms, representing morphemes, have a tighter connection to meaning. Because a Chinese syllable maps onto many different morphemes, the character's pronunciation cannot activate a unique morpheme. Thus, using phonology alone to access meaning is an indeterminate process and direct mapping from orthography to semantics is critical for meaning identification (Tan & Perfetti, 1997). Moreover, the visual form of Chinese is relatively complex in that the spatial layout of characters is non-linear, usually with components arranged in left-right, top-down, and inside-outside combinations. The nature of Chinese reading acquisition is to associate characters with phonology and meaning, but the association between visual forms and phonology is arbitrary due to the lack of grapheme-phoneme-correspondence. Therefore, consolidating the association requires a robust visuo-orthographic representation. In summary, character-specific orthographic representations are very important in

Chinese reading acquisition because of (1) the coarser mapping with phonology, (2) the complex visual configuration of characters, and (3) the tighter connection with semantics. Therefore, no studies have focused on phonologically-based training in Chinese word learning, even though there is very limited research on reading remediation in Chinese in general.

Orthographic learning is helpful in non-alphabetic lexical learning

Orthographic skills have been found to be highly important in Chinese reading acquisition and development (Tan, et al., 2005). Visual and orthographic skills have a larger contribution than phonological skills to reading in Chinese children (Siok & Fletcher, 2001; McBride-Chang, 2005). Writing scores have been found to be the primary predictor of reading scores in Chinese children aged 7–10, followed by rapid naming and phonological awareness (Tan, et al. 2005). Thus, phonological skills play a limited role in Chinese (Vellutino, et al., 1972; Vellutino, et al., 1975; Peng, 1985; Song, 1995; McBride-Chang, 2005; McBride-Chang, et al., 2005). Consistently, neuroimaging studies have demonstrated the important role of visuo-orthographic processing in Chinese reading and Japanese Kanji reading (Koyama, et al., 2011), showing increased activation in the bilateral visual cortex with age (Cao, et al., 2009; Cao, et al., 2009; Cao, et al., 2015), and a skill-related increase in right middle occipital gyrus (Siok, et al., 2009). At the same time, the phonological processing region in left STG shows reduced involvement with age in reading Chinese words (Cao, et al., 2010).

It seems that the key to learning to read Chinese is to establish high-quality orthographic representations of characters, allowing reliable and fast activation of meaning and phonological constituents associated with the orthographic form. However, orthography is one of the most challenging aspects of learning Chinese, as it is very complex in two related ways: the number of orthographic units (characters) to be learned is very large, several thousand for a skilled reader, and the individual characters can be visually complex. Effective support for learners in handling the complexity of the characters should lead to higher quality orthographic representations and thus improve their ability to read Chinese. Previous studies suggest that visual chunking and handwriting are both effective in learning Chinese orthography (Pak, et al., 2005; Guan, et al., 2011; Cao, et al., 2013; Cao, et al., 2013). In an ERP study (Cao, et al., 2013), it was found that the amplitude of N170 was greater during Chinese character recognition following visual chunking training in English speaking adults learning Chinese, while the amplitude of P100 was greater following handwriting training in the same subjects in comparison to a passive viewing learning baseline and that the P100 amplitude right after learning is predictive of character retention three months later for the handwriting learned characters. Visual chunking reduces the complexity of Chinese orthography by teaching the recognition of commonly used visual units that appear in different characters. Therefore, orthographic recognition is more robust (greater N170) in the visual chunking condition. Handwriting, on the other hand, enhances early visual attention to the character; therefore, the P100 is greater. In another fMRI study (Cao, et al., 2013), it was found that handwriting produced more robust lexical learning in English speaking adults learning Chinese. In this study, greater activation in the bilateral lingual gyri, bilateral STG/MTG and left IPL was found for characters learned through character handwriting than those learned through pinyin writing in an implicit writing task. Greater activation in bilateral lingual gyri may be due to the more elaborated visuo-orthographic representations developed through character handwriting. Greater activation in bilateral STG/MTG may be due to the greater activation of phonology and semantics (Fiez & Petersen, 1998; Booth, et al., 2002), while greater activation in the left IPL may be due to the more elaborated conversion to phonology (Booth, et al., 2002). Taken together, findings from this fMRI study suggest more robust lexical learning through character writing than pinyin writing. Learning methods with an emphasis on orthographic learning seems to have advantages in learning Chinese words for the English speaking adults, presumably because Chinese orthography is very different than their L1, and only when orthography is acquired, meaning and sound can be attached to the visual form.

Orthographic learning is also helpful in alphabetic lexical learning

While the importance of phonological skills in alphabetic reading acquisition is well established (Perfetti, 1984; Snowling, et al., 1986; McBride-Chang & Kail, 2002), phonological skill alone is insufficient for the development of reading speed and fluency; reading acquisition also requires development of orthographic skills in alphabetic languages (Frith, 1986; Byrne & Fielding-Barnsley, 1989; Byrne, et al., 1992; Olson, et al., 1997; O'Brien, et al., 2011). In both children and adults, the efficiency of orthographic processing accounts for variance in word recognition after the variance associated with phonological processing skills has been partialed out (Stanovich & West, 1989; Cunningham & Stanovich, 1990), and a developmental increase in the involvement of the left occipito-temporal cortex in English reading has also been shown, underscoring the importance of orthographic processing (Booth, et al., 2003; Cao, et al., 2006; Shaywitz, et al., 2007). Moreover, orthographic training improved word-reading of alphabetic languages in children with reading disabilities (Gillingham, 1956; Bradley, 1981; Thomson, 1991; Broom, 1995;

Gustafson, et al., 2007; Berninger, 2008; Berninger, et al., 2013), and orthographic training includes visual imagery of the word (Berninger, et al., 2013), building words with letters (Gustafson, et al., 2007), and simultaneous oral spelling (Bradley, 1981; Thomson, 1991; Broom, 1995). Two neuroimaging studies on children with dyslexia have found that spelling intervention increased activation in left fusiform gyrus and left temporal-occipital area (Shaywitz, Shaywitz, et al., 2004; Gebauer, et al., 2012), suggesting improved orthographic processing. In normal children, handwriting has demonstrated advantages in written word learning for alphabetic languages as well (Longcamp, et al., 2005), and is accompanied by increased activation in bilateral fusiform gyri in a letter recognition task (James, 2010). Thus, orthographic skills are essential in learning to read alphabetic languages, and orthographic training including handwriting facilitates written word learning.

The interaction between learning method and language

According to the literature review above, different optimal learning methods may exist depending on the properties of the writing system. Specifically, orthographic learning is essential in both alphabetic and non-alphabetic languages, whereas phonological learning works better with alphabetic languages. However, very few studies have addressed this cross-linguistic difference in the effectiveness of different learning methods. In a recent study, for the first time, researchers compared the effectiveness of phonological training and orthographic training in learning alphabetic and non-alphabetic written words (Cao, 2017). Specifically, we compared phonological learning and handwriting learning in English-speaking adults learning Spanish and Chinese words. We found that the handwriting learning condition produced greater activation in the left temporal pole than the phonological learning condition, suggesting greater connections between orthography and semantics built through writing. We also found that there was greater activation in the left MFG for handwriting than phonological learning only in Chinese but not in Spanish, while there is greater activation in the left STG for handwriting than phonological learning only in Spanish but not in Chinese. It suggests that handwriting facilitates written word learning in both Chines and Spanish, however, through different mechanisms. For Chinese, handwriting enhances the addressed phonology at the left MFG by connecting orthography and phonology, while for Spanish, handwriting facilitates assembled phonology at the left STG by building the grapheme-phoneme-correspondence. There is also evidence that phonological learning is more robust in Spanish than Chinese, because there was greater activation in the left MFG for the phonological learning condition than the passive viewing condition only in Spanish.

Why does writing help reading?

As mentioned above, writing helps reading in both alphabetic and logographic languages. Specifically, handwriting may promote reading via the following mechanisms: (1) it adds a motor memory trace to the visual form, which may facilitate recognition, especially in second language learners whose quality of visual representation is weak. Supporting this hypothesis, the premotor cortex is activated when recognizing letters/characters that are learned through writing in comparison to those learned through viewing only (Longcamp, et al., 2003; James & Gauthier, 2006; Cao, et al., 2013). In neuropsychology, there is also evidence of the efficacy of kinesthetic facilitation of writing while reading for pure alexia (Seki, et al., 1995); (2) the quality of visuo-spatial representation of print increases through writing by increasing activation in the bilateral superior parietal lobules (Naka, 1998; Longcamp, et al., 2005; Cao, et al., 2013); (3) it establishes a high-quality orthographic representation because there is, increased activation in the left fusiform gyrus (James & Atwood, 2009; James, 2010; Cao, et al., 2013); (4) it improves visual attention to print as evidenced by a greater P100 in an ERP (Cao, et al., 2013); (5) it accelerates association between orthography, phonology, and semantics (Guan, et al., 2011; Cao, et al., 2013; Cao, et al., 2013), due to the dedicated attention to the word's print, sound and meaning during writing, and (6) it accelerates the understanding of alphabetic principles by increasing the time and attention devoted to individual letters and their corresponding sounds during writing (Cao, et al., 2013), which may promote phonological decoding. Taken together, previous studies suggest that writing is an active encoding mechanism that can accelerate the process of establishing and refining the orthographic representation, strengthening the connection among orthography, phonology, and semantics due to the extra attention and memory resources involved. Writing also boosts the understanding of phonological structure by forcing the breakdown of a word into smaller phonological units.

Conclusion

The brain network involved in Chinese word reading is slightly but significantly different from that involved in alphabetic languages, such as English, which is due to the different features of the language. This cross-linguistic difference of brain activation develops with experience in one's own language as revealed in developmental studies comparing Chinese reading and English reading, suggesting increased neural specialization to the writing system with exposure. In bilinguals, the brain adapts to the second language by engaging appropriate regions for that specific L2, which is also influenced by L1 background suggesting the dynamic interaction between L1 and L2 during neural specialization to each language. Optimal learning method would facilitate the process of neural specialization during language learning. Future research should integrate behavioral, neuroimaging and computational modelling methods to reach a more complete understanding of neural specialization in language learning.

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CHAPTER 8

Semantic and lexical processing of words across two languages in Chinese-English bilinguals

Fengyang Ma[i], Haiyang Ai[i] and Taomei Guo[ii,iii]
[i]School of Education, University of Cincinnati / [ii]State Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern Institute for Brain Research, Beijing Normal University / [iii]Center for Collaboration and Innovation in Brain and Learning Sciences, Beijing Normal University

The present fMRI study examined the neural correlates of semantic and lexical processing in unbalanced Chinese-English bilinguals with two lexical decision tasks in both their languages. Results showed that when contrasted the participants' responses to words with those of pseudo-words, there was no significant difference between the first language (L1) and the second language (L2), suggesting that comparable neural networks are involved in semantic processing during word recognition in unbalanced bilinguals' two languages. However, when contrasted the neural activation patterns of words and cross strings (i.e., ++++), the weaker L2 elicited stronger activation in the left middle occipital gyrus, the left precentral gyrus, and the right superior parietal lobule, relative to the dominant L1. This indicates that more resources are engaged in lexical processing in the L2 than in the L1.

Keywords: semantic processing, lexical processing, neural mechanism, bilingualism

Introduction

More and more people become bilinguals and use two or more languages in the world. An enduring question is how bilinguals' two languages are organized within one brain. Some cognitive models on bilingualism, such as the Revised Hierarchical Model (Kroll & Stewart, 1994) and the Bilingual Interactive Model (the BIA model, Dijkstra, & van Heuven, 1998), assume that the lexical systems of a bilingual's two languages share a common semantic representation.

With the advancement of neuroimaging techniques such as fMRI (functional Magnetic Resonance Imaging) and PET (Positron Emission Tomography), a number of studies have examined the neural overlap and dissociation of a bilingual's

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two languages and provided support for the assumption of shared semantic representation of bilinguals' two languages (e.g., Grill-Spector, Henson, & Martin, 2006; Grill-Spector et al., 1999; Grill-Spector & Malach, 2001). One set of related questions arises with regard to whether bilinguals access the meaning of words in their two languages in a similar way, and how it could be modulated by factors such as the age of acquisition (AOA) and proficiency of a second language (L2). Neuroimaging investigations have offered valuable evidence to address these issues by comparing the activated brain regions and their degrees of activation between L1 and L2 lexical semantic processing in a variety of bilingual sub-populations. Previous fMRI research with early proficient bilinguals has reported similar recruitment of overlapping regions when processing the meaning of words in two languages. For example, in Illes et al.'s (1999) study, both balanced English-Spanish and Spanish-English bilinguals were required to perform a semantic decision task, where they judged whether a word is concrete or abstract. Results revealed a consistent activation pattern in the bilateral inferior frontal gyrus for semantic analysis in both languages. This observation led the researchers to conclude that the semantic processing in proficient bilinguals' two languages was mediated by a convergent neural system, which was in line with the assumption of the available cognitive models.

On the other hand, late unbalanced bilinguals (i.e., bilinguals with a dominant language) present a different scenario. As indicated by accumulative behavioral evidence in the past two decades, less-proficient L2 learners need the mediation of translation words in the first language (L1) to access the meaning of the words in the L2 (e.g., Ferré, Sánchez-Casas, & Guasch, 2006; Guasch, Sánchez-Casas, Ferré, & García-Albea, 2008; Kroll & Stewart, 1994; Talamas, Kroll, & Dufour, 1999). Thus, an intriguing question arises: Do less proficient bilinguals activate more brain regions when they access the meaning of words in the L2, compared to words in the L1?

Several fMRI studies have investigated this issue and revealed additional brain regions recruited when retrieving lexical meaning in the weaker language. For example, in the fMRI study by Chee et al. (2000), English-Chinese bilinguals performed a semantic judgment task, in which they chose a word semantically related to a given sample word. It was found that the left prefrontal areas showed greater activity for Chinese than English. Considering that participants were more proficient in English than Chinese, the researchers suggested that access to the meaning of words in the weaker language required more cortical efforts. Using the same task, Chee, Hon, Lee, and Soon (2001) further tested English-Chinese and Chinese-English bilinguals, both dominant in their first languages (L1). It was observed that the English-Chinese bilinguals activated certain regions to a larger volume in the less dominant language than the more proficient language, including the left middle frontal gyrus, left inferior frontal gyrus, and left parietal region. Likewise, for the Chinese-English bilinguals, the weaker L2 yielded greater activation in the left middle frontal gyrus, as well as in the left and right inferior frontal gyrus than did the stronger L1. Furthermore, in a more recent fMRI study by Sebastian, Kiran, and Sandberg (2012), Spanish-English bilinguals shifting to L2 dominance performed a semantic judgment task. Results showed that the processing of word meaning in the weaker native language generated more cortical activation compared to the stronger L2 in the left frontal cortex and anterior cingulate gyrus.

In addition to these studies employing an explicit semantic judgment task, a few fMRI studies using relatively implicit semantic tasks provided additional evidence. For example, Meschyan and Hernadez (2006) used a silent word reading task to test Spanish-English bilinguals whose L2, English, became the dominant language. Results showed that word reading in the weaker language, Spanish, yielded greater activity in left superior temporal gyrus (STG), supplementary motor area (SMA), the putamen, and the insular than word reading in the stronger language, English. In another study, Marian et al. (2007) asked late proficient Russian-English bilinguals to perform a passive reading task, in which they read words and pseudo-words (i.e., letter strings follow phonological rules but do not exist in the language of interest) silently without overt responses. Words and pseudo-words are both phonologically and orthographically legitimate, but only words are meaningful and require semantic processing. Thus, by comparing activation patterns of reading words and pseudo-words, they investigated the semantic processing of words in bilinguals' two languages. Results revealed that a larger cortical area in the inferior frontal gyrus was activated by L2 than their L1. Additionally, in Park, Badzakova-Trajkov, and Waldie (2012)'s study, late proficient Macedonian-English bilinguals performed a lexical decision task, in which they were instructed to press a button when the stimuli presented were real words, and not to respond when the stimuli were pseudo-words. By comparing the lexical decision condition and the baseline condition of fixation blocks, Park et al. (2012) found that participants responding to L2 words showed relatively stronger activation in the right middle frontal gyrus. Notably, they also suggested that words and fixations differ at multiple linguistic levels, including sub-lexical orthography and phonology, lexical orthography and phonology, and semantics. Therefore, the comparison between the two conditions did not allow for the disentanglement of processing at the semantic level from the other levels.

In sum, the past literature has provided converging evidence on greater activation generated by processing semantics of the weaker language in less proficient bilinguals. As different baselines were used across studies, the greater activation in the L2 revealed processing efforts involved in L2 word processing at different levels. Critically, the dissociation among processing at various levels has been largely under-investigated, particularly in less proficient bilinguals whose two languages are linguistically distant with different orthographical systems. Thus, the present fMRI study aims to further explore this issue with L1 dominant Chinese-English bilinguals in a lexical decision task. By adopting two baselines separately (i.e., pseudo-words and cross strings in the form of "++++"), the present study examines whether different neural correlates are engaged when unbalanced bilinguals process their two languages at various linguistic levels. Specifically, contrasting the participants' responses to words with pseudo-words would reveal semantic processing of the words. Contrasting the activation patterns of words and cross strings would index semantic and lexical processing. Based on the prior findings, we also predict greater involvement of the cortical regions associated with L2 semantic and lexical processing compared to that of the L1.

Method

Participants

Twenty-three Chinese-English bilinguals were recruited for the experiment. They were right-handed and had normal or corrected to normal vision. In addition, they were free of depression, emotional disorder, or any brain lesion. Data from one participant were excluded from final analysis because of exclusive head movement during the experiment. All of the remaining 22 participants (16 females, average age = 22.41, $SD = 1.56$) started learning English at about age 10 and had no experience of living or studying abroad. According to their self-rating scores on a 10-point scale about their L1 and L2 proficiency in listening, speaking, reading and writing (higher score means higher proficiency), they were more fluent in Chinese ($M = 8.51$, $SD = 1.12$) than in English ($M = 5.53$, $SD = 1.46$), $t(21) = 10.15$, $p < .001$. In addition, all of them took the CET-4 (College English Test, Band 4), a standardized English proficiency test in China, and achieved a mean score of 546 out of 710 total points. Therefore, they were considered as late unbalanced but relatively proficient bilinguals.

Materials

One hundred and eighty Chinese words and their English translation equivalents were selected as the experimental materials. In addition, 180 Chinese and English pseudo-words, which were closely matched with the real words in each language on visual perception in terms of the number of strokes in Chinese or word length in English were also included. Another 90 stimuli "++++" were used as baselines.

Procedure

The study was approved by the Institutional Review Board of the Imaging Center for Brain Research of Beijing Normal University. Written informed consent was obtained from all the participants before the experiment. The Chinese and English stimuli were presented separately in two runs in a counterbalanced design. Each participant saw only half of the Chinese or English words, so that they did not see any translation equivalents. Each run included 90 real words, 90 pseudo words, and 90 baselines plus 4 baseline trials presented at the beginning and end of each run, resulting in 274 trials in total. For each trial, a stimulus was presented for 1 s, and followed by a blank screen for 1 s.

During the experiment, the participants were instructed to judge whether a stimulus on the screen was a real word or a pseudo-word by pressing a corresponding key as quickly and accurately as possible. If the stimulus was a baseline stimulus, they did not need to make a response. The stimuli were presented semi-randomly.

A practice was provided prior to the formal experiment to make sure that participants understood the instructions. After the formal experiment, they were asked to stay in the scanner for eight minutes for a structural scan. The entire experiment lasted for about one hour.

Image acquisition and analysis

All images were acquired using the 3T Siemens Sonata whole-body MRI scanner. 274 functional scans were obtained by using a single shot T2-weighted gradient echo planar imaging (EPI) sequence. The following scanning parameters were used: TR = 3,000 ms, TE = 30 ms, *flip angle* = 90°, *field of view (FOV)* = 200 × 200 mm^2, *matrix size* = 64 × 64, *voxel size* = 3.1 × 3.1 × 4 mm^3. 144 high-resolution T1 weighted anatomical scans were also obtained. The following scanning parameters were used: TR = 2,530 ms, TE = 3.39 ms, *flip angle* = 7°, FOV = 256 × 256 mm^2, *matrix size* = 256 × 256, *voxel size* = 1.3 × 1.0 × 1.33 mm^3.

Image processing and statistical analyses were performed using SPM8 (Welcome Department of Cognitive Neurology, London, UK). Preprocessing included slice timing correction and realignment eliminating the participants' head movement to the best extent. The realigned functional images were registered to anatomical images. Images were then normalized to the Montreal Neurological Institute (MNI, Montreal, Canada) echo planar imaging reference brain with a 2 × 2 × 2 mm^3 spatial resolution. All functional images were smoothed with a cubic Gaussian filter of 6mm full-width at half maximum.

An individual participant's activation t-map was generated by using the general linear model in which time series were convolved with the canonical hemodynamic response function and were high-pass-filtered at 128s on a voxel-by-voxel basis. On the first level, we obtained each individual participant's images of (1) real words minus pseudo-words and (2) real words minus cross strings in Chinese and English respectively. An individual's first level contrast images were then used in a random-effects model to create group analysis. To explore potential differences in neural correlates of semantic processing in between L1 and L2, we contrasted the participants' responses to words with pseudo-words in L1 and L2. To reveal semantic and lexical processing of the words in different languages, we contrasted the activation patterns of words and cross strings in L1 and L2. Clusters above the height of threshold of $p < .001$ (FDR corrected for multiple comparison) were considered as significant.

Results

Behavioral results

Participants were faster at responding to Chinese real words (625 ms) than at English real words (698 ms), $t(21) = 9.47$, $p < .01$. This was also mirrored by their higher accuracy to Chinese words (97.22%) than to English words (94.90%), $t(21) = 2.70$, $p < .05$. These results indicated that the participants were more proficient in Chinese than in English.

fMRI results

To reveal the neural networks involved in semantic processing in unbalanced bilinguals' two languages, we directly contrasted the neural activations associated with words and psudo-words in each language. However, we did not find any significant difference. This suggests that semantic processing of words in L1 and L2 evoked similar activations.

To reveal the neural correlates of lexical processing, we also directly contrasted the neural activations associated with words and cross strings in each language. The neuroimaging data showed that compared to the dominant L1 (Chinese), the weaker L2 (English) elicited stronger activation in the left middle occipital gyrus (MOG), the left precentral gyrus (LPG), and the right superior parietal lobule (SPL) (see Table 1 and Figure 1). In contrast, no stronger activation was evoked by the L1 as compared to the L2.

Table 1. Significant differences in activation within the neural regions (L2 minus L1; FDR corrected, *k* > 10)

Cluster size	Brain Regions	BA	MNI coordinate			T value
			x	y	z	
293	L_Middle Occipital Gyrus	19	−28	−84	32	8.94
41	L_Precentral Gyrus	9	−54	6	38	7.35
22	R_Superior Parietal Lobule	7	18	−64	54	6.83

Note. L, left; R, right; BA, Brodmann area

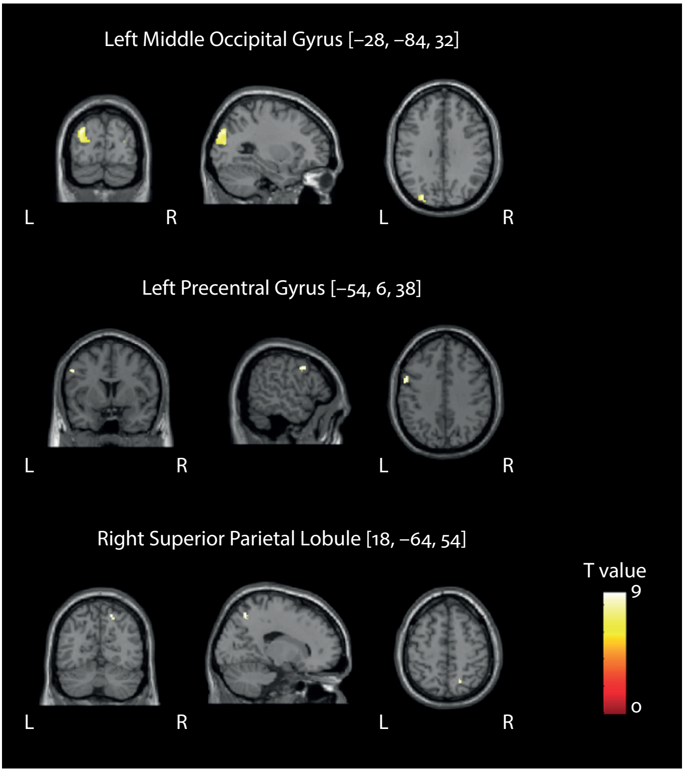

Figure 1. Differences in activation (L2 minus L1) of lexical processing
Note. L2 means the second language; L1 means the first language. Areas significantly more active for L2 than L1 are shown in the left precentral gyrus (upper), the left middle occipital gyrus (middle), and the right parietal lobule (lower).

Discussion

The current study investigated the neural correlates for lexical semantic processing of the L1 and the L2 with unbalanced but relatively proficient Chinese-English bilinguals by using a lexical decision task. Behaviorally, participants made faster and more accurate responses to Chinese words than to English words, suggesting that Chinese is their dominant language. To reveal the neural correlates of lexical semantic processing, we directly contrasted the neural activation associated with words and pseudo-words in each language. The neuroimaging data showed no significant differences in the activation patterns between the dominant L1 and the weaker L2. Furthermore, contrasting the neural activation patterns associated with words and cross strings (++++) in each language reveals the neural correlates of lexical processing at various levels. The neuroimaging data showed that the weaker L2 (English) elicited stronger activation than the stronger L1 (Chinese) in a number of regions, including the left middle occipital gyrus (MOG), the left precentral gyrus (LPG), and the right superior parietal lobule. In contrast, no stronger activation was evoked by the L1 than the L2.

Contrary to our prediction, the direct contrast between words with pseudo-words showed no significant difference in the neural activation patterns between the L1 and L2 words used in this study. This is inconsistent with the findings of previous studies examining semantic processing in unbalanced bilinguals' word recognition (e.g., Chee et al., 2000, 2001; Marian et al., 2007; Sebastian et al., 2012). As mentioned in the Introduction, previous literature showed greater activity during visual word recognition in the L2 relative to the L1 in certain brain regions, although the reported brain areas varied across studies. Specifically, the left inferior frontal gyrus was found to be associated with stronger activation for L2 processing in some studies (Chee et al. 2000, 2001; Marian et al. 2007), whereas other brain regions were also observed for greater L2 activation, including the left middle frontal gyrus and left parietal region (Chee et al. 2001), left frontal cortex and anterior cingulate gyrus (Sebastian et al. 2012). We speculate that two factors may contribute to the incongruent findings of the specific areas showing differential activation in the current literature, including the different tasks used and the varying proficiency levels of the two languages in the bilingual participants. As previously discussed, the semantic judgment task (e.g., Chee et al., 2000; 2001; Sebastian et al., 2012) examines the lexical semantic processing more explicitly, whereas the lexical decision task used in the present study does so more implicitly. It is possible that the potential differences in semantic processing between unbalanced bilinguals' two languages are more likely to be observed in tasks that are more sensitive to semantic manipulations. Also, the participants' proficiency levels in the weaker language differ largely across studies, even though they were all dominant in one language. If a standardized measure of L2 proficiency, such as the Boston Naming test (Kaplan, Goodglass, & Weintraub, 1983), was employed across studies, more insights would have been gained on how the neural systems mediating the semantic processing in bilinguals' two languages are modulated by the proficiency in the weaker language. It would be useful for future studies to investigate this issue.

Furthermore, several important findings were revealed by contrasting the neural activation patterns associated with words and cross strings in each language. Given that similar patterns were observed between processing semantics in L1 and L2, any difference found in this contrast was more likely to reflect lexical processing in two languages. Our data showed that the weaker L2 (English) elicited stronger activation than the stronger L1 (Chinese) in a number of regions, including the left middle occipital gyrus (MOG), the precentral gyrus (LPG), and the right superior parietal lobule (SPL). On the contrary, no stronger activation was evoked by the L1 than by the L2.

First of all, enhanced activation was observed for L2 words than for L1 words in the left MOG, a region which has been linked to visuo-orthographic processing in the literature of visual word recognition (e.g., Bolger, Perfetti, & Schneider, 2005; Hauk, Davis, Ford, Pulvermüller, & Marslen-Wilson, 2006; Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin, 1999; Wheat, Cornelissen, Frost, & Hansen, 2010). Interestingly, the left MOG has been suggested to be involved in both alphabetic processing of single alphabetic letters (e.g., Flowers et al., 2004) and visuo-orthographic processing of Chinese characters (Tan, Liard, Li, & Fox, 2005), despite the distinct designing characteristics across the alphabetic orthography of English and the logographic orthography of Chinese. Thus, the greater activation in the left MOG during the L2 visual word recognition seems to suggest that unbalanced Chinese-English bilinguals recruit more neural resources for orthographic processing in the less proficient L2 than in the dominant L1.

Secondly, results showed greater activity for the L2 as compared to the L1 in the left LPG. In the literature on visual word recognition, the LPG has been related to sub-lexical phonological processing commonly referred to as the grapheme-phoneme conversion or phonological assembly (e.g., Mechelli et al., 2005; Nosarti, Mechelli, Green, & Price, 2010; Twomey et al., 2015). Thus, the enhanced activation during L2 word recognition probably indicates that more neural resources are devoted to phonological assembly for English lexical items. One possible explanation is that for the Chinese-English bilinguals, the L2 engages more resources for phonological retrieval due to its lower proficiency as compared to the stronger L1. As suggested by previous studies (e.g., de Bruin, Roelofs, Dijkstra, & FitzPatrick, 2014), unbalanced bilinguals require more cognitive resources associated with phonological retrieval in their weaker language. Another possibility could be partly attributed to the more transparent orthography of the English writing system, relative to the Chinese writing system. Employing a logographic/morpho-syllabic writing system, Chinese has been considered to have a deep orthography (e.g., Mei et al., 2013; Tan & Perfetti, 1998; Tzeng, 2002). In Chinese orthography, multiple graphs (characters) typically map to one syllable (unit of sound) and morpheme (unit of meaning). Therefore, visual word recognition in Chinese should involve less phonology assembly than that in English. Thus, the increased activity at the LPG seems to suggest that unbalanced Chinese-English bilinguals recruit more resources for the grapheme-phoneme conversion in English than in Chinese. We recognize that language proficiency and orthography depth are two confounding factors in the present study. It would be reserved for future studies to further investigate the role of each factor during bilingual visual word recognition.

Lastly, the present study revealed greater activation of the right superior parietal lobule (SPL) in the L2 relevant to the L1. As the activation of the right SPL has been associated with visuospatial attentional control (e.g., Kiyonaga, Korb, Lucas, Soto, & Egner, 2014; Lobier, Peyrin, Le Bas, & Valdois, 2012; Szczepanski, Konen, & Kastner, 2010), the greater activation in the right SPL during the L2 word recognition seems to suggest that unbalanced Chinese-English bilinguals recruit more resources for directing visuospatial attention to words in their weaker L2, as compared to words in the dominant L1 during visual word recognition. For example, Lobier and colleagues examined the role of the bilateral SPL in a visual categorization task with alphanumeric (i.e., alphabetic letters and digits) and non-alphanumeric characters (i.e., pseudo-letters and Japanese Hiragana). It was shown that multiple-character strings elicited enhanced activation in the SPL, as compared to single-character presented together with hash signs. Additionally, this pattern did not vary across different character types. Based on these results, the authors concluded that SPL is involved in the pre-orthographic processing of multiple-character strings. In line with this interpretation, the increased activation in the right SPL during L2 word recognition suggests that unbalanced Chinese-English bilinguals recruit more neural resources in the pre-orthographic processing of multiple-letter strings in English, relative to that of one-character or two-character words in Chinese.

Collectively, the greater activation in the left MOG, LPG, and right SPL during word recognition in the L2 could be most likely reflect the greater cognitive resources engaged in unbalanced Chinese-English bilinguals' visual word recognition in the less dominant language. Our results indicate that visuo-orthographic processing, grapheme-to-phoneme mapping, and visuospatial attentional control over pre-orthographic processing are more demanding in the bilinguals' weaker L2, leading to the involvement of greater resources in the neural correlates in charge of these functions. In general, the current finding of greater activation associated with visually processing word in the weaker language is consistent with the general pattern reported in the literature (Chee et al., 2000, 2001; Marian et al., 2007; Meschyan & Hernandez, 2006; Park et al., 2012; Sebastian et al., 2012), further indicating that increased neural resources are deployed to meet the higher demands of processing words in the less proficient language at different levels of visual word recognition, with the exception of meaning access.

In conclusion, our findings suggest that similar resources are deployed to process the meaning of words in unbalanced bilinguals' two languages during visual comprehension. Furthermore, increased activities in the brain areas associated with lexical processing, including visuo-orthographic processing, grapheme-phoneme conversion, and pre-orthographic processing of multi-character strings, are found when unbalanced bilinguals visually comprehend words in the less proficient L2. These findings contribute to the current understanding of cortical bases for various levels of processing during visual word recognition in unbalanced bilinguals.

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PART 2

Japanese

CHAPTER 9

Introduction to the multi-script Japanese writing system and word processing

Terry Joyce and Hisashi Masuda
Tama University, Japan / Hiroshima Shudo University, Japan

The general consensus among writing-systems researchers is that the Japanese writing system (JWS) is remarkably complex (Joyce, 2002a, 2011). This introductory chapter consists of two main parts that, respectively, provide an overview of the multi-script JWS and a selective review of psycholinguistic research on Japanese visual word processing. More specifically, after outlining its historical development, Part 2 focuses on the contemporary JWS and on highlighting the complex conventions that simultaneously underlie how the component scripts are employed together in essentially complementary ways while effectively sanctioning its pervasive levels of orthographic variation. In contrast, the shorter Part 3 reflects on how JWS's complexity both poses certain challenges and affords unique opportunities for investigating the complicated interactions involved in word processing.

Keywords: Japanese multi-script writing system, Japanese word processing, orthographic conventions, orthographic variation

1. Introduction

Given the common consensus among scholars of writing systems that the Japanese writing system (JWS) is so remarkably complex that it is essentially unrivalled among both historical and modern writing systems (Joyce, 2002a, 2011), it becomes almost inconceivable to start an introduction to the JWS without at least briefly noting just a few of their descriptions. Although varying somewhat in candour, the following highly selective sampling is generally representative. For example, in contrast to the directness of DeFrancis (1989: 138) who claims that the Japanese "ended up with one of the worst overall systems of writing ever created", Coulmas (1989: 122) comments that the JWS "is often said to be the most intricate and complicated writing system ever used by a sizable population". Similarly, while Fischer (2001: 167) asserts that the JWS's mixture of scripts that are "written

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together following arbitrary rules perhaps embody the most complicated form of writing ever devised", Sproat (2010: 47) remarks that "Japanese is a complex system, certainly the most complex writing system in use today and a contender for the title of the more complex system ever". And yet, while it is undeniably true that the JWS is rather complicated in nature, it should also be equally acknowledged that, as Yamada (1967) astutely suggested some time ago, the JWS is, by sheer dint of its complexity, also unquestionably of unique importance for its potential to challenge and extend our understandings of writing systems, of written language and even of language itself.

Presenting an introductory overview of the JWS, this chapter consists of two main parts. Commencing with an historical outline, the more substantial Part 2 focuses on describing the contemporary JWS and its component scripts. In contrast, the more compact Part 3 offers a highly selective review of psycholinguistic research on Japanese visual word processing.

2. JWS

2.1 Historical development of the JWS

Reflecting the conspicuous rarity of truly independent inventions of writing systems throughout human history (i.e., just Sumerian, Chinese and Mayan), obviously, it is merely inevitable matters of geographical proximity and ancient circumstance that the initial emergence of writing within Japan – earliest extant texts being 古事記 /ko-ji-ki/ (712 CE) and 日本書紀 /ni-hon-sho-ki/ (720 CE) (within glosses, hyphens mark kanji-kanji boundaries; periods mark kanji-hiragana boundaries) – was wholly dependent on the Chinese writing system (albeit as meditated via the Korean peninsula) (Coulmas, 1989; Lurie, 2012; Miller, 1967). However, that historical twist has also had far-reaching ramifications that have reverberated down in shaping the contemporary JWS.

Miller (1967: 92) has remarked that the Chinese writing system was generally 'admirably' suited to the Chinese language, but, as Lurie (2012: 163) muses, if one were to create an experiment to investigate script adaption for profoundly different languages, "it would be difficult to find a more vivid case of linguistic contrast than that provided by Japanese as it comes into contact with the Chinese script". Accordingly, the Japanese had to adapt the Chinese writing system consisting of Chinese characters, referred to as 漢字 /kan-ji/ (literally, 'Chinese characters') in Japanese, to function in orthographically representing their language. And, as Lurie (2012) convincingly argues, the core adaptive technique utilized was 訓読 /kun-doku/ 'reading by gloss'. At some risk of oversimplification, kundoku essentially entailed associating kanji with Japanese words and then rearranging their order to read them according to Japanese syntax (Habein, 1984; Lurie, 2012; Miller, 1967). Moreover, as Lurie (2012) also incisively observes, while there are some parallels with conventional translation, there are also crucial differences in the notions of generation and production. A key insight is that, while primarily a reading practice for rendering a Chinese text interpretable as Japanese, kundoku was also, in reverse, a method for implementing written language.

The kundoku-mediated account is particularly appealing in explaining how a number of key aspects of the JWS emerged and meshed together within an overarching system. Principal among them is the origin and the continuity of the dual-reading, or dual pronunciation, system of both 訓読み /kun-yo.mi/ 'native-Japanese pronunciations' and 音読み /on-yo.mi/ 'Sino-Japanese pronunciations' being associated with kanji. Mirroring the basic morphographic relationship between Chinese characters and Chinese language morphemes, no leap of imagination is required to readily grasp how kanji would have been linked to existing native Japanese morphemes for the same things. For instance, borrowing Coulmas' (1989) example, it was quite natural that the Chinese character of 人 meaning 'person' would have been *glossed*, or became associated, with the Old Japanese morpheme of /fitö/, which underlies the modern Japanese kunyomi of /hito/. However, kundoku also had a supplementary counterpart known as 音読 /on-doku/ 'reading by sound', where characters were read according to Sino-Japanese approximations of their Chinese pronunciations. Although traditional accounts of the adaption process (i.e., Miller, 1967) have assigned a more pivotal role to ondoku, current evidence accords greater precedence to kundoku (Lurie, 2012). Initially, ondoku was only employed rather haphazardly on a lexical basis, such as a reader's stylistic whim to eschew a particular kunyomi, but it steadily became the natural resort for coping with the considerable influx of Chinese loanwords into the Japanese lexicon by the eighth century (Lurie, 2012). Hence, 人 is also associated with a modern onyomi of /jin/, based on the Old Chinese pronunciation of /jen/.

Another particularly compelling piece of the kundoku-mediated account relates directly to the emergence of the syllabographic kana scripts during the ninth century. The keen realization is that, although the two kana scripts developed from separate practices, both scripts originated out of a shared core strategy of using Chinese characters as phonographs – ignoring their semantic referents to use just for their phonetic values – that "evolved in order to record *kundoku* readings and only subsequently came to be employed more independently" (Lurie, 2012: 174). Crucially, however, rather than becoming completely autonomous and replacing kanji usage, the kana scripts essentially remained as complementary components of the overall contemporary multi-script JWS. Similar to how the Chinese orthographically represented foreign names, the phonographic strategy was employed in the 万葉集 /man-yō-shū/ anthology of Japanese verse (759 CE), and, retrospectively, the term 万葉仮名 /man-yō-ga-na/ has often been applied to the set of phonographic characters used at that time (Lurie, 2012; Miller, 1967; Shibatani, 1990). Over time, kundoku conventions came to include the annotation of Chinese texts with man'yōgana to indicate kunyomi and Japanese grammatical elements, particularly by Buddhist priests engaged in textual studies. However, their scribal practices fostered abbreviations of the man'yōgana, usually by emphasizing a character's distinctive feature, that eventually developed into the contemporary 片仮名 /kata-ka-na/ script. In contrast to abbreviation for katakana, the process for 平仮名 /hira-ga-na/ was one of cursive writing, where, by the early Heian period (794–1185), man'yōgana evolved into a form known as 草仮名 /sō-ga-na/ 'grass style', which, in turn, eventually lead to the even more simplified and cursive forms of contemporary hiragana (Habein, 1984; Lurie, 2012).

Yet another key historical development has been the contemporary policies generally aimed at restricting the number of kanji in daily use (Seeley, 1984, 1991; Twine, 1991). Since the mid-twentieth century, the Japanese government has issued a series of guidelines concerning kanji usage; the first was the 当用漢字表 /tō-yō-kan-ji-hyō/ list of 1,850 kanji issued in 1946, which was followed by the 常用漢字 /jō-yō-kan-ji/ 'characters for general use' list of 1,945 kanji in October 1981, which was revised to include 2,136 kanji in November 2010 (Bunkachō, 2010).

Admittedly, these few fleeting observations are inadequate to fully convey the sense of continuity that characterizes the historical development of the JWS, but its quintessentially multi-script nature was established relatively early during the seventh and eighth centuries and has endured to the present day (Lurie, 2012; Martin, 1972).

2.2 Contemporary JWS and its multi-scripts

Generally referred to as 漢字かな交じり文 /kan-ji.kana.ma.jiri.bun/ 'mixed kanji and kana writing', the standard orthographic conventions for the contemporary JWS are to employ its multi-scripts – namely, morphographic kanji (Joyce, 2002a, 2011, 2016), the two syllabographic scripts of hiragana and katakana, the phonemic alphabet of ローマ字 /rōma.ji/ 'Roman alphabet', and 数字 /sū-ji/ 'Arabic numerals' – in essentially separate and complementary ways in representing the Japanese language in writing. These conventions effectively function in visually differentiating between content words – usually represented in kanji but often in katakana and occasionally in rōmaji – and grammatical elements – mainly in hiragana – and also in distinguishing, to a lesser degree, between the main lexical stratums of Japanese – usually native-Japanese in kanji and hiragana, Sino-Japanese in kanji, and foreign-Japanese in katakana and increasingly in rōmaji in some domains (Gottlieb, 2008; Igarashi, 2007; Kess & Miyamoto, 1999; Joyce, 2011; Joyce, Hodošček, & Nishina, 2012; Joyce, Masuda, & Ogawa, 2014; Smith, 1996; Taylor & Park, 1995; Taylor & Taylor, 2014; Tranter, 2008).

Naturally, the proportions by which the multiple scripts are mixed in any given text depend on a variety of sociolinguistic factors, including the nature of the content and its context, reflecting intended audiences and publication format, as well as an author's stylistic freedoms and preferences (Joyce & Masuda, 2016, 2017). An initial rough sense of the mixture can be gained from a study by Chikamatsu, Yokoyama, Nozaki, Long and Fukuda (2000) which analysed one year (1993) of Asahi Newspaper's articles to find that, of the approximately 56.6 million character tokens, kanji accounted for 41.38%, hiragana for 36.62%, katakana for 6.38%, punctuation and symbols for 13.09%, Arabic numerals for 2.07% and Latin alphabet for 0.46%. However, as character-token data alone is not so informative, a complementary perspective on typical script proportions and their latitudes can be gained from Igarashi's (2007) analyses of a word-type list extracted from nine magazines, three newspapers and some TV commercials (depending on which of the National Language Research Institute's historic word definitions is employed, Igarashi's list contains either 22,612 β unit words (basically morphemes and simplex words) or 7,351 α unit words (complex words)). Across the three genres, the average percentages for the four script-types were 60.72% kanji words, 20.51% hiragana words, 12.69% katakana words and 6.09% alphabetic symbols and numbers, but the percentages also varied noticeably for the different genres. At one extreme, the newspaper sub-list consisted of 72.33% kanji words, 18.24% hiragana words, 5.73% katakana words and 3.81% alphabetic symbols and numbers, while, at the opposite extreme, the TV commercials sub-list consisted of 51.38% kanji words, 20.51% hiragana words, 17.35% katakana words and 10.80% alphabetic symbols and numbers. Moreover, while the average percentages for the magazine sub-list fell between these divergent trends, Igarashi also reported considerable degrees of script-type variation across the range of sampled magazines.

Obviously, no single authentic Japanese sentence can encapsulate all aspects of the JWS, but the sentence in Figure 1 is a fairly illustrative example taken from the Japanese Wikipedia entry for JIS X 0208 (a Japanese Industrial Standard (JIS) character set that will be mentioned again shortly).

JIS X 0208（ジス X 0208）は、日本語表記、地名、人名などで用いられる6,879図形文字を含む、主として情報交換用の2バイト符号化文字集合を規定する日本工業規格である。

jisu ekusu rei-ni-rei-hachi (…) wa, ni-hon-go-hyōki, chi-mei, jin-mei nado de mochi.irareru rokusen-happyaku-nanajū-kyū zu-kei-mo-ji o fuku.mu, shu.toshite jō-hō-kō-kan-yō no ni.baito fu-gō-ka-mo-ji-shū-gō o ki-tei.suru ni-hon-kō-gyō-ki-kaku dearu.

JIS X 0208 is a Japanese Industrial Standard that stipulates the 2-byte encoded character set primarily utilized for information exchange, which includes 6,879 graphic characters used for Japanese language writing, place names and personal names, etc.

Figure 1. Example of Japanese sentence, with phonological gloss and translation

As noted already, kanji are generally used to represent native-Japanese and Sino-Japanese content words, including nouns, the stems of verbs and of some adjectives, and some adverbs. For instance, consistent with the morphographic nature of kanji (Joyce, 2002a, 2011), the first string of five kanji in Figure 1 is a polymorphemic word, which consists of 日本 'Japan' + 語 'language' + 表記 'representation, writing', and one of the native-Japanese verbs is 含む /fuku.mu/ 'include', where the stem is represented by one kanji and the present-tense inflection is represented by one hiragana character. Hiragana are usually used to represent functional words, including the copula verb and the auxiliary する /suru/ 'do' verb, inflectional elements of verbs and some adjectives (when they are referred to as 送り仮名 /oku.ri.ga-na/), grammatical case markers and conjunctions. Figure 1 sentence ends with the copula である /dearu/ in the formal present-tense, has the Sino-Japanese noun 規定 /ki-tei/ 'stipulations' combined with する to form the verb 'stipulate', and includes the most frequent grammatical marker of の /no/ 'possessive; nominalization'. Katakana is usually used to represent 外来語 /gai-rai-go/ 'foreign-Japanese' (referring to loanwords of foreign origin but excluding those from Chinese), foreign names, animal and plant species names, onomatopoeic expressions, and for emphasis and as glosses. Figure 1 contains one loanword バイト /baito/ 'byte' and is also used within the parentheses to indicate the pronunciation of JIS as ジス /jisu/. Rōmaji is usually used to represent foreign words and names, most commonly within advertising and the mass media. The single example in Figure 1 is JIS within JIS X 0208, where it forms an element of the standard reference code as an abbreviation of the established English translation for 日本工業規格. Arabic numerals are also widely used to represent numbers, particularly in scientific and financial domains. There are two Arabic-numeral strings within Figure 1; the first is 0208, as part of the standard's reference code, which is read digit by digit, and the second is 6,879 for the number of graphic characters, which is read as a number. Clearly, 6,879 is much shorter than the corresponding kanji representation of 六千八百七十九, where digit values must be indicated (which is also obligatory when reading as a number, as the phonological gloss indicates; just as one would read the number in English as 'six-thousand, eight-hundred and seventy-nine').

Notably, one earlier kundoku practice to persist is the strategy of margin annotations, now known as ルビ /rubi/. The most common application is – when there is some expectation, such as in children's reading materials, that a kanji's pronunciation might not be known by a reader – to indicate it with a kana gloss (also referred to as 振り仮名 /fu.ri.ga-na/) that is usually placed above. However, the basic technique is extendable to any component script for more diverse purposes, such as indicating an alternative pronunciation for effect, offering explanation of a word, and simultaneously evoking additional concepts (Joyce & Masuda, 2016).

While these basic orthographic conventions are generally adhered to, patently, orthographic variation is also an inherent property of the JWS by simple virtue of its multi-scripts. The pervasive nature of orthographic variation, at least for the most common Japanese words, is strikingly evident in the analyses that Joyce et al. (2012) conducted on the corpus word lists (CWLs) that they extracted from the large-scale Balanced Corpus of Contemporary Written Japanese (BCCWJ; Maekawa et al., 2013; see also Joyce, Hodošček, & Masuda, 2017). More specifically, they found that the average number of orthographic variations is 8.44 (min 6.46, max 10.19) for the most frequent 100 short-unit words (essentially simplex words) across the four main word classes of nouns, verbs, i-adjectives and adverbs. For example, five orthographic variants are attested for the noun of 玉葱 /tama-negi/ 'onions', nine for the verb of 聞き取る /ki.ki.to.ru/ 'hear, catch (words)', 11 for the i-adjective of 面白い /omo-shiro.i/ 'interesting; amusing' and 13 for the adverb of 全然 /zen-zen/ 'not at all; entirely'. As Joyce and Masuda (2016, 2017) illustrate, there are a number of motivating factors for these high degrees of orthographic variation, including aesthetics factors, desires to avoid complex kanji or ones with negative connotations, differentiating meaning nuances, and orthographic balance between words.

2.2.1 *Morphographic kanji*

As already alluded to, kanji remain the principal script for the orthographic representation of native-Japanese and Sino-Japanese content words. As also noted, the Japanese government's official jōyō kanji list specifies 2,136 kanji; it consists of 1,006 教育漢字 /kyō-iku-kan-ji/ 'education kanji', that are taught during elementary school, and 1,130 kanji, that are taught at high-school (Bunkachō, 2010; Joyce et al., 2014). It should, however, be quickly stressed that this list does not represent an absolute ceiling on the number of kanji in daily usage. Like so many facets of the JWS, the situation is naturally rather more nuanced and a few comments of further clarification are warranted. In particular, it is helpful to understand that the 2010 revision was not a radical reform of kanji policy; rather, it is more appropriate to regard it as a periodic tweaking of the official list that involved the removal of five characters and the addition of 196 kanji compared to the previous version. It is also beneficial to bear in mind that the list only has guideline status; while generally conformed to in official documents and in newspapers, it is not prescriptive for all written Japanese language. As referred to earlier in Figure 1, JIS X 0208 specifies a set of 6,879 graphic characters for the present era of electronic information exchange, which effectively imposes more practical restrictions on kanji usage in actually specifying 6,355 kanji, including 2,965 level 1 and 3,390 level 2 kanji (Lunde, 1993). Hence, it is also valuable to look at corpus data in order to gain more informed insights concerning actual kanji usage. Also analysing kanji coverage for their BCCWJ-based CWLs, Joyce et al. (2012) report that, although the revised jōyō kanji only represent 33.03% of kanji types, they account for the majority of kanji tokens at 96.12%. Moreover, while 4,093 of the remaining JIS kanji represent 63.30% of the types, they only account for 3.60% of the tokens, with another 237 kanji making up the final 3.67% of types and only a negligible 0.27% of the tokens. With these few caveats lodged, it becomes clearer that while the jōyō kanji list has considerable status as a de facto standard for functional Japanese literacy, generally, educated Japanese people are still expected to know substantially more kanji that continue to be associated with areas of cultural significance, such as their use in place and family names.

Beyond their numbers, another important aspect of kanji is that they naturally vary a great deal in their visual complexity. For instance, the number of strokes to write the jōyō kanji ranges from one (i.e., 一 /ichi/ 'one') to 29 strokes (i.e., 鬱 /utsu/ 'depression'), with the average count being 10.47 strokes (*SD* 3.79) (Joyce et al., 2012). Obviously, complexity on such a scale is only feasible because the majority of kanji possess internal structure (i.e., basic kanji or variant forms) related to the various formation principles that underlie their creation (Joyce, 2011); the dominant principle being that of 形声文字 /kei-sei-mo-ji/ 'phonetic compound kanji', where a 部首 /bu-shu/ '(semantic) radical' is combined with an 音符 /on-pu/ '(phonological) radical', such as 言 'speak' combined with 吾 /go/ 'I; my' to indicate 語 /go/ 'language'. Analysing the internal structures of jōyō and JIS level 1 (JIS1) kanji in terms of three basic configurations (namely, left-right, top-bottom, and enclosure-enclosed, plus a non-divisible category for the remainder), Joyce et al. (2014) report that 91.3% of jōyō and 92.6% of JIS1 kanji possess these basic configurations. Their analysis also involved the identification of 1,072 and 1,290 component elements for jōyō and JIS1 kanji, respectively.

As acknowledged earlier, one particularly compelling factor of the kundoku-mediated account is in elucidating the origins and persistence of the dual-reading system of both kunyomi and onyomi associated with kanji. Once again, however, the complete picture is rather more nuanced in nature, because there is also variation in the numbers of readings associated with particular kanji. A major factor being that there are actually three different kinds of onyomi, reflecting the fact that Chinese characters were borrowed at different periods and from different regions of China (Lurie, 2012; Miller, 1967; Shibatani, 1990). Although Coulmas (1989: 126) singles out 頭 'head; counter for large animals' as a rather extreme example, associated with four onyomi, /zu/, /tō/, /do/, and /ju/, and six kunyomi, /saki/, /atama/, /kashira/, /kōbe/, /kaburi/ and /tsumuri/, it should also be noted that the Japanese government's guideline policies have generally sought to reduce the number of official pronunciations associated with jōyō kanji. As Joyce et al. (2014) report, although the number of onyomi associated with jōyō kanji ranges from 0–5 and the number of kunyomi ranges from 0–10, the frequency distribution is skewed towards small sets of associated pronunciations. Accordingly, while 92.0% of jōyō kanji are associated with 0–2 kunyomi and 0–2 onyomi, 34.7% have only one onyomi and no kunyomi and 32.1% have only one onyomi and one kunyomi. However, as explained further within the next sub-section on the kana scripts, reflecting the relatively uncomplicated nature of Japanese phonology, the comparatively high incidences of Japanese homophones are particularly associated with onyomi. For instance, 67 jōyō kanji are associated with the onyomi of /kō/ and 66 are associated with /shō/. As noted earlier, onyomi are derived from Japanese approximations of associated Chinese pronunciations, but, many Chinese phonological distinctions, including tone distinctions, in particular, were effectively lost due to the simpler syllable structure of Japanese. In illustration, Martin (1972: 98f) suggests that the diverse classical Chinese syllables of /ko/, /kau/, /kou/, /kwang/, and /kong/, with either aspirated or unaspirated initial as well as three separate tones, all coalesced as the Japanese onyomi of /kō/.

2.2.2 *Syllabographic kana*

As already stressed, the kundoku-mediated account also provides a persuasive explanation of how from the very beginning the syllabographic kana scripts emerged to fulfil complementary functions that led to the contemporary multi-script JWS. As also noted earlier, although hiragana and katakana developed in separate ways, they essentially overlap in their potential to orthographically represent the syllables of Japanese phonology, or, more precisely, 拍 /haku/ 'mora' referring to equal-duration syllables.

Joyce et al. (2017) classify Japanese morae according to three main types of 71 basic, 33 contracted and 64 extended morae, for which there are only a few exceptions to having one-to-one mapping relations to the kana scripts. The basic mora group includes the five Japanese vowels of /a/, /i/, /u/, /e/ and /o/, for which the hiragana are あ, い, う, え, and お and for which the katakana are ア, イ, ウ, エ, and オ, respectively. The contemporary kana sets also consist of 39 consonant-vowel (CV) combinations of nine unvoiced consonants and 20 CV combinations with four voiced consonants and one semi-vowel consonant (although the calculation of 5 times 14 (9+4+1) returns 70, some CV combinations were never or are no longer distinguished from the corresponding vowels). For instance, the k-V combinations of /ka/, /ki/, /ku/, /ke/, and /ko/ are represented by the hiragana か, き, く, け, and こ and by the katakana カ, キ, ク, ケ, and コ, respectively. The basic mora group also includes one moraic nasal, /N/, hiragana ん and katakana ン, and one 促音 /soku-on/ 'glottal stop' of consonant gemination, hiragana っ and katakana ッ. One of the rare exceptions to the one-to-one relationship between kana and mora involves the hiragana を and katakana ヲ symbols, which historically corresponded to /wo/ but are now pronounced as /o/ and are restricted to orthographically representing the 'object' grammatical marker. The basic kana sets are often described as consisting of 46 basic characters (5 vowels, 39 unvoiced CV combinations, plus /N/ and /wo/), because the other 20 CV combinations are orthographically derived by adding diacritics to some of the basic characters. Thus, for example, hiragana が /ga/ and katakana ガ /ga/ are derived by adding ゛, known as 濁音 /daku-on/ 'voiced', to か and カ /ka/, respectively, while hiragana ぱ /pa/ and katakana パ /pa/ are derived by adding ゜, known as 半濁音 /han-daku-on/ 'semi-voiced', to は and ハ /ha/, respectively. The 33 contracted mora group consists of CyV clusters, known as 拗音 /yō-on/, which involve combining 11 of the basic CV mora ending with /i/ vowels with reduced forms of either /ya/, /yu/ and /yo/. For example, /kya/, /kyu/ and /kyo/ are represented by the hiragana きゃ, きゅ, and きょ and by the katakana キャ, キュ, and キョ, respectively. The third main type of 64 extended mora relates to the additions to the traditional Japanese mora inventory to cope with the transcription of foreign loanwords and names, for which the katakana script is usually used. The extended morae are somewhat similar to the contracted group in that they all involve either a basic V or CV mora combined with either a V alone or one of the /ya/, /yu/ and /yo/ CV combinations, such as ク /ku/ and a reduced ワ /wa/ combined as クヮ /kwa/ and テ /te/ and a reduced ュ /yu/ as テュ /tyu/.

Reflecting the strong societal expectations that Japanese children have generally learnt hiragana before entering elementary school, as Taylor and Taylor (2014) observe, first grade reading materials are initially only in hiragana, but katakana and some basic kanji are taught during the first grade. Even though kanji are graphically more complex, Steinberg and Yamada (1978–1979) have reported that three- and four-year-old Japanese children can find some kanji easier to recognize than kana symbols, because they represent meaningful concepts rather than abstract sounds.

2.2.3 *Phonemic rōmaji, Arabic numerals and punctuation*

Japanese contact with phonemic rōmaji can be traced back to Portuguese missionaries in the late 16th and early 17th centuries (Lurie, 2012; Okada, 2016). However, it is only really appropriate to regard it as a component of the JWS since the mid-twentieth century, when first taught at elementary schools (currently introduced during grade 4), and, even now, it remains the most peripheral or niche of the component scripts in terms of usage. In addition to representing foreign names and words, rōmaji is also used to represent Japanese words, especially Japanese-coined English terms, in general media contexts, particularly in advertising and information contexts, such as supplementary glossing of names for stops on public transport systems potentially for the benefit of foreigners. CM /shīemu/

‘TV commercial, ad’ seems to be a model example of rōmaji usage within the JWS; in addition to being almost exclusively represented in rōmaji (99.92% of BCCWJ occurrences; Joyce et al., 2012), it is an abbreviation for ‘commercial message’ which is a Japanese-coined term that is attested only once within the BCCWJ in full in katakana script, and, naturally, is of high frequency within the world of advertising. Yet again, orthographic variety is the norm because alternative transcriptions conventions exist; the government official 訓令式 /kun-rei-shiki/ ‘Cabinet ordinance system’, the ヘボン式 /hebon.shiki/ ‘Hepburn system’ (proposed by the American missionary James Curtis Hepburn (1815–1911), which is used for the phonological transcriptions provided throughout this chapter), and the oldest but least commonly used 日本式 /ni-hon-shiki/ ‘Nihon system’. Thus, for instance, 富士山 ‘Mount Fuji’ is rendered as either /huzisan/ (kunreishiki), /fujisan/ (hebonshiki), or /hudisan/ (nihonshiki). It also bears mentioning that, while kana-input modes are also available, the most commonly used method of inputting Japanese on computers with the QWERTY keyboard is the rōmaji-input mode (Okada, 2016), but kana-input methods tend to dominate for small screen devices, such as mobile and smart phones.

Even though the jōyō kanji list includes kanji that represent large numbers (up to 京 /kei/ ‘10^{16}’) and kanji are commonly used in representing numbers, particularly for vertically-arranged texts, as already noted, Arabic numerals are also frequently used as part of the JWS, especially for scientific and financial texts that tend to be arranged horizontally.

While it is true that Japanese is written without spaces between words, as the sentence in Figure 1 illustrates, the JWS includes a number of punctuation marks; some of which are similar to those of European languages in terms of form and function and some of which are specific to the JWS. As a full description of Japanese punctuation is beyond the scope of this chapter, only a few examples are mentioned. Somewhat differing in form but generally similar in function, JWS has 、読点 /tō-ten/ as a comma and 。句点 /ku-ten/ as a full stop. It also has quotation marks that are essentially similar in function, but very different in form; 「…」鉤括弧 /kagi-kak-ko/ ‘single quotation marks’ and 『…』二重鉤括弧 /ni-jū-kagi-kak-ko/ ‘double quotation marks’. One punctuation mark that is specific to the JWS is ・中黒 /naka-guro/ lit. ‘middle black (dot)’ that usually functions as a separator (of characters or words).

3. Psycholinguistic studies of Japanese word processing

3.1 Misleading, but enduring, dichotomies

In their important book reviewing psycholinguistic studies of kanji and kana processing, Kess and Miyamoto (1999) remark that such research has been one of the most active areas of Japanese psycholinguistics (for other reviews and edited collections, see Akita & Hatano, 1999; Chen (Ed.), 1997; Chen & Zhou, 1999; Flores d'Arcais, 1992; Hatta & Saito (Eds.), 1999, 2000; Kaiho & Nomura, 1983; Kess, 2005; Leong & Tamaoka (Eds.), 1998; Paradis, Hagiwara, & Hildebrandt, 1985; Saito, 1997, 2006; Sato, 2015; Tamaoka, 1991, 1994; Taylor & Taylor, 2014; Wydell, 2006; Yamada, 1997). While the JWS's unique multi-script nature undoubtedly opens up many potentially interesting opportunities for investigating the processes of visual word recognition, such as comparing functionally different scripts (i.e., morphographic, syllabographic and phonemic), as Part 2 sought to portray, the JWS's complex orthographic conventions also pose special challenges in terms of not confounding various lexical properties across experimental contrasts. Although highly selective in nature, Part 3 seeks to single out a few studies that substantiate Kess and Miyamoto's core insight of denouncing the simple 'early dichotomies' between phonological routes for kana and semantic routes for kanji, which regrettably continue to endure, as woefully inadequate to account for the complex interactions involved in word processing.

3.2 Studies of single kanji processing

Notwithstanding their morphographic nature (Joyce, 2002b, 2011) – such that, while many kanji do represent *free morphemes* (i.e., simplex words), in the vast majority of cases, kanji represent the constituents of *polymorphemic words* (i.e., verb and adjectives stems and elements of compound words) – a great deal of psycholinguistic research has focused on the single kanji to examine the balance between phonological and semantic activation within lexical retrieval (Flores d'Arcais, 1992; Flores d'Arcais, Saito, & Kawakami, 1995; Mizuno, 1997; Saito, Masuda, & Kawakami, 1998; Sakuma, Sasanuma, Tatsumi, & Masaki, 1998; Shimomura & Yokosawa, 1995; Wydell, 1991; Wydell, Patterson, & Humphreys, 1993). Accordingly, many of these studies have focused on phonetic compound kanji – as already noted, the dominant principle of kanji formation combines a semantic marker with a phonetic marker – and, taken together, they generally demonstrate that the lexical retrieval of single kanji involves rather complex interactions within the activation of orthographic, phonological and semantic information.

For instance, one such early study is by Flores d'Arcais (1992), who argues that, while phonological information appears to be activated before semantic information in the naming task, which particularly emphasizes a kanji's pronunciation, the meanings of component radicals are activated during the recognition of complex kanji, even when not semantically related to the kanji meaning. Consistently, Flores d'Arcais and Saito (1993) have also reported semantic activation for component radicals in a speeded semantic-categorization task, where they observed interference in all critical conditions of graphically similar kanji pairs (仲 'friend' and 伸 'extend'), part-whole related kanji pairs (石 'stone' appears to contain 口 'mouth'), and opaque-component related kanji pairs ('mouth' element of 石 and 目 'eye').

Studies have also reported evidence for the phonologically-mediated activation of kanji words. For example, in a semantic categorization task, Wydell et al. (1993) have reported, in addition to significant effects of visual similarity, significant homophone effects with reactions times longer and greater error rates when responding to homophone distractors compared to correct exemplars. While Sakuma et al. (1998) have also obtained similar results for the same task, they also found that the homophone effect was reduced in a masked condition, but the effects of orthographic similarity remained strong. Moreover, Saito et al. (1998) also provide further evidence for both orthographic and phonological activation using a delayed matching task, where participants judged whether a 'probe' kanji (e.g., 畔) was one of two briefly presented 'source' kanji (e.g., 略 and 伴). Only observing a homophone effect when the probe was orthographically similar to the source kanji, they interpreted their findings as indicating that phonological information is automatically activated for both radicals and whole kanji, even though it is not explicitly required for the task.

3.3 Studies of kana processing and kana-kanji comparisons

To the extent that the JWS's orthographic conventions are generally adhered to, one experimental manipulation that can be (cautiously) exploited is orthographic familiarity. In one early naming study of katakana, Besner and Hildebrandt (1987) contrasted orthographically familiar words (i.e., normally represented with katakana) with orthographically unfamiliar words (i.e., normally represented with kanji), as well as non-words. The researchers interpreted their findings of orthographically familiar words being named faster than both orthographically unfamiliar words and non-words as indicating that phonological recoding is not obligatory for familiar kana.

Naturally, a number of studies have also sought to compare the processes of visual word recognition for kana and kanji (Hino, Lupker, Ogawa, & Sears 2003;

Kim, 2012; Shimamura, 1987; Yamada, 1997, 1998). For instance, employing the Stroop task and an interesting paradigm variation, Shimamura (1987) conducted an early comparative study that underscores the important dissociation between word naming and word comprehension. The Stroop effect is where participants are slower to name the ink colour of a printed word when the word itself is the name of a colour that is incongruent with the ink colour (Stroop, 1935). Shimamura reported greater Stroop interference for conflicting colour words represented in kanji compared to katakana, even though katakana representations were named faster. In the paradigm variation, participants were asked to indicate the spatial location of a stimulus, such as a conflicting arrow (↓), kanji word (下), or katakana word (シタ) indicating 'down' in an *up* position. While interference was also observed for the conflicting arrow condition, it was greatest in the kanji word condition, but, again, words represented in kana were named faster than the kanji-orthography words.

More recently, Kim (2012) conducted an eye-tracking study with Japanese adults reading both a conventional multi-script version and a hiragana-only version of a text. Although the participants were equally effective in recounting the passage content in both orthographic conditions, they were much slower to read the hiragana-only version, which required both more and longer fixations compared to the authentic multi-script version. Consistent with the empirical eye-tracking data that indicated that the hiragana-only version was read less fluently, all participants self-reported on experiencing the hiragana-only version as being harder to process and less natural to read.

3.4 Studies of compound word processing

As an agglutinative language, Japanese certainly has a substantial degree of affixation, but in contradistinction to Myers' (2006: 169) pronouncement that "Chinese is the poster child of compounding, the language to cite for an example of morphology without much affixation", unquestionably, Japanese also offers some of the most intriguing cases for research into the morphology of compound words, given that compounding is a highly productive principle of word-formation involving both Sino-Japanese and native-Japanese morphemes (Joyce & Masuda, 2013; see also Masuda & Joyce, 2018). Particularly germane to the point, Nomura's (1988) assertion that two-kanji compound words are the most common word structure in the Japanese language is essentially validated by Joyce et al.'s (2014) analyses of the orthographic structures of Japanese words; particularly, their analysis of approximately 215,600 headwords of the 広辞苑 /kō-ji-en/ dictionary (Shinmura, 2008) that found that the three most frequent orthographic codes were 2C (two-kanji) at 37.5%, 3C (three-kanji) at 15.1% and 4C (four-kanji) at 8.9%.

As one of the first studies to specifically consider the lexical representation of two-kanji compounds within the mental lexicon, the lexical decision task experiments conducted by Hirose (1992) merit brief attention. Employing a form of constituent-morpheme priming to investigate the pattern of facilitations on lexical decisions for two-kanji compound-word targets following one of three prime conditions (first-constituent, second-constituent, or unrelated kanji), Hirose observed significant priming in both constituent conditions. Moreover, because significantly greater priming was observed for the first-constituent condition compared to the second-constituent, somewhat reminiscent of Forster's (1976) serial search model, Hirose hypothesized that the lexical retrieval of two-kanji compound words might be based on search mechanisms for clustered arrangements of compound words according to their shared first-constituents. This notion would, however, seem to entail some curious repercussions for the representation of related compound words within the mental lexicon. For instance, if clusters are only based on shared first-constituents, related compounds like 学習 /gaku-shū/ 'learning' and 大学 /dai-gaku/ 'university' would not be linked, which would seem to be even more problematic for the synonyms of different lexical stratum, such as Sino-Japanese 登山 /to-zan/ 'mountain-climbing and native-Japanese 山登り /yama-nobo.ri/ 'mountain-climbing'. Accordingly, Joyce (2002a, 2002b) sought to essentially replicate Hirose's experiments, but by also controlling for and contrasting five word-formation principle conditions underlying the two-kanji compound-word targets. Similar to Hirose's results, compared to the unrelated prime conditions, Joyce observed significant priming effects in the two constituent-morpheme conditions across all word-formation principle conditions. However, quite dissimilar to Hirose's results, Joyce also found that the levels of priming in the two constituent conditions were similar across four out of the five word-formation conditions; a result that is not compatible with search mechanisms that prioritize the first-constituent (see also Masuda & Joyce, 2018).

To account for those findings, Joyce (2002a, 2002b, 2004) proposed the Japanese lemma-unit model (JLUM) as a model of the Japanese mental lexicon, that was largely inspired by the version of the multi-level interactive-activation framework proposed for the Chinese mental lexicon by Taft, Liu, and Zhu (1999). In a significant modification of an earlier model (Taft & Zhu, 1997), Taft et al. (1999) advocated the incorporation of lemma unit representations to mediate the connections between both orthographic and phonological access representations and semantic representations, as a solution to issues of representational redundancy, homographs and semantic transparency. In addition to benefiting from these advantages – which remain problematic areas for Saito's (1997) companion-activation model and Tamaoka and Hatsuzuka's (1998) interactive-activation model, although, arguably, less so for Ijuin, Fushimi, Patterson, and Tatsumi's (1999) distributed connectionist model of naming – JLUM can also provide a more appealing account of the constituent-morpheme priming results just outlined. Given that the lexical retrieval of two-kanji compound words is assumed to be mediated by mechanisms of spreading activation, it can readily accommodate priming effects for the second-constituent condition. However, the most distinctive feature of the JLUM is that it is the first model of the Japanese mental lexicon that, on the one hand, seeks to capture the nuances of the dual-reading system of both kunyomi and onyomi, and, on the other hand, attempts to unify the processing of the JWS's multi-scripts within a single integrated model (see also Masuda & Joyce (2018) for further explanation).

4. Conclusion

This chapter has attempted to tender a concise yet informative introduction to the multi-script JWS and Japanese word processing; a rather daunting challenge in view of the scholar judgements, acknowledged at the outset, concerning its considerable complexity. After singling out just a few key historical developments, Part 2 presented a succinct outline of the contemporary JWS's standard orthographic conventions that effectively serve both to visually differentiate content words from grammatical elements and to distinguish, to a lesser extent, between the main lexical stratums. It is, however, also paramount to appreciate how both the co-existence of multiple scripts and the highly malleable nature of these standard orthographic conventions combine to produce remarkable levels of orthographic variation (Joyce et al., 2012). Echoing Backhouse's (1984) perceptive remark about the incredible potential for orthographic flexibility, the JWS's multi-scripts undoubtedly foster highly imaginative and innovative ways of thinking about the orthographic representation of language. Writing in Japanese potentially involves making script selections that, arguably, reflect a unique awareness of written language (Joyce & Masuda, 2016, 2017).

Contrastive in terms of both its brevity and focus, Part 3 presented a highly-selective review of psycholinguistic research on Japanese visual word processing. While sounding cautionary notes about methodological challenges for experimental designs, such as the wide prevalence of orthographic variation potentially diminishing the significance of orthographic familiarity contrasts, and about the enduring influences of misleading theoretical dichotomies concerning processing routes, Part 3 sought to highlight with a small selection of examples how the multi-script nature of the JWS unquestionably offers some of the most exciting prospects for investigating the complex interrelationships between orthography, phonology and semantics, that are foundational issues for more adequately understanding writing systems and word processing.

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CHAPTER 10

L1-referenced phonological processing in Japanese-English bilinguals

Michelle Broekhuyse and Marcus Taft
University of New South Wales, Sydney, Australia

Previous research investigating second-language processing difficulties experienced by Japanese native speakers is consistent with the notion that these individuals are representing foreign words in terms of their native phonological structure at an abstract underlying level. This issue is illustrated here by an experiment that compared Japanese-English bilinguals and native English speakers on their immediate recall of English pseudo-words. Recall performance was dependent on the number of phonemes within list items for the monolingual participants, but on the number of morae for the Japanese bilinguals, indicating that they were indeed automatically activating "Japanized" abstract representations upon encountering the non-native constructions. It is particularly noteworthy that this appeared to be true regardless of the age at which the bilinguals had learnt English.

Keywords: L2 phonological processing, Japanese-English bilinguals, immediate serial recall, phonological representations

Introduction

It is now well established that the processing of L2 speech is influenced not only by the categorisation of speech sounds in the bilingual's L1, but also by L1-specific constraints on the possible *combinations* of those speech sounds (e.g., Flege, 1989; Kabak & Idsardi, 2007; Martinez-Garcia & Tremblay, 2015; Rochet & Putnam Rochet, 1999; Vokic, 2008; Weber & Cutler, 2006). Indeed, even if a particular phoneme is attested in an individual's native language, L2 processing issues may result from differences in the phonotactic rules governing its placement within a word or in relation to other phonemes (Vokic, 2008). Given that their native language places very strict constraints on syllable structure, particularly when compared to English, it is unsurprising that Japanese native speakers regularly encounter difficulties when processing non-native speech (e.g., Dupoux, Kakehi, Hirose, Pallier, & Mehler,

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1999; Masuda & Arai, 2010). The present chapter explores the possibility that, for Japanese-English bilinguals, such difficulties are attributable to L1-influenced representations of L2 phonology.

Japanese phonological structure and the processing of consonant clusters

There is evidence to suggest that, when compared to English speakers (for whom the phoneme is the smallest functional segment), Japanese native speakers process words by means of a larger phonological unit (Verdonschot et al., 2011). This unit, the mora, is most easily defined with reference to the native Japanese syllabaries, *Katakana* and *Hiragana*; in both scripts, each character uniquely represents a single mora. Thus, although the word *nihon* (にほん) comprises two syllables (i.e., *ni* and *hon*), it is represented by three characters and consists of three corresponding morae (i.e., *ni, ho*, and *n*). In Japanese, each mora corresponds to one of five types: CV (consonant, vowel), C/j/V (consonant, palatal glide, vowel), V (vowel), nasal coda, or the first part of a geminate consonant.

As a consequence of this, when compared to English, Japanese places much more restrictive constraints on the permissible combinations of phonemes in the language. For example, syllable-initial consonant clusters are illegal in Japanese[1] and only a single geminate or nasal consonant is permitted in coda position (Gussenhoven & Jacobs, 2011). Thus, aside from a few minor exceptions, Japanese syllables are typically of the form CV or V and, phonologically, the incidence of consonant clusters in the language is very low. This is in stark contrast to English, which allows long sequences of consonants both at the beginning and end of a syllable.

There is much evidence to suggest that the strict constraints on Japanese syllable structure have significant implications for both the perception and production of English by native Japanese speakers (e.g., Dehaene-Lambertz, Dupoux, & Gout, 2000; Dupoux et al., 1999; Dupoux, Pallier, Kakehi, & Mehler, 2001; Masuda & Arai, 2010; Shibuya & Erickson, 2010). Studies have shown that, when producing English words or nonsense words, Japanese learners of English tend to make use of vowel epenthesis by inserting a vowel (typically /u/) between adjacent consonants so that the words conform to Japanese syllable structure (e.g., Masuda & Arai, 2010; Shibuya & Erickson, 2010). For example, in an experiment by Masuda and Arai (2010, Experiment 2), acoustic analysis revealed the presence of consonant-medial vowels in Japanese participants' production of pseudo-words of the form VCCV (e.g., the stimulus *akmo* was typically misread as /akumo/). This was the case even for advanced learners of English who had resided in an English-speaking country

1. With the exception of the sequence C/j/ as in *kyoku* /kjoku/.

for at least two years prior to testing, which indicates that the difficulties persist even after extensive exposure to non-native constructions.

The influence of Japanese phonological structure on native speakers' perception of consonant clusters has been researched by means of the ABX paradigm. Here, participants are presented with three auditory stimuli, A, B, and X, and are instructed to identify whether X is identical to stimulus A or to stimulus B (e.g., Dupoux et al., 1999; Dupoux et al., 2001; Masuda & Arai, 2010). This research has consistently demonstrated that Japanese speakers find it more difficult to differentiate between two non-words of the form VCCV and VCuCV (e.g., *ebzo* and *ebuzo*) than do speakers of languages that allow consonant clusters, such as English and French. Moreover, in a study by Dupoux et al. (1999), Japanese native speakers tended to report "hearing" an intrusive vowel between adjacent consonants (e.g., between the /b/ and /n/ in *abno*), despite a total lack of acoustic correlates in the experimental stimuli.

In order to explain these phenomena, Dupoux et al. (1999; see also LaCharite & Paradis, 2005; Peperkamp & Dupoux, 2003; Smith, 2006) appeal to the notion that an individual's perceptual system is predisposed to perceive the sounds and sound sequences permissible in that individual's native language. According to this account, when processing non-native speech, the incoming signal is mapped onto the closest native-language phonetic category. For example, when a Japanese speaker is exposed to the stimulus *ebzo*, the /ɛ/ and /zo/ are faithfully perceived, but the /b/ must be assimilated to the closest native CV sequence because consonant clusters are illegal in Japanese. Dupoux et al. (2001) suggest that /bu/ is favoured over other potential candidates, such as /ba/ or /bo/, due to the fact that /u/ is the vowel with the most variable acoustic realisation and the shortest spoken duration in Japanese. Thus, it is argued that *ebzo* is perceptually identical to *ebuzo* for native Japanese speakers.

According to this account, the intrusive vowels experienced by Japanese speakers when processing non-native constructions are merely "perceptual illusions" that arise at the acoustic surface level, and therefore depend on phonetic properties of L1 (Dupoux et al., 1999; Peperkamp & Dupoux, 2003). However, consonant clusters and word-final consonants do in fact occur quite frequently in natural Japanese speech, by virtue of the process of high vowel devoicing (Fais, Kajikawa, Amano, & Werker, 2010), and it is therefore not always the case that a CVCV sequence will be the acoustically closest native equivalent of non-native constructions. Crucially, there is great variability in the acoustic manifestations of this devoicing process, such that, in some cases, the vowel is not merely devoiced, but completely deleted (Dupoux et al., 2001). For example, the underlying form /gakusei/ is often produced as /gaksei/ in casual Japanese speech, with the word-medial consonant cluster /ks/. The fact that Japanese speakers encounter instances of these constructions in everyday conversation casts doubt on a “perceptual assimilation” account of the difficulties they experience when processing non-native discourse.

Nevertheless, the existence of consonant clusters in fluent Japanese speech does not necessarily preclude an acoustic explanation of these processing difficulties. Indeed, it may be argued that such problems are actually an artifact of the vowel devoicing process itself. That is, upon encountering a non-native consonant cluster, Japanese speakers might infer the presence of a consonant-medial vowel due to the perception of acoustic cues typically associated with devoiced vowels in natural Japanese discourse. This kind of explanation was previously proposed by Davidson and Shaw (2012) to account for the difficulties experienced by native English speakers when processing unfamiliar constructions. Specifically, the researchers found that, in an ABX discrimination task, English speakers tended to confuse CCaCV pseudo-words, where the initial consonant cluster was illegal in English, with pseudo-words of the form CəCaCV (e.g., /fmatu/ being confused with /fəmatu/). In order to account for this finding, Davidson and Shaw highlighted the fact that vowels in unstressed syllables in English words are often substantially reduced in fluent speech, yielding sequences that are acoustically very similar to the consonant clusters under investigation in the study. Hence, they argued that the participants’ performance stemmed from the fact that the initial consonant of the CCaCV stimuli contained acoustic cues that typically signal the presence of an adjacent schwa in everyday English speech.

In the light of Davidson and Shaw’s (2012) findings, it does seem reasonable to suggest that, as for native English speakers, Japanese speakers experience difficulties with non-native consonant clusters as a result of their experience with acoustically equivalent native constructions (i.e., consonant clusters resulting from vowel devoicing). A study by Dupoux et al. (2001) provides evidence against this proposition, however, by demonstrating that the perception of intrusive vowels by Japanese speakers is no more common between voiceless consonants (the environment necessary for vowel devoicing to occur) than between voiced consonants. Thus, it does not seem likely that the process of vowel devoicing accounts for their treatment of non-native constructions.

Overall, the research investigating Japanese speakers’ treatment of consonant clusters in foreign or nonsense words may be more consistent with the notion that, at an abstract phonological level, they are representing these forms with consonant-medial vowels, such that they respect Japanese restrictions on syllable structure. For example, it may be that both items in the pair *ebuzo-ebzo* are activating the abstract mental representation /ebuzo/, and that this accounts for the observed difficulties in discrimination and the “perception” of intrusive vowels. More broadly, these results are consistent with the idea that, when processing non-native or nonsense words, Japanese speakers are activating underlying representations that conform to their native phonological structure. This chapter will describe a new experiment that explores whether this is true for Japanese-English bilinguals.

If these individuals are indeed making reference to their native phonology upon encountering L2 speech, it is possible that processing impairments might be observed even for those whose overt pronunciation is equivalent to that of a native English speaker. In other words, it is possible that the proposed "Japanization" of English might be so abstract that it holds even for early acquirers of English who do not speak with a Japanese accent. In fact, although it is now well established that an earlier age of L2 acquisition is related to superior long-term L2 performance (e.g., Flege, Yeni-Komshian, & Liu, 1999; Long, 1990; Oyama, 1976; Piske, MacKay, & Flege, 2001), several studies have demonstrated that one's native language does have some impact on second-language processing even for adult "early" bilinguals who have been raised and educated in an L2-speaking society (e.g., Flege, Frieda, & Nozawa, 1997; Nguyen-Hoan & Taft, 2010; Yeni-Komshian, Flege, & Liu, 2000). Thus, whilst we might still expect the degree of L1 interference to be lower for early acquirers of English as compared to late bilinguals, these individuals may still be employing different L2 processing strategies when compared to monolingual speakers.

Immediate serial recall and the word length effect

As a task that is sensitive to differences in word length, immediate serial recall is a potentially suitable measure for determining whether bilingual Japanese speakers are indeed processing novel words in terms of a "Japanized" underlying representation: Phonological repair of illegal consonant clusters and word-final consonants, by means of vowel epenthesis, results in longer word forms (i.e., forms that consist of a greater number of syllables and phonemes). The immediate recall paradigm, which requires that participants reproduce a sequence of words in the correct order immediately after presentation, has been used extensively to investigate the mechanisms involved in verbal working memory (see Mueller, Seymour, Kieras, & Meyer, 2003). One of the key discoveries that has emerged from this research is the finding that performance declines as word length increases.

This "word length effect" has been interpreted in terms of the phonological loop model of working memory, and is considered by many researchers to depend primarily on the articulatory duration of the words being recalled (e.g., Baddeley & Hitch, 1994; Baddeley, Thomson, & Buchanan, 1975; Mueller et al., 2003). According to this account, verbal information that is entered into short-term memory decays as a function of time, unless it is maintained by a process of subvocal rehearsal. Words of a longer spoken duration result in poorer working memory performance because a smaller number of these words can be rehearsed in a fixed period of time.

This account was first proposed by Baddeley et al. (1975), who found superior serial recall performance for words of a shorter articulatory duration, even when the number of syllables and phonemes was matched across the "long" and "short" stimulus conditions. However, many studies have failed to replicate these results with novel stimulus sets (e.g., Caplan, Rochon, & Waters, 1992; Lovatt, Avons, & Masterson, 2000; Neath, Bireta, & Surprenant, 2003; Service, 1998), demonstrating either no difference in recall performance as a function of spoken duration, or a "reverse" word length effect, whereby longer items actually result in superior recall performance.

Thus, it has been suggested by some (e.g., Lovatt et al., 2000; Neath et al., 2003) that the word length effect demonstrated by Baddeley et al. (1975) was merely an artifact of the particular stimulus set chosen for their study. In contrast to the articulatory duration account, therefore, other researchers (e.g., Caplan et al., 1992; Caplan & Waters, 1994, 1995; Hulme, Surprenant, Bireta, Stuart, & Neath, 2004; Service, 1998; Neath & Nairne, 1995) have argued that the disadvantage observed for lists of "longer" words actually results from an increase in phonological complexity, as indexed by the number of syllables or phonemes comprising the underlying phonological representations.

In an attempt to provide support for this account, Service (1998) conducted a serial recall study in which performance was compared for three kinds of Finnish pseudo-word stimuli: "short" two-syllable items of the form CVCV (e.g., /hine/), "long" two-syllable items containing both a long vowel and geminate consonant (e.g., /hi:n:e/), and "long" items consisting of three CV syllables (e.g., /hasuli/). Immediate memory was significantly poorer for the three-syllable condition than for either of the other two conditions, despite the fact that spoken duration did not differ between the two "long" item types. That is, a word length effect resulted from differences in phonological complexity, and not from differences in articulatory duration alone.

In order to tease apart the relative contributions of the number of syllables and the number of phonemes, Service (1998) conducted a follow-up experiment in which performance was again compared for three kinds of pseudo-word stimuli: Two of the conditions remained unchanged, whilst the "long" two-syllable items were replaced by two-syllable items comprising six phonemes (e.g., /hjenti/). Participants performed significantly better for lists in the four-phoneme condition than for those in either of the other two conditions, indicating that the word length effect may depend on the number of phonemes, and not the number of syllables.

In attempting to explain such results, Service (1998) and others (e.g., Neath & Nairne, 1995) have proposed explanations that attribute word length effects to differences in the number of segments (e.g., phonemes) within individual list items. According to this account, the greater the number of segments, the greater the overall probability for an error to occur during either encoding or retrieval processes. The impairment in memory performance observed for lists comprising "long" stimuli is therefore postulated to result from the fact that these stimuli comprise a greater number of phonological units.

Although the nature of the mechanism underlying the word length effect remains a controversial issue, the majority of recent evidence has accumulated in favour of an account in which underlying phonological representations, rather than articulatory processes, are key (see Neath et al., 2003). Whilst the literature has focused only on the potential involvement of the number of syllables or phonemes, it is reasonable to postulate that, for Japanese native speakers, the mora may be critical to performance in a recall task.

A new experiment

An experiment was designed to investigate the level of processing at which Japanese bilinguals' difficulties with non-native constructions arise. Specifically, the experiment aimed to determine whether, in contrast to the surface-level acoustic accounts discussed above, native Japanese speakers are actually activating Japanized underlying representations when processing L2 speech. Furthermore, it examined whether the degree to which this is the case depends on specific language background factors, including age of L2 acquisition, the relative degree of L1 and L2 use, and length of exposure to English.

To this end, the current study compared the performance of Japanese-English bilinguals and English monolinguals on an immediate serial recall task using pseudo-words spoken in an (Australian) English accent. Three different types of pseudo-words were used. Items in the "2S–4M" condition were constructed such that underlying representations conforming to Japanese phonological structure consisted of a greater number of morae (i.e., four) than there were syllables at the surface level (i.e., two). For example, the spoken pseudo-word /gænɪks/ (see Table 1) has two syllables (i.e., /gæ/ and /nɪks/), but the corresponding Japanized underlying representation would have four morae (i.e., /ga/, /ni/, /ku/, and /su/). In the other two conditions ("2S–2M" and "4S–4M"), the number of morae was identical to the number of syllables (i.e., two and four respectively; see Table 1 for examples). In addition, stimuli in the 2S–2M condition comprised fewer phonemes

Table 1. Examples of stimuli used for the immediate recall task

Condition	Orthographic transcription	Pronunciation*	Possible Japanized UR**
2S–2M	seddy	/sɛ.di/	/se.di/
2S–4M	ganics	/gæ.nɪks/	/ga.ni.ku.su/
4S–4M	marenity	/mə.ɹɛ.nɪ.ti/	/ma.re.ni.ti/

Note.UR = underlying representation.
* Periods are used to separate syllables.
** Periods are used to separate morae.

than those in the 2S–4M condition, which in turn consisted of fewer phonemes than the items in the 4S–4M condition (M = 4, 5.5, 7.9, respectively).

In the light of previous research demonstrating the effects of increasing phonological complexity on immediate serial recall, the English monolinguals' performance was expected to vary according to the number of phonemes within the list stimuli; that is, mean recall was predicted to be highest in the 2S–2M condition and lowest in the 4S–4M condition, with performance in the 2S–4M condition falling in between. In contrast, if the Japanese bilinguals were indeed activating Japanized underlying representations, the number of morae was expected to be crucial to their performance. Thus, for this group, superior recall was predicted for the two-mora condition (2S–2M) over the four-mora conditions (4S–4M and 2S–4M) which, in turn, were not predicted to differ from each other. In other words, an interaction was expected between word list condition and language background, with the difference between the 4S–4M and 2S–4M conditions being greater for the monolinguals than for the bilinguals. On the other hand, given that the number of both phonemes and morae was higher in the 2S–4M condition than in the 2S–2M condition, the difference in performance between these two conditions was not expected to depend on language background; that is, this contrast was expected to be equivalent for the bilingual and monolingual groups.

The Japanese-English bilinguals' performance was expected to differ from the monolinguals' performance to a greater extent when the amount of L2 usage and years of English exposure were lower, given that both of these factors have previously been shown to correlate positively with L2 proficiency in the phonological domain (e.g., Flege & Fletcher, 1992; Flege et al., 1997; Flege & MacKay, 2004; Flege, Munro, & MacKay, 1995; Piske et al., 2001). Finally, the extent to which recall performance depended on the moraic structure of the stimuli was predicted to be greater for the late bilinguals than for the early bilinguals, whose performance was nevertheless expected to differ from that of the monolingual group.

Method

Participants

The bilingual group consisted of 27 native Japanese speakers (five male, M_{age} = 36.7 years) who were also fluent in English. Although the majority reported having learnt English either during or after high school, there were five bilinguals who began learning English before the age of six. When asked to estimate their own proficiency in L1 and L2, all except two of the bilinguals provided higher ratings for Japanese than for English, with regard to both written and verbal communication. The participants in this group were recruited through various Japanese clubs and societies in Sydney, Australia.

The monolingual sample consisted of 23 native English speakers (12 male, M_{age} = 19.4 years) recruited from the first-year undergraduate psychology cohort at the University of New South Wales, Sydney. Although almost half indicated that they could speak a second language, this was never Japanese.

Materials

Three sets of 20 English pseudo-words (i.e., nonsense words that respected English syllable structure, stress patterns, and phonotactic constraints) were constructed, with each set corresponding to a different condition. It was impractical to utilize real English words for this experiment because of the strict criteria used to define the three conditions, as detailed below.

In the 2S–2M and 4S–4M conditions, the items conformed to Japanese syllable structure (i.e., comprised only syllables of the form CV, C/j/V or V), such that a Japanized underlying representation would consist of an equal number of morae as there were syllables at the surface level (i.e., two in the former condition and four in the latter). Conversely, the 2S–4M stimulus set consisted of bisyllabic pseudo-words containing diphthongs (which typically constitute two morae when reproduced in Japanese) and sequences that are illegal in Japanese (namely, consonant clusters and word-final consonants). As a result, the number of morae constituting Japanized underlying representations for these items was twice that of the number of syllables (see the Appendix for a complete list of the stimuli used in the experiment).

Using Adobe Audition CC (2015), separate recordings of each item were made by a native speaker of Australian English. For each condition, 10 four-item sequences were constructed by sampling at random from the appropriate stimulus set, such that each pseudo-word was included in exactly two lists. Because the phonological similarity of the items within a list has also been shown to be detrimental to immediate recall performance (see Baddeley, 1966; Conrad & Hull, 1964), attempts were made to limit the repetition of both whole syllables and individual phonemes within each sequence.

Procedure

The immediate recall task involved the auditory presentation of each of the four-item sequences, by means of the DMDX computer program (Version 5; Forster, 2016), with an interval of 300ms between each word, and 10sec of recall time between each list. Participants were first presented with three practice trials to acquaint them with the task, followed by the experimental trials. They were instructed to recall each list aloud as accurately as possible immediately after the final word was presented, and responses were recorded via microphone. The order of presentation of the 30 trials was completely randomized for each participant.

Following the immediate recall task, all participants were required to complete a demographics questionnaire that assessed their age, gender and languages spoken. The bilinguals were also asked to provide the approximate age at which they began learning English, an estimate of the percentage of time spent communicating in Japanese and English on a day-to-day basis (hereafter, referred to as “L1 usage” and “L2 usage” respectively), and a rating of their own literacy and verbal communication proficiency in both languages (on a 7-point scale, with 1 = “very poor” and 7 = “very good/native-like”).

Results

For each trial, a score was calculated based on the number of complete syllables correctly recalled, as a percentage of the total number of target syllables. Specifically, with four items in each list, there were eight target syllables per trial in the bisyllabic conditions, 2S–4M and 2S–2M, and 16 target syllables per trial in the 4S–4M condition. Whilst syllables recited in the correct serial position were assigned a full mark, those recalled out of sequence were assigned a score of 0.5.

The mean recall scores for the English monolinguals and Japanese bilinguals are shown in Figure 1. A two-way mixed-design ANOVA was conducted, with word list condition as the within-subjects factor and language background (Japanese-English bilingual; English monolingual) as the between-subjects factor. Two planned contrasts were assessed using a Bonferroni-adjusted alpha level of .025. In order to test for the predicted interactions between list type and language group, as discussed above, these contrasts examined the difference between the 2S–2M and 2S–4M conditions, and between the 4S–4M and 2S–4M conditions.

There was a significant main effect of language background, such that, averaged across the word list conditions, the English monolingual group demonstrated superior performance when compared to the Japanese-English bilinguals, $F(1, 48) = 52.44$, $p < .001$. Averaged across the two groups, recall scores were significantly higher in the 2S–2M condition than in the 2S–4M condition, $F(1, 48) = 205.09$, $p < .001$, and this difference did not appear to depend on language background, $F(1, 48) = 0.504$, $p = .481$. On average, performance in the 2S–4M condition was significantly better than that in the 4S–4M condition, $F(1, 48) = 35.27$, $p < .001$. However, in this case, the difference between the two conditions was significantly greater for the monolinguals than for the bilinguals, $F(1, 48) = 11.26$, $p = .002$.

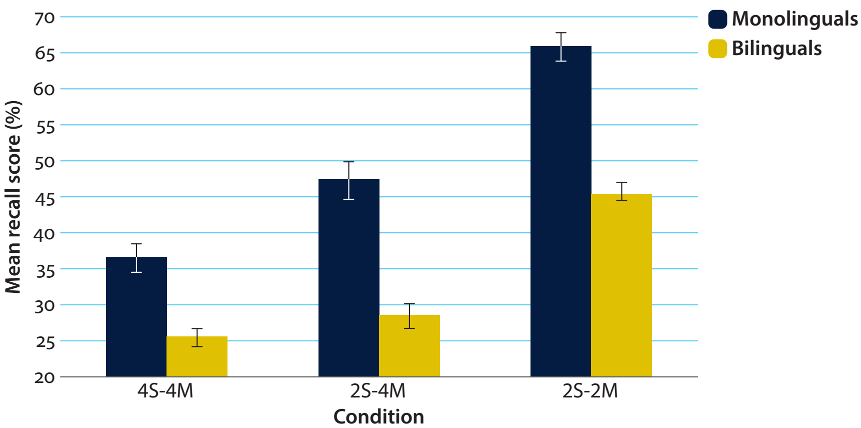

Figure 1. Mean recall scores as a function of word list condition for the Japanese bilinguals and English monolinguals. Error bars indicate standard error

It should also be noted that the occurrence of vowel epenthesis (either within consonant clusters or after word-final consonants) in the bilinguals' reproduction of the pseudo-word stimuli was extremely rare, with only 28 individual instances across the entire experiment.

The effect of demographic and language background variables

Simultaneous regression analyses were also carried out in order to determine whether the variation in performance between the word list conditions was dependent on specific demographic and language background variables. Because the aim was to investigate the contrast between conditions rather than the absolute level of accuracy, two difference scores were computed for each participant, reflecting the same relationships that were assessed by the ANOVA contrasts (i.e., 2S–2M vs. 2S–4M; 4S–4M vs. 2S–4M). Each of these scores was regressed on age, and then separately, for the Japanese participants only, on L2 usage (M = 44.26%) and years of English exposure (defined as the number of years since English acquisition, as a proportion of the participant's age; M = .65). None of these variables was a significant predictor of either of the contrast scores.

The effect of age of English acquisition

Based on the findings of an extensive literature review conducted by Long (1990), the Japanese participants were classified as "early" bilinguals or "late" bilinguals if they began learning English before age six or after age 12 respectively. Although there were very few of the former, a post-hoc analysis was nevertheless carried out to investigate whether there was any indication of a qualitative difference in performance between the two groups.

The mean recall scores for the two groups are presented in Figure 2. The two-way ANOVA was carried out again with the now-three-level between-subjects factor (monolingual; early bilingual; late bilingual), and two additional between-subjects contrasts to assess the difference between the early and late bilingual groups, and between the English monolinguals and the early bilinguals. Once again, the Bonferroni procedure was used to control the family-wise error rate at .05. There was no significant difference between the late and early bilingual groups for either the 2S–2M vs. 2S–4M contrast, $F(1, 47) = 0.095$, $p = .759$, or the 4S–4M vs. 2S–4M contrast, $F(1, 47) = 1.43$, $p = .238$. Moreover, whilst the difference between the 4S–4M and 2S–4M conditions was significantly greater for the monolinguals than for the early bilinguals, $F(1, 47) = 8.51$, $p = .005$, there was no significant difference between these two groups for the 2S–2M vs. 2S–4M contrast, $F(1, 47) = 0.02$, $p = .88$. That is, the early bilingual participants interacted with the English monolinguals in the same way as did the bilingual group as a whole.

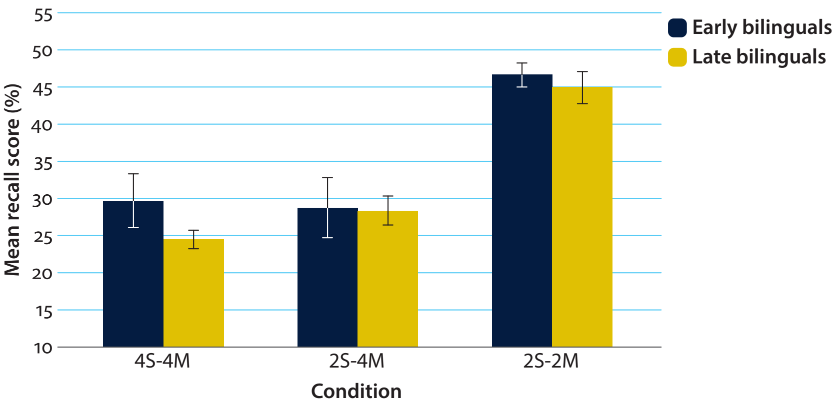

Figure 2. Mean recall scores as a function of word list condition for the early and late bilingual groups. Error bars indicate standard error

Discussion

The results of the interactions between list type and language background indicate that the monolingual and bilingual participants were indeed employing different processing strategies during the immediate recall task. Specifically, the findings are consistent with the notion that recall was dependent on the number of underlying morae for the Japanese native speakers, but on the number of phonemes for the monolingual participants. This study therefore provides support for the proposition that Japanese-English bilinguals make reference to their native phonological structure whilst processing L2 speech, and that this might largely account for the difficulties experienced by these individuals when they encounter non-native constructions.

Although items in both the 2S–2M and 2S–4M stimulus sets were bisyllabic, performance was significantly better for sequences in the former condition, averaged across the two language groups. Crucially, the fact that this effect did not interact significantly with language background indicates that the difference between these two list types was equivalent for the Japanese and monolingual participants. This suggests that recall performance did not depend on the number of syllables within list stimuli for either of the two language groups. The difference between the 4S–4M and 2S–4M conditions, on the other hand, was greater for the monolingual participants than for the bilinguals, which reflects the fact that, whilst the native English speakers performed better for lists in the 2S–4M condition, the Japanese participants' mean recall scores did not appear to differ significantly across these two conditions.

Thus, for the English monolinguals, the results of the present study are in keeping with those of Service's (1998) experiment: An increase in the number of phonemes within list stimuli was detrimental to recall performance for this group. By contrast, it appears that the Japanese-English bilinguals' performance was in fact dependent on the number of morae posited to comprise Japanized representations. These findings may be explained by appeal to the segment-based theories of working memory proposed by researchers such as Service (1998), and Neath and Nairne (1995). According to these accounts, successful recollection of the stimuli in an immediate recall task is dependent on the correct encoding and retrieval, not just of the syllables as a whole, but of each of the individual segments comprising those syllables. The addition of morae or phonemes across the different list types therefore results in an increase in the probability of an error in recall occurring somewhere within each syllable and, in turn, reduces the likelihood of accurate reproduction.

Crucially, for the Japanese-English bilinguals, it was the inclusion of additional *morae* that was detrimental to performance. Indeed, despite the fact that they had acquired a second language in which the smallest functional segment is the phoneme, and although they were engaging with pseudo-words spoken by an English speaker, the Japanese native speakers did not appear to be affected by variations in the number of phonemes, given that they performed equally well in the 4S–4M and 2S–4M conditions. Rather, their scores are indicative of phonological interference from their native language, as moraic structure was crucial to performance.

It was also apparent that these results reflected processes occurring at an abstract phonological level. As outlined above, recent accounts of the word length effect have stressed the involvement of underlying representations rather than surface forms in the immediate recall task (e.g., Caplan et al., 1992; Caplan & Waters, 1994, 1995; Service, 1998). Indeed, the fact that performance was comparable across the 4S–4M and 2S–4M conditions for the Japanese participants provides further support for this claim: Items in the 2S–4M stimulus set consisted of fewer syllables at the surface level than those in the 4S–4M condition, and were, on average, of a shorter spoken duration. Moreover, the fact that the bilinguals' overt pronunciation was typically accurate (i.e., the incidence of vowel epenthesis in production was very low) suggests that the pseudo-word stimuli were faithfully perceived during the recall task. This is inconsistent with the models previously proposed to account for Japanese speakers' difficulties with certain non-native constructions (e.g., Dupoux et al., 1999; Peperkamp & Dupoux, 2003), which have consistently emphasized the involvement of phonetic properties of L1 at the perceptual level. Rather, this study provides evidence in support of the hypothesis that these difficulties actually arise at an abstract underlying level, as a consequence of L1-referenced phonological processing.

It should also be noted that the bilinguals seemed to experience greater difficulty with the recall task overall when compared to the English monolingual participants. This could potentially be explained by the fact that the pseudo-word stimuli were recorded in an Australian English accent, which may have been relatively more difficult for the Japanese speakers to process due to disparities with their native-language pronunciation. For example, Japanese employs a "pitch accent" system, in contrast to the English stress system, which may have resulted in additional comprehension difficulties for the bilingual participants across all word list conditions.

The effect of language background factors

In contrast with previous research (e.g., Flege & Fletcher, 1992; Flege & MacKay, 2004; Flege et al., 1995; Piske et al., 2001) that has demonstrated variation in the degree of L1 interference with L2 as a function of specific language background factors, the variables that were assessed in the current experiment did not appear to have any effect on the results. Specifically, for the bilingual participants, neither L2 usage nor years of English exposure was a significant determinant of the differences in recall performance across the word list conditions.

Whilst language background factors such as these have been implicated in the achievement of second-language proficiency in the phonological domain, the evidence is not always conclusive, nor consistent (see Piske et al., 2001 for a review). Moreover, the studies investigating such factors have focused heavily on overt skills such as the attainment of a native-like accent, and it may be that the kind of abstract phonological processing assessed in the current study does not interact with these variables in the same way. It is also possible that the findings relate to the specific operationalization of these factors, which varies widely across different studies. For example, in this experiment, the L1 usage variable targeted only recent communication, which may be misleading given the potential for variation over the course of the L2-speaking period. Moreover, passive listening may be just as important to language development as is active communication.

Remarkably, recall performance also appeared to be unaffected by the age of English acquisition, since the early bilingual group's results paralleled that of the late bilingual group. That is, even for the bilinguals in this study who had started learning English before the age of six, and had received all of their formal education in L2, there was evidence of L1 interference with the processing of English structures. These results are consistent with previous research that has demonstrated non-native-like proficiency even in adult early bilinguals whose second language is now dominant (e.g., Flege et al., 1997; Nguyen-Hoan & Taft, 2010; Yeni-Komshian et al., 2000). What is of central importance, though, is the fact that the degree of phonological transfer was equivalent for the late and early bilingual groups, which suggests that the automatic activation of L1-referenced phonological representations was not mitigated by early exposure to L2 constructions.

The nature of phonological representations

The findings of the current study provide support for the notion that the phonological representations generated in response to spoken pseudo-words may be considerably more abstract than the corresponding surface phonemic forms. Despite the fact that the bilinguals' production of the pseudo-word stimuli was typically accurate, the pattern of results across the three conditions suggests that they were activating underlying representations that conformed to their native phonological structure. Consequently, for items in the 2S–4M condition, it is proposed that the Japanese speakers' mental representations were not veridical with the surface pronunciation (e.g., the pseudo-word /bɒkɹəm/ may have been mentally represented as /bokuramu/). Specifically, the phonological representations comprised elements (e.g., /u/) that were not phonemically realised in either the spoken stimuli or, for the most part, the bilinguals' own reproductions of those stimuli.

There is evidence to suggest that this kind of non-transparent relationship between abstract phonological representations and surface forms also exists for speakers of other languages. For example, in a study that investigated non-rhotic speakers' ability to silently generate an English word (e.g., *soak*) as a homophone of a pseudo-word stimulus (e.g., *soke*), performance was impaired when either the stimulus or target word contained a post-vocalic *r* in its orthographic representation, despite the fact that this would not affect the surface pronunciation (Taft, 2006). For example, when presented with *cawn* or *forl*, non-rhotic participants (i.e., Australian English speakers) struggled to generate the appropriate homophonic response: *corn* and *fall* respectively. This suggests that the underlying representation for a word like *corn* contains a post-vocalic /r/, and as such, does not match the underlying representation for the homophonic stimulus *cawn*. In other words, for non-rhotic English speakers, the abstract phonological representation for *corn* is not equivalent to its overt phonemic form and, in fact, appears to be more closely aligned with the orthographic representation (where an *r* exists).

Based on these results, Taft (2006) posited that abstract phonological representations might be primarily shaped by orthography (see also Kim, Taft, & Davis, 2004 for an example in Korean) and, indeed, the findings of the present study are compatible with this proposition. Because each character in the Japanese syllabaries (i.e., *Katakana* and *Hiragana*) represents a single complete mora, most commonly of the form CV, it is reasonable to suggest that the moraic underlying representations activated by the Japanese participants during the recall task may have been orthographically influenced. In fact, the proposed underlying forms correspond directly to potential Japanese transcriptions of the experimental stimuli. This implies that an individual's native orthographic system might have an impact on phonological representations generated in response to unfamiliar spoken input, not just visually presented text.

Concluding remarks

In this chapter, we described a new experiment that explored the nature of L2 processing in Japanese-English bilinguals. This study provided evidence to suggest that, regardless of language background factors such as the amount of exposure to the second language, and in spite of the attainment of native-like communication skills, bilingual individuals may still be employing subtly different L2 processing strategies when compared to monolingual speakers. Specifically, it was suggested that Japanese-English bilinguals make reference, at an abstract level, to their native-language phonological structure when engaging with non-native constructions, a processing strategy that does not appear to be affected by the age of L2 acquisition. The implication of these findings is that, when Japanese speakers are exposed to a lexical item with an L1-incompatible phonological structure, they can be expected to encounter processing difficulties. However, the extent to which this might impair everyday comprehension or communicative ability is not yet clear.

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Appendix 1. Stimuli used in the immediate recall task

2S–4M		4S–4M		2S–2M	
Pronunciation	**Possible Japanized UR**	**Pronunciation**	**Possible Japanized UR**	**Pronunciation**	**Possible Japanized UR**
/æspɪt/	/a.su.pi.to/	/æbəɹinoʊ/	/a.ba.ɾi.no/	/batʃoʊ/	/ba.tʃo/
/bleɪta/	/bu.re.e.ta/	/ʌmɛnɜɹi/	/a.me.na.ri/	/dagoʊ/	/da.go/
/bɒkɹəm/	/bo.ku.ra.mu/	/bəfɒɹʌnju/	/ba.fo.ra.nju/	/iboʊ/	/i.bo/
/deɪkl/	/de.e.ku.ru/	/dətæʤəni/	/da.ta.ʤa.ni/	/ɛkʌ/	/e.ka/
/fɪktəs/	/fi.ku.ta.su/	/dɪsɒpɪkʌ/	/di.so.pi.ka/	/fæɹi/	/fa.ri/
/gænɪks/	/ga.ni.ku.su/	/ɛbjuɛɹi/	/e.bju.e.ri/	/fɪtʃu/	/fi.tʃu/
/gɹɪsəf/	/gu.ri.sa.fu/	/ɛpəsɛloʊ/	/e.pa.se.ro/	/ganu/	/ga.nu/
/haɪʃən/	/ha.i.ʃa.nu/	/fəɹɪsɪkʌ/	/fa.ri.si.ka/	/hɛnʌ/	/he.na/
/ʤɒpɹəs/	/ʤo.pu.ra.su/	/fəzuniʌ/	/fa.zu.ni.a/	/ʤati/	/ʤa.ti/
/kɹubl/	/ku.ru.bu.ru/	/gəsɛtɜɹi/	/ga.se.ta.ri/	/kjunʌ/	/kju.na/
/mɪpɹɪʃ/	/mi.pu.ri.ʃu/	/həsadioʊ/	/ha.sa.di.o/	/mɪʃʌ/	/mi.ʃa/
/nɛspli/	/ne.su.pu.ri/	/ɪɹɛtʃɪnʌ/	/i.re.tʃi.na/	/nuvʌ/	/nu.ba/
/naʊstʌ/	/na.u.su.ta/	/məɹɛnɪti/	/ma.re.ni.ti/	/pæɹoʊ/	/pa.ro/
/peɪfəd/	/pe.e.fa.do/	/məgɒɹɪti/	/ma.go.ri.ti/	/ɹadu/	/ɾa.du/
/ɹoʊkli/	/ro.o.ku.ri/	/məsænɪkʌ/	/ma.sa.ni.ka/	/ɹəpju/	/ɾa.pju/
/spɪlba/	/su.pi.ru.ba/	/nəsɒʤəli/	/na.so.ʤa.ri/	/sɛdi/	/se.di/
/spoʊdi/	/su.po.o.di/	/pəkɒʤulʌ/	/pa.ko.ʤu.ra/	/ʃədu/	/ʃa.du/
/stæpɪd/	/su.ta.pi.do/	/sədɪgjuʌ/	/sa.di.gju.a/	/tɪloʊ/	/ti.ɾo/
/tɛnsəm/	/te.n.sa.mu/	/sænɪkidoʊ/	/sa.ni.ki.do/	/jɛni/	/je.ni/
/zaɪʤəs/	/za.i.ʤa.su/	/təmɒnɜɹi/	/ta.mo.na.ri/	/zubi/	/zu.bi/

Note. Periods are used to separate morae. *UR* = underlying representation.

CHAPTER 11

Constituent-priming investigations of the morphological activation of Japanese compound words

Hisashi Masuda and Terry Joyce
Hiroshima Shudo University, Japan / Tama University, Japan

This chapter reports on two experiments conducted to investigate the morphological activation of two-kanji compound words using the constituent-morpheme priming paradigm with a series of very-brief masked stimulus onset asynchronicity (SOA) conditions. In contrast to Experiment 1 where the word-formation principle (WFP) conditions all involved Sino-Japanese (SJ) compound word targets, the WFP conditions for Experiment 2 included both SJ and native-Japanese (NJ) WFP targets. The results from both experiments provide evidence for the early contributions of morphological information to the lexical processing of compound words, in terms of advantages for left-to-right processing, for head-morphemes and for lexical-stratum. The results are discussed in the context of the Japanese lemma-unit model (Joyce, 2002a, 2002b).

Keywords: Japanese compound words, morphological activation, constituent-morpheme priming paradigm, Japanese lemma-unit model

1. Introduction

At the start of a review chapter on the processing of Chinese compound words, Myers (2006) singles out two factors why the Chinese language deserves the attention of psycholinguistic research investigating morphological processing. The first is his assertion that "Chinese is the poster child of compounding, the language to cite for an example of morphology without much affixation" and, reflecting the considerable influence of Chinese orthography on compound processing, the second is "its notoriously unusual writing system" (p. 169). However, the same basic criteria can also be rallied with substantial justification, to support the claim that the Japanese language also warrants particularly special attention for the insights

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that it can potentially yield towards advancing our understanding of morphological processing.

Indeed, as Joyce and Masuda (2018) essentially corroborate, scholarly portrayals concerning the complexity of the Japanese writing system indicate that it easily surpasses the category of 'notoriously unusual' (see also Joyce, 2011). Moreover, while it is certainly the case that, as an agglutinative language, Japanese possesses various forms of affixation, it is also true that compounding is a highly productive principle of Japanese word formation, involving both 漢語 /kan-go/ Sino-Japanese (SJ) and 和語 /wa-go/ native-Japanese (NJ) morphemes (within glosses, hyphens mark kanji-kanji boundaries; periods mark kanji-hiragana boundaries). Hence, there are a number of Japanese terms that generally correspond to the term of compound word. For instance, although Tamamura (1985) distinguishes between 合成語 /gō-sei-go/ ([combine + form] + word) 'complex words' and 複合語 /fuku-gō-go/ ([multiple (elements) + combine] + word) 'compound words' within his structural classification of Japanese words, he also acknowledges that the terms are often used interchangably. In contrast to these more specialist terms of linguistics, a more generalist term is 熟語 /juku-go/ (mature + word), as in 漢字二字熟語 /kan-ji-ni-ji-juku-go/ 'two-kanji compound word'. While exceptions exist, notably in 熟字訓 /juku-ji-kun/ 'monomorphemic words' orthographically represented by two kanji (e.g., 薔薇 /bara/ 'rose'), in the vast majority of cases, two-kanji compound words correspond to two-morpheme compound words. Essentially, the term is a shorthand convention, from an orthographic perspective, for complex words where, consistent with the morphographic nature of Japanese kanji (Joyce, 2011, 2016), the constituent morphemes are represented by their conventionally-associated kanji (Joyce, 2002a); although, naturally, the degree of semantic transparency between constituent and compound-word meanings can vary (Joyce, Masuda, & Hodoščk, 2016; Masuda, 2014). Two-kanji compound words are particularly significant within the Japanese lexicon for a few interrelated reasons. Despite being amongst the simplest possible Japanese polymorphemic words formed by combining two morphemes, there is considerable diversity within their formation principles that encompass approximately nine main relationships (Kageyama, 1982; Nomura, 1988; Tamamura, 1985), they represent the most common Japanese word structure by word-type counts (Joyce, Masuda, & Ogawa, 2014; Nomura, 1988), and, they are, in turn, extremely important building blocks for the formation of longer compound words (Joyce et al., 2014).

As such, the morphological structures, or word-formation principles (WFPs), of two-kanji compound words are unquestionably also of special significance for research into modeling the Japanese mental lexicon, given the need for mental lexicon research to provide some coherent account concerning the representation of morphological information (Feldman (Ed.), 1995; Libben & Jarema (Eds.), 2006; Sandra & Taft (Eds.), 1994; Taft, 1991). And yet, rather surprisingly, even though many visual word recognition studies have used two-kanji compound words as their experimental stimuli (e.g., Fujita, Ogawa, & Masuda, 2014; Hino, Kusunose, Miyamura, & Lupker, 2017; Hirose, 1992; Ijuin, Fushimi, Patterson, & Tatsumi, 1999; Morita & Saito, 2012; Ogawa & Saito, 2006; Tamaoka, 2007; Tamaoka & Hatsuzuka, 1998), relatively few have specifically considered the WFPs that underlie two-kanji compound words. Thus, the series of constituent-morpheme priming paradigm studies conducted by Joyce (1999, 2002a, 2002b, 2003a, 2003b, 2004) and the two experiments reported in this chapter (some aspects of which have been partially presented at conference in Joyce & Masuda, 2005, 2008, 2009, 2013) are unique in systematically investigating the morphological structures of Japanese two-kanji compound words.

The primary motivation behind Joyce's (2002b) study that utilized the constituent-morpheme priming paradigm with the lexical decision task (LDT) was to investigate the hypotheses proposed by Hirose (1992) based on the results of his own similar experiments. More specifically, Hirose's experiments contrasted LDT reaction times (RTs) for two-kanji compound word targets across three prime conditions of first-constituent, second-constituent and unrelated kanji. His basic findings were that, while there was significant priming for both constituent conditions compared to unrelated primes, significantly greater priming was also observed for the first-constituent compared to the second-constituent condition. Those results prompted Hirose to hypothesize, firstly, that the lexical retrieval of compound words involves search mechanisms that progress serially from left to right utilizing the first constituent as a retrieval cue, and, secondly, that compound words that share the same first-constituent kanji are represented together within clustered arrangements. Notwithstanding the waning influence of search-based models, such as Forster's (1976) serial search model, since the emergence of connectionist models that assume activation mechanisms, such as McClelland and Rumelhart's (1981) interactive-activation and competition model, from a representational perspective, the notion of clustered arrangements based only on common first constituents would, however, seem to yield some rather odd consequences. For example, it implies that, despite belonging to very different semantic domains, the two NJ compounds of 青空 /ao-zora/ 'blue sky' and 青物 /ao-mono/ 'green vegetables' and the two SJ compounds of 青年 /sei-nen/ 'adolescence' and 青銅 /sei-dō/ 'blue bronze' would all be clustered together based solely on the shared first-constituent of 青 'blue; green' (/ao/ and /sei/ are this kanji's 訓読み /kun-yo.mi/ 'NJ pronunciation' and 音読み /on-yo.mi/ 'SJ pronunciation', respectively, under the system of dual-readings for kanji as explained further later; see also Joyce &

Masuda, 2018). Moreover, such clustering also appears to pose serious problems for capturing the substantial semantic overlap between synonyms from different lexical stratum, such as SJ 登山 /to-zan/ and NJ 山登り /yama-nobo.ri/, both meaning 'mountain-climbing', which would be represented within separate clusters because of the reversed ordering of their constituents.

Thus, Joyce (2002b) sought to replicate Hirose's experiments, but with an additional independent variable that contrasted the morphological structures of the SJ two-kanji compound word targets. The five WFP conditions were (1) modifier + modified (MM), such as 'country' modifying 'road' in 国道 /koku-dō/ 'national road'; (2) verb + complement (VC), such as 'climb' followed by the object 'mountain' in 登山 /to-zan/ 'mountain-climbing'; (3) complement + verb (CV), such as the location noun 'outside' combined with 'eat' in 外食 /gai-shoku/ 'eating out'; (4) associated pair (AP), such as 'man' and 'woman' combined in 男女 /dan-jo/ 'man and woman; men and women'; and (5) synonymous pair (SP), such as two morphemes that both mean 'mountain' combined in 山岳 /san-gaku/ 'mountains'. The independent variable of the prime-target relationship was unchanged with the three conditions of first-constituent, second-constituent and unrelated kanji (as baseline). The study consisted of two experiments; Experiment 1 closely replicated Hirose's (1992) presentation procedure involving a long stimulus onset asynchronicity (SOA) of 3,000 ms, while Experiment 2 adopted a shorter SOA of 250 ms, where a prime was presented for 200 ms followed by an asterisk (※) mask for 50 ms.

Joyce's (2002b) two experiments yielded highly similar results. Similar to Hirose's (1992) results, significantly faster RTs were observed for both constituent-prime conditions across all five WFP conditions in both experiments. However, in sharp contrast to Hirose's results, no significant differences were observed between the two constituent conditions in four of the five WFP conditions; only the VC conditions had significance differences, where first constituents elicited faster RTs than the second constituents. Intrigued at only observing a significant difference between constituent-prime conditions within the VC condition in Joyce (2002b), Joyce (2003a, 2003b) subsequently utilized constituent-morpheme frequency data (Joyce & Ohta, 2002) to calculate positional frequency ratios – how frequently a kanji is either the first or second constituent of two-kanji compound words – in order to contrast low and high positional ratios for the verbal constituents in the reversed WFPs of VC and CV compounds. The results of Joyce's (2003a, 2003b) two further experiments were very similar. In the two high-positional-ratio (HPR) conditions of HPR-V+C and C+HPR-V, the verb-constituents elicited significantly faster RTs compared to the complement-constituents, such that the first-constituents of HPR-V+C elicited significantly faster RTs compared to the second-constituents, while the second-constituents in the reversed WFP condition of C+HPR-V elicited significantly faster RTs compared to the first-constituents. These findings also indicate that the activation of semantic information from the head verb-constituents may be more effective in priming LDT responses to VC and CV compounds. Given that the results from Joyce's (2002b, 2003a, 2003b) experiments are far from compatible with Hirose's hypotheses of search mechanisms that prioritize the first constituent as a retrieval cue, Joyce (2002a, 2002b) proposed the Japanese lemma-unit model (JLUM), which, as outlined in the General discussion, is an adaption of the multi-level interactive-activation framework to the Japanese mental lexicon that draws inspiration from the version for the Chinese mental lexicon proposed by Taft, Liu and Zhu (1999).

This chapter reports on two experiments that also utilize the constituent-morpheme priming paradigm to further explore the morphological activation of two-kanji compound words within the Japanese mental lexicon. More specifically, both experiments seek to examine the early contributions of morphological information by employing a series of very-brief masked SOA conditions. Even though the prime presentation duration of 200 ms used in Joyce's (2002b) Experiment 2 approaches the threshold of conscious attention (Neely, 1977), especially in contrast to Hirose's (1992) long 3,000 ms SOA, the present experiments employ a series of very-brief masked SOAs in order to completely eliminate any possibility of conscious processing of the constituent-morpheme primes. Thus, both experiments investigate whether the influence of morphological information can be detected within the early stages of lexical processing. Moreover, extending on the range of WFP conditions from Experiment 1, which continues to focus on SJ two-kanji compound words, Experiment 2 includes both SJ and NJ compound words. Adding an interesting dimension relating to the different phonological properties of SJ and NJ compounds that more closely approximate the complexities of the Japanese writing system (Joyce & Masuda, 2018), the present experiments provide further evidence for the early contributions of morphological information within the visual word recognition processing of Japanese compound words. The chapter concludes by discussing how the findings from the present experiments are also compatible with the JLUM (Joyce, 2002a, 2002b, 2004).

2. Experiment 1: SJ compound words under brief SOAs

This experiment investigates whether priming effects can be observed at brief SOAs, shorter than the 250 ms SOA employed in Joyce's (2002b) Experiment 2.

2.1 Methods

2.1.1 *Design*

A 4 × 3 × 4 (WFP x prime-type x SOA) three-factor design was used. The four WFP conditions were VC, CV, MM, and SP (the AP condition in Joyce (2002b) was dropped due to difficulties with matching familiarity scores for sufficient target items). The three prime-type conditions were first-constituent, second-constituent, and unprimed (blank, as a more neutral baseline than the unrelated condition used in Joyce (2002b)). The four SOA conditions were 60, 90, 120, and 150 ms. Both the WFP and prime-type factors were within-participant variables, while the SOA factor was a between-participant variable.

2.1.2 *Materials*

As in Joyce (2002b), the stimuli were selected from Joyce and Ohta's (1999) database of 1,000 two-kanji compound words, surveyed for native-speaker ratings concerning the appropriateness of WFP classifications. For each WFP condition, 30 compound words were selected with both classification scores and familiarity scores (Amano & Kondo, 1999) of 5.5 or higher on 7-point scales. The mean classification scores (and standard deviations (*SD*s)) were VC = 6.56 (0.46), CV = 6.48 (0.37), MM = 6.59 (0.33), SP = 6.22 (0.35) and the mean familiarity scores were 5.93 for all conditions (*SD*s: VC = 0.25, CV = 0.27, MM = 0.32, SP = 0.25). Nonword combinations of two kanji were generated from the same database by randomizing second-constituent kanji and 96 items were selected controlling for low 'word-like-ness' ratings.

Notwithstanding Joyce's (2003a, 2003b) findings relating to positional-frequency ratios, which should be interpreted as a form of type frequency related to morphological-family sizes (Schreuder & Baayen, 1997), no attempts were made to control for the token frequencies of the constituent-kanji primes. Given the very high familiarity scores for all compound targets and, particularly, in the absence of any systematic relationships for a given prime across experimental conditions (beyond the WFP conditions being contrasted within the experimental design), implementing such control was deemed both impractical and unnecessary. To counterbalance the compound-word targets over the three prime conditions, three presentation lists were prepared. Participants were assigned evenly to these lists that were randomized for each participant.

2.1.3 *Apparatus*

SuperLab Pro (Version 1.77, Cedrus, San Pedro, CA, USA), running on a personal computer (Power Mac G4, Apple, Cupertino, CA, USA), controlled the presentation of stimuli on a CRT (RD17GXII, Mitsubishi, Tokyo, Japan) and recorded LDT RTs collected via a keyboard. Stimuli at a font size of 36 points were displayed on the computer screen at a viewing distance of approximately 50 cm.

2.1.4 *Procedure*

The procedure was similar to that of Joyce's (2002b) Experiment 2 that used a 250 ms SOA. At the start of a trial, a plus symbol (+) was displayed in the center of the screen as a fixation point for 250 ms. Then, a prime kanji (or blank for the unprimed condition) presented for 40 ms was followed by a mask (※) for 20 ms. In the 60 ms SOA condition, a target compound word was presented immediately after the mask, while in the 90, 120, and 150 ms SOA conditions, a target was preceded by a blank screen for 30, 60, and 90 ms, respectively. A target was displayed until either participants made a lexical decision by pressing a key or a duration of 1,500 ms elapsed. The inter-trial-interval was 1,000 ms. Participants were instructed to press one key (either the 'v' key for left-handed or the 'm' key for right-handed participants) for a compound word and the alternative key for a nonword as quickly and as accurately as possible. The whole experiment, including a practice session of 12 trials, took between 20–25 min to complete.

2.1.5 *Participants*

The participants were 180 undergraduate students of Hiroshima Shudo University, who were assigned across the four SOA conditions, such that each condition had 45 participants. All were native-Japanese speakers who had normal or corrected-to-normal vision and received course credit for their participation. In order to limit the potential effects of speed-accuracy trade-offs, participants who made 20% or more errors for either word or nonword trials were eliminated from the analyses and were replaced by another participant from the same pool.

2.2 Results and discussion

2.2.1 *Overall analyses*

Table 1 presents the mean RTs and priming effects (RT differences from the unprimed baseline condition) (with *SD*s) for Experiment 1 as a function of the SOA and WFP conditions. In the interests of brevity, as Table 1 also presents statistical values (F, p, and η_p^2) for all significant differences observed within the planned comparisons conducted for the participant data, we only describe such differences below. As the data indicate, the patterns of priming effects from first- and second-constituents vary across the WFP conditions. In order to examine the effects of both constituents in each WFP condition, analyses of variance (ANOVAs) were conducted on data for both RTs and priming-effects. Planned comparisons conducted for RTs within both the participant and item data contrasted the RTs for the first- and second-constituent conditions with those for the baseline condition for each SOA condition. Planned comparisons conducted for priming effects contrasted RTs for the first- and second-constituent conditions. Error responses

Table 1. Mean RTs and priming effects (RT differences from unprimed baseline condition) (with *SD*s) for Experiment 1 as a function of the SOA and WFP conditions, together with statistical values (F, p, and η_p^2) for all significant differences observed within planned comparisons conducted for the participant data

SOA	WFP	Reaction times									Priming effct					
		First	$F(1, 44)$	p	η_p^2	Second	$F(1, 44)$	p	η_p^2	Unprimed	First		Second	$F(1, 44)$	p	η_p^2
60ms	VC	553 (93)	10.52	.002	.19	570 (82)				574 (87)	22 (44)	>	4 (56)	5.15	.028	.10
	CV	566 (91)	3.79	.058	.08	561 (86)	5.95	.019	.12	581 (79)	15 (53)		20 (55)			
	MM	565 (88)	4.45	.041	.09	583 (88)				582 (78)	17 (52)	>	−1 (56)	3.35	.074	.07
	SP	538 (85)	20.80	.000	.32	554 (77)	11.47	.002	.21	580 (83)	42 (61)	>	26 (51)	5.45	.024	.11
90ms	VC	569 (85)				580 (75)				582 (92)	12 (53)	>	2 (52)	2.89	.096	.06
	CV	594 (81)				584 (86)				590 (86)	−4 (52)		6 (52)			
	MM	581 (81)	13.84	.001	.23	599 (79)				608 (90)	28 (49)	>	10 (59)	5.91	019	.12
	SP	559 (87)	9.05	.004	.17	565 (77)	6.52	.014	.13	581 (75)	22 (49)		16 (42)			
120ms	VC	544 (83)	5.21	.027	.11	558 (72)				565 (74)	21 (62)		7 (41)			
	CV	570 (76)				557 (77)	9.03	.004	.17	580 (83)	10 (51)	<	24 (52)	5.02	030	.10
	MM	549 (82)	9.44	.004	.18	583 (71)				575 (70)	26 (56)	>	−9 (53)	26.92	000	.38
	SP	533 (72)	26.00	.000	.37	558 (76)	4.70	.036	.10	574 (73)	42 (55)	>	16 (50)	12.97	.001	.23
150ms	VC	539 (59)	4.76	.035	.10	552 (52)				555 (65)	15 (47)	>	3 (46)	3.49	.069	.07
	CV	558 (58)				545 (62)	9.03	.004	.17	569 (64)	11 (47)	<	23 (51)	3.41	.072	.07
	MM	560 (66)				572 (60)				568 (52)	8 (54)		−4 (45)			
	SP	532 (68)	12.96	.001	.23	542 (53)	5.95	.019	.12	557 (59)	26 (47)		15 (42)			

Note. Planned comparisons for RTs compared the two constituent conditions to the unprimed condition and those for the priming effects compared the first-constituent to the second-constituent.

(1,092 data points, 5.06%) were excluded from all analyses and, conforming to common procedures within the literature (e.g., Hino et al., 2017), responses outside the range of ± 2.5 *SD*s calculated from the mean RT for each condition for a given participant were regarded as outliers and adjusted to the relevant cut-off point (295 data points, 1.37%). (Similar ANOVAs conducted for the error-rate data revealed no significant main effect of prime-type, which indicates that the RT data is free from speed-accuracy trade-offs.)

In the 60 ms SOA condition, first-constituent priming effects were significant in all WFP conditions (albeit only marginally so in the CV condition) and second-constituent effects were significant in the CV and SP conditions. First-constituent priming effects were significantly greater than second-constituent effects in the VC and SP conditions, marginally so in the MM condition, but not significant in the CV condition. In the 90 ms SOA condition, first-constituent priming effects were significant in the MM and SP conditions and the second-constituent effect was significant in the SP condition. First-constituent priming effects were significantly greater than the second-constituent effects in the MM condition and marginally so in the VC condition. In the 120 ms SOA condition, first-constituent priming effects were significant in the VC, MM and SP conditions and second-constituent effects were significant in the CV and SP conditions. First-constituent priming effects were significantly greater than second-constituent effects in the MM and SP conditions, but the difference was reversed in the CV condition with the second-constituent effect being significantly greater than the first-constituent effect. In the 150 ms SOA condition, first-constituent priming effects were significant in the VC and SP conditions and second-constituent effects were significant in the CV and SP conditions. The first-constituent priming effect was significantly greater than the second-constituent effect in the VC condition, but the pattern was reversed in the CV condition.

Summarizing across SOA conditions, priming effects were most robust for SP compounds, with priming effects observed for both constituents. That may reflect the substantial semantic overlap between both constituents and the compound word itself. Within MM compounds, although the second constituent is linguistically the head noun, the absence of second-constituent priming compared to some first-constituent priming might be because general nouns tend to be constituents for many compound words. First-constituent priming effects were most visible in the 60 ms SOA condition, but the effects diminished somewhat at longer SOAs, particularly for CV compounds. Moreover, the patterns of constituent priming across SOA conditions were generally reversed for VC and CV compounds words, such that first-constituent priming effects were larger than second-constituent effects for VC compounds, but the trend was reversed for CV compounds, which is consistent with Joyce's (2003a, 2003b) results.

2.2.2 *Focusing on the VC and CV contrast*

In order to further examine that reversed pattern of constituent priming, 2 × 3 (WFP [VC, CV] x prime-type) ANOVAs were also conducted for the RT data at each SOA condition. Again, in the interests of brevity, statistical values for all significant differences observed are presented in Table 2. In the 60 ms SOA ANOVAs, both constituents elicited significant priming in the CV condition, but only the first-constituent effect was significant in the VC condition. In the 90 ms SOA ANOVAs, RTs were faster for the VC condition compared to the CV condition. In the 120 ms SOA ANOVAs, the first-constituent priming was significant in the VC condition, but the second-constituent priming was significant in the CV condition. In the 150 ms SOA ANOVAs, similar to the 120 ms SOA results, the first-constituent priming was significant in the VC condition, but the second-constituent priming was significant in the CV condition.

Summarizing these focused comparisons for the VC and CV compound words, first-constituent priming effects were significantly greater than second-constituent effects for VC compounds across all four SOA conditions. In contrast, for CV compound words, the first-constituent priming effect was only significant in the 60 ms SOA condition, but second-constituent effects were significant in both the 120 and 150ms SOA conditions.

Table 2. Statistical values (F, p, and η_p^2) for all significant differences observed within planned comparisons conducted for the RT data at each SOA condition within the 2 × 3 (WFP [VC, CV] x prime-type) for the participant data (F_1) and the item data (F_2)

SOA	Significant effect	F_1				F_2			
		df	*F*	*p*	η_p^2	*df*	*F*	*p*	η_p^2
60	Prime-type	2, 88	4.77	.011	.10	2, 116	2.50	.086	.04
	Interaction	2, 88	2.81	.066	.06				
90	WFP	1, 44	7.73	.008	.15				
120	WFP	1, 44	10.93	.002	.09				
	Prime-type	2, 88	4.32	.016	.09	2, 116	3.31	.040	.05
	Interaction	2, 88	4.39	.015	.09				
150	WFP	1, 44	4.98	.031	.10				
	Prime-type	2, 88	5.26	.007	.11	2, 116	4.71	.011	.08
	Interaction	2, 88	3.15	.048	.07	2, 116	3.40	.037	.06

2.2.3 *Discussion*

The more frequent observations of first-constituent priming effects compared to second-constituent effects, particularly in the 60 ms SOA condition, indicate the presence of a left-to-right processing advantage within the constituent-primed activation of compound words. Simply put, in contrast to merely extending on phonological information activated by first constituents, the reversal operation required for second constituents would seem to be more demanding. While acknowledging that it was essentially such an advantage that prompted Hirose (1992) to evoke search mechanisms that prioritize the first constituent as a retrieval cue, supplementing Joyce's (2002b, 2003a, 2003b) earlier results, the results from Experiment 1 that employed a series of brief SOA conditions further undermine such a hypothesis. More specifically, these findings also demonstrate that the patterns of constituent-priming effects vary across WFP conditions, indicating that morphological information is activated early within the lexical processing of two-kanji compound words. In particular, the reversed pattern of constituent-priming for VC and CV compound words also indicates a head-morpheme advantage, where prior presentations of head-morphemes generally elicit larger priming effects. In order to adequately account for such findings, a model of the Japanese mental lexicon needs to represent compound-word structures, as well as the orthographic, phonological and semantic relationships between words and their constituent-morphemes, such as the JLUM (Joyce, 2002a, 2002b, 2004).

3. Experiment 2: Mixed SJ and NJ compound words

As Joyce and Masuda (2018) describe in some detail, one factor that contributes to the complexity of the Japanese writing system is the dual-reading, or dual pronunciation, system of both kunyomi and onyomi associated with kanji. In essence, the core technique by which Chinese characters were adapted to orthographically represent the Japanese language was 訓読 /kun-doku/ 'reading by gloss' (Lurie, 2012), such that the Chinese character 山 meaning 'mountain' became associated with the existing native Japanese morpheme of /yama/ as a kunyomi. However, over time, through the supplementary convention of 音読 /on-doku/ 'reading by sound', onyomi, as SJ approximations of the pronunciations for Chinese morphemes, also became associated with kanji, and so 山 also has an onyomi of /san/. Two-kanji compound words are predominately combinations of SJ morphemes. For example, 大 means 'big' and its onyomi and kunyomi are /dai/ and /ō.kii/, while 学 means 'study' and its onyomi and kunyomi are /gaku/ and /mana.bu/, and when combined as 大学 meaning 'university', the compound word is pronounced by the onyomi of /daigaku/. All the target stimuli investigated in Joyce (2002b) and in Experiment 1 reported here were SJ compound words. However, there are also many two-kanji compound words that are formed as combinations of NJ morphemes, which are pronounced according to their kunyomi. For instance, 雨 means 'rain' and its onyomi and kunyomi are /u/ and /ame/, but when combined with 大 in 大雨 'heavy rain', it is pronounced /ō-ame/ according to the constituent kanji's kunyomi.

Moreover, while a few of the 2,136 official 常用漢字 /jō-yō-kan-ji/ 'characters for general use' have both multiple kunyomi and onyomi, the frequency distribution is generally skewed towards small sets of associated pronunciations, such that 34.7% jōyō kanji only have a single onyomi and no kunyomi (Joyce & Masuda, 2018; Joyce, et al., 2014). Thus, also interacting with kanji usage, which, in turn, reflects their status as either free or bound morphemes, kanji can vary in terms of the association strengths for particular pronunciations, such that, some kanji can be said to be kunyomi-dominant while some kanji are onyomi-dominant. Interestingly, Nomura (1978) has reported faster semantic activation from kunyomi-dominant kanji compared to onyomi-dominant kanji. Although Experiment 2 does not control for the pronunciation dominance of its constituent primes, it compares the patterns of constituent-morpheme priming for both SJ and NJ compound word targets across a range of SOA conditions, as a potentially interesting extension of our investigations into the morphological activation of compound words that further examines the interactions between orthography, phonology and semantics.

3.1 Methods

3.1.1 *Design and materials*

A 5 × 3 × 3 (WFP x prime-type x SOA) three-factor design was used. In contrast to Experiment 1, the WFP conditions for Experiment 2 also included NJ compound words. As examples of NJ-SP and NJ-VC compound words are relatively rare, the five WFP conditions were three SJ conditions of SJ-VC, SJ-CV and SJ-MM compounds and two NJ conditions of NJ-CV and NJ-MM compounds. The three prime-type conditions were unchanged from Experiment 1. Excluding Experiment 1's shortest SOA condition (where the left-to-right processing advantage was most conspicuous), the three SOA conditions were 90, 120, and 150 ms. Again, both the WFP and prime-type factors were within-participant variables, while the SOA factor was a between-participant variable.

Experiment 2 stimuli were also selected from the same database used for Experiment 1. Again, 30 compound words for each of the five WFP conditions were closely matched for both classification and familiarity scores of 5.5 or higher. The mean classification scores (with *SD*s) were SJ-VC = 6.46 (0.38), SJ-CV = 6.31 (0.44), SJ-MM = 6.21 (0.48), NJ-CV = 6.18 (0.35), NJ-MM = 6.32 (0.36) and mean familiarity scores were 5.87 for four conditions and 5.86 for NJ-MM (*SD*s: SJ-VC = 0.08, SJ-CV = 0.13, SJ-MM = 0.10, NJ-CV = 0.18, NJ-MM = 0.22). Similarly, controlling for low 'word-like-ness' ratings, 120 nonword combinations of two kanji were selected.

3.1.2 *Apparatus and procedure*

Both the apparatus and procedure used in Experiment 2 were identical to those employed in Experiment 1.

3.1.3 *Participants*

The participants were 144 undergraduate students of Hiroshima Shudo University; none had participated in Experiment 1. They were assigned across the three SOA conditions, such that each condition had 48 participants. All were native-Japanese speakers who had normal or corrected-to-normal vision and received course credit for their participation. Again, participants who made 20% or more errors on either word or nonword trials were eliminated from the analyses and were replaced by another participant from the same pool.

3.2 Results and discussion

3.2.1 *Overall analyses*

Table 3 presents the mean RTs and priming effects (with *SD*s) for Experiment 2 as a function of the SOA and WFP conditions, together with the statistical values for all significant differences observed within the planned comparisons conducted for the participant data. As with Experiment 1, error responses (1,089 data points, 5.04%) were excluded from the analyses, and a similar treatment of outliers was applied (191 data points, 0.88%). (Similar ANOVAs also conducted for the error-rate data revealed no significant main effect of prime-type, which indicates that Experiment 2's RT data were also free from speed-accuracy trade-offs).

In the 90 ms SOA condition, first-constituent priming effects were significant in all WFP conditions apart from the NJ-MM condition (albeit only marginally so in the SJ-CV condition) but the second-constituent effect was only significant in the NJ-CV condition. First-constituent priming effects were only significantly greater than second-constituent effects in the SJ-MM condition. In the 120 ms SOA condition, first-constituent priming effects were significant in the SJ-VC, SJ-MM and NJ-CV conditions and second-constituent effects were significant in the SJ-CV and NJ-CV conditions. In the 150 ms SOA condition, first-constituent priming effects were significant in the SJ-VC, SJ-MM and NJ-CV conditions, matching the 120 SOA results, and second-constituent effects were significant for all WFP conditions (albeit only marginally so in the SJ-VC, NJ-CV and NJ-MM conditions).

Summarizing across SOA conditions, similar to Experiment 1 results, the patterns of constituent-morpheme priming were generally reversed in the SJ-VC and SJ-CV conditions; although that trend was weaker due to the absence of second-constituent priming in the SJ-CV condition at the shortest 90 ms SOA.

Table 3. Mean RTs and priming effects (RT differences from unprimed baseline condition) (with *SD*s) for Experiment 2 as a function of the SOA and WFP conditions, together with statistical values (F, p, and η_p^2) for all significant differences observed within planned comparisons conducted for the participant data

SOA	WFP	Reaction times									Priming effect					
		First	$F(1, 47)$	p	η_p^2	Second	$F(1, 47)$	p	η_p^2	Unprimed	First		Second	$F(1, 47)$	p	η_p^2
90ms	SJ-VC	587 (94)	4.49	.039	.09	597 (74)				604 (82)	17 (56)		7 (54)			
	SJ-CV	591 (89)	2.95	.093	.06	597 (82)				607 (80)	16 (64)		10 (64)			
	SJ-MM	590 (81)	5.99	.018	.11	607 (81)				615 (83)	25 (69)	>	8 (63)	4.68	.036	.09
	NJ-CV	578 (95)	7.53	.009	.14	586 (73)	4.91	.032	.09	605 (80)	27 (68)		18 (57)			
	NJ-MM	588 (81)				582 (78)				593 (75)	5 (48)		11 (46)			
120ms	SJ-VC	564 (75)	7.60	.008	.14	579 (75)				585 (60)	21 (53)	>	6 (54)	4.76	.034	.09
	SJ-CV	575 (78)				569 (73)	7.07	.011	.13	591 (77)	16 (65)		22 (57)			
	SJ-MM	574 (71)	8.83	.005	.16	587 (79)				594 (67)	20 (45)		7 (48)			
	NJ-CV	554 (80)	12.22	.001	.21	565 (86)	5.00	.030	.10	583 (74)	29 (57)		18 (56)			
	NJ-MM	573 (83)				557 (71)				567 (73)	−7 (65)	<	10 (53)	3.25	.078	.06
150ms	SJ-VC	567 (68)	19.77	.000	.30	576 (63)	6.33	.015	.12	598 (80)	32 (49)		22 (61)			
	SJ-CV	583 (60)				567 (65)	3.71	.060	.07	587 (68)	4 (60)	<	21 (74)	3.73	.060	.07
	SJ-MM	580 (74)	6.69	.013	.12	581 (71)	8.79	.005	.16	606 (72)	25 (67)		25 (57)			
	NJ-CV	548 (78)	16.75	.000	.26	568 (69)	3.63	.063	.07	580 (68)	32 (53)	>	12 (44)	7.48	.009	.14
	NJ-MM	564 (61)				560 (67)	4.03	.051	.08	576 (60)	11 (56)		16 (55)			

Moreover, the patterns of constituent-morpheme priming were somewhat different in the SJ-CV condition compared to the NJ-CV condition despite the shared morphological structure. Finally, as the patterns of priming for the SJ-MM and NJ-MM conditions also seem to differ, we also further examined the contrasts between the SJ and NJ compound-word conditions.

3.2.2 *Focusing on the lexical stratum contrasts*

In order to further examine the lexical stratum contrasts (SJ versus NJ) within the CV and MM compound words, 2 × 3 (WFP [SJ, NJ] x prime-type) ANOVAs were also conducted for the RT data for both WFPs conditions at each SOA condition. The statistical values for all significant differences observed are presented in Table 4.

Table 4. Statistical values (F, p, and η_p^2) for all significant differences observed within planned comparisons conducted for the RT data at each SOA condition within the 2 × 3 (WFP [SJ, NJ] x prime-type) for the participant data (F_1) and the item data (F_2)

SOA	WFP	Significant effect	F_1				F_2			
			df	*F*	*p*	η_p^2	*df*	*F*	*p*	η_p^2
90	CV	Prime-type	2, 94	5.49	.006	.10	2, 116	4.91	.009	.08
	MM	WFP	1, 47	11.48	.001	.20				
		Prime-type	2, 94	2.96	.057	.06				
		Interaction	2, 94	2.76	.068	.06				
120	CV	WFP	1, 47	5.11	.028	.10				
		Prime-type	2, 94	8.40	.000	.15	2, 116	6.37	.002	.10
	MM	WFP	1, 47	20.29	.000	.30	1, 58	4.06	.049	.07
		Interaction	2, 94	4.64	.012	.09	2, 116	4.02	.021	.06
150	CV	WFP	1, 47	9.56	.003	.17				
		Prime-type	2, 94	5.74	.004	.11	2, 116	3.70	.028	.06
		Interaction	2, 94	5.09	.008	.10	2, 116	3.13	.048	.05
	MM	WFP	1, 47	20.47	.000	.30	1, 58	4.05	.049	.07
		Prime-type	2, 94	5.40	.006	.10	2, 116	6.19	.003	.10

The results for the two CV WFP conditions were as follows. In the 90 ms SOA ANOVAs, both constituents elicited significant priming in both the SJ-CV and NJ-CV conditions. Similarly, in the 120 ms SOA ANOVAs, both constituents elicited significant priming in both WFP conditions. In contrast to the 90 ms SOA, however, RTs were faster for the NJ-CV condition compared to the SJ-CV condition. In the 150 ms SOA ANOVAs, only the second constituent elicited significant priming in the SJ-CV condition, but only the first constituent elicited significant priming in the NJ-CV condition.

The results for the two MM WFP conditions were as follows. In the 90 ms SOA ANOVAs, only the first constituent elicited significant priming in the SJ-MM condition and no differences were observed in the NJ-MM condition. Similarly, in the 120 SOA ANOVAs, only the first constituent elicited significant priming in the SJ-MM condition and no differences were observed in the NJ-MM condition. In the 150 ms SOA ANOVAs, both WFP and prime-type effects were significance, such that both constituent conditions elicited significant priming in both the SJ-MM and NJ-MM conditions, and RTs were faster for the NJ-MM condition compared to the SJ-MM condition.

Summarizing these focused comparisons, while a reverse trend was observed in the 150 ms SOA condition, such that only the second constituent elicited faster RTs in the SJ-CV condition and only the first constituent elicited faster RTs in the NJ-CV condition, both constituents elicited faster RTs in the other combinations of SOA and WFP conditions. For the MM conditions, the results were more complicated, in that all first-constituent priming effects were significant for the NJ-MM conditions across all SOA conditions, but first- and second-constituent priming effects were only observed in the SJ-MM and the NJ-MM conditions in the 150 ms SOA condition.

3.2.3 *Discussion*

Expanding on the range of WFP conditions by including both SJ and NJ compound words, Experiment 2 provides further evidence for the early activation of morphological information within the processing of compound words. More specifically, in addition to providing further support for the advantages of left-to-right processing and of head-morpheme observed in Experiment 1, with its wider variety of WFP conditions, Experiment 2 also provides evidence of a lexical-stratum advantage. There would seem to be two aspects to this advantage. The first is the phonological match between first-constituent primes and the initial pronunciation of NJ compound words, and the second aspect is that, as the constituents of NJ compound words tend to be kunyomi-dominant, the constituent-primed processing of NJ compounds may also benefit from the faster activation of semantic information from such primes compared to onyomi-dominant kanji (Nomura, 1978).

4. General discussion

In order to further investigate the morphological activation of two-kanji compound words, the two experiments reported within this chapter employed a series of very-brief masked SOA conditions with the constituent-morpheme priming paradigm. Extending on the findings of Joyce's (2002b, 2003a, 2003b) studies, the present experimental results provide evidence for complex interactions between different forms of morphological information across the different WFPs. The three processing advantages observed within the results – the left-to-right processing advantage, the head-morpheme advantage and the lexical stratum advantage – are intricately intertwined with the complex interactions between orthography, phonology and semantics underlying the complicated nature of the Japanese writing system (Joyce & Masuda, 2018).

Prima facie, the left-to-right processing advantage could be interpreted in terms of orthographic information. Even though the point should be self-evident, it is worth stressing that for two-kanji compound word targets within the constituent-morpheme priming paradigm, there is always an orthographic overlap between the constituent prime and one of the target's constituents; only its position varies. However, while it is true that first-constituent priming effects were more frequently observed than second-constituent effects, if the left-to-right processing advantage were purely a matter of orthographic overlap, then, one would expect this advantage to be even more prominent across the WFP and SOA conditions. Moreover, the significantly greater second-constituent priming effects for CV compounds in both the 120 and 150 ms SOA conditions of Experiment 1, in particular, suggest that the observed constituent-priming effects are also partially semantic in nature.

As hinted already, the activation of phonological information is potentially a factor underlying both the left-to-right processing and the lexical-stratum advantages. Both advantages could reflect the varying combinations of phonological ordering and overlap intervening between the constituent-morpheme primes and the compound word targets. In terms of the left-to-right processing advantage, the processing entailed in merely extending on the onyomi activated by the first-constituent primes of SJ compound words would seem to be less burdensome that the reversal operation necessary for the onyomi activated by second-constituent primes. Similarly, the lexical-stratum advantage, as manifested in the significant main effects of WFP between the NJ-CV and SJ-CV conditions within Experiment 2, could be reflecting the phonological match between kunyomi-dominant constituent kanji and NJ compound words. One must, however, be wary of attempting to account for all of the observed constituent-morpheme priming effects purely in terms of the phonology activated by constituent-primes, especially, when the activated phonology is not always consistent with the phonology of the compound word targets (i.e., kunyomi-dominant constituent primes to SJ compound word targets).

Moreover, a number of the observed constituent-priming effects seem to strongly indicate the early activation of semantic information. In particular, the most robust priming effects for both constituents were observed in the SP condition in Experiment 1, where the semantic overlap between the meanings of both constituents and the meaning of the compound word itself is always substantial, such as 山岳 where both constituents mean 'mountain' and the compound word means 'mountains'. Similarly, the overall trend towards greater constituent-priming effects from the verbal constituents of the reversed WFP conditions of VC and CV compound words across the two experiments also indicates greater degrees of semantic similarities between the meanings of the verbal constituents and the compound word meanings.

As noted within the Introduction, Joyce (2002a, 2002b) has proposed JLUM as a model of the Japanese mental lexicon that is capable of providing a plausible account of the constituent-primed lexical processing of two-kanji compound words. Part of the model is depicted in Figure 1. JLUM has a close affinity with the multi-level interactive-activation framework that Taft has been developing for some time, from his (1991, 1994) initial extensions of McClelland and Rumelhart's (1981) model by incorporating word-body and morpheme-level representations, respectively, to the AUSTRAL version (Taft, 2015) for the English mental lexicon, as well as applications to the Chinese mental lexicon (Taft et al., 1999; Taft & Zhu, 1995, 1997). However, JLUM was most directly inspired by Taft et al.'s (1999)

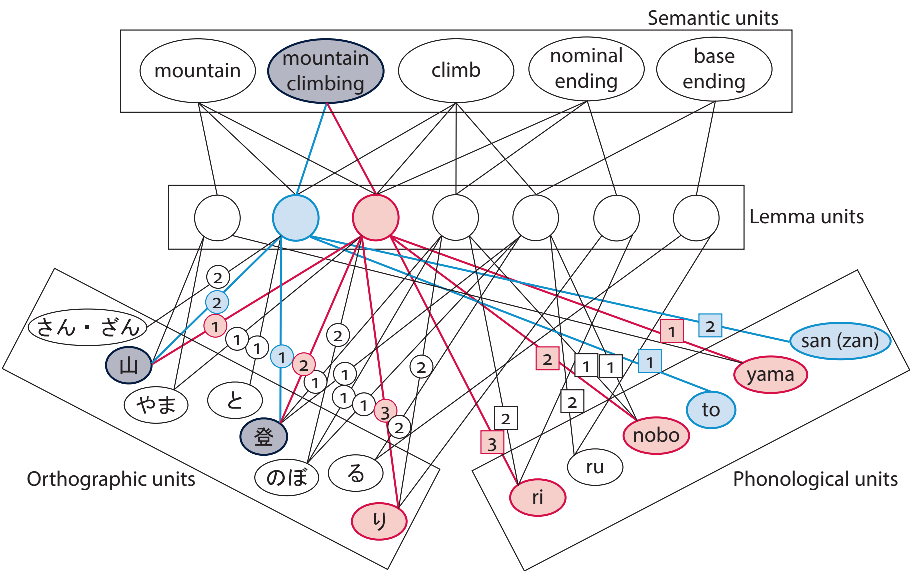

Figure 1. Part of the JLUM representations for the synonymous SJ 登山 and NJ 山登り compound words for 'mountain-climbing' (Adapted from Joyce's (2002a: 89) Figure 1 to specifically highlight the lemma-unit representations of these synonyms, the figure omits lower-level orthographic and phonological representations and although constituent ordering is indicated by numbers on some links, that is actually assumed to be a lemma-unit property)

Chinese version that first incorporated lemma-unit representations as connections or way-stations mediating the links between both orthographic and phonological access representations and semantic representations. That modification was proposed as an effective solution to issues associated with earlier Chinese versions (i.e., Taft & Zhu, 1997) relating to representational redundancy, homographs and semantic transparency. Given that they are all vexing issues for earlier Japanese models, such as Saito's (1997) companion-activation model and Tamaoka and Hatsuzuka's (1998) model, the inclusion of lemma-unit representations is also well-motivated for models of the Japanese mental lexicon.

However, an even more distinctive feature of the JLUM is that it is the first model of the Japanese lexicon that unifies the processing of the Japanese writing system's multi-scripts within a single integrated model. A fundamental challenge for any comprehensive model of the Japanese mental lexicon is to model the connections between the Japanese writing system's multi-scripts and meaning, particularly, given the pervasive nature of orthographic variation (Joyce, 2004; Joyce, Hodoščék, & Nishina, 2012; Joyce & Masuda, 2018). JLUM's lemma-unit representations also provide an elegant solution to that dilemma, as it is far simpler to extend the range of orthographic representations linking directly to the relevant lemma units, such that the kanji 山, the hiragana やま, the katakana ヤマ and the alphabetic representation *yama* can all be linked to the meaning of 'mountain' via its lemma unit. JLUM is also able to more realistically model the nuances of kunyomi and onyomi usages. Although rote-learning of the distinctions is an integral aspect of kanji instruction in school, knowledge of these readings within the adult native-speaker can also be assumed to be greatly dependent on usage frequencies, as reflected within the network of links from phonological access representations to lemma units.

As implied already, a core motivation for proposing JLUM was its potential to provide a more plausible account of the results from the constituent-morpheme priming paradigm that demonstrate priming effects for both constituents (Joyce, 2002a, 2002b). Unlike Hirose's (1992) hypotheses that evoked search mechanisms with a pivotal retrieval-cue role for the first constituent, JLUM assumes mechanisms of spreading activation as underpinning the lexical retrieval of two-kanji compound words. More specifically, it assumes that two-kanji compound words are activated via activation that passes in parallel from both orthographic representation units for its constituent kanji to the compound word's lemma unit. Moreover, constituent-morpheme priming effects are explained by assuming that lingering activation within the network of lemma units linked to the orthographic units of constituent kanji provides those lemmas with an advantage over other units, and, thus, the lingering activation leads to faster RTs compared to unrelated or unprimed lexical access. Figure 1 illustrates part of JLUM, highlighting the representations for the synonymous SJ 登山 and NJ 山登り compound words. While both compound words are assumed to activate the meaning of 'mountain-climbing', their lexical status as independent words is represented by the separate lemma units. While the SJ compound word 登山 and its onyomi of /to-zan/ would be activated when the constituent kanji of 登 /to/ and 山 /san (zan)/ are combined together as SJ morphemes in that order, the NJ compound word 山登り and its kunyomi of /yama-nobo.ri/ would be activated when the compound word is a combination of the NJ morphemes of 山 /yama/ and 登り /nobo.ri/, respectively.

Finally, we conclude by acknowledging some concerns relating to the reported experimental results that point to some issues that will be addressed within future research. The first concern is that the observed constituent-morpheme priming effects were not constant across the various WFP and SOA conditions over the two experiments. One point that warrants stressing in that context is that although both experimental designs consisted of SOA conditions that manipulated the interval between prime-stimulus offset and target-stimulus onset – ranging from 60, 90, 120 to 150 ms over both experiments – for all SOA conditions, primes were only presented for 40 ms followed immediately by a mask for 20 ms. And yet, even with such minimal presentation durations, significant priming effects (albeit only marginally so in a few cases) were observed in 58% of the experimental conditions (with 58% and 42% of those from the first- and second-constituent conditions, respectively). Moreover, the general trends within these results are highly consistent with the results previously reported by Joyce (2002a, 2002b, 2003a, 2003b, 2004). A second concern relates to the WFP conditions, and although they were controlled for based on Joyce and Ohta's (1999) database of WFP classification scores, the differing trends within the priming effects for SJ-CV and NJ-CV, in particular, suggest that more detailed analyses of the morphological structures of Japanese compound words could be beneficial for future constituent-morpheme priming experiments. A third possible concern is that, given morphological processing has been shown to be influenced by the degree of semantic transparency, or associations, between constituent and compound word meanings (Libben, 2006; Sandra, 1994), future priming studies will also utilize the database more recently compiled by Masuda and colleagues that has surveyed the semantic relatedness of compound word constituents (Joyce et al., 2016; Masuda, 2014; Masuda, Joyce, Ogawa, Kawakami, & Fujita, 2014). While these concerns are closely related to the complexities of the Japanese writing system's multi-scripts, and, thus, undeniably pose some special challenges for conducting constituent-priming investigations into the morphological activation of Japanese compound words, as the reported experiments demonstrate, such studies can also yield some potentially interesting insights into the richness of morphological processing.

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CHAPTER 12

The intertwining effects of first language and learning context on the bilingual mental lexicon

Nobuhiko Akamatsu
Doshisha University, Japan

This study examined the possible effects of learners' first language (L1) and learning context on the mental structures of second language (L2) polysemous words: the English prepositions *at*, *in*, and *on*. The study found that Japanese learners of English as a foreign language (EFL) who had lived in an English-speaking country had developed native-like mental structures of the three prepositions. By contrast, those with little or no experience living in an English-speaking country showed native-like mental structures only for *on* – the preposition denoting the most concrete notion among the three prepositions. These findings suggest that learners' L1 may affect their mental representations of L2 prepositions, particularly those denoting abstract notions, but significant L2 exposure can diminish such L1 effects.

Keywords: first-language effects, learning contexts, bilingual lexicon, polysemy, prepositions

Introduction

A first language (L1) plays a crucial role in the development of the bilingual mental lexicon. Second language (L2) lexical development, particularly at the initial stage, involves linking an L2 word to its L1 equivalent. When an L1 is linguistically distant from an L2, therefore, cross-linguistic differences could prevent learners from developing appropriate L2 lexical representations. In particular, when an L2 word and its L1 equivalent share the same semantic properties but differ in conceptual representation, learners need to engage in not only mapping an L2 word to its L1 equivalent's concepts, but also restructuring conceptual representations (Pavlenko, 2009). Conceptual restructuring, nevertheless, is hard to bring about. In fact, research on L2 acquisition has shown that many learners experience difficulty

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in appropriately using L2 lexical items whose meanings are closely related to, but slightly different from their L1 equivalents (e.g., Ijaz, 1986; Jarvis & Pavlenko, 2008). Research on learning in other areas – mathematics, science – also shows that, once knowledge has been conceived, it is often resistant to change, and various forms of explicit teaching fail to induce the *conceptual change* kind of learning (Sinatra & Pintrich, 2003).

The central issue of this study concerns the degree to which cross-linguistic differences affect the bilingual mental lexicon. The study compares L2 learners' and English-L1 speakers' mental structures of L2 words and explores to what extent an L1 affects L2 lexical representations. The study also examines the degree to which the context of L2 learning and use affects learners' mental structures of L2 words. The study focuses on L2 polysemous words that often require learners to adapt the conceptual representations of their L1 equivalents in the appropriate use of L2 words.

The bilingual mental lexicon

The question – how two languages are stored in one mind – has stimulated intellectual inquiry for decades. Early studies on the bilingual lexicon mainly focused on the mapping of words to meanings. Their central issue frequently concerned whether each of the two lexicons has its own concept or the two lexicons are linked to one shared concept (Keatley, 1992; Weinreich, 1953/1963/2011); many current models of the bilingual lexicon, except the connectionist models assuming no lexicon, appear to be consistent in that the two lexicons are held to share the same concept. These models claim that "while phonological and morphosyntactic forms differ across languages, meanings and/or concepts are largely, if not completely, shared" (Pavlenko, 2009: 125). The consensus on the relationship between multiple lexicons and their shared concept has shifted researchers' attention to how word learning and bilinguals' conceptual system interact, resulting in a new line of L2 research: cross-linguistic effects on bilinguals' cognition.

In the past two decades, research on bilingualism has witnessed an increasing number of studies focusing on cross-linguistic influence in language and cognition (e.g., Cook, Bassetti, Kasai, Sakai, & Takahashi, 2006; Jarvis & Pavlenko, 2008; Pavlenko, 2009, 2014). These studies explored bilinguals' cognition in different conceptual domains (e.g., space, time, emotion, objects); their findings suggest that the degree of L1 influences on bilinguals' cognition varies according to crucial factors, such as the amount of language exposure, the context of language learning and use, and the nature of to-be-learned lexical items. Cook and colleagues (2006), for example, examined how Japanese learners of English as a second language (ESL) classified objects and substances. They showed three kinds of items – complex objects, simple objects, substances – to the learners and asked them to classify the items. They found that the learners who had stayed in an English-speaking country for more than two years demonstrated a native-like way of categorizing objects and substances. Because these findings support the idea that a non-native language affects the ways in which its learners perceive objects to a similar, if not identical, degree as does a native language, they propose that extensive exposure to an additional language may influence the way in which its speakers develop conceptual representations of objects. They also suggest that the impact of an additional language relates to the context where learners are exposed to the language. Specifically, learners need to be exposed to the target language in various sociocultural settings, so that they can receive *significant* exposure:

> [Significant] exposure is widely conceived as immersion in the L2 context, which provides learners with a variety of contexts of use and interaction. In other words, it is considered that learners have significant exposure when they are able to carry out a variety of speech acts over a wide range of situations and topics, and to participate in social settings effectively. (Muñoz, 2008: 585)

With respect to the nature of linguistic items, it is pointed out that cross-linguistic influence often manifests itself, when an L2 word and its translation equivalent represent a similar, if not the same, cognitive category, but each has distinctive sematic boundaries. For instance, the English verb *wear* has a broader semantic boundary than do its Japanese counterparts. Japanese verbs representing the notion of "wearing" are sensitive to the type of objects to be worn (e.g., *kaburu*: *wear* a hat; *kiru*: *wear* a shirt, a coat; *haku*: *wear* jeans, skirts, shoes; *kakeru*: *wear* a pair of glasses; *tsukeru*: *wear* perfume). By contrast, the English verb *wear* does not exhibit such sensitivity in its usage. Japanese learners of English, therefore, need to restructure their conceptual representations of the Japanese translation equivalents, so that they can acquire appropriate conceptual representations for the English verb *wear*. Such conceptual restructuring, however, may not be so easy to achieve.

Imai (1993) underscores the difficulty which learners experience in conceptual restructuring. She asked Japanese learners of EFL to categorize English sentences including *wear* according to its semantic properties. She found that the categorical patterns of the Japanese learners were distinctive, different from those of native speakers of English. She concluded that the discrepancy stemmed from the ways in which the Japanese learners perceive the English verb *wear*, because the learners' categorical patterns corresponded to those based on the Japanese translation equivalents. In other words, the Japanese learners failed to acquire appropriate concepts for *wear*; instead, they categorized English sentences using their conceptual representations of the Japanese translation equivalents. This cross-linguistic influence was also observed in L2 words whose semantic boundaries were narrower than the translation equivalents (e.g., Jiang, 2002, 2004).

As mentioned above, cross-linguistic influence is often observed when an L2 word partly overlaps with its translation equivalent in concept. In this regard, polysemy has attracted attention in research on cross-linguistic influence. Polysemous words have more than one sense. *Word senses* differ from *word meanings* in that senses refer to different and yet related meanings of a single word. The multiple senses of a polysemous word reflect the history of the word – how the word has been used over time. Naturally, synchronic variation and diachronic change are determined by a complex interplay of linguistic and social factors. Even when the core sense of an L2 polysemous word corresponds to its L1 counterpart's meaning, its other senses may not relate to the translation equivalent's concepts, because the two words share little or no sociocultural background.

Among polysemous words, prepositions are the most distinctive in nature: most prepositions are highly frequent, and they are regarded as reflecting how people conceive space. Because of these features, much research in cognitive psychology has explored human cognition via prepositions (e.g., Bowerman, 1996; Bowerman & Choi, 2001; Levinson, 2003; Levinson & Wilkins, 2006; Zhang, Segalowitz, & Gathbone, 2011). Prepositions also have attracted the attention of many cognitive linguists, not only because they represent human's spatial perception, but also because their polysemous senses denote more abstract concepts (e.g., Saint-Dizier, 2006; Tyler & Evans, 2003; Zelinsky-Wibbelt, 1993). Many studies in both camps suggest that prepositions represent both universal and language-specific senses.

Prepositions

Prepositions belong to a closed class of words. They share distinctive features with other closed-class words (e.g., determiners, conjunctions, auxiliaries) in linguistic function: closed-class words normally serve grammatical or relational functions. The major role of prepositions is to provide linguistic connections among open-class words (e.g., nouns, verbs, adjectives, adverbs), which have denotational functions, and to express the semantic relations between them. The interpretations of prepositions are often dependent on context, and they play a very important role in generating appropriate propositions (Saint-Dizier, 2006).

Most prepositions are highly polysemous, and their distinct senses are associated in such a way that the relationship among the senses can be classified as core or periphery (e.g., Lakoff, 1987), family resemblance (e.g., Taylor, 2003), or lexical networks (e.g., Tyler & Evans, 2003). In the core-or-periphery view of polysemous words, for example, "to go very quickly" may be considered as the core sense of *run*, whereas "to flow" as in "A river runs through the forest" or "to make something operate" as in "You should keep the engine running" is regarded as a peripheral sense. The family-resemblance view, on the other hand, claims that multiple senses have no such core-to-periphery relationships; it rather highlights the notion that the senses of a polysemous word are linked by a chain of intermediate senses with which they share semantic features. Despite these differences in perspective, however, the distinct senses are thought to be associated through meaning chains, rather than related on the basis of one semantic or cognitive commonality (Gibbs & Matlock, 2001).

Prepositions vary in meaning and the degree of polysemy, but the core of the multiple senses of many prepositions is seen to represent the same domain: physical space. This centrality of the spatial domain for prepositional representation may relate to the fact that space is fundamental to human cognition. A substantial number of studies show that basic prepositions in many languages represent locative and orientational notions, and that they have both universal and language-specific features in how they represent spatial relations (e.g., Bowerman & Choi, 2001; Levinson, 2003; Levinson & Wilkins, 2006; Zelinsky-Wibbelt, 1993; Zhang et al., 2011).

English prepositions

As observed in other languages, basic spatial prepositions in English have multiple senses to express very subtle differences in spatial relations. Many prepositions, including those space prepositions representing subtypes of spatial senses, are also used to express more abstract relations. Evans and Tyler (2004), for example, propose that the core sense of the English preposition *in* represents a spatial relation and a functional element of containment (e.g., "John is *in* the house"). Major clusters of senses derived from the core sense relate to (a) location, (b) vantage point (interior), (c) vantage point (exterior), (d) segmentation, and (e) reflexivity. Some clusters contain several distinct senses: the location cluster contains four different senses, such as the in situ sense (e.g., "He stayed *in* for the evening"), the state sense (e.g., "We are *in* a hurry"), the activity sense (e.g., "She is *in* graduate school"), and the means sense (e.g., "She wrote *in* ink").

Dirven (1993) compared 12 prepositions in English (*at*, *in*, *on*, *by*, *with*, *through*, *about*, *under*, *over*, *from*, *off*, and *out of*) and claimed that these prepositions share commonalities in the structure of prepositional semantics. Specifically, they all represent spatial relations as the core of the semantic network, and they also denote senses in all or some of the six other areas: time, state, area, means or manner, circumstance, and cause or reason. It is noteworthy that highly frequent prepositions tend to denote more senses than others. In particular, the basic and most general place prepositions *at*, *in*, and *on* are the only prepositions that represent senses in all domains.Dirven also proposed that the senses of these 12 prepositions are extended from physical space (i.e., the core sense) to more abstract domains (i.e., the peripheral senses) in such a way that peripheral senses are linked linearly or radially. Thus, although the senses remote from the core sense may lose semantic relations with the core sense, the neighboring senses remain semantic relations.

Rice and colleagues examined the structure of the polysemous senses of each of the basic space prepositions: *at*, *in*, and *on* (Cuyckens, Sandra, & Rice, 1997; Rice, 1996; Sandra & Rice, 1995). Unlike Dirven (1993), who categorized prepositional senses into seven classes, they grouped prepositional senses into three types: spatial, temporal, and abstract. Their main interest was in whether spatial senses are prototypical in usage for each preposition, whether or how the three types of prepositional senses are interconnected, and how tightly prepositional senses of each type are clustered. Based on the findings from a variety of experimental tasks (e.g., sentence similarity judgment, sentence generation, sentence sorting, acceptability decision), they concluded that spatial senses are prototypical for *at*, *in*, and *on* and that the spatial and the temporal senses tend to make separate clusters. By contrast, the abstract types of senses are not clustered as one entity, but loosely connected with all the three types of prepositional senses.

Japanese postpositions

Japanese has postpositions rather than prepositions. Japanese postpositions and English prepositions are both highly polysemous, but they differ in how they express senses. For example, the postpositions *ni* and *de* are often regarded as the equivalents of the English space prepositions *at*, *in*, *on*; there are, however, some differences in usage between them (e.g., Cho, 2010; Hawkins, 1993). The Japanese equivalents are sensitive to the type of verbs used in sentences: The locative postposition *ni* is often used with a stative verb (e.g., believe, know, like), while the postposition *de* is used when the verb is dynamic (e.g., eat, go, write) (Hawkins, 1993). English prepositions, on the other hand, do not exhibit such sensitivity:

takusan no hito ga yakyuujoo <u>ni</u> imasu
'Many people are <u>at</u> the ballpark.'
reizooko <u>ni</u> keeki ga arimasu
'I have some cake <u>in</u> the fridge.'
shashintate wa hondana <u>ni</u> arimasu
'The picture frame is <u>on</u> the bookshelf.'

furansu resutoran <u>de</u> yuushoku wo tabeta
'We had a dinner <u>at</u> a French restaurant.'
kooen <u>de</u> yakyuu wo shita
'We played baseball <u>in</u> the park.'
mizuumi <u>de</u> sukeeto wo shita
'We skated <u>on</u> the lake.'

One may wonder if the fundamental sense of spatial relations that each of the three English prepositions implies would be lost in translation via the Japanese postpositions, because *at*, *in*, and *on* are all translated into *ni* or *de*. Japanese has another way to use postpositions when the prototypical spatial sense needs to be emphasized in phrases or sentences: using spatial nominals with postpositions. For example, by placing the possessive case marker *no* and the spatial nominal *naka* – which refers to the relationships of containment and enclosure – before the postposition *ni* or *de*, one can express the topological relation of the preposition *in*:

> *reizooko <u>no</u> <u>naka</u> <u>ni</u> keeki ga arimasu*
> 'I have some cake <u>in</u> the fridge.'
> *kooen <u>no</u> <u>naka</u> <u>de</u> yakyuu wo shita*
> 'We played baseball <u>in</u> the park.'

Less prototypical senses, on the other hand, are often accompanied by specific verbs describing the particular characteristics of their senses. For example, the locative preposition *on* refers to support or contact relationships in various ways: support embedded (e.g., picture on a mug), adhesion (e.g., stamp on an envelope), hanging (e.g., coat on a hook), and point-attachment (e.g., clothes on a line) (e.g., Bowerman & Choi, 2001; Landau, Johannes, Skordos, & Papafragou, 2017). Because neither postpositions nor spatial nominals in Japanese can express the distinctive senses of these subtypes, verbs play an important role in denoting the subtle differences that these subtypes imply – describing how two objects are attached.

Another difference between Japanese postpositions and English prepositions can be observed in the semantic network of senses. Moriyama (2008), for example, proposes that the semantic network of the Japanese postposition *de* consists of five categories or clusters of senses: (a) location (*tookyoo de*: in Tokyo), (b) time (*ato de*: later), (c) tools or means (*ohashi de*: with chopsticks), (d) cause or reason (*byooki de*: because of sickness), and (e) manner (*jibun de*: by oneself). The core of the semantic network denotes location, and the time and the tools-or-means cluster of senses are each seen to be extended from the core sense. Furthermore, the senses referring to cause or reasons and manner are considered to be the extensions of the tools-or-means senses. These five categories of senses have been observed in a variety of written documents since medieval Japan (Mabuchi, 2000).

It is noteworthy that, despite the fact that the postposition *de* is seen as the equivalent of the English general space prepositions *at*, *in*, and *on*, these prepositions no longer express various senses of the Japanese postposition *de*. This appears to reflect the diversity of the way in which prepositional or postpositional senses are extended from the spatial domain in each language. Moreover, the Japanese postposition *ni*, the other equivalent of *at*, *in*, *on*, differs from the postposition *de* in prototype and constituent clusters of senses: direction (*tookyoo ni iku*: go to tokyo) is the prototypical sense, and location (*tookyoo ni sumu*: live in Tokyo), time (*9 ji ni*: at 9 o'clock), cause or reason (*byooki ni kurusimu*: suffer from sickness), and effect or result (*mizu ga koori ni naru*: water turns into ice) are seen to be clusters of extended senses (i.e., non-prototypical senses) (Moriyama, 2008).

The acquisition of L2 prepositions and postpositions

In contrast to cross-linguistic studies on L1 prepositions or postpositions, there are only a handful of studies on the acquisition of L2 prepositions or postpositions. Their findings, nonetheless, highlight some commonalities in the acquisition of L2 prepositions and postpositions. Regardless of L1 differences, in general, learners appropriately use prototypical senses of L2 prepositions or postpositions. For non-prototypical senses, however, learners' L1 is likely to affect acquisition and result in erroneous use.

Ijaz (1986) argues that non-prototypical senses of English prepositions are difficult to acquire due to the cross-linguistic differences in prepositional semantics. She investigated the ESL users' knowledge of English spatial prepositions which involve the same semantic dimensions, and yet differ in the precision of meaning: *on*, *upon*, *onto*, *on top of*, *over*, and *above*. The ESL users' L1 varied (e.g., German, Urdu); they all had native-like oral proficiency in English. Their performance in a semantic-relatedness and a sentence-completion test showed that they did not grasp subtle differences between some of the prepositions (e.g., *on* versus *over*, *onto* versus *on top of*, *on* versus *above*). Furthermore, although they generally had appropriate knowledge of usage for prototypical senses (e.g., There is a basket *on* the floor), their use of non-prototypical senses (e.g., the keys are hanging *on* the hooks; dogs must be kept *on* a leash) was likely to be less accurate. The German-native speakers, for example, under-emphasized the semantic element of *contact*, but over-emphasized that of *movement* in the use of *on*. Ijaz pointed out that the German preposition *auf* – the German translation equivalent of *on* – might have affected the German speakers' mistaken usages of *on*, because *auf* can denote both contiguous and non-contiguous meanings. She suggests that "[the] finding that non-central semantic concepts constitute language specific combinations of differentially weighted semantic dimensions may, in part, account for the different linguistic classification of semantic concepts across languages" (p. 448).

Lowie and Verspoor (2004) also found that the similarity in meaning between L1 and L2 prepositions facilitates learning. In the use of the English prepositions denoting central senses in different domains, such as space (e.g., *in* his room), time (*for* three months), direction (*off* the table), possession (the legs *of* the table), and beneficiary (I bought the present *for* my friend), most Dutch learners demonstrated more accurate knowledge for the English prepositions similar to their equivalent Dutch prepositions. This benefit of L1-L2 similarity, however, was not observed for highly frequent prepositions, suggesting that the learners' L1 was less likely to affect the acquisition of prototypical senses of L2 prepositions.

Similar findings are reported in research on the acquisition of L2 postpositions. Specifically, Moriyama (2008) found that, regardless of learners' L1 (Chinese, Korean, or English), L2 learners of Japanese acquired various senses of the postposition *de* in the same order. They first learned the appropriate usage of the postposition for the locative senses and then improved their usages of the senses of tools or means, manner, cause or reason, and, finally, for time (in that order). Moriyama suggests that this acquisition order appears to reflect the semantic network of the postposition *de*: from the prototypical sense to more abstract senses extended from the spatial senses. He also pointed out that L2 learners showed unique patterns: unlike native speakers of Japanese, L2 learners' senses loosely clustered together, such that these clusters did not necessarily reflect the distinctive features of each domain. Furthermore, the prototypical senses for Korean learners related to location, while those for Chinese learners were associated with tools or means. Moriyama speculated that the learners' L1 might have affected how they developed their knowledge of appropriate usage of the postposition *de*, resulting in un-native-like performance.

The rationale of the study

Due to the distinctive features of prepositions, a substantial number of L1 studies concerning English prepositions have explored the relationships between human cognition and language. There have been, however, few, if any, studies that examine the L2 learner's mental structures of the English prepositions. Because L1 research has shown that prepositions have both universal and language-specific features in their senses and usages, it is worth exploring whether or to what extent cross-linguistic differences affect L2 learners' mental representations of English prepositions.

Because general prepositions or postpositions across many languages are highly frequent and their prototypes denote spatial relations, this research hypothesizes that learners benefit from such cross-linguistic commonalities. Specifically, the prototypical senses of prepositions in the mental lexicon would not differ between L2 learners and L1 speakers. For non-prototypical senses, on the other hand, the mental structures or networks of prepositional semantics are quite diverse across languages. The learners, therefore, would possibly develop distinctive representations of L2 prepositions reflecting the language specific features of their L1 equivalents.

Such L1 effects, however, may vary according to such related factors as the context of L2 learning and use, L2 proficiency, and the nature of to-be-learned items (Muñoz, 2012; Piske & Young-Scholten, 2008).

The study addresses the following research questions (RQs):

RQ 1: Does the EFL learner's mental structure of prepositional senses differ from the English-L1 speaker's?
RQ 2: Does the experience of living in an English-speaking country contribute to the acquisition of a native-like mental structure of prepositional senses?
RQ 3: Does the EFL learner's English proficiency relate to the development of a native-like mental structure of prepositional senses?

Method

Participants

A total of 65 EFL learners (i.e., Japanese undergraduates) participated in the study. They were divided into two groups according to the length of residence in an English-speaking country (LOR): 38 EFL learners with less than a two-month LOR (i.e., the NSE group: the non-significant exposure group) and 27 EFL learners with more than twelve-month LOR (i.e., the SE group: the significant exposure group). All the EFL learners took the Vocabulary Size Test (Nation & Beglar, 2007) and TOEFL-PBT; the scores were used to assess their English proficiency (see Table 1). Thirty-eight university students whose L1 was English (i.e., the NS group: the native speakers of English) also participated in the study.

Table 1. Descriptive statistics of the participants (EFL learners only)

	NSE (n = 38)				SE (n = 27)			
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Age	18	21	19.2	0.6	18	21	19.8	0.9
TOEFL	410	567	501.7	48.5	480	640	570.0	42.0
Voc	33	76	39.2	9.7	38	81	61.5	12.6
AOA	N.A.	N.A.	N.A.	N.A.	1	17	8.9	5.2
LOR	N.A.	N.A.	N.A.	N.A.	12	132	55.4	32.2

Note. *SE* = the significant exposure group; *NSE* = the non-significant exposure group; *Voc* = the Vocabulary Size Test; *AOA* = the age of arrival in an English-speaking country; *LOR* = the length of residence (months) in an English-speaking country.

Task

Following Rice's experiment (1996), this study used a sentence-generation task. This task was chosen because the type frequency of polysemous senses is regarded as reflecting learners' mental structure of prepositional senses: learners' "prototypical usages should be more easily recalled and therefore produced with the greatest frequency, [whereas] non-prototypical usages associated with the prepositions should also emerge, but at a reduced frequency" (Rice, 1996: 148).

The participants were asked to write 10 sentences containing each of three basic and very common general place prepositions – *at*, *in*, and *on* – on the computer screen. The time allowed for generating sentences for each preposition was 10 minutes.

Experimental design and data analysis

The author and an EFL instructor independently classified and coded the sentences according to the usage type of the target preposition. The author adapted Rice's coding system (1996). It consisted of four types of prepositional usages (spatial, temporal, abstract, phrasal-verb usages) and two types of erroneous responses (inappropriate prepositional usages, incomplete sentences). In deciding which type of the four prepositional usages the responses belong to, we referred to Dirven (1993), Rice (1996, personal communication, May 1, 2014), and the *Oxford Phrasal Verbs Dictionary for Learners of English* (McIntosh, 2006). The following are sample sentences generated by the participants for *in*:

> She is already in the room. (spatial)
> I need to leave in an hour. (temporal)
> I left in a hurry. (abstract)
> Can you please put it in? (phrasal verbs)

After we reviewed the coding results and discussed the items on which we disagreed, the inter-rater agreement reached approximately 99 percent. For the items of disagreement, we used the author's coding results. The sentences generated by the participants who produced more than three erroneous responses were excluded from the data analysis.

For each preposition, we calculated the frequency of each type of prepositional usage for each participant group. Pearson's chi-square tests were used to analyze the differences in the frequency distribution of prepositional usage-type between the participant groups.

Correlation analysis was also carried out to examine to what extent the EFL learners' proficiency of and experience in English – TOEFL scores, Vocabulary-Size-Test scores, the length of residence, the age of arrival – related to the development of the mental representation of the target prepositions. We used chi-square goodness-of-fit tests to determine how close the EFL learners' mental structure of prepositional usage was to the English-L1 speaker's. We computed chi-square test statistics by applying each EFL learner's frequency distribution of the prepositional usage-types as an observed value and the English-L1 speakers' mean frequency distribution as an expected value. The logic behind the chi-square goodness-of-fit test is that the closer the observed value is to the expected one, the smaller it becomes. In other words, these computed chi-square test statistics were used as an index for native-like-ness with respect to the mental representation of the target prepositions.

Results

The results of TOEFL-PBT and the Vocabulary Size Test showed that the SE group was more proficient in English than the NSE group, $F(1, 63) = 21.29$, $p < .001$ (the Vocabulary Size Test) and $F(1, 63) = 43.72$, $p < .001$ (TOEFL-PBT). The error rates in the sentence generation task also highlighted the SE group's superiority. The SE group's error rates (1.5% for *at*, 1.9% for *in*, 3.0% for *on*) were significantly lower than the NSE group's (8.0% for *at*, 7.9% for *in*, 11.1% for *on*), $F(1, 55) = 7.51$, $p = .008$, $F(1, 59) = 7.51$, $p = .001$, $F(1, 60) = 7.51$, $p = .001$, respectively.

The results of Pearson's chi-square tests indicated that the differences in the frequency distribution of prepositional usage-type between the three participant groups varied (see Table 2). For the prepositions *at* and *in*, the proportion of the four types of prepositional usages (spatial, temporal, abstract, phrasal-verb usages) significantly differed between the groups, $\chi^2(6, N = 920) = 29.19$, $p < .001$ for *at* and $\chi^2(6, N = 952) = 14.60$ for *in*, $p = .024$. For *on*, however, no statistically significant difference was observed, $\chi^2(6, N = 945) = 11.29$, $p = .089$ (see Figure 1).

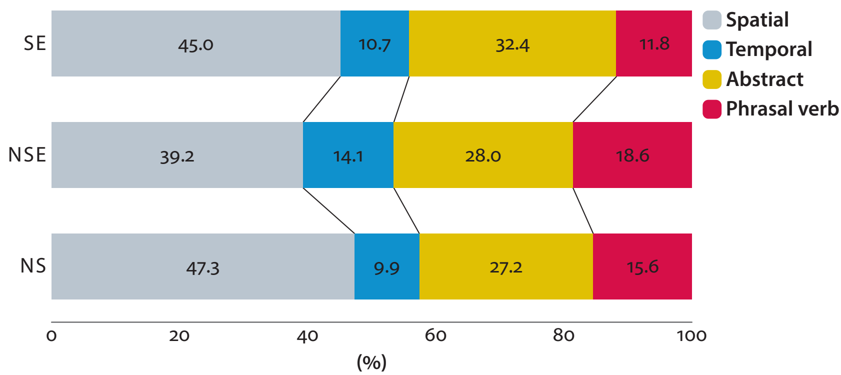

Figure 1. Each group's proportions of prepositional usages for the preposition *on*. *SE* = the significant exposure group; *NSE* = the non-significant exposure group; *NS* = native speakers of English

Table 2. Numbers and proportions of prepositional usages for each group

Preposition	Group	N	Prepositional usage				SUM
			Spatial	Temporal	Abstract	PV	
AT	SE	27	145 (54.5%)	50 (18.8%)	48 (18.0%)	23 (8.6%)	266 (100.0%)
	NSE	30	97 (35.1%)	82 (29.7%)	73 (26.4%)	24 (8.7%)	276 (100.0%)
	NS	38	180 (47.6%)	73 (19.3%)	102 (27.0%)	23 (6.1%)	378 (100.0%)
IN	SE	27	142 (53.6%)	36 (13.6%)	62 (23.4%)	25 (9.4%)	265 (100.0%)
	NSE	34	137 (43.8%)	60 (19.2%)	92 (29.4%)	24 (7.7%)	313 (100.0%)
	NS	38	208 (55.6%)	45 (12.0%)	89 (23.8%)	32 (8.6%)	374 (100.0%)
ON	SE	27	118 (45.0%)	28 (10.7%)	85 (32.4%)	31 (11.8%)	262 (100.0%)
	NSE	35	122 (39.2%)	44 (14.1%)	87 (28.0%)	58 (18.6%)	311 (100.0%)
	NS	38	176 (47.3%)	37 (9.9%)	101 (27.2%)	58 (15.6%)	372 (100.0%)

Note. SE = the significant exposure group; *NSE* = the non-significant exposure group; *NS* = native speakers of English; *N* = the number of participants; *PV* = Phrasal Verbs.

For *at* and *in*, post-hoc analyses were conducted to examine which pair of the three groups yielded significant results, using Pearson's chi-square tests with adjusted alpha levels of .0167 per test (.05/3). The post-hoc pair-wise comparisons for *in* indicated that statistically significant differences were observed only between the NS and the NSE group, $\chi^2(3, N = 687) = 12.63$, $p = .006$ (see Figure 2). Residual analyses identified the spatial and the temporal usage as the contributing factors for the significant result. The adjusted residual of 3.092 for the spatial usage showed that the NS group (55.6%) used spatial senses more often than the NSE group (43.8%) ($p < .001$). The adjusted residual of −2.589 for the temporal usage, on the other hand, suggested that the NSE group (19.4%) used more temporal senses than the NS group (12.0%) ($p < .01$).

Results indicated that the differences between the NS and the NSE group were statistically significant for *at*, $\chi^2(3, N = 654) = 14.67$, $p = .002$ (see Figure 3). As observed in the results for *in*, residual analysis identified the spatial and the temporal usage as the factors contributing significantly to the result. The adjusted residual of 3.189 for the spatial usage showed that the proportion of the spatial usage for the NS group (47.6%) was significantly larger than that for the NSE group (35.1%) ($p < .001$). The adjusted residual of −3.088 for the temporal usage, on the other

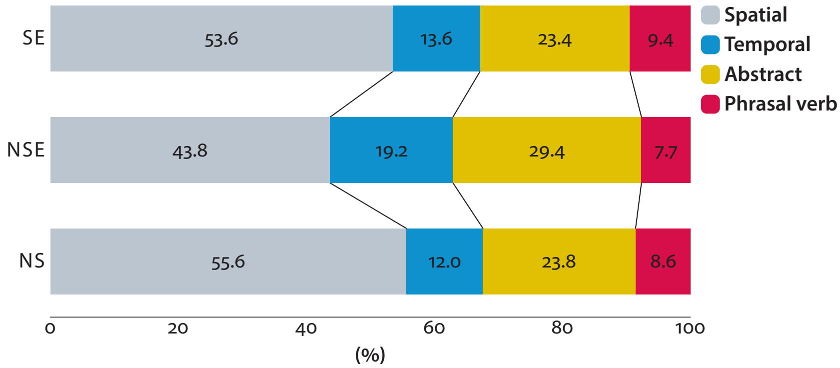

Figure 2. Each group's proportions of prepositional usages for the preposition *in*. *SE* = the significant exposure group; *NSE* = the non-significant exposure group; *NS* = native speakers of English

hand, suggested that the NSE group (29.7%) showed more temporal usage than the NS group (19.3%) ($p < .001$).

Results also showed that the SE and the NSE group significantly differed in *at*, $\chi^2(3, N = 542) = 22.29$, $p < .001$ (see Figure 3). According to the residual analysis, the two EFL groups differed in the spatial, the temporal, and the abstract usage. The adjusted residual of 4.534 for the spatial usage showed that the SE group's proportion of the spatial usage (54.5%) was larger than the NSE group's (35.1%) ($p < .001$). By contrast, as the adjusted residual of −2.959 for the temporal usage and that of −2.349 for the abstract usage indicated, the percentages of these usages for the SE group (18.8% and 18.0%) were significantly lower than those for the NSE group ($p < .01$ and $p < .05$). It is noteworthy that the post-hoc analysis of the

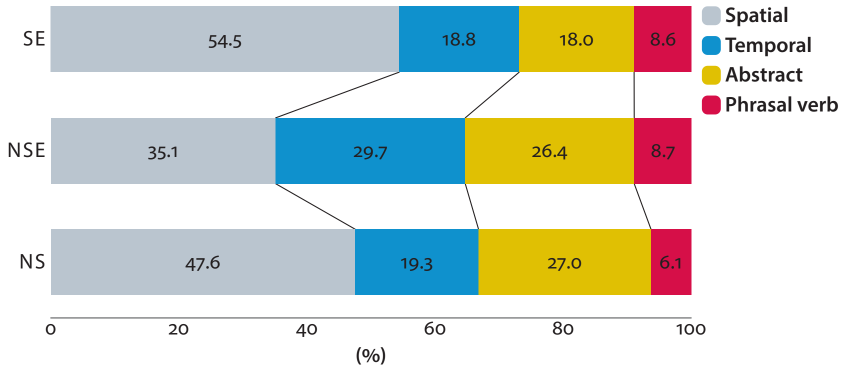

Figure 3. Each group's proportions of prepositional usages for the preposition *at*. *SE* = the significant exposure group; *NSE* = the non-significant exposure group; *NS* = native speakers of English

differences between the NS and the SE group produced no statistically significant results, $\chi^2(6, N = 644) = 8.28$, $p = .041$.

In correlation analyses, the chi-square goodness-of-fit test statistics of greater or less than 2 SD from the mean for each EFL group, across all prepositions, were regarded as outliers and eliminated from the analyses. Accordingly, two participants in each EFL group were eliminated from the correlation analysis of the preposition *at*.

Results (i.e., one-tailed tests) revealed that the relationships between the learner's proficiency of English and their mental structure of the prepositional senses varied according to the nature of the prepositions (see Table 3). Whereas the EFL learners' English proficiency related to the native-like mental structures for the preposition *at*, neither *in* nor *on* exhibited such statistically significant relations. Both the TOEFL and the Vocabulary-Size-Test scores were significantly negatively correlated with the chi-square goodness-of-fit test statistics for *at* ($r = -.358$, $p = .004$ and $r = -.373$, $p = .003$, respectively), suggesting that the more proficient the EFL learners were in English, the closer their mental representations of *at* were to those of native speakers of English.

Table 3. Correlations of the chi-square goodness-of-fit tests with TOEFL scores, vocabulary-size-test scores, LOR, and AOA

Preposition		**SE**	**NSE**	**SE & NSE**
AT	*TOEFL Scores*	−.377 (.031)	−.217 (.134)	−.358 (.004)
	Voc. Scores	−.434 (.015)	−.213 (.138)	−.373 (.003)
	LOR	−.360 (.039)	Not Applicable	Not Applicable
	AOA	.261 (.104)	Not Applicable	Not Applicable
IN	*TOEFL Scores*	.068 (.373)	−.093 (.307)	−.015 (.455)
	Voc. Scores	.284 (.084)	.044 (.405)	.137 (.155)
	LOR	.127 (.272)	Not Applicable	Not Applicable
	AOA	.042 (.421)	Not Applicable	Not Applicable
ON	*TOEFL Scores*	.094 (.323)	.089 (.305)	−.054 (.339)
	Voc. Scores	.108 (.300)	.055 (.377)	−.034 (.396)
	LOR	.037 (.429)	Not Applicable	Not Applicable
	AOA	−.178 (.192)	Not Applicable	Not Applicable

Note. P-values (one-tailed test) are in parentheses. *SE* = the significant exposure group; *NSE* = the non-significant exposure group; *LOR* = the length of residence in an English-speaking country; *AOA* = the age of arrival in an English-speaking country; *Voc. Scores* = Vocabulary-Size-Test Scores.

When such relationships were examined independently according to the EFL learners' experience in English, however, the two subgroups yielded different results (see Table 3). For the NSE group, neither TOEFL nor the Vocabulary-Size-Test scores statistically significantly correlated with the chi-square goodness-of-fit test statistics for *at*. By contrast, For the SE group, statistically significant relationships between the learners' English proficiency and the native-like mental structures for *at* were observed ($r = -.377$, $p = .031$ for TOEFL; $r = -.434$, $p = .015$ for the Vocabulary Size Test) (see Figures 4 and 5). Moreover, the LOR also significantly correlated with the chi-square goodness-of-fit test statistics ($r = -.360$, $p = .039$). When the LOR was partialed out, however, the associations between the English proficiency measures and the native-like mental representations lost statistical significance.

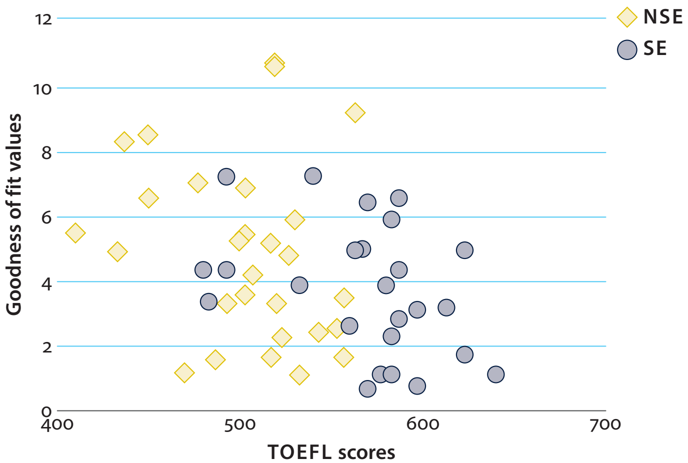

Figure 4. Scatter plot of the goodness-of-fit test values for the preposition *at* and the TOEFL scores for the EFL learners. *SE* = the significant exposure group; *NSE* = the non-significant exposure group

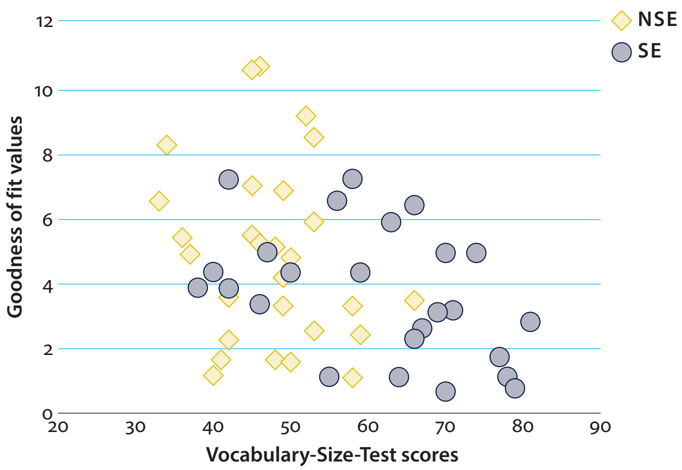

Figure 5. Scatter plot of the goodness-of-fit test values for the preposition *at* and the Vocabulary-Size-Test scores for the EFL learners. *SE* = the significant exposure group; *NSE* = the non-significant exposure group

Discussion

The present study addresses the issue of L2 learners' mental representations of the English prepositions *at*, *in*, and *on*. Specifically, the study explored (1) differences and commonalities in the mental structure of the English prepositional senses between Japanese EFL learners and English-L1 speakers, (2) the influence of learning context (*significant* versus *insignificant* exposure to English) on the learner's mental structure of prepositional senses, and (3) the impact of the learners' English proficiency on the acquisition of the native-like mental structure of prepositional senses. The major findings of the study suggest that Japanese EFL learners' mental representations of prepositional semantics were intertwined with such related factors as the learners' L1, the context of L2 learning and use, L2 proficiency, and the nature of prepositional senses.

Possible L1 effects on the mental structure of L2 prepositional semantics were observed only among the learners who had little or no experience living in an English speaking country (i.e., the NSE group). In addition, such L1 effects were found only in the use of *at* and *in*. In other words, regardless of different learning experiences in English, the EFL learners showed native-like mental structures of *on*.

This discrepancy may relate to the core sense of each preposition. The differences in meaning between these prepositions are often explained using the Euclidian view of space as being three dimensional (e.g., Dirven, 1993; Takahashi, 1969). Specifically, *at* views space by reducing all dimensions; it denotes place as being a point (zero dimension). Accordingly, *at* abstracts topological attributes and it is seen to be the most neutral spatial preposition among the three. *In* and *on*, on the other hand, represent distinctive aspects of space. *In* denotes place as a surface (two dimensions) or a volume (three dimensions) and represents containment or enclosure, whereas *on* denotes place as a line (one dimension) or a surface (two dimensions) and represents support or contact. Due to the fact that *at* represents more neutral spatial concepts than *in* or *on*, and that *in* denotes more abstract concepts than *on*, it seems plausible that the prepositional semantics of *on* were the easiest to learn:

> Within the set of the three most productive prepositions *at*, *in*, *on*, *on* is more concrete than *at* and *in*, since it has, as a major component, the notion of "physical contact". This feature may explain why *on* does not form "active" state predicates like *at* or *in* can (at work, in search of): *on* just like *under* only forms "passive" state predicates such as *on display* ("being displayed") or *under arrest* ("being arrested").
> (Dirven, 1993: 85)

In the use of *in*, the NSE group showed distinctive features. Specifically, they generated fewer sentences with the spatial usage of *in* than did the English-L1 speakers, whereas they produced more sentences with the temporal usage than did the English-L1 speakers. These findings underscore the fact that spatial senses took a major part of the mental structure of prepositional semantics for English-L1 speakers, but the centrality of spatial prepositional senses was less prominent for EFL learners with little or no significant exposure to English.

It may appear that the NSE group's English proficiency and/or learning context resulted in their distinctive mental structures of *in*. These factors, however, may not be plausible reasons, because the NSE and the SE group did not differ in the mental structures for *in*. Furthermore, regardless of different experiences in English learning and use, the EFL learners' English proficiency and vocabulary knowledge had no meaningful associations with native-like mental structures. The author rather speculates that the NSE group's distinctive performance related to the learner's L1 equivalents of *in* (i.e., the Japanese postposition *de* or *ni*).

The polysemous senses of these postpositions have distinctive semantic networks or structures; the proportion of each sense can be quite different from that of the English prepositions. Moriyama (2008), for example, reported that the prototypical sense of *ni* was not location but direction, which was more equivalent to the English preposition *to*. Moriyama also found that in a sentence generation task, the prototypical sense of *de* denoted an abstract domain such as tools or means. These findings were consistent with those of previous research, which showed that the L1 equivalents of L2 prepositions or postpositions often prevented L2 learners from acquiring appropriate representations when the L1 equivalents had a language-specific semantic network (e.g., Ijaz, 1986). It is, therefore, plausible that, if Japanese learners of English develop the representations of English prepositional semantics via their Japanese equivalents, the mental structures of the prepositional semantics can be far from those of English-L1 speakers.

The findings from the EFL learners' performance in the use of *at* highlight the importance of the context of language learning and use in the acquisition of L2 prepositional semantics. In contrast to the results of *in*, there were statistically significant differences in the mental structure of *at* between the two EFL subgroups. The proportion of the spatial usage for the SE group and that for the English-L1 speakers were significantly larger than that for the NSE group. This result implies that the EFL learners who once had been exposed to English in the sociocultural setting had developed a native-like mental structure of multiple senses even for such an abstract preposition as *at*.

The discrepant findings in the use of *at* between the SE and the NSE group may relate to the following reasons. As mentioned above, one plausible reason is the difference in learning experience between the two groups. The NSE group had little or no experience living in an English-speaking country; therefore, their mental representations of prepositional senses developed in a formal setting in Japan. Naturally, English discourse in class meetings and in English textbooks were their major English input. The SE group, on the other hand, had lived abroad for at least one year and had been exposed to English in both formal and informal settings in countries such as Canada, the UK, and the USA. Obviously, the English exposure that these two groups had received was quite different in its intensity, quantity, and quality. It should be noted that, for the SE group, the length of residence in an English-speaking country (LOR) was also positively associated with the native-like mental representation of *at*: the more *significant* exposure to English the learners received, the more native-like their mental structures of *at* were. This finding, therefore, highlights the importance of the context of L2 learning and use in diminishing the adverse effects of L1 equivalents of English prepositions and acquiring a native-like mental structure of L2 prepositional semantics.

One may speculate that the learners' proficiency in English can also explain the discrepant findings between the SE and the NSE group. Because the EFL learners in the SE group were generally more proficient in English and produced fewer erroneous responses for *at* in the sentence generation task than those in the NSE group, it is possible that the learners' English proficiency related to the native-like mental structure of *at*. The extent to which English proficiency contributed to the native-like mental structure, however, varied between the EFL subgroups. The NSE group showed no statistically significant associations between English proficiency measures and the native-like mental representations of *at*. In the SE group, on the contrary, the learners' general proficiency in English (i.e., the TOEFL scores) and vocabulary knowledge (i.e., the Vocabulary-Size-Test scores) were positively associated with the native-like mental representations of *at*. One should remain aware, however, that English proficiency measures and LOR could confound each other, because both factors were associated with the native-like-ness of the mental representation of *at*. When either factor was controlled, the association with the native-like-ness of the mental representation of *at* lost statistical significance.

It is noteworthy that English proficiency measures for the NSE group showed no statistically significant associations with the native-like mental structures of *in* and *at*. Even though there was a gap in the centrality of spatial senses in the mental structure between the NES group and the English-L1 speakers, neither general English proficiency nor English vocabulary knowledge made observable contributions to the native-like mental structures for the EFL learners with little or no experience living in an English-speaking country. This finding underlines the importance of learning context in the acquisition of L2 prepositions: English proficiency developed in the formal EFL settings may not help learners develop native-like mental representations of complex prepositional senses.

Conclusion and limitations

This study examined the possible effects of the learner's L1 and learning context on the mental structures of highly polysemous L2 words: the English prepositions *at*, *in*, and *on*. The study found that, regardless of the difference in the context of English learning and use, Japanese EFL learners had native-like mental structures of the English preposition *on* – the preposition denoting the most concrete notion among the three prepositions. In the use of *at* and *in*, by contrast, Japanese EFL learners with little or no experience living in an English-speaking country – and thereby little or no *significant* exposure to English – showed distinctive, less native-like mental structures. The spatial senses were not necessarily prototypical in their mental representations of these English prepositions. This was quite contrary to the features observed in the prepositional usages of the native speakers of English and those of Japanese EFL learners with significant exposure to English: the centrality of spatial prepositional senses. These findings suggest that learners' L1 could affect their mental representations of L2 prepositions, particularly those denoting abstract notions; such L1 effects, however, can be diminished by significant exposure to the target language – developing L2 proficiency in various sociocultural settings.

There were some limitations in this study that need to be acknowledged. The participants in the SE group were smaller in number than those in the NSE and the NS groups; the total number of the sentences generated by the participants varied across the groups. In addition, the NSE group members produced fewer sentences and made more errors in the sentence-generation task for *at* than did the other two groups, probably reflecting the abstract and complex nature of its prepositional representation. Because the analyses were based on the frequency distribution of prepositional usage-type in the sentences generated by the participants, the discrepancy in the number of generated sentences might have affected the results. Furthermore, the SE group tended to be more proficient in English than the NSE group. There is, therefore, a concern that English proficiency and learning context might be confounding factors for the discrepant findings between the two EFL groups in the use of *at*. Follow-up studies are needed to resolve the discrepant findings and to corroborate the findings of this study.

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CHAPTER 13

Orthographic and phonological processing in L2-English word recognition

Longitudinal observations from Grade 9 to 11 in EFL learners in Japan

Junko Yamashita
Nagoya University, Japan

There has been a general consensus that readers develop different cognitive mechanisms in response to linguistic properties of languages and writing systems in which they read, and that processing capacities acquired in the first language (L1) may transfer to reading in another language. However, findings from developmental studies are substantially mixed. To address the conflicting results, this study examined an English word recognition trajectory in L1-Japanese secondary school students from Grade 9 to 11 using a longitudinal research design and observing the relative contribution of orthographic and phonological processing to word recognition. Contrary to the developmental trend in L1-English readers, the significant predictor of word recognition was orthographic processing in lower grades and phonological processing in Grade 11, suggesting the different developmental pathway between L1 and L2 word recognition for the readers of multi-script Japanese.

Keywords: orthographic processing, phonological processing, longitudinal study, secondary school students, Japanese EFL learners, L2-English word recognition

Introduction

Reading is a complex cognitive skill enacted by intricate interactions among various components that involve both linguistic and non-linguistic sub-skills and knowledge sources. There are ample theoretical and empirical supports that word recognition is one of the most fundamental and critical components of reading (e.g., Grabe, 2009; Koda, 2005; Jeon & Yamashita, 2014). The process of word recognition involves identification of word forms and activation of lexical meanings in the

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mental lexicon. The representations of forms encompass variations in phonology and orthography of words (Cunningham, Nathan, & Raher, 2011). Thus, there is a general agreement that the two major processes underlying word recognition are phonological and orthographic in nature, and the development of these processes and their interactions are considered key factors that lead to efficient word recognition (Nassaji, 2014).

Phonological processing in reading refers to the ability to use phonological information in recognizing written words. It is built upon various interrelated abilities including phonological awareness (the ability to identify and manipulate phonological constituents in the language), phonological decoding (to transform written words into their phonological forms), phonological recoding (to access lexical meaning through the use of phonological information), and phonological memory (to use phonological codes for storage in working memory) (Koda, 2005; Nassaji, 2014).

Orthographic processing broadly refers to the use of visual-orthographic information in recognizing words. Although its constituents are less well understood compared with phonological processing, due probably to a smaller amount of research on this subject compared to more extensively studied phonological processing, two types of orthographic knowledge are distinguished in the literature. One is *word-specific* knowledge, which is pertinent to information about the spelling of a specific word and includes knowledge of letters and their shapes as well. The other is *general* orthographic knowledge, which relates to conventional patterns of letter combinations in a given language. It is more abstract in nature and includes various orthographic information such as sequential dependencies (letters that are likely to follow other letters), structural redundancies (letter combinations that occur in different words), and letter position frequencies (Conrad, Harris, & Williams, 2013).

Readers develop different processing mechanisms in response to properties of languages and writing systems in which they read, and once acquired in one language (here we presume in the first language or L1), cognitive processing capacities may transfer to reading in another language (we presume in a second/foreign language or L2) (Koda, 2005). The transfer of L1 cognitive processing can be manifested in the way in which readers utilize phonological and orthographic information. Therefore, this study examined how phonological and orthographic processing contributed to individual differences in L2-English word recognition among L1-Japanese secondary school students and observed how the contribution of the two processes changed in the course of development. The following review mainly covers research discoveries pertinent to phonological and orthographic processing in English and Japanese.

Writing systems and cognitive processes in reading

Various writing systems in the world are distinguished in light of linguistic units that individual written symbols represent (phonemes, syllables, or morphemes). English is an alphabetic language where a symbol/letter represents a phoneme, whereas Japanese uses a mixed system including both phonographic and logographic scripts. The Japanese phonographic script is syllabic where a letter maps onto a roughly syllabic unit in Japanese called mora (*Kana*, with two subcategories: *Hiragana* and *Katakana*), and its logographic system is morphosyllabic that represents both syllables and meanings (*Kanji*, or characters of Chinese origin). In terms of orthographic depth (Frost, Katz, & Bentin, 1987), *Kana* is highly shallow (letter-sound correspondences are regular and consistent, nearly one-to-one), but *Kanji* is deep with usually multiple pronunciations depending on the context, which makes a contrast to Chinese logographic characters (Cook & Basseti, 2005). In normal Japanese texts, *Hiragana* is used for function words and morphological endings; *Katakana* is used to write loan words from foreign languages; *Kanji* is used for content words (nouns and routes of verbs and adjectives). Because of relatively simple visual shapes and transparent sound-symbol correspondences, acquiring *Kana* is not very difficult; children usually master *Kana* reading at an early stage in the first year of schooling or even before the start of schooling. *Kanji* characters are in general more complex in visual configurations with multiple strokes involved. Because of visual and phonological complexity, *Kanji* acquisition is much more cognitively demanding and requires a time commitment for acquisition (cf. Koyama, Hansen, & Stein, 2008).

Given the distinct nature of the writing systems in Japanese and English, we might anticipate different involvement of orthographic and phonological processing in reading these languages. The literature appears to support this line of reasoning, but it is important to keep in mind that both orthographic and phonological skills are critical in reading virtually any language. Therefore, it is a matter of the relative degree of importance that distinguishes cognitive processes involved in reading English and Japanese.

It is widely known that phonological processing is of primary importance in acquiring L1-English reading skills (Adams, 1990; Sprenger-Charollers, Siegel, Bechennec, & Serniclaes, 2003; Wagner et al., 1997). Especially for beginning readers, phonological awareness at the phoneme level is strongly associated with reading skill development because a grapheme maps onto a phoneme in alphabetic scripts. However, English readers cannot rely solely on grapheme-phoneme correspondences because English is a deep orthography wherein sound-symbol correspondences are highly irregular and inconsistent. To accommodate this property of their language, native speakers of English develop larger processing units than phonemes as well, and adaptively use both small (phonemes) and larger (rimes, syllables, morphemes, or whole words) units in word recognition (Goswami, 2008; Zieglar & Goswami, 2005). To read in larger units, knowledge of spellings of common rimes and syllables is necessary. Thus, readers in deep orthographies depend more on both phonological and orthographic processing than those in shallow orthographies. The fact that deep orthographies require readers to use both phonological and orthographic processing does not mitigate the importance of phonological processing in English literacy acquisition. Oft-cited Ehri's (2005) phase model, for example, depicts the primacy of phonological processing, with orthographic processing gradually being involved and entangled in the reading process along the line of development. The model contends that children go through four phases in English reading acquisition. The first phase is a pre-literate phase called *prealphabetic*, when children have no knowledge of alphabetic principles and use outstanding visual features of letters, word shapes, or contextual cues such as logos to recognize words (e.g., reading *look* through association of *oo* with the image of eyes). The second phase is called *partial alphabetic*, where children have learned some letter names or letter sounds and use them to read (e.g., reading *jail* by connecting the first and last letters *J* and *L* to their letter names but ignoring the middle letters, Ehri, 2005: 143). The third is the *full alphabetic* phase, where children have obtained full knowledge of grapheme-phoneme correspondences and utilize them in their reading. The final phase is called the *consolidated alphabetic* phase when children can use both smaller and larger units of reading by using common spelling chunks (e.g., ing, str, ight, est) or word-specific orthographic knowledge. As this model suggests, researchers regard phonological processing as the first and foremost important factor that determines early English literacy acquisition, and orthographic processing as the next significant contributor that accounts for the development at later stages (Cunningham et al., 2011).

Both phonological and orthographic skills play important roles in reading logographic scripts as well (e.g., Ho & Bryant, 1997; Sakuma et al., 1998). However, phonological skills may be less important (Huang & Hanley, 1994; McBride-Chang et al., 2005), and conversely visual skills may be more important (Huang & Hanley, 1994; Sakuma et al., 1998) in reading logographic languages than alphabetic languages, despite some inconclusive findings that call for more research endeavors (Koyama et al., 2008). For example, Huang and Hanley (1994) investigated predictors of word reading in Chinese and English among children aged eight to nine. The significant predictor in Chinese was visual skills, while that in English was phonological skills. Similarly, McBride-Chang et al. (2005) examined the contribution of morphological awareness, vocabulary, and phonological awareness to second graders' word recognition in Chinese, Korean, and English. In Chinese, phonological awareness was not a significant contributor, but in Korean and English, it was. Sakuma et al. (1998) observed effects of phonological and orthographic processing on *Kanji* reading by adult Japanese readers. Although effects of both processing were identified, the effect of orthography was more reliable, because it was observed in all conditions manipulated in their study, but the effect of phonology disappeared when the item was presented only for a brief moment. This result led the authors to the conclusion that orthography is the primary source of the meaning activation of *Kanji* words.

Although Sakuma et al. (1998) examined only *Kanji* reading in Japanese, different cognitive processes may be involved in reading *Kana* and *Kanji*. Koyama et al. (2008) addressed this issue and compared the contribution of phonological and visual-orthographic skills to the acquisition of *Kana* writing and *Kanji* reading/writing skills in Japanese children.[1] Visual memory predicted *Kanji* but not *Kana* skills, whereas phonological awareness predicted *Kana* but not *Kanji* skills. Orthographic knowledge and phonological short term memory were associated with both *Kanji* and *Kana* skills. Overall, the findings were in line with expectations from the linguistic properties of *Kana* and *Kanji* in that, albeit the concomitant involvement of phonological and orthographic skills, *Kana* writing skills were more associated with phonological processing and *Kanji* skills were more related to visual skills. Koyama et al (2008). also shed light on an interesting result that may suggest a difference between *Kanji* and Chinese characters. In contrast to Chinese reading which is predicted by phonological awareness (Ho & Bryant, 1997), phonological awareness did not predict *Kanji* skills in their study. Koyama et al (2008). offered the following possible explanations: Firstly, Chinese is far more tonal than Japanese; secondly, Chinese children use pinyin (a Romanized phonetic system for learning to read Mandarin Chinese). These differences between Chinese and Japanese systems may have made the contribution of phonological processing weaker in reading *Kanji* than Chinese characters, although we should bear in mind that their discussion is only speculative, and more studies are warranted.

To reiterate, orthographic and phonological processes are fundamental cognitive processes involved in reading. Which becomes more dominant depends on various factors including reading tasks, reader's proficiency, and frequency and familiarity of words. However, cross-linguistic research has discovered that the properties of writing systems formulate fundamental cognitive processes that readers utilize in reading (e.g., Koda, 1998; Ziegler et al., 2010). Broadly, phonological processing is the primarily important skill in reading alphabetic languages like English with the significant effect of orthographic processing gradually emerging

1. *Kana* reading was measured but not analyzed because of the ceiling effect.

at later developmental stages (Cunningham et al., 2011). Compared to English, visual-orthographic processing is likely to be more important in reading Japanese because it uses logographic *Kanji*. Even if Japanese has both phonographic and logographic systems, the fact that the majority of content words are conventionally written in *Kanji* suggests that *Kanji* recognition skills are of vital importance in Japanese literacy.

Orthographic and phonological processing in L2-English word recognition by L1-non-alphabetic readers

Given the widely acknowledged cross-linguistic influence on L2 acquisition in general, effects of L1 orthography on L2 reading has been one of the dominant research agenda in L2 word recognition studies (e.g., Akamatsu, 1999, 2003, 2005; Hamada & Koda, 2008, 2010; Koda, 1998, 1999; Muljani, Koda, & Moates, 1998; Pae & Lee, 2015; Sasaki, 2005; Wade-Wolley, 1999; Wang & Koda, 2005; Wang, Koda, & Perfetti, 2003). Considering the aforementioned linguistic properties entailed in alphabetic and logographic languages, we could hypothesize that L2-English readers with L1-alphabetic backgrounds would be more adept at phonological processing making use of phonemic information by way of grapheme-phoneme correspondences and read more similarly to native speakers of English, whereas L1-logographic readers may be more likely to draw on holistic visual-orthographic information and use different cognitive processes from those usually employed by native speakers of English. With various L2 reader populations and experimental tasks, much extant research has supported this general hypothesis. For example, Akamatsu (1999, 2003) compared L2-English reading performances across L1-Chinese, Japanese, and Persian groups by utilizing the visual distortion effect manipulated by a case alternation technique (presenting stimuli in alternating cases, e.g., AlTeRnAtIoN). The assumption is that if readers use more visual cues, they are more strongly affected by visual distortion. The Chinese and Japanese groups demonstrated a stronger visual distortion effect than the Persian (alphabetic) group, indicating heavier reliance on visual cues by readers with logographic than alphabetic L1 backgrounds. Expanding this line of research, Pae and Lee (2015) included intraword visual distortions (using case alternation) and holistic visual distortions (using upside-down fonts), and examined lexical decision performance of L1-Chinese and L1-Korean readers. The visual distortion effect was larger on the Chinese group than the Korean group. Furthermore, they also found a greater degree of effect of the holistic visual distortion than that of intraword distortion in the Chinese group. These results underscored the Chinese group's reliance on holistic visual cues.

The majority of aforementioned L2 word recognition research has examined adult (college level) L2 readers. Unlike these studies, which have highlighted the L1 orthographic influence, results from developmental studies that examined younger readers in cross-sectional or longitudinal designs are much less conclusive. The same type of expectation has guided research in this domain as well; namely, L2 readers with the L1-logographic (typically Chinese) background would rely more heavily on visual-orthographic processing compared with native speakers of English. However, this hypothesis has not been supported or only partially been supported (McBride-Chang & Treiman, 2003; Leong, Tan, Cheng, & Hau, 2005; Yin, Anderson, & Zhu, 2007; Yeong, Fletcher, & Bayliss, 2011). For instance, McBride-Chang and Treiman (2003) examined pre-school Chinese children and found that the children's English word reading skills were more strongly associated with phonological, rather than visual, skills. Moreover, the children showed reliance on letter names and letter sounds at earlier and later stages of development, respectively. This pattern was, according to the authors, remarkably similar to that observed among native speakers of English, leading to the conclusion in support of the commonality in the reading development between L1 and L2 readers. Yin et al. (2007) tested their stage model of the acquisition of English word reading by L1-Chinese children. Based on Ehri's (2005) phase model, they hypothesized four stages in the development: the prealphabetic stage, the partial alphabetic stage, the orthographic analogy stage, and the full alphabetic stage. Different from Ehri's model, which holds that orthographic analogy is used after children have reached the full alphabetic phase, Yin et al. (2007) hypothesized a distinct orthographic stage where children rely on recurring orthographic patterns in reading words before reaching the final stage. Examining children in grades two, four, and six, the researchers found only partial support for their model. Broadly, the children went through the predicted developmental trajectory, but differently from the model's prediction, no distinct orthographic analogy stage was identified. Rather than having a distinct stage where the orthographic analogy was the major processing option, the children had orthographic processing available for use at all stages of development. Thus, the study highlighted both similarities and differences in learning to read English between native speakers and L1-Chinese readers. Furthermore, Leong et al. (2005) investigated the contribution of orthographic-lexical knowledge and phonological sensitivity to English literacy skills (word reading and spelling) among L1-Chinese children in grades four, five, and six. They found that orthographic-lexical knowledge made a much larger contribution than phonological sensitivity to English literacy skills. Although their result lends support for the expected effect of Chinese background, caution should be exercised in generalizing the result because their orthographic-lexical knowledge measures included morphological, semantic, and syntactic factors as well.

In this area of research, Yeong et al.'s (2014) study deserves a particular attention in this review because their study is most relevant, amongst others, to the present study regarding their central focus on the relative contribution of orthographic and phonological processing. Although they have reported many important findings by identifying factors that influence English word reading among their participants with the L1-Chinese background, the results are substantially mixed when we try to draw implications for the L1 orthographic effect. The researchers compared three groups of children: a group of English monolinguals and two groups of English-Chinese bilinguals. The bilingual groups consisted of the English-L1 group (ethnic Chinese who were exposed to English prior to Chinese at home) and the Chinese-L1 group (ethnic Chinese who were exposed to Chinese prior to English at home). Using a cross-sectional design, they observed development at two points in time (grade 2–3). A battery of tasks including phonological processing, orthographic processing, and word reading was administered. Although overarching trends of group differences were in line with expectations from children's linguistic backgrounds, predictors of English word reading were in stark contradiction. The significant predictor was orthographic processing in the English monolinguals and conversely phonological processing in both groups of English-Chinese bilinguals. The authors provided several explanations for these unexpected outcomes. Regarding the reliance on orthographic processing on the part of English monolinguals, they contended that the children might have already possessed substantial letter-sound knowledge (i.e., beyond the full alphabetic phase in the Ehri's model) and were able to consolidate orthographic skills. Regarding the reliance on phonological processing by the bilinguals, they speculated that because of the distinct differences between English and Chinese, these bilingual children might have treated English as a separate language system and learned skills that were essential to English literacy rather than relying on Chinese based skills.

In summary, highly mixed results have been reported among L2 word recognition studies. On the one hand, as studies with college level L2 readers have demonstrated, cognitive processing capacities acquired in L1 appear to have a lasting influence on L2 word recognition. A recurring finding is that L2-English readers with the L1 non-alphabetic background rely more on holistic visual-orthographic processing than analytical phonological processing compared with their counterparts with L1 alphabetic backgrounds or native speakers of English. On the other hand, results from developmental studies seeking to find predictors of L2 word recognition during the course of development are inconclusive. Both similarities and differences have been found between native speakers of English and L2-English readers, and it is not always the case that readers with the L1 logographic background rely more heavily on visual-orthographic than phonological processing. Discrepancies among studies are difficult to resolve immediately because of the huge variations across studies in light of, for example, age, L2 proficiency, developmental stage, learning environment, educational background, tasks, and materials. Therefore, the field benefits from more research efforts. Another trend in the literature that deserves our attention is that the L1 logographic language in the majority of developmental studies has been Chinese. Although Chinese and Japanese both use logographic characters, their systems are not identical, which may lead to somewhat different cognitive capacities involved in reading each of them as suggested by Koyama et al. (2008) reviewed above. Thus, data from readers with the L1-Japanese background would be a valuable addition to this field of inquiry.

Measurement of orthographic and phonological processing

Orthographic processing and phonological processing are construed as dissolvable constructs in many theories of word recognition (Roberts, Christo, & Shefelbine, 2011). However, researchers are aware of methodological difficulties in operationally separating them in actual measurement (e.g., Conrad et al. 2013; Cunningham et al., 2011; Nassaji & Geva, 1999; Leong et al., 2005). This may be partly because psychological processes in human cognitive operations, especially those that are presumed to underlie a common construct, tend to overlap, and also because orthographic processing skills are built upon phonological processing skills at least in learning to read in L1 (Cunningham et al., 2011; Share, 1995; Sprenger-Charolles et al., 2003). Despite this difficulty, a broad range of tasks used to measure orthographic or phonological processing has been devised in past research. There is some empirical evidence supporting the validity of the time-tested tasks in the field. For example, Cunningham, Perry, and Stanovich (2001) showed that six different orthographic processing measures loaded on a single factor, suggesting the same underlying construct that these measures commonly tapped. Hagiliassis, Pratt, and Johnston (2006) examined various measures of orthographic or phonological processing. Their factor analysis primarily supported the validity of the examined tasks when accuracy data were analyzed. Two separate factors (interpretable as phonological and orthographic processing) emerged, although the tasks also loaded on the other factor to varying degrees. Results from response time measures were less clear-cut, and this might be because a general speed factor obscured the factor structure of the included tasks (Cunningham et al. 2011).

To summarize, despite the theoretical and empirical support for the separability between orthographic and phonological processing (Cunningham et al., 2011), operationally distinguishing them is not an easy task, and there is a general consensus among researchers that there is no "pure" measure of orthographic or phonological processing. Given this measurement difficulty, Cunningham et al. (2011: 264) argue that “this does not present an insoluble problem” and “it is only necessary that tasks have *differential* weighing on phonological and orthographic processes.” (emphasis in original). We take the same stance in this study and choose measures for orthographic and phonological processing that have been commonly adopted in the field.

The present study

This study examined the relative contributions of phonological and orthographic processing to individual differences in L2-English word recognition performance by L1-Japanese learners of English as a foreign language (EFL). Considering the linguistic properties of the two languages and findings from developmental studies, it was hypothesized that if EFL learners went through the same developmental trajectory as did native speakers of English, phonological processing would make a larger contribution in earlier stages of development and be replaced by orthographic processing later. In contrast, if L2 readers transferred their L1 cognitive processes and went through the different developmental trajectory from that of native speakers, orthographic processing would make a larger contribution in earlier stages and be replaced by phonological processing later.

The present study was primarily planned to investigate cognitive processes employed when the readers recognized English words that were represented in their memory (i.e., known words). This means that the central point of this study was speed (how fast readers can read familiar words accurately). This is because word recognition in L2 is generally slower than in L1, and we intended to investigate what factors developmentally contribute to improving the processing speed. The material of this study was developed with this purpose in mind as detailed below.

Method

Participants

Data used for this study were part of a longitudinal data set collected for a larger research project that was conducted in collaboration with a secondary school in Central Japan. This study drew on a sample of 152 students (74 males and 78 females) through Grade 9 to 11 (age: 14 to 18). They were all L1-Japanese speakers and learning EFL at school. The mean age upon initial measurement was 14 years and 11 months. About 60% of the students reported that they started studying

English after the age of 10 (10 to 13), but the mean age of initial exposure to English was 9 years and 6 months.

Since exposure to English outside the school was very limited, formal instruction was the major opportunity for learning English for these students. There were four compulsory 50-minute EFL classes per week: three integrated skills courses and either a conversational course (G9) or a grammar/writing course (G10 and G11). There were a few optional English courses offered at G11 that focused on reading, listening, vocabulary, and grammar. In addition, it is generally a common practice that students make use of study opportunities in the private sector such as cram schools, home tutoring, and distant learning. In this sample, the rate of the students utilizing such opportunities was 66.7%, 71.8%, and 88.0% in G9, G10, and G11, respectively.

Materials

The material comprised a set of items for computer-based self-paced tasks.[2] The basic task format was to respond to an item that appeared on the computer screen in light of the prompt by pressing one of the two designated keys on the keyboard as quickly and accurately as possible.

Numeral processing

A task measuring numeral processing was included to control for individual differences in processing speed not pertinent to alphabetic and linguistic processing following suggestions by Haynes and Carr (1990) and Shiotsu (2010). The material were 18 pairs of three-digit numbers. Nine pairs contained two identical numbers (923/923), and the other nine had different numbers by one digit (536/526). The task was to make judgment regarding whether the two numbers were identical or different.

Word recognition

A lexical decision task (LDT) was used to measure word recognition speed. The material included 20 real words (e.g., bird, boy, and cat) and 20 pseudowords (letter strings that accord with the English orthography, e.g., cad, dit, gak) of three to four letters. These items were selected from those used by Fujita (2010: 199),

2. The materials are available from the author upon request.

who examined a group of students similar to the participants in this study. All the real words were in the most frequent 1000 words in the JACET word list (JACET Committee of Basic Words Revision, 2003), which were expected to be known even to G9 students. The participants were instructed to make judgment as to whether the stimulus was a real English word or not.

Orthographic processing

The speed of applying *general* orthographic knowledge was assessed, which taps into the ability to evaluate orthographic patterns and to judge their conformity to the English orthographic conventions. Word-specific orthographic knowledge was not included because this might be confounded by vocabulary knowledge. A nonword choice task (Siegel, Share, & Geva, 1995) was used as a measure. The material comprised 20 pairs of letter strings. One in the pair followed the English orthographic conventions but the other did not (rreaiv/vairer, remond/rdenmo). The items were selected from a pool of items that were employed by Fujita (2010: 197–198) or Kato (2009: 488), who also studied L1-Japanese EFL students and adopted their materials from previous studies. The participants' task was to decide which letter string in the pair looks more like an English spelling.

Phonological processing

Phonological decoding and phonological recoding were included in the measurement by using a phonological choice task (Olson, Kliegl, Davidson, & Foltz, 1985). There were 20 pairs of letter strings. Both items in the pair were decodable pseudowords, but only one was homophonic to a real English word (gome/gaim, klass/cliss). The materials were selected from Kato (2009: 487) who adopted his items from Olson et al.'s (1985). The students were asked to make a judgment regarding which in the pair of pseudowords sounds like an English word. Although this task utilizes pseudowords, it necessitates accessing phonological representations of real words. Therefore, efforts were made to remove the undesired influence of vocabulary knowledge as much as possible.[3]

3. In a series of pilot studies, G8 students were asked to write down pronunciations of candidate real words (homophonic to experimental items) in *Kana*, and only high accuracy items (> 85%) were selected for use in the study. Thus, phonological forms of real words in the task were most likely to be known to the participants.

Procedure

The data were collected annually at the end of each grade. The tasks were administered to a class of students (*n* = app. 40) by five administrators (the author and four trained graduate students) in the school's computer lab during one of the EFL class hours with the presence of their EFL teacher. Each student sat in front of a desktop computer and completed the tasks individually at their own pace. The author provided a general instruction and guidance, and all the five administrators carefully monitored the students' performance. In case of any questions or technical problems, one of the administrators immediately attended to the case.

The tasks were given in the following order: numeral, word recognition, orthographic processing, and phonological processing. In all tasks, the students first read the instruction in Japanese on the screen, then tried practice items. They were strongly asked to raise and solve any questions before they went on to the main test session. The task procedure was as follows. First, a fixation point (+) appeared in the center of the computer screen (1000 ms), which was followed by a blank screen (500 ms), and finally a test item was presented. In the numeral, orthographic, and phonological tasks, two items were presented with one on top of the other. There was no time-out (i.e., item stayed on the screen until a response was made). Once the student pressed a key the item disappeared, and another item appeared starting the next cycle. This set of tasks was administered using a program written with a programming language called HSP.[4] Items in each task were randomized individually by the program. Both response times (RT) and accuracy were recorded. Generally, the participants completed the whole task in 15 minutes.

Analysis

Analysis for this study only included students who attended all three measurement occasions (*n* = 127). Preliminary data screening was conducted by closely inspecting task response patterns of the participants. Data from students who showed suspicious patterns (responding all items uniformly [all Yes or No] or responding unreasonably quickly [$RT < 300$ ms] to over half of the items) were removed from both accuracy and RT analyses since such patterns may be a symptom of the lack of motivation. Also, for RT data, incorrect responses and those that were outside the low and high cutoff points were removed. The low cutoff point was 300 ms;

4. Hot Soup Processor <http://hsp.tv/>. We thank Kunihiro Kusanagi and Daisuke Abe for their technical support throughout the experiment.

the high cutoff point was either 5000 ms (numeral processing and LDT) or 10,000 ms (orthographic and phonological processing). RTs that were three standard deviations away from each participant's mean were trimmed. This preliminary data screening led to the removal of 1.1% and 11.4% of data points in accuracy and RT data respectively.[5] Descriptive statistics were computed using the resulting data. For ANOVA, correlation, and multiple regression analyses that followed, RT data were log-transformed.

A one-way ANOVA was run for each task to examine the change of processing speeds across three grades. Then, correlation patterns were observed before multiple regression analyses. Since the accuracy was already high in G9, as somewhat expected, very little significant correlations were observed between accuracy scores. Therefore, this study further examined RT data only. Since positive and significant correlations were obtained across all RT measures both concurrently and longitudinally (details below), all variables were used in the multiple regression analyses to determine significant predictors of word recognition performance.

Two series of hierarchical multiple regression analyses were performed. The first was conducted in each grade separately and attempted to predict word recognition speed by the concurrent orthographic and phonological processing. The numeral processing was entered in the first step, and the order of the independent variables (orthographic and phonological processing) was alternated. That is, in one analysis, we entered orthographic processing in the second step and phonological processing in the third, while in the other we entered phonological processing in the second step and orthographic processing in the third. By manipulating the order of entry, we tried to observe the unique contribution of each processing in word recognition. The second series of multiple regression controlled for the influence of word recognition speeds in previous years. When G10 word recognition was the dependent variable, G10 numeral processing was entered in the first step, G9 word recognition in the second, and either G10 orthographic or phonological processing in alternation in the third or fourth step as explained above. When G11 word recognition was the dependent variable, G11 numeral processing was entered in the first step, G9 word recognition in the second, G10 word recognition in the third, followed by G11 orthographic or phonological processing in the fourth or fifth step in the same alternating manner. Assumptions of multiple regression were checked and confirmed both numerically (consulting coefficients such as Durbin-Watson

5. The data screening resulted in some missing variables in some students' data sets. Rather than removing such participants entirely, however, we conducted the following analyses utilizing the maximum number of cases available in different steps of analyses.

statistic, Torelance, and VIF) and graphically (inspecting plots of standardized residuals) (Field, 2013). Outlier cases were removed when detected based on Cook's distance and Centered leverage values.[6]

Results

Table 1 summarizes descriptive statistics of accuracy scores and RT in each grade. High accuracy rates were obtained in all tasks. Those of numeral and real word tasks were especially high, which was probably because the items were real symbols. These results suggest that the students had adequate representations of numerals and high frequency English words in their memory. High scores in the orthographic processing imply that, even though it is unlikely that teachers specifically teach general orthographic knowledge in EFL classes, the students can develop a high degree of sensitivity to general conventions of English orthographic patterns after at least three years of English learning. The accuracy of phonological processing also approached the ceiling, implying that the students have acquired an ability to successfully use sounds to access words in their mental lexicon (at least those words that they had learned by G8, cf. note 3).

Table 1. Means and SDs in each grade

	G9		G10		G11	
	Mean (%)	***SD***	**Mean (%)**	***SD***	**Mean (%)**	***SD***
Accuracy						
Numeral	16.76 (.93)	1.30	17.12 (.95)	1.03	17.27 (.96)	0.92
Word	19.27 (.96)	1.00	19.30 (.96)	1.14	19.53 (.98)	0.69
Orthography	17.43 (.87)	2.44	17.66 (.88)	2.38	18.13 (.91)	2.01
Phonology	17.42 (.87)	2.49	17.81 (.89)	2.15	18.06 (.90)	2.34
RT (milliseconds)						
Numeral	690	110.71	669	110.17	655	107.48
Word	711	142.79	655	108.05	653	110.95
Orthography	1668	800.13	13640	549.04	1443	585.73
Phonology	2139	786.74	1775	642.35	1773	668.95

Notes: The maximum score is 18 in Numeral and 20 in all the other tasks.
The sample size ranged from 124 to 127 across variables.

6. Multicollinearity was not a problem in the multiple regression analyses in this study (e.g., the minimum tolerance value was .54).

The main effect of grade in the ANOVA was significant in all tasks: $F(2,250) = 24.98$, $p < .001, \eta_p^2 = .167$; $F(2,210) = 16.94$, $p < .001, \eta_p^2 = .123$; $F(2,214) = 27.42$, $p < .001, \eta_p^2 = .187$, in LDT, orthographic, and phonological processing, respectively.[7] However, Bonferroni-adjusted multiple comparisons identified the progress only between G9 and G10, that is, there was virtually no increase in the speed from G10 to G11.

Table 2 shows correlation coefficients across all RT measures throughout grades. Measured variables were all significantly correlated ($p < .05$). The number processing speed was also significantly correlated with linguistic processing. This may be because of the involvement of a certain general speed factor commonly underlying the speeded tasks as assumed by some researchers (Haynes & Carr, 1990; Shiotsu, 2010). This correlation pattern suggests that it would be reasonable to partial out the effect of numeral processing in the following multiple regression analyses. Correlations among autoregressive variables (the same variables measured in previous years) tended to be higher than those among different variables, showing unsurprisingly the stronger connection of cognitive processes involved in the same tasks than across different tasks.

Results of multiple regression analyses in each grade are summarized in Table 3. In all analyses, statistically significant models appeared, $F(3, 114) = 32.213$, $p < .001$, Adjusted $R^2 = .445$; $F(3, 117) = 59.359$, $p < .001$, Adjusted $R^2 = .593$; $F(3, 117) = 36.564$, $p < .001$, Adjusted $R^2 = .471$, in G9, G10, and G11 respectively.[8] Numeral processing was a significant predictor in Step 1 and remained so even with the presence of orthographic and phonological processing, but in reporting results below, we focus on the linguistic processing since they are the core variables in this study. An interesting developmental change was observed in the relative importance of orthographic and phonological processing. In G9 and G10, only orthographic processing was the significant predictor in the final model, uniquely explaining 13.5% and 6.6% of the variance, respectively. Contrarily in G11, only phonological processing emerged as a significant predictor, uniquely accounting for 2.6% of the variance. It should also be noted that the unique contribution of orthographic processing gradually diminished and became statistically insignificant in the final year.

7. When the sphericity assumption was violated, Greenhouse-Geisser correction was adopted.

8. Since identical F values were obtained regardless of the order of entry, they were reported once in each grade.

Table 2. Correlations among all RT measures throughout grades (n = 117)

		2	3	4	5	6	7	8	9	10	11	12
1	G9 Numeral	.433**	.276**	.292**	.648**	.474**	.322**	.368**	.552**	.436**	.257**	.225*
2	G9 Word	–	.584**	.468**	.477**	.666**	.456**	.492**	.372**	.615**	.394**	.325**
3	G9 Orthography		–	.500**	.216*	.372**	.545**	.387**	.204*	.331**	.456**	.331**
4	G9 Phonology			–	.243**	.357**	.364**	.589**	.246**	.323**	.382**	.577**
5	G10 Numeral				–	.700**	.428**	.393**	.677**	.553**	.345**	.287**
6	G10 Word					–	.618**	.517**	.560**	.654**	.459**	.336**
7	G10 Orthography						–	.581**	.417**	.424**	.701**	.407**
8	G10 Phonology							–	.378**	.486**	.497**	.748**
9	G11 Numeral								–	.658**	.452**	.360**
10	G11 Word									–	.500**	.451**
11	G11 Orthography										–	.578**
12	G11 Phonology											–

Notes: * $p < .05$, ** $p < .01$.

Table 3. Summary of multiple regression analysis in each grade

	G9 (n = 118)			G10 (n = 121)			G11 (n = 121)		
	ΔR^2	Final Beta	t	ΔR^2	Final Beta	t	ΔR^2	Final Beta	t
Step 1									
Numeral	.208**	.306	4.163**	.455**	.481	7.312**	.408**	.523	7.185**
Step 2									
Orthography	.234**	.427	5.335**	.137**	.330	4.398**	.049**	.156	1.933
Step 3									
Phonology	.017	.155	1.875	.012	.142	1.864	.026*	.188	2.442*
Total R^2	.459			.603			.484		
Step 1									
Numeral	.208**	.306	4.163**	.455**	.481	7.312**	.408**	.523	7.185**
Step 2									
Phonology	.116**	.155	1.875	.083**	.142	1.864	.059**	.188	2.442*
Step 3									
Orthography	.135**	.427	5.335**	.066**	.330	4.398**	.016	.156	1.933
Total R^2	.459			.603			.484		

Notes: * $p < .05$, ** $p < .01$.

This developmental trend was also observed when autoregressive effects were partialled out (Table 4). As expected, the autoregressive effect was strong both in G10 and G11, endorsing that students who were able to recognize words accurately and quickly tended to carry over their superior skills to following years. Confirming the aforementioned results, the variable that made a unique contribution was orthographic processing in G10 and phonological processing in G11 explaining 5.4% and 1.6% of the variance, respectively: F (4, 115) = 47.542, p < 001, Adjusted R^2 = .610; F (5, 114) = 37.873, p < 001, Adjusted R^2 = .608. Beta coefficients corroborated the shift of the predictor from orthographic to phonological processing as well (.303 vs. .080 in G10 to .030 vs. .150 in G11). Moreover, orthographic processing did not add any significant variance even if it was entered before phonological processing in G11, which indicated the negligible role of orthographic processing in the final year.

Table 4. Summary of multiple regression analyses in G10 and G11

	G10 (n = 120)				G11 (n = 120)		
	ΔR^2	Final Beta	t		ΔR^2	Final Beta	t
Step1				Step1			
G10 Numeral	.424**	.396	5.936**	G11 Numeral	.404**	.333	4.770**
Step 2				Step 2			
G9 Word	.107**	.237	3.414**	G9 Word	.161**	.302	4.102**
Step 3				Step 3			
G10 Orthography	.088**	.303	4.071**	G10 Word	.036**	.226	2.897**
Step 4				Step 4			
G10 Phonology	.004	.080	1.049	G11 Orthography	.008	.030	.407
Total R^2	.623			Step 5			
				G11 Phonology	.016*	.150	2.188*
				Total R^2	.624		
Step1				Step1			
G10 Numeral	.424**	.396	5.936**	G11 Numeral	.404**	.333	4.770**
Step 2				Step 2			
G9 Word	.107**	.237	3.414**	G9 Word	.161**	.302	4.102**
Step 3				Step 3			
G10 Phonology	.037**	.080	1.049	G10 Word	.036**	.226	2.897**
Step 4				Step 4			
G10 Orthography	.054**	.303	4.071**	G11 Phonology	.023**	.150	2.188*
Total R^2	.623			Step 5			
				G11 Orthography	.001	.030	.407
				Total R^2	.624		

Notes: * $p < .05$, ** $p < .01$.

Discussion

This longitudinal study investigated the contributions of phonological and orthographic processing to English word recognition performance by L1-Japanese EFL learners in G9, 10, and 11. The main purpose was to observe the underlying cognitive processes that explained the variance in word recognition speed along the course of development. The results showed that the cognitive process that predicted individual differences in word recognition was not identical at different stages of learning to read in English. The significant predictor was orthographic processing in G9 and G10, but it was phonological processing in G11. Moreover, orthographic processing reduced its contribution steadily across grades. This developmental trend stayed consistent in the second series of analyses when autoregressive effects were partialled out. Again, the major determinant of individual differences was orthographic processing in G10 and phonological processing in G11 over and above the carryover of the word recognition skill from previous years. The results therefore converged on the indication that the significant predictor of word recognition shifted from orthographic processing to phonological processing during the years of investigation, and that the shift happened in G11 after the students had learned EFL for five years through schooling.

Although it is perhaps too early to conclude that phonological processing dominates L2 word recognition in the final year because of the small amount of variance explained in G11, the current data suggest the shift of predictors from orthographic to phonological processing. Therefore, in light of the hypotheses formulated in the earlier discussion in consideration of the properties of English and Japanese writing systems, the findings of this study have lent support for the L1-orthographic influence on the development of L2 word recognition. In this study, L1-induced processing gradually decreased its role and L2-based processing started to be more important in G11.

In addition to the main purpose, we also tested the change in linguistic processing speed. The increase was observed only between G9 and G10. This result pointed to an interesting gap between quantitative (the speed itself) and qualitative (the change in predictors) facets of the development of word recognition. The speed increased only between G9 and G10, whereas the qualitative change was observed between G10 and G11. Thus, the quantitative change occurred before the qualitative change as far as this set of data was concerned. Although this phenomenon indicates the importance of examining the development from different angles, it still remains as a puzzle why the students did not improve their speed from G10 to G11 despite a year longer exposure to English. To solve this issue, it would be useful to examine the development for longer periods of time such as five to six years.

Supporting the L1 orthographic influence that leads to highlighting different developmental processes in L1 and L2 word recognition, this study does not align well with the previous studies that attested the commonality between L1 and L2 readers. As is frequently the case, consolidating the differing research outcomes is not an easy task due to many variations across studies. One factor that may be responsible is the English learning environment. A much larger number of studies have been conducted in English as a second language (ESL) contexts where learners are daily exposed to massive amounts of spoken and written English than in EFL contexts. Readers' oral language skills are likely to be more advanced in ESL than EFL contexts. As Nassaji (2014) states, many cross-linguistic studies in word recognition have been conducted in second language or bilingual contexts, and those in foreign language contexts are much limited. We should call for more research efforts from foreign language environments.

Another possible factor is a feasible difference between logographic languages (characters in Chinese vs. *Kanji* in Japanese). If implications from Koyama et al. (2008) reviewed earlier held, *Kanji* processing mechanisms might be more dependent on visual processing (which leads to relatively less reliance on phonological processing) than Chinese character processing. If so, the hypothesized reliance on orthographic processing at earlier stages of L2-English reading acquisition might surface more strongly in L1-Japanese than L1-Chinese readers. Although Chinese and Japanese are often treated together as logographic languages, the possibility of their subtle differences might lead to the possibility of differing manifestation of L1 orthographic influences. This is as yet merely a speculation, and future studies are needed to evaluate these ideas.

There are several limitations that make implications of this study suggestive rather than conclusive. The first is the lack of L1-English control group. To confirm the difference between L1 and L2 reading, we should compare performance between L1-English and L2-English readers within the same study. The second is a possible effect of the learning environment and teaching method. Unlike L1-English or ESL readers, EFL learners typically start learning English using both oral and written languages simultaneously. This may increase the reliance on visual-orthographic processing from the outset of their learning to read. Although this does not immediately lead to the denial of the possible L1 orthographic effect, environmental and instructional factors may confound the relative dependency on orthographic or phonological processing. Thirdly, as discussed earlier, researchers have to face difficulties in operationally disentangling orthographic and phonological processing. Although this study adopted one of the common tasks that have been contributing to discoveries in the field, Hagiliassis et al. (2006) suggest that the nonword choice task may not be one of the best methods for measuring orthographic processing. It is, therefore, worth testing the replicability of the findings using different tasks. Also, efforts should be continued to improve and refine the measurement tasks to make better tasks available for researchers. In relation to the measurement, this study used only one task to measure each construct. Employing multiple tasks is recommended to capture various dimensions of the key constructs and also to reduce task specific effects. Lastly, this study focused on speed by examining RT data because of our planned focus. Although this has its own merits, an evaluation of the process of acquiring new knowledge (accuracy) will also be important and should be examined in future studies.

Conclusion

The present study contributed research results in support of the difference between L1 and L2 word recognition from the developmental perspective by identifying the hypothesized L1-orthographic influence using a longitudinal data set from an EFL context. Considering aforementioned limitations as well as substantial variations in research findings underscoring commonalities or differences in the development of L1 and L2 word recognition, more research is necessary to enhance our understanding in this field.

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CHAPTER 14

Cross-linguistic interactions in L2 word meaning inference in English as a foreign language

Keiko Koda and Ryan T. Miller
Carnegie Mellon University, U.S.A / Kent State University, U.S.A.

L2 reading entails a complex cross-linguistic interaction between L1 reading ability and L2 linguistic knowledge. As such, it is seen as a dynamic process of coalescing diverse resources, including cognitive skills, linguistic knowledge, and metalinguistic awareness, in two languages. In this chapter, we explain the nature of morphological awareness as an abstract, yet language-dependent, construct. We then analyze systematic variations in grapheme-morpheme relationships in typologically different languages. Based on the analysis, we propose specific predictions regarding the joint contributions of L1 reading and L2 resources to the development and utilization of L2 morphological awareness. We report a summary of a study addressing the relative contributions of L1 reading ability, L2 morphological awareness and L2 linguistic knowledge to L2 word meaning inference.

Keywords: cross-linguistic interaction, L1 influence, L2 proficiency, word meaning inference, morphological awareness, L2 knowledge

As a process of text meaning construction, reading heavily relies on knowledge of word meanings. It entails retrieving word meanings from memory and integrating them into a coherent message intended by the author. Successful comprehension demands both effortless access to the meaning of familiar words and the ability to infer the meaning of unfamiliar words through word form analysis. Metalinguistic awareness, an explicit representation of the abstract structure of language, provides vital assistance in word form analysis. As abstract insight, metalinguistic awareness enables readers to segment a familiar word into its phonological and morphological constituents, and in so doing, allows them to identify familiar sub-lexical elements in the unfamiliar word and use them to infer its pronunciation and meaning (Ehri, 2014). Metalinguistic awareness emerges through detecting and

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abstracting structural regularities of words implicit in linguistic input. Once sufficient abstraction is achieved, metalinguistic awareness serves as a powerful tool for "self-teaching" words during reading (e.g., Share, 2008).

Over the past two decades, metalinguistic awareness has attracted considerable attention among second language (L2) reading researchers. As an abstract representation, metalinguistic awareness is distinct from linguistic knowledge in that it is relatively independent of surface form variation. In principle, therefore, once formed in one language, metalinguistic awareness is serviceable in another language as a cross-linguistically sharable resource. A central question is to what extent first language (L1) metalinguistic awareness facilitates L2 word reading and learning. A large number of studies have investigated the utility of L1 phonological awareness in L2 reading development. The cumulative evidence suggests that L1 phonological awareness makes intra-lingual and inter-lingual contributions to L2 word reading in bilingual children learning to read two languages; that phonological awareness is systematically related between two alphabetic languages; and that the utility of L1 phonological awareness is relatively unaffected by L2 proficiency (Abu-Rabia, 1995; Da Fontoura & Siegel, 1995; Durgunoglu, Nagy, & Hancin, 1993; Geva & Siegel, 2000; Gholamain & Geva, 1999; Wade-Woolley & Geva, 2000; Wang, Perfetti, & Liu, 2005).

Of late, interest in morphological awareness is escalating. As the smallest functioning unit of a language, morphemes convey rule-governed grammatical information and arbitrarily assigned functional information. Morphological awareness, as their abstract representation, comprises, at the minimum, the internal structure of words, rules of morpheme concatenation, and functional constraints on the concatenation rules. Morphological awareness is more varied and language-specific and as such, less independent of linguistic knowledge than phonological awareness. The linguistic dependency makes morphological awareness harder to acquire and more susceptible to language-specific formal variation. A clear implication for L2 reading development is that the utility of L1 morphological awareness is constrained by both L2 linguistic knowledge and structural similarity between two languages. To clarify the linguistic dependency of morphological awareness and its implication, the sections that follow describe (a) the role of morphological awareness in reading acquisition, (b) cross-linguistic variation, (c) the mechanisms of cross-linguistic sharing, and (d) the utility of L1 morphological awareness in L2 reading development.

Morphological awareness and reading acquisition

Word reading entails grapheme-phoneme-morpheme mappings. In learning to read, children rely on emerging sensitivity to a word's internal structure to figure out how phonemes and morphemes are mapped onto the graphic symbols that encode them (Ehri, 2014; Frost, 2012; Nunes & Bryant 2006). Each instance of word reading contributes to the formation of a representation of a word in memory. Durable and complete representations of words allow children to read them instantly and effortlessly from memory (Share, 2008). Morphological awareness plays a significant role in grapheme-morpheme mappings in unfamiliar word reading. Through its capacity for word segmentation, morphological awareness enables children to infer the sound and meaning of an unfamiliar word based on the information supplied by its morphological constituents. Morphological decomposition is particularly critical in later stages of reading development in which knowledge acquisition occurs through reading and word learning. Because most of the words children learn in the "reading to learn" stages are multi-morphemic, the ability to use morphological awareness for word form analysis during reading is a reliable predictor of successful reading achievement (Ehri, 2014; Ku & Anderson, 2003).

Morphological awareness develops gradually over time as its diverse facets mature at disparate rates following their own timetables. English-speaking children, for example, are sensitized to inflectional morphemes in structurally transparent words well before schooling (Berko, 1958; Carlisle, 2003), but the productive use of such sensitivity does not occur until Grades 2 or 3 (Bear, Invernizzi, Templeton, & Johnston, 1996). The awareness of derivational morphemes develops over a longer period of time – between Grades 4 and 8 (Tyler & Nagy, 1989, 1990; Ku & Anderson, 2003). Studies have shown that morphological awareness is a reliable indicator of reading ability. Skilled readers, for example, are more sensitive to a word's morphological structure than less skilled readers (e.g., Chilant & Caramazza, 1995; Fowler & Liberman, 1995; Stolz & Feldman, 1995; Taft, 1991, 1994; Taft & Zhu, 1991, 1995). Children with poor reading ability commit far more errors of affix omissions in their writing and speaking (e.g., Duques, 1989; Rubin, 1991). Children's ability to spell inflectional morphemes is a reliable predictor of their ability to infer the meaning of morphologically complex words (Nunes, Bryant, & Bindman, 2006). The efficient use of morphological information, moreover, distinguishes competent and less competent high-school readers (e.g., Tyler & Nagy, 1989, 1990). Thus, in short, morphological awareness is a critical component of reading that supports word recognition, word meaning inference, and text comprehension.

Cross-linguistic variation in morphological awareness

Morphological awareness reflects the grapheme-phoneme-morpheme relationships in a particular writing system. For example, the English orthography is alphabetic in nature, and generally bound by phonemic constraints. However, its strong tendency to preserve morphological information allows phonemic constituents to account for its orthographic conventions only partially. As an illustration, distinct orthographic patterns are used to differentiate two unrelated morphemes sharing the same pronunciation, such as "sale" and "sail." Conversely, shared morphemes are spelled identically despite their distinct pronunciations, as in "anxious/anxiety" and "electric/electricity," or the past tense marker "-ed" (e.g., /-d/ in *moved*, /-t/ in *talked*, /-ɪd/ in *visited*).

In contrast, Hebrew is a root-derived language and a word's base is a root morpheme. Root morphemes generally consist of three consonants (e.g., *gdl*) that convey abstract semantic information (e.g., "largeness"). Hebrew words are formed by intertwining root morphemes with word-pattern morphemes. Each word-pattern morpheme comprises built-in slots for the root's consonants to fit into. The Hebrew orthography encodes root morphemes, certain vowels (represented by letters that can also stand for consonants), as well as consonants that appear in patterns, prefixes, and suffixes. Reflecting the grapheme-morpheme-consonant linkages, children learning to read Hebrew are known to develop strong sensitivity to consonants (Geva, 2008; Tolchinsky & Teberosky, 1998). In contrast, studies involving skilled readers have shown that lexical knowledge and sensitivity to the morphological structure are strong predictors of word recognition efficiency (Feldman, Frost, & Pnini 1995; Frost, 2012; Frost, Katz, & Bentin, 1987). These findings suggest that Hebrew readers rely on solid lexical representations and metalinguistic structural understanding when supplying the unspecified information in graphemes during print word recognition.

In morphosyllabic Chinese, most characters map directly onto morphemes. The vast majority of characters (80 to 90%) are composite characters consisting of two graphic components called radicals. While a phonetic radical indicates the pronunciation of its character, a semantic radical conveys the semantic category of its character's meaning. Thus, in Chinese, morphological information is encoded by both a character and its semantic radical. Because of this dual-level encoding, character recognition entails information retrieval both at the character and radical levels. Research has shown that skilled readers are capable of such parallel information processing during character recognition (Taft & Zhu, 1995; Zhou & Marslen-Wilson, 1994). Although radical information is insufficient for character meaning retrieval, studies demonstrate that Chinese readers draw on semantic radical information when encountering an unfamiliar character in context (e.g., Ku & Anderson, 2003; Shu, Anderson, & Zhang, 1995).

In addition, Chinese word formation heavily relies on lexical compounding. According to the Dictionary of Usage Frequency of Modern Chinese Words (Beijing Language Institute, 1986), roughly 80% of Chinese words are compounds consisting of two or more characters. The formation of multi-character compound words is bound to certain concatenation rules. For example, in the two-character word 猪肉 (pork), the first character 猪 (pig) modifies the second character 肉 (meat). It has been reported that frequency of the component characters in a compound word affects recognition speed and accuracy among native Chinese readers (Zhang & Peng, 1992) and Chinese-English bilinguals (Wang, Lin & Gao, 2010). Recent studies have shown that a grasp of the semantic relationship between the component characters in a compound word is a significant predictor of word knowledge development (Chen, Hao, Geva, Zhu, & Shu, 2009; Liu & McBride-Chang, 2010). Collectively, these findings suggest that word reading and learning entail morphological decomposition, and that morphological awareness plays a central role in reading and word knowledge development in Chinese.

Viewed as a whole, studies involving readers of diverse languages demonstrate that morphological awareness is highly language-specific, reflecting the grapheme-morpheme relationships in the language in which reading is learned. Yet, morphological awareness plays an equally central role in word reading and learning in typologically diverse languages.

Cross-linguistic sharing of metalinguistic awareness

Recent psycholinguistic theories hold that linguistic knowledge emerges from abstracting structural regularities that are implicit in input (Ellis, 2002; Tomasello, 2003). In this view of learning, language is seen as a set of relations between forms and functions (Van Valin, 1991), and its acquisition as the internalization of those relationships through cumulative experience of mappings between corresponding forms and functions (MacWhinney & Bates, 1989). The more frequently a particular pattern of mappings is experienced, the stronger the links holding the corresponding elements together. Learning thus involves a gradual transition from deliberate execution to effortless access to emerging representations of the form-function relationships in memory. The internalization of a particular form-function relationship can be recognized as such when the activation of the mapping it entails becomes automated (Logan, 1988).

Under this view of learning, cross-linguistic sharing can be conceptualized as automatic activation of *previously established* (L1) mapping patterns triggered by language input in a *later acquired* (L2) language (Koda, 2007). L1 mapping occurs regardless of the learner's intent (non-volitional), and its occurrence cannot be easily controlled (non-selective). The conceptualization presupposes that L2 mappings emerge from cross-linguistic interactions between automatically activated L1 mappings and L2 linguistic input, that the shared patterns continue to evolve through mapping experience in the target language, and that the resulting L2 form-function relationships reflect both L1 and L2 structural properties.

By extending this line of reasoning, emergence of L2 morphological awareness can be seen as a result of continual adjustments on automatically activated L1 morphological awareness to accommodate the properties of morphemes specific to the target language. Given the linguistic dependency of morphological awareness, it can be hypothesized that the utility of L1 morphological awareness and other reading subskills in L2 word reading and learning is determined in part by similarities between two languages, as well as by knowledge of L2-specific morphological and other linguistic properties.

Morphological awareness in L2 reading development

In recent years, considerable attention has been given to the utility of L1 morphological awareness in L2 reading development. A growing body of research has examined the contribution of L1 morphological awareness to L2 reading subskills, including decoding (Geva & Wang, 2001; Ramirez, Chen, Geva, & Kiefer, 2010; Wang, Ko, & Choi, 2009), vocabulary knowledge (Chen, Ramirez, Luo, & Ku, 2012; Kieffer & Lesaux, 2012), word meaning inference (Zhang, 2010; Zhang & Koda, 2012), and reading comprehension (Jeon, 2011; Koda, Lu, & Zhang, 2013; Lam, Chen, Geva, Luo, & Li, 2012; Wang et al., 2009; Zhang & Koda, 2013).

Reflecting the complexity of the construct, the findings are not always consistent. For example, some studies found significant intra-lingual effects of morphological awareness only on decoding speed (Marcolini, Traficante, Zoccolotti, & Burani, 2011), while others have shown its contributions to both decoding speed and accuracy when whole word frequency and sub-lexical morpheme frequency were controlled (Verhoeven & Schreuder, 2011). In examining cross-linguistic effects of morphological awareness, Ramirez et al. (2010) demonstrated a significant direct contribution of L1 morphological awareness to L2 word reading in L1 dominant Spanish-English bilingual children. It is less than certain to what extent such cross-linguistic contributions of morphological awareness can be generalized to other bilingual groups whose literacy learning involve two typologically distinct languages and writing systems.

Zhang (2010), for example, investigated the relative shareability of two-word formation processes (derivation and compounding) in Grade 6 Mandarin speaking children learning English as a foreign language in China. His data revealed that the two facets of morphological awareness were differentially related between the two languages. Their cross-linguistic relationship was stronger in compound awareness (used in both languages) than derivational awareness (dominant in L2). He also found that L1 compound awareness contributed to L2 lexical inferencing only indirectly through L2 compound awareness and L1 lexical inferencing ability, but such (indirect, yet significant) facilitation was not observable in L1 derivational awareness. His findings seem to suggest that the shareability of morphological awareness and the resulting cross-linguistic contributions vary across distinct awareness facets.

To summarize, previous research has shown (1) that morphological awareness plays a critical role in word reading and learning; (2) that it emerges from experience of decoding and encoding morphemes in print; and (3) that L2 morphological awareness emerges from continual cross-linguistic interactions between L1 morphological awareness and L2 linguistic input. Given the linguistic dependency of morphological awareness, it is critical to explore how L2 linguistic knowledge affects the utility of L2 morphological awareness in L2 reading development. The sections that follow describe a summary of a study directly testing the hypothesized effect of L2 linguistic knowledge on the formation of L2 morphological awareness and its utility in word meaning inference.

The study

This study aimed to investigate the role of L2 morphological awareness in relation to L1 reading ability and L2 linguistic knowledge as they contributed to L2 word meaning inference among L1 Japanese learners of English as a foreign language (EFL). In addition, it explored how differing levels of L2 linguistic knowledge impacted these relationships. The study had the following research questions:

1. Do L1 Japanese EFL learners' L1 reading ability and L2 linguistic knowledge contribute directly to L2 word meaning inference, or are they mediated by L2 morphological awareness?
2. Does learners' degree of L2 linguistic knowledge affect the relationships among L1 reading ability, L2 linguistic knowledge, and L2 morphological awareness as they contribute to L2 word meaning inference?

Method

Setting and participants

Data for the study were collected at a mid-sized (approximately 6,000 students) private university in central Japan. In total, 182 EFL learners participated in the research. The majority of the participants (170) were majoring in English, while 12 were majoring in Chinese. All participants were enrolled in EFL classes at the time of the study. There were 92 females and 85 males, while 5 did not report their gender. Most participants were in their first year (n = 90) or second year (n = 40) of university, and the average age was 19.7 years (SD = 1.47). Most had begun formal EFL learning in junior high school (grade 7), and at the time of the study, had been studying EFL for approximately 8 years.

Instruments

L2 morphological awareness. In the present study, morphological awareness was defined as the ability to segment words into their constituent morphemes. Participants completed a morpheme counting task consisting of 60 items, including 9 monomorphemic words, 9 words with inflectional morphology (3 plural, 3 past tense, and 3 continuous aspect), 5 with compound morphology, 16 with low-transparency derivational morphology (with orthographic shifts), and 21 with high-transparency derivational morphology (without orthographic shifts). Because this measure sought to tap morphological awareness rather than tacit knowledge of morphemes, only high-frequency affixes were used, based on Blevins (2001, cited in Kieffer & Lesaux, 2007), Stahl and Shiel (1992), and Wurm (1997, 2000). Furthermore, a pilot study was conducted with 34 L1 Japanese university EFL learners who did not participate in the main study and participants' English instructors were consulted to confirm that affixes should be known to participants. The words were projected onto a screen, and participants had five seconds to mark the number of morphemes in each word. The reliability (Cronbach's alpha) was .81.

L2 linguistic knowledge. Linguistic knowledge was operationalized as vocabulary breadth and grammar knowledge. L2 vocabulary breadth was measured using an adaptation of Schmitt, Schmitt, and Clapham's (2001) version of the Vocabulary Levels Test (VLT). The VLT is made up of a series of three-item groups, containing three target words/phrases. Participants then choose from among six choices the three words that best match the target words/phrases. Because words are presented without contextual clues, the VLT is thought to be a purer measure of vocabulary breadth than tasks that present words in context. The present study made use of a shortened version of the VLT by Shiotsu (2003; Shiotsu & Weir, 2007), who trialed the task extensively with L1 Japanese university students similar to the participants in the present study, resulting in a smaller set of items with a high degree of reliability. This version of the test has 60 items and participants were given 10 minutes to complete the test. Cronbach's alpha was .89. L2 grammar knowledge was measured using a multiple-choice test from Shiotsu and Weir (2007). In that study, a grammar test was developed which reduced confounds with other reading-related constructs by minimizing the degree of meaning extraction necessary. Shiotsu and Weir's (2007) 35-item test was trialed extensively with L2 English learners in the UK and evaluated by 10 experts in applied linguistics and 20 ESL teachers. In the present study, Shiotsu and Weir's test was further reduced to 25 items by removing 10 items that showed low discrimination in a pilot study conducted with 45 L1 Japanese university EFL students who did not participate in the present study. Cronbach's alpha was .60. A composite L2 linguistic knowledge score was calculated for each participant using *z*-scores from the vocabulary and grammar measures.

L1 reading ability. Participants' L1 Japanese reading ability was measured using a rational cloze task (Yamashita, 2003). In this task, participants read an expository text, an excerpt from the book *Joho no Nawabari Riron* (Territory of Information; Kamio, 1990). The excerpt was 957 characters in length, and there were 30 blanks in the cloze task (approximately 3% of the text). All target items were content words (as recommended by Koda, 2005). Participants were given a word bank containing the 30 words that had been removed from the text, with an additional 20 filler words. To increase reliability, the task was piloted with a group of 45 L1 Japanese university EFL learners who did not participate in the study, and items that showed the least discrimination were eliminated. Cronbach's alpha was .73.

L2 word meaning inference. In the present study, L2 word meaning inference was defined as making appropriate guesses as to the meanings of unknown morphologically complex words through integration of word-internal morphological information and word-external contextual information (see also Brusnighan & Folk, 2012; Hamada, 2014). Participants were presented with 16 short texts (mean length = 132 words, *SD* = 32.17, range: 92–216), each of which contained two unknown words which were underlined (32 items in total). Participants were instructed to read the texts for comprehension, and comprehension was confirmed using comprehension question after each text. The unknown words were constructed from pseudo-word roots that were five characters in length and followed English graphotactics, to which real derivational prefixes and suffixes were added. High frequency affixes were used (see above, in the description of the morphological awareness task, for how these were determined). For each of the unknown words, participants were asked to choose the best meaning from among four choices, one which incorporated contextual but not morphological information, one which incorporated morphological but not contextual information, one which incorporated both morphological and contextual information, and one which incorporated neither (see Mori & Nagy, 1999 and Zhang, 2015 for similar tasks measuring L2 word meaning inference in Japanese and Chinese, respectively). Cronbach's alpha was .71.

Analysis

The data were analyzed using SPSS v.21 to calculate means and standard deviations of all variables and correlations among them. Then, recursive path analysis (Wolfle, 1980) was conducted using AMOS v.21 in order to determine direct and indirect effects. Together with path analysis, bootstrapping was also performed. Bootstrapping is a data-based simulation method that produces a large number of samples (1000) using replacement data, and parameter estimates are computed for each sample. Bootstrapping avoids potential issues arising from non-normal data and also provides more stable estimates of path coefficients (Schumacker & Lomax, 2010). In addition, bootstrapping allows significance testing of indirect effects by providing a distribution for these indirect effects. In order to retain power, bias-corrected bootstrapping was used, as suggested by Hayes and Scharkow (2013).

Results

Examining the collected data, 15 participants' data was found to be incomplete, and 10 participants reported speaking a language other than Japanese at home. These participants' data were removed from the dataset, leaving a final sample of 157 participants. Table 1 shows descriptive statistics of the raw scores and bivariate correlations between each of the variables. All variables significantly and positively correlated with all other variables, except for the correlation between L1 reading and L2 grammar knowledge (p = .05).

Table 1. Descriptive statistics and bivariate correlations

	1	2	3	4	5	M	SD
1. L2 MA	–					41.96	6.68
2. L2 V	.390**	–				21.33	9.24
3. L2 G	.267**	.465**	–			10.37	3.51
4. L1 R	.371**	.247**	.157†	–		7.14	3.28
5. L2 INF	.217**	.595**	.338**	.189*	–	10.01	4.48

Note: *MA* morphological awareness, *V* vocabulary knowledge, *G* grammar knowledge, *R* reading ability, *INF* word meaning inference.
† p = .05, * p < .05, ** p < .01

To answer the first research question, about effects of L1 reading ability and L2 linguistic knowledge on L2 word meaning inference, both directly and mediated by L2 morphological awareness, a path model was constructed. After optimizing the model by removing non-significant paths, the model showed good fit, χ^2 (2, N = 157) = 0.475, p = .788 (CFI = 1.000; $RMSEA$ = .000, 90% CI = .000, .102). Overall, the path model predicted approximately 35% of the variance in L2 word meaning inference.

Table 2 shows all direct and indirect parameter estimates. There was a significant direct effect of L2 linguistic knowledge on L2 word meaning inference (β = .573, z = 7.494, p < .001). However, the direct effect of L1 reading on L2 word meaning inference was non-significant (β = .040, z = 0.578, p = .563), as was the effect of L2 morphological awareness (β = .015, z = 0.190, p = .850). Because of the lack of a significant effect of L2 morphological awareness, the indirect effects of L1 reading and L2 linguistic knowledge on L2 word meaning inference were also non-significant (β = .004, z = 0.172, p = .817 and β = .007, z = 0.200, p = .789, respectively).

Table 2. Parameter estimates between L2 morphological awareness, L2 linguistic knowledge, L1 reading, and L2 word meaning inference

Paths		**Direct effects**				**Indirect effects**		
		β	z	p	R^2	β	z	p
L2 MA					.348			
	← L1 R	.257	3.848	< .001		–	–	–
	← L2 LK	.470	7.044	< .001		–	–	–
L2 INF					.351			
	← L1 R	.040	0.578	.563		.004	0.172	.817
	← L2 LK	.573	7.494	< .001		.007	0.200	.789
	← L2 MA	.015	0.190	.850		–	–	–
L1 R								
	↔ L2 LK	.250	3.030	.002		–	–	–

Note: MA morphological analysis, *R* reading ability, *LK* linguistic knowledge, *INF* word meaning inference

The second research question asked whether L2 linguistic knowledge moderated the relationships among L1 reading ability, L2 morphological awareness, and L2 word meaning inference. To answer this question, multiple-group path analysis was conducted. Participants were divided into a higher L2 linguistic knowledge group (n = 72) and a lower L2 linguistic knowledge group (n = 85) based on z-scores, and the path models of the two groups were compared.

Table 3 shows the parameter estimates for the lower L2 linguistic knowledge group. Together, the variables predicted only 9.3% of the variance in L2 word meaning inference. The results were similar to those for the whole group, with L2 linguistic knowledge showing a significant and positive direct effect on L2 word meaning inference ($\beta = .276$, $z = 2.402$, $p = .031$) and the direct effect of L1 reading being non-significant ($\beta = .101$, $z = 0.909$, $p = .363$).

In addition, there was a significant negative effect of L2 morphological awareness on L2 word meaning inference ($\beta = -.251$, $z = -2.151$, $p = .016$); as a result, the indirect contributions of L1 reading and L2 linguistic knowledge through L2 morphological awareness were also negative ($\beta = -.060$, $z = -1.428$, $p = .040$ and $\beta = -.084$, $z = -1.633$, $p = .022$, respectively). Thus, the results for the lower L2 linguistic knowledge group indicate that although there was a cross-linguistic effect (as shown by the significant positive effect of L1 reading on L2 morphological awareness), lower L2 linguistic knowledge might have prevented the utilization of these skills for L2 word meaning inference.

Table 3. Parameter estimates for the lower L2 linguistic knowledge group ($n = 85$)

Paths		Direct effects				Indirect effects		
		β	z	p	R^2	β	z	p
L2 MA					.210			
	← L1 R	.237	2.357	.018		–	–	–
	← L2 LK	.334	3.315	< .001		–	–	–
L2 INF					.093			
	← L1 R	.101	0.909	.363		−.060	−1.428	.040
	← L2 LK	.276	2.402	.031		−.084	−1.633	.022
	← L2 MA	−.251	−2.151	.016		–	–	–
L1 R								
	↔ L2 LK	.267	2.195	.018		–	–	–

Note: MA morphological analysis, *R* reading ability, *LK* linguistic knowledge, *INF* word meaning inference

The direct and indirect parameter estimates for the higher L2 linguistic knowledge group are presented in Table 4. Among the higher L2 linguistic knowledge group, the model predicted 36% of the variance in L2 word meaning inference.

Similar to the lower L2 linguistic knowledge group, the direct effect of L2 linguistic knowledge on L2 word meaning inference was positive and significant ($\beta = .449$, $z = 4.389$, $p < .001$), and the direct effect of L1 reading was non-significant ($\beta = .015$, $z = 0.147$, $p = .883$).

However, different from the previous analyses, L2 morphological awareness had a significant positive effect on L2 word meaning inference ($\beta = .257$, $z = 2.369$, $p = .018$). Furthermore, both L1 reading and L2 linguistic knowledge had significant positive indirect effects on L2 word meaning inference through their contributions to L2 morphological awareness ($\beta = .081$, $z = 2.000$, $p = .007$ and $\beta = .083$,

Table 4. Parameter estimates for the higher L2 linguistic knowledge group (n = 72)

Paths		Direct effects				Indirect effects		
		β	z	p	R^2	β	z	p
L2 MA					.230			
	← L1 R	.316	3.004	.003		–	–	–
	← L2 LK	.323	3.074	.002		–	–	–
L2 INF					.356			
	← L1 R	.015	0.147	.883		.081	2.000	.007
	← L2 LK	.449	4.389	< .001		.083	2.091	.004
	← L2 MA	.257	2.369	.018		–	–	–
L1 R								
	↔ L2 LK	.126	1.056	.291		–	–	–

Note: MA morphological analysis, *R* reading ability, *LK* linguistic knowledge, *INF* word meaning inference

z = 2.091, p = .004, respectively). These findings suggest that, different from the lower L2 linguistic knowledge group, among the higher L2 linguistic knowledge group, L2 morphological analysis had a significant positive effect on L2 word meaning inference, and this effect allowed transferred L1 reading skills to impact L2 word meaning inference indirectly through their contribution to L2 morphological awareness.

Figure 1 shows a schematic of the relationships among the variables for both the lower and higher L2 linguistic knowledge groups. Taken together, the results suggest that L1 reading competencies consistently impacted L2 morphological awareness. However, without a requisite level of L2 linguistic knowledge, these transferred competencies could not be utilized for L2 word meaning inference.

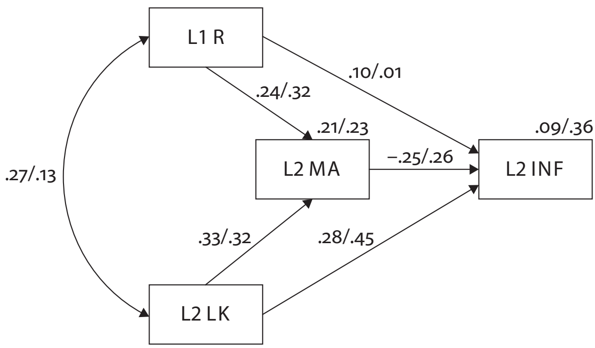

Figure 1. A schematic diagram of the results. Numbers on the left are the parameter estimates for the lower L2 linguistic knowledge group; numbers on the right are estimates for the higher L2 linguistic knowledge group

Discussion

This study investigated relationships among L1 reading ability, L2 morphological awareness, and L2 linguistic knowledge as they contribute to L2 word meaning inference among L1 Japanese EFL learners. To do this, we made use of recursive path analysis in order to investigate both direct and indirect effects. Overall, the results showed a coalescence of reading sub-skills, both within and across languages, in their contributions to L2 word meaning inference.

The first research question asked whether the contributions of L1 reading ability and L2 linguistic knowledge to L2 word meaning inference were direct effects, or whether they were mediated by L2 morphological awareness. The results from the full sample found only a direct effect of L2 linguistic knowledge on L2 word meaning inference, and neither a direct nor an indirect effect of L1 reading ability. However, L1 reading ability was found to be a significant predictor of L2 morphological awareness. The finding that contributions of L2 linguistic knowledge to L2 reading outcomes (in this case, word meaning inference) were greater than the contributions of L1 reading mirrors a number of previous studies that have investigated similar variables, particularly in EFL contexts (e.g., Haynes & Carr, 1990; Lee & Schallert, 1997; Yamashita & Shiotsu, 2017), as well as Jeon and Yamashita's (2014) meta-analysis, which showed that components related to L2 linguistic knowledge accounted for L2 reading more than L1 reading did.

However, we did see a consistent and strong positive contribution of L1 reading to L2 morphological awareness. This is consistent with previous studies of cross-linguistic transfer of reading subskills, particularly morphological awareness (e.g., Jeon, 2011; Lam, Chen, Geva, Luo, & Li, 2012; Zhang & Koda, 2012). In the present study, L1 reading had a considerably stronger relationship with L2 morphological awareness than with any other variables, as shown in the bivariate correlations ($r = .371$, $p < .01$, all other $rs < .247$) and in the positive significant direct effects across all of the path models, suggesting that morphological awareness may be a shareable resource across the two languages. This finding is interesting especially in light of the substantial differences in morphological structure between Japanese and English, suggesting that morphological awareness may be a shareable resource even among typologically disparate languages. The full mediation of L1 reading by L2 morphological awareness is especially interesting in the present study in light of the task used to measure L1 reading, a gap-filling task, which could be expected to have more similarity with word meaning inference. Nonetheless, L1 reading most strongly contributed to L2 morphological awareness.

The findings also demonstrate that although morphological awareness may be shareable across languages, there is nonetheless a degree of linguistic knowledge required in order to make use of this shared resource. As described earlier, morphological awareness is less independent of linguistic knowledge than other types of metalinguistic awareness, such as phonological awareness. The comparison in the present study of participants with differing degrees of L2 linguistic knowledge showed that utilization of morphological awareness (and the transferred L1 competencies) for word meaning inference was dependent upon L2 linguistic knowledge. That is, without a requisite amount of L2 linguistic knowledge, the L2 learners were unable to make use of their morphological awareness for word meaning inference, even though morphological awareness still received significant contributions from L1 reading ability and L2 linguistic knowledge. This result is similar to those of previous studies that suggested that a threshold level of L2 linguistic knowledge is necessary for making use of L1 reading skills, or, alternatively, that a lack of L2 linguistic knowledge short-circuits the use of L1 reading skills for L2 reading (e.g., Bernhardt, 2005; Bernhardt & Kamil, 1995; Clarke,, 1980; Cummins, 2000; Lee & Schallert, 1997; Yamashita & Shiotsu, 2017). In the present study, it was found that L2 linguistic knowledge might constrain the utilization of shared resources such as morphological awareness.

Summary conclusions

In this chapter, we have discussed the importance of metalinguistic awareness, particularly morphological awareness, as a shareable resource for second language reading. Through cumulative experience and exposure to text in their L1, readers develop an awareness of linguistic structure that is abstract in nature and which can be utilized when reading in later-acquired languages. Thus, a reader's morphological awareness that is developed through input in their L1 may be a shareable resource for L2 reading and learning as well. As shown in the study reported here, this may also occur across languages with disparate writing systems and morphological structures, though with the requirement that the L2 reader have a certain amount of linguistic knowledge in the L2 in order to utilize the shared resources.

The findings reported here underscore the importance of conceptualizing reading as a multi-componential system when exploring cross-linguistic interactions in L2 reading development. As a complex information processing system, reading involves a number of distinct mechanisms working in unison to construct meaning from text. Reading in an L2 additionally implies the involvement of two or more languages working together in this multi-componential system. Research such as the study reported here illustrates the complex cross-linguistic interactions that occur between L1 competencies and L2 linguistic knowledge as L2 learners' reading skills develop.

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CHAPTER 15

Sociocultural implications of the Japanese multi-scripts

Translanguaging in translation

Eriko Sato
SUNY Stony Brook University

This chapter analyzes the development of the Japanese writing system and the use of multiple types of scripts in translated texts in Japanese based on *translanguaging*. The sociolinguistic concept of translanguaging refers to the strategic use of linguistic repertoires across language boundaries by bilingual language users. In the case of translations of texts into Japanese, various scripts provide numerous communicative and expressive functions which allow users to adapt new concepts, creatively represent ideas, and critically convey their viewpoints. These abilities are often afforded by unconventional use of *furigana*, or small-sized *kana* that indicate the proper pronunciation of *kanji* characters. This study argues that translanguaging occurs not only in oral communications, but also through scripts, and is essential for languages to evolve by incorporating the surrounding sociocultural contexts.

Keywords: script, translanguaging, translation studies, sociolinguistics, pragmatics

Introduction

The Japanese writing system is extremely complex because multiple types of scripts coexist even in the same sentence. In addition to the phonographic systems of *hiragana* and *katakana* and the logographic system of *kanji*, it also employs the Roman alphabet and Arabic numerals. Despite the established usage conventions for each type of script, considerable flexibility still exists. The choice of script varies depending on the context and the writer's sociocultural or sociopolitical stance. In addition, *kanji* characters have been used creatively beyond the usage conventions of the traditional Chinese-derived characters. For example, *kanji* characters are sometimes used for visually representing native Japanese words through the

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convention of *ateji* (phonological representation of Japanese words using *kanji*) and *jukujikun* (semantic representation of Japanese words using *kanji*). For example, 世話 *se-wa* (care) is an *ateji* and the sounds of the two *kanji* characters, *se* (世) and *wa* (話), jointly represent this native Japanese word, but their meanings, *world* and *speak*, respectively, are irrelevant to the word meaning "care." On the other hand, 今朝 *kesa* (this morning) is a *jukujikun* and the meanings of the two characters, *now* (今) and *morning* (朝), represent the word meaning *this morning*, but their sounds, *kon* and *chō*, are disregarded. These native Japanese words can be adequately represented by *hiragana*, but the writers can express subtle nuances by representing them using *kanji*. Moreover, *furigana*, which are usually small-sized *hiragana* or *katakana* that accompany *kanji* characters to indicate their proper pronunciation, also serve as vehicles for implicitly conveying the writer's intentions or perspectives. For example, *furigana* may indicate a *kanji's* non-standard pronunciation, derived from loanwords from the West. Evidently, *furigana* can facilitate the crossing of language boundaries. Such flexibility found in the use of multi-script systems in Japanese especially in translated texts can be analyzed based on the concept of translanguaging.

Translanguaging is a bilingual's language use that disregards the boundary between named languages (Baker, 2003; Makoni & Pennycook, 2007; García, 2007, 2009; Blackledge & Creese, 2010; Creese & Blackledge, 2010; Canagarajah, 2011; Li, 2011, 2017; Lewis et al., 2012; García & Li, 2014; Lin, 2014; Otheguy et al., 2015). Although the concept is mainly applied in pedagogical contexts, it has been assumed by García and Li (2014) to apply to all modes of communication for creative and critical meaning-making and trigger natural language evolution driven by sociocultural factors.

After surveying recent developments in translation studies and translanguaging, this chapter analyzes the development of the Japanese multi-scripts based on the translanguaging perspective conceptualized by García and Li (2014) and illustrates the wide-ranging expressive ability of multi-scripts in Japanese and the unique use of *furigana* in translated texts. The Japanese translated texts examined in this chapter are *Romeo and Juliet* (William Shakespeare) translated by Shōyō Tsubouchi in 1910 and 1933, and *Breakfast at Tiffany's* (Truman Capote) translated by Naotarō Tatsunokuchi in 1968 and by Haruki Murakami in 2008.

Literature review

Translation studies[1] emerged as an academic discipline in the second half of the 20th century. Its initial inquiry was how to approach to the traditional paradox of translation, the dichotomy between literal translation and free translation. Some scholars in 1960s took a structure-based linguistic approach to construct a system for transforming the source text (ST) to the target text (TT) (Nida, 1964; Nida & Taber, 1969; Catford, 1965). It is followed by a context-based linguistic approach to view translation as a part of communication (House, 1977, 1997; Gutt, 1991; Baker, 1992; Hatim & Mason, 1990, 1997). On the other hand, some scholars took a prescriptive functionalist approach that could undermine the ST as well as its culture in order to fully respect the purpose of translation within the culture of the TT (Nida, 1964; Vermeer, 1989/2012). Since 1990s, many scholars of translation studies have focused on the sociocultural and sociopolitical conditions and ideologies that surround translation (Bassnett & Lefevere, 1990; Venuti, 1995, 1998). Descriptive studies of translated texts have been essential for identifying societally constructed norms of translation (Toury, 1995; Chesterman, 1997).

The descriptive analysis of translated texts in terms of their surrounding sociocultural and sociopolitical conditions can be tied to the recent theory of sociolinguistics and bilingualism, namely, translanguaging. Translanguaging conceptualized by García and Li (2014) is a bilingual's language use that manipulates the boundary between named languages for creative and critical meaning-making. It is based on the assumption that languages are not static sets of rules and words, but rather actions that constantly self-evolve, reflecting the surrounding sociocultural contexts. Most existing research on translanguaging investigate spontaneous oral communications among bilinguals in multilingual contexts such as classrooms, hospitals, and households, focusing on urgent issues in the current globalized world, for example, identity, transnationalism, ethnicity, social inequality, language policy, education and pedagogy. However, there is no reason for limiting translanguaging to spontaneous oral communication because an oral communication can be as deliberate as a written communication, and a written communication can be as spontaneous as a slip of tongue. García and Li (2014) assume that translanguaging applies to all semiotic modes of communication including literacy practices. A translanguaging perspective is applied to writing (Canagarajah, 2011), song lyrics (Lin, 2014) and visual arts (Lee, 2015). Li (2017) emphasizes the multimodal and multisensory nature of translanguaging and argues that translanguaging allows humans "to go

1. The name of the discipline "translation studies" was created based on the paper "The name and nature of translation studies" delivered by James S. Holmes (1924–1986) in 1972 (Munday, 2012: 10).

beyond narrowly defined linguistic cues and transcend culturally defined language boundaries to achieve effective communication" (p. 17).

Translanguaging and translation may appear to be mutually exclusive, or two sides of the same coin, in a practical sense: A translanguaging practice deliberately flouts the boundary between two named languages, but a translation practice maximally respects it. Accordingly, translanguaging "in" translation can be a paradox or a sign of imperfection that puts translators at a serious professional risk. However, translation is ultimately a bilingual's communicative act that involves interpretation and expression. Although it is very rare, translators occasionally do push and flout language boundaries in desperate situations or to effectively communicate their interpretation with their target readers, or even to experiment new rhetorical style. In fact, artifacts of translanguaging in translated texts can serve as rich resources for examining the precise mechanism of translanguaging with its cause and its consequence. Research projects on oral translation have been emerging in the field of multilingualism in the past few years, relating translation to the new concept of bilinguals' language use, *translanguaging*. This concept can also be applied to the study of translated texts. Sato (2017) and Sato and Sharma (2017) analyze corpus of translated texts focusing on the traces of translanguaging.

The development of the Japanese writing system

The first text produced in Japan dates back to the fifth century although fully fledged literacy practices started in the seventh and eighth centuries (Lurie, 2011: 1). While scripts were transforming from "alegible" entities (Lurie, 2011: 2) to more or less linguistic signs, the boundary between writing and drawing and the boundary between literacy and art remained blur. The subsequent development of the writing system in Japanese was heavily influenced by sociocultural ideologies and sociopolitical power. This section reanalyzes *kanbun-kundoku, kun'yomi*, Chinese-Japanese hybrid writing, *kana*-only writing and *kanji-kana* mixed writing from the perspective of translanguaging.

Kanbun-kundoku and *kun'yomi*

During the 6th and 7th centuries, Chinese Buddhism was brought into Japan through Korea, causing the necessity for the Japanese to read numerous Chinese texts. Chinese texts, *kanbun*, were read in two ways: either *ondoku* (sound reading) or *kundoku* (gloss reading). *Kanbun-ondoku* (the sound reading of Chinese texts) is the mere vocalization of Chinese texts as Chinese, whereas *kanbun-kundoku* (the gloss reading of Chinese texts) is the "verbalization of Chinese texts in vernacular

Japanese. *Kanbun-kundoku* involves not only verbalizing Chinese words in Japanese, but also mentally rearranging the Chinese characters and adding Japanese grammatical particles and inflectional endings.[2] It often required *kunten* (reading marks), which is "diacritic transposition marks and phonographic annotations" added to Chinese texts to facilitate reading them as Japanese (Lurie, 2011: 184).

At morpheme levels, Chinese characters, *kanji*, were read either in *on'yomi*, the approximation of the Chinese pronunciation of the *kanji*, or in *kun'yomi*, the native Japanese words that represent the approximate meaning of the *kanji*. For example, the *kun'yomi* of the *kanji* 山 is *yama*, which is a native Japanese word that means a "mountain."

Kanbun-kundoku "involved finding suitable translation equivalents in Japanese for content and function words in the Chinese texts" (Frellesvig, 2010: 259). Wakabayashi (2005: 24) considers *kanbun-kundoku* a "mental translation." Most interestingly, Lurie (2011: 10) considers *kanbun-kundoku* a combination of "aspects of reading and of translation" (p. 10). Thus, *kanbun-kundoku* can be viewed not only as the earliest form of translation in Japan, but also as the earliest form of translanguaging through scripts in Japan, where a reader saw a Chinese text and verbalized it in Japanese. In this method, linguistic features in both Chinese and Japanese were simultaneously deployed by the reader of the text while the entire process was held together by scripts. The boundary between verbalization and comprehension as well as the boundary between Chinese and Japanese were strategically manipulated. Similarly, *kun-yomi* can be viewed as an instance of translanguaging at the morpheme level, where the graphic features of Chinese characters are matched with the phonological and semantic features of Japanese words. Due to lexical differences between Chinese and Japanese, we have situations where one *kanji* character has multiple *kun-yomi* readings, multiple *kanji* characters have an identical reading, and compounds of two or more *kanji* characters can take unitary *kun-yomi* reading Lurie (2011: 177). This shows that the translanguaging practice through scripts in Japan was fluid and flexible at least at early stages of literacy practices.

Chinese-Japanese hybrid writing

The *Kojiki* (*Records of Ancient Matters*), completed in AD 712, can be viewed as a representation of the earliest translanguaging writing in Japan. In the *Kojiki*, the author/compiler, Yasumaro, deliberately used three ways of writing: Chinese style (the logographic use of *kanji*), Japanese style (phonographic use of *kanji* commonly

2. According to Lurie (2011: 5–6), it is almost certain that the practice of kundoku was pioneered by "scribes in the sixth-century Korean states" and then brought to Japan although we do not have surviving materials that could serve as conclusive evidence.

called *man'yōgana*), and Chinese-Japanese hybrid style: (i) the Chinese-style was used for writing the preface to indicate formality; (ii) the Japanese-style was used for writing songs to represent the Japanese language respecting the way it was spoken, which was suitable for straightforwardly expressing feelings and emotions; (iii) the Chinese-Japanese hybrid style was used for writing the main text, successfully maintaining the formality and the brevity needed for the text body while facilitating readability for the Japanese (Seeley, 1991: 46).

In the Chinese-Japanese hybrid style, the writer was using the linguistic features of Japanese and Chinese languages and mixing them freely within the same text to maximize expressiveness while minimizing reading effort. This flexible deployment of linguistic features for rhetorical and communicative effectiveness disregarding the boundary between languages is evidently translanguaging.

Kana-only writing

Kana, more precisely, *hiragana* and *katakana*, evolved from *man'yōgana* in the Heian period (794–1185). *Hiragana* are a set of cursively written whole *man'yōgana* and *katakana* are another set of parts of *man'yōgana*. Interestingly, the transformation from *man'yōgana* to *kana* took place gradually and thus, there was a period of "coexistence between *kana* and *man'yōgana*" (Frellesvig, 2010: 162). *Hiragana* were cursive and "aesthetically pleasing and were associated with literature and calligraphy," whereas *katakana* consisted of straight lines and angles and were "practical to use in annotations on texts where space is limited" (Frellesvig, 2010: 162).

Hiragana and *katakana* were unambiguously recognizable as Japanese scripts rather than Chinese scripts and as phonographs rather than logographs. They enabled the Japanese to straightforwardly write any Japanese sentence phonographically in vernacular Japanese. In the Heian period, a literary genre called "*kana* literature" emerged. Most works in *kana* literature were written by women. *Hiragana* was called "*onna-de* (women's script/hand)" and was "the only script normally used by women" (Seeley, 1991: 78) although men could also write in *hiragana* as well as in *kanji*. On the other hand, "*otoko-de*" (men's script/hand) was the term devised to denote *kanji* (Seeley, 1991: 79). Paradoxically, *Tosa Niikki* (*The Tosa Diary*) was actually written by a male poet, Ki no Tsurayuki, in *hiragana*, but starts with his statement that he was writing "as a woman" (Seeley, 1991: 79). However, Japanese male literary authors, in general, "considered writing in Japanese to be beneath them" and devoted themselves to write in Chinese using *kanji* (Keene, 1955: 24). "Academic, intellectual or public writing was mostly done in Classical Chinese (Frellesvig, 2010: 162), presumably by men, while women were traditionally excluded from "the world of learning and Classical Chinese" (Frellesvig, 2010: 157).

Evidently, the choice of scripts was deliberately made for rhetorical effectiveness and reflected the user's sociocultural and sociopolitical ideologies in terms of gender and power. The Japanese were recognizing an authoritative value in *kanji* that originated from China. Accordingly, *hiragana* was not a part of the writing practice associated with sociopolitical power and intellect, and women were normally writing only in *hiragana* in the Heian Period. Ki no Tsurayuki's use of *hiragana* can be an instance of translanguaging in that he strategically disregarded the boundary, not between two named languages, but between two gender-based orthographic varieties of a language, obviously motivated by rhetorical effectiveness, but possibly to voice his critical view on gender.

Kanji-kana mixed writing

From the middle of the Heian period (794–1185), a writing style called *kanji-kana* mixed writing (*kanji-kana majiribun*) started to be used more widely, replacing *kana*-only writing (Frellesvig, 2010: 157). In *kanji-kana* mixed writing, content words were mainly written in *kanji* while grammatical items and endings were written in *katakana*. *Kanji-kana* mixed writing "arose as a transfer of the techniques of *kunten*" to the writing of Japanese (Frellesvig, 2010: 158). The shift from perfectly feasible *kana*-only writing to more complex *kanji-kana* mixed writing was partially motivated by the efficiency of reading. Reading a *kanji-kana* mixed text requires less time than reading an all-*kana* text due to the fact that the presence of *kanji* helps readers quickly identify content words. In addition, *kanji-kana* mixed texts are almost always shorter than all-*kana* texts, and writing in *kanji* can visually disambiguate many homophones in Japanese. In the Edo period (1603–1867), the Tokugawa *shogunate* promoted "Chinese studies in general, and Neo-Confucianist studies in particular," which were useful for preserving the status quo in the society and this naturally fostered the use of the Chinese-style writing among scholars, but what was firmly established was *kanji-kana* mixed writing (Seeley, 1991: 101). The practice of *kanji-kana* mixed writing is still used in modern writing system, except that grammatical particles and inflectional endings are now written in *hiragana* rather than in *katakana*.

The shift from *kanji*-only writing to *kana*-only writing was driven by the ease of writing and by the desire to write in the vernacular Japanese. The following shift from *kana*-only writing to *kanji-kana* mixed writing was partially driven by the ease of reading, but it was also socioculturally and sociopolitically conditioned, often driven by the ideology in the pre-modern era in Japan, the admiration of Chinese culture and philosophy. This societally constructed ideology-driven dynamic transformation of the norms of writing that manipulate the boundary between Japanese and Chinese shows that scripts serve as spaces for translanguaging.

Creative and critical literacy practices

The Japanese multi-scripts have the ability to creatively represent new concepts and implicitly express a writer's critical views. This section provides writing practices that embraces translanguaging for creative and critical meaning-making found in unique ways of combining scripts and their sociocultural implications.

Kokuji, *ateji* and *jukujikun*

Some *kanji* characters were made in Japan combining existing *kanji* or parts of existing *kanji* following the structural principles of Chinese characters. These Japan-made *kanji* characters are called *kokuji* (country character). *Shinsen Jikyō* (*newly-compiled mirror of characters*) compiled by the priest Shōjū sometime between 898 and 901 represent early examples of this category including the following (Seeley, 1991: 203):

(1) a. 人 person + 動 move → 働 work
b. 山 mountain + 上 (go) up +下 (come) down → 峠 mountain pass
c. 身 body + 美 beauty → 躾 upbringing

Some combination of *kanji* characters were assigned to existing native Japanese words. Such assigned *kanji* compounds are classified into *ateji* and *jukujikun*. *Ateji* are chosen arbitrarily for their sound value. For example, the native Japanese word, *sewa*, means "care." To represent this word, the two *kanji* characters 世 *se* and 話 *wa* were assigned due to their pronunciations (*on'yomi* pronunciation) although their meanings are irrelevant to "care": 世 means *world* and 話 means *speaking*. The basic idea of *ateji* is similar to *man'yōgana*, but the choice of the *kanji* characters for a given *ateji* is fixed unlike *man'yōgana*. According to Seeley (1991: 188), *ateji* was developed in the Kamakura period (1185–1333) and the Muromachi period (1336–1573) onwards. Additional examples of *ateji* include 風呂 *furo* (bath), which is the combination of 風 *fū* (wind) and 呂 *ro* (backbone), and 出鱈目 *detarame* (nonsense), which is the combination of 出 *de-ru* (come out), 鱈 *tara* (cod fish) and 目 *me* (eye).

Jukujikun are combinations of *kanji* characters chosen for their combined semantic value. For example, the native Japanese word *kesa* means *this morning*. To represent this word, the two *kanji* characters 今 *kon* (current) and 朝 *chō* (morning) were chosen and combined because of their meanings. The sounds of these *kanji* characters are completely disregarded, and the pronunciation of the native Japanese word *kesa* was assigned to the entire sequence of the two *kanji* characters 今朝. Additional examples of *jukujikun* include 大人 *otona* (adult), the combination of 大 *dai* (big) and 人 *jin* (person), and 土産 *miyage* (souvenir), the combination of 土 *do* (soil) and 産 *san* (produce).

According to Seeley (1991: 188), *ateji*, and presumably *jukujikun* also, were motivated by the writer's desire to write words solely by *kanji* in the premodern time. Sasahara (2010) lists over 11,000 of *ateji* and *jukujikun*. In the modern era, a relatively small number of *ateji* and *jukujikun* have been used since *kanji* reforms, but some are still frequently used. Interestingly, the practice of *ateji* and *jukujikun* extends to Western names and concepts. Although they are usually written in *katakana*, some are still written in *ateji* or *jukujikun*. For example, 巴里 (*Pari*, Paris), 倶楽部 (*kurabu*, club) and 珈琲 (*kōhī*, coffee) are *ateji*, whereas 麦酒 (*bīru*, beer) and 煙草 (*tabako*, tobacco) are *jukujikun*.

Japan-made *kanji* characters as well as Japan-made *kanji* compounds discussed above are the products of creative meaning-making or redefinition of existing words with new visual representation, and they were created by strategically disregarding the boundary between named languages. Through such translanguaging practices, language users can enrich or fine-tune the nuance of each word based on their view and ideas.

Sino-Japanese coinage of Western concepts

The modernization of Japan in the Meiji period (1868–1912) required the adaptation of a large number of concepts from the West. Translating Western words that represent abstract concepts such as "society," "liberty," "individual," and "right" were significantly challenging because of the lack of equivalent words and/or equivalent realities that stood for them in Japan at that time (Yanabu, 1982/2015: 3). One strategy was to represent them in *katakana* or *ateji* (Seeley, 1991: 137). For example, the English word *club* can be represented as クラブ *kurabu* in *katakana* or as 倶楽部 *kurabu* in *ateji*. However, the predominant approach that the Japanese took was to use the meanings and the sounds (*on'yomi*) of *kanji* as "building blocks" and combine them freely (Seeley, 1991: 136) to create Sino-Japanese compounds. Numerous Sino-Japanese words were coined through this process during the Meiji period during the effort of translating a large number of Western documents to Japanese. In fact, many of them are attributable to prominent individuals in the Meiji period such as Amane Nishi (1829–1897), Yukichi Fukuzawa (1835–1901) and Tetsujiro Inoue (1856–1944). Translations of Western words by these three individuals yielded over 2500 Sino-Japanese words including 社会 *sha-kai* (society), 民主主義 *min-shu-shu-gi* (democracy), 自由 *ji-yū* (liberty), 哲学 *tetsu-gaku* (philosophy), 会社 *kai-sha* (firm, company), 会計学 *kai-kei-gaku* (accounting), 労働 *rō-dō* (work, labor), 郵便 *yū-bin* (postal service), 自動車 *ji-dō-sha* (automobile) and 鉄道 *tetsu-dō* (railroad) (Frellesvig, 2010: 409).

Directly borrowing English words using *katakana* would have caused only confusion during this important period in Japan. *Kanji* were ideal building blocks because each of them has an abstract meaning and can be pronounced by one or two syllables and the Japanese were already familiar with them. Furthermore, the foreignness or remoteness of *kanji* that the Japanese perceive could have been helpful for them to construct a new concept using them. Without coining Sino-Japanese compounds, the Japan would not have been able to absorb new concepts from the West (Frellesvig, 2010: 409). *Kanji* played crucial roles for creating new concepts needed to modernize Japan during the Meiji period. Sino-Japanese coinage is a part of translanguaging practice, where Chinese characters are creatively combined to adapt concepts from the West for the Japanese.

Choice of scripts

The choice of scripts can influence the perception of words and the concepts that they represent. Usui (2012) argues, from a Japanese medical expert's point of view, that the perception of *tobacco* is different depending on which type of script is used in Japan. He claims that if we follow Japanese cultural norms, *tobacco* written in *kanji* (煙草) would wrongly give the impression that tobacco has existed in Japan from ancient times, *tobacco* written in *hiragana* (たばこ) would give the misleading impression that it is safe for health, and *tobacco* written in *katakana* (タバコ) would be most appropriate if we want to express that *tobacco* is harmful for our health.[3]

The choice of scripts is also sociopolitically sensitive. Konno (2009: 46) provides a very interesting case when multiple cities, whose names were written in *kanji*, merged and adopted a new name written in *hiragana*, entirely or partially: *Urawa* City (浦和市), *Ōmiya* City (大宮市), and *Yono* City (与野市) in *Saitama* Prefecture (埼玉県) merged and became *Saitama* City, which is written in *hiragana*, さいたま, as in さいたま市 *Saitama* City. Similarly, *Akikawa* City (秋川市) and *Itsukaichi* Town (五日市町) in Tokyo merged and became *Akiruno* City, which is written partially in *hiragana* (あきる *akiru*) and partially in *kanji* (野 *no*), as in あきる野市 *Akiruno* City. It is possible that the sociocultural, sociohistorical and sociopolitical perceptions bundled in the original names written in *kanji* could be removed by not continuing to use the *kanji* characters used in these place names, which must have been crucial for creating a sociopolitically neutral name for the new city.

The choice of script types is also socioeconomically sensitive and it has been taken seriously when creating names for companies, brands, and products. SONY's initial name was written in *kanji* as 東京通信工業株式会社 *Tokyo Tsūshin Kōgyō*

3. The foreign words that were borrowed from Dutch and Portuguese before the Meiji period (1868–1912) have been naturalized, but the Western words borrowed in and after the Meiji period are conventionally written in katakana (Mackey & Ornstein, 1979: 287).

Kabushiki-Gaisha (Tokyo Telecommunications Engineering Corporation) when the company was first established in 1946. However, its name changed to ソニー株式会社 *Sonī Kabushiki-Gaisha* (Sony Corporation), written in *katakana*, in 1958.[4] A name written in *katakana* allows the company to be perceived as more modern and globalized than a name written in *kanji*. Konno (2009: 46) provides an example of companies that changed their names to those written in Roman alphabet. 飯山電機 (*Iiyama Denki*, Iiyama Electric) first changed its name to *katakana* イーヤマ (*Iiyama*), and then to Romanization "iiyama."

This shows that different types of scripts construct different images of companies and places, and scripts serve as powerful translanguaging sites when used for proper names.

Furigana

Furigana is a small-sized *kana* that typically accompanies *kanji* characters to indicate their readings. *Furigana* tends to be placed either above or next to *kanji* depending on whether the text is written horizontally or vertically. Konno (2009: 68) shows that the prototype of *furigana* was used as a part of *kunten* in *Nihon Shoki* (*The Chronicles of Japan*), completed in AD 720, clarifying the intention of the author on how a particular Chinese character should be read in Japanese. *Furigana's* existence was crucially interconnected with the presence of two languages (Konno 2009: 28). Thus, *furigana* played a vital role for translation and translanguaging in the early stage of the Japanese literacy practice through script-based mental translation, regardless of whether it appeared as *man'yōgana* or *kana*.

Although *furigana's* major role is to facilitate the reading of *kanji* as mentioned above, its use gradually expanded to include the expression of "double meanings or overlapping significations" in early modern period (Tanaka 2014: 70). *Furigana* is the space where authors can creatively and critically express their views and ideas. For example, Konno (2009: 198) points out that the novel *Sorekara* (*And then*) written by Soseki Natsume (1867–1916) in 1909 and first published in serial form in *Asahi Newspaper* appeared slightly differently between the newspaper circulated in Tokyo and the one circulated in Osaka: the *furigana* added to *kanji* 長椅子 ("long" + "chair") was ソーファ *sōfa*, the approximation of the English word *sofa* written in *katakana*, in the Tokyo version, but it was ながいす *naga-isu*, a native Japanese word that means *long chair* written in *hiragana*, in the Osaka version. In the Meiji period (1868–1912) many Western concepts and words were brought to

4. See Sony's homepage available at <https://www.sony.co.jp/SonyInfo/CorporateInfo/History/history.html> (15 November, 2017)

Japan. Thus, at the time this novel appeared in the newspaper, the vocabulary choice must have been in the middle of the transition. The reason why some *furigana* in a novel had to be differentiated between Tokyo and Osaka versions must have been relevant to the readiness or ideological difference toward Westernization, but it is clear that *furigana* has been serving as a venue to convey the writer's critical view on the society and on the norms of language use. Wilkerson and Wilkerson (2000) show a number of extremely unconventional use of furigana, for example, a loan-word マジカル *majikaru* (magical) accompanied by a Sino-Japanese 不思議 *fushigi* (marvelous) in *furigana*[5] and an English word STYLE accompanied by a loanword ファッション *fasshon* (fashion) in *furigana*.[6]

Analyses of *furigana* in translated texts

This section explores the possibility of translanguaging evidenced in the use of *furigana* in translated texts. Translated texts to be examined are two versions of the translation of William Shakespeare's *Romeo and Juliet* by Shōyō Tsubouchi as well as the translations of Truman Capote's *Breakfast at Tiffany* by Naotarō Tatsunokuchi and by Haruki Murakami.

Romeo and Juliet

Tsubouchi's translation of *Romeo and Juliet* published in 1910 (Shakespeare 1910) is most well recognized among the earliest translations of this play published in the Meiji period (1868–1912). A slightly different version of his translation was published in 1933 (Shakespeare, 1933).

Creating neo-loanwords

The word "Cupid" appears five times in the ST. The first instance of "Cupid" occurs in Act I, Scene 1. It is rendered as a Sino-Japanese compound word, 戀愛神 (*ren-ai-shin*, "romantic love" + "love" + "god"), but is accompanied by the transliteration of *Cupid* written in *katakana*, キューピッド *kyūpiddo*, in *furigana*, in both versions of Tsubouchi's translation. However, the following four instances of "Cupid" are all rendered as a loanword キューピッド *kyūpiddo*. Evidently, translanguaging through

5. This example was taken from a fashion magazine in Japan called "More" (Nov. 1986, 39) by Wilkerson and Wilkerson (2000: 253).

6. This example was taken from a fashion magazine in Japan called "With" (June 1995, 8) by Wilkerson and Wilkerson (2000: 254).

furigana for the first instance of *Cupid* created a neo-loanword, where the Japanese audience could read the unfamiliar loanword in *furigana* while recognizing its meaning through the Sino-Japanese compound. It shows the translator's faithfulness to the source text and also his intention to gradually introduce English words in Japan.

Additional examples of English words that appear as a Sino-Japanese word accompanied by *furigana* as a translanguaging site include *club* (Act I, Scene 1), *table* (Act I, Scene 5) and *Easter* (Act III, Scene 1):

(2) a. *clubs*: 棍棒 *konbō* with クラッブ *kurabbu* in *furigana*
b. *table*: 食卓 *shokutaku* with テーブル *tēburu* in *furigana*
c. *Easter*: 復活祭 *fukkatsusai* with イースター *īsutā* in *furigana*

Rhetorical effect

Stylistic markedness and rhetorical effects are often sacrificed to retain propositional meanings through translation. However, some of such problems are solved by translanguaging through *furigana* in Tsubouchi's translation of *Romeo and Juliet*. For example, in Scene 1 in Act I, Sampson and Gregory talk as they play with four words that sound similar: *coals, collier, choler*, and *collar*:

(3) SAMPSON: *Gregory, o' my word, we'll not carry* ***coals***.
GREGORY: *No, for then we should be* ***colliers***.
SAMPSON: *I mean, an we be in* ***choler****, we'll draw*.
GREGORY: *Ay, while you live, draw your neck out o' the* ***collar***.
(Shakespeare 1993, Act I, Scene 1)

The idiom *carry coals* means "suffer insult," a *collier* is a coal seller, *choler* means "anger," and *collar* in this case means "a hangman's noose" (Hagar, 1999: 17). In Tsubouchi's translation published in 1910, "collier" and "collar" are deleted, and "coals" and "choler" are semantically translated, replacing the original phonological markedness with a newly invented Japanese-based language play. However, Tsubouchi's later translation published in 1933 renders the four English words as Sino-Japanese compounds accompanied by their transliterations written in *katakana* appearing in *furigana*:

(4) a. *coals*: 石炭 (coals) with コール *kōru* in *furigana*
b. *collier*: 奴隷 (slaves) with コーリヤー *kōriyā* in *furigana*
c. *choler*: 癇 (temper) with コーラー *kōrā* in *furigana*
d. *collar*: 頸輪 (neck ring) with コラー *korā* in *furigana*[7]

7. 頸輪 kubiwa with furiganaコラー korā is followed by 首枷 kubikase in parentheses. It means "pillory" and is accompanied by furigana written in hiragana, くびかせ (kubikase), in parentheses.

The phonological similarity among these four English words and the propositional meanings are successfully preserved. Tsubouchi's approach in his translation in 1910 is *domestication* (Venuti, 1995, 1998) whereas his approach in his later translation in 1933 is translanguaging.

Similarly, the two rhyming words *love* and *dove* in Mercutio's lines in Scene 1 in Act II, where he tries to use a magic spell to make Romeo appear, their phonological markedness and their semantic meanings are successfully preserved by the combination of *kanji* and *furigana*. In both versions of Tsubouchi's translation, *love* is rendered as 戀 (*koi*, romantic love) with ラブ *rabu* in *furigana*, and *dove* is rendered as 鳩 (*hato*, dove) with ダブ *dabu* in *furigana*. The use of *kanji* with *furigana* is crucial for preserving the original rhyming between the two English words preserving their meanings.

In Scene 3 in Act V, one of the watchmen says the following after seeing the staggered bodies of Romeo and Juliet:

(5) *We see the* ***ground*** *whereon these woes do lie*;
But the true ***ground*** *of all these piteous woes*
We cannot without circumstance descry. (Shakespeare 1993, Act V, Scene 3)

Here, the two instances of *ground* stand for two different meanings: the first one refers to *physical ground* and the second one refers to *cause*. In Tsubouchi's translation published in 1910, both of them are rendered as a Sino-Japanese compound, 地盤 (*jiban*, ground). By contrast, in his translation published in 1933, they are rendered as 地盤 (*jiban*, ground) and 原因 (*gen'in*, cause), but both of them are accompanied by the transliteration of *ground*, グラウンド *guraundo* in *furigana*. The rhetorical effect produced by the two instances of *ground* with two different meanings in the ST is preserved without distorting the semantic meanings.

Refining meanings

The word "kiss" in *Romeo and Juliet* is rendered differently depending on the context in Tsubouchi's translations. When it is a part of "tender kiss" or "holy palmers' kiss" that Romeo and Juliet mention, "kiss" is rendered as 接觸 ("contact" + "touch") and 接吻禮 ("contact" + "lips" + "ritual"), respectively, and both of them are accompanied by direct rendering of *kiss*, キッス *kissu*, in *furigana*. Their first "kiss" in the script direction is also rendered as 接吻 ("contact" + "lips") with キッス *kissu* in *furigana*. Interestingly, "kiss" is rendered as 接吻 with せっぷん *seppun* in *furigana*, when Juliet kisses Romeo to bring him back from death in his dream, when Romeo kisses Juliet before he takes a poison to kill himself, and when Juliet kisses him before she stubs herself to death. In these contexts, "kiss" is connected to life or death. Sino-Japanese pronunciation, せっぷん *seppun*, sounds heavier and more serious than English-based pronunciation, キッス *kissu*. This subtle nuance is expressed by *furigana* by Tsubouchi, in both versions of his translation. In the Japanese society where there is no kiss for social function and any kind of kiss in public is not commonly practiced, Tsubouchi successfully introduced varied types of kissing in each scene through the choice of *furigana* and *kanji*.

Providing pragmatic information

Tsubouchi's translation also takes advantage of *furigana* for filling the pragmatic gap between the culture of the source language and the culture of the target language. In Act II, Scene 4, Benvolio asks what kind of man Tybalt is. Mercutio responds to him by saying, "More than prince of cats, I can tell you." Tybalt, in fact Tibert, is the "Prince of Cats" in *Reynard the Fox*. However, this pragmatic information is not accessible to the TT audience. To show that what Mercutio means is Tybalt (Tibert), the prince of cats, *furigana* チッバルト *Chibbaruto* is added to 猫王 *neko-ō* (cat-prince) in both versions of Tsubouchi's translation.

Similarly, *furigana* fills the pragmatic gap between the ST and the TT audience when Peter talks with three musicians in Act IV, Scene 5. The musicians' names are comically improvised: *Simon* ***Catling***, referring to the material of his viol strings; *Hugh* ***Rebeck***, referring to the ancient English fiddle with three strings, and *James* ***Soundpost***, referring to the sound post in string instruments (Naylor, 1965: 129). These names are rendered as Japanese names written in *kanji* that semantically represent similar connotations, accompanied by the transliteration of the English names in *furigana*:

(6) a. *Simon Catling*: 猫腸絃子 with サイモン・キャトリング *Saimon Kyatoringu* in *furigana*
b. *Hugh Rebeck*: 三絃胡弓子with ヒュー・レベック *Hyū Rebekku* in *furigana*
c. *James Soundpost*: 提琴柱子with ヂェームズ・サウンドポスト *Jēmusu Saundoposuto* in *furigana*

All names end in the *kanji* 子, which is the ending of a name.[8] 猫 *neko* and 腸 *chō* mean *cat* and *intestine*, respectively. 絃 *gen* means *strings*. 三絃 *sangen* is an ancient three stringed instrument and 胡弓 *kokyū* is an ancient string instrument played with a bow. 提琴 *teikin* refers to a four stringed instrument or violin, and 柱 *hashira*/

8. Until the end of the 8th century, the kanji character 子was used as the ending of a person's name regardless of the gender. In the Meiji period (1868–1912), it was used as the ending of a female name or a respectful title used after a female's name. Currently, it is used as the ending of a female's name. The character's meaning is currently child.

chū means "pole." The creative combination of *furigana* and *kanji* afford to express connotative and comical meanings hidden in the names of the three musicians. Names are usually rendered directly in translated texts (Newmark, 1981), but names have meanings that reflect the identity embraced by the sociocultural and sociohistorical context (Tymoczko, 1999; Sato, 2016). In this case, *furigana* provides direct renderings of the three names whereas the *kanji* logographically provide the hidden connotations in a form of proper names.

Breakfast at Tiffany's

Breakfast at Tiffany's was written by Truman Capote and first published in 1958. It was translated into Japanese by Naotarō Tatsunokuchi in 1968 and by Haruki Murakami in 2008. This section shows evidence of translanguaging afforded by *furigana* in these translations.

Creating neo-loanwords

Tatsunokuchi and Murakami's translations of *Breakfast at Tiffany's* have over a dozen of words that involve direct renderings of English words, but some of them are represented differently between the two translations. For example, "*delicatessen*" (Capote, 1993: 55) is rendered as a Sino-Japanese word 調製食料品店 (*chōsei-shokuryōhin-ten*, prepared food item store) with, デリカテッセン *derikatessen* in *furigana* in Tatsunokuchi's translation (Capote, 1968: 79), but simply as a loanword written in *katakana*, デリカテッセン *derikatessen*, in Murakami's translation (Capote, 2008: 88). The word デリカテッセン *derikatessen* was not an established loanword at the time when Tatsunokuchi's translation was published, but it was commonly used at the time when Murakami's translation was published. This shows that *furigana* facilitates the creation of neo-loanwords. Similar examples include *block, cover girl* and *carnivals*, which appear as Sino-Japanese words (街区, 表紙絵美人 and 謝肉祭) accompanied by neo-loanwords in *furigana* (ブロック *burokku*, カバーガール *kabāgāru*, and カーニバル *kānibaru*) in Tatsunokuchi's translation in 1968, but as fully-fledged loanwords written in *katakana* in Murakami's translation in 2008. In some cases, some neo-loanword appears as *furigana* in Murakami's translation, but not in Tatsunokuchi's. For example, "to trot" in "Very gently the horses began to trot, waves of wind splashed us, spanked our faces, we plunged in and out of sun and shadow pools, and joy, a glad-to-be-alive exhilaration, jolted through me like a jigger of nitrogen" (Capote, 1993: 87) is rendered as "跑をふむ" (*daku o fumu*) by Tatsunokuchi (Capote, 1968: 124), but as "だく足に移った" (*daku-ashi ni utsutta*) with a neo-loanword "トロット" *torotto* in *furigana* over だく足

in Murakami's translation (Capote, 2008: 136). If this novel is translated again after a few decades, トロット *torotto* may be used as a fully-fledged loanword. These cases show that *furigana* serve as translanguaging spaces, accommodate neo-loanwords and facilitate the evolution of languages through translation.

Refining meanings

Some *furigana* play a crucial role for expressing subtle pragmatic meanings. The card on Holly's mailbox reads "Miss Holiday Golightly: Traveling," where "traveling" is printed in lieu of her occupation (Capote, 1993: 11). In both Tatsunokuchi and Murakami's translations, "traveling" is rendered as a Sino-Japanese word 旅行中 (*ryo-kō-chū*, traveling) with トラベリング *toraberingu* in *furigana*. 旅行中 conveys the concrete word meaning needed to be placed on the mailbox, but fails to capture the nuance of vagueness associated with Holly's unique life-style, which is unpredictable, unstable, and on-going. The latter is successfully expressed by トラベリング *toraberingu*, translanguaged through *furigana*.

Expressing the third language in translation

The protagonist in *Breakfast at Tiffany's*, Holly, often mixes French and English, as in "He said dear old Sally had long admired me *à la distance*, so wouldn't it be a good deed if I went to visit him once a week" (Capote, 1993: 26). This is rendered as a Japanese phrase, 遠くから (*tōku-kara*, from a distance) with ア・ラ・ディストーンス *a ra disutōnsu* in *furigana*, in Tatsunokuchi's translation (Capote, 1968: 40) and in Murakami's translation (Capote, 2008: 41). Holly's fluid translanguaging practice that captures her identity is maintained by translanguaging through *furigana* within translation without risking intelligibility.

Conclusions

The earliest literacy in Japan emerged through translation and translanguaging practices, where the boundaries between Japanese and Chinese, phonographs and logographs, verbalization and comprehension, and writing and drawing were blur or flouted, allowing any features to be interwoven to facilitate communication or expression. The development of the Japanese literacy system has closely reflected sociocultural and sociopolitical ideologies in Japan in each era. *Kana* have allowed the Japanese to write in their vernacular language, whereas *kanji* have symbolized their sociopolitical power. *Kanji* have also served as major building blocks for creating concepts that were desperately needed for Japan's modernization. The current *kanji-kana* mixed writing allows language users to creatively or critically choose script types based on phonological, semantic, pragmatic, sociocultural, sociohistorical, sociopolitical, socioeconomical and/or aesthetic factors. Furthermore, *furigana* serve not only as pronunciation aids for *kanji*, but also as translanguaging spaces, where linguistic features are deployed across boundaries between named languages.

The analyses of the two versions of Tsubouchi's translation of *Romeo and Juliet* (Shakespeare, 1910, 1933) as well as the two translations of *Breakfast at Tiffany's* by Tatsunokuchi (Capote 1968) and by Murakami (Capote 2008) have revealed that translators strategically manipulate language boundaries through *furigana* without risking intelligibility. *Furigana* allow translators to refine word meanings, fill the pragmatic gap between the ST culture and the TT culture, and preserve stylistic markedness in the ST without losing the original propositional meanings. Furthermore, *furigana* facilitate the creation of neo-loanwords within translation and indeed transform the norms of language.

There are few studies of scripts as well as translated texts through the perspective of translanguaging.[9] Future research should examine the use of scripts in a wider variety of texts including advertisement, menus, comic strips, and subtitles, as well as their translated counterparts in order to gain more sociocultural implication of scripts as spaces for translanguaging.

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9. See Lee (2015) for an insightful study of translanguaging and visuality found in Square Word Calligraphy by Xu Bing.

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PART 3

Korean

CHAPTER 16

The Korean writing system, *Hangul*, and word processing

Hye K. Pae
University of Cincinnati, U.S.A.

This chapter reviews the development of the Korean script, *Hangul*, from its birth to linguistic and psycholinguistic implications for word reading. It first discusses the language family and the structure of the Korean oral language. Given that the emergence of the script is unlike most scripts or writing systems, it next overviews the invention background of *Hangul*. The script encompasses the characteristics of phonemic, syllabic, and alphasyllabic writing systems by means of the systematic union of consonants and vowels as well as the regular phoneme-grapheme correspondence. As these characteristics result in significant consequences in processing texts, the structure of *Hangul* is surveyed from linguistic aspects, while its orthography is reviewed from psycholinguistic aspects. The chapter ends with a call for moving from the accumulation of empirical evidence to the phase of building theoretical models.

Keywords: Korean *Hangul*, syllabic configuration, alphasyllabic features

The Korean script, *Hangul*, has been viewed as a unique invention. The uniqueness points to its originality, the full reflection of the Korean oral language in the syllabic block, philosophical references to the universe, pictorial references to articulatory speech organs, and scientific combinatory rules of segmentals (i.e., consonants and vowels). These features offer pragmatic efficiency in the learnability and pedagogy of *Hangul*. Linguists have claimed that *Hangul* represents the apex of writing systems and marks the best writing system in the world (King, 1996; Sampson, 2015). It is worthwhile to closely examine how the aforementioned unique characteristics of *Hangul* influence psycholinguistic processing of words.

This chapter first provides an overview of the Korean language in terms of language family and its characteristics. Second, it reviews a brief history of *Hangul*. Third, it explains the structure of the *Hangul* script regarding the distinctive segmentals, their combinatorial rules, and syllabic structures. Next, it examines the

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orthography of *Hangul* in psycholinguistic aspects, including alphabetic, syllabic, and alphasyllabic features. Finally, it concludes with suggestions for future research and theoretical considerations.

The Korean language and linguistic genealogy

There are distinct features in the Korean oral language. Due to the indispensable relationship between oral and written languages, a brief overview of the Korean oral language is in order. As mentioned in Chapter 1 in this volume, the Korean oral language is different from Chinese in many respects, but similar to Japanese. The primary difference can be found in the language family. There are, at least, two camps interpreting the lineage of the Korean language. One camp finds its origin in the Altaic language family. The other camp views Korean as an isolate language or a language isolate. The first view that Korean is an Altaic language has long been accepted due mainly to the overlap of many linguistic features with other Altaic languages. The primary characteristics of Altaic languages that are found in Korean are as follows, ranging from word features to syntactic rules.

– Vowel Harmony (모음조화, 母音調和)
– Onset Sound Rule (두음법칙, 頭音法則) with Constraints on Onset Consonants
– No Ablaut (Vowel Variation)
– Agglutination
– One-to-One Letter-Sound Correspondence
– Nonconclusive Adverbialization of Verbs and Adjectives (부동사, 副動詞)
– No Grammatical Gender Marker
– No Relative Clauses and Conjunctions
– Canonical Subject-Object-Verb (SOV) Word Order

Some characteristics among these features are briefly explained here. At the word level, *vowel harmony* between syllables within the word is sustained, meaning that the same category of vowels (i.e., the category of "dark" vowels and "bright" vowels in reference to *yin* and *yang*, respectively) needs to be used within the word. Specifically, vowel sequence 'ㅏ - ㅏ' [ɑ – ɑ] is grammatically correct, but the combination of 'ㅏ - ㅓ' [ɑ – ə] is not; e.g., 바빠 ([bɑ-b'ɑ], correct) vs. 바뻐 ([bɑ-b'ə], incorrect). Likewise, the vowel sequence, 'ㅗ – ㅗ' [ɔ – ɔ] is acceptable, but 'ㅗ-ㅜ' [ɔ – ʊ] is not; e.g., 오손도손 ([ɔ-sɔn-dɔ-sɔn], correct) vs. 오순도순 ([ɔ-sʊn-dɔ-sʊn], incorrect). *Yin* vowels convey a comparatively dull and heavy feeling, while *yang* vowels express a lively and cheerful sentiment. This vowel harmony is to avoid a clash between the *yin* and *yang* vowels in speech so that articulation economy can be achieved. The feature of vowel harmony is "very salient and well-defined" in Altaic languages (Sampson, 2015: 149). Sampson (2015) asserts that Korean is a vowel-harmony language like other Altaic languages.

An incorporation of the economy of articulatory labor in speech is also found in the *onset sound rule*.[1] This rule applies to certain onset consonants whose sounds are a little laborious to pronounce, compared to others. This linguistic rule involves mostly Sino-Korean words which have Chinese origins but employ the Korean way of pronunciation. It pertains to the cases of nasal "ㄴ" [n] and liquid "ㄹ" [l] in the beginning of the word: (1) The word that begins with "녀, 료, 뇨, 뉴, or 니" goes through a sound transformation of the first syllable into "여, 요, 유, or 이," respectively, for the ease of pronunciation [e.g., 년세(年歲)→ 연세; 료금 (料金) → 요금)]; (2) the initial sound of "랴, 려, 례, 료, 류, or 리" changes into "야, 여, 예, 요, 유, or 이," respectively [e.g., 량심(良心)→ 양심; 력사 (歷史)→ 역사"]; (3) the onset of "라, 래, 로, 뢰, 루, or 르" becomes "나, 내, 노, 뇌, 누, or 느," respectively [e.g., 래일 (來日)→ 내일; 뢰우 (雷雨)→ 뇌우]. Another common feature found in Altaic languages is no ablaut (i.e., vowel variation) in the language system. The feature of vowel variations is commonly found in Indo-European languages (e.g., man-men; strike-stroke). In Altaic languages, variations are found at the syllable level through affix conjugation, not at the segmental level (먹다→ 먹고, [məg-da]→ [məg-gɔ]; note the complete change of the second syllable). The rich conjugation or inflection of affixes reflects the agglutination principle largely found in Altaic languages.

Despite these and other commonalities between Korean and other Altaic languages, the other school of thought cast skepticism regarding the linguistic affinity to the Altaic language family. The base of this doubt is mainly related to the lack of substantial cognates and no correspondence in phonological features between Korean and other Altaic languages. As a result, a view of Korean as a language isolate has emerged. This view also has at least two limitations: (1) Reliance on vocabulary and phonology that are susceptible to constant changes over time and (2) Dismissal of linguistic affinity to Japanese. First, although vocabulary cognates provide a clue to historical traces, relying solely on vocabulary and phonology in tracing back or classifying the linguistic pedigree may tackle a slice of the linguistic phenomenon because of the nature of the linguistic evolution of words and phonology over time. Syntax is comparatively steady and stable. Unlike loan-words, loan-syntax is rarely found in languages. Hence, it may be reasonable to take syntax into consideration

1. North Korea does not employ this rule. They use "로동" (勞動, ro-dong) without applying the onset-round rule, while South Korea uses "노동" (no-dong) with the onset sound rule applied. Phonetically speaking, the pronunciation "ro-dong" is more laborious than "no-dong" because the sounds [r] (*voiced, liquid*) and [d] (*voice, stop, alveolar*) share only the *voiced* quality, whereas [n] (*voiced, stop, nasal, alveolar*) and [d] (*voice, stop, alveolar*) share three qualities, including voiced, stop, and alveolar.

as well in determining the language genealogy. Second, although the sound system is different from each other, modern Japanese and Korean are more similar to each other than any other languages on the globe in terms of syntactic structures and morpheme-to-morpheme translatability (Hong, 2005; Sampson, 2015). Therefore, the view of Korean as a language isolate and Japanese as another language isolate may be subject to question. The designation of the language family of Korean still remains to be scientifically determined.

Given that the assertion made by each camp is incomplete, each view stays as a hypothesis or theory that should be falsifiable. Irrespective of the controversy over the language genealogy, the Korean writing system[2] is deemed significant from its birth to specificity involved in word reading.

A brief history of the meticulous invention of *Hangul* and its implications

Hangul has a relatively short history spanning fewer than 600 years and has a unique evolutionary point. Unlike other scripts that have evolved over time as needs arise, the Korean script was astutely designed by *King Sejong the Great* (1397–1450) and was publicized with 28 letters in 1443 as *HunMinJungUm* (훈민정음, 訓民正音), meaning the "Standard Sounds for the Instruction of the People." A copy of detailed accounts of the new script, along with specific examples of each letter, was available in 1446.

Hangul has at least four characteristics that stand out among a multitude of scripts available in the world. Firstly, the originality of the script is peerless in terms of the purpose-driven invention and scientific formulation of the syllable. *Hangul* is the only script of which the inventor and the date of promulgation are recorded and known. The motivation behind the invention was to combat the public's illiteracy prevalent at the time. Learning to read in Chinese meant learning a large number of characters that were incongruent with the Korean oral language; therefore, literacy was confined only to elites. *King Sejong* emphasized, upon the promulgation, that bright people could learn to read the script within one morning and slow-witted people could learn to read within 10 days. This is a striking contrast to Chinese that takes, in general, about four years for school-age children to learn to read. The phonetic script *Hangul*, wherein (1) each letter signifies a single sound and (2) syllables are formed through the systematic blending of segmentals, is a prime example of a phonemic script, and is, further, a democratic script (Diringer & Minns, 2010).

2. Sampson (2015) classifies Korean *Hangul* as a "featural" writing system under "phonographic," along with "syllabic" (e.g., Japanese) and "segmental" (e.g., alphabets). The "featural" notion is based on the *Hangul* letters' graphic depictions of vocal organs. Since it is covered in Chapter 1 in this volume, a further explanation about this is not provided here.

The *Hangul* creation resulted in a democratization of the process of learning among learners regardless of social class, cognitive ability, and gender (women were not encouraged to learn to read in the old days), yielding a vast spreading of information and knowledge without boundaries.

There have been two dominant views on the role of *King Sejong* in the invention process. The first is that he ordered his scholastic subjects to design the writing system and script (the *command hypothesis*). The second is that *King Sejong* actively and collaboratively participated in the development of the script (the *cooperation hypothesis*). These two views have been accepted predominantly based on the historical record of scholars' names and the research center (집현전, 集賢殿) that was in operation at the time. However, a new theory that *King Sejong* himself deliberately designed the script independently and clandestinely (Yeon, 2010) has also emerged recently based on a series of historical records as well as logical considerations about the socio-political climate and the delicate diplomatic ties with China at the time. China exercised political and cultural dominance over the *Chosun* dynasty (to which *King Sejong* belonged) for about 500 years. It is reasonable to presume that *King Sejong* invented the script in isolation and kept the invention effort as a secret so as not to fuel a political and diplomatic tension between China and the dynasty. Sampson (2015) noted the Chinese influence on Korea as in "[o]ne consequence of this cultural dependence of Korea on China was that the Korean language was not much written until recently" (p. 144). It is known that *King Sejong* even concocted a scheme as a prequel to the promulgation of the new script in a mystical way as a means of convincing both the uneducated and the educated in order not to spark the resistance to the invention due to the heavy reliance on China. He wrote each one of the newly designed letters with honey on a large leaf that was fallen in the palace garden. In the next morning, the king and his subjects found the leaves of which insects had eaten the leaf fiber along the honey line. He showed the letter-etched leaves to the people, stating that the letters were a true gift from heaven for the people of the Chosun dynasty.

The terminology of the Korean script had changed over time until *Hangul* was settled on in 1910. When it was promulgated, *King Sejong* focused on the function and utility of the script as *HunMinJungEum*. In the detailed accounts of the script (1446), *King Sejong* not only provided a description of the 28 letters he designed, but also explained with examples of how to form syllabic writing (음절문자, 音節文字, *um-jul-mun-ja*) using the phonemic letters (음소문자, 音素文字, *um-so-mun-ja*). It was also called *EonMun*[3] (언문, 諺文, vernacular writing) in juxtaposition to the

3. There are two camps that interpret this term: One is the view of the newly invented script in a pejorative way, and the other view is to interpret it as the script intended to serve the general public including women and uneducated lower class, as opposed to Chinese that was reserved for elites only.

Chinese writing valued at the time by erudite upper class people who called Chinese *JinSeo* (진서, 眞書, true writing). The neologism *Hangul*, meaning the "Great Script," came to presence in 1910 when Korean linguists, *Ju Si Kyung* and his colleagues, began to use it to better address the unique quality of the script. *Hangul* finally included 24 letters in the current inventory out of the 28 that were originally crafted. Before the name *Hangul* was officially adopted, the script was called as *JungUm* (정음, 正音, correct or standard sounds), or *KukMun* (국문, 國文, national script), along with *EonMun* (언문, 諺文, vulgar script).

Secondly, the *Hangul* script was designed to fully mirror the Korean oral language. Sampson (2015) noted that Chinese and Korean are essentially different. The Korean oral language has three segments of the syllabic sound, which is plainly called "three sounds" (3성, 三聲, *sam-sung*). The three sounds of a syllable are literally called initial, middle, and final sounds (초성,初聲, *cho-sung*; 중성, 中聲, *jung-sung*; 종성, 終聲, *jong-sung*, respectively). The full reflection of the oral language was applied to the formation of syllables by judiciously assigning three phonemes in the initial, middle, and final positions. *King Sejong* specifically articulated the rationale for the script invention in the disclaimer that the disparity between the Korean oral language and Chinese characters was so great to the degree that people whom he deeply cared about could not express their thoughts and ideas in writing; therefore, he invented the script for them. Before the new script was available, laypeople had used crude writing systems (i.e., *Idu*, 吏讀, for prose transcription or for grammatical markers; *HyangCha*l,[4] 鄕札, for lyric texts and local letters and poetry; *KuGyul*, 口訣, for an annotation of Chinese texts and insertions for oral recitation) that partially adopted the sounds and shapes of Chinese for the writing of their oral language. Given that Chinese and Korean are typologically and fundamentally different languages, as *King Sejong* bemoaned, using Chinese characters to write down the Korean oral language created sheer limitations that could not be inherently overcome. The King finally liberated Korean people from illiteracy by designing the script that was consistent with their oral language and was easy to learn to read.

Next, the script had philosophical ideations reflected in the script. The philosophical reference to the universe was intelligently utilized in the creation of the vowels resting on the representation of the mystical trinity heaven, earth, and human (" ·, 一, ㅣ " respectively). The reference runs deep in that not only are the heaven, earth, and humans three basic elements in the universe, but also their harmonious combinations are the starting point of crafting the segmentals. In consideration of the extent that reading and writing are indispensably crucial in our

4. After *Hunminjungum* was promulgated, *Hyangchal* was moribund, but *Idu* and *Kugyul* were still in use for a while.

lives, its implications associated with the universe and harmony among the three rudimentary elements are beyond description. Based on these three core signs, a gradient addition rule of strokes to the base was employed. Besides, a complementarity of *yin* and *yang* was also permeated in the vowel formulation. For example, the *heaven* stroke "·" attached to the right from the *human* stroke " ㅣ " or above the *earth* stroke "ㅡ" represents *yang* vowels (e.g., ㅏ, ㅑ and ㅗ, ㅛ, respectively), whereas the *heaven* stroke to the left or below the *earth* stroke represents *yin* vowels (ㅓ, ㅕ, and ㅜ, ㅠ, respectively). Utilizing the three atomic symbols of the dot, horizontal stroke, and vertical stroke, mutually exclusive 21 vowels, including 10 bases and 11 compounds, came into existence and are currently in use.

Finally, the design of the consonants was based on the articulatory vocal organ, which makes the script graphically distinctive. Paralleled with the vowels, the Korean consonants were designed to refer to the featural depiction[5] of speech organs involved, such as the tongue, lips, and palate. For example, each sound of the consonants "ㄱ" and "ㄴ" depicts the shape of the tongue when it is vocalized; the consonant "ㄹ" represents the visual image of the liquid sound [ㄹ]. There are five canonical consonants including "ㅁ, ㄱ, ㄴ, ㅇ, and ㅅ". Utilizing these base letters, *King Sejong* designed additional consonants by adding one or two strokes to each base. These systematic designs resulted in 14 base consonants and 5 doublets (ㄲ, ㄸ, ㅃ, ㅆ, ㅉ) that are in the current inventory. In terms of the order of the consonants, the first eight letters (i.e., ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, and ㆁ) in the consonant inventory are entitled to be placed in either the onset or final position and have the full sound values, except for the " ㆁ " in the onset position as a place-holder.

The structure of *Hangul*: Linguistic aspects

Consonants and vowels

As briefly explained earlier, there are five base consonants, including "ㅁ, ㄱ, ㄴ, ㅇ, and ㅅ". The way that additional consonants were additively created based on these five letters by adding a stroke or two (i.e., ㅁ→ㅂ→ㅍ, ㄱ→ㅋ, ㄴ→ㄷ→ㅌ, ㅅ→ㅈ→ㅊ, and ㅇ→ㅎ) accords the agglutinative structure of the Korean oral language, which is one characteristic of the Altaic language. Hence, it seems that *King Sejong* tried to factor in all features associated with the Korean oral language in the new script.

5. This appears to be the true motivation for Sampson (2015) to classify *Hangul* as a "featural" script. As the "featural" component only represents *Hangul* consonants, it is likely that this classification addresses only part of *Hangul* segmentals.

The systematic additive principle is shown in Figure 1. As seen in the figure, the signs for heaven (dot), earth (horizontal line), and human (vertical line) are at the center for the vowel formulation. The cosmic principle of *yin-yang* posits that seemingly opposite forces are actually complementary to, interconnected with, and interdependent of each other. The combination of the signs of the *heaven* and *human* yields the left-to-right vowel structure (note that humans moves horizontally on the earth), representing the concepts of *yin* (i.e., to-the-left vowels) and *yang* (i.e. to-the-right vowels). This vowel structure further defines the left-to-right syllabic structure when combined with other consonants (e.g., 가, 너, 대, etc.). On the other hand, the combination of the *heaven* and *earth* signs yields the top-to-bottom vowel structure (note that the connection between the heaven and earth is always vertical) with the *yin* (i.e., below-the-center-line vowels) and *yang* (i.e., above-the-center-line vowels) concepts, and, in turn, it defines the top-to-bottom syllabic structure (e.g., 고, 누, 둘, etc.). The *yin-yang* concept is applied to vowels only because the vowel is the backbone of the syllable and has the full sound value.

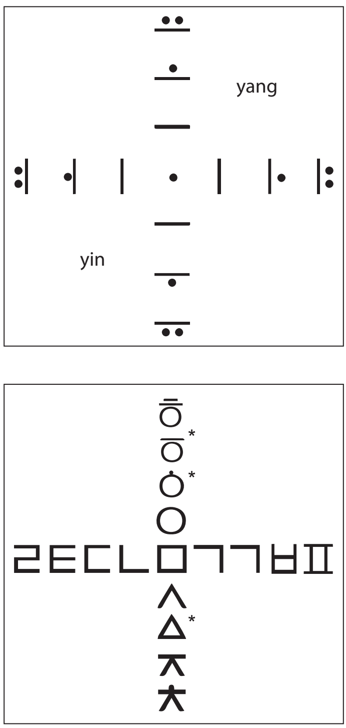

Figure 1. Vowel formulation (top) and consonant formulation (bottom) in *Hangul*
Note: * These signs are not currently in use.
Modified from Bae (2010).

The same scheme was followed for the consonant formation. At the center is the square-shape consonant "ㅁ" representing the mouth. Note that the starting point of the consonant formulation begins with the pictographic representation of the speech organ, *mouth*, and that the Chinese character meaning the *mouth* is "口", *gu* [gʊ]. The square-shaped consonant "ㅁ" is diametrically broken into two signs to generate different consonant signs; that is, "ㄱ" [gi-yuk] and "ㄴ" [ni-eun]. From there, the addition rule is applied to the production of a new consonant in the horizontal axis. Since they do not have the full sound value, the *yin-yang* concept is not integrated into the consonants, but the segmentals depict the shape and place of articulation.

In addition, the Sino-Korean word for vowels is 모음 (母音, *mo-um*) literally meaning "mothersound," while that for consonants is 자음 (子音, *ja-um*) literally meaning "sonsound." Like the terms *motherboard* and *daughtercard* used in microcomputers, the words of the *mothersound* (vowel) and *sonsound* (consonant) convey their meanings to the fullest. The *mothersound* (vowel), as the name suggests, is referred to as the "mother" of all segmentals used in the word, holding and allowing for combinations between crucial components of the word. Likewise, the *sonsound* (consonant) is used as the "son" of a *mothersound* to expand the basic functionality of the mothersound (vowel). Vowels are also dubbed "홀소리" [hol-so-r]), meaning that they stand alone to make an utterance, whereas consonants are called "닿소리" [dat-so-ri] meaning that they need to be attached to the other entity to make a sound. Based on the names for the vowel and consonant, it is clear that vowels play an essential role in Korean *Hangul*.

Syllabic structures

The syllabic structure of *Hangul* shows two fundamental characteristics: (1) the systematic segmental blending and (2) the visual configuration. Firstly, as briefly mentioned earlier, the combination of a consonant and a vowel for a functional syllable is an extension of the *yin-yang* complementarity in that the consonant sets the articulatory context without the full sound value. Besides, the vowel complements the consonant with the clear sound value so that the byproduct of the blending can serve its purpose as an independent unit, which is a syllable. In other words, consonants and vowels give rise to each other as they interconnect with each other; thus, neither of which can fully function without the other.

In the reflection of the Korean oral language that has the three-sound units, the standard syllable is the consonant-vowel-consonant (CVC) form; that is, a consonantal sound is positioned in the beginning, a vowel in the middle, and another consonantal sound at the end. The standard form of CVC syllables that reflect the three sounds requires the use of a dummy consonant "ㅇ" that does not have a sound value but serves as a place-holder at the initial place in some cases (e.g., 안,

엄, 올, etc.). The use of the dummy consonant is to achieve an architectural balance and easy reading through the consistent CVC pattern. Vowel-only syllables are also plausible (e.g., 아, 야, 어, 여, 오, 요, 우, 유, 으, 이), but, again, the dummy consonant is used at the onset. This is different from English, in which a single vowel letter, "a," is a real word as an indefinite article.

CV or VC syllables are frequent in Korean (e.g., 가, 나, 다 for CV syllables; 알, 암, 앗 for VC syllables with a dummy consonant "ㅇ" in the beginning). The most complex form in *Hangul* is the CVCC syllable. There is a rule for only 12 consonant sequences that can come at the end as collocational doublets (i.e., ㄲ, ㄳ, ㄵ, ㄶ, ㄺ, ㄻ, ㄼ, ㄽ, ㄾ, ㄿ, ㅀ, and ㅄ). There is also a rule for the final sound of the syllable (음절 끝소리 규칙) that allows for only seven sounds (i.e., ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, and ㅇ). In short, the phonetic rule results in four types of the syllabic structure (i.e., V, CV, VC, and CVC), while the orthographic rule yields seven types of the syllabic structure; i.e., V (e.g., 아, 어), left-to-right CV (e.g., 가, 나), top-down CV (e.g., 고, 노), left-right-down CVC (e.g., 각, 난), top-down-down CVC (e.g., 곡, 눈), left-right-down CVCC (e.g., 값, 낳) and top-down-down CVCC(e.g., 곯, 몫).

Consonant strings or vowel strings are not permitted in *Hangul*, except for the 12 final CC strings in the CVCC format, as a consonant cannot stand alone without a vowel. This is different from English that has unclear blending patterns of consonants and vowels within syllables and words. For example, English allows for not only consonant strings in the beginning, middle, and final positions (e.g., <u>str</u>ong, o<u>phth</u>almology, stre<u>ngths</u>, respectively), but also vowel strings at the three positions (e.g., <u>ai</u>lment, l<u>iai</u>son, onomatop<u>oeia</u>, respectively). When loan words or English words are transcribed into Korean, a schwa-like vowel (/ə/ approximant; semi-epenthesis) needs to be attached to each consonant in consonant strings. For example, the word "sports" is a one-syllable word in English, but it becomes a three-syllable word "스포츠" in Korean by adding an epenthetic vowel "ㅡ" to the initial and final sounds (s-por-ts). This circles back to the C-V complementarity. In a nutshell, a syllable is the *minimal unit of utterance* in Korean.

In terms of the position within a syllable, all 19 consonants (ㄱ, ㄲ, ㄴ, ㄷ, ㄸ, ㄹ, ㅁ, ㅂ, ㅃ, ㅅ, ㅆ, ㅇ, ㅈ, ㅉ, ㅊ, ㅋ, ㅌ, ㅍ, and ㅎ) can come to the onset position. All 21 vowels (ㅏ, ㅐ, ㅑ, ㅒ, ㅓ, ㅔ, ㅕ, ㅖ, ㅗ, ㅘ, ㅙ, ㅚ, ㅛ, ㅜ, ㅝ, ㅞ, ㅟ, ㅠ, ㅡ, ㅢ, and ㅣ) can come to the center position. There are 27 consonants (ㄱ, ㄲ, ㄳ, ㄴ, ㄵ, ㄶ, ㄷ, ㄹ, ㄺ, ㄻ, ㄼ, ㄽ, ㄾ, ㄿ, ㅀ, ㅁ, ㅂ, ㅄ, ㅅ, ㅆ, ㅇ, ㅈ, ㅊ, ㅋ, ㅌ, ㅍ, and ㅎ) that can come to the final position as a singlet or doublet. This systematic combinatory rule of segmentals can generate 1,638,750 syllables, in principle, using only five[6] types of syllabic formats (i.e., V, CV, VC, CVC, and CVCC) in terms of CV combinations.

6. Note that this type is different from the seven types of syllables that are classified based on the grapheme orientation of left-to-right or top-down.

However, 11,172 syllables (19 × 21 = 399 CV syllables plus 399 × 27 = 10773 CVC or CVCC syllables) are plausible ones in the current inventory. Of these syllables, 2,350 syllables are frequently used, while 8,822 syllables are infrequently used.

The other crucial element is the visual configuration of the syllable structure, which is similar to those of Chinese and Japanese. The characters of both Chinese and Japanese *Kanji* are packed within square blocks, and each character represents a syllable. Despite the visual similarity among Chinese, Japanese, and *Hangul*, the point of departure of *Hangul* from the other two is that each character is composed of more than one phoneme/grapheme to represent a syllable (i.e., alphabetic principle). As a matter of fact, the distinct syllabic block as well as the alphabetic principle makes *Hangul* stand out among all writing systems and scripts available in the world.

Due to the clear syllabic characteristic, *Hangul* can be written vertically or horizontally. When it came first into existence in the 15th century, it was written vertically. Until about three decades ago, all newspapers and many books were printed vertically,[7] but, due to the Western influence, all is currently printed in the horizontally linear railway sequence. The syllabic characteristic also makes acronyms be formed at the syllable level. For example, a four-syllable compound "정치·경제" becomes "정경" as an acronym at the syllable level. This is different from English in which acronyms are made using the first grapheme of each word, as seen in "APA" for the "American Psychological Association." This shows that the nature of Korean *Hangul* is more skewed toward the syllabic structure than the phonemic structure unlike other phonemic scripts.

The orthography of *Hangul*: Psycholinguistic aspects

Alphabetic aspects

As indicated earlier, Korean *Hangul* is different from Chinese and Japanese, despite the visual similarity, because a character consists of more than one phoneme/grapheme in *Hangul*, whereas a character represents a syllable in Chinese and Japanese. This characteristic makes *Hangul* an alphabetic[8] or phonemic script. Alphabets

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7. It would be interesting to investigate comparative efficiency of processing words and sentences between vertical and horizontal writing. From an anecdotal observation, rolling eyes vertically is easier than horizontally. It warrants a scientific study on the effectiveness of reading Korean vertically.

8. A recent classification of typology is in favor of addressing the nature of phonemic quality and using a *phonemic* script in place of *alphabetic*. Although the author agrees on this notion, the word "alphabetic" is used for the sake of consistency with the literature depending on context.

close the gap that logographic systems intrinsically cannot fill particularly in the number of syllables and the flexibility of processing units at phoneme, onset-rime, and body-coda levels. The stipulated criteria for a true alphabet (Wolf, 2007) are as follows: First, a limited number of letters or characters, ranging from 20 to 30 letters, can fully represent a spoken language. This offers not only economical use of the letters in forming more than 10,000 plausible syllables, but also efficiency for learning to read. Learners of alphabetic scripts do not need to rote-memorize the whole set of syllables in the language, as in Chinese. Second, the minimal unit of sound in the language is fully reflected in the inventory of letters or characters. This significantly reduces the number of homophones in the language, although a small extent of homophones is inevitable in the union of letters. Third, a clear mapping system between phonemes and graphemes is demonstrated in the linguistic system. Based on the degree of consistency between phonemes and graphemes, orthographies are broken down into a shallow orthography and a deep orthography. Alphabetic languages have different degrees of the grapheme-phoneme correspondence wherein English is at the one end of irregular mapping (deep orthography) and Finnish is at the other end of regular mapping (shallow orthography). Korean *Hangul* is placed near Finnish in the linguistic continuum. As it was deliberately designed, Korean *Hangul* fully satisfies the above three criteria as a true alphabet with a shallow orthography. Note that if the criterion is not the grapheme-phoneme correspondence, Korean can be categorized as a deep orthography due to various sound variations within and between words (The phonology of Korean is beyond the scope of this chapter). Only 24 Korean segmentals, compared to 900 cuneiform characters and thousands of hieroglyphs, provide the high level of efficiency through the economy of letter bindings. This not only efficiently reduces learners' learning time to read, but also saves attention and memory resources involved in word recognition and reading (Wolf, 2007). In short, Korean *Hangul* provides cognitive automaticity by freeing attentional resources, allowing for efficient blending of segmentals, and granting economical use of the base letters.

As alphabetic languages have the minimal sound unit at the phonemic unit, the role of phonemes in reading has been emphasized. The alphabetic nature of *Hangul* has been demonstrated in research findings. Specifically, research evidence has steadily shown that phonological awareness skills are a precursor to and a salient predictor of successful reading (Cho & McBride-Chang, 2005; Pae, Sevcik, & Morris, 2004, 2010), which is consistent with the findings in other alphabetic languages. Cho and McBride-Chang (2005) have demonstrated that native Korean children's phonological awareness skills are a significant predictor of reading skills in L1 Korean and L2 English. In a similar vein, Pae and her colleagues (2004) have also found that metalinguistic skills, including phonological awareness skills and working memory, are dominant predictors of L2 reading skills, regardless of differences in phonology and orthography between L1 and L2. Pae et al. (2010) also report, in a study of Korean children who have learned Korean as a heritage language, that high level of phonological awareness and naming speed in L1 are the pathway to reading success in L2. They also report the children's performance on a phoneme detection task. The children performed differently across the positions of phonemes, but the overall pattern is similar across dominant (English) and less dominant (Korean) languages. A notable pattern is that the performance on the Korean phoneme detection shows less fluctuation (i.e., more consistent) in Korean than in English. This suggests that onset sounds of the Korean syllable may function differently from those of English syllables. Given that Pae et al.'s (2010) study did not specifically focus on the sensitivity to the positional sound of the syllable in the article, further research on the sound sensitivity to phoneme position will explain the degree of sharedness with English and the uniqueness of Korean *Hangul* in terms of effects of phoneme positions.

Syllabic aspects

Korean *Hangul* also has a syllabic autonomy in printing, unlike other alphabetic scripts. As indicated earlier, a syllable is the *minimal unit of utterance* because consonants cannot stand alone without vowels and because consonant strings are not permissible. The union of a consonant and a vowel is not linearly spread but packaged within a block. Each letter never changes its sound in the word except for several sound variations within and between words. This is different from English in which vowel or consonant sounds have discrete phonetic values with no clear rule. For example, the "a" sound has many different sounds as a monogram or bigram as in *approve, car, have, save, hall, fare, heat, boat, instead, reach, learn, aisle, hair*, and *stay*. The sounds of consonants and a mixture of vowels and consonants also vary (e.g., *arch-monarch; though-thought-tough-bough-through*).

Since *Hangul* was created in an effort of the full representation of the oral language at the phonemic level rather than at the syllable level like Chinese and Japanese, it is possible, in principle, to write down any oral language. Aside from the fact that more than a million syllables (i.e., 1,638,750 syllables) can possibly be created using the *Hangul* consonants and vowels, even any foreign words can be easily transcribed into *Hangul* (if the current use of the syllabic convention is not followed). For example, the word "sports" can be written in a one-syllable word *Hangul* as in "ㅅ포ㅊ", although the syllabic convention imposes three syllables (i.e., 스포츠) with the epenthetic vowel insertion to the stand-alone consonant in Korean. This underscores the syllabic nature of *Hangul*, which cannot be overlooked in the categorization or classification of the writing system.

Research shows that syllabic units of *Hangul* take a special processing status in reading partly due to the autonomy of the syllable in printing. For example, Simpson and Kang (2004) have shown that the visually clear structure of syllables serves as a functional unit in word recognition and is independent of lexical and subsyllabic characteristics. They have found that free syllables that have stand-alone morphemes are named faster than bound syllables that cannot stand alone but are used in combination with other syllables (Experiment 1). When syllable frequency is controlled, naming speed differences between high and low-frequency words disappears (Experiment 2). Naming speed for bound syllables is faster than that of pseudosyllables (Experiment 3). A difference in naming speed between high- and low-frequency bound syllables is found (Experiment 4). Taken together, the authors claim that the printing convention of syllable blocks provides cues to word identification. As a result, syllables are assumed to be a "third route" (p. 148) beyond the 'dual routes' (i.e., lexical route and grapheme-phoneme conversion route) involved in word processing (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) or a syllable route for *Hangul* processing, as they indicate "[w]hereas in English the sublexical unit is presumed to be the grapheme-phoneme correspondence, in this research it is the syllable" (p. 148).

Lee and Taft (2009) examined transposed letter effects in English and Korean using onset-onset swap, coda-coda swap, and coda-onset swap (e.g., English: *pagmie* vs. *pagnie*; *nankip* vs. *nankid*; *widsom* vs. *widrom*, respectively; Korean: 남눅 vs. 밤룩; 낙붐 vs. 밤룩; 납묵 vs. 납눅, respectively; see Lee and Taft, 2009, for more information). The results showed that transposed effects were substantially more reduced in *Hangul* reading than in English. The authors attributed the weaker transposed effect on reading Korean to the structural cue generated from the syllabic format in *Hangul*. In the CVC syllable, the position of onset and final consonants is always predictably characterized by the syllable configuration; that is, the initial consonant is always present at the top or to the left of the vowel in the upper part, while the last consonant is always placed at the bottom (e.g., 건, 곡), regardless of the vowel orientation. This is different from English in which the syllabic boundary is ambiguous. This finding suggests that the *Hangul* syllabic block facilitates reading, even transformed forms of words, which points to the efficiency of the syllabic block configuration in reading (and learning).

Alphasyllabic aspects

Although it has alphabetic features, the syllabic component of *Hangul* cannot be ignored linguistically and typologically. Under the heavy influence of Chinese, King *Sejong* might have intentionally kept the visual resemblance with Chinese characters so as not to introduce a completely foreign script to the public while astutely incorporating all other linguistic features into the invention. Due to both alphabetic and syllabetic characteristics, *Hangul* is more accurately regarded as a phonemic-syllabary or alphasyllabary (Pae, 2011).

Empirical evidence has been accumulated to support the notion of alphasyllabic nature of *Hangul*. Pae and her colleagues (2015, 2017) note that orthographic distance or typological relatedness between Korean as the first language (L1) and English as a second language (L2) plays a significant role in the performance on L2 reading among native speakers of Korean, compared to that of Chinese and English speakers. Specifically, native Korean speakers' performance is consistently placed in between Chinese and English speakers when they are asked to read words that were visually manipulated in size, shape, and orientation (typical vs. ǝsɹǝʌuᴉ). Pae et al. attribute the differing performance among the three L1 groups to the orthographic distance, supporting the alphasyllabic nature of *Hangul*.

While English speakers tend to segment a syllable into onset and rime (e.g., *cat* into /c/ + /at/; Ziegler and Goswami 2005), Korean speakers are more likely to prefer the body-coda division than the onset-rime segmentation (e.g., cat into /ca/+/t/; Baek, 2014; Lee & Goldrick, 2008). The body-coda preference may result from the structure of the oral language as well as the syllabic block of *Hangul*; note that the three sounds of a syllable in the oral language and the first consonant need to be combined with the second vowel to create a full sound. Another explanation is the visual configuration of CVC syllables. As explained earlier, the vowel can be located to the right of the initial consonant (e.g., 가), but the final consonant (i.e., coda) is always placed at the bottom in the syllable block (e.g., 국). This visual allocation of the graphemes within the syllable may be the source of the salient body-coda segmentation for native Koreans.

A comparative study by Lee and Hwang (2015) between children with and without hyperlexia, a syndrome of reading without meaning, reports an interesting point. Results showed no significant group difference between children with and without hyperlexia in both accuracy and latencies of reading words and pseudowords (Study 1) and reading words preceded by semantically related and unrelated pictures (Study 2), although there were significant differences in the main effects in reading two conditions of words and pseudowords. This provides an empirical support for the effectiveness of *Hangul* regardless of the presence of reading deficits characterized by hyperlexia. Although subsequent research needs to be conducted to further validate this claim, this result has a direct reference to *King Sejong*'s assertion made in the promulgation that *anybody* can learn to read *Hangul* without trouble and to the current high literacy rate (about 98%; United Nations, 2003) in Korea.

Conclusion

Through the unique birth of the Korean writing system and script, *Hangul* has shed significant influences on the society in general and on literacy in particular. In essence, *Hangul* was created in the spirit of (1) *King Sejong*'s compassion with lay-people's inability to express their thoughts and ideas in writing, (2) autonomy from the Chinese writing system that was inconsistent with the Korean oral language, and (3) pragmatic and "democratic" utility of the script that *anybody* could easily learn to read within a short period of time and without much rote memorization. As a result, Korean people are able to enjoy the utility of the efficient script to the fullest with an illiteracy rate of about 2% and less than 1% of reading disability in school-aged children. Its efficiency has been validated by Sampson's (2015) remark, as in "… Hangul must surely rank as one of the great intellectual achievements of Mankind" (p. 165). For scientific aspects, empirical research has been carried out to examine the role of the *Hangul* script in reading and the effectiveness of the syllabic autonomy. This has made the scholarly effort move on to a theory-driven phase. This phase gives rise to theoretical models for the processing of lexicons in both monolingual and bilingual contexts.

The major findings of recent research support the multifaceted functional units of *Hangul*, which is consistent with *King Sejong*'s original intention for the design of the script, as evidenced by the dominant role of syllables (to maintain the resemblance to Chinese characters), phonemes (to be effective as the optimal script), and the combination of the two (to gain the flexibility of utilizing the merits of both syllables and phonemes). The commonality with other alphabetic languages in the internal characteristics of the syllable, as well as other syllabic languages in the visual configuration, positions the *Hangul* script in the territory of alphasyllabary. This may lead to a reconsideration of the typological classification of *Hangul* as a "featural" script (Sampson, 2015) because the categorization of the "featural" script reflects only the articulatory description of the segmentals, ignoring the functionality of the *Hangul* segmentals in many meaningful ways. Besides, the classification of Korean as "featural" along with "syllabic" and "segmental" under phonography is based on an inconsistent criterion. The other two branches of "syllabic" and "segmental" represent functional units, whereas the "featural" branch represents the descriptive nature of the *Hangul* segmentals. Although the syllabic and segmental characteristics of the languages have been systematically examined or tested, the featural characteristics can neither be tested in a scientific way, nor allow for falsification.

Psycholinguistic explorations are typically predicated on the existence of the functional units of a language under consideration. As the empirical evidence accumulates on the *Hangul* script, its implications for both reading and psycholinguistic fields increase. Simpson and Kang (2004) suggest a “third route” for syllable processing in Korean *Hangul*, based on the finding that the role of syllables in processing *Hangul* is independent of both lexical and subsyllabic properties of words, which goes beyond the grapheme-phoneme level. Lee and Taft (2009) also suggest that currently dominant models for letter processing lack a consideration for the involvement of subsyllabic structures, based on the findings of the transposed letter effects in English and Korean. As such, evidence from reading processes of *Hangul* has the great potential to fill the gap, if any, in the current models of reading.

Compared to other languages, research into Korean *Hangul* is just growing out of a nascent stage with gradual theoretical advances through a multitude of empirical studies in the last decade. More research is warranted to build more rigorous theoretical models or theoretical accounts drawing on the extant literature available in *Hangul* in monolingual and bilingual representation, processing, and acquisition.

It is still unclear what features *Hangul* and English or other alphabetic languages share. The degree of sharedness between those languages can be examined in the property of phonemes or syllables and in the combination of both. The strength of connection in cross-linguistic processing is another research agenda that will continue to be examined in bilingual or multilingual contexts in an effort to build developmental and dynamic models and theories for bilingual representation and processing as well as for cross-language influences or transfer. Further research should also be carried out to investigate the unique nature of the bilingual or multilingual lexicon, transferability, and constraints associated with cross-linguistic processing.

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CHAPTER 17

Crosslinguistic influences of script format

L1-derived syllabification in reading L2 English among native Korean readers

Hye K. Pae[i], Sun-A Kim[ii], Quintino R. Mano[i] and Min Wang[iii]
[i]University of Cincinnati, U.S.A. / [ii]The Hong Kong Polytechnic University / [iii]University of Maryland, U.S.A.

This study investigated cross-linguistic influences of the Korean script's syllabic format on L2 English word reading. A total of 103 college students participated in two naming experiments in Korea and the U.S. Experiment 1 used Korean graphemes presented in both block (i.e., *Hangul* printing convention) and left-to-right linear (i.e., English printing convention) formats. Results from Experiment 1 showed that Korean participants were significantly faster in reading Korean graphemes presented in the block format than in the linear format. Experiment 2 utilized English words that appeared to participants as having random spaces but in fact the spaces corresponded to Korean syllabic boundaries (e.g., *un der s tan d*, 언더스탠드). Results from Experiment 2 revealed that native Korean readers did not show a significant interference effect in reading L2 words that were derived from L1 syllabic boundaries. Findings are interpreted within the context of the Syllabic Autonomy Saliency Hypothesis for *Hangul*.

Keywords: Korean *Hangul*, block formats, syllabic Boundary Saliency Hypothesis

Cross-language psycholinguistic research of word reading has the potential to reveal new insights into how language units, internal structures, and syllables play a role in reading. The purpose of this cross-language study was to investigate how the syllabic format of the Korean script affected word reading in English as a second language (L2). In order to achieve this goal, it first examined the magnitude of reading efficiency in the syllable-pivotal Korean script as the first language (L1), compared to a graphemic arrangement that has no syllabic demarcation. Using the first experiment as an instrumental examination, the second experiment was carried out to examine how Korean natives read artificially syllabified words in English as L2.

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Theoretical background

Theoretical considerations for this study centered on the linguistic units explained by the psycholinguistic grain size theory. Given that a minimal processing unit can be reinforced through prolonged literacy experience in L1, its impact on L2 reading is likely to be robust. Drawing on the notion of cross-linguistic influences on L2 reading, the grain size theory and the role of syllables are discussed below.

Psycholinguistic grain size theory

The grain size theory concerns consistency and granularity. First, languages vary in the level of consistency with which the sound is represented in the written symbol. The level of consistency between graphemes and phonemes defines orthographic depth. Orthographically shallow scripts have, by and large, a 1:1 correspondence between letters and sounds, as in Italian and Spanish, whereas orthographically deep scripts have a one-to-many correspondence. In English orthography, while most written letters are single phonemes and graphemes, some phonemes and graphemes have exceptions. For example, the phonemes [tʃ] and [ʃ] take two letters "ch" and "sh," respectively. To the contrary, one phoneme may take the form of more than one grapheme (e.g., the sound /f/ in *fun, photograph*, and *enough*). One letter can also have multiple sounds depending on neighboring letters (e.g., arch, approve, have, save). These features make English a deep orthography in which letter-sound mapping is relatively irregular and inconsistent. Grapheme-phoneme recoding skills become more important in less transparent orthographies. Because irregularities between graphemes and phonemes make the small grain size insufficient for correct word reading in deep orthographies, readers develop recoding strategies at multiple levels of the grain size (Ziegler & Goswami, 2005).

Second, granularity is also closely related to the unit of processing. The characteristics of structural regularity and neighborhood similarity become the basis of word segmentation and learning. The minimal unit of alphabetic languages is the phoneme, while that of morphographic languages (e.g., Chinese) is the syllable. From this minimal unit, there exists a hierarchy of grain sizes (i.e., letters → graphemes → onset/rime or body/coda → syllables; Ziegler & Goswami, 2005). In a shallow alphabetic orthography, phonemes are, in general, the minimal grain size. In a deep orthography, however, readers tend to make use of larger and often multiple grain sizes than those of a shallow orthography (Zeigler & Goswami, 2005). According to Ziegler and Goswami (2005), the degree to which availability of phonology, consistency between letters and sounds, and granularity of the phonological system are reconciled within word reading has a dynamic effect on reading acquisition across languages.

Role of syllables

Although the grain size theory does not particularly address the role of syllables in word reading, syllables have been examined in the literature in terms of mental representations, processing units, and mediating processes involved in sublexical and lexical processing. Research has shown that syllables are processed as "psychological units" involved in reading (Álvarez, Garcia-Saavedra, Luque, & Taft, 2017). The unit of syllables becomes important when syllabic parsing or syllabic decomposition is involved in word identification. Álvarez and colleagues (2017) examined syllable parsing in Spanish among children in Grades 2 and 6. Using a word-spotting paradigm, participants were instructed to detect a monosyllable word at the onset of a pseudoword. For example, the monosyllabic FIN was to be identified from the pseudoword FINLO (i.e., FIN·LO segmentation) where the syllabic boundary of a real word was psychologically present, as opposed to FINUS (i.e., FI·NUS division) where the syllabic boundary of a real word was psychologically absent. They found that both groups of children were faster with the (psychologically present) syllabic boundary stimuli than those without, suggesting "early universality" in syllable recognition in Spanish.

Research shows significant syllable effects in both monosyllabic and multisyllabic words in English and Spanish (Alvarez, Cottrell, & Afonso, 2009; Ferrand, Segui, & Humpreys, 2003; Taft, 1992). Research also shows that the effect of syllabic length is modulated by word frequency. For example, Jared and Seidenberg (1990) showed that the effect of syllabic length was restricted to low-frequency words only. Ferrand and New (2003) also found, in a study of French word length effects, that syllabic length effects became significant in nonwords and low-frequency words only, but became negligible in high-frequency words. Another study conducted by Ferrand and colleagues (2003) also indicated that the syllabic effect found using a masked priming paradigm (e.g., the prime "*bal*" yielded faster pronunciation of the word "*balcony*" than the prime "*ba*") was constrained to syllabifiable words only.

Artificial syllabic demarcations have been tested in a shallow orthography. For example, a study of Finnish first and second graders, using polysyllabic words with and without the indication of syllable boundaries (i.e., hyphenation and different color used to indicate a syllable), showed that hyphenation at syllable boundaries had the effect of slowing reading speed (Haikio, Hyona, & Bertram, 2015). This finding is deemed interesting because not only is syllabification with hyphens very common in Finnish reading instruction, but also because all first-grade textbooks include hyphens at syllable boundaries (Haikio et al., 2015). Moreover, when hyphens appeared between a consonant and a vowel (e.g., *t-alo vs. ta-lo*), the disruption was greater than that for syllabic boundaries. However, alternating colored syllables did not affect beginning readers' reading speed. The authors concluded that hyphenation forced readers to process syllables sequentially one by one, even though the readers were able to recognize words holistically via the "whole-word route."

Effects of transposed letters and syllables have also been examined. For example, Lee and Taft (2009) found a diminished effect of transposed letters among Korean speakers compared to that of English speakers. They attributed the reduced effect to the Korean script's format in which functional information is inflated by the visual autonomy of syllabic representation. In a study of syllabic transposition effects on Korean word recognition, Lee and colleagues (2015) also found that Korean syllables serve as a functional orthographic coding unit in Korean word recognition. This finding supports the general notion surrounding word recognition of Korean given that perceptual syllabic salience is greater in Korean than in English.

Korean writing system: *Hangul*

The Korean writing system, *Hangul*, is unique in terms of both historical origins and its visual presentation. Unlike most scripts that have had multiple cultural contributions and have evolved over time, *King Sejong* purposefully developed *Hangul* in the 15th century (see Pae's Chapter 16 in this book for more information) to reflect the geocultural traditions of the people while also fulfilling societal needs.

The orthographic feature of *Hangul* was philosophically inspired while also having unique articulatory representations. Specifically, in terms of philosophy, the vowels include three prototypical elements, representing heaven (·), earth (ㅡ), and human beings (ㅣ). Through the systematic addition of strokes to these three referents, a large inventory of vowels was created. A total of 21 vowels is currently in use, including 10 mono-vowels (ㅏ, ㅓ, ㅗ, ㅜ, ㅡ, ㅣ, ㅐ, ㅔ, ㅚ, ㅟ) and 11 compound vowels (ㅑ, ㅒ, ㅕ, ㅖ, ㅘ, ㅙ, ㅛ, ㅝ, ㅞ, ㅠ, ㅢ). Each vowel in Korean has a mutually exclusive sound, which is different from English wherein a vowel can have multiple sounds in both monogram and bigram forms (e.g., have, save, may, weather, reach, coal, and coalese). Moreover, the shape of consonants is based on the shape of the tongue, teeth, and lips. Nineteen consonants are currently in use, including five doublets (i.e., ㄲ ㄸ, ㅃ, ㅆ, ㅉ). Each grapheme corresponds to one phoneme, which makes *Hangul* a shallow orthography. Note that, if a different criterion is used, it is possible to categorize Hangul as a deep orthography. However, this is beyond the scope of this chapter.

The visual representation of *Hangul* is also unique. Unlike Roman alphabetic orthographies, graphemes are packed in a square-like block. Although Korean is an alphabetic phonography, the visual representation of *Hangul* looks more like syllabic scripts, such as Chinese and Japanese. Syllabic cues within *Hangul* are unambiguously distinct, as consonants and vowels are combined within syllable blocks (e.g., the graphemes “ㅎ ㅏ ㄴ ㄱ ㅡ ㄹ” are packed together into syllable blocks “한글”). The common form of syllables in Korean is CVC, and the longest grapheme string is CVCC with only 12 permissible consonant sequences at the final position. This is different from the English orthography, in which letter strings are used not only in consonants (e.g., strength, sports), but also in vowels (e.g., queue, liaison, Hawaii).

The present study

Although research exists regarding reading in Korean in its own form and in comparison to English, a solid model or theory of crosslinguistic influences has been lacking, particularly with respect to word processing. This is because efforts so far have been made to generate empirical evidence from reading Korean as a data-to-theory approach. Based on accumulating evidence, the present study aims to facilitate building a data-driven theory of Korean word recognition.

Two experiments were conducted. The overarching hypothesis of Experiment 1 was that Korean readers would show word recognition and naming efficiency in the block format rather than in the linear format. Indeed, this hypothesis reflects common sense, given that the block format is in fact the script convention of Korean. In order to more rigorously examine the effect of the block format on efficiency in reading Korean, a control analysis of the phonological property of consonants was performed, specifically of the degree of consonant sonority of the first consonant. This control analysis was based on the findings of first-letter effects on reading (Johnson & Eisler, 2012). Moreover, consonants are not only first letters in *Hangul*, but they also have different levels of acoustic intensity. Specifically, plosives (e.g. /p/, /b/, /t/, /d/, /k/, /g/) are the most obstruent sounds, followed by fricatives (e.g., /f/, /v/, /z/, /s/) and nasals (e.g., /m/, /n/). The liquid (e.g., /l/) is the most sonorant consonant. In the vowel sonority scale, the sound /a/ is the most sonorant, followed by /e/, /o/, /i/, and /u/ sounds (Maionchi-Pino, de Cara, Ecalle, & Magnan, 2015). If the sonority of first consonant was miniscule, then the sound effect could be controlled in an attempt to identify the locus of interferences in format effects.

As for cross-linguistic influences, one way to determine L1 effects is to examine the magnitude (i.e., unstandardized effect sizes) of the strength of L1 skills and the familiarity of L2 words. L1 strength was operationalized as an index of the mean difference between typical and atypical written forms in L1. L2 familiarity was operationally defined as an index of the mean difference between familiar and unfamiliar written forms in L2. Experiment 2 addressed this subject.

Experiment 1

This experiment was designed to investigate the tension between efficiency (i.e., typical format) and complexity (i.e., atypical format) involved in reading. The layout of segmentals packed within the syllable block, as seen in the typical Korean writing convention, may serve as a catalyst for recognition or processing, because (1) it makes visual input more efficient, and (2) thus makes instantaneous syllable parsing unnecessary. In order to gauge the difference between typical and atypical formats, two written layouts, including block and left-to-right linear formats, were employed in this experiment.

Two research questions were addressed in this study.

1. Do Korean readers read words in nonsyllabic formats as efficiently as in the typical printing convention?
2. Are Korean readers affected by the articulatory properties of the initial sound of the syllable?

If syllabic parsing occurs regardless of the syllabic format due to psychological syllabic segmentation of polysyllabic words into their syllabic constituents, then native Korean readers would read the format of left-to-right grapheme arrangement (as in English) as efficiently as the packaged arrangement (as in typical *Hangul* prints). If word reading is characterized by the syllabic format in the script system, then Korean readers would read the typical print significantly faster than the atypical print. It was hypothesized that Korean readers would read faster in the canonical representation of Korean words (i.e., block formats) relative to the horizontally linear format. Due to the unique characteristics of the Korean script, it was also hypothesized that reading speed would not be modulated by the syllabic structure (i.e., CV vs. CVC). If the results of the first question were negative, the locus of the difference would need to be identified. In order to rule out the possibility of articulation obtuseness of the syllable, the second question was posed. If reading efficiency lies in the grapheme arrangement, then the articulation property would not influence reading per se. Hence, it was hypothesized that native Korean readers would not be affected by the articulatory properties of initial sounds of syllables.

Participants

Sixty five university students were recruited from Pusan National University in South Korea. All participants spoke Korean as their native language. The mean age of the participants was 21.58 years (*SD* = 2.73; range: 19–33; Male: 29, 45%). Their vision or corrected vision was within the normal range. Skilled adult readers were recruited for this study, instead of children, in order to preclude factors associated with developmental aspects given that proficient adults have stabilized L1 reading skills.

Measure

A naming test using E-Prime was constructed to measure accuracy and RT of Korean disyllabic words in the regular format (i.e., block format; e.g., 소리) and a linear layout like English (e.g., ㅅㅗㄹㅣ). This manipulation was possible only because Korean is a phoneme-based script and has the syllabic format. The stimuli were 40 two-syllable high frequency Korean words, including 20 CV and 20 CVC syllabic structures, as CV or CVC two-syllable words are common in Korean vocabulary. The items were drawn from textbooks used for 1st and 2nd graders in Korea (Korea Institute for Curriculum and Evaluation, 2013). Word frequency (Kim, 2005) was obtained for each stimulus. The mean frequency of the entire stimuli was 718.28 (SD = 863); the mean of CV forms was 916.95 (SD = 1002.64), while that of CVC forms was 519.60 (SD = 665.18). The means of the two syllabic forms were not significantly different ($t(38) = 1.47, p > .05$). Table 1 shows examples of the stimuli used in this experiment. The mean number for phonemes across both CV and CVC structures was 4.78 (SD = 1.21) and 5 for graphemes (SD = 1.01). For the CV structure, the mean number of phonemes was 3.70 (SD = .66) and that of graphemes was 4 (SD = 0). For the CVC structure, the mean number of phonemes was 5.85 (SD = .37) and that of graphemes was 6 (SD = 0).

Table 1. Examples of typical and atypical stimuli

Syllabic structure	Korean printing convention	Linear format
CV	자리	ㄴ ㅏ ㅁ ㅜ
CV	기자	ㅅ ㅏ ㄱ ㅗ
CV	머리	ㄱ ㅗ ㅁ ㅜ
CVC	학생	ㅅ ㅓ ㄴ ㅅ ㅐ ㅇ
CVC	손발	ㄱ ㅗ ㄹ ㅁ ㅗ ㄱ
CVC	동산	ㄷ ㅗ ㅇ ㅅ ㅏ ㄴ

Procedure

The computer-based naming test was individually administered in a quiet room. The participant was asked to read aloud typical or atypical formats of high-frequency Korean words that appeared at the center of the computer screen. A fixation point

(+) was presented for 500 miliseconds (ms) before each target stimulus appeared on the screen. Repetitions and self-corrections were considered correct. Reading time (RT) was measured by a tester's button press upon completion of reading the stimulus, which has been used in behavioral measures of reading. The way of measuring RT for this study can be considered nontraditional. However, this method was adopted for three reasons: First, the presence of the tester is a common practice in administering psychoeducational tests. Specifically, reading time is measured by the tester in ms in the standardized serial naming tests, such as RAN/RAS (Wolf & Denckla, 2005), the Rapid Color/Object/Digit/Letter Naming subtests of the *Comprehensive Test of Phonological Processing* (Wagner, Torgesen, & Rashotte, 1999) as well as timed-reading tests, such as the Sight Word Efficiency and Phonemic Decoding Efficiency subtests of the *Test of Word Reading Efficiency* (Torgesen, Wagner, & Rashotte, 1999). Second, the use of the voice-box trigger for measuring RT for this study was considered inappropriate because it is too premature to capture the examinee's idiosyncratic responses, such as repetitions, prolonged articulation, and self-correction especially for the atypical target. Hence, we were convinced that the method adopted for this study was more adequate than the traditional way given the purpose of the study with the use of atypical targets. Third, when the variance-covariance structure involved in the two techniques (i.e., voice-box trigger and button press) are considered, the same results of analyses are expected to be found.

Results and discussion

As expected, participants showed ceiling effects (100% correct on the block form; 99.8% correct on the linear form), suggesting that the participants processed the L1 stimuli with maximum efficiency. This result likely stemmed from the fact that the stimuli were selected from textbooks for Korean 1st and 2nd graders coupled with the fact that the participants were skilled readers. Therefore, accuracy data were not further examined. RTs of incorrect responses were excluded from analysis. Table 2 shows the means and standard deviations for latency in ms. The latency data were positively skewed. Hence, we used natural logarithmic values[1] in subsequent analyses to increase normality and precision of test statistics.

1. Natural logarithmic values were chosen rather than common logarithm because they showed better distributions than those with common logarithms.

Table 2. Means and standard deviations by subject

	All stimuli		CV		CVC		Paired-*t*
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Linearity	1410.89	279.90	1224.99	229.98	1596.79	385.05	$t(64)=-10.05^{***}$
Block	850.88	24.06	846.14	79.12	855.62	82.67	ns

Note. *** $p < .001$; *ns* = not significant

RQ 1: Korean readers' performance on typical and atypical formats of words

There was no difference in performance as a result of the number of graphemes and phonemes, which is likely due to the clear letter-sound correspondence in Korean. Since (1) the test-taker's performance is due in part to the interaction between *person ability* and *item difficulty* (Bond & Fox, 2007; see Pae, 2012 and Pae, Greenberg, & Morris, 2012, for more information on how *person ability* and *item difficulty* intersect with each other in language tests) and (2) effects tend to be overestimated with separate subject and item analyses, an omibus analysis was deemed appropriate. When the performance on the two visual formats (i.e., linearity and block) and the syllabic structures (i.e., CV and CVC) was considered concurrently with the latency, main effects were found in the visual format and the syllabic structure ($F(1,36) = 144.39$, $p < .001$; $F(1,36) = 10.04$, $p < .01$, respectively). This indicated that the Korean participants read the linear format more slowly than the block and that the CVC structure resulted in longer responses than the CV structure in the linear sequence. There was also a significant interaction effect between the format and syllabic structure ($F(1,36) = 8.72$, $p > .01$), indicating that performance on the two visual formats was dependent on the feature of the syllabic formats. However, when the two formats were analyzed separately, the difference disappeared. When the latency of the two syllabic structures (i.e., CV vs. CVC) was compared within the block format, no significant difference was found, suggesting that the Korean participants were not affected by the different syllabic structures. However, more syllables took longer to read in the linear formats ($F(1,18) = 7.02$, $p < .05$). This is in line with the finding of previous research that showed longer latency with more syllables in unfamiliar words (i.e., low-frequency words; Jared & Seidenberg, 1990). This suggests that the source of the complexity (i.e., the length of grapheme strings) effect was likely to reside in the written format (i.e., linear format only).

RQ 2: The effect of the articulatory property of the syllable on reading speed

Since there was a significant difference between the block and linear formats, additional analyses were performed as a control analysis in terms of the initial sound properties of the stimuli in order to identify the locus of the difference. The main aim for this analysis was to eliminate a possible interpretation of pronunciation easiness or obtuseness involved in naming. The initial sound properties were examined based on the place and manner of articulation. S*top* sounds (i.e., ㄱ, ㅋ, ㄷ, ㅌ, ㅂ, ㅍ) appeared the most in the first syllable, followed by *fricatives* (i.e., ㅅ, ㅎ) and *nasals* (i.e., ㅁ, ㄴ, ㅇ), while *fricatives* and *liquid* sounds (i.e., ㄹ) appeared the most in the second syllable, followed by *stop* sounds.

Figure 1 shows RTs of words by sound type. It was classified based on the manner of articulation of the first sound (i.e., initial consonant) of the words. As seen in Figure 1, RTs performed on the typical block format were nearly stable, while RTs performed on the atypical linear format were relatively variable according to the sound types. This is another piece of evidence for the block format's stability. Since the linear format showed fluctuation across the sound types, the combination of the initial sound within each syllable of the disyllabic words was also examined. Figure 2 shows the pattern of combinations of the sound feature of the first and second phonemes for the linear form only. The trendline in the line graph refers to a moving average trendline that smoothed out fluctuation in data to show the pattern more clearly. The combination of *stop-affricate* (e.g., 교사, 동작) took the longest, followed by the *affricate-stop* (e.g., 초보, 작품) and *nasal-stop* (e.g., 물건) combinations. The array of *nasal-nasal* (e.g., 나무, 눈물) was named most quickly, followed by those of *null*[2]*-stop* (e.g., 운동) and *affricate-fricative* (e.g., 책상).

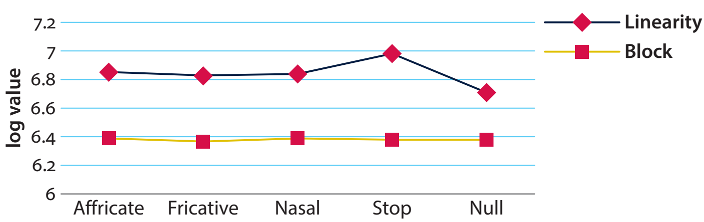

Figure 1. Latency for words classified by the manner of articulation in the two forms

2. The *null* notation indicates the place-holder "ㅇ" in the initial position.

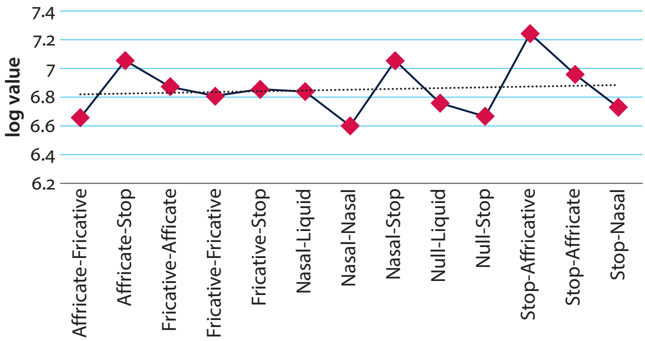

Figure 2. Linear form only
Note: The dotted line is a trendline showing the averaged fluctuation pattern graphically

Using dummy variables (i.e., 1 for presence or 0 for absence) for each category of the sound feature, a stepwise multiple regression analysis was performed with the dummy variables as a predictor and latency as a dependent variable. The stepwise method was considered to be appropriate for this analysis because it was exploratory and was not hypothesis- or theory-driven. The sound feature did not predict a significant variance in the latency ($p > .05$). This finding indicates that, although the Korean participants performed differently between the two written forms, the sound feature did not predict speed of response when a shallow orthography was read. This suggests that since it does not require instantaneous syllabic parsing, the efficiency of the block format may outweigh the demand imposed by the articulatory idiosyncrasies of words. This point warrants more focused research. The current finding is consistent with the result that the Korean readers were not affected by the syllable structure (CV vs. CVC) or length. Because it was not significant, the results are not reported here.

In short, the results of Experiment 1 offered important evidence for the efficiency of processing the *Hangul* block layout as well as its independence of articulatory characteristics of words. These results can be explained in two ways. One interpretation is the effectiveness of the *Hangul* script, perhaps reflecting the ingenuity of its original design. Another interpretation is L1 strength that has been established through continuous use of L1. Because they were accustomed to the block format of *Hangul*, the Korean participants might have been able to process it with greater speed and efficiency than that in the atypical format. However, this conclusion is incomplete given the insufficient evidence produced from one script without a comparison group. To further examine the effect of syllabic structures, Experiment 2 was carried out in English as an L2 with a comparison group of English-speaking university students.

Experiment 2

To augment the findings of Experiment 1, this experiment was designed to investigate how the syllabic unit functioned when L2 English words were orally read. If the syllabic unit in words served as an enabling factor behind efficient reading, then Korean readers would take advantage of an artificial prompt, due to L1 effects wherein syllabic chunks (i.e., broken down according to Korean syllabic boundaries) are exaggerated. In other words, if syllabic blocks facilitated word recognition, then Korean readers would not show a significant difference between typical print (i.e., familiar formats) and manipulated visual noise (i.e., letter strings were visually broken along syllabic boundaries) in L2. The magnitude of the familiarity effect on L2 reading would be smaller than or similar to that of the comparison group of native English speakers, due to the possibility that Koreans would make use of the syllable boundary more than the other language group. In order to investigate the familiarity effect, performance on manipulated stimuli with syllable chunks resulting from unnecessary spaces within the word was compared to performance on allographs (i.e., lowercases and uppercases of English words) of typical fonts.

The following research question guided Experiment 2: How do Korean readers read English words with carefully placed spacing (yet unbeknownst to participants) so as to indicate Korean syllabic boundaries, compared to native English readers? If proficient Korean readers automatically parse words into syllables in the course of visual scanning, then stimuli showing artificial syllabic units would be processed in a similar manner to that of typical words. If they do not parse words according to Korean syllabic systems, then Korean readers would read atypical words more slowly than typical words. It was hypothesized that due to L1 script effects, Korean readers would make use of syllabic boundaries in visual screening and be more tolerant of visual noise as long as the noise is Korean syllable-related.

Participants

Of the participants who participated in Experiment 1, 38 Korean students were randomly selected for Experiment 2. A comparison group of 38 native English speakers were recruited from the University of Cincinnati in the U.S. The mean age of the Korean participants was 22.26 years (*SD* = 3.07; Male: 21, 55%; Female: 17, 45%), while that of the English-speaking group was 19.5 years (*SD* = 1.13; Male: 3, 8%; Female: 35, 92%). All participants reported normal or corrected-to-normal vision. The English group never learned to read in Korean. The Korean participants' self-reported reading skills in English were at 5.5 (*SD* = 1.45) on a 10-point Likert scale, with 10 for native-like skills.

Procedure

The procedure was the same as that in Experiment 1.

Measure

A computerized naming test, including 35 items (10 lowercase, 10 uppercase, 15 Korean syllabic space) and 25 distractors was constructed to measure accuracy and RT for typical lowercase and uppercase fonts as well as the manipulated English word forms. The base words of the experimental conditions were matched in terms of word length and word frequency. The word stimuli were drawn from Fry's sight words for third graders (Fry, 2004). Word frequency information was obtained from the Corpus of Contemporary American English (COCA, Davies, 2015). This corpus contains 20 million words from 1990–2012 from equally divided spoken, fiction, popular magazines, newspapers, and academic texts. The mean frequency for the lowercase words was 107,923 occurrences (SD = 70,954), 98,779 occurrences for the uppercase words (SD = 102,467). The mean frequency for unnecessary space stimuli was 69,101 occurrences (SD = 63,597). There was no significant difference among the three stimulus types ($p > .05$). The word frequency was used as a co-variate in analysis.

The manipulated words were constructed to represent the number of syllables in Korean when the English word was transcribed in Korean. This resulted in multiple letter chunks with a mixture of consonants and vowels. For example, the word "*understand*" was written in the form "*un der s tan d*" because when the word "*understand*" was phonetically transcribed in Korean, the three-syllable word turned into five syllables with an addition of an epenthetic vowel to each consonant (i.e., 언더스탠드). Specifically, all English stimuli were transcribed into Korean in order to derive its syllabic structure; the English words were then visually deconstructed based on the number of Korean syllables of the given word. As this procedure was not disclosed to the English participants, it naturally gave the impression of random spacing to them, when in fact it reflected the Korean syllabic unit. Table 3 shows examples of the stimuli used in this experiment.

Table 3. Examples of the stimuli

Lowercase	UPPERCASE	Korean syllabic spaces
across	CAREFULLY	be ca me
during	ISLAND	de ci ded
happen	LANGUAGE	p ro du ce
usually	SPECIAL	sci en ti s t
hundred	SCHOOL	un der s tan d

Results and discussion

The Korean participants' accuracy of this test also showed a ceiling effect, as predicted (99.9% correct). This demonstrates that the Korean participants had adequate proficiency in word reading and that other English proficiency tests were deemed unnecessary for this study. Table 4 shows the means and standard deviations for RTs of the two groups. As in the analyses of Experiment 1, natural log values were used in further analyses to improve normality and precision of test statistics. The two groups performed differently in terms of reading speed in the three types of stimuli with native English speakers being faster than Korean speakers: $t(74) = 6.46$, $p < .001$ for the lowercase condition; $t(74) = 9.26$, $p < .001$ for the uppercase condition; and $t(74) = 7.30$, $p < .001$ for the artificial space condition. This demonstrated that L1 was processed faster than L2, which was intuitive and was typically found in L2 studies.

Table 4. Response time by language group

Stimuli type	Korean		English	
	Mean	SD	Mean	SD
Typical lowercase	1310.86	300.23	993.57	463.36
Typical uppercase	1568.84	524.15	955.31	524.15
Artificial space	1567.53	382.57	1132.47	382.57

Only correct RT was subject to statistical analyses. The Korean speakers showed no significant differences in RT between the seemingly random-spaced stimuli and typical fonts (i.e., the composite of lowercase and uppercase) and RTs among the artificial space, lowercase, and uppercase conditions ($p > .05$). However, native English speakers performed differently in RT between the artificial space and typical fonts ($t(23) = 3.80$, $p < .01$). When compared on RT among the lowercase, uppercase, and artificial-space stimuli, the English-speaking group showed a significant difference in RT ($F((2, 22) = 7.77$, $p < .01$). A post-hoc Tukey test showed a significant difference between the space and lowercase conditions ($p < .05$), and between the space and uppercase conditions ($p < .01$), indicating that the space condition took longer than the lowercase and uppercase conditions. However, there was no significant difference between the lowercase and uppercase ($p > .05$). This was consistent with the prediction. Since their performance on the lowercase and uppercase stimuli was not significant, the RT was collapsed to gauge the familiarity effect. The mean RT for typical fonts (i.e., baseline RT) was 1,439 ms, and the mean RT for the space stimuli was 1,524 ms for the Korean participants, with no significant difference in RT between those two stimuli types. The English-speaking participants showed the mean RT of 974 ms for the typical fonts and 1,132 ms for the space stimuli. Here, there was a significant difference between the performance of the two stimuli types ($t(37) = 4.39$, $p < .001$). In short, the Korean readers did not show a familiarity effect, while the English-speaking readers' performance was influenced by the stimulus noise. This result was congruent with the hypothesis formulated above.

Frequency data were taken into account in order to test if the difference among the three stimulus types resulted from word frequency. A one-way ANOVA showed no significant difference in RT among the lowercase, uppercase, and artificial-space conditions and between the typical (i.e., lowercase and uppercase combined) and space conditions for the Korean speakers.

The Korean-speaking group's RT did not show a significant correlation with stimulus length in the artificial-space and typical-font conditions, including the number of phonemes, graphemes, syllables, and chunks (i.e., the grapheme chunks resulting from spacing within the word). However, the native speakers' performance on the unnecessary space condition was correlated with the length of phonemes, syllables, and chunks: $r = .58$, $r = 61$, $r = 56$, respectively; all p's $< .05$. The correlation for RT between the two language groups was significant ($r = .63$, $p < .05$). For the typical fonts, RT of the two groups did not show significant correlations with any of the length variables. This demonstrated that the Korean participants performed L2 reading at their own pace regardless of the length in both typical and manipulated forms, while the native English speakers' performance was correlated with stimulus length, perhaps in resolving the unfamiliarity. This also supported the hypothesis that the Korean readers would not be too sensitive to visual noise as long as Korean syllabic cues were present.

Next, the results of Experiment 1 and Experiment 2 were compared to ascertain the dimensions of the interference effect (e.g., difference between the manipulated and the baseline RT) between L1 and L2 for the Korean readers and between the two language groups. Although we acknowledged that this was a little farfetched, it would provide useful information given the same experimental site, participants, and procedure across the two experiments. This was done because if the finding of Experiment 1 truly resulted from L1 dominance, a similar pattern would be observed at a similar level of strength among the native English speakers as well. The interference effect (difference = 560 ms for the Koreans' L1; difference = 213 ms for the Koreans' L2; difference = 138 ms for the English speakers' L1) was standardized and z-scores were used in the analysis. A one-way ANOVA revealed a significant difference in the interference effect among L1 Korean, L2 English, and L1 English ($F(2,138) = 25.76$, $p < .001$) with a covariate of word frequency. A Tukey post-hoc test showed that the difference was found between Koreans' L1 and L2 RTs as well as between Koreans' L1 and English speakers' L1. This indicated that the interference effect was greater in L1 than L2 for the Korean readers, suggesting that linguistic skills established in the L1 were much stronger than skills learned in the L2. This result also suggests that the stronger linguistic skills, the greater interference effects. One interesting aspect of this finding is that there was a significant difference in the standardized RT score between native speakers of Korean and English ($p > .001$). This was important because this result allowed us to rule out L1 strength as a factor in the performance difference found in Experiment 1. In addition, there was no significant difference between Koreans speakers' L2 and English-speakers' L1 RTs in the same language, English. This is also important because different levels are typically found between L1 and L2. This counter-intuitive result supports the hypothesis that native Korean speakers take advantage of syllabic saliency in visual processing in an L2 and are more tolerant with visual noise, as long as the noise is related to Korean syllabic boundaries.

General discussion

This study investigated the effects of the orthographic format of Korean segmentals and L1-derived syllabification on L2 word reading. The first experiment was developed to address L1 strength by examining typical and atypical written formats (i.e., block vs. linearity) shown by skilled native Korean readers. Due to the phonemic nature as well as the unambiguous syllabic segregation in a block, Korean *Hangul* is a useful candidate for examining L1 effects on L2 reading within the syllable. This flexibility cannot be found in English and other languages. The second experiment was designed to augment the findings of the first experiment by investigating L1-derived sylllabification effects on reading English as L2. In so doing, skillful readers of Korean and English were asked to read regular formats and manipulated formats (i.e., letter chunks separated according to Korean syllabic boundaries) in English.

The results of Experiment 1 showed that once segmentals were packed within the block, the syllabic structure (i.e., CV vs. CVC) did not affect reading speed, suggesting that some reading skills may be constant regardless of the length of the graphemes and the syllabic structure in Korean. This is somewhat different from previous research indicating that CV words are recognized faster than CVC words among young children (Cole, Magnan, & Grainger, 1999). However, when the Korean graphemes were written horizontally as in English, reading speed was significantly delayed compared to performance in the block format. This finding collectively gives rise to at least two interpretations: (1) weaker skills in L2 than L1, and (2) the inefficiency of the linear format. Because L1 skills tend to be stabilized rather than transitory or variable, skills in the L1 are more likely to be stronger than those in the L2. Grapheme linearity may also not be as effective as syllable blocks because a longer array of graphemes may require more attention and cognitive processing resources.

Overall, the Korean participants showed greater efficiency in the *Hangul* block format than in the linear format. This finding might be considered intuitive, given that the block format is indeed the printing convention of Korean *Hangul*. However, one of the important implications of Experiment 1 is the empirical evidence for the strength of L1 skills. Another implication is the provision of a basis for theory building, which is a necessary step in building a theoretical framework for crosslinguistic influences. The Korean readers were sensitive to neither the syllabic structures (i.e., CV vs. CVC) nor the articulatory features (i.e., manner of articulation) of the onset sounds of the stimuli. Furthermore, processing speed was independent of the word length, suggesting that speed of processing could be attributable to the syllabic efficiency that the Korean script offers.

In Experiment 2, one of the objectives was to test the familiarity effect. The hypothesis was that if the familiarity effect was not found in the Korean speakers, then we could minimize the possibility of familiarity effects and highlight the effectiveness of syllabic units in reading. With seemingly random spaces within the word, we found that both groups performed differently. The Korean participants demonstrated no significant difference among the three stimulus types (i.e., typical lowercase fonts, typical uppercase fonts, and artificial space stimuli). This suggests that Korean students might not be too sensitive to the visual shape of the stimuli once they reach a certain level of reading proficiency in L2 English. However, the English speakers performed differently across the conditions, suggesting that they were disrupted by the visual noise despite no significant difference between typical allographs (i.e., lowercase and uppercase fonts). The results of Experiment 2 were consistent with the hypothesis that Korean participants were more tolerant of visual noise in English than native English speakers, so long as the noise is related to Korean-derived syllabification.

Given that (1) all stimuli were drawn from the 3rd grade word lists (Fry, 2004) and (2) the participants' accuracy rate reached near perfection, the possible lack of optimal word reading skills of the Korean participants in L2 English was ruled out. Hence, it was reasonable to compare the findings of the two experiments. The integrated results of Experiments 1 and 2 paint an interesting picture. The Korean readers did show a significant difference in RT between L1 and L2; however, there was a difference in processing speed between Korean speakers' L1 and English speakers' L1. In addition, there was no difference in RT between Koreans' L2 English and English-speakers' L1. These two patterns are counter-intuitive because (1) L1 strength should be found at a similar level across languages, given that the two language groups are at the same level of education regardless of the language they speak, and (2) L1 and L2 abilities are likely to be different in terms of linguistic skill dominance. It seems that when figural attributes, such as linearity, block, and unnecessary spaces within the word are taken into account, the effect of syllabic structures becomes more inflated in L1 and L2 processing.

Taken together, based on the evidence that reading Korean script is not susceptible to word complexity, word length, and articulatory or sonorant features, this finding may support a claim that the efficiency of reading Korean *Hangul* is primarily due to the syllabic saliency or the structural autonomy of the syllabic block. The block format is likely to facilitate more automatic processing simply due to the packed segmentals within the syllabic boundary, while a linear railway sequence of graphemes is likely to require more conscious or controlled processing simply because the same information is horizontally more dispersed. Based on these empirical findings, a Syllabic Autonomy Saliency Hypothesis is proposed for the Korean *Hangul* script. Within the benefit of the syllabic autonomy, readers do not have to go through instantaneous syllable parsing, and, as a result, this leads to efficient word reading in Korean.

The findings of this study also point to the nature of crosslinguistic influences. Previous research has been successful in providing empirical evidence of L1 script effects. However, the nature or locus of the L1 script effect has not been fully explained. The facilitatory effect found in the Korean participants' performance on the artificially created syllable chunks in L2 English allows us to add another evidence to the literature.

Future directions

This study provides new insights into the effect of syllabic autnomy of Korean on L2 English word reading. A follow-up study is needed to validate the findings of this study. A subsequent study that includes different language groups learning Korean as an L2 will be useful for endorsing the hypothesis proposed in this chapter. This kind of study not only corroborates the findings of this study, but also facilitates a better understanding of linguistic interactions in learning Korean as an L1 and L2. Secondly, a cross-language study examining syllablic units, the role of vowels, and consonantal strings concurrently would expand the horizon of our understanding of word recognition or reading. The considerable role of consonants has been documented in Roman script, but the role of consonants and vowels in *Hangul* still remains under-investigated.

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CHAPTER 18

Subunit priming effects on lexical decision in Korean

Both body and rime units are important in Korean

Sungbong Bae[i], Hye K. Pae[ii] and Kwangoh Yi[i]
[i]Yeungnam University, South Korea / [ii]University of Cincinnati, U.S.A.

There have been conflicting results in the literature regarding the dominant linguistic unit (body-coda units vs. onset-rime units) in reading Korean *Hangul*. In an attempt to resolve the contradictory views between the phonotactic constraint (support for body-coda) and the universal rime bias (support for onset-rime) in reading, this chapter examines subunit priming effects on rapid word recognition among native Korean readers. Thirty five university students participated in a lexical decision task using Korean words and nonwords as targets. Primes included related and unrelated bodies, rimes, and consonants of disyllabic targets. Results of a linear mixed model showed that both body and rime units played significant roles in response time. Rime primes also affected accuracy of rapid lexical decision. Unlike previous research that showed body primacy, the results indicated that both body and rime units are important in reading Korean.

Keywords: Korean *Hangul*, phonotactic constraints, universal rime bias

Introduction

Research shows that differential psycholinguistic grain sizes, such as phonemes, onset-rime units, body-coda units, or syllables, are involved in reading according to the scripts being read (Baek, 2014; Berg & Koops, 2010, 2015; Da Cara & Goswami, 2002; Kessler & Treiman, 1997; Kim, 2007; Lee & Goldrick, 2008). One of core discussions in the internal structure and salient subunits of the syllable has centered on the onset-rime (e.g., "*h-at*" in "*hat*") and body-coda (e.g., "*ha-t*" in "*hat*") divisions. Since Korean *Hangul* is a phonemic[1] script in nature and has

1. Given that this chapter focuses on the linguistic unit, the word "phonemic" is used instead of "alphabetic" to refer to the Korean script.

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a syllabic configuration in appearance, a contrast between English and Korean has frequently been made to tease apart the function of intrastructure of syllables and words. In doing so, various measures and methodological paradigms, such as oddity or similarity judgment (Baek, 2014; Yoon & Derwing, 2001), blending tasks (Derwing, Yoon, & Cho, 1993; Kim, 2007), recall tests (Lee & Goldrick, 2008; Yoon & Derwing, 2001), word games (Treiman et al., 1995; Yi, 1995, 1998), and naming and lexical decision tasks (Kim & Davis, 2002), have been employed. Building upon the findings of previous research, this study examined to what extent native speakers of Korean make use of the sub-syllabic constituent structure (i.e., body or rime) in online speeded judgment of words or nonwords. This study had at least four strengths: (1) the use of the priming paradigm that has rarely been used to date for this particular inquiry; (2) primes written in left-to-right linearity to rule out the effect of essential square-block formats of Korean *Hangul*; (3) adult participants with stable linguistic skills, as opposed to children who are still in the developmental phase; and (4) the use of disyllabic words as targets, as opposed to monosyllabic words that previous studies mostly utilized.

The first strength involves a methodological expansion. Method effects in the measurement of linguistic skills are one of concerns for accurate assessment because researcher-developed measures are mostly used in psycholinguistic experimental research. This concern is largely related to sound psychometric properties to avoid measure-specific findings of research, as standardized tests have rarely been used in linguistic experiments due mainly to heterogeneity in the pool of potential normative groups in terms of linguistic and cultural backgrounds. One remedy for the lack of norm-referenced standardized measures can be replications of previous research or utilization of different methods to address the same linguistic phenomenon. Evidence gleaned from empirical findings allows for synthesizing findings and interpretations. This study utilized a different method than those of previous studies for this purpose.

The second merit relates to the attempt to rule out script format effects by eliminating orthographic overlap between primes and targets. As explained in Chapter 16 in this book, Korean *Hangul* has a unique syllable format that cannot be found in other phonemic scripts. Research shows that syllables are functional units in both production and recognition. Specifically, Stenneken, Conrad, and Jacobs (2007) have examined the role of syllables and cognitive accessibility to syllables in word production and recognition. They have found that participants respond faster for syllables than non-syllables in naming and lexical decision tasks in German, and concluded that syllabic units play a significant role in both recognition and production. Since Korean syllabic boundaries are unambiguously clear, syllable effects are likely to be present in priming tests. In order to mitigate the syllable effect, we used atypical primes by using English-like grapheme arrangement; that is, the primes were fragments of syllables that were presented in a horizontally linear format, not in the conventional block format of *Hangul*. This arrangement also allowed us to examine the role of individual letters because the primes did not represent Korean syllables.

Next, given that children are still in the process of language development, we recruited skilled adult readers who, in theory, demonstrated stable linguistic skills in order to corroborate the findings of children studies (Baek, 2014; Kim, 2007). There has been a paucity of studies that investigate developmental trajectories of word recognition in Korean *Hangul*. The findings of this study are expected to provide insights into word processing in skilled readers of Korean.

Finally, the use of disyllabic words as target stimuli would expand the extant body of knowledge on word recognition in Korean. Monosyllabic words have predominantly been used in word recognition studies (Kessler & Treiman, 1997, 2001; Treiman, Mullenniz, Bijeljacbabic, & Richmond-Welty, 1995). It makes sense to focus on monosyllabic words in English due to their predominant presence in lexicons. Since two-syllable words are more frequent in Korean lexicons (Lee, 1989), however, it is more appropriate to investigate word processing in disyllabic words in Korean.

The unique characteristics of *Hangul*

As described in Chapter 16 in this book, Korean *Hangul* stands out among phonemic scripts, such as Roman alphabets, especially in the representation of segmentals (i.e., consonants and vowels) and their combinatory rules. Korean consonants and vowels have unique characteristics compared to other phonemic scripts. Whereas consonants and vowels of Roman script are arbitrary symbols, *Hangul* segmentals mirror the nature of the universe and the human vocal system. The consonants represent the articulatory vocal system, such as the shape of lips, the place of the tongue, teeth, and the intensity of airstream when a consonant is sounded out. The vowels metaphysically represent *heaven*, *earth*, and *humans* with the shape and direction of atomic strokes (see Chapter 16 for more information).

Among many characteristics, two features are particularly related to this study: (1) the combinatory rule of a consonant and a vowel within the syllable and (2) visual structure. First, the blending of segmentals is straightforward and consistent. A consonant always joins a vowel except for the final consonants of the consonant-vowel-consonant (CVC) and CVCC syllables. This means that consonants cannot stand alone without vowels; as a result, consonant strings are not permitted except the very limited cases of CC at the final (only 12 consonant sequences are plausible due to the restrictions for collocational graphemes). In contrast, vowels can stand alone, in principle. However, a vowel is also to be combined with a consonant within a square block, because, although a vowel itself can form a syllable, a vowel alone within the syllable block is a deviation from the CV complementarity in *Hangul*. When a vowel is located at the initial position (as in "*a*" or "*an*" in English), a filler or place-holder (i.e., "ㅇ") is used as an onset consonant to match the canonical CV or CVC formats. The filler has no sound value in the initial position, but the sound is folded into the subsequent vowel.

The organization of the body unit (C_1V-) through C-V binding is related to Berg and Koops' (2015) notion of coarticulation due to the C-V union and complementarity in Korean. The mandatory binding of a C and a V is related to the phonotactic constraints (i.e., the permissable combinations of phonemes) of Korean because it defines the plausible syllable structure. This feature is directly linked to the absence of C or V strings in *Hangul*. Unlike English that permits up to five consonants in a row (e.g., twelfths, strengths, CCVCCCCC, CCCVCCCCC, respectively), the longest consonant string in *Hangul* is CC at the final (i.e., CVCC; only one phoneme is sounded out in the final CC with the other to be a silent, however).

Second, the visual configuration of *Hangul* is outstanding due largely to the unambiguous syllabic boundary. Graphemes are not arranged in the horizontal railway sequence but are grouped within the block. In essence, the vowel at the center of the syllable defines the shape of syllable blocks; that is, the left-to-right or top-down format in a square block. Korean *Hangul* has six different syllabic formats with distinguished syllabic boundaries in terms of the structural orientation; i.e., left-to-right CV (가), top-down CV (고), left-right-down CVC (각), top-down-down CVC (곡), left-right-down CVCC (값), and top-down-down CVCC (몫). Note that this syllabic classification based on grapheme orientation is catalogued differently from another classification. Specifically, Lee (1972) classified Korean syllables into six types based on the vowel format, including CV_1 (가), CV_2 (고), CVV (귀), CV_1C (각), CV_2C (곡), and CVVC (권), where V_1 refers to a left-to-right vowel and V_2 refers to a top-bottom vowel, in which a compound vowel is considered two vowels. Irrespective of these classifications, the distinct syllabic boundary shown by the syllable block is different from English in which no demarcation is present for the syllable (e.g., <English> vs. <Eng·lish>). Given that models and theoretical considerations of word recognition have generally been spawned from research in English and that English and Korean are categorized as alphabetic languages, below is a brief review of the subunits of syllables and its role in reading English.

Onset-rime and body-coda units in English

Scientific queries focusing on readers' and listeners' encoding of subsyllabic units have yielded consistent patterns in English; that is, the onset-rime division is more prominent than the body-coda unit (Da Cara & Goswami, 2002; Kessler & Treiman, 1997). A leading interpretation of the onset-rime primacy in English has to do with the statistical distribution of phonotactics and graphotactics in the rime unit. Treiman and her colleagues (1995) have systematically examined the consistency of letter-sound correspondences in CVC words of English and indicated that the rime unit (i.e., VC_2) has more stability in pronunciation but less restrictions in terms of the combinatory rule than the body unit (i.e., C_1V) in English. Children and adults showed no sign of utilizing body units in their recognition in Treiman et al. study (1995). Hence, they concluded that the recognition of rime units "helps to regularize the links between spelling and sound in the English writing system" (p. 130). Similarly, Kessler and Treiman (1997) analyzed the distributions of phonemes in about 2,000 CVC words and found a significant cohesion between the vowel and the final consonant (i.e., 43.3% rime pairs) as well as its more frequent occurrences of rimes than expected by chance. However, significant associations between the initial consonant and the following vowel (i.e., 6.9% of body pairs) were not observed in CVC words of English.

Kessler and Treiman (2001) have also found, in a statistical analysis of 3,117 English monosyllabic words, that vowels are the least consistent in the word and that the density of associative links are low in the body unit of CVC words. Onsets have consistency of .91 on average, while codas have consistency of .82 on average. Spelling consistency in codas increases from .82 to .93 when neighboring vowels are taken into consideration. Onset spelling is also significantly affected by the vowel, but the extent of the influence (increase from .91 to .94) was smaller than are codas (increase from .82 to .93). There are only a few onset spellings that are affected by subsequent vowels. These findings suggest that the internal structure of English CVC syllables hinges upon the internal constituents of the onset-rime unit rather than those of the body-coda segment. In a similar vein, De Cara and Goswami (2002) examined phonological similarities among onset neighbors (e.g., *hat* vs. *ham*), consonant neighbors (e.g., *hat* vs. *hit*), and rime neighbors (e.g., *hat* vs. *cat*) in monosyllabic spoken words in English, under the assumption that neighborhood density effects would reflect the level of segmental representations beyond the phoneme. They found that the rime set was the strongest phonological neighbor among the three conditions.

Body-coda units in Korean

Although it is a phonemic script in nature, Korean *Hangul* is considered to be phonemic-syllabary[2] in that salient syllabic characteristics coexist with those of phonemic scripts. In support of the nature of the phonemic-syllabary script, research findings of Korean *Hangul* portray a different picture than that of English in terms of the functional subunit of the syllable. Unlike the onset-rime division that is dominant in English, empirical evidence converges on the saliency of the body-coda segmentation in Korean (Baek, 2014; Derwing, Yoon, & Cho, 1993; Kim, 2007; Yi, 1995, 1998; Yoon & Derwing, 2001). Baek (2014) examined sub-syllabic awareness skills of young Korean natives in Korea and Korean-English bilinguals in the U.S., using sound oddity and similarity judgment tests. Children who learned English as a foreign language in Korea were in favor of the body structure, while Korean immigrant children who spoke English as a second language (but a more dominant language than Korean) in the U.S. preferred the rime structure. He claimed that the difference found in the sub-syllabic preference between the Korean natives and Korean-heritage groups of children in the two localities was attributable to the difference in the placement of semivowels (i.e., /j/ and /w/) in the Korean and English languages. The difference was particularly meaningful for the Korean-heritage children in the U.S., who used dual languages and showed the dominance of English skills, indicating evidence of cross-linguistic transfer from English to Korean. Lee and Goldrick (2008) noted that the internal components of CVC words in Korean and English were different from each other and that the body sequence in Korean syllables had a stronger association than the rime sequence, compared to English CVC syllables. The results of their short-term memory experiments in Korean and English revealed that the general statistical regularities of sub-syllabic units associated with the given language as well as the phonotactic probability were likely to affect Korean and English speakers' performance.

Kim (2007) examined emergent readers' phonological awareness skills and found that young children's body-coda awareness was far better than sensitivity to onset-rime units and phonemes (34%, 5%, and 18%, respectively). Results showed that children demonstrated dominant body-coda reliance and that their body-coda awareness skills predicted a significant variance in word decoding and spelling performance in Korean. Based on both behavioral evidence and corpus data, she concluded that the phonotactic feature of Korean and the frequency of the CV type were the source of body-coda saliency in Korean.

2. The word "alphasyllabary" has also been used in the literature. Given that the focus is placed on the linguistic unit, the word "phonemic-syllabary" is used instead in this chapter.

The results of empirical studies so far that are in favor of the body-coda structure in Korean can be summarized as follows. First, given the cohesiveness of the initial consonant and the following vowel (i.e., body unit), the general statistical regularities resulted from the combinatory rule for segmentals (i.e., C+V complementarity) and the phonotactic features of Korean (i.e., collocational phonemes and graphemes at the initial, middle, and final positions) seem to be attributable to the salient body-coda function. This notion is based on the researchers' observations that phonotactic constraints were placed more on the rime unit than the body part (Kim, 2007; Lee & Goldrick, 2008). Second, the general distributional properties of consonants and vowels in Korean have been considered a source of the difference. Lee and Goldrick (2008) have found that speakers' encoding of subsyllabic patterns and general dependencies on the body-coda unit are stronger than that on the onset-rime unit. Third, the frequency of the CV type in monosyllabic words is likely to be responsible for the body saliency. For example, Kim (2007) carried out a corpus analysis of monosyllabic words and found that CVC type syllables accounted for 69%, followed by CV syllables (19%), VC syllables (9%), and V syllables (3%). A similar pattern was observed in Lee and Goldrick's (2008) study. The results of an analysis of phonological neighbors in Kim's (2007) study were also in this line.

However, a more recent study shows a very different result than the above-mentioned dominant view of Korean. The argument made by Berg and Koops (2010, 2015) is diametrically opposed to the notion of the phonotactic feature raised by other researchers (Kim, 2007; Lee & Goldrick, 2008; Yoon & Derwing, 2001), highlighting the phonotactically *symmetrical* syllable structure between body and rime units in Korean (Berg & Koops, 2010, 2015). Berg and Koops (2015) have claimed, by reanalyzing their previous data and Lee and Goldrick's (2008) data, that Korean syllables impose weights neither on the body unit (they use the phrase "hierarchical left-branching" to refer to the body unit) nor on the rime unit (they use the phrase "hierarchical right-branching" to refer to the rime unit). They assert that "phonotactic constraints cannot be used as an argument for sub-syllabic constituency [in Korean]" (p. 3) because Korean has a *symmetrical* syllable structure in which "phonotactic constraints are about equally distributed across the body and the rime domains" (p. 5). This contention specifically dismisses the prominent role of body-coda units in processing of Korean *Hangul*. Their reasoning is that there is a universal and inherent bias for the subunit rime (VC_2) based on the phonotactic criterion because the phonotactic rime (VC_2) "follows the general aspects of speech processing" (p. 5). By contrasting the Korean syllable structure to that of Finnish, Berg and Koops (2015) conclude that subsyllabic constituency for the body unit in Korean *Hangul* cannot be attributable to the phonotactic constraints. Instead, they turn to the notion of solid coarticulation involved in the onset consonant and the subsequent vowel (i.e., body) as a possible explanation for the body-coda structure in Korean. The "coarticulation" of the two graphemes of the body part (i.e., C_1V), not the phonotactic restrictions imposed on the body position, has a potential to be a feasible argument for the body-coda structure in Korean. Note that combinatory patterns in the rime (VC_2) part in the Korean syllable cannot be freely organized because some combinations in the rime are not permissible in the CVC syllable at the final position (e.g., 갖, 갘, 걓, etc. are illegal syllables to name only a few with the first consonant (i.e., ㄱ) and the first vowel (i.e., ㅏ) in the Korean segmental inventory). More specifically, only seven consonants are permitted at the coda position. In contrast, the onset in the C_1V part can be any consonant among 19 consonants in Korean, including the five doublets.

The role of consonants and vowels in reading

In Roman script, the preeminent role of consonants has been well documented (Bonnati, Peña, Nespor, & Mehler, 2005; Toro, Nespor, Mehler, & Bonnatti, 2008; Perea & Lupker, 2004; Lupker, Perea, & Davis, 2008). For example, words preceded by transposed consonant letters (e.g., *caniso – CASINO*) are processed faster than substituted consonants (e.g, *carivo – CASINO*) in masked priming tasks. Importantly, this saliency has been found only for consonant letters (e.g., aminal-ANIMAL) and not for vowel letters (e.g., *anamil – ANIMAL* or *anomel – ANIMAL*) in Spanish, French, and English (New, Perea, & Lupker, 2004; New, Araujo, & Nazzi, 2008; Lupker, Perea, & Davis, 2008). The saliency of consonants in lexical activation and processing has been consistently found in infants (Hochmann et al., 2011), children, and adults (Havy, Serres, & Nazzi, 2014) as well as in speech stream and reading in French (Bonatti et al., 2005). The eminent role of consonants has been steadily found in research that employs various tasks and paradigms, including ERP (Carreiras, Vergara, & Perea, 2009), reading aloud and lexical decision tasks (New, Perea, & Lupker, 2004; New, Araujo, & Nazzi, 2008; Lupker, Perea, & Davis, 2008), and fMRI (Carreiras & Price, 2008). Taken together, it is clear that consonant letters play a stronger role than vowels in Roman script.

English words become legible, to a large extent, without vowels, as seen *n ths xmpl* (key: in this example). However, Korean words become indecipherable without vowels because of too many degrees of freedom for candidates for the missing vowel. Given Korean's idiosyncratic vowel dominance in both the script and oral language, it is possible to find a more prevailing role of vowels than consonants or no difference between consonants and vowels.

The current study

With the aforementioned characteristics in mind, we attempted to investigate the effect of subset primes, including body, rime, and CC strings, on word and nonword judgment among adult native readers of Korean. Moreover, this study aimed to resolve the conflicting arguments especially between the two views of phonotactic constraints (Kim, 2007; Lee & Goldrick, 2008) and the universal rime (VC_2) bias for the phonotactic criterion (Berg & Koops, 2015) by providing another piece of behavioral evidence. Despite a handful of studies that examined the role of body-coda units in Korean, there has been a lack of research that employs the priming paradigm that takes the script format into consideration in speeded lexical decision. The masked priming paradigm has been known to tap into lexical access necessary to retrieve the lexical information. Kim and Davis (2002) used the paradigm to investigate the role of various subsyllabic units, such as onsets, bodies, rimes, and syllables, and found the significant effects of onsets, bodies, and syllables when a naming test was used with monosyllabic target words. However, they found no effect of rimes as a prime for target words. Interestingly, the effects of onset and body units disappeared when a lexical decision task was employed for the targets. A possible explanation for no effects of the body unit in lexical decision would be that the targets used in their study were all monosyllabic words. Monosyllabic words are not very common in the Korean language, and are often ambiguous in meaning; as a result, they usually take longer in lexical decision than disyllabic words. When a decision takes longer in one way than the other, it is assumed that cognitive loads are greater in one way or another due to ambiguity and/or that some confounding factors interfere with rapid decision. In order to eliminate ambiguity inherently found in monosyllabic words and other confounding factors involved in processing, we utilized disyllabic words for this study.

Based on the dominant view of the body saliency in Korean, we hypothesized that body primes would facilitate online lexical judgment of *Hangul* among native readers of Korean. Based on Berg and Koops' (2015) claim of the universal rime bias and Korean's *symmetrical* subsyllabic structure, we also hypothesized that rimes would also play a role in rapid lexical decision by skilled native readers of Korean.

Methods

Participants

Thirty-five university students participated in the study from Yeungnam University in South Korea. All of them were native speakers of Korean. The mean age of the participants was 22.97 (SD = 2.55) ranging from 19 to 30. Male students comprised 43% (15 individuals). Their vision or corrected vision was in the normal range.

Measure

Ninety-six disyllabic words were selected as targets. The syllables of each word were in C_1VC_2 format. The design included 12 (2 × 2 × 3) experimental conditions with two target types (words vs. nonwords) by relatedness (related primes vs. unrelated primes) and by three prime types (body primes vs. rime primes vs. consonant primes). The primes consisted of four letters. Specifically, the *body* prime type included C_1V (English-equivalent example: "*ha*" for "*hat*"); the *rime* prime type included VC_2 (English-equivalent example: "*at*" for "*hat*"); and the consonant prime type included C_1C_2 (English-equivalent example: "*ht*" for "*hat*"). An example of the stimuli is shown in Table 1. The mean word frequency of the target words was 126.32 (*SD* = 228.24) ranging from 0 to 1,238 (Kim, 2005). The nonword target was a combination of two syllables that did not represent a particular meaning. In order to eliminate *Hangul*'s syllabic block effects, the primes were presented in the disassembled linear form like English. In other words, potential effects of *Hangul's* unique syllabic configuration (i.e., top-down and left-to-right) were ruled out by presenting primes in a left-to-right linear format.

Table 1. Example of the stimuli used in the study

	Consistency	Condition 1		Condition 2		Condition 3	
		Body prime	Target	Rime prime	Target	Consonant prime	Target
Words	Related	ㅁ ㅏ ㅈ ㅗ	만족	ㅓ ㅁ ㅡ ㅇ	검증	ㅎ ㄹ ㅇ ㅂ	혈압
	Unrelated	ㅂ ㅓ ㅅ ㅣ	만족	ㅑ ㄱ ㅗ ㅂ	검증	ㄷ ㅊ ㄱ ㄴ	혈압
Nonwords	Related	ㅂ ㅜ ㅇ ㅓ	불업	ㅕ ㅂ ㄱ ㅜ	협군	ㅈ ㄴ ㅂ ㄹ	전발
	Unrelated	ㅈ ㅗ ㅅ ㅣ	불업	ㅏ ㄷ ㅠ ㅈ	협군	ㅍ ㅎ ㅇ ㅁ	전발

Procedure

Testing took place individually in a quiet laboratory. The participant sat in front of the computer and was asked to press one of two keys on the response box upon making judgment as to whether the stimulus appeared on the screen was a real word or not. Each trial included a set of a forward mask of six hash mark symbols (######) for 1,000 ms, a prime for 30 ms, a backward mask of six hash marks for 20 ms, and then the target for 2,000 ms or until a response was provided. There were 30 practice items prior to the presentation of the main experiment items.

Results

Response times (RTs) that were below 300 ms or above 1,500 ms as well as RTs associated with incorrect responses were eliminated for analysis. Of 3,360 cases, 400 RT cases were deleted for errors (11.9%), and additional 29 RTs (0.86%) were deleted due to the cut-off criteria for data trimming. Table 2 shows the means and standard deviations of RT and accuracy rates. RT for words was consistently faster with related primes than unrelated ones except for the consonant prime condition. The unstandardized effect size (i.e., mean difference) was greatest with the body primes in the judgment of words among the three conditions. The magnitudes of the mean difference among body, rime, and consonant primes was significantly different ($F(2,1543) = 8.63, p = .000$), with significant differences between the body and rime conditions and between rime and consonant conditions. The consonant prime effect was inconsistent with those of the body and rime.

Table 2. Means and standards deviations (in parenthesis) of RT and accuracy rates

	Words	**RT**		**NonWords**	**RT**	
	Body	**Rime**	**Consonant**	**Body**	**Rime**	**Consonant**
Unrelated	691.00 (97.42)	674.24 (107.87)	626.36 (91.21)	748.34 (102.10)	736.49 (96.15)	749.41 (97.34)
Related	653.60 (91.92)	651.92 (105.92)	651.07 (100.13)	745.09 (113.33)	723.66 (104.49)	711.01 (102.92)
Diff	**37.4**	**22.32**	**−24.71**	**3.25**	**12.83**	**38.4**
	Words	**Accuracy**		**NonWords**	**Accuracy**	
Related	96.07 (4.04)	92.68 (6.15)	95.36 (5.74)	92.68 (9.16)	94.64 (6.46)	95.71 (6.91)
Consistent	88.57 (10.45)	91.96 (5.79)	95.89 (5.24)	94.29 (6.84)	96.96 (5.33)	93.75 (8.71)
Diff	**7.5**	**0.72**	**−0.53**	**−1.61**	**−2.32**	**1.96**

Note: The RT of the unrelated stimuli was first presented in the table.

In order to consider fixed effects and random effects concurrently with respect to RT, a linear mixed model (LMM) was employed to estimate the effect of different conditions on RT, while adjusting correlations due to repeated measures of different conditions on each participant. The variance parameters were estimated based on the restricted maximum likelihood (REML) method. The experimental conditions and gender were specified as fixed factors which modeled the mean of the RTs, while subjects were specified as a random factor which modeled the covariance structure of the RTs.

The fixed effect estimates, which were estimates of mean parameters, indicating contrasts among levels of the experimental conditions, were significant: $F(5,170) = 14.58, p = .000$. The estimates of the fixed effects (i.e., estimates of mean parameters) on RT are shown in Table 3. The fixed effects of the conditions were significant, except for the unrelated primes for the rime format.

Table 3. LMM estimates of fixed effects for the word targets using RT

Parameter	Estimate	SE	*t*	*p*
Intercept	677.59	31.76	21.34	.026
Related body	−20.63	8.21	−2.82	.013
Related rime	−22.31	8.21	−2.72	.007
Related consonants	−23.17	8.21	−2.82	.005

Note: The unrelated control condition was set to zero as a baseline.

The estimate of covariance parameters for the random factor of subjects was significant (*Estimate* = 5688.13, *SE* = 2073.33, Wald $z = 2.74$, $p = .006$), indicating that random deviations from the relationships for the participants described by the overall fixed effects of the experimental conditions were significantly different. However, gender was not significant (Wald $z = .53$, $p = .596$). In short, different experimental conditions significantly affected word judgment speed for the participants.

As for accuracy, the unstandardized effect size was consistently greater in the body unit than in the rime unit (mean difference: 7.5 vs. 0.7), indicating that body primes facilitated the participants' accurate judgment of words from nonwords. The comparison between body and rime conditions resulted in a significant difference ($t(34) = 3.38$, $p = .002$). The accuracy rate for the comparison between the body and consonant conditions also yielded a significant difference ($t(34) = 4.33$, $p < .001$). However, the comparison between rime and consonant conditions was not significantly different.

Another LMM was performed using the accuracy data with the same entry scheme into the model. The experimental conditions and gender were used as fixed factors, while subjects were entered as a random factor. The fixed effect parameter for the accuracy rate was significant: $F(5,170) = 4.77$, $p < .001$. Table 4 shows the estimates of the fixed effects. The estimate of the fixed effect was significant only for the rime ($p < .001$). The estimate of covariance parameters for the random factor of subjects was significant: Estimate = 9.04, *SE* = 2.99, Wald $z = 3.01$, $p = .003$, *CI* = 3.72 – 17.32. In short, only the rime priming condition predicted the accuracy of word judgment in native Korean readers.

Table 4. LMM estimates of fixed effects for the word targets using accuracy

Parameter	Estimate	SE	*t*	*p*
Intercept	93.75	1.18	79.68	.000
Related body	2.32	1.50	1.55	.123
Related rime	−5.18	1.50	−3.45	.001
Related consonants	−1.07	1.50	−.71	.476

Note: The unrelated control condition was set to zero as a baseline.

Next, as the primes in this study were presented in a linear way, as indicated earlier, some primes were seemingly close to Korean syllables, especially when a consonant letter was adjacent to a vowel that characterized left-to-right orientation (i.e., ㅏ, ㅑ, ㅓ, ㅕ). In order to see whether or not this kind of pseudo-syllables yielded a facilitatory effect in speedy word recognition, a one-way ANOVA was performed for these prime items using three levels of occurrences (i.e., 0, 1, and 2). For example, the first set of CV combination in "ㅁㅏㅈㅗ" and both sets in "ㅇㅑㅁㅏ" look like real Korean syllables to a large extent, and have a similar configuration to the target, whereas a string "ㅅㅜㄱㅡ" does not have any part that looks like a Korean syllable. The RT was significantly different across the occurrences for the "look alike" pseudo-syllable: $F(2,29) = 3.53$, $p = .043$. Tukey post-hoc test showed that the presence of one pseudo-syllable was significantly faster than its absence and two pseudo-syllables ($p = .043$).

Discussion

This study examined the dominant intrinsic properties (i.e., bodies, rimes, consonants) of the syllable in Korean *Hangul* using a priming paradigm. Twelve different conditions were constructed with 96 words and nonwords consisting of two CVC syllables, including target-type dichotomy (i.e., words or nonwords), relatedness dichotomy (i.e., related primes or unrelated primes), and three units (i.e., bodies, rimes, and consonants only). In line with previous findings, significant effects of related primes were found in Korean readers' performance on word recognition. As expected, the results indicated that nonstandardized effect sizes for the body primes were greater than those of the rime primes and consonant primes in both accuracy and speed. When the unrelated control condition was set to zero for baseline, the results of an LMM analysis revealed that the body, rime, and consonant primes significantly affected lexical decision speed and that the rime primes had a significant effect on the accuracy of rapid word recognition.

The results of this study are noteworthy in three ways. First, unlike previous research that supported the salient body primacy, this study showed that both body and rime units facilitated rapid word recognition. Especially, only rimes played a significant role in the accuracy of lexicion decision. This result is consistent with Berg and Koops' (2015) *universal rime bias* and *symmetrical* syllable structure in *Hangul*. They further attributed the body primacy in Korean syllables to the high degree of coarticulation found in the body unit, dismissing phonotactic constraints for an explanation of sub-syllabic constituency. Coarticulation of the onset consonant and the following vowel in speech can be a byproduct of *Hangul*'s unique combinatory characteristics. As indicated earlier, a consonant and a vowel are packed in either a top-down or left-to-right block to form a syllable in *Hangul*, which makes *Hangul* a syllabic script in appearance. In other words, the minimal unit of the block format is the body unit in Korean. This notion accords the description provided in the *Standard Korean Language Dictionary* (National Institute of Korean Language, 1999) regarding the syllabic nature of Korean. This is also congruent with the Korean oral language that consists of three sounds (3 성, 三聲), including initial, middle, and final sounds, in the syllable. In consideration of the C-V union and complementarity in *Hangul*, the body-priming saliency reflects the cohesive combination of an initial consonant and the following vowel (i.e., body) in the script, which defines the phonotactic and graphotactic rules. As explained in Chapter 16 in this book, Korean consonant letters themselves cannot fulfill the function of sign systems unless they are combined with vowels, as the name of consonants indicates in Korean (i.e., 닿소리, a dependent sound), which, importantly, results in no consonant strings in Korean. When consonant strings in English are transcribed into Korean, an epenthetic vowel needs to be attached to each consonant to qualify as a syllable. For example, the word "Christmas" is a two-syllable word in English, but it becomes five syllables when it is transcribed into the Korean script (i.e., 크리스마스, chu-ri-su-ma-su), in which each consonant has a schwa-like vowel sound attached to it (i.e., Korean vowel "ㅡ") to make a syllabic chunk. This is a linguistic phenomenon that is also found in Japanese. Japanese learners of English tend to pronounce English words in syllabified units (see Broekhuyse & Taft's Chapter 10 in this book for this tendency found in a recall test among Japanese speakers). The difference between Korean and Japanese resides in the syllable length that the dominant syllable type of Korean is CVC, while that of Japanese is CV. For instance, if the word "ham" is transcribed into the Korean script, it becomes one syllable "햄 [hæm]" because Korean sounds allow for CVC three phonemes within a syllable. However, Japanese speakers tend to transcribe the word "ham" into two syllables "ha-mu" due to their CV dominant syllable structure in their language. Hence, it seems natural to find a body primacy in Korean *Hangul* due to the CV complementarity at the onset. Taken the result of rime-unit significance in this study as well as the Korean linguistic feature together, it may not be too farfetched to state that the Korean phonotactic criterion shows a *symmetrical* syllable structure, as Berg and Koops (2015) assert.

Second, it is important to note that linearly disassembled letter primes (i.e., fragments of the *Hangul* syllable) that had no feedback from real syllables or words significantly facilitated speeded word recognition. This suggests that letters may be an important unit that is identified first before the syllable, suggesting that a hierarchical progression from letters to body/rime units and to syllables in the process of activation. This is a new finding, as previous research in Korean has predominantly used word primes in the conventional square syllabic block. This result warrants further research in order to endorse the role of letters in Korean visual word recognition.

Third, there was no significant effect for consonant primes for accuraccy. This result offers an interesting interpretation about the role of consonants. Previous research has consistently indicated a more dominant role of consonants than vowels in reading Roman script (Carreiras, Gillon-Dowens, Vergara, & Perea, 2009; New, Perea, & Lupker, 2004; New, Araujo, & Nazzi, 2008; Lupker, Perea, & Davis, 2008). However, this study with consonant-only primes showed inconsistent results between RT and accuracy. Although the locus of the consonant primacy in Roman script is still under discussion, the inconsistent findings in *Hangul* may have to do with the unique syllabic structure in *Hangul*, including the vowel's central position of the syllable, C-V complementarity, relatively even numbers of Cs and Vs in the segmental inventory, and the printing convention. This finding also warrants more research for building theoretical models of word processing.

The additional finding using pseudo-syllables indirectly suggests a possibility of vowel importance. As indicated earlier, some primes included pseudo-syllables with a consonant and a vowel that would define a left-to-right syllabic format, and resulted in a stimulus that was seemingly close to a Korean syllable (e.g., the underlined first half of the prime in "<u>ㅁㅏ</u>ㅈㅗ" looks like a syllable, as opposed to "ㅅㅜㄱㅡ" that shows none). The results showed that the pseudo-syllabic primes yielded a significant effect on the participants' speedy judgment of words or non-words. This might have to do with their visual similarities to the body unit of CVC syllables. Importantly, only one pseudo-syllable (i.e., two-grapheme syllable) in a prime showed a significant effect, whereas two pseudo-syllables (e.g., ㅂㅏㅅㅣ, ㅇㅑㅁㅏ) did not. One explanation would be the SOA of 50 ms for prime presentation to be too short for the participant to recognize both two pseudo-syllables in linearity. It also indicates that *one* pseudo-syllable was salient enough to yield a significant effect on rapid word recognition in *Hangul*. The optimal length of SOA for recognizing the first Korean syllable calls for further examinations in follow-up studies.

Conclusion

Given that this study found that rime units played a significant role in RT in rapid lexical decision, unlike previous research, further research in this line is in need to validate the findings of this study. This is particularly important in the face of conflicting findings in the inquiry between Berg and Koops (2010, 2015) and the other studies (Kim, 2007; Lee & Goldrick, 2008). The difference in the approaches and methods employed in previous studies can be difficult to reconcile. However, the priming test used in this study that is different from previous studies provides a new addition to the extant literature in terms of methodology and behavioral evidence. In consideration that phonological mediation is crucial even in silent word recognition (Lukatela & Turvey, 1994), this study supports Berg and Koops' (2015) assertion that the body primacy in Korean syllables resides in the "coarticulation between the onset consonant and the following vowel" (p. 3). The results also suggest that the intrastructural property of the Korean syllable is characterized by the symmetry of body and rime units, as the vowel is at the core in both left branching (i.e., body) or right branching (i.e., rime). This is also consistent with the Berg and Koops' (2015) claim that Korean's *symmetrical* structure.

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CHAPTER 19

Cognitive-linguistic skills and reading and writing in Korean *Hangul*, Chinese *Hanja*, and English among Korean children

Jeung-Ryeul Cho
Kyungnam University, South Korea

This study examined the contribution of orthographic awareness (OA), rapid automatized naming of numbers (RAN), phonological awareness (PA), morphological awareness (MA) in L1 Korean to word reading and writing in L1 Korean Hangul, Chinese Hanja, and L2 English among 98 Korean 5th graders. Korean language and orthography have relatively transparent phonological and morphological structures. Korean children learn Hangul in kindergarten, Hanja in elementary school as an elective subject, and English in Grade 3 as an L2. Results showed that Korean OA accounted for significant variance of Hangul reading; and Korean PA explained English reading and writing and Hangul writing; Korean MA explained writing in Hangul, Hanja, and English; RAN explained English reading only. These results suggest that MA is the meta-linguistic skill that transfers across alphabetic and non-alphabetic languages, whereas PA transfers across alphabetic languages. However, orthographic awareness is language-specific.

Keywords: morphological transfer, phonological transfer, orthographic awareness, RAN, Korean Hangul and Hanja

Word recognition is related to phonology, morphology and orthography of a language and a writing system (Seidenberg & McClelland, 1989). A great number of studies on literacy and biliteracy development demonstrated that phonological, morphological, and orthographic processing skills are related to reading and writing among children. Relative contributions of the processing skills to literacy depend on writing systems and a learner's literacy proficiency. For example, phonological awareness (PA) is linked to reading skills in alphabetic languages as a first language (L1) and a second language (L2) (e.g., Adams, 1991; Cisero & Royer, 1995; Comeau, Cormier, Grandmaison, & Lacroix, 1999; Durgunoglu, 2002; McBride, 2015; Wagner & Torgesen, 1987). Morphological knowledge has been examined

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in the literature using both alphabetic and non-alphabetic languages (e.g., Deacon, Wade-Woolley, & Kirby, 2009; Feldman, 1995; Galambos & Goldin-Meadow, 1990; Geva, 1995; Kuo & Anderson, 2006).

Recent studies showed a significant association between orthographic processing and reading differences in alphabetic languages and Chinese language among monolingual children (e.g., Cassar & Treiman, 1997; Deacon, 2013; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009; Stanovich, West, & Cunningham, 1991). Rapid automatized naming (RAN) is also important to distinguish good readers from poor readers in clinical settings (Denkla & Rudel, 1976) although its conceptual and empirical evidence for literacy development is still being debated. However, few, if any, studies dealt with these issues in diverse orthographies in a group of participants to control for individual differences. The current study aims to examine how differently Korean phonological, morphological, and orthographic processing skills contribute to reading and writing abilities in Korean Hangul and Hanja (Chinese characters), as well as in English as a second language among Korean 5th graders.

Korean children learn to read and write three scripts of Korean Hangul, Chinese Hanja, and English as an L2. Hangul, a major script in Korea, is alphabetic just as is English. But Hangul is a shallow orthography having consistent grapheme-to-phoneme correspondences, whereas English is a deep orthography. In contrast, Hanja is adopted from non-alphabetic Chinese characters for the Korean language. Korean children also learn English as an L2 from the 3rd grade. Therefore, data from Korean children learning Hangul, Hanja, and English can provide good empirical evidence on how phonological, morphological, and orthographic processing skills in L1 contribute differently to reading and writing across first and second languages and writing systems.

Korean orthography: Hangul and Hanja

Hangul is an alphabet with 14 basic consonants (ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, ㅇ, ㅈ, ㅊ, ㅋ, ㅍ, ㅌ, ㅎ) and 10 basic vowels (ㅏ, ㅑ, ㅓ, ㅕ, ㅗ, ㅛ, ㅜ, ㅠ, ㅡ, ㅣ). Each Hangul letter represents a sound, showing relatively transparent grapheme – phoneme connections. For example, consonants ㄴ and ㅅ make the sounds /n/ and /s/, respectively, and the vowels of ㅏ and ㅗ make the respective sounds of /a/ and /o/. Although it is an alphabet, letters are written as a syllabary in a uniform square block, called Gulja (e.g., 사 /sa/ meaning *four;* 손 /son/ meaning *a hand*). Alphabet letters are written in order from left to right or from top to bottom within Gulja. Since each Gulja reflects both the entire syllabic structure and its constituent phonemes, Hangul is called an alphasyllabary (Taylor & Taylor, 2014). The structure of Gulja is relatively simple compared with English: Most Gulja are of CV (e.g., 나 /na/

meaning *I*), CVC (e.g., 산 /san/ meaning *a mountain*), or CVCC structure (e.g., 닭 /dak/ meaning *a chicken*).

Korean people used non-alphabetic Hanja, a subset of Chinese characters, as their writing system for more than 10 centuries before the Hangul alphabet was invented in the 15th century. Each Hanja character directly encodes and represents a syllable and a morpheme, a basic unit in meaning. In general, Hanja is similar to original Chinese characters in shape, meaning, and sound, but no tones. Although, recently, the use of Hanja decreases in Korea due to the policy of "exclusive use of Hangul", but it is still important in understanding of the Korean language. Korean children learn Hanja as an elective subject in elementary school and as a required subject in secondary school.

The Korean language has common features with Chinese in morphology. For example, more than 50% of Korean vocabularies were adopted from Chinese. Sino-Korean words denote abstract concepts and technical terms, whereas many Korean native words are frequently used common words. Sino-Korean words can be written in both Hanja and Hangul (e.g., 學校 학교 /hak.kyo/ meaning *a school*), whereas Korean native words and grammatical morphemes can only be written in Hangul. Sino-Korean words are compounds and have many homophones as are Chinese words. For example, since Sino-Korean words use a relatively limited number of about 400 syllables (Taylor & Taylor, 2014), many Sino-Korean morphemes and words are homophones. Hanja is used to differentiate homophones of Sino-Korean words because each meaning of a homophone will map onto a different Hanja character.

Korean children begin to learn Hangul in kindergarten or at home at the age of 4 or 5. They first learn to read CV and CVC Gulja and learn the Korean Hangul alphabet later. At age 6, when they enter primary school, most children can read regular words with consistent letter-sound correspondences. Children learn some phonological changes of the Korean language caused by resyllabification, assimilation, and palatalization in elementary school. They also learn compound concepts and words, Sino-Korean words in particular, in diverse classes from the 4th grade on. In most elementary schools, Korean students learn to read and write Hanja as an elective subject. Each Hanja is taught with a meaning and a sound together. For example, 一 is taught as *one* /il/ and 日 as *a day* /il/. Korean students also learn English as a second language from the 3rd grade on. They learn oral English consisting of greetings, phrases, and short sentences in the 3rd grade, and English alphabets and written English from the 4th grade. This study thus examined Korean fifth graders who had learned English from the 3rd grade and Hanja from the 5th grade to investigate whether or not Korean phonological, morphological, and orthographic processing skills would have differential associations with their reading and writing abilities across Hangul, Hanja, and English.

Phonological awareness

Phonological awareness (PA) is the ability to discriminate and manipulate the sound units of spoken words ranging from syllables to phonemes (see McBride, 2015, for a review). PA abilities have been considered a critical predictor of early literacy development for alphabetic orthographies (Adams, 1990; Wagner, Torgesen, & Rashotte, 1994). PA is also influential for early reading acquisition of Korean Hangul (Cho & McBride-Chang, 2005a; Cho, McBride-Chang, & Park, 2008; Kim, 2007). Cho and McBride-Chang (2005a), for example, demonstrated that both syllable and phoneme awareness significantly accounted for variability in Hangul word recognition among Korean kindergartners and second graders after controlling for vocabulary and naming speed. However, the relation of PA with Hangul reading was decreased in upper elementary school students (Cho, Chiu, & McBride-Chang, 2011) although not many studies tested old children in Korea. Given few evidence for the relation of PA with Hangul reading and writing among older children, this study aimed to include PA tasks in Korean to examine their associations with reading and writing in Hangul.

Studies on biliteracy and second-language acquisition have provided growing evidence that PA skills in an L1 are related to and predictive of reading skills in an L2 (Chiappe & Siegel, 1999; Chiappe, Siegel, & Gottardo, 2002; Cisero & Royer, 1995; Comeau et al., 1999; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Geva, Wade-Woolley, & Shany, 1993, 1997). Most of the early bilingual studies examined associations of PA skills across two alphabetic languages that share the same writing system, namely the Roman alphabet, such as English as an L2 and Spanish, or Italian as an L1 (e.g., Comeau, et al., 1999; Cisero & Royer, 1995; Durgonoglu et al., 1993). Phonological transfer was also demonstrated across two different writing systems, namely, Chinese and English (Chow, McBride-Chang, & Burgess, 2005; Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Wang, Perfetti, & Liu, 2005) and Korean and English (Wang, Park, & Lee, 2006). Among Chinese-English bilingual children, rhyme awareness (Gottardo et al., 2001) and syllable awareness (Chow et al., 2005) were associated with success of L2 English reading skills. In a Korean-English bilingual study, rhyme and phoneme awareness skills in L1 Korean were strongly related to L2 English reading (Wang et al., 2006). Cho and McBride-Chang (2005b) demonstrated that Korean phoneme awareness in the 2nd grade was predictive of subsequent word recognition in English as an L2 after 1 year. Similarly, Cho et al. (2011) found that L1 Korean PA was predictive of L2 English reading among Korean 4th graders over 2 years and their PA link was stronger for older children than younger ones. These Chinese and Korean studies tend to indicate that phonological transfer is not restricted to languages with similar structures. We, in the present study, aim to further validate the previous findings by examining whether Korean PA transfers to reading and writing of non-alphabetic Hanja.

RAN

Another phonological processing area of research has focused on rapid automatized naming (RAN) of familiar materials such as numbers, letters, or pictures. The process of RAN is supposed to include various skills such as phonological access in lexical memory (Wagner & Torgesen, 1987) and non-phonological skills of visual sequencing and symbol processing (Manis, Seidenberg, & Doi, 1999; Wolf & Bowers, 1999). The relation between RAN and reading skills varies across orthographies and reading proficiency (Cho & Chiu, 2015; Moll & Landerl, 2009). For example, RAN is related to early reading but not skilled reading in English as an L1 among English-monolingual children (Georgiou, Parrila & Liao, 2008) and as an L2 among Korean children (Cho & Chiu, 2015). Speeded naming is correlated more strongly than PA in some transparent orthographies such as German and Dutch and in the opaque orthography of Chinese (de Jong & van der Leij, 1999; Ho & Bryant, 1997; Wimmer, Mayringer, & Landerl, 2000). However, the contribution of RAN is likely to decrease in English when PA is taken into account. In a cross-language study with diverse alphabetic orthographies, Ziegler et al. (2010) demonstrated that reading accuracy was linked to PA but not RAN in second graders, suggesting that insufficiently sensitive PA tasks might allow the phonological factor of RAN to contribute to reading. Thus, the current study further tests this suggestion with an alphabetic orthography, Korean Hangul. Although Korean is a relatively transparent orthography, the role of RAN was found to be equivocal in early Hangul reading acquisition among kindergartners and 2nd graders (Cho & McBride-Chang, 2005a, b) and upper elementary school children (Cho & Chiu, 2015), but the role was significant in a study among kindergartners (Cho et al., 2008). The lack of consistency in previous findings requires further exploration. In addition, the current study also investigates whether RAN is related to less-skilled reading in English as an L2 among Korean children (e.g., Cho & Chiu, 2015).

Morphological awareness

Morphological awareness (MA) facilitates children's reading and writing in diverse orthographies including English and Chinese studies (Feldman, 1995; McBride, 2015 for a review). MA refers to the ability to manipulate and recognize morphemes. English studies have demonstrated the important roles of derivational and inflectional morphology in learning to read and write (Bryant & Nunes, 2004; Carlisle, 2000; Nagy, Berninger, & Abbott, 2006; Singson, Mahony, & Mann, 2000; Verhoeven & Perfetti, 2003). On the other hand, compound morphology is particularly important in the Chinese language in part because Chinese morphemes are relatively transparent in their meanings and most Chinese words consist of two or more morphemes (McBride, Shu, Zhu, Wat, & Wagner, 2003; Shu, McBride- Chang, Wu & Liu, 2006). The Korean language contains similar aspects with Chinese in the prevalence of lexical compounding and homophones (Taylor & Taylor, 2014). In Korean vocabulary, Sino-Korean words and even many Korean native words consist of multi-morphemes. For example, the English words *beef, pork and fish* are literally translated as *cow meat* (소고기 /so.ko.ki/), *pig meat* (돼지고기 /dæ.ʤi.ko.ki/) and *water meat* (물고기 /mul.ko.ki/) in Korean. Indeed, in a cross-cultural study, MA was found to be important in reading both Korean Hangul and Chinese, but not in English among monolingual 2nd graders who were from three different cultures of Korea, China, and the United States (McBride-Chang et al., 2005).

Morphological transfer across languages is an important issue in biliteracy studies (e.g., Carlisle, 2000; Nunes & Hitano, 2004). Because many uses of morphological knowledge in literacy are more or less conscious and explicit, that is, metalinguistic, it is hypothesized that morphological skills transfer across languages (e.g., Nunes & Hitano, 2004). Several studies have evidenced the transfer of MA across Indo-European languages such as English and Spanish (Galambos & Goldin-Meadow, 1990) and English and Hebrew (Geva, 1995), where two languages share grammatical and morphological principles. Recent studies have also examined this issue across languages with dissimilar morphologies among Chinese-English and Korean-English bilingual children. For example, Wang et al. (2006) demonstrated that lexical compounding morphology in L2 English contributed to reading in L1 Chinese among Chinese-English bilinguals although MA in L1 Chinese was not linked to reading in L2 English. In a recent Korean study, Korean compounding morphology in 5th grade is longitudinally predictive of English writing in 6th grade (Cho & Chiu, 2015). The present study investigates the relations of Korean children's knowledge of lexical compounding and homophones to their success in reading and writing of Hangul, Hanja, and English.

Orthographic awareness

Orthographic awareness (OA) refers to the use of orthographic knowledge which can be defined as graphic patterns of a written language or frequency of letter sequences and spatial position patterns in words (McBride, 2015; Wagner & Barker, 1994). Significant relations were found between children's OA and reading in alphabetic languages (e.g., Cassar & Treiman, 1997; Deacon, 2013; Roman et al., 2009; Stanovich et al., 1991). For example, French-speaking children in Grades 1 through 4 were more likely to classify pseudowords as word-like when they contained high frequency rather than low frequency doublets (e.g., mm-cc) (Pacton, Perruchet, Fayol, & Cleeremans, 2001). In particular, OA was found to be important in distinguishing poor readers from good readers in Chinese (Chung et al., 2010; Ho, Chan, Tsang & Lee, 2002). Mastering to read and write Chinese characters may require adequate orthographic knowledge since most Chinese characters have visual complexities and arbitrary correspondences between print and sound. However, not many studies have dealt with orthographic processing of reading and writing in Hangul.

There is far less evidence that OA transfers to word reading across Indo-European languages that share the same alphabetic writing system (Deacon et al., 2011; 2013). For example, Deacon et al. (2011) found that Spanish orthographic knowledge was related to English word reading for Spanish-English bilingual children in Grades 4 and 7. However, there is little evidence to date of cross-language transfer of OA to reading in two different writing systems such as Korean and English, and Chinese and English. For instance, Wang et al. (2006) showed that English OA contributed to English reading, and Korean OA contributed to Korean Hangul reading. Similarly, Deacon et al. (2011) demonstrated consistent results within language relations for Spanish-English bilinguals. The nature of orthographic processing skills in children learning to read in two or more languages is not yet clear. The current study thus examined orthographic processing skills of Korean Hangul and its relation to reading within languages and transfer to reading across languages among Korean children who learn to read and write all three languages.

Purpose of this study

This study investigated how differently Korean PA, MA, OA and RAN were associated with reading and writing skills in Korean Hangul and Hanja, and in English as an L2 among Korean 5th graders. We have four research questions. First, is Korean PA, i.e., syllable and phoneme awareness, related to reading and writing in alphabetic Hangul, non-alphabetic Hanja and English as an L2? Some studies demonstrated that PA was strongly associated with early Hangul reading (e.g., Cho, McBride-Chang, 2005a; Cho et al., 2008); however, it was not certain whether similar relations would be obtained in upper elementary students as in younger children. In addition, Korean PA was expected to be strongly associated with reading and writing in alphabetic English but not in non-alphabetic Hanja. Second, is Korean compounding MA related to reading and writing in Hangul, Hanja and English? We expected that compounding MA in Korean would be more strongly associated with reading and writing skills in Hanja than in English. The transfer of Korean MA to reading and writing in English and Hanja would suggest that it is a language-general ability that transfers across alphabetic and non-alphabetic scripts. Third, is Korean OA related to reading and writing in Hangul, Hanja and

English? We expect that Korean OA would be associated with reading and writing in Korean Hangul due to good evidence of its within- language relations and less evidence of cross-language relations. Fourth, is number RAN in Korean related to reading and writing in Hangul, Hanja and English? Since RAN was found to be related to early and less skilled reading in alphabetic languages such as English (e.g., Cho & Chiu, 2015), we expect that Korean RAN would be related to English reading as an L2 in this study.

Method

Participants

Participants were ninety eight 5th graders of a public primary school in Kyungnam Province, Korea. The mean age of students was 10.9 years. All of them were native Korean speakers. The students learned English as a required subject for more than 3 hours a week from the 3rd grade, whereas they learned Hanja for one hour a week from the 5th grade as an elective class. Children learned Hanja for about 5 months at school since they were tested in the middle of the 5th grade. Reading and writing skills in English and Hanja differ considerably among Korean children because many of them often learn English and Hanja at home or from private tutoring.

Procedure

Students participated in two testing sessions of individual and group testing, each lasting approximately 40 minutes. During individual testing, children were tested in quiet rooms at school by trained graduate students majoring in psychology whereas group sessions took place in the classroom. The measures were administered as follows.

Hangul word reading

Children were tested with a list of 90 words of two and three syllables in an individual setting. In order to increase the difficulty level of the words, all words in the list required the application of Korean phonological changes such as resyllabification, consonantal assimilation, and palatalization. The words were presented from easiest to most difficult. Children were asked to read from the beginning of the test. Testing was stopped when 5 consecutive items were failed. There was no time limit for the testing. One point was awarded for every item correctly read aloud based on phonological rules in Korean. Thus, the maximum score on this task was 90.

Hangul word writing

This task was done in a group setting. Children were orally presented 40 multi-syllable words and were asked to write the words on a paper. One point was allotted for every item correctly spelled. The maximum score on this task was 40.

Hanja character reading

This task was done in a group setting. It consisted of 40 Chinese characters that were selected from Hanja textbooks for Korean primary school children. The 40 characters were written in a page with a blank next to each character. The children were asked to write down the sound of each character in Hangul in the blank and every correct item was allotted one point. Although group testing does not reflect a typical procedure for a reading task, the Korean 5th graders did not have difficulty in writing the sounds of Hanja characters in Hangul because each Hanja character is a syllable consisting of CV or CVC and Hangul is a transparent orthography. The maximum score of this task was 40.

Hanja character writing

Children were orally presented 30 Hanja characters with a meaning in a group setting. They were asked to write the Hanja characters on a paper. One point was awarded for every item if correctly written. Thus, the maximum score on this task was 30.

English word reading

We administered a task of English word reading in an individual setting. This test consisted of 40 English words that were selected from English textbooks used in Korean primary schools. The words were presented in a graded list. Children were asked to read aloud, and testing was stopped when 5 consecutive items were failed. Every correct word was allotted one point. There was no time limit for the testing. All items were real words in this task. The maximum score of this task was 40.

English word writing

This task was done in a group setting. Children were orally presented 30 words and were asked to write the words on a paper. One point was given for every item if correctly spelled. Thus, the maximum score on this task was 30.

Korean PA

This task included two tasks of syllable deletion and phoneme onset deletion. The two tasks were administered individually. In syllable deletion task, children were orally presented with stimuli from which they were asked to delete a syllable. This task contained six 3-syllable words, six 3-syllable non-words, and six 4-syllable non-words, making 18 items in total. Children were asked to take away a middle syllable in each item. For example, *son jang mil* (손장밀) without *jang* (장) would be *son mil* (손밀).

In phoneme onset deletion task, children were orally presented with 18 one-syllable words and non-words with a CVC construction. Then they were asked to delete an initial phoneme from each syllable. An example is saying *tum* (텀) without the initial sound, to get *um* (엄).

Korean RAN of numbers

The task of number naming included the same five digits arranged in different orders across five rows. For the task, children were asked to name all items as quickly as possible. Trained experimenters measured children's naming time from the first item to the final with a stop watch. Testing procedure was similar to that of rapid naming of CTOPP (Wagner, Torgesen, & Rashotte, 1999). Two trials were administered in each task, and the average speed on each task was used for analysis.

Korean morpheme production

Morpheme production task was originally developed by Shu et al. (2006). It was administered in a group session. Children were orally presented with a two-syllable Korean word and informed a target syllable with its meaning. The target syllable represents a morpheme in each word and has homophones. Children were asked to produce and write two words in Hangul including the target syllable: One word had to include the target morpheme whereas the other word had a different morpheme from the target. Both morphemes were the same in sound and writing in Hangul. For example, when the experimenter orally presented the word 군밤 /kun.bam/ (meaning *roasted chestnut*), children were then asked to produce a new word with the morpheme 밤 /bam/ meaning *chestnut*. An answer could be 밤나무 /bam.na.mu/ (meaning *chestnut tree*). Children were also asked to produce a new word that included the morpheme 밤 /bam/ which has a different meaning from *chestnut*. An answer would be 밤낮 /bam.nat/ (meaning *day and night*). There were 30 items. The maximum score was 60 because each item had two answers.

Korean orthographic awareness

This task was done in a group setting. Children were given 80 items that consist of 1–3 Gulja. Half of them were real words that spelled correctly and another half were spelled wrong. Students were asked to choose the correct spelling for a real word among 80 items. The maximum score was 80.

Korean vocabulary

This task was adopted from the task of Korean receptive vocabulary (Kim, Chang, Yim, & Paek, 1995). Among 4 choices, students were to select a picture that correctly represents a word. There were 88 items in total. One point was given for every item if correctly chosen. Thus, the maximum score was 88 in this task.

Results

Means, standard deviations, and reliability estimates are shown in Table 1. In general, tasks showed adequate reliabilities and did not show any obvious ceiling or floor effects. Two exceptions were Hangul reading and syllable deletion, where children demonstrated relatively high performances, with the mean values of 88% and 86%, respectively, and low internal consistency reliabilities (.64 and .55, respectively).

Table 1. Means, SDs, and reliabilities of variables

Variable	Reliability	*M*	*SD*
Vocabulary (88)[a]	.99	81.32	4.17
Syllable deletion (18)[a]	.55	15.55	2.02
Phoneme deletion (18)[a]	.70	15.34	2.18
RAN (sec)[b]	.84	8.41	2.09
OA (80)[a]	.89	47.82	5.96
MA (60)[a]	.98	22.66	6.33
Hangul reading (90)[a]	.64	79.44	4.03
Hangul writing (40)[a]	.88	32.38	5.86
Hanja reading (40)[a]	.94	24.27	8.02
Hanja writing (30)[a]	.88	7.12	4.32
English reading (40)[a]	.98	27.13	13.39
English writing (30)[a]	.96	20.23	10.00

Note. $N = 98$. Total scores are in parentheses.

[a] Internal consistency reliability.

[b] Test-retest reliability.

Table 2 shows correlations among all variables included in the present study. OA, syllable and phoneme deletion RAN and MA tasks showed somewhat different patterns of associations with reading and writing across Hangul, English, and Hanja. RAN was significantly associated with Hanja writing ($r = -.20$, $p < .05$) and English reading ($r = -.30$, $p < .01$). Syllable deletion appeared to be significantly associated with reading and writing in Hangul and English ($.29 < rs < .36$, $ps < .01$) and Hanja writing ($r = .22$, $p < .05$). Similarly but relatively weakly, phoneme deletion was significantly associated with Hangul writing ($r = .24$, $p < .05$) and reading and writing in English ($.22 < rs < .28$, $ps < .05$). MA was strongly associated with reading and writing in the three scripts ($.30 < rs < .58$, $ps < .01$). However, OA was significantly related to Hangul reading only ($r = .22$, $p < .05$). Vocabulary was moderately associated with all the measures except RAN and OA ($.31 < rs < .58$, $ps < .01$). In addition, Hangul word reading was strongly associated with English reading and writing ($.43 < rs < .45$, $ps < .001$) but weakly associated with Hanja reading and writing ($.20 < rs < .25$, $ps < .05$). Hangul writing was strongly associated with reading and writing in English and Hanja ($.51 < rs < .62$, $ps < .001$). Correlations between reading and writing within each script were found to be strong, ranging from .48 to .88.

Table 2. Correlations of all variables

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Vocabulary											
2. Syllable deletion	.29**										
3. Phoneme deletion	.30**	.36**									
4. RAN	−.05	−.15	−.08								
5. OA	.05	.02	−.14	−.02							
6. MA	.55***	.21*	.10	−.04	−.01						
7. Hangul reading	.42***	.29**	.16	−.07	.22*	.30**					
8. Hangul writing	.58***	.36**	.24*	−.16	.03	.58***	.48***				
9. Hanja reading	.37***	.12	.12	−.18	.00	.35***	.25*	.56***			
10. Hanja writing	.31**	.22*	.17	−.20*	.08	.39***	.20*	.51***	.76***		
11. English reading	.35***	.36**	.22*	−.30**	.10	.32**	.43***	.61***	.47***	.35***	
12. English writing	.37***	.36**	.28**	−.17	.05	.42***	.45***	.62***	.51***	.41***	.88***

Note.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Finally, a multiple regression analysis with one set of predictors was conducted to evaluate how well Korean cognitive-linguistic measures predicted each of reading and writing skills in Hangul, English and Hanja. The predictors were vocabulary, PA, RAN, OA, and MA in Korean. Korean vocabulary, which has been shown to be important for reading abilities, was also entered into the equations to control for the variance in explaining reading and writing. Syllable and phoneme deletion scores were combined to make a PA composite score because the two tasks showed similar patterns of correlations. The linear combination of predictor measures was significantly related to each of reading and writing measures. That is, predictor variables accounted for a significant amount of Hangul reading $R^2 = .25$, $F(5, 92)=5.97$, $p < .001$; Hangul writing $R^2 = .48$, $F(5, 92) = 16.84$, $p < .001$; Hanja reading $R^2 = .19$, $F(5, 92) = 4.39$, $p < .001$; Hanja writing $R^2 = .22$, $F(5, 92) = 5.06$, $p < .001$; English reading $R^2 = .28$, $F(5, 92) = 7.03$, $p < .001$; and English writing $R^2 = .29$, $F(5, 92) = 7.65$, $p < .001$. Table 3 presents final beta weights for all variables to indicate the relative strength of the individual predictors. Results showed that OA and vocabulary were statistically significant to predict Hangul word recognition, and vocabulary, PA, and MA accounted for significant variance of Hangul word writing. On the other hand, vocabulary explained significant variance in Hanja reading, and only MA accounted for Hanja writing. PA and RAN accounted for significant variance in English reading, and PA and MA accounted for English writing.

Table 3. Standardized beta weights for regression equation with reading and writing in Hangul, Hanja, and English as the dependent measures

	Hangul				**Hanja**				**English**			
	Reading		**Writing**		**Reading**		**Writing**		**Reading**		**Writing**	
	B	***t*-value**	***B***	***t*-value**	***B***	***t*-value**	***B***	***t*-value**	***B***	***t*-value**	***B***	***t*-value**
Vocabulary	.29	2.51*	.31	3.23**	.25	2.11*	.09	.75	.15	1.37	.09	.844
PA	.16	1.59	.17	2.11*	−.00	−.03	.13	1.27	.23	2.40*	.29	3.01**
RAN	−.03	−.28	−.10	−1.36	−.16	−1.70	−.17	−1.78	−.25	−2.79**	−.11	−1.23
OA	.22	2.37*	.03	.37	−.02	−.19	.08	.87	.10	1.13	.07	.76
MA	.12	1.08	.38	4.22***	.21	1.85	.31	2.81**	.18	1.74	.31	2.94**

Note.
* $p < .05$, ** $p < .01$, *** $p < .001$.
Hangul reading: $R^2 = .25$; Hangul writing: $R^2 = .48$; Hanja reading: $R^2 = .19$; Hanja writing: $R^2 = .22$; English reading: $R^2 = .28$; English writing: $R^2 = .29$.

Discussion

Our results clearly highlighted the importance of Korean OA for Hangul reading and Korean RAN of numbers for English reading as an L2 among Korean 5th graders. PA appeared to be significantly associated with Hangul writing and English reading and writing and MA with writing in the three scripts of Hangul, Hanja, and English. These findings are discussed further as below.

In contrast to previous research on early Hangul acquisition among young children (e.g., Cho & McBride-Chang, 2005a; Cho et al., 2008; Kim, 2007), phonological awareness did not account for significant variance of Hangul reading in the current study once PA, OA, RAN, MA and vocabulary were included in a multiple regression equation as one set. Instead, OA explained significant variance in Hangul reading. Thus, the role of PA in Hangul word recognition seemed to diminish, instead students are sensitive to and rely on orthographic patterns in their Hangul reading during upper elementary grades (e.g., Olson, Forsberg, Wise, & Rack, 1994; Stanovich & West, 1989). These results support the traditional stage models that predicted orthographic stage at an older age (Ehri, 1999; Frith, 1980). Indeed, it is one of the first studies to demonstrate the significant relations of orthographic awareness to reading in Hangul among Korean upper elementary school students. However, Korean orthographic processing was not related to reading and writing in Hanja and English, which is in line with no evidence to date of the cross-language transfer of OA to reading in two different writing systems such as Korean and English (Wang et al., 2005; 2006). Note that transfer of orthographic processing across languages occurs only when children are learning to read in two languages that are represented with the same writing system of Roman alphabet (Deacon et al., 2011). Instead, our finding supports significant within-language relations of OA and literacy (e.g., Deacon et al., 2011; Wang et al., 2005; 2006).

Moreover, L1 Korean RAN of numbers was demonstrated to be important only for L2 English word reading, which supports previous findings in Korean-speaking children (Cho & Chiu, 2015), Chinese-speaking children (Chung & Ho, 2010; Pan et al., 2011), as well as in monolingual English-speaking young children (Meyer, Wood, Hart, & Felton, 1998; Torgesen et al., 1997). L1 Korean alphanumeric RAN might share some common arbitrary symbol processing with less-skilled reading of L2 English (e.g. Chow et al., 2005; Manis et al., 1999; Pan et al., 2011). Since Korean children were not skilled in English decoding, they are likely to read L2 English words by sight as young English-speaking children did. However, in the current study, L1 Korean RAN was not associated with Hangul reading and writing, suggesting that RAN might not be related to skilled reading and writing among Korean upper elementary school children (e.g., Cho & Chiu, 2015). Unexpectedly, L1 Korean RAN was not found to be linked to Hanja reading and writing, which is different from early findings in Korean- and Chinese-speaking children (Cho & Chiu, 2015; Chan et al., 2006; Chow et al., 2005). Further research may test their links among Korean students whose proficiency of Chinese Hanja are at a different stage.

As expected, Korean PA contributed to reading and writing in English as an L2, supporting previous findings on biliteracy and L2 acquisition among Korean children (Cho & McBride-Chang 2005b; Wang et al., 2006) as well as among Western children (Comeau, et al., 1999; Cisero & Royer, 1995; Durgonoglu et al., 1993; Lindsey et al., 2003). However, PA in Korean was not related to Hanja reading and writing in this study, although PA in L1 Chinese, for example, syllable or rime awareness, was found to be important in reading Chinese as an L1 (e.g., Chow et al., 2005; Ho & Bryant, 1997) and in reading English as an L2 in Chinese studies (Chow et al., 2005; Gottardo et al., 2001). However, there is little evidence to date of cross-language transfer of PA in an L1 alphabetic language to reading in non-alphabetic Chinese as an L2. The insignificant role of PA in Hanja reading and writing in this study indicates that Korean PA transfers to learning how to read and write alphabetic writing systems such as English but not to non-alphabetic writing systems such as Chinese Hanja. In this study, it was not surprising to find the significant role of Korean compounding MA skills in writing in both of Hangul and Hanja because the Korean language has a prevalent compounding morphology. Note that Sino-Korean words that can be written in both of Hangul and Hanja consist of multi-morphemes and each Hanja character is a morpheme. More importantly, Korean compounding MA explained a significant variance in writing English words after vocabulary, RAN and PA in Korean were controlled, although morphology between Korean and English is considerably different in their specifics as well as in principles. These results suggest that morphological transfer is not limited to languages with similar structures. In other words, MA may be a language-general ability that transfers across both alphabetic and non-alphabetic languages (e.g., Nunes & Hitano, 2004).

There were several limitations of the present study that could be improved in future works. First, lexical orthographic task used in this study might be too close to the format of reading tasks. This similarity problem might be resolved by including more diverse batteries of both lexical and sub-lexical tasks (e.g., Castles & Nation, 2006; Cunningham, Perry, & Stanovich, 2001; Deacon, 2013). Second, our tasks of MA captured only lexical compounding but no other important features of Korean morphology, such as inflections and derivations. Future research may need to develop various MA tasks including inflections, derivations, as well as compounding of Korean to further validate which morphological skills transfer to reading skills across languages with different structures. Third, this study was not longitudinal. Further research needs to demonstrate developmental associations between cognitive-linguistic skills and literacy across scripts employing longitudinal research designs. Finally, this study included cognitive-linguistic skills in L1 Korean only. Future study may need to include their skills in Chinese Hanja and L2 English. In particular, it would be interesting to examine bidirectional associations of L1 to L2 and L2 to L1.

In summary, L1 Korean OA appeared to be particularly important predictors of Hangul word reading in the upper elementary school students, whereas the influence of PA are likely to diminish. L1 Korean RAN was related to L2 English reading only, suggesting that RAN is more related to less-skilled reading of English as an L2 (Cho & Chiu, 2015). Korean PA contributed to reading and writing skills in English but not in Hanja. This indicates that phonological transfer likely occurs across alphabetic languages but not to non-alphabetic languages. Moreover, Korean MA was found to contribute a significant variance to writing in Hangul, Hanja, and English. It is thus suggested that MA is the language-general ability that transfers across both of alphabetic and non-alphabetic languages and writing systems with different structures. Our findings support the central processing hypothesis, which suggests that there are common fundamental cognitive and linguistic processes underlying learning to read languages (see e.g., Deacon, 2013; Gleitman, 1985). Our results provide some practical implications that Korean MA and PA skills could be trained for Korean upper elementary students to improve reading and writing skills in Korean Hangul and Hanja, as well as English as a second language.

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CHAPTER 20

Neural mechanisms of reading in Korean L1 and related L2 reading

Say Young Kim and Min Wang
Hanyang University, Seoul, Korea / University of Maryland, College Park, MD, USA

Korean has a unique status compared to other alphabetic orthographies in terms of its phonology-orthography mapping and visual-orthographic configuration. In this chapter we reviewed recent literature on the neural bases of reading in Korean L1 to understand whether and how the characteristics of Korean orthography are reflected in the brain network. We then reviewed recent neuroimaging literature concerning the L1 effect on L2 reading with Korean L1. Evidence suggests that when reading English L2, native Korean readers engage the brain network similar to the Korean L1 network (i.e., assimilation). In contrast, when reading Chinese L2, the brain network involved is significantly different from the Korean L1 network (i.e., accommodation). The L2 brain network seems to be shaped by L1 experience. The chapter concluded with a discussion of future research directions.

Keywords: neural mechanism, reading in Korean, L1 reading network, L2 reading network

Introduction

The Korean script, Hangul, was invented in the 15th century. With 14 consonants and 10 vowels, Hangul is an alphabetic system, in which letters are mapped onto phonemes similar to other alphabetic orthographies such as English, Spanish, and Italian. The letters in a Hangul syllable are arranged in a block from left to right and/or from top to bottom (e.g., 한글, "hangul"). Because the Hangul syllable blocks are visually clearly separated, similar to the logographic Chinese characters in which phonology is represented at the syllable level, Korean Hangul is often considered an alphabetic syllabary or syllabic alphabet (e.g., Taylor, 1980; see also Pae, 2011 for further discussion of Korean writing system). Hence, Korean Hangul has a unique

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status among the alphabetic orthographies in terms of its phonology-orthography mapping (alphabetic syllabary) and visual-orthographic configuration (nonlinear visual arrangement).

There is another script available for the Korean language; Hanja, the traditional Chinese script borrowed to write Korean words of Chinese origin long before Hangul script was invented. The majority of Korean content words can be written in both scripts with identical pronunciations and meanings (e.g., 학교 in Hangul and 學校 in Hanja are pronounced equally as /hak-kyo/ and mean *school*).[1] Note that about 25% among all Korean words are pure Korean words (K.H. Kim, 1993) that do not have Hanja correspondences. Based on the existence of Hangul and Hanja scripts for Korean words, a comparison of reading networks involved in each script can be insightful for understanding the underlying brain mechanisms for reading Korean words.

In this chapter, we seek to address whether and how the characteristics of the Korean writing system are reflected in the brain network. We first review research on the brain mechanism for reading Hangul words, how it is similar to or different from that for reading words in other alphabetic orthographies (e.g., English). Reading in Hanja words is compared with reading Hangul words, and reading in Hangul is compared with reading in Chinese words. Following that, we review neuroimaging research concerning the L1 effect on L2 reading by Korean L1 readers. Finally, limitations and future directions are discussed.

Neuroimaging studies on reading in Korean L1

To identify specific neural correlates of reading Korean Hangul words, Yoon and colleagues (Yoon, Cho, & Park, 2005) carried out an fMRI (functional magnetic resonance imaging) study comparing reading Hangul words and pictures. Native Korean participants performed semantic judgment tasks on both types of stimuli (judging whether each stimulus was considered a living or a nonliving object). As compared to the fixation baseline, both Hangul words and pictures elicited more activation in the bilateral occipitotemporal region including the fusiform gyrus. The results are more similar to those with Chinese than with other alphabetic orthographies. For example, Chinese words elicited bilateral activation in the fusiform

1. Until the 1990s Hanja was not only obligatorily taught in middle to high school, but also widely used in Korea. For example, most of major newspapers frequently used both Hangul and Hanja to deliver the exact meanings of given words. Nowadays, however, almost all newspapers use mainly Hangul due to the encouragement of using Hangul by the Korean government. Thus, the usage of Hanja is currently relatively infrequent.

region (e.g., Hu et al., 2010; Tan et al., 2000), while words in alphabetic orthographies such as Italian and English induced left dominant activation in the fusiform region (e.g., Devlin, Jamison, Gonnerman, & Matthews, 2006; Paulesu et al., 2000). In addition, the N400 ERP component in the posterior regions was observed bilaterally in the processing of Hangul words (K.H. Kim, Yoon, & Park, 2004), but it was left-lateralized in the processing of alphabetic orthographies such as English (Marinkovic et al., 2003). As compared to the picture condition, Hangul words showed more activation particularly in the left middle frontal gyrus, which has been found to be more critical for Chinese reading than alphabetic reading (Bolger, Perfetti, & Schneider, 2005; Cao et al., 2013b; Hu et al., 2010; Tan, Laird, Li, & Fox, 2005; see Perfetti, Cao, & Booth, 2013 for more discussion). Taken together, the similar characteristics in terms of visual configuration between Hangul and Hanja may be related to the significant activation in the bilateral fusiform gyrus and the left middle frontal gyrus. In contrast, alphabetic orthographies such as English and Italian are more involved with activation in the left fusiform region.

Reading in Hangul words vs. Hanja words

The existence of Hangul and Hanja scripts for Korean words provides a good opportunity to study the potentially different reading networks involved in reading different Korean scripts (Cho et al., 2014; K.H. Kim & J.H. Kim, 2006; Lee, 2004; Vaid & Park, 1997; Yoon et al., 2005). Vaid and Park (1997) examined whether Hangul and Hanja words are processed differently using a visual half-field paradigm and two types of task conditions, a phonetic matching condition and a script classification condition. Hangul and Hanja words were visually presented either in the left or right visual field. In the phonetic matching condition, participants were asked to judge whether or not a visually presented word matched in sound with a word auditorily presented. In the script classification condition, participants were instructed to judge whether a visually presented word was written in Hangul or Hanja. Thus, the phonetic matching condition directly involved active conversion from orthography to phonology, whereas the script classification condition seemed to entail a simple perceptual judgment on the surface form of the word. Results showed that the Hangul script elicited faster reaction time than the Hanja script only in the phonetic matching condition, but not in the script classification condition. In addition, this Hangul script advantage was found only when the stimuli were presented in the right visual field probably due to the fact that the left hemisphere is largely dominant for phonological processing. Therefore, it seems that processing Hangul, as compared to Hanja, relies more on a phonetic system than orthographic information.

A series of neuroimaging studies on reading Hangul versus Hanja words were conducted to reveal the corresponding brain networks. According to the Dual-Route Model (Coltheart, Curtis, Atkins, & Haller, 1993; Jobard, Crivello, & Tzourio-Mazoyer, 2003), word reading involves two possible pathways; one is a ventral lexical pathway to the mental lexicon that directly maps orthographic input onto stored word, while the other is a dorsal sub-lexical pathway that maps graphemic input onto phonological information. Cross-linguistic studies showed that transparent orthographies (e.g., Italian) engage the sub-lexical pathway to a greater degree, whereas opaque orthographies (e.g., English) are related to greater activation in the lexical pathway (Paulesu et al., 2000).

One of the early fMRI studies compared neural mechanisms between reading Hangul and Hanja words (Lee, 2004). This study used a silent reading task and showed that Hangul words, compared to Hanja words, elicited more activation in the bilateral inferior parietal lobules, angular gyrus, and right supramarginal gyrus. This finding was consistent with previous findings that these regions are involved in the assembly of phonology in word reading in alphabetic orthographies (Jobard et al., 2003; Pugh et al., 2001). In contrast, reading Hanja words elicited more activation in the bilateral occipito-temporal region including the fusiform gyrus and middle occipital gyrus, consistent with previous studies focusing on the Chinese logographic writing system (Bolger et al., 2005; Tan et al., 2005).

Cho et al. (2014) explicitly compared Hangul- and Hanja-related brain networks within the dual-route model. In this study, native Korean readers performed a silent reading task with Hangul and Hanja words. While Hangul words elicited greater activation than Hanja words in the left angular gyrus and left inferior/middle frontal region, Hanja words elicited greater activation in the bilateral fusiform gyrus, left middle occipital gyrus, and left superior parietal cortex. Taken together, the reading network for Hangul mainly engages in the dorsal pathway, but that for Hanja relies on both dorsal and ventral pathway, thus largely supporting the dual-route stream in reading network (Jobard et al., 2003; Pugh et al., 2001; see also Kumar, 2014). Note that the relative engagement of dual-stream for each script, Hangul and Hanja, may reflect the differential emphasis on the role of sublexical processing depending on which script to read.

In addition, differential processing in Hangul and Hanja words was supported by several lesion studies with stroke patients (e.g., Kwon, J.S. Kim, Sim, Nam, & Park, 2005; Park, Yang, Lee, & Kim, 2016). For instance, in Kwon et al.'s study (2005), two brain-damaged patients showed double dissociation patterns regarding words written in Hangul and Hanja. One patient who experienced a stroke in the left postcentral gyrus and left inferior parietal region (i.e., impaired in the dorsal pathway, not the ventral pathway) showed significant difficulties in reading Hangul words, but relatively intact in reading Hanja. The other patient with damage in the left parieto-occipital lobe and a surgical removal of a portion in the temporoparietal region (i.e., mostly impaired in the ventral pathway, not the dorsal pathway) showed a selective impairment in reading Hanja words, but not Hangul words. Thus, this double dissociation in lesioned cases supported the notion of the dual route pathways in the brain network corresponding to lexical (Hanja) and sublexical (Hangul) processing.

Reading Hangul words vs. Chinese words

Most of the tasks employed in the aforementioned studies (e.g., semantic judgment, silent reading, or passive viewing) may not be directly involved in the decoding process. To address the decoding process of Hangul words more directly, a recent study by S.Y. Kim et al. (2016) employed a visual rhyming judgment task where participants were presented with pairs of words and were asked to decide whether the two words rhymed or not (e.g., 화분/hwabun/ – 교문/kyomun/ for a rhymed condition; 신발 /sinbal/ – 영혼 / yʌŋhon/ for a non-rhymed condition). The choice of this task was motivated by the fact that the task required conversion from orthography to phonology emphasized in reading Hangul words. The researchers hypothesized that the brain network for Hangul reading would rely more on the dorsal sub-lexical pathway than the ventral lexical pathway as predicted by the Dual-Route Model of reading (Jobard et al., 2003), since Hangul is a transparent alphabetic script. This hypothesis was supported in that significant activation was shown for Hangul words, in comparison to the fixation baseline, in the dorsal sub-lexical pathway including the bilateral inferior/middle occipital gyrus, bilateral inferior frontal gyrus, left fusiform gyrus, left middle frontal gyrus, and right inferior/superior parietal lobule. In contrast, Chinese as a logographic writing system, had greater activation in the ventral lexical pathway, including left middle frontal gyrus and bilateral temporo-occipital regions (see S.Y. Kim, Liu, & Cao, 2017).

ERP studies on reading Hangul L1

In addition to the fMRI studies, several ERP studies on Korean reading have been conducted to reveal temporal resolution for Korean Hangul word recognition (K.H. Kim & J.H. Kim, 2006; K.H. Kim et al., 2004; Kwon, Lee, & Nam, 2011; Kwon, Nam, & Lee, 2012). As compared to fMRI, ERPs allow us to capture rapid neural activity of a specific cognitive process of a stimulus based on its high temporal accuracy. For instance, a study by K.H. Kim and J.H. Kim (2006) demonstrated that, the N1 component (a negative-going ERP component around 180ms after the onset of a stimulus) at the occipital-temporal electrodes was found bilaterally for Hanja words, but was left-lateralized for Hangul words suggesting letter-level processing. This is consistent with previous studies showing a left-lateralized N170 for reading in alphabetic languages such as English (e.g., Maurer, Brem, Bucher, & Brandeis, 2005; Rossion, Joyce, Cottrell, & Tarr, 2003). Furthermore, K.H. Kim et al. (2004) showed significant N400 component (a negative-going ERP component around between 350–500ms after the onset of a stimulus) for reading Hangul words in the posterior region (occipital and temporal lobe) for both hemispheres simultaneously, whereas reading words in other alphabetic orthographies such as English showed strong left lateralized activation. It is most likely that the difference in visual analysis due to the different spatial layout of the two scripts, alphabetic syllabary arrangement in Hangul and typical alphabetic arrangement in English contributes to this brain localization difference. Taken together, these results may suggest that reading Hangul word is processed by letter-level processing at the early stage based on the left-lateralized early ERP component (N1), and then visuo-spatial processing at the syllable level at a later stage (N400).

Other ERP studies have focused on the role of the sublexical properties of Hangul words such as phonological and orthographic syllable frequency (Kwon et al., 2011) and morphological family size (Kwon et al., 2012). Kwon et al. (2011) focused on an early component of ERP (e.g., P200) in which native Korean speakers performed a lexical decision task with disyllabic pseudowords in Hangul. The phonological and orthographic syllable frequencies were manipulated based on a 2 × 2 design: HH, HL, LH, and LL (H refers to High frequency, L refers to Low frequency). A significantly higher P200 amplitude (a positive-going ERP component around 200 ms after the onset of a stimulus) was shown for pseudowords with high phonological syllable frequency, but not for those with high orthographical syllable frequency. This result suggests that native Korean speakers are sensitive to the phonological neighborhood size rather than the orthographic neighborhood size. The researchers suggest that this finding may be attributable to the phonological complexity involved across the syllable boundaries, even though Korean Hangul is known for its transparent mapping of orthography to phonology. Phonological changes (e.g., phonological assimilation or tensification) occur depending on the initial consonant of the following syllable within the word. For instance, when a consonant, ㄴ /n/ in the coda position of the first syllable meets another consonant ㄹ /l/ in the onset of the second syllable, its sound should be changed to /l/. So, each syllable in a Korean word 신랑 (meaning *groom*) is pronounced as 신 /sin/ and 랑 /lang/, respectively, but as a whole word, it is pronounced as /sil-lang/, not /sin-lang/, as a result of phonological assimilation. This linguistic phenomenon of sound variations is to achieve the economy of articulation. Thus, the sensitivity to phonological syllable frequency obtained by the ERP experiment suggests that

Korean L1 readers rapidly process the phonological change resulted from the sound variation due to the neighboring grapheme.

In another study, Kwon et al. (2012) focused on ERP effects of the orthographic neighborhood density and the semantic richness. Korean participants performed a semantic categorization task. As in their previous study, the orthographic neighborhood density effect was manipulated by the first syllable frequency in disyllabic real words. The semantic richness was defined by counting how many words contain a specific morpheme (e.g., 국가, 국정, and 국악 contain the same morpheme 국 /kuk/ meaning *nation*). Their results showed that early component (P200) was sensitive to the orthographic neighborhood size. However, the N400, the so-called semantic component, was sensitive only to the orthographic neighborhood size, but not to the morphological family size. Instead, a later component, Late Positive Complex (LPC: measured between 500ms–700ms) showed a significant effect of morphological family size, which can be explained by the role of semantic richness.

No effect of morphological family size in N400 found in the previous study was surprising because some behavioral studies showed a tendency of morphological decomposition in Korean words via masked priming experiments (S.Y. Kim & Wang, 2014; S.Y. Kim, Wang, & Taft, 2015). In addition, a number of previous studies using ERPs or MEG (magnetoencephalography) measures showed that components around 350ms–500ms (i.e., N400 for ERPs and M350 for MEG) were sensitive to morphological structures and their manipulations in English (e.g., Morris, Frank, Grainger, & Holcomb, 2007; Pylkkänen, Feintuch, Hopkins, & Marantz, 2004). Clearly, further studies are needed to revisit the morphological effect in Korean. One possibility for the inconsistent result of N400 on morphological family size in Korean words was due to the morphological ambiguity in Korean words. Note that Kwon et al. (2012) used a semantic categorization task, which might not be sensitive to morphological structure. In addition, Kwon et al. (2012) counted the morphological family size based on the Sino-Korean words (words written in Hangul that originated from Chinese words, e.g., 국가, 국정, or 국악). However, as mentioned earlier, Korean words can be either Sino-Korean words (e.g., 국가: 국 meaning *nation*) or native Korean words (e.g., 국물: 국 meaning *soup*). Hence, the morphological family size needs to be carefully calculated and whether or not both Sino-Korean words and native Korean words are included in a study needs to be clarified.

Indeed a recent ERP study conducted by Chung, Park, and S. Y. Kim (under revision) obtained evidence showing that N400 was sensitive to morphological processing in Korean. They examined if compound words in Korean were rapidly decomposed into their constituents using a masked priming paradigm with unbalanced Korean-English bilinguals. The motivation of this study was partly from some behavioral studies in Korean-English bilinguals that provided evidence for morphological decomposition for Korean words using a lexical decision task with the masked and unmasked priming paradigm (S.Y. Kim & Wang, 2014; S.Y. Kim, Wang, & Ko, 2011; Ko & Wang, 2015; Ko, Wang, & S.Y. Kim, 2011). In Chung et al. (under revision)'s Experiment 1, targets were Korean L1 compound words (e.g., 꿀벌, /kulbʌl/, *honeybee*), and primes were English L2 words, in one of the three conditions, translated whole words (*honeybee*), translated morphemic constituents (*bee*), or unrelated words (e.g., *ear*). Experiment 2 was the same as Experiment 1, except that the targets were English compound words (L2) and the primes were in Korean (L1). In ERP results, the morphological priming effect was found for both experiments on the N400.

To summarize, the brain mechanisms seem to be different for reading L1 Korean words in Hangul as compared to reading Hanja. In line with the dual-route model of reading, reading words in Hangul may rely more on the dorsal route which is more related to mapping between orthography and phonology. In contrast, both Hanja and Chinese words were found to rely more on the ventral route. In addition, ERP evidence may suggest that sublexical properties are processed at different stages such that phonological and orthographic processing occurs at an early stage whereas morphological processing takes place at a later stage. In the next section, we review research focusing on L1 effects in L2 reading network in native Korean readers.

Research on bilingual reading related to Korean L1

How the reading brain handles more than two languages and scripts is a long-standing question. Many previous studies have provided evidence for what factors shape one's L2 related brain activity, such as age of acquisition (AOA) (e.g., K.H.S. Kim, Relkin, Lee, & Hirsch, 1997), language exposure (e.g., Mei et al., 2015) and proficiency (e.g., Cao, Tao, Liu, Perfetti, & Booth, 2013a). All of the evidence could be collectively understood within the *assimilation* and *accommodation* hypotheses (Liu, Dunlap, Fiez, & Perfetti, 2007; Nelson, Liu, Fiez, & Perfetti, 2009; Perfetti et al., 2007). The assimilation hypothesis predicts that the brain network for learning L2 largely overlaps with that for processing learners' L1. In contrast, the accommodation hypothesis predicts that learning L2 may engage the brain network that is required for L2 reading, but not involved in the L1's reading network.

S.Y. Kim et al. (2016) addressed this question by testing Korean-Chinese-English trilingual learners. The unique combination of the three languages in this group allowed the researchers to test directly whether the language distance between L1 and L2 may influence the assimilation and accommodation patterns of the L2 reading network. While English and Korean are alphabetic and the grapheme units map onto the phonemic units in both orthographies (e.g., *n* in *north* maps to /n/ and ㅂ in북 /pu:k/ maps to /p/), Chinese is logographic in which the grapheme units do not map onto phonemic units (e.g., no part of the character 北 /bei/ corresponds to /b/). Instead, the Chinese writing system is considered to be a system of coarse-grained units that provides syllable encoding rather than phoneme-level mapping (Perfetti et al., 2013). Although Korean and English share the same alphabetic principle in terms of the mapping between orthography and phonology, Korean, unlike English, is similar to Chinese in terms of its visually nonlinear arrangement in the formation of syllable blocks. Thus, the phonological and orthographic characteristics across these three orthographies provide the best testing case for the assimilation and accommodation hypotheses.

In their study, during an fMRI session, Korean trilingual participants performed a visual rhyming judgment task in the three languages (hereafter, KK for Korean group performed a Korean task; KC for Korean group performed a Chinese task; KE for the Korean group performed an English task). Two L1 control groups were native Chinese and English speakers performing the same task in their native languages (CC for Chinese group performed a Chinese task and EE for English group performed an English task). The general pattern of the brain activation of KC was more similar to that of CC than KK, suggesting accommodation. In other words, reading in Chinese by native Korean readers may require an additional brain network over their Korean reading network. In addition, higher accuracy in KC was associated with decreased activation in the regions of the KK network (i.e., Korean L1 reading network), suggesting reduced assimilation. In contrast, the brain activation of KE was more similar to that of KK than EE, suggesting assimilation. Namely, the Korean reading network in native Korean readers is employed for reading English L2 words. Higher accuracy in KE was associated with decreased activation in the regions of the EE network, suggesting reduced accommodation. Finally, a region of interest (ROI) analysis on the left middle frontal gyrus revealed greater activation for KC than KE, suggesting its selective involvement in the L2 with more arbitrary mappings between orthography and phonology (i.e., Chinese). As mentioned previously, the left middle frontal gyrus has been known to be involved more in Chinese reading than in English reading (Bolger et al., 2005; Tan et al., 2005) due to its significant role in the coarse-grained mapping between the Chinese characters and their corresponding syllables (Booth et al., 2006; Tan et al., 2005). Taken together, the brain network involved in English L2 reading was similar to the Korean L1 network possibly due to their similar mapping principle of orthography to phonology, whereas significant accommodation may be needed since Chinese L2 is more opaque than Korean L1. Hence, the findings from this study suggest that assimilation and accommodation patterns in L2 brain network can be predicted by the language distance between the two languages involved.

S.Y. Kim et al. (2017) took a different angle to examine the role of L1 in the L2 reading network by a direct comparison between Korean-English and Chinese-English bilinguals. This study was motivated by several behavioral studies supporting the notion that L1 reading skill/knowledge affects reading in L2 (D'Anselmo, Reiterer, Zuccarini, Fommasi, & Brancucci, 2013; Lallier, Acha, & Carreiras, 2015; Wang, Koda, & Perfetti, 2003). For instance, Wang et al. (2003) suggested that L1 (Korean or Chinese) reading skills required by their writing systems (alphabetic or logographic) influence L2 (English) reading. Wang et al. (2003) demonstrated that Korean learners of English, who relied on phonological processes in alphabetic L1 reading, were more sensitive to phonological information in English words than Chinese learners of English. In contrast, Chinese learners of English were shown to be more sensitive to orthographic information in English words as a result of the influence from their logographic L1 reading.

Unfortunately, the role of L1 in L2 learning has not gained enough attention in neuroimaging research. Jeong and colleagues examined sentence level processing with Korean speakers who learned Japanese and English (Jeong et al., 2007a, 2007b). The syntactic similarity between L1 and L2 led to a greater similarity in the brain activation when the Korean participants performed an auditory sentence comprehension task in Japanese or English. For example, since Korean and Japanese share the same word order (SOV), the brain network for a Japanese task, compared to English (SVO language), by native Korean speakers was similar to that for a Korean task.

S.Y. Kim et al. (2017) investigated the L1 influence on the L2 brain network by focusing on word reading. The brain network for Korean-English bilinguals during their rhyming judgment task was compared with that for Chinese-English bilinguals. Their conjunction analyses revealed that the right inferior frontal gyrus and medial frontal gyrus were more activated in KK and KE than CC and CE, suggesting that these regions were more involved in Korean speakers than Chinese speakers for both L1 and L2. In addition, an ROI analysis at the left middle frontal gyrus revealed greater activation for CE than for KE and a positive correlation with accuracy in CE, but a negative correlation in KE. Chinese has been found to be associated with great brain activation in the left middle frontal gyrus (Bolger et al., 2005; Perfetti et al., 2013; Tan et al., 2005). Thus, the results of S.Y. Kim et al. (2017) suggest that the brain network for reading English as an L2 is shaped by the L1, regardless of being Korean or Chinese. In addition, in both bilingual groups, higher proficiency in L2 is associated with greater involvement of the L1 network. This study provides important neurological evidence that L2 acquisition is affected by the existing L1 system in late bilinguals.

The effect of L1 on the L2 brain network was also supported by training studies. For example, Lee et al. (2003) studied native Japanese participants who newly learned Korean words for 15 days. Note that the Japanese participants in this study learned the sound of Korean words at the syllable level, not phoneme level. In the pre-training fMRI session, Japanese words elicited more activation than Korean words in the angular gyrus. Interestingly, after the learning Korean words for 15 days, the activation in the angular gyrus became similar for Korean words as for Japanese words. Angular gyrus has been found to mediate the phonological reading of Japanese Kana (Iwata, 1986). Therefore, it seems that native Japanese speakers recruited this angular gyrus region to help read aloud and memorize the Korean words, when getting more familiar with Korean words. However, caution is needed in interpreting the results of this study as the Japanese participants were trained by a syllable pronunciation with the Korean words only. Thus, the more involvement in the angular gyrus for reading Korean at post-training could be simply due to the syllable pronunciation that is similar to that for Kana reading. It will be interesting to examine the training effect if the Japanese speakers learn Korean through letter-to-sound mapping (e.g., Bolger, 2007). If Japanese participants are trained via alphabetic reading with Korean words, it is likely that a syllabic L1 effect could remain (assimilation pattern), or a phonemic L2 effect may be shown (accommodation pattern).

In summary, findings from neuroimaging studies among L2 readers of Korean L1 suggest that the language distance between the two orthographies involved is responsible for the assimilation and accommodation patterns in the L2 brain network. When the two orthographies are similar to each other, assimilation in the L2 brain network is likely to occur. When the two orthographies contrast sharply to each other, however, accommodation is likely to take place. The L2 brain network is indeed shaped by the L1 experience.

Limitations and future research directions

As there has been only handful of neurobiological studies on the reading mechanism in Korean, more research is certainly needed to reveal language-specific processing in Korean and to allow for opportunities to examine cross-linguistic differences/similarities in comparison to other orthographies. Several directions of future studies regarding Korean reading are as follows.

More studies are clearly needed to examine carefully the effects of Korean linguistic and orthographic features on reading. For example, despite the fact that Korean has a relatively transparent writing system, the consistency in mapping between orthography and phonology is asymmetric. There is a very low phonological inconsistency in Korean (the same spelling has different pronunciations, e.g., *bass* (fish) – *bass* (musical instrument), *record* (noun) – *record* (verb) in English), however, the orthographic inconsistency exists (a sound can be spelled in multiple ways, e.g., 낮, 낯, 낫 are equally pronounced /nat/). In fact, this asymmetric consistency effect on reading has not been studied at both behavioral and neuroimaging levels. Given that English has inconsistency in mapping between orthography and phonology in both directions, Korean may be an excellent testing case for more fine-grained understanding of orthographic depth in reading across languages.

Morphological processing in Korean needs to be more systematically studied using the neurobiological approach. A recent ERP study (Chung et al., under revision) suggests that native Korean speakers are sensitive to the morphological structure using compound words. Because many Korean syllables are homographs, each syllable within a multisyllabic Korean words may lead to a great deal of morphemic ambiguity when a syllable is corresponding to multiple morphemes. A recent behavioral study (S.Y. Kim et al., 2015) examined whether the morphemic ambiguity matters when native Korean readers process morphologically derived words. Results suggest that there may be two different processing mechanisms for derived words in Korean; supralexical analysis for prefixed words where a prefix is stripped off only after the whole word has been accessed and prelexical morphological decomposition for suffixed words. Future studies with electrophysiological measures (EEG/MEG) are called for to provide neural evidence that helps differentiate these two different morphological processing mechanisms.

It will also be interesting to compare Korean to a variety of different orthographies using both behavioral and neurobiological methodologies. The current literature has mostly focused on the comparison between Korean and Chinese or between Korean and English. Putting Korean in a wider context of different languages and orthographies for comparisons would better inform the universal and language-specific processes in reading.

Furthermore, there is very limited neurobiological research on reading development in Korean L1 and bilingual reading development in young children given that all of the previous studies reviewed in this chapter are based on adults. Studies on how reading skills are acquired and developed in comparison to adults or skilled readers will certainly help better understand the neural mechanism underlying reading across different languages and orthographies. Moreover, comparisons between typically developing children and dyslexic children in terms of neural markers are in need to help inform better reading and literacy pedagogy than current practices. Future research also needs to explore the pedagogical implications of neurobiological investigations on learning to read Korean.

Finally, studies on Korean as L2 are comparatively rare, but it will be useful to understand further how the L2 brain network is shaped by the relationship between the languages involved in reading. For example, examining the reading network for Korean as L2 among Chinese L1 and English L1 speakers could be another chance to understand the L2 brain mechanisms depending on L1 background and the similarity between L1 and L2.

Conclusion

Korean is one of the less studied languages particularly in the neurobiological approach. Current research evidence suggests that reading Hangul and Hanja words within the same Korean language utilizes different brain networks. Reading Hangul may rely more on the dorsal route that is dedicated to the assembled phonology. Reading Hanja, on the other hand, may rely more on the ventral route that is dedicated to the visual/orthographic process, just like reading Chinese characters. Finally, the L2 brain network seems to be shaped by L1 experience. English L2 readers of Korean are likely to be engaged in the brain network similar to the Korean L1 network (i.e., the assimilation process). In contrast, Chinese L2 readers of Korean engage the brain network that is different from Korean L1, but more similar to the Chinese L2 network (i.e., the accommodation process).

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CHAPTER 21

Constituent processing or gestalt processing?

How native Korean speakers read mutilated words in English

Hye K. Pae[i], Sun-A Kim[ii] and Xiao Luo[i]
[i]University of Cincinnati, U.S.A. / [ii]The Hong Kong Polytechnic University

This study examined how native speakers of Korean extracted letter-feature information from mutilated texts (i.e., top-half and bottom-half), compared to native speakers of Chinese and English. Hypothesized were (1) the upper-part saliency and (2) L1 script effects on L2 reading. A computer-based naming test was administered. Results showed eminent upper-part effects possibly due to more ascenders being at the top than descenders at the bottom of the English letters, but the magnitude of the effects was different among the three groups. Overall, the Korean group seemed to rely more on letter-constituent information drawn from letter features, while the Chinese participants are likely to rely on gestalt information of the word. The results were interpreted with L1 script effects and typology relatedness.

Keywords: native Korean readers, mutilated texts, ascenders and descenders, L2 English

Introduction

Research evidence has demonstrated that both bottom-up hierarchical extraction of word constituents and top-down holistic abstraction are involved in reading depending on the degree of grapheme-phoneme correspondence, text being read (e.g., words or nonwords, high or low frequency), and task being performed (e.g., naming, lexical decision, or translation). A remaining question is how readers process missing information when text being read is mutilated (i.e., only bottom-half or top-half of the print is visible). The answer to this question will lead to a further understanding of information processing in rapid word reading. In this light, this

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study investigated how native speakers of Korean (phonemic language) resolved visual noise resulted from mutilated text in speeded reading, compared to those of Chinese (syllabic language) and English (phonemic language).

Reading transformed words or texts in English

Reading nontraditional texts involves an activation of learned entries in the mental lexicon as well as a verification of perceptual representations of text. According to Paap, Newsome, McDonald, and Schvaneveldt (1982), the process of verification is carried out as an independent top-down analysis of the stimulus presented by going through an efficient comparison between a prototypical representation of candidate words and a holistic representation of the stimulus. The quick judgment of match or mismatch involves conscious recognition depending on the degree of fit between the target and activated candidate words. In a similar line is Kinoshita and Lupker's (2007) notion of *lexical checking* that is quickly activated in reading words and nonwords in order to determine whether or not the phonological information generated from the text matches the code stored in the mental lexicon. When typical texts are transformed in a certain way, such as cAsE aLtErNaTiOn, varied letters in siZe and shape, or mutilation (e.g., mutilation, mutilation), mental elaboration is involved to resolve the pending visual noise imposed in the stimulus.

Perea and colleagues (Perea, Comesaña, & Soares, 2012; Perea, Comesaña, Soares, & Moret-Tatay, 2012; Tejero, Perea, & Jiménez, 2014) examined the role of missing parts of words in lexical access using Portuguese words and nonwords. Parea et al. (2012) used both upper- and bottom-part missing primes (50 ms) of words and pseudowords in lexical decision experiments to find whether or not the role of whole-word representations (i.e., lexical level) is stronger than letter feature representations (i.e., letter level). They hypothesized that, if the upper-part effect was observed for both words and pseudowords, the effect was attributable to the idiosyncratic letter features; if the upper-part effect was observed only for real words, lexical information would be the source of the effect. Results showed that the upper-part primes yielded a significant effect on words only but not on pseudowords. The authors concluded that the advantage of upper-part words was likely to reside at the lexical level rather than at the letter (or letter feature) level in rapid lexical decision. They also found greater effects of the upper part on lowercase words than uppercase words. This might have to do with the fact that lowercase has the features of ascenders and descenders. These findings were consistently observed in the use of delayed-segment techniques, priming tasks, and Stroop tasks (Perea et al., 2012). Although these studies neither used English stimuli nor L2, the results indicated not only a somewhat universal role of the upper part of Roman script, as

100-year-old Huey's claim suggests (Perea et al., 2012, 2012; Tejero et al., 2014), but also processing of mutilated text at the lexical level (i.e., holistic processing rather than letter-level processing).

L1 script influences on L2 reading

Research has consistently shown that L1 scripts have cross-linguistic influences on L2 reading depending on the degree of L1-L2 script proximity in linguistic units, levels of phonological transparency or orthographic regularities, and L2 lexical properties, let alone individual differences. Despite some degrees of interference effects, cross-linguistic facilitatory effects tend to be stronger in languages when L1 and L2 scripts are congruent with each other. For example, readers of L1 Japanese who learned Chinese as a foreign language were faster than L1 alphabetic speakers in word naming in Chinese in which the script was similar to that of Japanese *Kanji* (Yang, 2000). This result can be intuitive because Japanese *Kanji* and Chinese *Hanzi* have overlapping qualities. However, L1 orthographic effects were sustained even when learners and the target language were reversed; that is, Chinese speakers who learned Japanese *Kana*, a unique phonetic syllabary which differs from Japanese *Kanji*, showed faster reading than those with alphabetic L1s (Chikamatsu, 1996, cited in Cook & Bassetti, 2005). Cook and Bassetti (2005) have nicely summarized cross-linguistic orthographic transfer to L2 reading with respect to the reliance on sight words among readers whose L1 script is morphographic[1] (i.e., Chinese and Japanese *Kanji*), based on the findings that they are less affected by unpronounceable English words than Spanish readers: that is, readers with morphographies tend to show less efficiency in reading pseudowords than Spanish readers; higher sensitivity to word familiarity than Spanish readers; faster word recognition than Arabic readers; and more disruption by shape alteration (see p. 39 for more information). Chikamatsu (1996) has shown that Chinese readers who learned Japanese as a foreign language are more likely to rely on visual information in reading *Kana* than do English-speaking counterparts. In contrast, English-speaking learners of Japanese tend to search for phonological cues in morphemic Japanese *Kanji*, as evidenced by the results that English speakers recalled *Kanji* words with pronounceable phonetic radicals more efficiently than those without (Mori, 1998). English speakers also showed more reliance on phonological decoding to read *Kana* words than Chinese learners of Japanese (Chikamatsu, 1996).

1. See Chapter Joyce and Masuda's Chapter 9 in this volume for more information about this term.

In a similar vein, Pae and colleagues (2015, 2017) have used visually manipulated words, such as case alternations, inverse (ᴉuʌǝɹsǝ) fonts, scrambled (srcambeld) letters in lexical decision and naming tasks in order to examine L1 script effects. They found that Korean and Chinese students performed differently from each other and that Korean speakers' performance was always placed in between Chinese and English speakers' performance, suggesting that Chinese tend to process words lexically, while Koreans are likely to process words sublexically. Pae et al. (2015, 2017) interpreted their results in terms of cross-linguistic script effects and L1-L2 script-relatedness.

Script differences in Korean, Chinese, and English

There are distinct differences in scripts among Korean, Chinese, and English. The differences can be viewed from (1) the printing convention between the two East-Asian scripts (Korean and Chinese) and English and (2) the minimal unit of the script between the alphabetic scripts (English and Korean) and the morphographic script (Chinese). First, the printing convention is dissimilar to each other between the two Asian scripts and English. The visual representation of block printing separates the two Asian scripts from English. Korean and Chinese have both left-to-right and top-down character formulation. In Korean, graphemes "ㅁ and ㅏ" are combined into "마" in the left-to-right format, while graphemes "ㅁ, ㅜ, and ㄹ" are combined into "물" in the top-down form. Chinese also enjoys the flexibility of left-to-right and top-down structures. For example, the syllable or word "日" (*sun*) and "月" (*moon*) are combined into "明" (*brightness*) to form a new word in the left-to-right manner; the syllable or word "火" (*fire*) and "火" (*fire*) are combined into "炎" (*fire blaze*) in the top-down format. To the contrary, English does not subscribe to this flexibility, and has only one way of a left-to-right linear grapheme arrangement (e.g., "*w, o, r, d*, and *s*" → *<words>*).

Another visual representation of script constituents involves uniformity in the height of letters. Korean and Chinese characters form relatively consistent height and width in the block, compared to English letters. As seen in Figure 1, Korean segmentals (i.e., consonants and vowels) show fairly consistent height and width in block. When segmentals are grouped together to form a syllable, the consistency in terms of height and width remains the same. Likewise, Chinese syllabic characters are written in blocks in which each character forms a square-like independent unit with the consistent height and width. In other words, Chinese and Korean scripts do not have ascenders and descenders because the height and width of all letters are leveled in the syllable block. In contrast, English alphabet letters carry different height across the letters. When two lines are drawn across the alphabet letters, the inventory of the letters can be classified into four categories: (1) ascenders (above the upper line; *b, d, f, h, i, k, l*, and *t*), (2) descenders (below the bottom line; *g, p, q*, and *y)*, (3) medians that fall between the two lines; (*a, c, e, m, n, o, r, s, u, v, w, x*, and *z*), and (4) an ascender-descender (both above the upper line and below the bottom line; *j*). About twice as many alphabet letters rise above the top horizontal line, all of which are consonants.

Script	**Example**
Korean consonants (Absence)	ㄱ ㄴ ㄷ ㄹ ㅁ ㅂ ㅅ ㅇ ㅈ ㅊ ㅋ ㅌ ㅍ ㅎ
Korean syllables (Absence)	가 나 다 라 마 각 난 단 랄 맘
Korean vowels* (Absence)	ㅏ ㅑ ㅓ ㅕ ㅗ ㅛ ㅜ ㅠ ㅡ ㅣ
Chinese syllables** (Absence)	一 二 三 四 五 六 七 八 九 十
English alphabet (Presence)	a b c d e f g h i j k l m n o p q r s t u v w x y z

Note.
* There are spaces above the top-down vowels (from the 5th through 9th vowels from the left) for the dummy consonant "ㅇ" as a place-holder. The inclusion of the dummy consonant allows the vowels to function as full syllables and to have consistent height with the let-to-right vowels.
** The Chinese characters indicate numbers 1 to 10, in which the unit is a syllable as opposed to Korean and English whose smallest unit is a grapheme/phoneme.

Figure 1. Presence and absence of ascenders and descenders among Korean, Chinese, and English

Based on the shape of the letters, another classification is also possible, if not mutually exclusive: (1) loop (*a* and *o)*; (2) open *(c, e, m, n, r, s, u, v, w, x*, and *z)*; (3) bars (*b, d, f, h, i, j, k, l, p, q, t*, and *y)*; (4) crosses (*f* and *t)*; and (5) points (*i* and *j)*. Bouma (1973) also classified the alphabet letters based on shape similarity among the letters as follows: (1) *a s z x*, (2) *e o c*, (3) *n m u*, (4) *r v w*, (5) *d h k b*, (6) *t i l f*, and (7) *g p j y q*. This kind of grapheme classification at the grapheme level is impossible in Chinese due to the syllable representation of the character, although it is possible for Chinese to be classified at the syllable level.

Second, the three languages are also different with respect to the minimal linguistic unit. Although they have a similar syllabic block presentation in appearance, Korean and Chinese scripts are inherently different from each other in terms of grain sizes and syllables. The minimal unit of Korean is a grapheme that is combined with other graphemes to form a syllable, which qualifies Korean *Hangul* as a phonemic orthography. This is the characteristic that makes the Korean script depart from Chinese but ally with English. Korean and English share the commonality of the alphabetic principle in which graphemes are combined to form a syllable. Due to the syllabic autonomy in appearance, however, Korean is considered a phonemic-syllabary or alphasyllabary. This makes Korean stand out among other alphabetic scripts. In contrast, each Chinese character represents a syllable, which qualifies the script as a syllabic morphography. When the three languages are placed in a linguistic continuum with respect to graphemes and visual representations, Chinese is placed on the one end, Korean in between, and English on the other end. The commonalities and differences in these three languages facilitate the understanding of the effects of scripts on reading.

Purpose and research questions

Skillful readers have developed functional autonomy and analytical skills that are directed at the physical attributes of letters and whole words through years of literacy experience. If cost-effective strategies that readers employ in reading English involve word shape or geometrical features, such as ascenders, descenders, bars, and curvature-based strokes, mutilated texts can be a useful tool for unfolding whether or not word features serve as a source of information processing for rapid recognition and reading. Notably, mutilated texts at the top or bottom preserve word length, partial word shape, and partial letter sequence including the first and last letters, same size, and same letter case. Hence, the manipulation at the top and bottom of words allows for a better understanding of operating mechanisms for recovering necessary information in speeded word recognition.

The objective of this study was to investigate effects of top-only texts on reading words using stimuli that were mutilated at the top or bottom among native speakers of Korean, Chinese, and English. At the same time, it examined whether or not previous findings of robust effects of upper parts (Perea et al., 2012, 2012; Tejero et al., 2014) could extend to reading English as L2. If there was no difference between the experimental conditions (i.e., no letter-feature effects), gestalt processing was assumed because readers might not have used cues generated from letter idiosyncrasies but have processed the stimuli as whole words. If there was significant differences between the two conditions (i.e., presence of ascender/descender effects), constituent processing relying on letter features was assumed because readers might have used letters' cuing information of letter-specific features (e.g., ascenders, descenders, curves, and bars).

Two research questions were addressed in this study.

1. How do Korean speakers perform on words that are mutilated at the top or bottom, compared to native speakers of Chinese and English?

This question was posed to examine the effect of the missing-part position and group differences. First, if reading depended upon holistic letter-shape-independent perception, partial information of the text would sufficiently extract the base word without much trouble; as a result, the three different conditions (standard print, top-only, bottom-only) would not yield a significant difference in reading performance. If letter-feature-dependent perception was involved in reading, partial information would generate a great deal of disruption because readers would not be able to use letters' visuo-spatial properties; as a result, readers would perform differently among the three conditions. In theory, given that the English letters are visually more prominent and broader in the top part than in the bottom part, these letter properties can function as cues for word recognition by evoking different levels of visual elaboration of the word. Hence, it was hypothesized that top-part stimuli (e.g., school) would be read faster and more accurately than bottom-part stimuli (e.g., school), as Perea et al. have found (2012, 2012; Tejero et al., 2014).

Second, if group differences were found in the performance of the three groups, L1 backgrounds or L1 scripts could be a plausible source of the difference. It was hypothesized that, due to differences in the language status (i.e., L1 for English speakers and L2 for speakers of Korean and Chinese) as well as L1 script effects on L2 reading, the three L1 groups would perform differently on the three conditions (i.e., both top part and bottom part as experimental conditions and standard print as a baseline). It was also expected that Korean speakers would be less tolerant of partial texts than Chinese participants when the baseline data were controlled, resulting in greater interference effects than Chinese counterparts on L2 English reading, because Chinese readers have been accustomed to processing Chinese characters lexically. Given that Korean is placed in between Chinese and English in the script continuum, the performance of Korean participants would fall somewhere in between Chinese and English speakers' performance.

2. What are the enabling word constituents that facilitate the reading of mutilated words in English?

This research question was posed in order to examine the respective role of intraword constituents in English, including ascenders/descenders, similar letters within the word, doublets, and length (i.e., the numbers of letters and vowels). If the first research question showed significant differences between the two experimental conditions and among the three groups, the next question would be which intraword constituents or letter features would contribute to efficient recovery of missing information in the text. Partly available print in the word may evoke each letter's visual cuing information to be processed differently. More prominent and broader strokes at the top part than bottom may facilitate rapid recognition because they help readers elicit different levels of visual elaboration of the word. If the word constituents were insignificant, its results might lead to L1 script effects on L2 reading as a feasible explanation.

Method

Participants

A total of 155 university students were recruited from three international academic communities. Fifty five Korean students participated in South Korea; 50 Chinese students in Hong Kong;[2] and 50 native speakers of English in the U.S. Their mean age of the entire group was 21.76 (*SD* = 2.56 years); the mean age for the Koreans was 24.18 years (*SD* = 2.14); that for the Chinese participants was 21.08 years (*SD* = 1.71); and that for the English speakers was 19.78 years (*SD* = 1.22). The gender distribution was more balanced for the Korean group (53% females) and the Chinese group (52% females), while that for the English speakers was skewed (88% females). The majority of the native English speakers were Caucasians: 90% Caucasians, 8% African Americans, and 2% mixed. The participants orally reported that their vision or corrected vision was in the normal range.

Procedure

Testing took place in a quiet room. The participant sat in front of the computer and was instructed to read out loud a mutilated word appeared on the computer screen as quickly and accurately as possible. A fixation point appeared for 500 milliseconds (ms), followed by a stimulus. The participant completed six practice items prior to the experiment. Reading time (RT) was measured by a tester's button press[3] upon completion of reading the stimulus in order to take self-correction, repetitions, and drawls into consideration. This method has been used in behavioral measures of reading and naming (Kumar, Das, Bapi, Padamannaya, Joshi, & Singh, 2010; Lee & Hwang, 2015).

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2. Chinese students participating in this study were all native Mandarin speakers who had completed their secondary education in mainland China and studied at a university in Hong Kong for less than two years.

3. The presence of a tester has been a common practice in experiments and psychoeducational testing (e.g., RAN/RAS, Wolf & Denckla, 2005; rapid naming tests of the CTOPP, Wagner, Torgesen, & Rashotte, 1999). Although this method could be considered nontraditional by *some* researchers, it was appropriate since the main focus of the study was placed on the difference in performance between baseline data and experimental data and among the three L1 groups. Besides, the variance homogeneity among the participant groups was tenable.

Measures

Computerized Naming Tests. Computerized tests were developed using DMDX (Foster & Foster, 2003) to measure reading accuracy and RT of mutilated texts, along with typical lowercase words as the baseline condition. The mutilated text at the top and bottom served as experimental conditions. Word frequency and the numbers of letters and syllables of the stimuli were statistically leveled across the conditions (see Preliminary and Descriptive Analysis below). The 120 stimuli (20 standard, 20 upperpart, 20 bottompart, and 60 distracters with various shapes) were drawn from Fry's lists of third-grade sight words (Fry, 2004). The Fry sight words for third grades were used in order to minimize (1) potential word frequency effects and other confounding effects that might be involved in reading the stimuli and (2) L2 proficiency effects among the nonnative speakers. Table 1 shows examples of the stimuli and the baseline words used in this study.

Table 1. Examples of the stimuli used in this study

Upper-part only	Bottom-part only	Standard print
high	every	light
near	add	under
food	between	important
own	below	children
country	plant	feet
last	school	across
father	keep	during
tree	never	happened
start	city	usually
earth	eyes	hundred

English Proficiency Test. To measure the nonnative participants' English proficiency, a *modified* version of the Word Ordering subtest of the *Test of Language Development Intermediate*: *4* (TOLD; Hammill & Newcomer, 2008) was administered. The subtest was originally designed as an oral measure to assess syntactic skills, but the modified version of the test was a written test. This grammar test[4] was used in order to ensure that the participants had adequate English skills, given that grammar skills are the backbone of language skills. Upon seeing three to seven words in random order presented for two seconds, the participant was asked to formulate a permissible sentence only using the words provided. Vocabulary knowledge was controlled

4. This test was administered as part of a bigger study and was considered a useful test for this study given that sentence formulation is fundamental skills in L2 proficiency.

by using words that were below the third-grade level, and the influence of memory was minimized by providing the small number of words (Hammill & Newcomer, 2008). Various types of sentences, including simple and compound sentences or declarative, imperative, or interrogative sentences, were acceptable.

Language Background Questionnaire. A language survey was also administered to gauge the participant's self-reported English skills as well as to obtain their demographic information and prior English learning experiences.

Design

This study was a 3 × 3 factorial design using three levels of conditions and three L1 groups. When the baseline data were used as a covariate in order to remove subject-specific variation only once during iterations of analysis for the sake of precision of test statistics, a 2 (conditions) x 3 (L1 groups) factorial design was used.

Results

Preliminary and descriptive statistics

Sentence formulation skills of the nonnative groups were compared. The two groups' syntactic skills measured using the TOLD were signficantly different: $F(1, 103) = 641.20$, $p < .001$; mean = 18.00 ($SD = 2.94$) for the Koreans; mean = 30.30 ($SD = 1.86$) for the Chinese. Self-rated reading skills were compared as well. The mean score of the Korean group's self-perception of reading was also lower than that of the Chinese group: $F(1, 103) = 19.1$, $p < .001$; mean = 5.56 ($SD = 1.52$) on a 10-point scale (10 = near native) for the Koreans; mean = 6.82 ($SD = 1.42$) for the Chinese students. This result might be reflective of L2 use and the learning context in which the nonnative speakers were situated (see Discussion later on this point).

Prior to the main analysis, data screening was performed by checking residual plots and normal probability plots. Neither significant outliers nor atypical data points were found. Raw scores of accuracy and RT were transformed to logarithmic values in order to improve normality and precision of test statistics because of the skewness in reading latency. RTs of incorrect items were excluded in analysis. Word frequency was obtained using the MCWord database (Medler & Binder, 2005). In order to ensure that the conditions were statistically matched in terms of word frequency, the numbers of letters, vowels, and syllables, a one-way ANOVA was performed. The results showed no significant differences in the three conditions in word frequency and the numbers of letters, vowels, and syllables of a word ($ps > .05$).

The three groups demonstrated optimal reading efficiency in the standard print (i.e., 100% accuracy), which qualified it as valid baseline data. For all three groups, the performance of reading accuracy and RT on the baseline stimuli was the best, followed by top-half stimuli and bottom-half stimuli. There were significant differences among the three groups except the baseline accuracy. Tukey post-hoc tests showed that all comparisons were significant for the accuracy data except for the lowercase accuracy. Specifically, all significances were found at the .001 level except the following two cases: The Korean group performed significantly better than the Chinese counterpart in accuracy for the top-part ($p < .05$); the native speakers performed significantly better than the Korean participants for the bottom-part ($p < .05$). Concerning RT, the three L1 groups showed significant differences among the three conditions: all *ps* < .001 except for the native speakers performing better than the Korean participants at the .01 level. These results are summarized in Table 2.

Table 2. Performance patterns and significance levels in each contrast among the three groups by accuracy and RT

		Contrasts		
		Korean-Chinese	**Korean-English**	**Chinese-English**
Accuracy	Top Part	KR > CH*	KR < EN ***	CH < EN ***
	Bottom Part	KR > CH***	KR < EN*	CH < EN ***
RT	Top Part	KR > CH***	KR < EN ***	CH < EN ***
	Bottom Part	KR > CH***	KR < EN **	CH < EN ***

Note. * $p < .05$; ** $p < .001$; *** $p < .001$
KR = Korean speakers; *CH* = Chinese speakers; *EN* = English speakers
The greater and smaller angle bracket signs indicate better or worse performance, respectively.

Sensitivity to mutilated words (Research question 1)

The position of mutilation was first examined using the three groups' reading accuracy and RT data on the words by condition.[5] Concerning words, accuracy on the standard print was constant as all the three groups demonstrated optimal efficiency (i.e., 100% correct) on baseline word reading. The three groups consistently showed better performance on the top-only texts than bottom-only texts,

5. Since the performance is an indicator of the confluence of *person ability* and *item difficulty* (see Bond & Fox, 2007, as to how these two constructs interact with each other in a language proficiency test), separate item and subject analyses were not performed. Moreover, the focus was placed on group differences.

which was consistent with previous research (Perea et al., 2012, 2012; Tejero et al., 2014). Regarding accuracy, Koreans showed a significant difference on the three conditions ($F(2, 27) = 6.88$, $p < .01$). Tukey post-hoc test revealed that the Korean participants performed significantly better on the top part than the bottom position ($p < .05$) and better on the standard print control than the bottom position ($p < .01$). Notably, the Chinese group's performance on the three conditions was not significantly different in accuracy. English speakers did not show a significant difference, either. As for RT, the Korean- and English-speaking groups showed significant differences on the three conditions: $F(2, 27) = 4.40$, $p < .05$ for Koreans; $F(2, 27) = 8.48$, $p < .01$ for English speakers. Interestingly, again, the Chinese group did not show a significant difference in reading speed among the three conditions. Table 3 summarizes the findings of these analyses.

Table 3. A summary of significance based on performance on the three conditions among the three L1 groups

	Korean speakers	**Chinese speakers**	**English speakers**	**Implications**
Accuracy	sig	ns	ns	• Koreans' reliance on the constituent properties of the word
RT	sig	ns	sig	• Chinese' reliance on the gestalt information of the word

Note. sig = significant difference among the three conditions (standard, top part, bottom part words); *ns* = not significant

Next, group differences in the experimental conditions were examined after controlling for the baseline data. A repeated-measures ANCOVA was run as an omnibus analysis to see the group differences. The baseline data served as a covariate in the model with the top-only and bottom-only conditions as a within-subject factor and the three L1 groups as a between-subject variable. The covariate was used in order to reduce the error variance and to adjust experimental conditions' means for differences among the three groups on the baseline data. Concerning accuracy, when the baseline was controlled, the results revealed no significant multivariate main effect for the condition and the covariate. The assumption of sphericity was presumed to be met because two conditions were involved and power to detect the effect was great. It showed a significant interaction effect between the conditions and the L1 groups with 0.77 of the variance unexplained by condition and excellent power to detect the effect, indicating that the mean change in the accuracy from the baseline to experimental conditions was significant in the groups: Wilks' $\lambda = .77$, $F(2, 152) = 22.97$, $p < .001$, $\eta_p^2 = .23$, power = 1. The univariate effect between-subject statistics was significant: $F(2, 152) = 42.36$, $p < .001$, $\eta_p^2 = .36$, power = 1. Pair-wise comparisons showed that all three groups were different from one another at different significance levels. The Chinese group's accuracy score was significantly lower than those of Korean and English speakers (*ps* < .001). The Korean group's accuracy was significantly lower than the English group ($p < .05$).

Another repeated-measures ANCOVA was performed for RT with the baseline lowercase RT as a covariate, the condition as a within-subject factor, and the group as a between-subject variable. When the experimental RT was adjusted for the standard print RT as a control variable, the results showed no significant multivariate main effect for the condition and the covariate. However, there was a significant interaction effect: Wilks' $\lambda = .88$, $F\ (2, 151) = 10.02$, $p < .001$, $\eta_p^2 = .12$, power = .98. The between-subject effects were significant for the covariate RT and group: $F\ (1, 151) = 114.49$, $p < .001$, $\eta_p^2 = .43$, power = 1 for the covariate; $F\ (2, 151) = 5.18$, $p < .01$, $\eta_p^2 = .07$, power = .82 for group. In short, the RT results showed that not only was the top part (i.e., ascender presence) faster to detect than the bottom part (i.e., descender presence), but also the three groups performed differently. However, note that the results on accuracy did not show a significant main effect. Hence, the hypothesis posed under Research Question 1 was partly supported. To summarize, there were no significant main effect but a significant interaction effect in both accuracy and RT. This indicates a cross-over interaction for mutilated word reading with no significant effects of conditions or groups, meaning that the effect of the experimental conditions is plotted opposite of groups or crossed each other.

Useful word constituents for recovering missing parts (Research question 2)

Based on the finding that cross-over interactions and the different patterns of results between accuracy and RT, a follow-up question was raised about the source that yielded different performance patterns across the conditions and groups. Intraword constituents, such as ascenders/descenders, similar letters within the word, the presence of doublets, and the numbers of letters and vowels, were taken into account to see whether or not they were independent facilitators for the integration of missing information in reading. Multiple regression techniques were performed in order to gauge the unique and shared variance in reading accuracy and RT using the intraword variables as predictors, including the numbers of letters and words as well as the number of ascenders or descenders, and accuracy and RT as dependent variables. Interestingly, none of the intraword variables predicted a significant variance in reading accuracy and RT. The results indicated that, although the intraword characteristics might be influential on reading accuracy and speed in an indirect, collective, way, word length and the presence of ascenders or descenders were not independently salient enough to be significant predictors of reading accuracy and speed.

Discussion

This study investigated how readers with different L1s integrated partial information available in the text (i.e., top only or bottom only) into reading so as to explain whether reading L2 English involved gestalt processing or constituent-letter sensitivity depending on the missing position of the word. The motivation behind this inquiry was the unique script characteristics of Korean as well as cross-language influences on L2 reading, given well documented L1 effects on L2 reading (Chikamatsu, 1996; Muljani, Koda, & Moates, 1998; Pae & Lee, 2015; Pae et al., 2017; Yang, 2000). Korean *Hangul* has similarities to Chinese characters in appearance in that it is printed in syllabic autonomy.

If words were processed holistically, partial texts would disrupt reading to some extent, but readers would still be able to read them with great efficiency. If words were not processed holistically, readers would experience a great deal of difficulties with the missing letter cues. The results showed that the Korean participants' accuracy rate and reading speed were better than those of the Chinese counterpart. This finding was interesting that the Chinese participants showed significantly higher English proficiency than that of Korean counterparts on the English proficiency test. They also rated higher marks on the self-report of reading skills than the Korean participants. It was highly possible that the Chinese students indeed had better English skills, given that they passed the English screening test to study at a university in Hong Kong where English is the medium of instruction. In contrast, the Korean participants were native Koreans who were residing in Korea where Korean was the societal language and the medium of instruction in school; however, they had passed the entrance examination that required proper English skills to get into a national university in Korea. Importantly, the difference did not invalidate the comparison of the two groups in this study, because the stimuli used were meticulously selected to eliminate confounding factors such as English proficiency by using the Fry sight-word lists (Fry, 2004); that is, the words used in this study were easy enough for the participants to read with no trouble, and this was validated by the 100% accuracy rate of word reading, which was used as a baseline control variable.

Despite their better L2 English skills measured using the TOLD test and the self-report, the Chinese participants' accuracy and RT were not on par with the Korean group. The fact that the Korean participants showed faster and more accurate performance than the Chinese counterpart can be explained in two ways: (1) Cross-linguistic facilitatory effects due to script proximity between L1 and L2 (Chikamatsu, 1996; Yang, 2000) and (2) switch costs among different visual manipulations. First, due to the similarity of Korean *Hangul* to English as a phonemic language, Korean readers might have been able to utilize their processing strategies used in L1 Korean when reading L2 English. In fact, this finding is consistent with previous research in which Koreans and other alphabetic L1 speakers (e.g., Indonesian readers) read L2 English faster than Chinese participants, although their English skills were comparable (Muljani et al., 1998; Pae & Lee, 2015; Pae et al., 2017). Second, since the experiment randomly shuffled the items of the three conditions rather than presented each condition in block, switch costs might have been greater for Chinese speakers than Koreans for the similar reason. As indicated earlier, the structure of Chinese characters has complex spatial symmetry and asymmetry due in part to left-right and top-down structures of characters at the syllable, and may require higher-order spatial processing. Korean *Hangul* also has left-right and top-down structures, but is a phonemic script, not a whole-word syllabic script. As a result, the switch cost to recognize the stimulus correctly might have been greater for Chinese natives than Koreans. Although switch costs between words and nonwords have been investigated in reading English (see Kinoshita & Lupker, 2007), the cross-language differences have not been fully investigated yet. The switch cost across different L1 readers is the area that needs to be investigated in a follow-up study. In order to combat the possible switch cost at the minimum, the baseline reading accuracy and RT were controlled in analysis. Results still showed that the Chinese participants experienced the greatest interference in accuracy. However, the magnitude of interference effects in both top-part and bottom-part stimuli in terms of reading speed for Korean readers was smaller than those of the Chinese counterpart. Notably, there was a significant difference in RT across the three conditions for the Korean and English readers but not for Chinese students. Trade-off effects were ruled out because RT data included in analysis were drawn from all correct items only.

For reading mutilated words, there were no main effects found in accuracy and RT, but significant interaction effects were found in both outcomes indicating that the participants' accuracy and RT were affected by the condition. Chinese readers showed an asymmetry between accuracy and RT; that is, a larger mean difference in accuracy but a smaller mean difference in RT. It seems that Chinese readers' reliance on visual cues may be different than readers of phonemic or alphabetic scripts. Specifically, they appear to be not as efficient as alphabetic L1 readers in identifying intraword and letter features, such as ascenders and descenders, but the processing speed might be normalized in resolving different types of visual disruption. A plausible interpretation of the group difference found in the performance of the three groups, after controlling for the baseline performance, would be L1 script effects. This is consistent with the findings of previous research (Chikamatsu, 1996; Muljani, Koda, & Moates, 1998; Pae & Lee, 2015; Pae et al., 2017; Yang, 2000).

The decelerated reading speed with the top-half and bottom-half target suggests that mutilated texts might have disrupted well-developed *shape-sensing operations*

(Rudnicky & Kolers, 1984) and *lexical checking* mechanisms (Kinoshita & Lupker, 2007) that skillful readers have developed over time. If accuracy is significantly different but RT is not significant in the performance on baseline, top-part, and bottom-part targets, a question is whether it should be considered different or not. Reading accuracy is considered to be one of key elements of fluency, as fluency is a confluence of both accuracy and speed; fluency, in turn, is a bridge to successful comprehension. This finding is important because it signals a possibility that Chinese readers may not rely on intraword and letter constituents such as ascenders as much as do readers of alphabetic scripts. Given that missing parts resulted in decelerating effects in the three L1 groups, it would be useful to identify which missing part had more dominant effects on reading accuracy and RT. Accordingly, the role of intraword and letter constituents, such as ascenders, descenders, doublets, and the numbers of letters and vowels, was examined. The results showed that the number of ascenders and descenders were not statistically significant enough to account for the unique variance in reading accuracy and speed for the three L1 groups. It seems that independent intraword letter features alone are not likely to be the salient source of information in recovering missing parts in text. The collective contour or shape of words appears to be an additional source of information involved in reading. By ruling out the independent contribution of the letter features to reading accuracy and speed, L1 script effects gain more weight in explaining the locus of the group difference in the performance. This result suggests that L1 script may outweigh the role of word constituents in reading L2. In addition, a possible explanation for the greater gap between accuracy and RT for the Korean natives than Chinese natives would be their going through a verification process due to their L1's alphabetic nature, as opposed to Chinese who are more likely to recognize words more lexically and holistically.

In summary, all three groups read targets with the top-half more accurately and faster than the bottom-half. At the same time, differences were also been observed in the performance among the three L1 groups in terms of the degree of efficiency in reading and the magnitude of performance difference on the three conditions. The difference can be attributable to cross-linguistic influences from their L1 scripts to L2 English reading. In both accuracy and speed, the performance of the Korean participants was consistently placed in between those of Chinese and English speakers. This suggests that script distance or script-relatedness be the source of the findings between Korean *Hangul* and English as alphabetic orthographies. In addition, it seems that the letter features affect reading accuracy and speed collectively, not individually.

Limitations and future directions

Although this study investigated visual noise using top-half and bottom-half stimuli, which was the first in L2 research, several points are worth mentioning. The limitations are closely related to the recommendations for future studies. First, the stimulus was derived from the third-grade sight-word lists. Based on the findings of this study, it would be useful to examine the effect of ascenders and descenders using a wider range of word frequency, lexical neighborhood, and lexical density. Although the advantage of the upper part of words at the lexical level has been found in Roman script (Perea, Comesaña, & Soares, 2012; Perea et al., 2012; Tejero et al., 2014), the letter features, such as ascenders and descenders, have not been considered in previous L2 research. All ascenders and descenders belong to consonants, as opposed to vowels (i.e., *a, e, i, o, u*) that do not contain as distinct features as ascenders or descenders. This can be attributable to the consonant primacy that has been found in the literature (Duñabeitia & Carreiras, 2011; Hochmann et al., 2011). In addition, the fact that ascenders have twice as many alphabet letters as descenders might have led to better performance in the top-part text than the bottom-part one. More in-depth studies addressing these features will enhance the understanding of L2 word processing.

Second, this study did not take graphotactic information into account in the stimuli because the aim of this study was to uncover the overall effect of mutilated texts. With the findings of this study, a subsequent study in this line will help understand the level of readers' conscious elaboration to resolve visual noise through the graphotactic rule, especially through the activation-verification process.

Next, this study adopted missing parts only at the top or bottom. Some other manipulations, such as missing letters in the beginning, middle, and final positions, can be employed to explain different types of facilitatory or interference effects in the letter position. In a similar vein, this study used only words as stimuli. A follow-up study using phrases and sentences will provide additional information on the role of mutilated texts in reading comprehension.

Finally, as briefly mentioned earlier, an investigation of switch costs from L1 to L2 or vice versa will allow for a better understanding of the intricacy of cross-language influence. The script difference among Korean, Chinese, and English provides an excellent case for this line of inquiry.

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CHAPTER 22

Looking ahead

Theoretical, methodological, and pedagogical implications

Han Suk Bae, R. Malatesha Joshi and Hye K. Pae
Dong-A University, South Korea / Texas A&M University, U.S.A. / University of Cincinnati, U.S.A.

This closing chapter briefly summarizes research findings on the processes of word reading in three East-Asian orthographies (Chinese, Japanese, and Korean) and calls for theoretical and practical attention related to word reading among speakers of these unique languages. Based on the analyses of and reflections on studies of the three orthographies, we first summarize what we know about word reading with respect to reading universals, reading particulars, and cross-language transfer. We then articulate theoretical, methodological, and pedagogical considerations to advance to the next phase of reading sciences in these three orthographies.

Keywords: three East-Asian scripts, theoretical advance, methodological advance

Reading is a multi-componential skill involving letter recognition, word identification, vocabulary, fluency, and comprehension. At the crux of successful reading are word identification skills which are manifested through the knowledge of letter positions, graphemic features, and morphemic regularities as well as the way in which words encode oral language (Perfetti, 2003). When an individual takes too long for identifying words, too much attention is consumed for word reading, yielding little cognitive resources left for comprehension. This is one of the reasons that the large portion of reading literature has been devoted to word recognition or word reading. The Simple View of Reading (Hoover & Gough, 1990) postulates that word identification skills are one of the critical elements of reading comprehension. According to the Simple View, reading comprehension is the product of word decoding and listening comprehension (i.e., *reading comprehension* = *word decoding* x *listening comprehension*). Specifically, when the value of word decoding skills is zero, the goal of reading (i.e., reading comprehension) becomes zero, regardless of

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how strong oral language skills (i.e., listening comprehension) an individual has. This model not only captures the importance of word identification skills in reading comprehension, but also addresses the inherent relationship between oral language and written language.

Given the critical role of word reading in reading comprehension, scientific attention has been paid to cognitive functions surrounding word reading. A multitude of research studies have been conducted in English and other Roman alphabetic languages, which has provided a solid knowledge base for theories and models of reading. This trend has been expanded to other non-alphabetic (e.g., Chinese, Japanese) or non-Roman alphabetic (e.g., Korean *Hangul*) scripts in recent decades. The expansion has been propelled by the notion of universality involved in language and reading, dubbed the *universal grammar of reading* by Perfetti (2003). This line of scientific inquiry can be solidified with systematic research in different scripts other than English. To this end, this book attempted to sort out reading processes and processing in the three East-Asian scripts, including Chinese, Japanese, and Korean. The writing systems of these languages have their own scriptal structures and qualities that are different from English and other Roman alphabets.

Drawing upon the established science of reading in English and other Roman scripts, this volume has covered the complexities and uniqueness of word reading as well as cross-language transfer in the three representative East-Asian scripts from multiple angles from phonological awareness to semantic processing of polysemous words within and between languages. The three scripts are representative among all scripts available in the world due to their typological, linguistic, and scriptal distinctiveness (i.e., morphosyllabic Chinese, multi-scriptal Japanese, and alpha-syllabic Korean *Hangul*). The benchmark importance of the coverage of these three scripts stems from the potential to generate theoretical accounts that are unique in the three scripts as well as to expand the Anglocentricism that has dominated the science of reading for many decades. Given that reading is, by and large, shaped by orthotactic and phonotatic knowledge (Apel, 2010; Apel, Wolter, & Masterson, 2006; Ehri, 2014), moreover, an investigation of different forms of orthotactic and phonotatic rules is necessary in order to explicate on commonalities and differences among different scripts. By synthesizing the literature of reading in Chinese, Japanese, and Korean within one volume, we are able to better understand the language-universal and script-specific characteristics of reading. This allows us to tease apart intricacies and idiosyncrasies involved in the scripts as the first language (L1) or a second language (L2). Not only does this book go beyond the Anglocentric focus on English by adding the literature of reading in the three East-Asian scripts, but also consolidates scientific inquiries into these three languages with Anglocentricity by employing English as L1 or L2 in empirical studies.

What we know: Reading universals, particulars, and cross-linguistic influences

Dominant research trend: Anglocentricity

The science of reading has advanced through focused research on English, although English is an outlier in terms of the spelling-sound correspondence. Share (2008) prudently sums up this phenomenon as *Anglocentricity*. The salient *Anglocentric* research trend has positively contributed to reading sciences in at least two ways. First, the status of being a qualitatively and quantitatively "abnormal" orthography has moved English to the forefront of theory building. Due to the letter-sound inconsistency, English has provided a useful platform for an examination of both regular words (shallow orthography) and irregular words (deep orthography) in testing a model concurrently, as opposed to shallow orthographies that cannot afford testing irregular words because of its absence in the inventory. Specifically, if it were a shallow orthography showing a regular letter-sound correspondence, English would not have been able to offer opportunities for developing a number of theories and models based on its orthography. Complexities and irregularities are likely to draw scientific attention and call for systematic research effort for figuring out the mechanism behind word identification by contemplating possibly separate paths for processing of regular words and irregular words. Hence, it is not surprising that the dual-route model (Coltheart, 2005) was developed within the English language to identify the psychological undercurrent behind the mapping relation between spelling and sound. The characteristics of English orthography also allowed for testing the rival theory of the connectionist model (Seidenberg & McClelland, 1989). These two models of reading have extensively served as theoretical frameworks for reading research in English and other scripts. In short, the Anglocentric focus has facilitated theory building using the *data-to-theory* approach.

Second, the skewed Anglocentric research trend has prompted comparative studies with other Roman alphabetic scripts and non-Roman scripts especially in the role of phonological awareness, orthographic processing, and semantic or morphological awareness. Comparative studies have allowed us to document similarities and differences involved in the interaction between reading processes and reading outcomes. The empirical legacy generated from *Anglocentric* research can be consummated with studies on cross-linguistic transfer to English as L2. An understanding of the nature and extent of cross-language effects on L2 not only broadens the perimeter of reading sciences of English, but also helps us develop comprehensive theories of L2 acquisition and learning. In short, the Anglocentric research trend has also facilitated the *theory-to-data* approach to other languages in cross-language research. As the majority of the chapters in this book have dealt with cross-language interactions, this book fuses the Anglocentric orientation with studies of the three East-Asian scripts.

Reading universals

Perfetti (2003) has astutely summarized the universal language property and constraint related to literacy (that is, all writing systems encode spoken language) as the "universal grammar of reading." As written language is spawned from oral language, the link between spoken language and reading is indispensable. The notion of the universality of reading has motivated researchers to focus on reading at the constituent levels of orthography, phonology, and morphology or semantics. Accumulated research evidence during recent decades has converged on support for language- and script-universal processes in reading. Specifically, underlying cognitive abilities, such as working memory, phonological awareness, phonological recoding (e.g., rapid automatized naming, RAN), and an awareness of morphological structures have been identified as universal precursors to successful reading. All chapters in this book have addressed these componential skills one way or another in reading Chinese, Japanese, and Korean independently or in relation to English as L2. Hence, it is fair to state that the arguments made through reviews of previous research and new findings of empirical studies included in this book are consistent with previous research findings in English and other scripts, supporting the universal nature of reading.

Reading particulars

Since reading involves particular graphic features of the script and orthographic arrangements, it is natural that reading is sensitive to the way in which the script is structured. Two lines of processing based on language-universal and script-specific features have become general consensus in the literature. Specifically, while metalinguistic phonological processing skills and morphological skills are considered to be language universal, orthographic processing is known to be script dependent.

The script-specific processes have certain implications in transfer research. The language-universal properties are assumed to be fluid and malleable across two languages and scripts being read. If reading in L2 is conditioned by L1, similarities and differences in scripts between L1 and L2 are deemed to be influential on L2 reading and to be viewed as enablers (i.e., cross-language facilitation) or detractors (i.e., cross-language inhibition) depending on their role in L2 reading. Focusing on the three East-Asian scripts is an especially novel way to examine these script-dependent facilitatory or inhibitory processes, as the three scripts demonstrate distinctive characteristics that no other languages or orthographies can provide in terms of the outer graphic structures and internal features of the scripts.

In addition, all the three East-Asian scripts have biscriptal or multiscriptal systems in use; that is, Chinese has morphosyllabic *Hanji* and alphabetic *Pinyin*; Japanese has Chinese-derived *Kanji*, phonosyllabic *Kana*, and alphabetic *Romaji*; and Korean has alpha-syllabic *Hangul* and Chinese-derived *Hanja*.[1] However, the use of the biscripts or multiscripts originated to serve different purposes. Specifically, the biscript or multi-script use for Chinese and Japanese was materialized for *supplemental* purposes because the morphosyllabic characters (i.e., *Hanji* for Chinese and *Kanji* for Japanese) are not substantially comprehensive to fulfill the linguistic demands for encoding and reading. However, Korean *Hangul* was designed for the purpose of *replacement* of the Chinese-derived writing practice that dominated the dynasty or country until the mid 15th century because of the impossible compatibility between the Korean oral language and Chinese characters (see Chapter 16 for details). Regardless of the purpose of its use (i.e., supplement or replacement), it is worthwhile to examine the effect of biscriptal use on L2 (English) reading in order to identify reading particulars in transfer research utilizing opportunities that other languages cannot provide. Beyond the concerted effort made in this book in order to address visual word processing within and across scripts of Chinese, Japanese, and Korean, scientific explorations to tackle reading particulars related to these scripts are expected to continue.

Cross-linguistic influences

As the Anglocentric research focus has been expanded to other languages, cross-linguistic influences or cross-language transfer has certainly been on target. With a myriad of research studies that have been conducted with bilinguals and multilinguals, this topic has become the mainstay in reading sciences during recent decades. As a result, identifying and quantifying transfer effects, setting the parameter of transfer, and defining underlying constructs and processes have been major emphases in transfer research. This line of work has continued in this edited volume for Chinese, Japanese, and Korean in relation to English in an effort to expand the existing literature and refine the knowledge base. However, we do not have much data on the analysis of students whose L1 is English and learn to read one of

1. Although the Korean government does not support *Hanja* use in school, *Hanja* can be found in public use.

the three East-Asian scripts as L2. Future cross-language studies with the specific language population would extend the scope of the previous studies in the field.

Quantifying transfer effects involves methodological rigor. Methodologically sound research designs allow for the feasibility of accurately addressing research questions or testing hypotheses, the appropriateness of measures and analyses, and the accurate interpretations of findings. Setting the parameter of transfer includes the operationalization of terms and the scope of a study as well as the identification of relations and interactions between and among variables included in a study. Defining underlying constructs and processes involves identifying relationships between independent variables and outcome variables and interpreting the relationships under proposed research questions and hypotheses. For example, the topic of *orthographic transfer* can generate feasible research questions or hypotheses based on existing literature as well as a sound research design; the term *orthographic transfer* needs to be operationally defined (e.g., does it include *writing-system transfer* or not?) within the scope of research questions or hypotheses; hypothesized relationships among variables are to be determined within the parameter; and, for accurate assessment and valid interpretations of findings, underlying constructs and processes of *orthographic transfer* are to be identified and other spurious variables need to be controlled.

There are many variations with regard to the directionality of the cross-language transfer effect. For example, Korean-to-English L2 learners utilized their L1 (Korean) morphological awareness in developing their L2 (English) word reading (Cho, Chiu, & McBride-Chang, 2011; Wang, Ko, & Choi, 2009). Chinese-to-English learners used their L2 (English) morphological awareness to enhance their L1 (Chinese) word reading (Wang, Cheng, & Chen, 2006). Unfortunately, adequate theoretical principles have not yet been established for explaining the directional variations in the literature (Koda, 2008). One possible reason may be the lack of extensive analysis on testing the cross-language transfer effect bidirectionally. In fact, most of the previous studies only tested the possibilities of unidirectional transfer effect (i.e., from L1 language constructs to L2 literacy outcomes). Future research needs to address reciprocal directions of cross-language transfer simultaneously.

What's ahead: Theoretical, methodological, and pedagogical considerations

Theory building

As indicated earlier, the complicated nature of English orthography in terms of the spelling-sound correspondence allowed for a robust *data-to-theory* approach within English. The solid Anglocentric research focus, in return, allowed for *theory-to-data* application to other languages and scripts, as the development of theoretical models in other scripts as well as the Chinese, Japanese, and Korean scripts has largely been based on English-driven theories and models.

Notwithstanding a multitude of studies especially conducted in Chinese, the applicability of theories developed within English to reading in the East-Asian scripts has not been fully facilitated. The regularity-oriented dual-route model may be questionable as to the applicability to theorizing word reading in the non-Roman scripts that have different degrees of consistency, different grain sizes, and different graphical structures. The same goes to the connectionist model. Although these two models have been tested in alphabetic scripts, it is still unclear whether either model or both models are applicable to reading in Chinese, Japanese, and Korean. Future studies are expected to scientifically address the feasibility in and applicability to these scripts. Testing of generalizability of the models to these scripts will broaden the horizon of reading sciences. Continued research endeavors will not only help set perimeters involved in reading according to a script, but also identify the most suitable architectural model of reading in the three scripts.

Another example is that the degree of the letter-sound correspondence in a written language has well been documented in English as an irregular orthography. The entropy value of vowels in letter-sound consistency is the highest in English among Dutch, English, French, German, Hungarian, Italian, and Portuguese (Borgwaldt, Hellwig, & de Groot, 2005; Share, 2008). The average consonantal entropy value in English is 3.89 phonemes per word-initial letter, followed by French with the value of 2.85 (Share, 2008). Despite the well documented quantification of the entropy value in English and Roman script, the same attempt has been lacking in the three East-Asian scripts.

Although the crucial role of phonological awareness has been emphasized in alphabetic languages, an attenuated role of phonological awareness has been pointed out in shallow orthographies and morphosyllabic scripts (Share, 2008). Further research in the contrast between English and Korean by controlling for the phonotactic rules and frequency will result in a full depiction of the role of phonological awareness in reading deep orthographies and shallow orthographies. This will also be applicable to orthographically deep Chinese and Japanese *Kanji* reading, which calls for further research in this area.

As mentioned in Chapter 1, the multicompetence framework proposed by Cook (1991, 2003) is useful to theorize cross-linguistic influences and the interaction between L1 and L2. Although not all chapters included in this book have directly addressed bilingual memory, bilingual mental lexicon, bilingual representation, and simultaneous bilingual script processing, theoretical accounts coupled with the multicompetence framework will better explain the overall functioning or the operating principle in biscriptal processing.

Methodological advances

Reading itself is a complex process. When it comes to reading in L2, its complexities intensify. The same goes for research methodology. The mainstream methodology that has been employed in research on English overshadows studies of other languages and scripts. This calls for caution because different factors or spurious variables may be involved in reading in L2 that has a different orthography than L1.

There are many challenges in achieving methodological rigor in cross-linguistic research. First, an initial challenge for cross-language transfer is to develop proper research questions or testable hypotheses. Formulating feasible and testable hypotheses that accommodate both L1 and L2 is a crucial step for a rigorous study. Second, developing reliable and valid measures that carefully consider linguistic features of stimulus items, such as word length, frequency, syllabic structure, and phonotactic or graphotactic features, as well as psychometric properties, is also essential in cross-language studies for precision of data analysis. Well-designed parallel measures between L1 and L2 enable us to interpret findings based on the same unit of analysis, which is a fundamental analysis requirement. Third, an identification of constraints on cross-linguistic transfer is important in order not to have confounding interpretations of results. Fourth, proper sample sizes need to be considered at the onset of research to have sufficient statistical power so that precise inferences can be made from a sample to a population based on estimates computed from analysis. Next, since language and reading skills are dependent on an individual's aptitude profile, intraindividual and group characteristics need to be taken into consideration in studies in L1 and L2. Individual differences can be examined at both microlevels (e.g., an analysis of performance patterns, error analysis within the individual) and macrolevels (e.g., subgroup analysis, performance differences between groups). Finally, identifying the causality of transfer is also important in order to accurately assess the directionality of transfer effects as well as direct and indirect effects, and to provide appropriate interpretations of findings. Since correlations do not mean causality, transfer effects need to be carefully assessed for precision of interpretations of relationships and interactions between and among variables. Identifying specific mediators and moderators in the study design and analysis becomes crucial in the course of research activities so that the locus of transfer can be accurately identified.

Pedagogical implications

Reading instruction in each language has been conventionalized by users along with the evolution of written language. However, there have been no studies investigating relative speed of acquiring the three East-Asian scripts. While Chinese orthography is more opaque than Japanese *Kana* or Korean *Hangul*, we do not have any empirical data to conclude that readers have more difficulty in learning to read the former compared to the other orthographies. Thus, both cross-sectional and longitudinal comparisons across the three East-Asian scripts are needed in the future to investigate whether the more transparent the orthography is, the easier the learners acquire word reading accuracy. Other factors, such as culture, educational value, parental involvement, motivation, and affective factors, seem to play a significant role in literacy development in L1. In learning to read in L2, learners' prior knowledge, learning goal, and L1-L2 relatedness will also affect learning outcomes beyond the factors mentioned above. Although they are essential in reading, these factors are beyond the scope of this book. Psycholinguistic results and reviews of previous research reported in this book indirectly suggest pedagogical implications.

Even though phonological awareness is one of the key components of reading success across languages, it has been noted that visual skills such as visual-spatial relationship and visual discrimination play prominent roles in learning to read Chinese (Liu, Chen, & Cheung, 2015) and Korean *Hangul* (Cho & Ji, 2011). Interestingly, copying skills (e.g., drawing lines, making dots, copying letter-by-letter sequences, etc.) would be very effective for distinguishing children with dyslexia and typically developing learners of Chinese in grade two; but not for their English counterparts (Kalindi, McBride, Tong, Wong, Chung, & Lee, 2015). In addition, even though students learn to read the same language, there are different dynamics for their success in reading. For example, Cho, McBride-Chang, and Park (2008) found that different cognitive demands are required for regular and irregular Korean *Hangul* words. The Korean kindergarteners in the study use more knowledge of syllable, coda, and onset units of words while reading regular words. However, they use more morphological awareness in reading irregular words. These results suggest that, as educators, we need to provide explicit instruction for students to develop their optimal reading skills for the target orthography.

Children and adult users of English as L2 are growing across the globe, as English is the most commonly spoken language as L2. According to the Internet World Stats: Usage and Population Statistics (2017), English is the top one language used on the Internet. The greatest use in the world produces high demands for effective teaching for children and adults who are learning English as L2. For effectiveness, pedagogical considerations need to include the following characteristics of writing systems: representivity, producibility, and interpretability of the writing systems and scripts (Adams, 1990). Representivity involves the understanding that writing systems represent oral language. Producibility is related to the rule of the systematic union of letters or strokes to form a word and letter sequence within a word. Interpretability is the ability to interpret written symbols and to make meaning out of the symbols. Depending on the degree and consistency of these characteristics, pedagogical implications may vary.

Although efforts have been made to connect, there has been a disconnection between research and pedagogy. The main reason for the disparity may be due to the standards of public education imposed by stake-holders, which have not been updated with the theoretically-informed and evidence-based curriculum. With the incongruency between the standards and research-based curricula, classroom teachers are often left with no room for implementing evidence-based instructional methods in their business-as-usual teaching in public schools. Another reason would be an inherent gap between teaching force in public schools and university researchers, as they work in different settings. The expanded concept of *teacher-researcher* may be helpful to fill the gap as we move along.

When an additional language is involved, pedagogical considerations also become complicated because of L1 facilitatory or inhibitory effects. With this interactional effect, a question would be how instruction is to be delivered to promote literacy skills in L2. If one takes the view of the universal properties of reading across scripts, similar methods of instruction to the conventional way used in L1 may work; in principle, hence, not much new challenges are expected in learning to read in L2. Adams (1990) notes that the connectionist framework explains the performance of human word recognition exceptionally well, and it extends well beyond issues of human word recognition. If this is correct, the connectionist model can serve as a theoretical framework for an instructional model in conjunction with the universality of reading. On the other hand, if one adopts a hypothesis of fundamental differences between L1 and L2, script-specific instructional methods are expected to be useful. This brings a question about instructional focus on the parts or the associations of the parts within a word, and further about the notion of the whole-word versus phonics methods, which was the long battle that dominated the educational field in the 20th century. What is still unclear is whether or not the knowledge of letter identities and letter orders within English words is equally important in reading Chinese, Japanese, and Korean and, in turn, in learning to read in English as L2 by speakers of these languages.

Regardless of reading in any language, the common ground of efficient reading is the ability to read words quickly, accurately, and effortlessly. If word reading is laborious or automaticity is not established, the hurdle at the threshold of efficient reading is too large to overlook. In this regard, pedagogical reflections should center around how to promote word-reading automaticity. Another consideration would be how to facilitate multicompetence through instruction. An eclectic teaching method depending on the target element of the script and the method of instruction may be useful. In addition, issues surrounding the treatment of learner errors in word reading may need to be carefully examined because they provide information about whether errors are due to imperfect learning, L1 influence (e.g., overgeneralization from L1, underuse of certain linguistic features, absence or presence of cognates, similarities or differences of phonological coding, etc.), or other language-related factors. The right amount of practice for the acquisition of the given scripts also needs to be explored within the context of dual-language learning.

Conclusion

This book has addressed unique opportunities and challenges for investigation of word reading in the three East-Asian scripts. The departure point of these three scripts from English and other Roman alphabetic scripts is their distinctive graphic structures and internal features. Building on the extant knowledge base of visual word processing and word reading, scientific inquiries will continue to move on to the next phase in reading science addressing learnability of the script in the context of sequential or simultaneous dual- or multiple-language learning. In general, spelling-sound relationships have been extensively discussed for many decades in the science of reading, while spelling-meaning relationships have been comparatively less discussed. The next phase of reading advancement should include the spelling-meaning relationships, along with the progression and extension of the existing knowledge base.

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This book provides readers with a unique array of scholarly reflections on the writing systems of Chinese, Japanese, and Korean in relation to reading processes and data-driven interpretations of cross-language transfer. Distinctively broad in scope, topics addressed in this volume include word reading with respect to orthographic, phonological, morphological, and semantic processing as well as cross-linguistic influences on reading in English as a second language or a foreign language. Given that the three focal scripts have unique orthographic features not found in other languages – Chinese as logography, Japanese with *multi-scripts*, and Korean as non-Roman *alphasyllabary* – chapters expound script-universal and script-specific reading processes. As a means of scaling up the body of knowledge traditionally focused on Anglocentric reading research, the scientific accounts articulated in this volume importantly expand the field's current theoretical frameworks of word processing to theory building with regard to these three languages.

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