Learning to Read Across Languages

Cross-Linguistic Relationships in First- and Second-Language Literacy Development

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2 Learning to read

General principles and writing system variations

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In learning to read, what is it that one learns? Reading educators have stressed the goal of learning to read in variations around meaning; e.g. learning to construct meaning, to get meaning from print, to comprehend. Although the goal of reading is indeed to obtain meaning from written language, this falls short of specifying what is actually learned. One general answer to the question of what is learned in learning to read was proposed by Perfetti & Zhang (1995): learning to read is learning how one's writing system encodes one's language. This claim reflects the view that reading is fundamentally about converting graphic input (letters, words, characters) to linguistic-conceptual objects (words, morphemes, and their associated concepts). Moreover, what really forces this view of learning to read is the fact that the world presents learners with different writing systems. In what sense is learning to read in English like learning to read in Korean, Arabic, or Chinese? Each language is written in one or more distinctive graphic forms. In each case, the graphic forms are different in appearance and in how they connect to the language. What they have in common is that the learner must figure out how the graphic forms work—how they map onto the learner's spoken language.

If the mapping involves a second language, one that the learner is still acquiring, the learning problem is the same in general (learning the new mapping), although it is severely complicated by the simultaneous acquisition of a second language and, in some cases, a second writing system or orthography. The advantage of first language (L1) literacy acquisition is that it can build on a well-established language system that a child has acquired, with little effort, prior to literacy instruction. If a second writing system is also involved, as when a Chinese learner acquires English, this presents an additional learning task, although one that in general should provide a relatively mild obstacle compared with learning the language itself. Learning to read in a new language (L2) would be facilitated to some extent if reading has universal properties that apply to all writing systems and all orthographies across all languages.

But are there universals in reading, or only a set of specific problems posed by each writing system and language? Comparative writing research shows both the universal dependence of reading on language and the accommodation of this universality to the properties of the writing system (Perfetti, 2003; Perfetti *et al.*, 2005). The most basic universal is the Language Constraint on Writing Systems: writing systems encode spoken language, not meaning. Put to rest by research on logographic systems (Chinese, Japanese kanji) is the idea that reading in such systems implements a simple visual form-to-meaning process that allows the reader to bypass spoken language. Instead, reading appears to depend on language in the most fundamental way: when a reader encounters printed words, he or she understands their meaning within the context of the language, not as signs that derive their meaning independently. This language constraint allows a second universal, The Universal Phonological Principle (UPP; Perfetti *et al.*, 1992). The UPP expresses the generalization that word reading activates phonology at the lowest level of language allowed by the writing system: phoneme, syllable, morpheme, or word (for research in support of this conclusion, see Tan & Perfetti, 1998; Perfetti *et al.*, 2005).

In summary, if there are universal principles, they must accommodate both the language constraint and variations within writing systems. Reading is a process that is embedded in both the language system and the writing system. Universals, therefore, must attend to the nature of both the graphic input and the nature of the linguistic-conceptual objects to which they connect. The Universal Phonological Principle does that. Finally, universals must take into account the properties of the developing human mind that allow the learning of such connections. Beyond universals are the specific variations in languages, orthographies, and writing systems that confront the learner.

In what follows we elaborate these general claims in a way that we hope is relevant for the broad practical issues of learning to read across languages. We begin by examining the basic properties of written language that matter for issues of reading.

Writing systems, scripts, and orthographies

The first thing a literate English speaker notices about written Arabic or Hindi is how different both look from written English. Similarly, Hebrew, Tamil, Khmer, Chinese, Japanese kana, and Korean all look different from English. Interestingly, to a reader familiar with the Roman alphabet, these last three look similar to each other, despite the fact that they represent three fundamentally different writing systems. Figure 2.1 shows some examples of the differences in the appearance of writing, illustrating the variability in both the appearance of writing (the script) and in the fundamental design of the writing system.

Scripts vary not only across writing systems, but also within a specific orthography. Thus English is printed in a Roman script, and children learning to read and write in English, after learning printed Roman letters, learn

Language	Writing system	Script example
English	Alphabetic	All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.
Dutch	Alphabetic	Alle mensen worden vrij en gelijk in waardigheid en rechten geboren. Zij zijn begiftigd met verstand en geweten, en behoren zich jegens elkander in een geest van broederschap te gedragen.
Spanish	Alphabetic	Todos los seres humanos nacen libres e iguales en dignidad y derechos y, dotados como están de razón y conciencia, deben comportarse fraternalmente los unos con los otros.
Korean	Alphabetic (Hangul)	모든 인간은 태어날 때부 터 자유로우며 그 존엄과 권리에 있어 동등하다. 인간은 천부 적 으로 이성과 양심을 부여받았으며 서로 형제애의 정신으로 행동하여야한다.
Arabic	Alphabetic (Consonantal)	يولد جميع الناس أحراراً متساوين في الكرامة والحقوق. وقد وهبوا عقلاً وضميراً وعليهم ان يعامل بعضهم بعضا بروح الإخاء.
Hebrew	Alphabetic (Consonantal)	כָּל בְּנֵי הָאָדָם נוֹלְדוּ בְּנֵי חוֹרִין וְשָׁוִים בְּעֶרְכָּם וּבִזְכֻיּוֹתֵיהֶם. כֻּלָּם חוֹנְנוּ בִּתְבוּנָה וּבְמַצְפּוּן, לְפִיכָךְ חוֹבָה עֲלֵיהֶם לִנְהֹג אִישׁ בְּרֵעֵהוּ בְּרוּחַ שֶׁל אַחֲוָה.
Lao	Alphabetic (Tonal)	ມະນຸດທຸກຄົນເກີດມາມີກຽດສັກສີ, ສິດທິ, ເສລີພາບແລະຄວາມສເມີພາບເທົ່າທຽມກັນ. ທຸກໆຄົນມີເຫດຜົນແລະຄວາມຄິດຄວາມເຫັນສ່ວນຕົວຂອງໃຜຂອງມັນ, ແຕ່ວ່າມະນຸດທຸກໆຄົນຄວນປະພຶດຕໍ່ກັນຄືກັບເປັນອ້າຍນ້ອງກັນ.
Khmer	Alphabetic (Syllabic)	មនុស្សទាំងអស់កើតមកមានសេរីភាពនិងភាពស្មើៗគ្នាក្នុងសិទ្ធិនិងសេចក្ដីថ្លៃថ្នូរ។ មនុស្សគ្រប់រូបសុទ្ធតែមានវិចារណញ្ញាណនិងសតិសម្បជញ្ញៈ ហើយត្រូវប្រព្រឹត្តចំពោះគ្នាទៅវិញទៅមកក្នុងស្មារតីភាតរភាពជាបងប្អូន។
Kannada	Alphabetic (Syllabic)	ಎಲ್ಲಾ ಮಾನವರೂ ಸ್ವತಂತ್ರರಾಗಿಯೇ ಜನಿಸಿದ್ದಾರೆ. ಹಾಗೂ ಘನತೆ ಮತ್ತು ಹಕ್ಕುಗಳಲ್ಲಿ ಸಮಾನರಾಗಿದ್ದಾರೆ. ವಿವೇಕ ಮತ್ತು ಅಂತಃಕರಣ ಗಳನ್ನು ಪಡೆದವರಾದ್ದರಿಂದ ಅವರು ಪರಸ್ಪರ ಸಹೋದರ ಭಾವದಿಂದ ವರ್ತಿಸಬೇಕು.
Chinese	Morphosyllabic (Logographic)	人人生而自由，在尊嚴和權利上一律平等。他們賦有理性和良心，並應以兄弟關係的精神互相對待。

Figure 2.1 Examples of writing systems.

to write in a cursive script. A modern computer font set may contain dozens of different scripts for the same alphabet. As illustrated in Figure 2.2, these visual differences within languages can be striking, but are usually superficial. Underneath their variability in appearance, these script variations within English, Chinese, and Hebrew each represent a single orthography and a single writing system. In contrast, note the graphic forms in Figure 2.3.

At a glance, it might seem that these are script differences, too. Instead, they are deep differences, not in script, but in writing system. Represented are the world's three major writing systems: alphabetic, syllabic, and "logographic." (The logographic designation for Chinese is common, but arguably misleading; see DeFrancis, 1989.) The defining feature of a writing system is its mapping principle—graph to phoneme (alphabetic), graph to syllable (syllabic), and graph to word or morpheme (logographic). Korean Hangul shows that we can represent alphabetic writing without a linear array of letters, but rather with a syllable-size square.

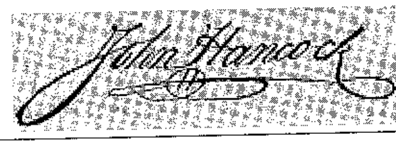
English	Print	CAPITALIZED or lower case Serif Font or San Serif Font
	Cursive	
Chinese	Traditional	漢
	Simplified	汉
Hebrew	With vowels	בְּרֵעֵהוּ
	Without vowels	ברעהו

Figure 2.2 Examples of different scripts in English, Chinese, and Hebrew. Where the script differences within English and Chinese are purely visual, the Hebrew script differences mark linguistic information. However, both Hebrew scripts (with and without vowels) are alphabetic.

Alphabetic	한글 Hangul (Korean)
Syllabary	ひらがな Hiragana (Japanese)
Logographic	中文 Zhōng wén (Chinese Mandarin)

Figure 2.3 The three types of writing systems.

Japanese is especially interesting because it can be written in all three types of writing systems (although only one of its syllabic kana systems is shown in Figure 2.3). One can write Japanese in a syllabary way (hiragana and katakana) or in a "logographic" way (kanji). The kanji system is a borrowing of Chinese characters (a logography), so each kanji graph corresponds to a word, pronounced (to complicate matters) either as it would be in Chinese (the "on" reading) or in Japanese (the "kun" reading). In addition, as an aid to foreign learners, Japanese can be written in "romaji," an alphabetic writing system using Roman letters.

With these examples, we can sharpen the distinction between superficial appearance and writing system design. A script is a systematic expression of visual forms for writing. A writing system expresses the basic principle that maps graphic units onto language units. Thus, Chinese and English differ in writing system design. The Chinese writing system maps graphs (characters) onto words and morphemes, units of meaning, and is thus logographic. English, Italian, and Danish writing systems map graphs onto speech sounds (phonemes) and are thus alphabetic. The Japanese kana system maps graphs onto spoken syllables, and thus is a syllabary. Korean, despite its visual departure from Italian and English, is nonetheless alphabetic because the graphs map to phonemes.

One final distinction is needed: an orthography is the implementation of a writing system to a specific language. Thus, written English is not a distinct writing system but an orthography. It differs from Italian orthography, although both represent alphabetic writing systems. Within alphabetic writing systems, orthographies vary in the transparency of mappings between letters and phonemes. Italian and Finnish are very transparent (or shallow), English is relatively nontransparent (deep or opaque), and Danish falls in between. As Figure 2.4 illustrates, transparency can be considered as a dimension along which orthographies can be ordered. The possible consequences for such an ordering are significant for learning to read. A learner can confidently connect a letter to a sound in the shallower or more transparent orthographies. However, the basis for such confidence wanes as one moves to the deeper or more opaque orthographies.

Which of these aspects of written language—script, orthography, and writing system—make a difference for reading? Perhaps all of them do. At the script level, there appears to be little evidence that, within a given orthography (e.g. English), script variations deeply affect reading. Some of the effects of scripts on readers are a matter of visual familiarity, and such effects can be modified with experience, as illustrated in studies that alter the normal orientation of printed input (e.g. Kolers, 1976, 1985). In learning to read, a child usually encounters a restricted number of closely related scripts, and this relative uniformity may aid the learning of graphic forms. Although a lack of clear evidence makes this conclusion tentative, it is probably safe to assume that, compared with orthography and writing systems, the superficial visual forms are not a major source of difficulty in learning.

Grapheme-to-phoneme correspondence	Some alphabetic languages
Transparent/Shallow 1 grapheme → 1 phoneme	Finnish Welsh Italian Serbo-Croatian Spanish Portuguese Korean German Danish Dutch Lao Khmer French English Arabic Hebrew
Opaque/Deep 1 grapheme → many phonemes many GPC exceptions/irregular words	

Figure 2.4 Orthographic depth of various languages.

However, because reading begins with visual input, the visual forms of the graph do matter for the visual stages of reading, as has been shown by differences between Chinese and English in the degree of involvement of right hemisphere visual areas (Tan *et al.*, 2005a).

Orthography

In the case of orthography, it appears that there can be significant effects on learning to read. Because of the distinction we must make between writing system and orthography, the most meaningful comparisons for orthographic effects are those within a writing system. Such comparisons are available only for alphabetic systems. The orthographic depth hypothesis (Frost *et al.*, 1987; Katz & Feldman, 1983; Katz & Frost, 1992) asserts that the continuum of orthographic transparency illustrated in Figure 2.4 influences the strategies adopted by readers. The more shallow or transparent the orthography—that is, the more reliable the correspondence between graphemes and speech segments—the more the reader uses a print-to-sound decoding strategy. The deeper or less transparent the orthography, the more the reader uses a direct look-up of the word, without grapheme-speech decoding.

Research has been directed at orthographic comparisons that involve the less transparent English compared with more transparent orthographies, such as German and Welsh. The research suggests that German children and adults trust their orthography to implement a reliable grapheme-phoneme conversion, whereas English children and adults come to rely more on

orthographic whole-word reading (Frith *et al.*, 1998; Landerl & Wimmer, 2000; Wimmer & Goswami, 1994). Thus, German children read pronounceable non-words nearly as well as real words, whereas English children do much more poorly on non-words. Although the interpretation of such results has some difficulties, the carefulness of the studies allows the interpretation that readers of the two orthographies differ in how they approach letter strings. German readers are more likely to treat a string of letters as decodable, English readers are more likely to first try to find the whole word that the string represents. Similar conclusions come from studies comparing children in Wales, who learn to read in English as well as in Welsh, a highly consistent alphabetic system (Ellis & Hooper, 2001).

Another way to understand the differences in orthographic depth is by observing the size of the units that readers use in mapping the graphemes to pronunciations. The unreliability of English grapheme-phoneme mappings may lead to more variability in the size of units that are successful in the orthography-to-phonology mappings. German, although it too has some inconsistencies (Ziegler *et al.*, 1997), provides a more uniform mapping pair at the lowest level allowed by writing systems (grapheme-phoneme). English has lower mapping consistency at the grapheme-phoneme level, but higher consistency at the rime level, the vowel plus consonant ending of a syllable (Kessler & Treiman, 2001, 2003; Treiman *et al.*, 1995). Instead of decoding letter-by-letter, readers of English may use a larger portion, or "grain size," of the printed word to map onto spoken language. This perspective, known as the grain-size hypothesis, can be applied across writing systems as well (see Wydell & Butterworth, 1999; Ziegler & Goswami, 2005). Transparent alphabetic systems apply a small-grain mapping; and syllabaries, which map graphs to syllables, apply a larger-grain mapping.

Writing system

Alphabetic reading can involve the use of letter-phoneme mappings, a level of mapping that can support both learning to read and adult skilled reading because the alphabetic system maps graphic units to phonemes. In contrast, the Chinese logographic and the Japanese kanji systems map graphic units to morphemes and words; they do not allow phoneme-level mappings to function in either learning to read or in skilled reading. Instead, they allow reading to proceed from graphic form to meaning and from graphic form to syllable. Notice that the graphic forms map not only to meaning, but also to pronunciation. The spoken syllable indeed is activated during silent skilled reading in Japanese kanji and in Chinese (Perfetti & Zhang, 1995).

Japanese writing allows the implication of syllable-level mappings on reading to be seen clearly. Japanese kanji (grapheme-word or grapheme-morae) and Japanese kana (grapheme-syllable) are very different in writing system design. However, both potentially provide relatively uniform mapping pairs from a graphic form to a spoken form. The learner can come to acquire these mappings, whether the corresponding spoken units have meaning or are only syllables that are parts of meaningful words. And because the mappings involve a relatively large-grain spoken unit, the syllable, they may be learned by a reader who has trouble learning alphabetic mappings. Indeed Wydell and colleagues (Wydell & Butterworth, 1999; Wydell & Kondo, 2003) reported the case of a bilingual child who, although dyslexic in English (an inconsistent small-grain size system), could easily read both kana and kanji (consistent larger-grain size systems).

These observations emphasize the differences in reading due to writing systems. Syllabaries and logographs provide larger spoken units for graphic mappings than alphabets. The greater accessibility of syllable units compared to phonetic units can affect reading acquisition and the process of skilled reading. However, universals emerge across different writing systems as well. One misconception about Chinese is that it is an exception to the principle that writing systems encode spoken language because it is pictographic, mapping referents and concepts directly. A more sophisticated form of this misconception is that Chinese, although not mainly pictographic, picks out the meaning level of the language to the exclusion of the phonology. This view treats Chinese as a morpheme-based system.

The first misconception is corrected by the observation that only about one or two percent of currently used Chinese characters have identifiable pictographic content (DeFrancis, 1989). Figure 2.5 illustrates the evolution of the form of the characters for "horse" and for "fish" in the clear direction away from literal depictions and toward abstraction. In Figure 2.5, it is difficult to discern the referent-object in the presently used traditional and simplified characters, no matter how pictographic the original appeared in its discovery in the Shang dynasty oracle bones (1000 BCE or earlier; DeFrancis, 1989; see also Luk & Bialystok, 2005).

With the abstract nature of the character established, the second issue is the claim that Chinese is morphemic. This description of Chinese is correct but incomplete and therefore slightly misleading. The characters do represent morphemes, but they also represent syllables. Thus, a character is morpho-syllabic, corresponding not to an abstract formless piece of meaning, but usually to a spoken Chinese syllable that is also a morpheme. Thus, to re-use the horse example, the character represents not horsiness but the Chinese single syllable word /ma/3 that means horse. (The number following the syllable indicates one of four pitch contours or "tones" that are part of all Chinese syllables.) This simple fact means that a Chinese character can be read to correspond to a meaning, to a spoken word, or to both. Because Chinese does not have graphic elements that correspond to phonemes, it is not alphabetic. But the writing unit does correspond to a meaning-bearing spoken language unit—the syllable. Thus it maps spoken language, as do all writing systems. Chinese is more complex than this simple example suggests, because most characters are compounds, the combination of two or more components (characters or radicals). One of the two components often gives

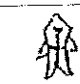
	fish	**horse**
Oracle Bone Script Shang and Yin Dynasties *c.* 1400–1200 B.C.E.		
Large Seal Script Zhou Dynasty *c.* 1400–1200 B.C.E.		
Small Seal Script Qin Dynasty 221–207 B.C.E.		
Traditional Script Han Dynasty 207 A.D.–present	魚	馬
Simplified Script People's Republic of China 1949–present	鱼	马
Pinyin People's Republic of China 1958–present	y	mă

Figure 2.5 Evolution of Chinese characters from pictographs to abstract character.

Source Information adapted from omniglot.com

information about pronunciation (the phonetic radical) and one often gives information about meaning (the semantic radical). Figure 2.6 provides an example of this kind of phonetic-semantic compounding. The character /ri/4 (sun) combines with the character for green (/qing/1), which donates its pronunciation to the compound as a whole. Thus the compound is also pronounced /qing/2 and means sunshine or clear weather.

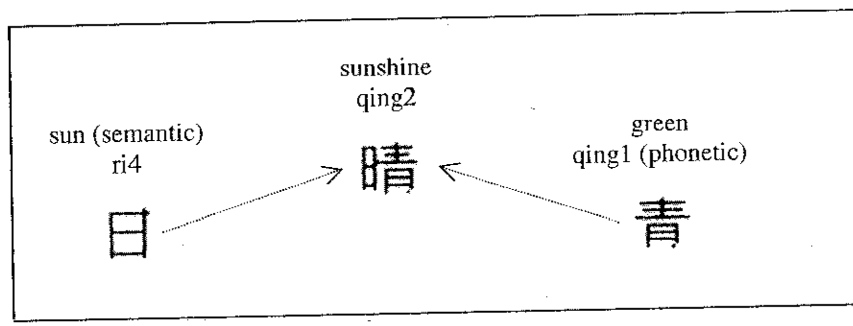


Figure 2.6 Chinese compound character with semantic and phonetic radicals.

However, this example does not do justice to the range of combinations that can occur in phonetic compounds, which make up the vast majority of characters. In most compounds, the phonetic component does not give a full mapping to the correct syllabic pronunciation. Sometimes the component and the character share a phoneme or two, other times nothing at all. On average, the potential phonetic part of the compound is more likely to have a pronunciation different from the character as a whole than it is to match it, even disregarding tone. (See Perfetti, 2003 for examples.)

With this brief and incomplete description of Chinese writing, we come to the simple point that Chinese maps spoken language as well as meanings. A character, whether simple or compound, associates with a spoken syllable (often a one-syllable word) that has a meaning. The speech mapping is non-compositional; that is, there is no part of the character that corresponds to a phoneme. But the mapping is highly deterministic; a given character is usually associated with a single syllable, allowing a consistent connection between writing and speech. Thus, the universal principle that writing systems map phonology unites the two highly contrasting writing systems: logographic (Chinese, Japanese kanji) and alphabetic. It encompasses as well the straight syllabary system of Japanese kana. All writing systems map graphic units to spoken language units.

Writing systems influence the implementation of the universal phonological principle

If all writing systems honor the Universal Phonological Principle, then we should expect to find evidence that reading in any writing system involves the use of phonology. Indeed, the evidence suggests that for skilled readers of Chinese, phonology is part of normal silent reading, including word identification (Perfetti & Liu, 2005; Perfetti *et al.*, 2005). It would be a mistake to conclude from this, however, that reading is identical across writing systems or that learning to read is unaffected by the writing system. The similarity of reading across writing systems lies at the highest and most general level. The differences lie in the details and, of course, details matter.

With respect to skilled reading, the Chinese use of phonology appears to be different from the alphabetic use of phonology. Reading a character uses a connection from the graphic form (the character) to its meaning, and a connection from the graphic form to its pronunciation, more or less in parallel. (See Perfetti *et al.*, 2005, for one way to model this structure.) Reading a character can activate its pronunciation first or its meaning first, but there is no necessary sequencing in which the pronunciation comes first to mediate the meaning. More fundamental is that the activation of phonology must await the orthographic identification of a character. It is "addressed phonology," based on retrieving an association of the character with a syllable-morpheme in the language. In Chinese, phonology is activated threshold style, triggered by the reader's representation of the character reaching its identification threshold (Perfetti *et al.*, 2005). In an alphabetic system, the phonological activation does not wait until an orthographic identification of the word is complete, but rather is immediately begun with identification of a letter or two, and "cascades" as more letters are identified from left to right (Coltheart *et al.*, 2001). These differences occur within the few hundred milliseconds it takes to identify a letter string as a word and to produce either its pronunciation or meaning (Perfetti, Liu, & Tan, 2005). Thus, the product of the identification is not necessarily different across writing systems. Only the rapid intermediate processes that bring this about are different.

In the case of learning to read, writing system differences also matter and may be simpler to observe. Although there is much variability in the teaching of English reading, the successful procedures somehow must help the learner acquire the alphabetic principle. The letters correspond not to meaning but to sound. The path to this learning may vary, but the successful result is more or less the same, and learners who fail to acquire the specific mappings will not succeed at reading. In learning to read Chinese, what is acquired is not the alphabetic principle, nor even a corresponding syllabary principle (which would apply to Japanese kana), but associations between specific character forms and their corresponding syllable morphemes. These associations are learned through a level of practice at writing as well as reading that is substantially more than what occurs in alphabetic learning (Perfetti & Zhang, 1995; Tan *et al.*, 2005b). Children in mainland China begin by learning alphabetic pinyin, which then supports the introduction of characters. In Hong Kong, the learning follows the traditional direct approach, with no alphabetic foundation. In either case, the product of learning is the ability to identify each character as a meaning-bearing syllable that occurs in the spoken language.

This is not to say the phonology is not relevant in learning Chinese. Ho and Bryant (1997) and others point to a predictive role of phonological awareness in learning to read Chinese, just as there is in English. However, morphological awareness, as one would expect, is also important (McBride-Chang *et al.*, 2003). A recent study (Tan *et al.*, 2005b) adds to the picture the importance of writing in learning to read Chinese characters. Tan *et al.* found that character-copying skill showed a much stronger association with children's character reading than did phonological awareness. Character-writing skills may be especially relevant for the specific character learning that is required for Chinese reading. To learn written Chinese is to acquire a lexicon of individual characters that follow an explicit compositional structure, but one that does not represent phonemes.

The larger picture is that reading, because of the Language Constraint, always takes the reader from a graphic form to language and to meaning. Conceptual understanding is not direct, but rather is mediated through language. This means that writing engages a reader's knowledge of phonology and morphology at the word level, and knowledge of syntax at the sentence level. Knowledge of a wide range of culturally embedded language and non-linguistic conventions is also very important for competent reading at all levels, and these become increasingly important beyond the level of the sentence. Our focus here is on the reading of words because this is where the writing system and the orthography make their major contribution. We turn now to a closer examination of how writing systems and language affect learning to read.

Learning to read in different languages and different writing systems

Across all languages and writing systems, the task of the learner is to learn how to obtain meaning from printed words and larger units of text. And for this, learners have to figure out how their writing system encodes their language. The first challenge for a learner of an alphabetic system is to appreciate that the smallest units of writing are arbitrary mappings of minimal, semantically meaningless units of speech—phonemes, not syllables or whole words. Each writing system presents its own distinctive mapping challenge. There has been sufficient comparative research to support some conclusions on how these challenges matter for learning. Indeed, the recognition that the world's variety of writing systems, orthographies, and scripts are relevant for understanding literacy acquisition is evidenced by the recent publication of a Handbook of Orthography and Literacy (Joshi & Aaron, 2005).

Comparisons within alphabetic writing systems

Much of the research on learning to read has been conducted with native speakers of English who were learning to decode words in their alphabetically written language. However, compared to most other modern languages, decoding English is rather difficult, owing to its inconsistent grapheme-phoneme correspondences. As illustrated in Figure 2.4, English is one of the least transparent of alphabetic writing systems, exceeded perhaps by Hebrew and Arabic when they are written without vowel markings. Resolving inconsistent connections between letters and phonemes and between letter strings and words places a demand on English word reading that is greater than for more transparent orthographies, such as Italian (e.g. Paulesu *et al.*, 2000, 2001) or Welsh (e.g. Ellis & Hooper, 2001; Spencer, 2001). For example, the dominant mapping for the letter "o" in the rime unit "-one" is its pronunciation in "bone," "tone," and "lone." When the reader encounters "gone," there is a conflict between this dominant letter-phoneme mapping and the pronunciation of "gone." As the dual-route models (Coltheart *et al.*, 2001) explicitly recognize, and connectionist models must capture in other ways, there are two pathways to get to a word's pronunciation, and sometimes, as in "gone," they are in conflict. In fact, even in skilled reading there is a small price to pay in reading time for such conflicts, at least when the word is encountered infrequently. The reader has to, in

effect, weigh knowledge of the letter-level mapping against knowledge of the word-level mapping. For learners, these conflicting pathways necessitate the use of error-prone reading strategies (Frith *et al.*, 1998). Although one can, because of these problems, characterize English as a "dyslexic" orthography (Spencer, 2000; see also Wydell & Butterworth, 1999), it is important to recognize that dyslexia appears to be general and not restricted to opaque orthographies nor even to alphabetic writing (e.g. Stevenson, 1984; Ziegler & Goswami, 2005). Nevertheless, there are specific challenges to word reading posed by an alphabetic writing system whose orthographic implementation deviates from its mapping principle as often as English does. To illustrate this, it is useful to contrast the English case with other alphabetic orthographies.

Compare English and Welsh, for example, both of which use a Roman-based alphabet. English uses 26 letters (graphemes) to represent 44 sounds (phonemes). Most letters have multiple possible pronunciations depending on the word context. The letter "g" has at least three different sounds (e.g. in "garage" or "giraffe" or "thing") or can be silent (e.g. "gnome"). Vowel sounds are especially unreliably mapped in English (e.g. "give" and "five"). The complex mappings and exceptions to decoding generalizations that characterize English are largely absent in Welsh. Indeed, Welsh letter-sound mappings are so consistent that Welsh dictionaries do not include pronunciation entries after each word in the way that English dictionaries do. Welsh uses 21 letters from the same Roman-based alphabet (some of them in two-letter digraphs such as "ch" or "ff") to represent roughly 40 sounds. But unlike English, Welsh has nearly one-to-one mapping for single consonants with some digraph combinations, and vowel sounds are spelled by single vowels, marked vowels, or diphthongs. With the exception of some initial letters altered by a Celtic system of mutations, Welsh is a transparent orthography. For instance, the letter "g" predictably sounds like /g/. It is this grapheme-to-phoneme predictability in Welsh relative to English that leads to different decoding strategies in the two cases.

Ellis and Hooper (2001) showed that six and seven-year-old children learning to read Welsh were able to implement their alphabetic mapping more easily than children learning to read English. The children were well matched in other relevant variables. Welsh children learn both English and Welsh in school, with geographical region (associated with language dominance) determining which language they learn to read first. The Welsh-reading children tended to use a decoding strategy based on letter-sound correspondences, which reliably predict the correct word pronunciation in their language. This strategy was apparent in their overall stronger reading ability and in the kinds of errors they made when they did misread words. They also correctly read aloud a greater number of low-frequency words, even some words for which they could not report the correct meaning. On the other hand, English-reading children had difficulty reading many words, even those for which they knew the meanings. And when they made errors, these errors were less likely to share many phonemes with the target word, as if higher weight were given to a whole-word route based on partial visual analysis of the letters. In effect, the evidence is that children learning English learned to use the alphabetic procedure unreliably and did not generalize it to decode new words.

One might wonder whether these cross-linguistic differences are simply due to instructional differences. Shallow orthographies lend themselves more readily to phonics instruction and phonics instruction appears to be used for all shallow orthographies. Instruction in English has tended to de-emphasize phonics. However, Ellis and Hooper (2001) controlled for this and a number of other factors by using participants in the same geographic region of Northern Wales who received equivalent phonics instruction in their respective classrooms. Language was the primary factor that differed. That differences were nevertheless found between Welsh and English readers lends support to the hypothesis that the orthographic transparency influences the reading strategies that learners acquire. Decoding letters to phonemes is more adaptive in a shallow orthography than in a deep orthography, and children learning to read appear to tune their reading to the functional properties of their orthography.

This demonstration that the consistency of orthography-to-phonology mappings can lead to different reading strategies fits well within the broad theoretical outlines of how word identification works. We noted above the assumption of dual-route theories that there are two ways to read printed words (Coltheart *et al.*, 2001). One is via an assembled (sublexical) pathway along which letters are mapped to phonemes, which are assembled into larger units. This route depends on reliable mappings, and works well for Welsh and German and for other shallow orthographies. The other pathway is an addressed or lexical route, in which the word corresponding to a full-word letter pattern is retrieved. This path is needed for irregular or exception words, words whose assembled letter-phoneme mappings fail to match the target pronunciation. Since English has many irregular words, children successfully learning to read English will learn to use the lexical pathway for many words. In fact, it is possible that they will come to use this pathway for all words, a strategy that will fail for words that readers have not experienced before or whose frequency has been too low to establish an addressable representation. For such children, whole-word or sight recognition comes to completely outweigh the letter-sound mappings. Although dual-route models provide a natural account of these phenomena, single route models, with the use of multi-layer networks, can also do so (Plaut, 1999; Plaut *et al.*, 1996; Seidenberg & McClelland, 1989). Additionally, models with learning mechanisms have the potential to account for how different orthographies might lead to different reading strategies (Harm & Seidenberg, 1999).

The two different strategies (henceforth "sublexical" and "lexical") lead to different types of errors, as shown in the English-Welsh studies. The lexical strategy leads readers, when they make errors, to respond with real words based on shared letters or partial visual overlap with the target word, for example, responding "near" for the word "never." The sublexical strategy leads to errors with high phonemic overlap with the target word, even when that means producing non-words (Ellis & Hooper, 2001). This difference in error patterns has also been found in comparisons of English with German, a transparent orthography. Wimmer and colleagues (e.g. Frith *et al.*, 1998; Landerl, Wimmer, & Frith, 1997; Wimmer & Goswami, 1994) have shown that German children decode words relying on the sublexical strategy, that is, grapheme-phoneme conversion, whereas English children decode words relying on a lexical strategy. The German children gave more non-word responses, indicating they were sounding out new words at the expense of lexicality, and remaining faithful to learned letter-sound correspondences. The English children were more likely to respond incorrectly with a real word that looked similar to the target item. Overall, English children made more errors than German children when reading both non-words and low frequency words, again lending support for the orthographic depth hypothesis.

Further evidence for orthographic factors comes from a comparison of English with Italian, which is orthographically very transparent. Paulesu and colleagues (Paulesu *et al.*, 2000, 2001) showed both behavioral and brain differences for native speakers of Italian versus English. Generally, both Italian and English participants read real words faster than non-words, indicating that lexicality, that is, whether a letter string is a word, plays a role even in a shallow orthography. However, Italian participants were faster than their English participants at reading both real words and non-words. Using positron emission tomography (PET), Paulesu found many common brain regions for Italian reading and English reading: left inferior frontal and pre-motor cortex, left temporal gyrus, left fusiform gyrus, and right superior temporal gyrus. Most of these left hemisphere regions were activated more in reading non-words than in reading words. In addition to these regions that were activated by both languages, there were regions whose activation was specific to each of the two languages. English reading activated the left posterior inferior temporal and inferior frontal gyrus. Italian reading activated the left superior temporal gyrus and inferior parietal cortex (planum temporale). The interpretation linking this pattern to the orthographic differences is that the superior temporal region is more active in Italian, because this region supports the sublexical letter-phoneme procedures that are encouraged by Italian's transparent orthography. The greater role of the left frontal and posterior inferior temporal regions for English may implicate English's greater reliance on a lexical procedure. Although there is some uncertainty in how to characterize the functionality of the brain's reading network in detail, the network is likely to be tuned by the reader's experience with word reading. If the orthography shapes a strategy that is adaptive to its use of sublexical versus lexical pathways, then the reading network will come to reflect this adaptation (Fiez, 2000).

The manifestations of dyslexia also seem to be affected by orthography. Readers of a shallow orthography may have reading problems, but these problems are less likely to involve sublexical phonology and more likely to involve slow reading rates and poor spelling (Landerl *et al.*, 1997). Dyslexic readers of English show these deficits in addition to impaired phonological decoding and phonological awareness (Ziegler & Goswami, 2005). Furthermore, the neuoroimaging study of Paulesu (2001) that compared French, Italian, and English found differences in brain activity for normal and dyslexic readers. For the dyslexic groups, compared with a non-reading baseline task, reading produced less activity in left hemisphere areas (middle, inferior, and superior temporal cortex) that were involved in normal reading of deep orthographies. Dyslexics also showed more activity in the left planum temporale, thought to be involved in processing shallow orthographies. One interpretation of this pattern is that the dyslexics were processing deep orthographies (English and French) as if they were shallow, that is, applying letter-phoneme decoding to irregular words. The dyslexic group did not have greater activation in any brain region relative to the control group. However, the controls did show greater activation in several regions relative to the dyslexic group: superior temporal gyrus, middle temporal gyrus, inferior temporal gyrus, and middle occipital gyrus. There were no orthography-specific effects among the three dyslexic groups. This again lends support to the notion that different strategies (alphabetic vs. whole word) possibly recruit different brain regions.

Korean provides an important comparison in that it is alphabetic but quite different in appearance from the horizontal arrangement of letters seen in most alphabetic writing. Instead of a horizontal arrangement, Korean letters are configured in square blocks that correspond to syllables. Most blocks represent a CVC syllable, with the initial consonant and vowel depicted on the top and the final consonant on the bottom (see Figures 2.1 and 2.3). The Korean reader can decode words at the subsyllabic level rather than the whole word level because the orthography represents an alphabetic writing system. Yoon, Bolger, Kwon, and Perfetti (2002) found that Korean children as young as five years old were sensitive to subsyllabic units within written Korean and that their preferred subsyllabic structure was body + coda (for "pin," /pI/ + /n/), rather than the onset + rime (/p/ + /In/) as it is in English. Such a difference in subsyllabic structure could arise because of the script—the visual differences between Korean and English in how the alphabet is displayed—or because of linguistic differences. Based on the fact that the preference differences were observed in speech as well as reading, Yoon *et al.* (2002) suggested it is a linguistic difference. Given our emphasis here on writing and orthography, this conclusion provides an equally important consideration. The language, not just the writing system, is critical in learning to read. Specific facets of language influence the development of the writing system and the orthography, and they influence the language units the reader uses in reading.

Finally, notice that the languages we have examined here—Welsh, German, Italian, and Korean—are just a few examples of orthographically shallow alphabetically written languages. Many other languages including those discussed in other chapters of this book are shown in Figure 2.4. For example, both Spanish and Dutch are high on the transparency scale. French, vowel-less Arabic, Lao, and Khmer, are less transparent, closer to English. All of these languages use alphabetic writing systems. We turn in the next section to non-alphabetic languages.

Comparisons across writing systems

Compared with alphabetic systems, both the Chinese and Japanese writing systems represent larger units of speech—syllables rather than phonemes. Chinese characters represent an onset-rime unit that by itself can usually be a one-syllable word, or can be combined to form multiple-character words. A beginning reader must learn and memorize the corresponding spoken syllable/morpheme for each new character. Approximately 2,000 distinct orthographic forms (characters) must be learned for a Chinese speaker to be considered basically literate (Kennedy, 1966). Given the design principle of Chinese, characters cannot be decoded at the level of graph to phoneme, as is possible in alphabetic writing. Furthermore, although characters correspond to syllables, Chinese is not a syllabary, which would require a systematic mapping from a meaningless (and productive) graphic unit to a spoken syllable, as occurs in Japanese kana. The characters map to meaningful morpheme-level syllables at a low level of systematicity. This structure appears to promote a whole character approach to reading.

In its kanji system, Japanese borrows the form of Chinese characters and, as we previously noted, applies either a Japanese ("kun") or a Chinese ("on") pronunciation to them. In contrast, Japanese kana is a writing system that uses a distinct graph for each possible syllable in the language. Once a reader has learned a few dozen correspondences, reading is a matter of combining syllables into multisyllabic words. Katakana and hiragana are the two types of kana syllabaries used in Japanese. The grain size of Japanese kana is smaller (one syllable of a multi-syllable word) than that of kanji (whole word). Reading at these two different levels of writing systems may involve different mixes of basic reading processes and may draw on somewhat different cognitive resources.

Shafiullah and Monsell (1999) conducted a study of reading processes using naming and semantic categorization tasks while continually switching between two types of scripts (kana and kanji). They found a very small (13 ms) but significant cost of switching between kana and kanji, but no cost of switching within the two equally transparent forms of kana (katakana and hiragana). This suggests that reading either type of syllabary involves shared kana orthographic processes; their differences are at the script level, not the system level. Kana processes and kanji processes, however, are different at the system level; the processes are sufficiently distinct to require different cognitive procedures; and a switch from one to the other bears some cost. Consistent with this conclusion is the finding that kana (syllabic) stimuli produce faster pronunciations than do kanji (whole word), whereas kanji stimuli produce faster semantic judgments, perhaps due to a more lexical approach to reading whole words (Shibahara *et al.*, 2003). This implies that different reading processes develop in specific adaptation to the basic mapping structures of these two writing systems.

Differences in the reading processes required by different writing systems may also be reflected in the neural organization of reading in the brain. Several brain-imaging studies suggest that Chinese reading and alphabetic reading recruit distinctive as well as overlapping brain regions. This general conclusion emerges from two reviews and meta-analyses of several such studies reported by Bolger *et al.* (2005) and by Tan *et al.* (2005a). Moreover, even within the Chinese writing system, there is evidence that different brain regions support different units of linguistic processing. Siok, Jin, Fletcher, and Tan (2003) investigated syllabic versus phonemic processing in an fMRI study in which native speakers of Mandarin made homophone judgments and initial consonant judgments on pairs of Chinese characters. Results showed that syllabic processing, as seen in the homophone judgment task, recruited areas of the left middle frontal cortex, whereas phonemic processing, as seen in the onset judgment task, recruited the left inferior prefrontal gyri. This result suggests that separate brain regions have functions that support distinctive processes at the phoneme level compared with the syllable level, even in a single writing system where stimuli are held constant across tasks.

Adult learning of a new writing system

When adults learn to read in a new writing system they face challenges beyond those faced by the native language reader. Lacking a native knowledge of the spoken language, they must learn the spoken language while simultaneously learning to read the written language. Furthermore, writing system differences across languages may provide unique challenges for the learner. For example, how does a native Chinese speaker learn to read English? Conversely, how does a native English speaker learn to read Chinese?

Addressing these learning questions can begin with another question: the relationship between reading in L1 and L2 across the two writing systems. Liu and Perfetti (2003) studied native Chinese speakers who were fairly fluent in English by recording event-related brain potentials (ERPs) during Chinese and English word reading. Specifically, participants performed a delayed-naming task with high- and low-frequency words in Chinese and English. The ERP recording showed clear differences between L1 Chinese and L2 English, beginning with ERPs that reflected early (100–200ms) graphic processing. In effect, Chinese characters showed slightly faster orthographic recognition than English words, and Chinese high-frequency words showed faster orthographic recognition than low-frequency words. Occipital area activation (reflecting visual-orthographic processing) was longer for L2 (English) words than L1 (Chinese) words, and longer for low-frequency words compared to high-frequency words in L1. Thus, graphical analysis requires more processing time for L2 than for L1 and for less familiar items compared with more familiar words. This graphic analysis is prior to phonological and semantic analysis.

Furthermore, source localization of the Liu and Perfetti (2003) ERP data showed some common brain regions for the two languages, as well as some brain regions distinctively involved in one or the other language. In line with general understanding of the brain's reading network, both Chinese and English showed early encoding of graphic forms in posterior visual areas, with later phonological and semantic processing involving anterior areas of the reading network. Language-distinct brain regions emerged also within the first 100–200 ms of word reading. Chinese high- and low-frequency words specifically recruited bilateral occipital regions, whereas English high-frequency words recruited only the left occipital cortex. Within 300–400 ms, Chinese activated right prefrontal regions, and English activated medial frontal regions. Thus even for speakers who have gained some fluency in both Chinese and English, we see differences between the two languages in the time course of word reading and in the brain regions that support word reading.

With such differences established, the question becomes whether learners of Chinese come to show language-specific patterns of the same type as shown by Chinese-English bilinguals. Liu *et al.* (2005) studied native speakers of English who learned a limited set of Chinese characters. Participants learned the pronunciation, the meaning, or both the pronunciation and meaning of 60 Chinese characters in the course of a three-day training period. Following learning, participants viewed the Chinese characters they had learned along with novel Chinese characters and English words in an fMRI procedure. Comparisons across conditions showed more activation for learned Chinese characters relative to English words at several areas, including a bilateral pattern in medial, middle frontal, insula, occipital, fusiform, and superior parietal regions. Conversely, English words produced more activation than learned Chinese words at bilateral superior and inferior frontal regions as well as middle and superior temporal gyri. The pattern for these learners while they were viewing Chinese overlapped in key regions found for native speakers of Chinese. These include both bilateral visual cortex (compared with left hemisphere for English) and the middle frontal gyrus, an area that seems specific to Chinese character reading (Tan *et al.*, 2005a). This suggests that, although there may be a universal brain network for reading, the network makes accommodations to the specific features of the writing system (the system accommodation hypothesis, Perfetti & Liu, 2005). Especially remarkable is how rapid at least some of this accommodation is, perhaps as soon as real learning is underway.

Finally, a related study investigated native speakers of English who were learning Chinese in a university setting (Nelson *et al.*, 2005). FMRI data collected after one year of classroom study showed that English speakers recruited new brain regions that have been shown to be used by Chinese readers, especially bilateral visual and visual-temporal cortex, as previously found (Liu *et al.*, 2005). Nelson and colleagues (2005) included an informative comparison with Chinese-English bilinguals. These readers showed high overlap in the visual brain regions for Chinese and for English. Specifically, the bilinguals showed, for both English and Chinese, the Chinese pattern of bilateral activation as opposed to the alphabetic pattern of left hemisphere dominance. This pattern may suggest that, whereas English speakers learning Chinese show brain network accommodation to the new system, a system that cannot be decoded phonemically like their L1, Chinese speakers who have learned English may use the same whole-word reading strategy for L1 Chinese and for their new L2 English. The too-simple idea here is that Chinese readers may read English as they do Chinese. It remains to be seen whether this is a characteristic of high levels of skill in the new system or one that really depends on the writing system. On the latter formulation, one might say something like Chinese-style reading can handle all systems, whereas alphabetic-style reading is specialized for alphabets. Again, this is a too-simple account that will be modified as we learn more about how the brain responds to learning to read.

These three studies of Chinese and English reading suggest that two very different languages with fundamentally different writing systems share reading processes, beginning with graphic encoding and including the retrieval of both phonological and semantic constituents of words. The brain's reading network shares much of its functionality across languages and writing systems, consistent with the existence of language-general processes in reading. The orthographic-phonological and semantic processes that operate in word-reading are similar across languages, but the time course of these processes depends on frequency or familiarity of words either within a language or across languages. In one's native language, a reader initiates more quickly and completes the processing of graphic forms and moves to pronunciation and meaning. Nevertheless, language-specific characteristics, including the writing system's mapping principles, the visual aspects of the script, and the orthographic consistency, determine variations in the details of these processes. These details are visible as variations in the contributions of specific components of the brain's reading network.

Transfer across systems

Finally, we turn to an issue raised by our discussion of learning across writing systems. Is the acquisition of reading in a second language dependent on the match between the first and second writing system? First, we observe that the match between L1 and L2 is a factor in the acquisition of a second language. The competition model (Bates & MacWhinney, 1987; MacWhinney, 1997) explicitly predicts that learners of L2 will have problems where their L1 grammar provides a point of difference in some grammatical feature. The parallel question is whether orthographies and writing systems present comparable points of match and mismatch.

An obvious candidate is the mapping system. For a Chinese native speaker, there is a mapping mismatch in learning an alphabetic system. Chinese children (in the mainland) learn the pinyin alphabet first, and thus they are familiar with alphabets when they encounter English or some other alphabetic system. However, pinyin is virtually never encountered in Chinese writing for adults, and it is not clear that later learning to read in English, especially as an adult, benefits much from knowledge of pinyin. The fact that pinyin is transparent, may further limit its easy transfer to the nontransparent orthography of English, particularly since pinyin is orthographically transparent.

Let us consider the Chinese L1 learner of English L2 compared with the Korean L1 learner of English L2. If mapping principles can be transferred, then the Korean learner has an advantage over a Chinese learner in learning an alphabetic system. Korean makes a solid comparison with Chinese for two reasons: Korean is linguistically distant from English, and its square, syllabic-size units do not resemble the alphabet used in English.

Wang, Koda, and Perfetti (2003) compared Korean L1 and Chinese L1 adults in their English reading. Their skill level in English was comparable, allowing the question to focus on the reading strategies used for English. If mapping transfers, despite the differences in visual appearance, then Korean readers may use the same sublexical (letter-phoneme) strategy that works in reading Korean in reading English as well. By contrast, Chinese readers may attempt to transfer their lexical (holistic) strategy to English, as implied by the brain imaging results (Nelson *et al.*, 2005) for Chinese bilinguals reading English. Wang *et al.* tested (2003) their Korean-English and Chinese-English bilinguals for their relative reliance on phonological and orthographic processing in English word identification. The hypothesis was that Korean would support sublexical strategies that result in phonological processing, whereas Chinese would support visual-lexical strategies that would show effects in orthographic processing. This hypothesis was tested in a semantic category judgment task that required participants to decide whether an English word belonged to a semantic category. Korean ESL learners showed a homophone effect: more false positive errors to homophones of category exemplars (e.g. Is bare an animal?) than to spelling controls. Chinese ESL learners showed a reduced homophone effect that depended on spelling similarity: only when homophones were visually similar to exemplars (creek, creak) did they make errors (cf. knows, nose). Chinese bilinguals also performed more poorly in a phonological awareness task, compared with Korean readers. Wang *et al.* suggested that writing system mapping principles are subject to transfer to new languages, and that the relative match of the mappings for Korean and Chinese produced the observed effects.

Wang *et al.* (2003) also pointed out that such results might also reflect language differences rather than writing system effects. This is a serious problem for studies of comparative reading generally, and for transfer effects in L2 in particular. Although it is nearly impossible to control fully for language factors (as opposed to orthography and writing system factors), the language factors are very important. They also have not been studied much in comparative reading research, which has focused mainly on written language factors. As the Korean-English comparisons of Yoon *et al.* (2002) suggest, it is very likely that language factors will emerge as important. These factors, after all, shape the writing system. English orthography is inconsistent partly because it has a very large vocabulary that derives from different languages with different phonologies. Further, written English has undergone only modest spelling changes compared with the larger changes in pronunciations that the spellings map. Chinese writing, or so it has been argued, is a poor candidate for an alphabet because of its many homophones and its tone system. Observations such as these make it apparent that the language itself inevitably affects reading: first through how it has influenced writing, and second through how it affects the output—the linguistic representations—of reading.

Summary and conclusions

In learning to read, part of the learning process is to figure out how the writing system encodes the reader's language. Because all writing systems work through language rather than through non-language concepts (the Language Constraint on Writing), there is a universal problem to be solved by all learners. The great variety of writing at the script level presents a problem for learning that may be relatively easily overcome. However, the fundamental principles of the writing system and the details of the orthography present deeper challenges for the learner, while the universal role of phonology in reading provides a common grounding.

For a child learning to read, the print-to-language mapping is the fundamental learning task. This task is challenging for different reasons in different systems. In Chinese, the problem is hundreds of characters to memorize with limited productivity possible. In English, the problem is the compromise made with the alphabetic principle, leaving many irregular letter-to-sound mappings. We focused more on the English problem than the Chinese

problem here. We reviewed a sample of the research that makes clear that in the family of alphabetic systems, the reliability of letter-phoneme mappings makes a difference for reading and learning to read in alphabetic systems. More generally, the size of the phonological unit mapped by the basic graphic unit, which varies across writing systems, may define the learning problem for the child. As a learner figures out the workings of the writing system and its orthography, there is an accommodation to these writing factors. This accommodation may be seen in the strategies for identifying words, as English readers develop a more lexical strategy while readers of transparent orthographies develop sublexical strategies.

At the writing system level, the accommodation is even more profound. The universal phonology is implemented in different ways across writing systems in skilled adult reading. One example is phonological activation, which may be implemented by a threshold procedure (Chinese) or a cascaded procedure (alphabetic). Learning to read in a second system presents a complex problem for the learner that involves language differences, that is, an incomplete learning of the second language prior to learning to read it. However, the writing system differences appear to be important beyond the language factors. Recent imaging research suggests that the brain network for reading accommodates to properties of the writing system, although this may be truer for learning Chinese than for learning an alphabetic system.

In the context of learning to read English, an especially important set of questions concerns the effect of the L1 (first language) and WS1 (first writing system) on learning to read in L2. At least one study illustrates the possibility that mapping principles learned as part of L1 reading are transferred to a second writing system, suggesting that Chinese readers learn to read English using a lexical strategy, whereas Korean readers transfer their sublexical strategy. There is much to learn about this possibility and about the role of language factors themselves in learning to read in a second language.

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