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Reading and Writing Words: A Cross-Linguistic Perspective

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ABSTRACT

We review cognitive-linguistic approaches to conveying meaning, sound, and orthographic information across scripts in order to highlight the impact of variability in written and spoken language on learning to read and to write words. With examples of word recognition and word writing from different scripts, including Chinese, Arabic, Persian, and English among others, we highlight 1) characteristics and boundaries of a word and how these sometimes present challenges for reading and spelling, 2) phonological sensitivity, including phonological omissions in print, suprasegmental processing, and "distance" between spoken and written forms, vis-à-vis literacy acquisition at the word level, 3) the importance of specific types of divergent visual-orthographic knowledge for the mastery of different writing systems, and 4) expanding understanding of visual-motor skills and their role in spelling across scripts. All of these aspects of variability in different writing systems should be more broadly integrated as theoretical models and intervention methods of reading or writing are tested across different writing systems.

Introduction

Theories of literacy development have been largely based on English and other alphabetic scripts (Dehaene, 2009; Katz & Frost, 1992; Ziegler & Goswami, 2005). In order to understand the universal and specific aspects of literacy development, it is essential to take into account literacy development across different scripts, including Chinese, abjads such as Arabic, and abugidas such as Thai. Daniels and Share (2018) highlighted 10 dimensions along which scripts can differ at the word level. In this review, we extend previous work on literacy across cultures (e.g., Chang, Chen, & Perfetti, 2018; Nag, 2011) to consider and expand upon the most important of these features both for word recognition (reading) and production (spelling, or dictation).

We favor an approach to literacy learning that assumes that various dimensions of words are universally important to consider but are weighted differently (Pae, 2018; Verhoeven & Perfetti, 2017) by script and language. These weightings are critical, particularly given an over-focus on English in literacy research worldwide thus far (e.g., Share, 2008). The many studies of English have resulted in an emphasis on phonological processing that may not apply equally even across other alphabetic languages and scripts (e.g., Landerl et al., 2019). This "Anglocentricity" (Share, 2008) likely resulted in less attention to other elements of word reading and word writing that are more or less important in different scripts. Weightings focus primarily on morphological/semantic, phonological, and orthographic skills (Pae, 2018). Below, we expand on each of these dimensions of cognitive-linguistic constructs required for early literacy acquisition. We highlight representation of meaning, or morphology, of words first. We then move on to discuss various aspects of phonological sensitivity at both the segmental and suprasegmental levels. A broad exploration of visual-orthographic information

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conveyed in different scripts then follows. We conclude with a discussion of the importance of visual-motor skills when considered from a multiscriptal perspective.

Meaning in words

We begin with a focus on meaning in print, particularly because a contrast of Chinese with alphabetic scripts often highlights the status of Chinese as a unique morphosyllabic script (McBride, 2016b). Generally, a Chinese syllable simultaneously represents a morpheme and a Chinese character. This unique feature of Chinese is fundamentally important for understanding how children and second language (L2) learners learn to read Chinese. For illustration, an analogy in English is the following: Knowing words represented as single morphemes here such as *black, brain, horse, mail, wash*, or *power* might help you to read and to understand other words such as *brainpower, powerboat* or *washcloth*. In these compound words, the meaning of each morpheme can be combined to derive a relatively transparent, holistic meaning. In other circumstances, knowing these single words/morphemes can also help you to read but not necessarily to understand other words such as *brainwash, blackmail*, or *horsepower*. In each of these examples, the meaning of the compound word is at least slightly different from the meaning of the combination of the individual morphemes. In Chinese, there are many words comprised of characters of both types, with both transparent and relatively opaque meanings.

Although some individual Chinese characters can function as independent words (e.g., 饭, meal), more than 70% of Chinese words are compound words that consist of more than one character (Institute of Language Teaching and Research [of China], 1986). A word in Chinese comprises from one to six characters. For example, the English word *capitalism* is written using four Chinese characters, 资本主义. Moreover, there are no differences in spacing, demonstrating what the conceptual words are within the text. In English, we can make an analogy to the word *ice cream*, arguably one word but written as two. Each Chinese character occupies a fixed square on a page, made up of strokes. Characters are individual written units, separated by space boundaries, quite different from the typical linear structure of words in alphabetic scripts.

With these illustrations, we hope to highlight the conundrum of whether the word is consistently the clearest unit in characterizing early reading and writing. Although existing models typically presume that the word concept and its boundaries are consistently clear across different scripts, this is not always the case. In Finnish and German, for example, words that are up to 30 letters in length appear with some (albeit infrequent) regularity, and even longer words are possible. In Thai and Chinese scripts, there are no clearly demarcated spatial word boundaries (McBride-Chang et al., 2012).

The concept of a word as a unit of analysis can be confusing in Arabic and Arabic-derived scripts as well. For example, readers may experience difficulty in deciding upon word boundaries when they encounter letters that do not join other letters, referred to as radical letters (ligaturing). Most of the letters of the alphabets in Arabic and Persian scripts have the potential to stick to adjacent letters within the word in order to form a coherent word unit. However, the 7 letters of ء /a/, ا /a/, و /v/, د /d/, ذ /z/, ز /z/, and ر /r/ in both Persian and Arabic and the additional ژ in Persian can only stick to the former letter but not to the next letter regardless of position in the word. The use of the E morpheme, specific to Persian, can also lead to confusion. This morpheme has a similar function to the apostrophe in English (e.g., "Ryan's book" کتابِ رایان). It can also indicate the function of an adjective phrase. Because this morpheme is omitted in print for expert readers (in this example, کتاب رایان instead of کتابِ رایان), there can be difficulties in determining phrase boundaries in noun phrases in Persian (Baluch & Besner, 1991). Finally, in Persian, some morphemes are written bound to the host, whereas others are free affixes. That is, some morphemes are attached in print and essentially form a single unit together (e.g., /ketabhayeman/کتاب‌های‌مان "our books" and ب عقیده من /beaghideyeman/ "in my point of view"), whereas some others are written as free affixes (e.g., بی حوصلگی /bi hoselegi/ "boredom" and احوال پرسی /ahval porsi/ "greeting").

However, although many languages and scripts may reveal instances in which the word boundary is not 100% clear, Chinese presents the best example of how the word concept can be blurred, with the

existence of two distinct but highly related units (Chen, Song, Lau, Wong, & Tang, 2003), namely, the character and the word. Children use somewhat different strategies in recognizing Chinese characters and words (Liu, Chung, McBride-Chang, & Tong, 2010), so which do they rely on in the literacy learning process? Some studies show that processing of Chinese text tends to focus on the word level in children and adults (Bai, Yan, Liversedge, Zang, & Rayner, 2008; Chen et al., 2003; Hsu & Huang, 2000a, 2000b; Shen et al., 2010; Yan, Kliegl, Richter, Nuthmann, & Shu, 2010). This is in line with the consensus in alphabetic languages that the saccade target during text reading is the word (Radach & Kennedy, 2004). After all, a Chinese word corresponds to a language unit conveying independent meaning. However, some characteristics of the characters (e.g., visual complexity, frequency) within multiple-character words also affect whole-word recognition (Chen et al., 2003; Yang & McConkie, 1999; Zhang & Peng, 1992), supporting the salience of character-level reading in Chinese as well. Moreover, Chu and Leung (2005) showed that children used word-level reading strategies for high-frequency words, but component character-level reading strategies for low-frequency words. This suggests that children may use flexible strategies in reading. Importantly, children tend to perform significantly better in reading the same character when it is embedded within a word than when it is presented alone (Li & McBride-Chang, 2013; Li, Wang, Tong, & McBride, 2017; Wang & McBride, 2016).

The existence of two distinct but highly correlated levels of reading units in Chinese is both practically and theoretically relevant for considering universal models of word reading and word writing. At the practical level, sometimes individual characters are more difficult to identify than are 2-character words. Identifying them requires excellent visual-orthographic skill; precise memorization of each individual character is key for character recognition. In contrast, recognition of words consisting of two or more characters makes use of both character recognition and understanding of how morphemes comprise words, i.e., morphological awareness and vocabulary knowledge. Thus, teaching character recognition requires a narrower focus on visual-orthographic memorization than does teaching word recognition. Theoretically, the extent to which the unit of reading is the character or the word is not yet clear; character and word units likely influence one another.

Meaning is constructed by combining morphemes across languages and scripts. Moreover, given the high number of homophones and homographs in Chinese, distinguishing these via lexical compounding is particularly important for literacy development in Chinese (Kuo & Anderson, 2006; Liu, McBride-Chang, Wong, Shu, & Wong, 2013; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Ruan, Georgiou, Song, Li, & Shu, 2018; Shu, McBride-Chang, Wu, & Liu, 2006; Yeung et al., 2011). For example, if learners know the character 球, meaning ball, in the word 乒乓球 /pīng pāng qiú/ (*ping-pong ball*), they may make an educated guess and read this word by recognizing the position of the character 球, making an analogy to its compound structure of 篮球 (basketball). When one is clear on compound word structures, one is better able to guess in recognizing semantically related words. In addition, most characters have more than one meaning; the specific meaning intended can be understood only within word context via lexical compounding (Shen & Bear, 2000). For example, the character 分 means *mark* in 分数 (score), while, in contrast, it means *divide* in 分担 (share responsibility). Moreover, there are many two-character real words in Chinese for which a reversal of characters also results in a real word (e.g., 带领 (lead) & 领带 (tie), Liu et al., 2010; Peng, Ding, Wang, Taft, & Zhu, 1999). An analogy in English would be *pancake* vs. *cake pan*. Because of the relative frequency of this phenomenon in Chinese, lexical compounding awareness is essential for reading and writing these "reversible" 2-character words.

Sound-to-spelling consistency is generally more complicated than spelling-to-sound consistency in most orthographies (Daniels & Share, 2018). This phenomenon is prominent in Chinese partly due to its large number of homophones. Morphological awareness, defined here as awareness of the morphemes of one's language and understanding of how these morphemes can be combined to make sense of words in that language, is, thus, uniquely important for Chinese word writing (Tong, McBride-Chang, Shu, & Wong, 2009; Yeung et al., 2011). For example, when one is required to write a character pronounced as /hong2/, it is ambiguous, since many Chinese characters correspond to this syllable. In

this case, if one is told to write 虹 /hong2/ in the word 彩虹 /cai3 hong2/ (rainbow), it will be clear. Indeed, even expert adults are better at writing single characters when they are embedded in 2-character words than when they are required to write single characters (R. Wang, Huang, Zhou, & Cai, 2020).

This fundamental issue of meaning-building highlights a potentially critical aspect of recognition and writing of words. Although lexical compounding has not been tested widely in other scripts, it has been uniquely linked directly to word reading in Chinese and Korean Hangul (e.g., McBride-Chang, Cho, et al., 2005), to dictation in Persian (Mohseni & McBride, 2019), and to vocabulary knowledge across other languages tested thus far, including Dutch (Rispens, McBride-Chang, & Reitsma, 2008) and English (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005). Vocabulary-building itself is fundamental for word reading (e.g., Ouellette, 2006).

Morphological awareness beyond lexical compounding, including inflectional and derivational morphology, uniquely contributes to word recognition in English (e.g., Kirby et al., 2012), Arabic (Saiegh-Haddad & Taha, 2017), Spanish (Ramirez, Chen, Geva, & Kiefer, 2010), Dutch (Rispens et al., 2008), Greek (Diamanti et al., 2017), and Portuguese (De Freitas, da Mota, & Deacon, 2017), among others. Thus, across languages and scripts, the importance of morphological awareness for word recognition is increasingly recognized (e.g., Carlisle & Stone, 2005). Even for English, researchers have called for a reduced emphasis on phonics in favor of a more general link of form and meaning in word reading and writing (Seidenberg, Borkenhagen, & Kearns, 2020). Syntactic aspects of words are additionally highlighted as important for meaning-building in word reading and writing across languages (Jongejan, Verhoeven, & Siegel, 2007; Plaza & Cohen, 2003).

Thus, meaning-building is key for early literacy, even at the word level. This is true across languages and scripts. Yet models of word recognition in Chinese particularly underscore this. For example, in contrast to parents who speak languages such as Hebrew or English, who tend to scaffold their children in how to write words based on phonological information, Chinese parents prioritize visual-orthographic or morphological cues; they only very rarely mention phonological elements of the script (Aram & Levin, 2001; Lin et al., 2009).

Theoretically, the Chinese case gives the clearest example of how universal models of word recognition should consider flexibility of the unit. In Chinese, the syllable, morpheme, and character almost always represent a single, clear unit of processing, but this unit is only a word on its own in context approximately 1/3 of the time. This is very different as compared to English where a morpheme could be a phoneme (e.g., "s" in *birds*), a syllable (e.g., *man*), or even more than one syllable (e.g., *lettuce*). Thus, morphemes are simply visually less distinguishable in the context of English, Arabic, and many other scripts. In English, for example, we typically judge a word to be one that appears in print with space on either side of it. However, as with Persian, it is not difficult to note some exceptions, such as *high school, mother-in-law*, or *last-minute*. In all of these cases, there is separation between morphemes in a word that only conveys full meaning with all components included. In other cases, such as German or Finnish, words can be comprised of many letters. Here, readers likely break them into chunks for optimized processing. Many, though by no means all, of these chunks are likely to be morphemes. Theoretically, the interaction of morphemes with words in the recognition and writing process is fundamental.

Practically, the interaction of morphemes with and within words underscores the importance of potentially learning morphemes separately from whole words to facilitate learning. In Chinese, character recognition may require somewhat different skills than word reading does (e.g., McBride, 2016b). In English, morphological sensitivity also contributes strongly to word reading (e.g., Carlisle, 2000; Henry, 1993). In Arabic, preliminary findings suggest that instruction in morphology is helpful in facilitating children's word recognition (e.g., Al Ghanem & Kearns, 2015). Thus, evidence across languages and scripts suggests that a greater focus on morphemes and morphological interventions (e.g., Goodwin & Ahn, 2013; Meaux, Wolter, & Collinsa, 2020) is essential for better literacy acquisition.

Phonological aspects of early literacy: what have we overlooked?

Although meaning and morphological aspects of word recognition and writing are particularly salient in cross-cultural comparisons of literacy acquisition models, phonology is obviously important to highlight as well (Pae, 2018). So much has been written about phonology and reading that one may wonder whether there is more to say on phonological aspects of word recognition across scripts. Researchers have called for a less "alphacentric" approach to reading, with an emphasis on the fact that phonemic awareness is less prominent in many scripts as compared to English (Share, Shany, & Lipka, 2019). There has also been an increasing appreciation for the role of suprasegmental processing, focused on prosodic sensitivity (e.g., Wade-Woolley & Wood, this volume; Whalley & Hansen, 2006; Wood & Terrell, 1998), particularly sensitivity to word stress (e.g., Wood, Wade-Woolley, & Holliman., 2009) in various alphabetic languages and to lexical tones in Chinese (e.g., Cheung et al., 2009; Zhang et al., 2012).

Beyond phonological awareness, one global, unique, relatively under-recognized source of difficulty worldwide for literacy skills is what Share and Daniels (2014) refer to as an "omission of phonological elements" (p. 24). For example, in Arabic, certain diacritics, when omitted from the script, create a number of homographs. Moreover, short vowels are represented as diacritics only for the early grades in Arabic (e.g., Abu-Rabia, 1998), Persian (e.g., Mohseni & McBride, 2019), and Urdu (e.g., Rao, Vaid, Srinivasan, & Chen, 2011). Therefore, many words are spelled the same but pronounced differently in these scripts. For example, the consonant string كرم /KRM/ could be /kerm/ كِرم"worm", /kerem/ كِرم "cream", /karam/ كَرَم or "munificent" in Persian. Although this situation makes reading difficult, the experience of reading in these scripts differs from the experience of reading in so-called "deep orthographies" such as English (Verhoeven & Perfetti, 2017). In English, letters are presented with different possible pronunciations, but in Arabic and Persian, the absence of vowels makes the reading process harder (Frost, Katz, & Bentin, 1987). Beyond diacritics which are used to teach children but no longer used in the adult form of the script, there are also no stressed symbols in Persian and Arabic. Moreover, changes in spoken Persian from the standard version have resulted in complete changes in stress assignments to a large number of words such as in the written format /mixa**ha**m/ [I want] and the spoken form /mixam/.

In fact, across Chinese, English, Arabic, Persian, and most other scripts, there is no indication of stress or lexical tone, suprasegmental indicators, within the text. Only in a few languages and scripts, including Greek, Spanish, Italian, and Portuguese, is stress indicated in print. Chinese phonological systems, including Pinyin and Zhuyin-Fuhao, mark lexical tone, but actual Chinese print does not. Moreover, the lexical tone of different Chinese characters sometimes changes depending upon context. This phenomenon is referred to as "sandhi rules." Thus, in a broad spectrum of scripts, stress or lexical tone, often critical for comprehension in the language, is not indicated in the script.

While we do not know enough yet about how important suprasegmental awareness is, ultimately, for word reading or word writing, such awareness seems at least somewhat relevant. This awareness likely interacts with other phonological information (e.g., Cutler, 2005; Wang & Arciuli, 2015) to highlight certain syllables more than others. Stressed syllables tend to be spelled more accurately than unstressed syllables (e.g., Treiman, Berch, & Weatherston, 1993). Stress in language also highlights aspects of morphology (e.g., Wade-Woolley & Heggie, 2015). Lexical tone sensitivity is fundamental for word recognition in Chinese (e.g., McBride-Chang et al., 2008).

Perhaps one of the most important ways in which to facilitate efficient word reading and word writing is to help children to recognize patterns in the literacy process. For example, recognizing that the letter T sounds like /t/ most of the time in English can help children to read new words. Yet T does not always produce the /t/ sound. For example, the pattern TH, as it appears in words such as *thumb* or *both*, usually is not pronounced as /t/ in English. In fact, the way in which word recognition takes place involves sensitivity to statistical regularities of the script (e.g., Seidenberg et al., 2020). Many of us informally begin to recognize these statistical regularities. However, some children have particular

difficulties in doing so. Thus, for those with specific difficulties in learning to read or to write words, one of the greatest challenges is in making the implicit explicit. This is a global truism.

The better scripts represent explicit features of the language, the easier words are for children to learn to recognize (e.g., Seymour, Aro, & Erskine, 2003) and to write. One of the greatest challenges for both word recognition and word writing is the difference between what children hear and how the word appears in print. This applies equally to Chinese with its many homophones and homographs, English with its various grain size patterns, Arabic and Persian with their many words that are spelled the same but pronounced differently because of vowel (diacritic) omissions in print, and print in the everyday context of diglossia (e.g., Swiss vs. "High" German; African American vs. "Standard" English) worldwide. Thus, a greater focus on particular phonological peculiarities of the script to be learned, such as stress or lexical tone changes or vowel omissions, is likely to be helpful for word reading and word dictation across scripts.

Theoretically, this approach to phonological aspects of word writing and reading acquisition again highlights the importance of context in models of early literacy acquisition. Where the stress is in a multi-syllable word, to a lesser extent how a character is pronounced including what lexical tone is assigned to a given Chinese character, and how to pronounce a word written in Arabic all depend upon contextual cues: What word are we talking about? What is its meaning? We cannot know how to pronounce *refuse, address*, or *desert* without knowing if each refers to a noun or a verb, for example. Children who must learn in the context of diglossia also take longer to learn to read and to spell accurately in the formal form of the language they are learning. This is because there is a great linguistic distance between the language the children use to communicate and the one they are using to read and to write (for a review, see Saiegh-Haddad et al., in press).

Practically, across cultures, we should pay more attention to multi-morphemic words and phonology (Clin, Wade-Woolley, & Heggie, 2009; Wade-Woolley & Heggie, 2015). Highlighting implicit features such as stress or lexical tone, both of which may not be a central feature of literacy training in certain contexts, might help children to become better readers over time (e.g., Calet, Gutiérrez-Palma, Simpson, González-Trujillo, & Defior, 2015). For example, in Chinese, using an invented spelling task that includes tone and sandhi rules can help to identify children's suprasegmental perceptions of Chinese, distinguishing those with and without reading difficulties (Ding, Liu, McBride, & Zhang, 2015).

Visual-orthographic challenges to literacy

Perhaps the greatest current challenge to universal models of word reading and word writing is at the level of visual-orthographic requirements (Pae, 2018). Alphabetic scripts include a small (less than 40) set of symbols to represent words, Indic scripts between 200 and 500 (Nag, Caravolas, & Snowling, 2011), and Chinese includes thousands. This so-called inventory size of symbols is an important dimension of writing system variation (Daniels & Share, 2018; Nag, 2011). The frequently used characters in modern Chinese number as many as 7000 (W. Li, Anderson, Nagy, & Houcan, 2002). In Arabic and other Arabic-derived orthographies, letter similarities and the dominance of dots to differentiate letters (ح ,ج ,خ ,حٓ) add to the visual complexity. Another feature of Arabic and its derived scripts is the allograph, which refers to letters that alter depending on positions in a word. In Arabic and Persian, most letters have different shapes based on their location in the initial, middle, or end of the word, or even when an individual letter stands alone (Abu-Hamour, Al Hmouz, & Kenana, 2013). For example, the sound /h/ is represented in these 4 shapes ofچهٔ ,مهربان, هوا, and,اره such that the commonality among them is difficult to perceive.

Existing theories for describing cross-script diversity, which have been derived mainly from a relatively narrow empirical base of alphabetic languages (e.g., orthographic depth, Frost, 2005; psycholinguistic grain size theory, Ziegler & Goswami, 2005), have typically paid scant attention to the broader visual demands of literacy acquisition. However, understanding the nature of the connections is fundamental for word reading and writing across scripts.

In order to examine the degree to which visual complexity leads to grapheme learning difficulty, Chang, Plaut, and Perfetti (2016) studied five major writing systems including Hebrew (abjad), Russian (alphabet), Cree (syllabary), Telugu (alphasyllabary), and Chinese (morphosyllabary). They found that perceptual judgments were affected by grapheme complexity as well as first language (L1) background. In another study, Chang et al. (2018) studied 131 written languages across writing systems to predict human perceptual judgments, using the dimensions of (1) perimetric complexity, including changes in luminance across space in a grapheme (Grainger, Rey, & Dufau, 2008), (2) number of disconnected components (e.g., Gibson, 1969), (3) number of connected points (e.g., Lanthier, Risko, Stolz, & Besner, 2009), and (4) number of simple features, defined as the extent to which the grapheme combines simple features such as a line, a dot, a circle, or a curved line. A typical example is a stroke within a Chinese character (Wu, Zhou, & Shu, 1999). Based on visual complexity alone, alphabetic scripts tend to be least difficult, Chinese the most, and others such as Hindi (an alphasyllabary) or Arabic (an abjad) are rated as in the middle in some computer learning simulations (Chang et al., 2016). In parallel, as reviewed by Chang et al. (2016), relatively transparent alphabetic scripts such as Finnish take children approximately one year, alphasyllabaries such as Kannada three to four years, and Chinese more than six years to master all graphemes. Presumably, the unit of identification implied in this comparison is oral word recognition, meaning that a child can pronounce a given word on a page.

Theoretically, the importance of visual-orthographic knowledge acquisition, including a broader consideration of visual complexity of the script, should be acknowledged more prominently in theories of literacy acquisition across cultures. This area has received relatively little attention thus far, but this attention is steadily increasing thanks to broader global considerations (e.g., Chang et al., 2016; McBride, 2016b; Nag, 2007; Share et al., 2019). As with differences in phonological transparency documented across Indo-European writing systems (Seymour et al., 2003), it is likely that differences in visual-orthographic complexity can alter, by several years, the amount of time it takes to master a script (Chang et al., 2016). Longitudinal comparisons of children's literacy development across scripts are, therefore, imperative for future work. Greater considerations of visual-orthographic complexity vis-a-vis word recognition should be particularly valued in research and teaching moving forward from a basic phonology-meaning-orthography model (Seidenberg et al., 2020; Seidenberg & McClelland, 1989).

Practically, researchers and teachers worldwide should embrace the importance of visual-orthographic skills for early word mastery in literacy acquisition. There continue to be stereotypes characterizing dyslexia in English as a difficulty in perception of backwards letters. For evidence of this, one need only google "dyslexia reversing letters." Vellutino (1979, 1987) debunked this myth elegantly for English readers. However, the demands of Hindi, Arabic, and Chinese visually are all greater than that of English (Chang et al., 2016), and these visual-orthographic skills that are required for optimal learning, including visual orientation, attention to detail, and contextual cues, should be better understood, both as early indicators of risk for literacy difficulties and as skills to develop and teach early, especially in writing systems that Nag (2007) describes as "extensive," with many distinct visual features.

Visual-motor skills probably count too

Beyond a focus on meaning, sound, and print for characterizing early literacy acquisition, motor skills are additionally important. Chinese is the clearest example of this because stroke order is essential for character and word writing (e.g., L. Lo, Yeung, Ho, Chan, & Chung, 2016). In English, there is not a lot of attention paid to how to write a given grapheme, though it is clear that even very simple grapheme writing requires cognitive resources (e.g., Richards et al., 2011). A culturally universal model of early literacy acquisition should, therefore, weigh the visual-motor aspects of learning.

Chinese literacy acquisition relies heavily on copying visual forms (X. Zhang, Zhao, Xue, & Dong, 2011). Emphasizing rote character copying as a method of instruction, teachers of Chinese children

teach their students to write characters stroke by stroke in a specific way (e.g., Lam & McBride-Chang, 2013). In contrast, parents and teachers in writing systems such as Hebrew tend to instruct children as to how to write words based on phonological information (Aram & Levin, 2001). Urdu reading is also typically taught with a focus on sounding out phonological clues (Mumtaz & Humphreys, 2002).

Thus, researchers have begun to explore visual-motor skills in Chinese because of their perceived importance. Vellutino (1979, 1987) demonstrated that copying of unfamiliar script (in his experiments, copying of Hebrew by English-speaking children) did not differ between those with and without dyslexia. However, it was not clear whether the same would be true in Chinese. Previously, Tan, Spinks, Eden, Perfetti, and Siok (2005) found that children's skills in copying Chinese pseudo-characters and line drawings were uniquely related to word reading in Chinese. However, this result was at least somewhat likely to have been influenced by previous experience with print (e.g., Vellutino, 1979, 1987): Children who are more strongly immersed in familiar print typically perform better on tasks requiring prior knowledge of this print.

To solve this problem of print familiarity, McBride-Chang, Chung, et al. 2011 selected Korean, Hebrew, and Vietnamese, all unfamiliar in context, to present to Chinese children. The features of these three different unfamiliar scripts, each entailing different visual-motor features and skills, were used as stimuli for the Chinese readers. Among these third and fourth grade Hong Kong Chinese children, those with dyslexia had more difficulties in copying Korean, Hebrew, and Vietnamese diacritics than did those without dyslexia, even beyond orthographic and other metalinguistic skills. Another study (Kalindi et al., 2015) obtained similar results for children with difficulties in reading of Chinese (but did not find evidence that such skills distinguished those with and without difficulties in reading in English as a second language). Moreover, studies of kindergartners in both Hong Kong (Lam & McBride, 2018) and Mainland China (Wang, McBride-Chang, & Chan, 2013) showed that this copying measure predicted unique variance in dictation in Chinese beyond various cognitive-linguistic skills.

Beyond copying, what do we know about writing in one's native script? Handwriting is a complicated perceptual-motor task that initially develops with a primary focus on legibility, and then its speed increases (Bourdin & Fayol, 1994, 2000; Graham, Berninger, Weintraub, & Schafer, 1998). Handwriting is described using static characteristics (i.e., the final graphical handwriting) and dynamical features (i.e., the kinematics, pressure, and tilt aspects of handwriting) (Asselborn et al., 2018). In a comprehensive study of adults, Wang et al. (2020) investigated the effects of different character-level variables on writing latencies, durations, and accuracy in Chinese spelling-to-dictation tasks. Results revealed that frequency, age of acquisition, and the word context were all predictors of orthographic access (measured by writing latency), motor execution of handwriting (evaluated by writing duration), and accuracy. Interestingly, in that study, phonological factors, including phonogram status, spelling regularity, and homophone density were only associated with orthographic access but not with handwriting execution; semantic factors such as imageability and concreteness only influenced accuracy.

In considering handwriting acquisition across scripts and languages, an important research question is whether the transfer of handwriting is positive or negative. For example, the Persian writing system goes from right to left. Therefore, Iranian students automatically retrieve the pen and write in the way that is easier for writing from right to left with development. When they inevitably begin learning English, they may then experience more difficulties in adapting to the new writing system, written from left to right (McBride & Mohseni, under review). As another example, in a study comparing Lebanese children, who learned both Latin and Arabic scripts simultaneously, and French children, who learned only French, the Lebanese children attained better writing quality scores in grade 1 (due to an earlier start in writing from age 5), while they achieved significantly lower scores in subsequent grades (2–5) in comparison to their French counterparts. These findings suggest that the large difference between two diverse graphic systems can potentially interfere with learning (Matta Abizeid, Tabsh Nakib, Younès Harb, Ghantous Faddoul, & Albaret, 2017). In contrast, Asselborn et al. (in press) tested 190 grades 1 to 4 children on copying skill in Cyrillic and Latin alphabets on a digital

tablet. Students learned Cyrillic at school but they did not receive any instruction in Latin. The results showed that, with increasing grades, the quality of both Cyrillic and Latin writing increased. Whereas improvement in Cyrillic was interpreted as being attributable to increased practice, the improvement in Latin script was likely a result of the positive transfer of fine motor control skills from Cyrillic to Latin, particularly given that both are written in the same direction (from left to right).

Models of word writing vary. One interesting model (McCloskey & Rapp, 2017) highlights the integration of semantic, phonological, and orthographic memory, allographic memory, and motor skills. Whereas the phonological aspects of word writing are particularly salient in English and many other alphabetic scripts, the semantic and orthographic aspects emerge as uniquely important for Chinese: Chinese learners who are better at perceiving characters analytically based on their constituent units develop better literacy skills. For example, Chinese children who were explicitly taught about semantic radicals yielded greater improvement in writing skills than the control group in an 8-week intervention study (Lam & McBride-Chang, 2013). Moreover, children's orthographic memory for a writing system measured with a delayed copying task, has been found to be uniquely important for reading and writing in Chinese (Anderson et al., 2013; Yeung, Ho, Chan, & Chung, 2016) and even in English as a second language/script (Lo et al., 2018). In general, delayed copying tasks require copying an unfamiliar character or word after seeing it presented only very briefly. This ability involves a combination of visual-orthographic skills, working memory in various aspects, and motor execution. Future research should strive to understand the elements and development of word writing further.

Conclusion

To summarize, a cross-linguistic perspective on word recognition and writing should highlight the classic elements of meaning, phonology, and print (Seidenberg & McClelland, 1989), including visual-orthographic and expanding further to visual-motor skills. For every script, the features and the nature of these that emerge as most important will likely differ. Whereas these elements themselves are universal, their weightings differ by writing system and language (Pae, 2018; Verhoeven & Perfetti, 2017).

Future research in the area of cross-cultural literacy acquisition will require a wider lens of investigation that includes varied and under-represented scripts. Research in each of the four areas highlighted here, namely, morphological/semantic, phonological, visual-orthographic, and visual motor skills, can be expanded within this wider lens. For example, more work on how to conceptualize morphological and syntactic elements, including inflectional, derivational, and lexical compounding features, in relation to word reading and word writing can highlight developmentally which aspects of morphology are important with age and learning in each script. Moreover, cross-cultural work on phonology should expand to a broader examination of suprasegmental aspects of reading and writing of words in context. In addition, the concept of linguistic distance (e.g., diglossia) between spoken and written representations and implications for literacy acquisition is clearly a "hot" topic in the area of global literacy research (e.g., Saiegh-Haddad, Laks, & McBride, in press). In the area of visual-orthographic learning, much more work needs to be carried out particularly on under-represented but "extensive" scripts (Nag et al., 2011) on specific aspects of a given orthography that make word reading and word writing easier and more difficult (e.g., Chang et al., 2018, 2016). Finally, although some work has been done on handwriting and spelling (e.g., Asselborn et al., in press; Wang et al., 2020) there is not yet a strong and cohesive theoretical understanding of how handwriting develops in children learning to write and to spell in different scripts. Research in this area also requires some focus on more complex but under-represented scripts (e.g., Chang et al., 2016) in order to identify typical and atypical variability in learning to write words across cultures.

In this article, we have specifically focused on words across scripts. Expanding further to understanding words within a sentential context is an important broad goal for future work. However, we must first recognize that our current understanding of word reading and word writing across scripts remains incomplete. As researchers get closer to establishing a universal model of literacy acquisition

(e.g., Daniels & Share, 2018; Nag, 2007), we welcome the deeper understanding that will inevitably emerge from research studies focused on these elements around the world.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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