The Learnability and Psychological Processing of Reading in Chinese and English: Differences and Similarities

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Running Head: Learnability in Chinese and English

Abstract

The main purpose of this paper is to briefly review some empirical findings on the processing mechanisms of skilled readers and beginning readers in Chinese and English and to compare the learnability of reading in the two languages. In the learning processes, a similar global-to-analytic developmental path exists in both languages, although there are differences in the kinds of predictors of early reading acquisition. It is argued that while Chinese-English orthography differences have some effect on the learning and processing mechanisms followed, the effect does not amount to making one system as a whole easier and faster to process or to learn than the other.

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While it seems unlikely that humans of diverse cultures and nationalities differ significantly in the anatomic and physiological structure of their brain, the fact that they do have developed a great diversity of writing systems has kept linguists and psychologists busy examining and testing the different claims of the linguistic determinism hypothesis (Tzeng & Hung, 1981). For example, some researchers investigating reading processes are concerned about whether the acquisition of reading skills is facilitated or hindered depending on how well the orthography represents the spoken language. There is also a great deal of interest in the possible effect of orthographic differences on visual information processing (Tzeng & Hung, 1981).

Does reading in different orthographies pose different task demands on the human processing system so that different processing mechanisms are involved? Is there an "optimal" writing system which has the greatest learnability? Empirical answers to these questions will not only be of great theoretical interest to reading theorists, but will also have important practical ramifications for practitioners faced with different reading instruction methods, and to language planners who are often split between the arguments for and against orthography reforms.

Providing answers to such questions has never been an easy task. On the one hand, there are often the conflicting findings of various experiments, which make interpretation and integration of research findings difficult. This is especially true in the area of research on reading in Chinese. On the other hand, researchers, whether from a Chinese or an English background, almost inevitably carry with them their own linguistic and cultural perspective, which seems to be a two-edged thing: it may help them see certain important things that others of a different linguistic background cannot see, but it can also bias them towards failing to see things that others can see.

In this paper, the authors attempt to embark on such a tricky task, by comparing the learnability and processing mechanisms of reading in Chinese and English in light of the major empirical findings accumulated mainly in the past two decades. The paper will start with a brief comparison of the Chinese and English writing systems, viewing them as occupying different, but not dichotomous positions on the chart of the world's orthographies. In many ways, as will be shown, the two systems are in fact more alike than different. Then the paper will proceed to the question of whether different processing mechanisms are involved in the reading of Chinese and English by skilled readers, followed by a section comparing the processes of learning to read in the two systems. Then the learnability question will be discussed in light of the available findings, and future research directions will be suggested.

Chinese and English in the World's Family of Orthographies

The world's diverse orthographies can be classified in a general framework along three major parameters: (1) the kind of linguistic unit (e.g. sound units such as phoneme, syllable; meaning units such as morphemes, words) that corresponds to the basic graphic unit (e.g. letter, syllabosymbol, character) of the orthography; (2) the manner of correspondence (e.g. degree of regularity: from one-to-one to many-to-many relationship; from selective to complete correspondence); (3) the size of the inventory of basic orthographic units (e.g. from a small set such as the English 26-letter alphabet, to a large set such as the approximately 45,000 characters in Chinese [Ai, 1950, p. 208]).

A "pure" phonemic system, for instance, would have basic graphic units each of which corresponds to its specific phoneme (e.g. Greek, Latin, Finnish). Chinese and English are alike in that both of them are not pure systems. They are what DeFrancis (1989) termed "morphosyllabic" (meaning-plus-syllabic-sound) and "morphophonemic" (meaning-plus-phonemic-sound) systems respectively. Neither Chinese nor English is regular in terms of correspondence between basic linguistic and graphic units.

According to Fan and his colleagues (1987), 80% of Chinese characters are "phonograms" which are made up of a meaning part and a sound part. The meaning indicated is often a rough semantic domain and the sound part, through history, has also become not always reliable as a clue to the pronunciation (syllabic sound plus tone[1]) of the character.

Similarly, English orthography is irregular in its relationship to phonemes. Chomsky and Halle (1968) pointed out that an abstract, morphological level is preserved in English orthography, at the expense of spelling-sound regularity. However, as DeFrancis (1989) rightly stressed, both the Chinese and English writing systems are still largely phonologically based[2], despite its partial indication of some semantic information.

However, all the similarities between the Chinese and English orthographies does not mean that the two orthographies have no difference at all. According to Holender (1987), there are at least five differences between the two languages that could have implications for the processing and learning of reading in each language:

i. While English letters correspond to phonemes, Chinese characters correspond to syllables and morphemes;

ii. The visual features of letters and characters are distinctly different. Letters are distinguished by fewer visually distinctive features than Chinese characters are. Besides, on the written page, letters are placed in horizontal linear sequences of different lengths while characters, whether they have a simple or complex configuration, always form a same-size square frame, which is a more compact visual representation;

iii. virtually all morphemes in Chinese are monosyllabic (except for loan morphemes originated from foreign words) while English morphemes can be bi- or polysyllabic;

iv. Chinese words are usually made up of two or more morphemes; in writing only the morphemes are marked out by spaces. There is no marking of word boundaries, unlike English which marks out word boundaries but not morpheme boundaries;

v. English makes use of a small inventory of graphic units (twenty-six letters) to form all words in English while Chinese makes use of four to five thousand commonly used characters to form many more thousands of words (Holender, 1987).

Do these linguistic differences lead to different processing mechanisms in reading Chinese and English? The following section will discuss major empirical studies addressing this question.

Psychological Processing of Skilled Readers in Chinese and English

A. Eye-Movement

The different graphic patterns of English words and Chinese characters may predict different eye-movement patterns in reading. The results of Gray □ s study showed that in fluent reading the average number of fixations is 1.6 words per fixation for English and 2.5 words per fixation for Chinese (Gray, 1956). However, if Gray meant "characters" by □ words □, then the difference in the average number of fixations may have derived from the fact that most Chinese words consist of two or more characters. While future research is needed to clarify this issue, Gray's general conclusion that fluent reading is roughly similar across orthographies has been met with support in the findings of other research paradigms.

B. Processing of Isolated Characters and Words

One important research paradigm has focused on the role of phonological recoding in word decoding. Tzeng & Hung (1980), studying the reading of isolated Chinese characters, found that rhyming judgment is slowed down by shadowing much more so than graphic comparison and synonym judgment are. Similar results were found with English words and English readers (Just & Carpenter, 1987). This seems to suggest that reading may be similar in the two languages, at least at the word decoding level.

Using a time course model of word recognition, Seidenberg also addressed some similarities in word-recognition processes between Chinese and English (e.g., Seidenberg, 1985a, 1985b). Seidenberg introduced a time course model of word recognition which places an emphasis on the interactive process of phonological and orthographic processing of stimuli (Seidenberg, 1985b). According to Seidenberg, word recognition is carried out in "a single interactive process with differences in the availability of orthographic and phonological information over time" (Seidenberg, 1985b, p. 227). In the time course model, therefore, orthographic and phonological processes are not seen as separate, parallel operations. Rather, orthographic and phonological coding are seen as concurrent phases of one operating process.

In recognizing a common word (high-frequency word), orthographic information obtained from the input permits recognition prior to the utilization of phonological information. This is because the orthographic information of the high-frequency word is sufficient to trigger the appropriate domain in the lexicon on the visual mediation only. After the recognition of a word through orthographic mediation, a representation of the phonological code stored in the central cognitive system is activated. Then, the postlexical phonological code is utilized to preserve the information in working memory (Baddeley, 1979).

On the other hand, an uncommon word (low-frequency word) is recognized through phonological mediation. Because the mental representation of the uncommon word's orthographic information is not sufficient to trigger its lexical representation through orthographic mediation only, phonological information is utilized to recognize the word. In short, orthographic and phonological coding concurrently operate in processing a visual word; which code accesses the lexical representation depends on the visual familiarity or frequency of a word. Thus, phonological codes are used at the postlexical level in the case of recognizing common words, whereas the phonological codes of uncommon words are used at the prelexical level. This leads Seidenberg to assume that phonological representations are consistently available after recognition in the time course model.

Seidenberg also claimed that a regularity effect (i.e., regular words are processed faster than exception words) is observed only in the naming of low-frequency words. This claim is based upon the concept underlying the time course model: there are differences in the availability of orthographic and phonological information in word recognition (Seidenberg, 1985a). He argued that if phonological mediation is involved in the process by which a letter string is identified, regular words should be recognized (or read aloud) faster than exception words whose pronunciations are irregular. The phonological coding of exception words, because of their irregularity in pronunciation, needs more time than regular words. However, if phonological information is not utilized for lexical access, then regular and exception words which are equivalent in other respects should be recognized at the same speed. Because prelexical phonological presentations are, according to Seidenberg, used only in low-frequency words, it is assumed that significant differences in the recognition speed between regular and exception words are only observed in low-frequency words. This assumption was verified in findings from a series of investigations (Seidenberg, 1985a, 1985b; Seidenberg & McClelland, 1989; Waters & Seidenberg, 1985).

The availability of prelexical phonological representations in word recognition was observed not only in English, but also in Chinese (Seidenberg, 1985a). Adult readers of Chinese were asked to name high- and low-frequency Chinese compound words containing phonetic components which provide phonological information of the words. This type of word is called a phonogram and, in terms of the availability of phonological information within a word, phonograms were considered equivalent to regular words in English. The same people (i.e., adult readers of Chinese) were also given high- and low-frequency non-phonograms and asked to name them. The results indicated that high-frequency Chinese words were processed through visual mediation only; there was no significant difference in reaction time between high-frequency phonograms and non-phonograms. Low-frequency phonograms, however, were processed faster than low-frequency non-phonograms, suggesting that low-frequency Chinese words were processed on a phonological basis.

Although the studies mentioned above may provide an impression that the Chinese and English adult readers recognize words in the same manner, some studies yielded somewhat different findings suggesting different word-recognition processes between Chinese and English.

For example, Biederman and Tsao (1979) argued that there are some fundamental differences in the perceptual demands of reading Chinese and English. Referring to their finding that the Stroop effect was stronger for Chinese characters than for English words, Biederman and Tsao suggested that obligatory, visual configurational processing of characters competes with color processing for right hemispheric capacities.

Hoosain and Osgood (1983) also found a difference in the processing of meaning between the Chinese and English adult readers. In their study, both Chinese and English subjects were asked to decide whether each word shown in the computer screen meant something □ positive □ or □ negative.□ The results showed that the affective judgment response times were significantly faster for the Chinese subjects than the English subjects. Because the peripheral perception and response processes for Chinese and English were comparable, Hoosain and Osgood concluded that □ the subjects processing the Chinese words did not require the same kind of phonological recoding that was required for English □ (Hoosain & Osgood, 1983, p. 575).

C. Processing of Characters and Words with Contextual Clues

Tzeng, Hung and Wang's seminal study on speech recoding in reading Chinese characters showed that phonemic similarity of characters in a sentence significantly slows down the reaction times for grammaticality judgment of both anomalous and normal sentences (Tzeng, Hung, & Wang, 1977). This seems to imply that post-lexical processing involves phonological recoding for short-term memory storage, which is needed for meaning integration of words in context. This finding is also evidenced in many other studies (Chu-Chang & Loritz, 1977; Hayes, 1988; Chitiri, Sun, Willows, & Taylor, 1992).

Parallel to Seidenberg's study of word frequency interaction with phonological code activation, Hue & Erickson (1988) studied the interaction of radical[3] and character frequency with short-term memory coding. It was found that high frequency radicals and characters, whose pronunciations are familiar, seem to be maintained in phonological form in short-term memory. Those that are low in frequency, with unfamiliar pronunciations, seem to be maintained in visual form in short-term memory. Memory span was much smaller (1.5 to 2.5 items) for these stimuli and is influenced by intercharacter frequency and complexity.

The important role of phonological recoding in maintaining an effective short-term memory of words for subsequent processing seems to be observed in any language (Perffeti, 1985).[4] This also implies that low frequency words with few graphic clues to their sound (e.g. the low-frequency Chinese non-phonograms and the low-frequency English exception words) may cause difficulties in subsequent processing.

Learning to Read in Chinese and Learning to Read in English

Learning to read Chinese involves first and foremost learning the characters. Van and Zian (1962, qtd. in Taylor, 1981) proposed that character learning takes place in three stages. In the first stage, children relate previously learned sound/meaning associations with only the global shape of characters. In the second stage, they associate sound/meaning with parts of characters and often wrongly substitute parts from similarly shaped characters. In the final stage, they can make correct associations between sound/meaning and the correct strokes of characters.

It was also found that the children tend to focus most of their attention on the visual aspects of characters. Most of their errors (79%) made in a dictation-recall test were visual while semantic and phonological errors were only 8% and 13% respectively. This focus on the visual aspects of characters was also observed among beginning readers of Chinese as a second language (Chu-Chang & Loritz, 1977; Hayes, 1988; Chitiri, Sun, Willows & Taylor, 1992).

Ehri proposed a model of developmental sight-word reading in English (e.g., Ehri, 1992, 1994, 1995, in press). Her latest model has four phases: pre-alphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic.[5] The label of each phase reflects "the predominant type of connection that links the written forms of sight words to their pronunciations and meanings in memory" (Ehri, 1995, p. 117).

In the pre-alphabetic phase reading, letter-sound connections are not involved; pre-alphabetic phase readers can read print by using visual cues accompanying the print, rather than the words in print (e.g., the golden arches behind the "McDonalds" sign). The pre-alphabetic phase readers are also observed to use particular visual cues in a word to remember words, such as two humps in the middle of "camel." Although the letter *m* is used to pronounce "camel," the sound /m/ has nothing to do with its phonological retrieval. Such letter-sound connections start to develop in the next phase: partial alphabetic phase.

In the partial-alphabetic phase, readers use some of the component letters of words and their sounds; they are observed to remember particular letter-sound correspondences and to be able to segment the initial and final sounds in words. For example, when the partial-alphabetic phase readers come across the written word "spoon", whose pronunciation and meaning they know, they may recognize only the initial letter "s" and the final letter "n." Because the letter names of "s" and "n" contain the relevant sounds (i.e., "ess" and "en"), the sounds of those letters tend to be easier to remember (Treiman, 1993). Then, the readers, looking at not only those letters they recognize, but also the other constituent letters, may say the word "spoon" with help from adults. This process, where the readers connect the component letters already known with the whole word, helps the readers remember how to read "spoon" when they see the word next time. This phase is termed partial alphabetic because the readers, although using letter-sound connections for reading words, still lack of full knowledge of letter-sound correspondence rules.

During the full alphabetic phase, children can read sight words by using most grapheme-phoneme correspondence rules; the full-alphabetic phase readers come to understand how the constituent letters are connected to their sounds. "In applying this knowledge to form connections for sight words, spellings become amalgamated or bonded to pronunciations of words in memory" (Ehri, 1995, p.120). Once children come to form complete connections between letters and sounds, their written vocabulary grows rapidly as they are exposed to print. Then, through repeated exposure to print, particular letter patterns, which are often encountered, become as multi-letter units such as onsets and rimes. These consolidated units become part of a child's "generalized knowledge" of the English orthography or spelling system.

Van and Zian s and developmental model of Chinese reading acquisition seems to parallel Ehri's model of sight-word reading: in both Chinese and English, first, children learn to read by associating an oral word with some printed stimulus. Learning is by paired associations and the critical feature of the stimulus is often a random cue (e.g. word length, or type font), and the cues vary from word to word. Then, children begin to analyze words into their components (e.g., radicals in Chinese characters; constituent letters in English) with respect to their corresponding sounds and develop general knowledge of the orthography.

Although we emphasized the similarities in reading acquisition between Chinese and English above, we acknowledge that this is a controversial issue. For example, the orthography effect in fact seems to be much more pronounced in the beginning reading process than in the skilled reading process. While phonemic awareness (e.g. as manifested in phonemic segmentation skills) has been found to be a strong predictor of subsequent reading ability in English (Adams, 1990), such awareness seems to be neither required nor entailed in the development of reading literacy in Chinese (Read, Zhang, Nie, & Ding, 1986).

On the other hand, knowledge of general information and verbal memory have been found to be consistently related to the ability to read Chinese and Japanese (Stevenson, Stigler, Lucker, Lee, Hsu, & Kitamura, 1982). Mann (1985) has also found that linguistic phonological memory as well as non-linguistic visual memory characterize good readers of both Japanese Kana (Japanese syllabary) and Kanji (Chinese characters).

The Learnability of Reading in Chinese and Reading in English

In view of the above discussions, the question arises whether one of the two writing systems is easier to learn to read than the other. While we have concluded in the previous section that for the skilled adult reader, reading across different orthographies is similar, the situation with the beginning reader may not be the same.

Some claim that learning to read Chinese is much more difficult, given the task to learn thousands of characters. If this is the case, then there should be more reading disabled children in Chinese societies than in English societies. Or, Chinese school children should be far behind their English counterparts of a similar grade level in their reading ability. Stevenson et al (1982)'s well-controlled cross-country study however finds that the general reading ability of school children, and the percentage of poor readers are in fact quite similar across Japan, Taiwan, and the United States. Similarly, the argument that Japanese (Makita, 1974) or Chinese (Rozin, Poritsky, & Sotsky, 1971) are easier to learn than English is not based on any solid empirical ground.

We are then left with this seemingly puzzling situation.; some orthographies are apparently much more difficult to learn than others but no significant differences can be found among children learning to read the different systems. One possible answer to this question might be that writing systems are in fact quite well suited to the languages they represent (Taylor, 1987), and with any writing system, there is always a certain percentage of children who find it difficult to learn. In other words, different writing systems may in fact be equally easy or equally difficult although they may be easy and difficult in their own special ways. Borrowing one script from one language to write another language (e.g. to use an alphabet for writing Chinese) is not necessarily a solution to the occurrence of reading disability, since by avoiding one set of problems, a different set of problems may be inadvertently invited by the new script, which may not be well suited to that language.

As Adams (1990) pointed out, the economy achieved by the alphabet (i.e. using a small set of basic graphic units to write all words in a language) is purchased at a price, and the price is a cognitive one: the referent of a letter is perceptually abstract and conceptually sophisticated. Learning the alphabet has created difficulties to a group of children who simply cannot "catch on" to the alphabetic principle.

On the other hand, the perceptual concreteness of the Chinese characters (e.g. a character always corresponds to a syllabic sound, which is perceptually more salient than the phoneme, and the syllable in the Chinese language also happens to always correspond to a meaningful unit) is also obtained at a cost: the thousands of different visual patterns that need to be committed to memory. This cost, however, seems to be compensated later on in the development of the child's vocabulary, as having mastered three to five thousand commonly used characters, the child may be able to guess the meanings of virtually all commonly used words (in terms of tens of thousands) which are formed from these characters. However, further research is needed to look into whether some children somehow cannot work this way in their vocabulary development (e.g. due to lack of guessing strategies) and whether explicit teaching of word formation patterns and guessing strategies is needed (a case similar to the explicit teaching of phonics to reading disabled children in English).

It is therefore the conclusion of this paper that future research efforts should be focused on achieving a greater understanding of the different sets of task demands that different orthographies pose to the cognitive capacities of children, and on the development of appropriate remedial measures. For instance, future research needs to explore the kinds of cognitive and linguistic abilities that predict reading acquisition of morphosyllabic systems like Chinese, hybrid systems like Japanese, regular alphabetic systems like Finnish, or consonantal systems like Urdu and Arabic. A comparison of the diverse task demands (and the related cognitive problems) posed by the world's diverse writing systems to the child will greatly enhance our understanding of the different ways the human mind adapts to the diverse reading environments.

REFERENCES

Adams, M. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, Mass: MIT Press.

Ai, J. (1950). A report on psychological studies of the Chinese language in the past three decades. *The Journal of Genetic Psychology*, *76*, 207-220.

Baddeley, A. (1979). Working memory and reading. In P. Kolers, M. Wrolstad, & H. Bouma (Eds.), *Processing of visible language* (pp. 355-370). New York: Plenum Press.

Biederman, I., & Tsao, Y. (1979). On processing Chinese ideographs and English words: Some implications from Stroop-test results. *Cognitive Psychology*, *11*, 125-132.

Chitiri, H.-F., Sun, Y., Willows, D., & Taylor, I. (1992). Word recognition in second-language reading. In R. Harris (Ed.), *Cognitive processing in bilinguals* (pp. 283-297). Amsterdam: Elsevier Science Publishing Company.

Chomsky, N., & Morris, H. (1968). *The sound pattern of English*. New York: Harper and Row.

Chu-Chang, M., & Loritz, D. (1977). Phonological encoding of Chinese ideographs in short-term memory. *Language Learning*, *27*, 341-352.

DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu: University of Hawaii Press.

Ehri, L. (1992). Reconceptualizing the development of sight word reading and its relationship to recoding. In P. Gough, L. Ehri, & R. Treiman (Eds.), *Reading Acquisition* (pp. 107-143). Hillsdale, NJ: Erlbaum.

Ehri, L. (1994). Development of the ability to read words: Update. In R. Ruddell, & M. Singer (Eds.), *Theoretical models and processes of reading* (4th Edition) (pp. 323-358). Newark, DE: International Reading Association.

Ehri, L. (1995). Phases of development in learning to read words by sight. *Journal of Research in Reading*, *18*, 116-125.

Ehri, L. (in press). Word reading by sight and by analogy in beginning readers. In C. Hulme, & M. Joshi (Eds.), *Reading and spelling: Development and disorder*. Hillsdale, NJ: Erlbaum.

Fan, L., Tong, L., & Song, J. (1987). The characteristics of Chinese language and Children's learning to read and write. In D. Wagner (Ed.) *The future of literacy in a changing world* (pp. 87-94). Oxford: Pergamon Press.

Gray, W. (1956). *The teaching of reading and writing*. Paris: UNESCO.

Hayes, E. (1988). Encoding strategies used by native and non-native readers of Chinese Mandarin. *Modern Language Journal*, *72*, 188-195.

Holender, D. (1987). Synchronic description of present-day writing systems: Some implications for reading research. In J. O'Regan, & A. Levy-Schoen (Eds.), *Eye movements: From physiology to cognition*. Amsterdam: Elsevier North Holland.

Hoosain, R., & Osgood, C. (1983). Processing times for English and Chinese words. *Perception & Psychophysics*, *34*, 573-577.

Hue, C., & Erickson, J. (1988). Short-term memory for Chinese characters and radicals. *Memory & Cognition*, *16*, 196-205.

Just, M., & Carpenter, P. (1987). *The psychology of reading and language comprehension*. Boston: Allyn & Bacon.

Leong, C. (1986). What does accessing a morphemic script tell us about reading and reading disorders in an alphabetic script? *Annals of Dyslexia*, *36*, 82-102.

Makita, K. (1968). The rarity of reading disability in Japanese children. *American Journal of Orthopsychiatry*, *38*, 599-612.

Mann, V. (1985). A cross-linguistic perspective on the relation between temporary memory skills and early reading ability. *Remedial and Special Education*, *6*, 37-42.

Perfetti, C. (1985). *Reading ability*. New York: Oxford University Press.

Read, C., Zhang, Y., Nie, H., & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition*, *24*, 31-44.

Rozin, P., Poritsky, S., & Sotsky, R. (1971). American children with reading problems can easily learn to read English represented by Chinese characters. *Science*, *171*, 1264-1267.

Sampson, G. (1985). *Writing systems: A linguistic approach*. London: Hutchinson.

Seidenberg, M. (1985a). The time course of phonological code activation in two writing systems. *Cognition*, *19*, 1-30.

Seidenberg, M. (1985b). The time course of information activation and utilization in visual word recognition. In D. Besner, G. Waller, & G. MacKinnon (Eds.), *Reading research: Advances in theory and practice*, *Vol. 5* (pp. 199-252). Toronto: Academic Press.

Seidenberg, M., & McClelland, J. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, *96*, 523-568.

Stevenson, H., Stigler, J., Lucker, G., Lee, S., Hsu, C., & Kitamura, S. (1982). Reading disabilities: The case of Chinese, Japanese, and English. *Child Development*, *53*, 1164-1181.

Taylor, I. (1981). Writing systems and reading. In G. MacKinnon, & T. Waller (Eds.), *Reading research: Advances in theory and practice*, *Vol. 2*, (pp. 2-49). New York: Academic Press.

Taylor, I. (1987). Scripts and Reading Research. *Interchange*, *18*, 78-88.

Treiman, R. (1993). *Beginning to spell*. New York: Oxford University Press.

Tzeng, O., Hung, D., & Wang, W. (1977). Speech Recoding in Reading Chinese Characters. *Journal of Experimental Psychology*, *3*, 621-630.

Tzeng, O., & Hung, D. (1981). Linguistic determinism: a written language perspective. In O. Tzeng, & H. Singer (Eds.), *Perception of print: Reading research in experimental psychology* (pp. 237- 255). Hillsdale, NJ: Lawrence Erlbaum.

Tzeng. O., & Hung, D. (1980). Reading in a non- alphabetic writing system: some experimental studies. In J. Kavanagh, & R. Venezky (Eds.), *Orthography, reading and dyslexia*. Baltimore: University Park Press.

Van, Y., & Zian, C. (1962). Memory of characters by first-graders. *Acta Psychologica Sinica*, *3*, 219-230 (in Chinese).

Waters, G., & Seidenberg, M. (1985). Spelling-sound effects in reading: Time-course and decision criteria. *Memory & Cognition*, *13*, 557-572.

FOOTNOTES

1. There are four lexically distinctive tones in Mandarin Chinese.

2. Chinese orthography has generally been classified as logographic or morphemic (e.g. Sampson, 1985), but as DeFrancis (1989) convincingly argues, Chinese orthography is in fact much more phonologically based than it has generally been assumed.

3. Radicals are the meaningful components that make up a character.

4. See also Taylor (1987), who found that the psychological processes of reading connected texts are similar across different scripts, and Leong (1986) who concluded that the processing of Chinese and English may differ at the initial stage and at the micro level but may likely converge at the later stage and at the macro level.

5. Ehri's earlier model has three phases: logographic, rudimentary alphabetic, and mature alphabetic; they are also called visual cue reading, phonetic cue reading, and cipher reading, respectively (e.g., Ehri, 1992). See also Ehri (1995) for the reasons for proposing her new model of sight-word reading.

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