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Chinese vs. English: Insights on cognition during reading

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Abstract

Chinese reading experiments have introduced important caveats to theories of reading that have been largely informed by studies of English reading—especially in relation to our understanding of lexical processing and eye-movement control. This article provides a brief primer on Chinese reading and examples of questions that arise from its study.

Keywords

Chinese; eye movements; reading; word identification

Recent interest in Chinese reading reflects a growing appreciation that the language and writing system can inform our understanding of the perceptual, cognitive, and motor processes involved in reading—an understanding that has largely been informed by studies of English and other Western languages and writing systems [1]. This article will review what is known about the reading of Chinese versus English, focusing on the Chinese logographic writing system and how its properties affect two important aspects of skilled reading—word identification and eye-movement control (for reviews, see [2–3]).

As Figure 1 shows, Chinese is visually denser than English. Unlike English words, which consist of letter strings, Chinese words are composed of *characters*—the smallest pronounceable and meaningful units in Chinese, corresponding to morphemic syllables having one of four possible tones (in Mandarin). Each character consists of 1–36 overlapping *strokes* occupying a uniformly-sized, two-dimensional box-shaped spatial layout in text. Strokes can be further arranged into *radicals*, some of which can also be characters, but most being within-character subunits. Additionally, the words (most of which consist of 1–4 characters) are not demarcated by clear word boundaries.

As Table 1 shows, with both English and Chinese, factors that increase the length or complexity of words also slow their identification. However, whereas word length and complexity are defined by the number of letters or morphemes in English, length and complexity are defined by the number of strokes, radicals, or characters in Chinese. The latter has enabled demonstrations that complexity modulates lexical processing when

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controlling for visual acuity in a manner not possible in English; for example, readers tend to fixate longer on complex than simple characters that are equally proximal to the center of vision [4]. Visual processing also likely plays a less important role in English word identification because their visual features (e.g., line segments) can be rapidly converted into abstract orthographic codes that represent individual letters devoid of case or font (e.g., "cat" and "*CAT*" are represented identically). In contrast, the visually dense, two-dimensional and hierarchical arrangement of features in Chinese words probably make their conversion to abstract orthographic codes more difficult (see [5]).

Despite the marked visual differences between English and Chinese, factors that influence how well the *orthographic* forms are represented in memory similarly affect their identification in both writing systems. For example, with Chinese, as the frequency of radicals, characters, and words increases, so too does word-identification efficiency. And as with English, the orthographic-neighborhood (i.e., number and/or frequency of orthographically similar words) influences Chinese word identification, although there might be more inconsistencies because there are more ways to define orthographic similarity (e.g., shared strokes vs. radicals vs. characters) [6].

There are also unexpected similarities between the two writing systems in terms of how the pronunciations and meanings of words are represented in and accessed from memory. For example, English word pronunciations can be generated by direct retrieval from memory and/or spelling-to-sound conversion rules. Additionally, whereas these spelling-to-sound rules are completely consistent in languages like Finnish, they are only "quasi-regular" in English; words that are pronounced according to the rules are *regular* (e.g., "cat" |kæt|) but others are *irregular* (e.g., "yacht" |jat|), and words can be pronounced in a manner that is *consistent* (e.g., "cat" rhymes with "bat", "rat", etc.) or *inconsistent* (e.g., "pint" does not rhyme with "hint", "mint", etc.) with similarly spelled words. Although Chinese characters are not pronounced using spelling-to-sound conversion rules, there is a remarkable degree of consistency in how characters are pronounced. For example, approximately 80% of Chinese characters are *phonograms* that contain one radical expressing pronunciation and one radical expressing meaning, allowing a character's pronunciation to be generated by retrieving the pronunciation associated with its radical.

As Figure 1A shows, phonograms can be regular if the character is pronounced the same (ignoring possible tonal differences) as the phonological radical embedded within it; otherwise the phonogram is irregular. And as Figure 1B–C show, a phonogram's pronunciation can be consistent or inconsistent with those of other phonograms. As with English, regular/consistent Chinese words are identified more rapidly than irregular/inconsistent words, showing that readers of Chinese are able to abstract grapheme-phoneme correspondences despite their complex nature (see [7]). Similarly, word identification is affected by homophony, or the number of words pronounced the same, in a way that is still poorly understood [8]. This may reflect the fact that Chinese word pronunciations become available in a "threshold-style" manner, directly from memory (see [9]), whereas most English word pronunciations can also be generated using spelling-to-sound conversion rules.

Perhaps not surprisingly, semantic variables known to affect English word identification also affect Chinese word identification. For example, with all else being equal, words with unambiguous meanings, concrete meanings, or learned early in life tend to be more rapidly identified. As Table 1 shows, such effects have been demonstrated in both writing systems, but with Chinese are also predicted for radicals and characters—at least for those that are also words. And as Table 1 shows, supra-lexical effects of word predictability are also evident in both languages—with all else being equal, word_N is easier to identify to the extent that it is constrained by its preceding sentence context.

Finally, as Table 1 shows, several inter- and supra-lexical variables similarly influence the reading of English and Chinese. For example, the difficulty associated with processing word_{N-1} "spills over" to slow the processing of word_N, possibly by reducing preview of word_N [10]. However, several important differences also result from the fact that English is written with spaces between words whereas Chinese is not. These spaces allow English words to be rapidly identified as discrete "objects" for the purposes of lexical processing and eye-movement control during reading. One implication of this is that readers tend to direct their eyes slightly left of a word's center because that is the *preferred-viewing location* that affords efficient lexical processing. In contrast, the lack of clear word boundaries in Chinese text increases the difficulty associated with both the segmentation of words for the purpose of their identification, and the selection of saccade targets for the purpose of moving the eyes from one word to the next. Both of these differences may contribute to reports of larger *preview effects*, where the parafoveal preview of word_N modulates the time spent looking at word_N, as well as the presence of *parafovea-on-fovea effects* in Chinese (which are absent in English), where the processing difficulty associated with word_{N+1} modulates the fixation time on word_N [11]. Both effects likely reflect how the absence of word boundaries makes it more difficult to accurately coordinate the eyes and attention, so that, for example, there are more instances of attention being on a region corresponding to word_{N+1} with the eyes inadvertently being on a region corresponding to word_N. The lack of clear word boundaries also likely contributes to the absence of preferred-viewing locations, with fixation landing-site distributions being fairly uniform [12].

These differences between the reading of English versus Chinese are intriguing and allow us to compare how attention, word identification, and saccadic programming operate under conditions that respectively impose less versus more extreme demands on the perceptual, cognitive, and motor systems supporting reading. (The separation of words using spaces is a recent cultural convention adopted to make reading easier.) To date, efforts to explain how these systems operate and are coordinated have focused largely on English, with current models explaining only limited aspects of Chinese reading, such as how characters are identified, how words are segmented, or how saccade targets are selected (for a review, see [13]). More comprehensive models are necessary to determine how these processes are coordinated—to understand how characteristics of the Chinese writing system affect word identification in continuous text, and how this in turn influences (and is influenced by) the progression of the eyes during reading [14]. Another question concerns the role of phonology in Chinese reading: Given the evidence that phonology becomes available in an all-or-none manner, what role does it play in reading, where words are typically identified by integrating parafoveal information with information that becomes available after the words are fixated? Finally, understanding how two-dimensional arrays of strokes are configured to produce radicals and characters might provide new insights into the *alignment problem*, or the question of how the relative order of letters in alphabetic languages is encoded and represented. We suspect that future research will reveal a plethora of new questions not anticipated by this review.

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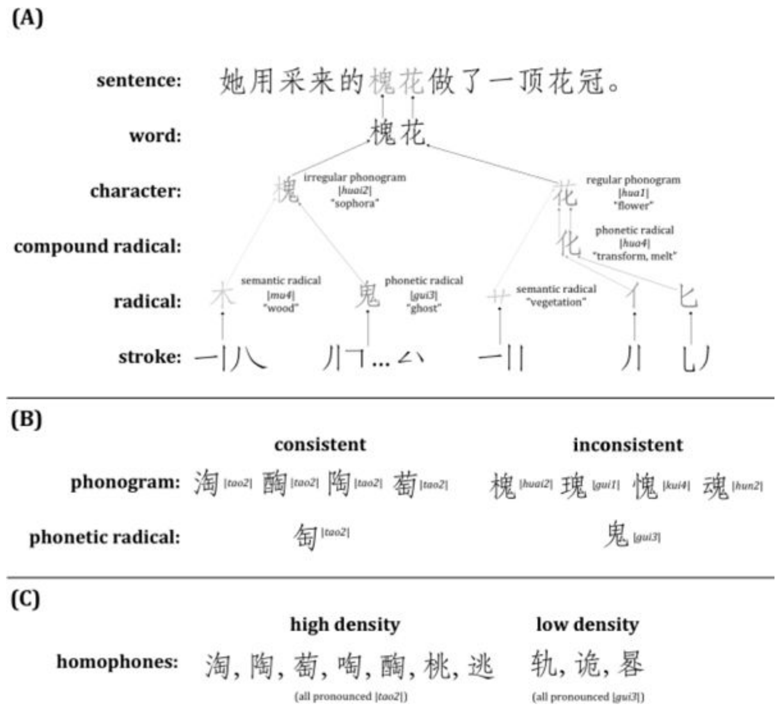

Figure 1.

Panel A shows a single sentence (meaning: "She collected the sophora flowers to make a crown.") containing words comprised of a variable number of characters, which in turn are composed of radicals and strokes (the numbers next to the pronunciations of characters denote the four possible tones). Individual radicals can convey meaning and phonological information, but in ways that are often complex. For example, in Panel A, character "花" is a *regular* phonogram because it has an identical pronunciation as its phonetic radical "化" (ignoring tonal differences), while character "槐" is an *irregular* phonogram. Panel B shows two groups of characters, one that is pronounced *consistently* with its component phonological radical and another where this relationship is *inconsistent*. Similarly, Panel C shows that there is a large degree of homophony in Chinese that varies in terms of its *density*. Finally, note that some simple characters can also be radicals embedded within other characters (e.g., "木", "鬼" and "化" in Panel A are characters but also radicals in the characters "槐" and "花"), and that some radicals (e.g., the rightmost radical in "化" in Panel A) actually have neither a meaning nor pronunciation.

Table 1

Factors affecting word$_N$ processing during reading of English vs. Chinese.

Factors[1]			Observed Effects[2] on Word$_N$	English	Chinese
Sub-Lexical & Lexical Characteristics of Word$_N$	Orthography	Length	Inhibitory	letters & morpheme s	characters
		Complexity	Inhibitory	morphemes	strokes & radicals
		Frequency/Familiarity	Facilitative	morphemes & words	radicals, characters, & words
		Neighborhood Density	Inconsistent	defined using letters	defined using strokes, radicals, or characters
	Phonology	Grapheme-Phoneme Regularity	Facilitative	defined relative to other words	defined by nature of phonogram
		Grapheme-Phoneme Consistency	Facilitative		
	Meaning	Ambiguity	Inhibitory	morpheme s & words	words, but predicted for radicals & characters
		Concreteness	Facilitative		
		Acquisition Age	Inhibitory		
Inter- & Supra-Lexical Factors Related to:	Word$_{N-1}$	Processing Difficulty (i.e., Spillover)	Inhibitory	orthographic & phonologic al, limited semantic	orthographic, phonologic al, & semantic
	Word$_N$	Pre-Processing Difficulty (i.e., Preview)			
		Word Boundaries	Preferred-Viewing Location	present	absent
		Predictability/Plausibility	Facilitative	meaning & syntactic category of words	meaning & syntactic category of characters & words
	Word$_{N+1}$	Processing Difficulty	Inhibitory (Parafove-a-on-Fovea Effect)	absent	present

Notes:

[1] N is the index of the word being processed.

[2] The effects are for increasing factor values (e.g., increasing word length inhibits word$_N$ processing).