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Pre-lexical phonological processing in reading Chinese characters: An ERP study

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ABSTRACT

Sinograms (i.e., Chinese characters) are usually composed of radicals which do not correspond to phonemes; instead, some radicals can occur as freestanding sinograms and have their own pronunciations. Previous research has demonstrated that the pronunciations of both radicals and sinograms are activated in reading low-frequency sinograms. However, the relative timing of activation between sinogram pronunciation and radical pronunciation has not been addressed. We examine this issue by comparing the interference effects exerted by two types of primes on the targets in an event-related potential (ERP) experiment: RADICAL-RELATED primes, which are homophonic with a radical embedded in the targets; and SINOGRAM-RELATED primes, which are homophonic with the targets. A radical interference effect is found for N170, P200 and N400 responses, whereas a sinogram interference effect is found only for N400. Our findings demonstrate that the pronunciations of radicals are activated pre-lexically, i.e., prior to those of their host sinograms. The role of this early sub-lexical phonology is discussed within an interactive activation framework, wherein two types of pronunciations—(1) the radical pronunciations and (2) the set of pronunciations associated with the sinogram's orthographical neighbors—are both present and operate interactively.

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1. Introduction

The question of how early phonological information is activated in visual word recognition is essential for understanding the role of phonology during reading. This question has been extensively studied with alphabetic scripts in which sub-lexical units (i.e., letter strings) correspond to phonemes (e.g., Jared & Seidenberg, 1991; Perfetti, Bell, & Delaney, 1988; see Frost, 1998, for a review). A general consensus is that this sub-lexical phonological information (i.e., phonemes) of alphabetic words is activated pre-lexically, i.e., prior to the access of dictionary-like lexical phonology. For example, in English, the first two phonemes of the word 'plague', /p/ and /l/, are activated before the full lexical phonology /pleig/ (Tan & Perfetti, 1998). This has been widely evidenced by behavioral studies on reading alphabetic scripts, such as English (Perfetti et al., 1988), Serbo-Croatian (Lukatela & Turvey, 1990), French (Ferrand & Grainger, 1993), Dutch (Brysbaert, 2001), and Hebrew (Gronau & Frost, 1997). Further supporting evidence comes from event-related potential (ERP) studies, which show that the properties of sub-lexical units have earlier effects on brain responses than lexical properties in reading alphabetic polysyllabic words (Barber, Vergara, & Carreiras, 2004; Carreiras, Vergara, & Barber, 2005; Chetail, Colin, & Content, 2012; Doignon-Camus, Bonnefond, Touzalin-Chretien, & Dufour, 2009; Hutzler et al., 2004). For example, Barber, Vergara, and Carreiras (2004) find that in reading disyllabic Spanish words, the frequency of the first syllable modulates both P200 and N400 responses whereas lexical frequency modulates only N400, but not P200. In particular, compared with words containing low-frequency syllables, words containing high-frequency syllables produce smaller P200 and larger (i.e., more negative-going) N400. By contrast, high-frequency words elicit a smaller N400 than low-frequency words. These results are interpreted in a two-stage framework for lexical access wherein P200 and N400 are thought to index sub-lexical and lexical processing, respectively.

In contrast, as a logographic script, Chinese characters, i.e., sinograms (Wang & Tsai, 2011), are monosyllabic, and their sub-lexical units, referred to as radicals, do not correspond to phonemes. Instead, radicals are sometimes freestanding sinograms themselves, and thus have their own pronunciations and meanings. For example, the sinogram 植 (*zhi2*[1], '*plant*') is composed of a semantic radical, 木 (*mu4*, '*wood*'), and a phonetic radical, 直 (*zhi2*, '*vertical*'). Such a sinogram is also referred to as a *phonogram*—phonograms account for around 80% of sinograms (Zhou, 1978). Moreover, because this sinogram has identical pronunciation to its phonetic radical, it is called a *regular phonogram*—regular phonograms constitute less than 30% of phonograms (Zhou & Marslen-Wilson, 1999a). By contrast, *irregular phonograms,* e.g., 贻 (pronunciation: *yi2;* phonetic radical: 台, *tai2*), are pronounced differently from their phonetic radicals in terms of both consonant and rime (Zhou & Marslen-Wilson, 1999a).

Despite the unreliability of the mapping between the pronunciations of sinograms and radicals, radical pronunciations are nonetheless activated during sinogram reading (Zhou & Marslen-Wilson, 1999b; Zhou, Peng, Zheng, Su, & Wang, 2013). Specifically, in a primed naming experiment, irregular primes (e.g., 粹, *cui4,* '*essence*') are found to facilitate the naming of targets (e.g., 族, *zu2*, '*clan*') that are homophonic with the phonetic radicals (e.g., 卒, *zu2*, '*soldier*') embedded in the primes, but only when low-frequency primes are used (Zhou & Marslen-Wilson, 1999b). Similar facilitation is also obtained in Zhou et al. (2013) when the targets (e.g., 辈, *bei4, 'generation'*) are homophonic with the semantic radicals (e.g., 贝, *bei4*, *'shell'*) embedded in low-frequency primes (e.g., 贻, *yi2*, '*present*'). Therefore, in reading a low-frequency sinogram, phonological processing apparently involves both the sinogram level (i.e., the host sinogram) and the radical level (i.e., radicals).

The question can be asked whether the phonological information of sub-lexical units (i.e., radicals' pronunciation) is activated earlier than that of the word as a whole (i.e., host sinograms' pronunciation) during reading low-frequency sinograms, as is the case in reading alphabetic words. Some evidence can be obtained by comparing findings of primed naming experiments that involve the use of different stimulus onset asynchronies (SOAs). Specifically, the aforementioned facilitatory effects of phonological primes that are homophonic with targets at the radical level are observed at SOAs of 57 ms (Zhou et al., 2013) and 100 ms (Zhou & Marslen-Wilson, 1999b). By contrast, the facilitatory effects of

[1] The letters represent the official Romanization of standard Chinese, that is, Pinyin, while the number indicates the corresponding tone.