

LIMITED ROLE OF PHONOLOGY IN READING CHINESE TWO-CHARACTER COMPOUNDS: EVIDENCE FROM AN ERP STUDY

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Abstract—This study investigates the role of phonology in reading logographic Chinese. Specifically, whether phonological information is obligatorily activated in reading Chinese two-character compounds was examined using the masked-priming paradigm with event-related potential (ERP) recordings. Twenty-two native Cantonese Chinese speakers participated in a lexical decision experiment. The targets were visually presented Chinese two-character strings and the participants were asked to judge whether the target in each trial was a legitimate compound word in Chinese. Each target was preceded by a briefly presented word prime. The prime and target shared an identical constituent character in the Character-related condition, a syllable in the Syllable-related condition, were semantically related in the Semantic-related condition, and were unrelated (both phonologically and semantically) in the control condition. The prime–target relationship was manipulated to probe the effects of word-form (i.e., character- or syllable-relatedness) and word-semantic relatedness on phonological (as indexed by an N250 ERP component) and semantic (as indexed by an N400 ERP component) processing. Significant and comparable facilitation effects in reaction time, relative to the control, were observed in the Character-related and the Semantic-related conditions. Furthermore, a significant reduction in ERP amplitudes (N250), relative to the control, was obtained in the Character-related condition in the time window of 150–250 ms post target. In addition, attenuation in ERP amplitudes was found in the Semantic-related condition in the window of 250–500 ms (N400). However, no significant results (neither behavioral nor ERP) were found in the Syllable-related condition. These results suggest that phonological activation is not mandatory and the role of phonology is minimal at best in reading Chinese two-character compounds. © 2013 IBRO. Published by Elsevier Ltd. All rights reserved.

Key words: visual word recognition, Chinese two-character compound, masked priming, N250, phonology in reading.

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Abbreviations: ANOVAs, analyses of variances; EOG, electrooculogram; ERP, event-related potentials.

INTRODUCTION

The role of phonology in accessing meaning from print has long been an important issue in psycholinguistics. Three different hypotheses have been proposed namely direct print-to-semantic access (i.e., word's orthographic information is taken directly to activate the corresponding lexical representation for semantic retrieval), indirect phonological mediation (i.e., phonological correspondence of the orthographic input is activated first and based on which the semantic information is retrieved), and dual-route activation where both orthographic and phonological information are activated and interact with each other (Frost, 1998). Evidence from early behavioral studies on alphabetic languages has shown a pre-dominant role of phonology (e.g., Rubenstein et al., 1971). For instance, by using a semantic categorization task (where participants were asked to judge if the target belongs to a specific semantic category, such as "A FLOWER"), Van Orden (1987) found a higher false-positive error rate when the target (e.g., ROWS) was homophonic to a category exemplar (e.g., ROSE) relative to an orthographic control (e.g., ROBS), indicating a mediating role of phonology in semantic retrieval. Supporting evidence can also be found from recent electrophysiological studies recording event-related potentials (ERPs).

Grainger et al. (2006), for instance, investigated the time course of phonological activation in visual word recognition using a masked-priming paradigm. Participants in their study judged the animacy of the target word and the critical targets were inanimate (e.g., BRAIN). Each inanimate target was preceded by a briefly presented (50-ms) pseudo-homophone prime (e.g., brane) or control (e.g., brant). A reduced negative-going ERP component, relative to the control, was observed over anterior sites with pseudo-homophone primes in the time window of 200–300 ms post target. This ERP component was labeled N250 and interpreted as a signature for word-form processing. Importantly, these results suggest that the phonological code of the visual target was activated very early in time during semantic access. Using a similar masked-priming paradigm and ERP recordings (with either a semantic categorization or lexical decision task), other researchers observed a significant reduction in ERP amplitude when the prime and target shared merely an identical syllable (Ashby and Martin, 2008; Ashby, 2010), phoneme (Carreiras et al., 2009a,b,c), or sub-phonemic feature (Ashby et al., 2009), and the

onset latencies of the observed ERP effects have been found as early as 80 ms following target presentation (Ashby et al., 2009). Taken together, these findings indicate that phonological information is activated very early in time during skilled reading and has a prominent role to play in visual word recognition.

However, the studies cited above were all conducted with languages using alphabetic scripts (where the grapheme-to-phoneme correspondence is usually transparent), whether the prominent role of phonology is universal across different writing systems is debatable. To address this, researchers have adopted languages with opaque print-to-sound relationship, such as Chinese, as a test case. Chinese adopts a logographic script in which the basic orthographic unit (i.e., character) maps directly onto a syllable in speech, and the orthography-to-phonology correspondence is arguably low and inconsistent (Chen and Juola, 1982). Furthermore, the cases of homophony are prevalent in Chinese: a given syllable (e.g., /si1/in Cantonese) might correspond to a number of homophonic characters with distinct orthographic features and meanings (e.g., 思, 師, 司, 斯, 絲, 詩, 施, 私, 屍, 廡, 獅, 尸, 俛, to name but just a few). This unique property of the Chinese language provides an interesting opportunity to study the effect of phonology without orthographic confound. Therefore, if the prominent role of phonology in reading alphabetic scripts can similarly be observed in reading logographic Chinese, then that will provide strong support for the universal role of phonology in reading comprehension.

Regarding the role of phonology in reading Chinese, equivocal findings were observed in early behavioral studies (e.g., Tan and Perfetti, 1997; Perfetti and Tan, 1998; Zhou and Marslen-Wilson, 1999; Chen and Shu, 2001). Some researchers reported early and notable effects of phonology in processing Chinese single characters and argued for a universal role of phonology in semantic access (Tan and Perfetti, 1997; Perfetti and Tan, 1998), however, their results were found to be difficult to replicate (Zhou and Marslen-Wilson, 1999; Chen and Shu, 2001). In addition, using a similar semantic categorization task as the one employed by Van Orden (1987) with Chinese stimuli, other researchers found that targets (e.g., 狐/wu4¹ and 呱/gwa1/) which were orthographically similar to a semantic category exemplar (e.g., 狐/wu4/, meaning “fox”) were more difficult to reject than an unrelated control, and the effect was not affected by the phonological similarity between orthographic foil and semantic exemplar (Chen et al., 1995; Leck et al., 1995). Although findings from early behavioral studies were mixed, recent related ERP studies tend to suggest a subsidiary role of phonology in reading Chinese (e.g., Zhang et al., 2009; Wang et al., 2010; Lin et al., 2011; Liu et al., 2011; Wang, 2011; but see also Liu et al., 2003; Ren et al., 2009). Wang et al. (2010), for instance, investigated the time course of semantic and phonological activation in processing Chinese single

characters using the Stroop paradigm with ERP recordings. Significant differences in ERP waves were observed between congruent and incongruent color words or word-semantic associates in the time window of 400–500 ms post target. However, the congruency effect induced by color word homophones was found only in the late 600–800-ms window, indicating a post-semantic processing role of phonology. Nevertheless, the above-referenced ERP studies focused exclusively on the processing of Chinese single-character words. In fact, a majority (over 70%) of lexical items in written Chinese is composed of two-character compounds (Zhou et al., 1999), and there is evidence to suggest dissimilar semantic processes for reading single- and two-character lexical items in Chinese (Wong and Chen, 2012). The present study was therefore conducted to investigate the role of phonology in reading Chinese two-character (disyllabic) compounds (e.g., 機場/gei1 coeng4/, meaning “airport”) using a masked-priming paradigm with ERP recordings.

Similar to the masked-priming study conducted by Zhou et al. (1999), a lexical decision task was employed. Specifically, participants were asked to judge whether the target (i.e., a string of two Chinese characters) in each trial was a real Chinese compound by pressing the corresponding keys on a computer keyboard, and each target was preceded by a briefly presented masked visual word prime. Four types of prime were included in the present study including Character-related (where the prime and target shared an identical character only; e.g., 機會/gei1 wui6/, “opportunity”), Syllable-related (where the prime and target shared an identical syllable only; e.g., 基礎/gei1 co2/, “foundation”), Semantic-related (where the prime and target were semantically related; e.g., 跑道/paau2 duo6/, “runway”), and Unrelated controls (where the prime and target were neither phonologically nor semantically related; e.g., 政策/zing3 caak3/, “policy”). Furthermore, for half of the target compounds their form-related primes (i.e., Character-related and Syllable-related primes) shared with them similar features on the first character position, whereas for the other half the overlapping word-form features were located at the second character position. This manipulation was done to balance the priming position and to investigate if there would be any positional effect on word-form priming.

Dissimilar to Zhou et al. (1999), ERP signals were also recorded to reveal the temporal dynamics underlying visual word recognition in real time (Holcomb and Grainger, 2006). Two ERP components are of particular interest for the present study, namely N250 and N400. Past research combining the masked priming paradigm and the ERP technique has repeatedly shown a reduction in N250 and N400 amplitudes when the prime and target shared similar word-form or word-semantic features, respectively, than when they were unrelated (e.g., Holcomb, 1993; Grainger et al., 2006). Holcomb and Grainger (2006) therefore argued that the N250 relates to sub-lexical processing, whereas the N400 relates to the interface between word-form and word-semantic processing. Accordingly, if phonology plays a

¹ This is the Cantonese pronunciation of the character. The number besides the syllable denotes the lexical tone of the syllable.

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