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LOCUS OF ORTHOGRAPHIC FACILITATION EFFECT IN SPOKEN WORD PRODUCTION: EVIDENCE FROM CANTONESE CHINESE

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ABSTRACT

Previous research of picture naming in a picture-word interference paradigm has demonstrated independent facilitative effects of orthographic and phonological similarity in Chinese, as homophonous characters can be visually dissimilar. This study investigated the locus of orthographic priming in Chinese and assessed the hypothesis that the effect can be in part semantically based, through manipulating the extent of orthographic and semantic relatedness between target-distractor characters. Our findings replicated previous results of independent orthographic facilitation and semantic interference, as well as different time courses of these effects. More importantly, we observed longer naming latencies when the distractor was both semantically and orthographically related to the target compared with orthographically similar distractors, and an interaction between semantic and orthographic similarity. These findings suggest that orthographic facilitation on picture naming in Chinese is located at the semantic or the lemma level.

Index Terms—picture-word interference, orthographic facilitation, semantic interference, Cantonese.

1. INTRODUCTION

Picture-naming performance in English and Dutch can be enhanced by the presentation of a word that is similar in form to the picture name [1-4]. For example, naming a picture of a PLANE when the distractor word ‘lane’ is superimposed on the picture leads to faster naming when compared to an unrelated word. This phenomenon, termed the orthographic facilitation effect, has also been shown in French [5] and Chinese [6-9].

It has been argued that Chinese provides an ideal script to investigate the orthographic facilitation effect. Unlike picture naming studies in alphabetic languages where orthographic similarity and phonological similarity between the target and the distractor are often confounded, it is possible to separate the effects of orthographic and phonological similarity between target picture names and word distractors in Chinese. This is because orthography and phonology are relatively independent variables in the Chinese script. To illustrate this point, consider the many heterographic homophones in Chinese, which are visually dissimilar characters that are pronounced in the same way (e.g., 如, 魚, and 餉, are all pronounced jyu² in Cantonese Chinese). Conversely, there are many visually similar characters that are pronounced differently (e.g., 痒 – gam1, 痠 – taan2, and 瘢 – zeoi1). Weekes and colleagues [7] showed that orthographic facilitation could be isolated from phonological priming in Chinese through using target-distractor pairs that were similar orthographically or phonologically only. The two effects did not interact with each other when orthographic and phonological similarity were manipulated in a factorial design [see also 6].

While the phenomenon of orthographic facilitation has been observed across scripts, its locus remains unclear with various models proposing that the effect lies in different levels of processing. The name retrieval account [3, 4] suggests that shorter naming latency is the result of the distractor’s orthography priming the picture name segments at the level of phonological retrieval. On the other hand, the lemma account [10-12] posits that orthographic facilitation is not limited to the phonological encoding stage, but could also affect the level of lemma retrieval (lexical selection). The written distractor word activates its own orthographic code and its neighbors at the input orthographic stratum and the lexico-semantic (i.e. lemma) level, thereby enhancing the activation and favoring the selection of the target lemma [13].

A similar third account referred to here as the semantic account is based on a model of oral reading in Chinese consisting of three interconnected levels of representations including semantic, orthographic and phonological [14]. The main difference between the lemma account and the semantic account lies in that the latter does not postulate an independent lemma representation level. The observations of independent effects of orthographic and phonological similarity in Chinese suggest that orthographic priming could arise either at the level of mappings between orthography-to-semantic representations or in semantic representations themselves. If orthographic facilitation can be generated via the semantic reading pathway, then one
prediction is that it may interact with effects of semantic interference at some point during picture naming [9, 13].

Experiments reported in English, Dutch and Chinese have shown that orthographic facilitation is observed when a visually similar distractor word is presented -150ms before to +150ms after the presentation of the target picture, and semantic interference from -300ms before the onset of the target picture to 0ms (simultaneous) presentation, with some evidence of an interaction [3, 4, 15]. There is therefore evidence to support the semantic hypothesis from studies conducted in alphabetic scripts. However, this evidence cannot currently be viewed as conclusive for several reasons: (1) In Rayner and Springer’s [15] Experiment 1 that varied semantic category, word form shape (i.e. visual similarity) and preservation of first letter, only 8 participants and 10 pictures were used. (2) In Experiment 2 that focused on the time course by manipulating stimulus onset asynchrony (SOA) and incorporating more stimuli and participants, a ‘pure semantic’ condition was not included. Therefore, it is not clear when the interaction occurs across SOA’s. (3) Starreveld and La Heij’s [3] study nevertheless did specifically manipulate the semantic and orthographic relatedness at +102ms SOA (picture first), however, due to the unavoidable confound of script (which they acknowledge), the orthographic facilitation effect and interaction with semantics is complicated by phonological overlap.

The aim of the present study was to test the semantic hypothesis directly by varying the relationship between orthographic and semantic similarity. Today, over 85% of Chinese characters are considered phono-semantic compound characters composed of two parts, a semantic radical that can give cues to the semantic category of the character, and a phonetic component that can give clues of the pronunciation of the character. A semantic radical may vary in the extent to which it is consistent with the meaning of the characters containing it, for instance the semantic radical 木 ‘plant/wood’ in 柏 ‘cypress’ or 植 ‘banyan’ vs. 權 ‘power’. Therefore, it is possible to keep the orthography of a distractor partially constant through using the same semantic radical as the target, but manipulate the semantic relation of the character pair. Note that in contrast characters sharing a phonetic radical are rarely semantically related.

2. METHOD

2.1. Participants

Forty-eight native Cantonese-speaking undergraduate students (24 males, M = 21.7 years, SD = 1.12) took part in the picture-naming task. All reported no history of speech and language difficulties and normal or corrected to normal vision.

2.2. Materials

Twenty pictured objects with monosyllabic Cantonese names were selected as targets from the colored version of Snodgrass and Vanderwart picture database [16]. All were phono-semantic compound characters consisting of a semantic radical and a phonetic component. Each target picture was matched with four distractor character types, corresponding to orthographically related (O+S-) with a common semantic radical, orthographic and semantically related (O+S+), semantically related (O+S-), and unrelated (O-S-), giving a total of 80 distractors. The O+S- and O-S+ conditions were included to replicate previously reported orthographic and semantic priming effects respectively. The condition of interest was O+S+, which allowed us to observe any interaction between orthographic facilitation and semantic interference if orthographic priming resides along the semantic pathway. All distractor characters were phonologically dissimilar to the target name.

<table>
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<th>Table 1. Properties of target and distractor conditions</th>
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<td><strong>Target</strong></td>
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Note. O+S- = Orthographically related, O+S+ = Ortho-semantically related, O-S+ = Semantically related, O-S- = unrelated; OS = Orthographic Similarity rating, SR = Semantic Relatedness rating; 1 = Very dissimilar/ unrelated; 5 = Very similar/ related; Standard errors are given in parentheses.

Ratings of orthographic and semantic relatedness were obtained from 30 different native Cantonese speakers (not tested in picture naming) based on a 5 point Likert scale of orthographic similarity (N = 15; five males; M = 22.33 years, SD = 1.35) and semantic relatedness (N =15; six males; M = 21.87 years, SD = 2.07) of character pairs (higher is more similar visually or more related in meaning). Games-Howell pair-wise comparisons were adopted (Levene’s test showed all p’s < .001). Ratings of orthographic similarity were significantly higher in the O+S- and O+S+ conditions than the unrelated conditions (p’s < .001), while the two conditions did not differ significantly from each other (p = .99), see Table 1. Ratings of semantic relatedness were significantly higher in the O-S+ and O+S+ conditions than all other conditions (p’s < .001), while there was no significant difference between them (p = .83).
In addition, distractor conditions were matched for mean character frequency, based on Cheung and Chan (1997) database (all pairwise $p$'s $>.05$) and mean number of strokes (all Games-Howell corrected $p$'s $>.05$).

### 2.3. Tasks and procedures

The target pictures were initially presented in a familiarization phase allowing participants to name each picture without error. Incorrect responses were corrected by the experimenter. Experimental blocks were administered only after participants were able to consecutively name all the pictures correctly. Participants were then instructed to name as quickly as possible the picture presented on the computer screen, whilst ignoring the distractor word during the experimental phase. Twelve practice trials and two experimental blocks were provided. Trials were presented in a pseudorandom order so that no target pictures were repeated over two consecutive trials to avoid priming effects. Participants were allocated to different SOA groups by random assignment.

Each trial began with a fixation point (+) centered in the screen for 500 ms, followed by a blank screen of 500 ms. Then, depending on the pre-determined SOAs, either distractor characters were presented 100 ms before (SOA -100), simultaneously (SOA 0ms), or 100 ms after target pictures (SOA +100). The presentation of stimuli was terminated once the participant produced a vocal response or after 2000ms and the next trial would begin after a blank screen was presented for 800ms. Naming latencies were determined from the onsets of the target picture presentation and vocal response. Incorrect responses and invalid vocal responses (i.e. early onset due to irrelevant vocal response and delayed onset due to low intensity of vocal response) were recorded on-line.

Pictures and distractors were presented using a laptop with a high-resolution monitor (800*600 pixels) running the E-Prime 2.0 program. A microphone was connected to the laptop through the Serial Response Box (SRBOX) that recorded the onset of naming response. Target pictures were digitized images displayed at a size 850*600mm (281*197 pixels), and distractor characters were presented as digitized images (Arial Unicode MS font) measuring 16*16mm (60*60 pixels). All participants were tested in a well-lit sound proof room and seated at a viewing distance of approximately 60 cm.

### 2.4. Data analyses

To test the hypothesis that orthographic facilitation is modulated by semantic interference, a 3-way mixed ANOVA was implemented with orthographic similarity, semantic relatedness, and SOA as independent variables. Distractor orthographic similarity with two levels (similar vs. dissimilar) and distractor semantic relatedness with two levels (related vs. unrelated) were both within-subjects factor variables. And SOA with three levels (-100ms, 0ms, +100ms) was a between-subjects factor variable. Dependent variables were target picture naming latencies and percentage naming errors.

One target (葉 /ji6j/ leaf) and all corresponding distractors were excluded from further analyses, due to the majority of participants reporting that they were unfamiliar with the HO distractor (備 /sat8/ borrow). Naming latencies from incorrect and invalid responses (3.35%) and those shorter than 300ms or longer than 2000 ms (0.01%) were discarded. Latencies that deviated by more than $\pm$ 3SD were replaced by the mean (0.01%). All analyses were performed on the remaining data. When assumptions of sphericity and homogeneity were not met in the by-participant and by-items ANOVA’s for the latency and error analysis, Greenhouse-Geisser, Bonferroni and Games-Howell correction were reported, respectively.

### 3. Results

Figure 1 illustrates the effects of orthographic facilitation and semantic interference across the different SOA durations. Results showed main effects of orthographic facilitation, $F_1 (1, 45) = 24.23, p < .001$; $F_2 (1, 216) = 22.84, p < .001$, where targets with distractors that were visually similar to the target character ($M = 650.77, SE = 8.37$) were named faster than distractor characters that were visually different ($M = 675.82, SE = 8.62$). The effect of semantic interference was also significant, $F_1 (1, 45) = 63.35, p < .001$; $F_2 (1, 216) = 43.42, p < .001$, indicating that distractors that were related in meaning to the target ($M = 683.67, SE = 9.10$) took longer to name than semantically unrelated distractors ($M = 642.92, SE = 7.83$). SOA was found to be significant in the item analysis, $F_1 (2, 45) = 1.79, p = .18$; $F_2 (2, 216) = 5.16, p < .01$, showing that target pictures were named the fastest when distractors were presented simultaneously with the target ($M = 639.77, SE = 8.02$), compared with being presented 100ms earlier ($M = 656.37, SE = 8.02$) or 100ms after target presentation ($M = 675.43, SE = 8.02$).

Interaction effects between orthographic similarity and semantic relatedness were significant by item $F_1 (1, 45) = 2.07, p = .16, F_2 (1, 216) = 6.25, p < .05$, showing that visual similarity facilitated target naming of semantically unrelated distractors (O+S- vs. O-S-, $p < .001$), but not semantically related distractors (O+S+ vs. O-S+, $p > .05$). A significant interaction between semantic relatedness and SOA by participant was also found $F_1 (2, 45) = 3.77, p < .05, F_2 (1, 216) = 1.18, p = .31$, indicating that participants were significantly faster to name semantically unrelated target-distractor pairs at SOA 0 than SOA+100 ($p < .05$) with no differences found for semantically related target-distractor pairs.

To locate the time course of the orthography by semantics interaction, 2-way ANOVAs across SOAs were conducted. Main effects of semantic interference were found
for all SOAs both by item and participant (p’s < .05). The same was true of orthographic facilitation (p’s < .05) except at +100 ms by participant (p = .11). Crucially, the interaction was significant at SOA +100 (F1 (1, 15) = 3.97, p = .065; F2 (1, 72) = 5.00, p < .05), during which items in the O+S- condition were significantly faster to name compared to all other conditions (all p’s < .007), see Figure 1 for mean differences across distractor conditions at each SOA.

The results replicated independent effects of orthographic facilitation and semantic inhibition in picture naming. Moreover, orthographic facilitation was most evident when semantic inhibition had subsided at SOA +100ms, thereby confirming the hypothesis that effects of orthographic facilitation on spoken word production depend in part on semantic competition.

As in the studies reported by Weekees and colleagues [7], the orthographic facilitation effect is independent of phonology because orthographically-related distractors do not share any phonological representations (lexical or sublexical) with the target picture. These findings challenge the name retrieval account of picture word facilitation since orthographic facilitation cannot result from phonological encoding [3, 4, 17].

The novel finding of this study is that O+S- items produce orthographic facilitation that is affected by the strength of semantic effects, most apparently at SOA +100ms. Given Sternberg’s additive factors logic [18] which assumes that interaction/non-additive effects should be observed when factors affect the same processing stage, the interactive effect supports the hypothesis that orthographic facilitation is achieved via the semantic reading pathway in Chinese as assumed in Weekees et al.’s model [14]. In that framework, picture naming can be enhanced due to the distractor activating a cohort of items that are similar in form, including the target character, at the level of orthography. These co-activated candidates then feed forward to the semantic level. At the semantic level, activation of the target conceptual representation from the picture is further enhanced by input from the target character (from the co-activated form-related candidates), which then facilitates selection for further phonological actualization. As the cohort of characters are only related in form and have little overlap in meaning, less competition is encountered at the semantic level. When distractors are orthographically and semantically related (i.e. O+S+) to the target, greater competition arises at the conceptual level given that the co-activated form related candidates also boost the activation of conceptually related representations, hence creating greater interference.

The interaction between orthographic facilitation and semantic inhibition is also compatible with the lemma retrieval account of orthographic facilitation [2, 11, 12, 19]. In this account, orthographic facilitation can occur at the lemma level and lexical phonological level [13]. Given that independent orthographic and phonological facilitation effects have been demonstrated for Chinese speakers, we assume that orthographic facilitation cannot be located at the lexical phonological level, hence orthographic facilitation can be located at the lemma level [see also 13]. The orthographically related distractor activates its orthographic code as well as its neighbors, including the target item, at the orthographic stratum and the lemma level. This additional activation consequently increases the activation of the target lemma and thereby facilitates the selection of the picture name. With respect to O+S+ distractors, not only do these activate orthographically related neighbors but also semantically related candidates. This in turn, enhances the activation of semantically related items that then compete

Figure 1. Effects of distractor orthographic similarity and semantic relatedness on picture naming with error bars.

In the error analyses, only the effect of semantic relatedness was significant, F1 (1, 45) = 23.75, p < .001; F2 (1, 216) = 15.16, p < .001, whereby participants were more prone to make errors when targets and distractors were semantically related (M = 2.68%, SE = 0.37), compared with semantically unrelated distractors (M = 0.71%, SE = 0.22).

4. DISCUSSION

The results replicated independent effects of orthographic priming and semantic interference in picture naming. Moreover, orthographic facilitation was most evident when semantic inhibition had subsided at SOA +100ms, thereby confirming the hypothesis that effects of orthographic

![Figure 1](image-url)
and impede the selection of the appropriate lemma representation.

To conclude, we found independent effects of orthographic facilitation and semantic interference effects in Cantonese picture naming, similar to studies conducted in Mandarin, Dutch and English. These findings show that the interaction found between orthographic facilitation and semantic inhibition supports the hypothesis that orthographic facilitation has a semantic locus.

5. FOOTNOTES

1. Phonetic transcriptions are given in the romanized jyutping system developed by the Linguistics Society of Hong Kong. The number in the transcription denotes the tone.

6. REFERENCES


