Acta Psychologica 139 (2012) 272–280

Contents lists available at SciVerse ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/ locate/actpsy

Orthographic and phonological facilitation in speech production: New evidence from picture naming in Chinese ☆

Haoran Zhao [a], Wido La Heij [b,*], Niels O. Schiller [b,c]

[a] Dalian Maritime University, Dalian, China
[b] Leiden University, The Netherlands
[c] Leiden Institute for Brain and Cognition, Leiden, The Netherlands and Leiden University Centre for Linguistics, Leiden, The Netherlands

ARTICLE INFO

Article history:
Received 15 March 2011
Received in revised form 29 November 2011
Accepted 1 December 2011
Available online xxxx

PsycINFO codes:
2340 Cognitive Processes
2720 Linguistics & Language & Speech

Keywords:
Word production
Chinese
Picture–word interference
Orthographic facilitation
Phonological facilitation

ABSTRACT

Picture naming is facilitated when a target picture (e.g. of a cat) is accompanied by a form-related context word (e.g. CAP) relative to an unrelated word (e.g. PEN). Because in alphabetic languages phonological and orthographic similarity are confounded, Chinese, a logographic language, has been employed to study these two effects in isolation. The results obtained suggest that the orthographic facilitation effect is localized at an earlier processing level than the phonological facilitation effect. In the present study we examine this issue again, using an experimental design in which the context words in the related and unrelated conditions are optimally matched. In contrast to the earlier studies Experiments 1 and 2 fail to show differences in the time course of the two context effects. Moreover, Experiment 3 provides direct evidence against an early, conceptual locus of orthographic facilitation. Our findings indicate that in Chinese language production both orthographically and phonologically related context words have their effect at the rather late level of word-form encoding.

1. Introduction: Disentangling the contributions of orthographic and phonological priming in speech production: New evidence from picture naming in Chinese

The picture–word interference task, a variant of the Stroop task, is a widely used paradigm to study the cognitive process involved in speech production. In this task, a participant is asked to name a picture and to ignore a superimposed distractor word (e.g., Lupker, 1979; Rosinski, Golinkoff, & Kukish, 1975). Two effects obtained with this paradigm have been studied extensively: semantic interference (e.g., Glaser & Düngelhoff, 1984; La Heij, 1988) and orthographic/phonological facilitation (e.g., Lupker, 1982; Rayner & Springer, 1986; Starreveld, 2000; Starreveld & La Heij, 1995, 1996b).

The semantic interference effect refers to the finding that it takes longer to name a target picture when the distractor word and the target picture belong to the same semantic category than when word and picture are unrelated. In two-stage models of lexical access, in which a lexical–syntactic (lemma) level and a phonological word-form (lexeme) level are distinguished, the effect is generally localized at the stage of selecting the lemma of the response word (e.g., Levelt, Roelofs, & Meyer, 1999; see however, Mahon, Costa, Peterson, Vargas, & Caramazza, 2007, for an alternative account). The orthographic/phonological facilitation effect refers to the finding that when the distractor word is orthographically and/or phonologically related to the name of the target picture, it takes less time to name the picture than when the distractor word is unrelated. This effect is commonly localized at the level of retrieval of the phonological word form (lexeme) of the target word (Roelofs, 1992; Schriefers, Meyer, & Levelt, 1990), although it has been argued that under special circumstances an orthographic/phonological relation may also affect the assumed lemma-retrieval stage (Roelofs, Meyer, & Levelt, 1996).

In alphabetic languages, the basic orthographic unit represented by a grapheme often corresponds a phoneme, although languages differ in the nature of this correspondence. In some languages, like Italian and Serbo-Croatian, there is a closer grapheme–phoneme correspondence (so-called *shallow orthographies*) than in other languages, like English, in which the relation is more complex (many one-to-many correspondences between graphemes and phonemes in both directions; so-called *deep orthographies*). Dutch is an orthographically shallow language, and as a consequence, in a Dutch picture–word interference task as employed by, for instance, Starreveld and La Heij (1996b), orthographic similarity and phonological similarity are

☆ We are indebted to two anonymous reviewers for helpful suggestions on an earlier version of this article and to Jun Lai and Kalinka Timmer for their advice in performing the mixed-models regression analyses. NOS was supported as a Fellow-in-Residence 2010/2011 at the Netherlands Institute for Advanced Study (NIAS) in the Humanities and Social Sciences, Wassenaar, The Netherlands.

* Corresponding author at: Faculty of Social Sciences, Cognitive Psychology Unit, P.O. Box 9555, 2300 RB Leiden, The Netherlands. Tel.: +31 71 5273636.
E-mail address: laheij@fsw.leidenuniv.nl (W. La Heij).

0001-6918/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.actpsy.2011.12.001

confounded. Therefore, the "phonological facilitation effect" observed cannot unequivocally be attributed to the phonological relation between target name and distractor word. Attempts in English to disentangle the contributions of orthographic relatedness (e.g., year–bear) and phonological relatedness (brain–plane; Lupker, 1982; see also Damian & Bowers, 2009; Posnansky & Rayner, 1978) suggest that the contribution of orthographic relatedness may be stronger than the effect of phonological relatedness.

To study the independent contributions of orthographic and phonological relatedness in the picture–word interference task, researchers have taken refuge to written Chinese. Logographic by nature, the most significant unit of the written Chinese language is the character (e.g., 书, 'book'), which has a highly arbitrary symbol-to-sound correspondence. In addition to this characteristic, in Chinese characters can be found that are (a) visually very similar but phonologically very different or (b) phonologically very similar (e.g., only different in tone), but very different in written form (heterographic homophones; Chen & Juola, 1982; Leck, Weekes, & Chen, 1995). For example, the Chinese words 创 (/chuang4/, 'creation') and 庆 (/qing4/, 'celebration') are phonologically and orthographically similar to the name of the target picture *bed* (床, /chuang2/), respectively.

A consequence of the arbitrary symbol-to-sound correspondence in Mandarin Chinese is that readers of this language are unable to use a direct grapheme-to-phoneme route that is available to readers of alphabetic scripts (Bi, Xu, & Caramazza, 2009; we return to this issue in the introduction of Experiment 2). This characteristic facilitates the interpretation of verbal context effects in word production in Chinese in comparison to alphabetic languages. We discuss the possible ways in which verbal context can affect picture naming in Mandarin Chinese with the help of the model in Fig. 1, adapted from Bi et al. (2009; see also Zhang & Weekes, 2009). This model distinguishes a conceptual (non-verbal) level, an orthographic input level, a level of lexical (word) representations and a level of phonological features. In explaining the main features of the model, the picture of a *bed* (床, /chuang2/) is used as an example of a to-be-named target, the character 创 (/chuang4/) as the phonologically related but orthographically unrelated distractor (/chuang2/ and /chuang4/ only differ in tone, whereas 创 and 床 are orthographically dissimilar), the character 庆 ('celebration') as an orthographically related but phonologically unrelated distractor (/chuang2/ and /qing4/ are phonologically dissimilar but 床 and 庆 are orthographically very alike), and the character 叶 (/ye4/, 'leaf') as an unrelated distractor.

Within the model presented in Fig. 1, the phonological facilitation in naming the picture of a bed (床, /chuang2/) induced by a written distractor word (创, /chuang4/) can be attributed to the activation of the target's phonological representation (/chuang2/) by the distractor word via the phonological features that the two words have in common (Perfetti, Liu, & Tan, 2005). The latter possibility is illustrated in Fig. 1. The orthographic facilitation in naming the picture of a bed (床, /chuang2/) induced by a written distractor word (庆, /qing4/) may come about in the following way. In the process of recognition of the character 庆, representations of form-related characters may become activated, including 床 (the written name of the target picture; see Damian & Bowers, 2009, for an identical proposal). This orthographic representation may facilitate picture naming in two ways: (a) it may directly activate the corresponding phonological representation (/chuang2/, the correct response; cf. Weekes, Davies, & Chen, 2002; Zhang & Weekes, 2009) or (b) it may activate its semantic representation at the conceptual level (cf. Zhang & Weekes, 2009), thereby facilitating the conceptual identification of the target picture. Fig. 1 illustrates both possibilities.

Although in this account orthographically related and phonologically related distractor words affect different representations via different processing routes, it is important to note that they have a common locus of impact on word production: the retrieval of the phonological word form of the target word. The main difference is that orthographic representations may also affect an early level of picture identification. In the General discussion, we will address an alternative view in which orthographic representations are actively involved in the process of word production (Damian & Bowers, 2003). For the moment, we conclude that – given the assumptions depicted in Fig. 1 – one may predict orthographic and phonological facilitation at a relatively late stage in word production (i.e. at a relatively late SOA) and an isolated orthographic facilitation effect at an earlier stage of word production (i.e. at an earlier SOA), reflecting facilitation at the conceptual level.

These predictions of the model in Fig. 1 are in line with the results of recent studies on orthographic and phonological facilitation in Chinese picture naming. Zhang and Weekes (2009) examined orthographic and phonological similarity in speakers of Mandarin using SOA steps of 100 ms, ranging from −300 ms (distractor word first) up to +300 ms (target picture first). Their main findings were: (a) orthographic similarity and phonological similarity induced facilitation effects at SOA +100 and (b) orthographic similarity induced

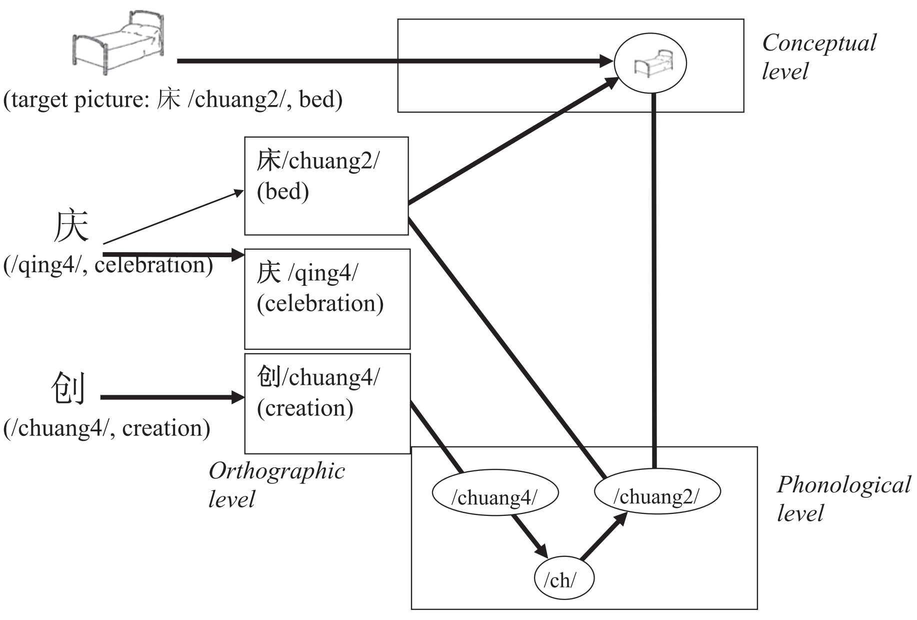

Fig. 1. A functional model of picture naming with word distractors in Chinese.

additional facilitation effects at SOAs of −100 ms and 0 ms. Zhang, Chen, Weekes, and Yang (2009) reported somewhat similar findings, although in their experiment the isolated orthographic facilitation effect was obtained at SOA −150 ms whereas at SOAs of 0 ms and +150 ms both orthographic and phonological facilitation effects were observed. Zhang and Weekes (2009) tentatively accounted for the presence of an early orthographic effect in the following way: "The results therefore suggest a course of orthographic facilitation that proceeds from orthography to conceptual representations and then to phonological output (via the lexical–semantic pathway)" (p. 1093). This route is shown in Fig. 1 and was discussed above.

To summarize, recent research on orthographic and phonological facilitation in Mandarin Chinese suggests that the two effects have different time courses, with an early effect restricted to orthographic similarity. In combination with the finding that the two effects are additive at SOA 0 ms, the authors of earlier studies suggested that orthographic and phonological facilitation affect different stages in word production. This finding is important for two reasons. First, it may shed light on the processing of Chinese characters. Second, if the differential effect is genuine and generalizes to alphabetic languages, previous findings obtained with the manipulation of orthographic/phonological similarity probably need to be reinterpreted (cf. Zhang & Weekes, 2009).

In the present study, we (a) attempt to replicate the differences in time course of activation using a somewhat different design than employed in previous studies (Experiments 1 and 2) and (b) test Zhang and Weekes' (2009) proposal that in Chinese orthographic similarity affects an early process of picture identification (Experiment 3).

2. Experiment 1

In the picture–word interference task, the effects of a semantic, orthographic or phonological relation between target and distractor are determined by comparing the results obtained by the distractor words in these conditions with those obtained by unrelated distractor words. To obtain an unbiased measure of the context effects, it is crucial that distractor words in the related and unrelated conditions *only* differ in the relevant dimension, i.e. the presence or absence of a specific relation (semantic, orthographic or phonological). The common way to achieve this goal is to use the same set of distractor words in the related and unrelated condition and to create the unrelated condition by re-coupling target pictures and distractor words. In that way, one can be sure that the two sets of distractor words are identical with respect to all known and unknown variables that may affect picture-naming latencies.

In the studies on Chinese word production discussed above, a different approach was taken, in which the distractor words in the two sets were different, but matched with respect to a number of relevant variables. Although this approach is hard to avoid in studies in which the interaction between two types of relatedness is investigated (as in Starreveld & La Heij, 1995, and Zhang et al., 2009), it comes with the risk of sub-optimal matching. In the study by Bi et al. (2009), for instance, the distractor words in the orthographically related and unrelated conditions were matched with respect to language frequency, but not with respect to imageability (Lupker, 1979). Moreover, the words differed in syntactic word class. For example, the number of nouns and adjectives in the orthographically related condition were 10 and 2, respectively, whereas these numbers were 2 and 6, respectively, in the unrelated condition. It is conceivable that less interference is obtained when target and distractor do not belong to the same word class (see, e.g., Mahon et al., 2007; Melinger & Koenig, 2007; Pechmann & Zerbst, 2002; Pechmann, Garrett, & Zerbst, 2004). Given these considerations, it seems worthwhile to examine the time course of orthographic and phonological facilitation again, using the conventional method of re-coupling targets and distractor words to create the unrelated condition. The same SOA conditions were used as in Zhang et al. (2009), i.e. −150 ms, 0 ms and +150 ms.

2.1. Method

2.1.1. Participants

Eighteen Chinese native speakers, living in the Netherlands, participated (12 female; mean age: 25.7 years; SD = 5.3). Sixteen of these participants were students (BA, MA or PhD level). All spoke Mandarin Chinese and came to the Netherlands after their 20th birthday. They had normal or corrected-to-normal eyesight.

2.1.2. Apparatus

The experiment was run using E-Prime Professional Software (Beta 2.0) on a Pentium PC. Naming responses were recorded by a microphone connected to the computer via a Serial Response Box, and reaction times were determined by the triggering of a voice-key.

2.1.3. Materials

Twenty black-and-white line drawings corresponding to a monosyllabic name in Chinese were selected as targets. Each of these target pictures was presented with four types of monosyllabic Chinese distractor words: (a) words orthographically related (the target name shared at least half of the visual components – or radicals – such as 蛇 and 舵) but phonologically unrelated to the picture name, (b) the same words as under (a), but in semantically, orthographically and phonologically unrelated combination with the target pictures ("orthographic control"), (c) words phonologically related but orthographically unrelated to the picture name (the two words only differed in tone), and (d) the same words as under (c), but in semantically, orthographically and phonologically unrelated combination with the target pictures ("phonological control"). Orthographically and phonologically related distractors were matched in terms of word class and language frequency. The mean log frequencies for orthographically and phonologically related words were 9.2 and 9.8 respectively, $t(19) = 1.03$, $p > .30$. In creating the unrelated conditions, an attempt was made to select an unrelated distractor word that matched the frequency of occurrence of the phonologically or orthographically related distractor word.

The phonological related distractors only differed from the correct target names in tone. As to the orthographically related distractors, we made sure that the distractor word and the target name shared at least half of the visual components (or radicals), such as 蛇 and 舵. Evidently, it is impossible to match the strength of the phonological relation with the strength of the orthographic relation. As a consequence, a possible difference in the absolute size of the orthographic and phonological facilitation effect is hard to interpret. That is the reason the current study focuses on the time course of both effects.

Neither phonological nor orthographic distractors were semantically related to the corresponding target names. In addition, we used noun distractors across all conditions except for two words, which are used both as verb and noun: 庆 /qing4/ ('celebration') with 床 /chuang2/ ('bed'), the other was 染 (dye). We also made efforts to select concrete, imaginable words, although a few less concrete words remained (e.g., 碱 /jian 3/, 'alkali', and 国 /guo2/, 'country'). A complete list of target pictures and distractor characters is shown in Appendix A.

2.1.4. Design

The design included three within-participant factors: orthographic relatedness (related versus unrelated), phonological relatedness (related versus unrelated) and SOA (−150 ms, 0 ms, and +150 ms).

2.1.5. Procedure

The order of presentation of the three SOA blocks (6 possible orders) was counterbalanced across participants. In each SOA block, participants were presented with 20 target pictures in each of the four context conditions: orthographically related, orthographic control, phonologically related, and phonological control. Consequently, each participant received 3 (SOA) × 20 (target pictures) × 4 (context conditions) = 240 experimental trials. In addition, each block was preceded by two warm-up trials, which were not included in the analysis. For each participant, pseudo-random lists were constructed per block, to avoid repetition of the target within three consecutive trials. The manipulation of SOA as a within-participant factor implies repetition of the target pictures, a procedure that is the rule rather than the exception in language production research (see e.g., Glaser & Düngelhoff, 1984; Schriefers et al., 1990; Starreveld & La Heij, 1996b). Repetition of targets may reduce context effects (see La Heij & van den Hof, 1995), but there is no indication that this characteristic affects the time course of the context effects. Also, note that the longest pre-exposure of the context stimulus is −150 ms, which makes it unlikely that the findings are affected by prediction strategies.

The overall experiment was preceded by a familiarization session, in which the participants were shown the pictures and their names and a practice session, in which the participants were asked to name the pictures, presented without a distractor character, as fast as possible.

The pictures were black line drawings on a white background, superimposed by a distractor character in their center. Each warm-up and experimental trial comprised the following sequence: a fixation point (+) appeared in the middle of the screen for 1000 ms. Next, the first stimulus was presented (either the distractor or the target), followed by the second item after a pre-specified SOA. The stimulus disappeared from the screen after triggering of the voice key or after an interval of 2000 ms had elapsed. The experimenter judged the response as correct or incorrect. Inappropriate triggering of the voice-key or a failure to trigger could also be registered. Next, the fixation point for the next trial appeared. Participants were asked to name the target picture aloud as quickly and accurately as possible while ignoring the superimposed character. There was a short break between SOA blocks.

2.2. Results

Naming latencies were discarded from the analyses when any the following conditions were met: (a) incorrect naming response (1.6% of the trials), (b) the voice-key did not trigger or was triggered by a sound other than the vocal utterance (4.8% of the trials), (c) correct RTs smaller than 300 ms or greater than 1500 ms (0.3% of the trials). The remaining data were used to calculate means. Mean naming latencies, facilitation effects and error percentages for each condition are shown in Table 1.

The data of all experiments in this article were analyzed in a mixed-models regression analysis with participants and items (pictures) as random factors, using the SPSS "mixed" function (see, for an excellent primer on mixed effect models, Brysbaert, 2007). In the first analysis, SOA (−150 ms, 0 ms and +150 ms), type of relation (orthographic versus phonological) and relatedness (related versus unrelated) were treated as fixed factors. Significant main effects were obtained for SOA, $F(2,3976)=42.07$, $p<.001$ (mean RTs of 588 ms, 595 ms, and 561 ms in the −150 ms, 0 ms and +150 ms SOA conditions, respectively) and relatedness, $F(1,3976)=72.89$, $p<.001$. The two-way interaction between SOA and relatedness was significant, $F(2,3976)=21.47$, $p<.001$, indicating that the size of the relatedness effect differed across SOAs, as was the three-way interaction between SOA, type of relation and relatedness, $F(2,3976)=3.37$, $p<.05$.

Table 1
Average naming latencies (RT, in ms), error percentages (%e) and facilitation effects for the various conditions of Experiment 1.

SOA						
Distractor type	−150 ms		0 ms		+150 ms	
	RT	%e	RT	%e	RT	%e
Orthographically related	578	1.7	577	1.1	557	1.4
Orthographically unrelated	593	1.7	619	3.6	571	1.7
Phonologically related	584	2.2	555	0.6	554	1.4
Phonologically unrelated	596	1.1	627	1.4	562	1.7
Orthographic facilitation	15	0.0	42	2.5	14	0.3
Phonological facilitation	12	−1.1	72	0.8	8	0.3

Similar mixed-models regression analyses were performed on the data of each SOA separately with type of relation and relatedness as fixed factors. At SOA −150 ms only the main effect of relatedness was significant, $F(1,1301)=7.03$, $p<.01$. At SOA = 0 ms the effect of relatedness was significant, $F(1,1299)=103.06$, $p<.001$, as was the interaction between type of relation and relatedness, $F(1,1299)=6.49$, $p<.05$, indicating that at this SOA the phonological facilitation effect was larger than the orthographic facilitation effect. At SOA +150 ms only the effect of relatedness was significant, $F(1,1304)=4.49$, $p<.05$. Further tests revealed that at SOA = 0 ms both the 44 ms orthographic facilitation effect and the 73 ms phonological facilitation effect were significant: $F(1,629)=27.32$, $p<.001$, and $F(1,634)=94.37$, $p<.001$, respectively. The percentages of errors were considered too small to allow for a meaningful analysis.

2.3. Discussion

The data of all experiments in this article were analyzed in a mixed-models regression analysis using the SPSS "mixed" option (see, e.g., Brysbaert, 2007). In line with previous studies on Chinese picture naming, our data show both orthographic and phonological facilitation. However, our findings deviate from those of earlier studies (Bi et al., 2009; Zhang & Weekes, 2009; Zhang et al., 2009) in two respects. First, the orthographic facilitation effect at SOA 0 ms was not larger than the phonological facilitation effect at that SOA. In fact, the opposite was true: the phonological facilitation effect was larger than the orthographic facilitation effect. However, as discussed above, a difference in absolute size of the two effects is hard to interpret given the fact that the strength of the relation between phonologically related pairs (differing in tone) and orthographically related pairs (that differed in a subset of the strokes making up the characters) is hard to compare. Second and most important, unlike Zhang and Weekes (2009) and Zhang et al. (2009) – who obtained an early orthographic facilitation effect without a concomitant phonological facilitation effect – the time courses of orthographic and phonological facilitation did not differ in our experiment. At SOA = −150 ms, for example, we obtained an orthographic effect of 15 ms and a phonological effect of 12 ms.

Before concluding that our data indicate that orthographic and phonological similarity have their effect at the same stage or stages in Chinese picture naming, two potential problems with the interpretation of the results of Experiment 1 need to be addressed. First, some of the distractor words used in the phonologically related condition of Experiment 1 contained a so-called "phonetic radical", i.e. a part of a character that indicates how the character as a whole is pronounced. Although it is far from clear how these radicals are used (e.g., they do not always indicate the correct pronunciation of the character) and processed, we cannot fully exclude the possibility that characters containing phonetic radical are processed via a direct route from orthography to phonology, not unlike the grapheme-to-phoneme conversion route in alphabetic scripts (see Bi et al., 2009, for a discussion of this issue). If participants in Experiment 1 used such a route, this could explain the relatively large phonological facilitation effect obtained.

A second problem with the interpretation of the results of Experiment 1 is that subtle differences in the time course of phonological and orthographic facilitation may have gone undetected because of the relatively large SOA intervals of 150 ms employed.

3. Experiment 2

Given the considerations mentioned above, Experiment 2 differed in two respects from Experiment 1. First, a new set of stimuli was selected with distractor characters that do not contain phonetic radicals[1]. Second, SOA was again varied from −150 ms up to +150 ms, but now in intervals of 75 ms. That is, five SOA intervals were employed (i.e. −150 ms, −75 ms, 0 ms, +75 ms, and +150 ms) to examine the time course of orthographic and phonological facilitation in more detail.

3.1. Method

3.1.1. Participants

Twenty-five Chinese college sophomores (11 female; 14 male; mean age 20.6 years; SD = 1.7), from Dalian Maritime University, participated. All spoke Mandarin Chinese and had normal or corrected to normal eyesight.

3.1.2. Apparatus

The equipment was similar to Experiment 1 except that the stimuli were presented on a LCD monitor.

3.1.3. Materials

Twenty black-and-white line drawings corresponding to a monosyllabic name in Chinese were selected as targets, fifteen of which were the same as in Experiment 1. Each of these target pictures was presented with four types of monosyllabic Chinese distractor words using the same constraints as in Experiment 1. For the distractor words in the phonologically related condition care was taken not to select characters containing phonetic radicals. The distractor words in the orthographically related condition and phonologically related condition were matched in terms of word class and language frequency. The mean log frequencies for orthographically and phonologically related words were 9.28 and 9.96, respectively; $t(38) = 1.29$, $p > .20$. In creating the unrelated conditions, an attempt was made to select an unrelated distractor word that matched the frequency of occurrence of the phonologically or orthographically related distractor word. A complete list of target pictures and distractor characters is shown in Appendix B.

3.1.4. Design

The design included three within-participant factors: orthographic relatedness (related versus unrelated), phonological relatedness (related versus unrelated) and SOA (−150 ms, −75 ms 0 ms, +75 ms and +150 ms).

3.1.5. Procedure

The order of presentation of the five SOA blocks was balanced across participants. In each SOA block, the same procedure was followed as in Experiment 1. Altogether each participant received 5 (SOA) × 20 (target pictures) × 4 (context conditions) = 400 experimental trials.

3.2. Results

Naming latencies were discarded from the analyses when any the following conditions were met: (a) incorrect naming response (1.6% of the trials), (b) the voice-key did not trigger or was triggered by a sound other than the vocal utterance (2.1% of the trials), (c) correct RTs smaller than 300 ms or greater than 1500 ms (0.5% of the trials). The remaining data were used to calculate means per condition. The mean naming latencies and error percentages for each condition are shown in Table 2.

Mixed-models regression analyses were carried out with participants and items as random variables and type of relation (orthographic versus phonological), relatedness (related versus unrelated) and SOA (−150 ms, −75 ms, 0 ms, +75 ms, and +150 ms) as fixed variables. The main effect of relatedness was highly significant, $F(1,9555) = 95.89$, $p < .001$, reflecting faster naming latencies in the related compared to the unrelated conditions. Also the main effect of SOA was significant, $F(4,9555) = 6.59$, $p < .001$. Finally, the interaction between SOA and relatedness reached significance, $F(4,9555) = 4.12$, $p < .01$, indicating that the size of the facilitation effects differed across SOAs. Similar mixed-models analyses were performed on the data of each of the SOA conditions separately, with type of relation and relatedness as factors. The main effect of relatedness was significant at all SOA intervals: SOA = −150 ms, $F(1,1885) = 8.13$, $p < .005$; SOA = −75 ms, $F(1,1883) = 11.43$, $p < .01$; SOA = 0 ms, $F(1,1869) = 56.86$, $p < .001$; SOA = +75 ms, $F(1,1872) = 20.46$, $p < .001$; and SOA = +150 ms, $F(1,1874) = 13.62$, $p < .001$. All other main effects and interaction effects failed to reach significance (all p values > .10). The percentages of errors were considered too small to allow for a meaningful analysis.

3.3. Discussion

The first objective of this experiment was to examine whether the substantial phonological facilitation effect observed in Experiment 1 could have been due to the presence of phonetic radicals in the distractor characters used in that experiment. The results of the present experiment, in which phonetic radicals were avoided, showed that the phonological facilitation effect at SOA = 0 ms is numerically somewhat reduced in comparison to Experiment 1 (72 ms in Experiments 1 compared to 38 ms in Experiment 2), but still substantial.

The second issue examined in this experiment was the time course of orthographic and phonological facilitation, using smaller intervals than in Experiment 1. The results of this manipulation are clear: there is no evidence for the two facilitation effects having different time courses. Hence, on the basis of the results of Experiments 1 and 2 there is no reason to assume that orthographic and phonological facilitation are localized at different stages in the process of Chinese word production. In Experiment 3, we put this conclusion to an additional test.

4. Experiment 3

As discussed in the Introduction, two earlier PWI studies in which SOA was manipulated showed an early orthographic facilitation

Table 2
Average naming latencies (RT, in ms), error percentages (%e) and facilitation effects for the various conditions of Experiment 2.

SOA										
Distractor type	−150		−75		0		+75		+150	
	RT	%e	RT	%e	RT	%e	RT	%e	RT	%e
Orthographically related	605	0.8	609	1.6	592	1.6	595	1.2	591	1.0
Orthographically unrelated	618	1.2	621	1.4	629	2.2	612	1.6	618	1.4
Phonologically related	611	2.6	600	0.6	591	1.0	584	0.8	595	0.4
Phonologically unrelated	623	2.2	619	2.0	629	2.2	611	2.2	605	2.2
Orthographic facilitation	13	0.4	12	−0.2	37	0.6	17	0.4	27	0.4
Phonological facilitation	12	−0.4	19	1.4	38	1.2	27	1.4	10	1.8

[1] Dependent on the definition used, one of the selected distractor characters could be argued to contain a phonetic radical (颅, lu2, head). Because eliminating the results obtained with this character had no effect on the outcomes, we report the analyses on the complete set of materials.

effect. For example, Zhang and Weekes (2009) reported significant orthographic facilitation effects at SOA intervals of −100 ms, 0 ms, and 100 ms, whereas the phonological facilitation effect was confined to the SOA interval of +100 ms. The authors argued that this finding is not in line with predictions of theoretical models in which both effects are localized at a relatively late stage of retrieval of the phonological word form. Therefore, the authors suggested that the orthographic facilitation effect may be localized at the earlier, conceptual level of target-picture processing. The pathway responsible for this facilitation effect is depicted in Fig. 1 as the direct connection between orthographic word forms and conceptual representations.

The results of our Experiments 1 and 2 do not indicate the presence of an early orthographic context effect. Hence, we propose that both orthographic and phonological facilitation effects should be localized at a relatively late level of word-form retrieval. If this hypothesis is correct, we predict no effect of orthographically related context words on the conceptual identification of a target picture. If we do find such an effect, however, we would need to reconsider our earlier conclusion. Hence, Experiment 3 was devised to determine whether or not orthographically related Chinese characters facilitate picture processing at an early level of picture identification, as suggested by Zhang and Weekes (2009).

Within research on picture naming in alphabetic languages, the question whether a context word is able to affect the identification of a target picture has been examined by, among others, Glaser and Düngelhoff (1984). These authors asked their participants to categorize the target picture of, for instance, a *hand* as "body part" in the context of a categorically related word (e.g., "leg"), an unrelated word (e.g., "factory"), or the picture's name ("hand"). The general finding was that whereas word categorization is strongly facilitated by context pictures, the reverse effect was not obtained: picture categorization was hardly affected by context words. Even the picture's own name ("hand") only started to facilitate picture categorization when presented 200 ms in advance of the target. At SOA = −100 ms and with simultaneous presentation, no effect was obtained. Given this finding, it seems unlikely that context words that are not identical to, but only orthographically similar to a picture's name can facilitate picture identification. However, Chinese logographic script may have a stronger and perhaps more direct access to conceptual representations than words in alphabetic languages (see e.g., Zhou & Marslen-Wilson, 1999). Therefore, we examined this issue in Experiment 3.

Like in the study of Glaser and Düngelhoff (1984), the rationale behind Experiment 3 is that if an orthographically related distractor (e.g., 庆 /qing4/, "celebration") facilitates the identification of the target picture (e.g., of a *bed*, 床 /chuang2/), participants should be faster in determining the picture's semantic category in the orthographically related condition than in the orthographically unrelated condition. In contrast, if orthographic similarity only affects the later stage of lexical access of the picture's name, orthographic relatedness should have no effect in a categorization task. To determine the size of the orthographic facilitation effect in picture naming in this group of participants, also a picture-naming task was administered. Note that the stimulus materials in both tasks, picture naming and picture categorization, were identical, only the task differed. Since both Experiments 1 and 2 showed that orthographic and phonological facilitation were maximal with simultaneous presentation of picture and distractor, only one SOA condition (SOA = 0 ms) was examined in this experiment.

4.1. Method

4.1.1. Participants

Eighteen Chinese male college students, all speaking Mandarin Chinese, of Dalian Maritime University (Dalian, China) participated. They all had normal or corrected-to-normal eyesight. The mean age was 23 years (SD = 1.9).

4.1.2. Materials

Four black-and-white pictures corresponding to monosyllabic names were selected from each of five different semantic categories: animals, body parts, kitchen utensils, clothing, and furniture. The orthographically related and unrelated distractor words met the same criteria as the orthographically related and control conditions in Experiment 1. A complete list of target pictures and distractor characters is shown in Appendix C.

4.1.3. Apparatus

The experiment was run using E-Prime Professional Software (Beta 2.0) on a Samsung PC. Like in Experiment 1, naming responses were recorded by microphone, connected to the computer via the Serial Response Box, and the reaction times were determined by the triggering of a voice-key.

4.1.4. Design

The design included two within-subjects factors: task (picture naming versus picture categorizing) and distractor relatedness (orthographically related versus unrelated).

4.1.5. Procedure

The order of the tasks was counterbalanced across participants. Each task involved two blocks of 40 trials each (20 target pictures × 2 relatedness conditions). The order of the trials in each block was pseudorandom, with the restriction that a target picture was not repeated in two consecutive trials. As in the previous experiments, each task was preceded by a familiarization block, in which the pictures were shown with their basic-level name (in the naming task) and with their category name (in the categorization task) and a practice block, in which isolated pictures had to be named. Each block started with two warm-up trials. Each experimental trial (and the warm-up trials) involved the following sequence: a fixation point (+) appeared in the middle of the screen for 1000 ms and was replaced by the distractor–target combination. The stimulus disappeared from the display when the voice-key was triggered or an interval of 2000 ms had elapsed. The experimenter entered a code into the computer to indicate the correctness or incorrectness of the response. Failure to trigger or inappropriate triggering of the voice-key could also be indicated. Upon entering the code, the fixation point for the next trial appeared. The participant was asked to name the target aloud as quickly and accurately as possible.

4.2. Results

Naming latencies were discarded from the analyses when any of the following occurred: (a) incorrect naming (2.8%), (b) voice-key trigger failure or the voice-key was triggered by an invalid sound other than the vocal utterance of the character (4.5%) and (c) correct reaction times smaller than 300 ms or greater than 1500 ms (2.6%). The remaining data were used to calculate means. Mean naming latencies and error percentages for each condition are shown in Table 3.

Mixed-models regression analyses were carried out with participants and items as random variables and task (picture naming versus picture categorization), block (first series versus second series of trials) and relatedness (related versus unrelated) as fixed variables. Significant main effects were obtained for task, $F(1,157) = 17.01$, $p < .001$, showing that picture categorizing took longer than picture naming, relatedness, $F(1,2529) = 23.85$, $p < .001$, showing that orthographically related distractors resulted in smaller response latencies than unrelated distractors, and block, $F(1,2530) = 47.33$, $p < .001$, showing that RTs were smaller in the second block of trials than in the first block of trials. Significant interaction effects were obtained

Table 3
Average naming latencies (RT, in ms), error percentages (%e) and facilitation effects for the various conditions of Experiment 3.

Distractor type	Picture naming				Picture categorization			
	Block 1		Block 2		Block 1		Block 2	
	RT	%e	RT	%e	RT	%e	RT	%e
Related	677	1.7	652	0.6	841	3.6	822	2.8
Unrelated	757	4.7	699	3.3	844	3.1	804	3.1
Facilitation	80	3.0	47	2.7	3	−0.5	−18	0.3

between task and relatedness, $F(1,2529)=33.71$, $p<.001$, indicating that the orthographic facilitation effect was larger in the picture-naming task than in the categorizing task. The interaction between block and relatedness only approached significance: $F(1,2529)=3.05$, $p<.10$, suggesting that orthographic facilitation was smaller in the second block than in the first block.

Mixed-models regression analyses performed on the data of the naming and categorization task separately, showed that in the naming task the orthographic facilitation effect was significant, $F(1,1277)=34.09$, $p<.001$, as was block, $F(1,1277)=68.01$, $p<.001$, and the interaction between both factors, $F(1,1277)=4.73$, $p<.05$, indicating that the orthographic facilitation effect was larger in the first block than in the second block. In the categorization task only the factor block reached significance, $F(1,1238)=17.43$, $p<.001$.

Finally, a similar mixed-models regression analysis was performed on the incorrect responses. Significant effects were obtained for relatedness, $F(1,2837)=5.21$, $p<.05$, indicating that somewhat fewer errors were made in the related condition (2.2%) than in the unrelated condition (3.5%), and for the interaction between task and relatedness, $F(1,2837)=6.30$, $p<.05$, indicating that the relatedness effect on the number of incorrect responses was larger in the naming task (2.85%) than in the categorization task (−0.1%).

4.3. Discussion

The results of this experiment are clear. In the picture-naming task, the orthographically related characters induced a sizable facilitation effect. This effect was larger than in Experiments 1 and 2, which may be due to the new set of materials employed in the present experiment as the overall increase in RT suggests that this new set of pictures was harder to name. More importantly, in the categorization task no effect of orthographic similarity was observed although the categorization task took on average 132 ms longer than picture naming and, hence, the context words had more time to influence picture processing.

5. General discussion

The picture–word interference task is widely used to study the processes underlying simple forms of language production. One of the main findings obtained with the paradigm is the orthographic/phonological facilitation effect. Although Roelofs et al. (1996; see also Starreveld & La Heij, 1996a) suggested that under very specific circumstances part of this facilitation effect may also be localized at the level of selection of an abstract word representation (i.e. the "lemma"), researchers agree that under most conditions the effect is localized at the later level of word-form encoding. Given this conclusion, the orthographic/phonological facilitation effect has been used to examine issues concerning, for instance, the seriality versus interactivity of the stages involved in word production (e.g., Bonin & Fayol, 2000; Starreveld & La Heij, 1995, 1996b) and the locus of gender-congruency effects (e.g., Starreveld & La Heij, 2004).

Since in alphabetic languages orthographic and phonological relatedness are confounded (the degree of confounding varying between languages), it is interesting to examine the form-facilitation effect in logographic languages in which the two components can be assessed independently. Indeed, previous research on word production in Chinese has reported independent contributions of orthographic relatedness and phonological relatedness. Two additional findings have been reported: (a) the orthographic facilitation effect is often larger than the phonological facilitation effect and (b) the time-courses of the two effects differ. In the present study, we re-examined this issue using a somewhat different design, allowing for a better matching between the distractor characters used in the related and unrelated conditions.

Consequently, Experiments 1 and 2 replicated earlier experiments with one important modification: instead of one common control condition containing unrelated context words, the orthographically related and phonologically related conditions each had their own control condition, in which the same set of characters was recombined with the target pictures to form unrelated pairs. This procedure, we argued, ensures that the facilitation effects cannot be attributed to uncontrolled differences between sets of words (in characteristics like word class and imageability). In Experiment 1, in which three SOA intervals were used (−150 ms, 0 ms, and +150 ms), we obtained substantial orthographic and phonological facilitation effects at SOA = 0 ms. Most importantly, the time courses of the two effects did not differ. This result was also obtained in Experiment 2, in which the distractor did not contain phonetic radicals and that allowed for a more fine-grained time course analysis with SOA intervals of 75 ms. In this experiment, the orthographic and phonological facilitation effects were of equal size and had very similar time courses.

The results of Experiments 1 and 2 can be accounted for by the assumption that orthographic facilitation and phonological facilitation are localized at the same stage, most probably the stage of retrieval of the word's phonological word form. To further investigate the possibility that orthographic facilitation is (also) localized at an earlier stage of picture identification, in Experiment 3 a categorization task was employed. The rationale underlying of this experiment was that if an orthographically related distractor affects the speed of identification of the target picture, this should be reflected in faster picture-categorization times. The results of Experiment 3 clearly refute this hypothesis: whereas an orthographic relation strongly facilitated the naming of the objects, no effect whatsoever was obtained in the categorization task.

According to the model depicted in Fig. 1, picture naming involves picture identification as well as retrieval and production of the phonological representation of the picture's name. It clearly does not involve the activation of the orthographic representation of the picture's name. Consequently, we did not discuss the possibility that the orthographic facilitation effect may be localized at an orthographic input level. However, in previous studies on orthographic facilitation in Chinese picture naming it has been suggested that orthographic representations may be involved in picture naming. Zhang and Weekes (2009) refer to work by Damian and Bowers (2003) who, using a form-preparation paradigm, showed that responses in phonologically homogeneous blocks with inconsistent orthography (e.g., "camel"–"kayak"–"kidney") were slower than in blocks with consistent orthography (e.g., "camel"–"coffee"–"cushion"). This finding suggests an effect of orthography on word production. However, Chen, Chen, and Dell (2002) did not obtain this effect in the Chinese language, Damian and Bowers (2009) did not obtain an orthographic facilitation effect when distractors were presented auditorily and Alario, Perre, Castel, and Ziegler (2007) failed to obtain the original effect in French. The latter authors concluded: "spoken word-production processes are insensitive to the orthographic properties of the words being produced …" (p. 472).

These results, in combination with our finding in Experiment 3 that the orthographic facilitation effect in Chinese picture naming is most probably not localized at the conceptual level, strongly suggests that the phonological level is the main locus of both orthographic and phonological facilitation, also in Chinese word production. Of course, orthographically and phonologically related distractors may induce different effects at the various processing levels that precede their ultimate effect on the retrieval of the target's phonological word form. For instance, spreading activation from the picture's semantic representation to the corresponding orthographic representation (a link not shown in Fig. 1) in combination with the presentation of an orthographically related distractor may induce activation at the orthographic input level that could be detected in neuroimaging studies (e.g., Weekes et al., 2005). For now we conclude that orthographic and phonological facilitation effects in the (Chinese) PWI task used in the present study have very similar time courses, indicating that there is no imminent need for a theoretical re-interpretation of the results of previous picture–word interference studies in which orthographic and phonological similarity were confounded (e.g., Starreveld & La Heij, 1995, 1996b, 2004).

Appendix A. Stimuli used in Experiment 1

Target picture name			Orthographically related distractor			Phonologically related distractor		
蛇	/she2/	Snake	舵	/duo4/	Helm	舍	/she4/	Shed
针	/zhen1/	Needle	叶	/ye4/	Leaf	枕	/zhen3/	Pillow
床	/chuang2/	Bed	庆	/qing4/	Celebration	创	/chuang4/	Creation
树	/shu4/	Tree	椒	/jiao1/	Pepper	书	/shu1/	Book
鞋	/xie2/	Shoe	蛙	/wa2/	Frog	蟹	/xie4/	Crab
眼	/yan3/	Eye	根	/gen1/	Root	燕	/yan4/	Swallow
猪	/zhu1/	Pig	赌	/du3/	Bet	柱	/zhu4/	Pillar
船	/chuan2/	Ship	铅	/qian1/	Lead	串	/chuan4/	Bunch
梨	/li2/	Pear	染	/ran3/	Dye	理	/li3/	Reason
枪	/qiang1/	Gun	村	/cun1/	Village	墙	/qiang2/	Wall
锯	/ju4/	Saw	钱	/qian2/	Money	桔	/ju2/	Orange
鹿	/lu4/	Deer	席	/xi2/	Mattress	炉	/lu2/	Stove
碗	/wan3/	Bowl	碱	/jian3/	Alkali	湾	/wan1/	Gulf
锅	/guo1/	Pan	锚	/mao3/	Anchor	国	/guo2/	Country
杯	/bei1/	Cup	杖	/zhang4/	Stick	臂	/bei4/	Arm
虾	/xia1/	Shrimp	虹	/hong2/	Rainbow	匣	/xia2/	Box
包	/bao1/	Bag	句	/ju4/	Sentence	豹	/bao4/	Leopard
桶	/tong3/	Bucket	柚	/you4/	Citrus	铜	/tong2/	Bronze
兔	/tu4/	Rabbit	色	/se4/	Color	图	/tu2/	Picture
帆	/fan1/	Sail	帕	/pa4/	Handkerchief	饭	/fan4/	Meal

Appendix B. Stimuli used in Experiment 2

Target picture			Orthographically related distractor			Phonologically related distractor		
蛇	/she2/	Snake	舵	/duo4/	Helm	舍	/she4/	Shed
针	/zhen1/	Needle	叶	/ye4/	Leaf	枕	/zhen3/	Pillow
床	/chuang2/	Bed	庆	/qing4/	Celebration	创	/chuang4/	Creation
树	/shu4/	Tree	椒	/jiao1/	Pepper	书	/shu1/	Book
盒	/he2/	Box	盆	/pen2/	Basin	鹤	/he4/	Crane
眼	/yan3/	Eye	根	/gen1/	Root	燕	/yan4/	Swallow
扇	/shan4/	Fan	房	/fang2/	House	山	/shan1/	Mountain
笛	/di2/	Flute	苗	/miao2/	Sprout	弟	/di4/	Brother
梨	/li2/	Bear	染	/ran3/	Dye	礼	/li3/	Politeness
壶	/hu2 /	Kettle	壳	/ke2/	Crust	虎	/hu3/	Tiger
锯	/ju4/	Saw	钱	/qian2/	Money	菊	/ju2/	Chrysanthemum
鹿	/lu4/	Dear	庙	/miao4/	Temple	颅	/lu2/	Head
鱼	/yu2/	Fish	角	/jiao3/	Corner	雨	/yu3/	Rain
锅	/guo1/	Pan	锚	/mao3/	Anchor	国	/guo2/	Country
杯	/bei1/	Cup	杖	/zhang4/	Stick	贝	/bei4/	Shell
虾	/xia1/	Shrimp	虹	/hong2/	Rainbow	匣	/xia2/	Box
包	/bao1/	Bag	句	/ju4/	Sentence	豹	/bao4/	Leopard
桶	/tong3/	Bucket	柚	/you4/	Citrus	童	/tong2/	Child
兔	/tu4/	Rabbit	色	/se4/	Color	图	/tu2/	Picture
帆	/fan1/	Sail	帕	/pa4/	Handkerchief	犯	/fan4/	Criminal

Appendix C. Stimuli used in Experiment 3

Category	Target picture			Orthographically related distractor		
Animal	Dog	/gou3/	狗	Sentence	/ju4/	句
	Bird	/niao3/	鸟	Island	/niao3/	岛
	Rabbit	/tu4/	兔	Color	/se4/	色
	Deer	/lu4/	鹿	Temple	/miao4/	庙
Body part	Eye	/yan3/	眼	Root	/gen1/	根
	Ear	/er3/	耳	Moon	/yue4/	月
	Lip	/chun2/	唇	Insult	/ru3/	辱
	Hand	/shou3/	手	Thousand	/qian1/	千
Kitchen utensil	Kettle	/hu2/	壶	Crust	/ke2/	壳
	Pan	/guo1/	锅	Diamond	/zuan4/	钻
	Stove	/lu2/	炉	Cannon	/pao4/	炮
	Knife	/dao1/	刀	Strength	/li4/	力
Clothing	Sock	/wa4/	袜	Sister	/mei4/	妹
	Cap	/mao4/	帽	Sail	/fan1/	帆
	Shoes	/xie2/	鞋	Child	/wa2/	娃
	Skirt	/qun2/	裙	County	/jun4/	郡
Furniture	Bed	/chuang2/	床	Celebration	/qing4/	庆
	Chair	/yi3/	椅	Ride	/qi2/	骑
	Wardrobe	/gui4/	柜	Torch	/ju4/	炬
	Table	/zhuo1/	桌	Chestnut	/li4/	栗

References

Alario, F. -X., Perre, L., Castel, C., & Ziegler, J. C. (2007). The role of orthography in speech production revisited. *Cognition*, *102*, 464–475.

Bi, Y., Xu, Y., & Caramazza, A. (2009). Orthographic and phonological effects in the picture–word interference paradigm: Evidence from a logographic language. *Applied Psycholinguistics*, *30*, 637–658.

Bonin, P., & Fayol, M. (2000). Writing words from pictures: What representations are activated and when? *Memory & Cognition*, *28*, 677–689.

Brysbaert, M. (2007). The language-as-fixed-effect fallacy. *Some simple SPSS solutions to a complex problem (Version 2.0). Technical report*. Royal Holloway: University of London.

Chen, J. Y., Chen, T. M., & Dell, G. S. (2002). Word-form encoding in mandarin Chinese as assessed by the implicit priming task. *Journal of Memory and Language*, *46*, 751–781.

Chen, H. -C., & Juola, J. F. (1982). Dimensions of lexical coding in Chinese and English. *Memory & Cognition*, *10*, 216–224.

Damian, M. F., & Bowers, J. S. (2003). Effects of orthography on speech production in a form-preparation paradigm. *Journal of Memory and Language*, *49*, 119–132.

Damian, M. F., & Bowers, J. S. (2009). Assessing the role of orthography in speech perception and production: Evidence from picture–word interference tasks. *European Journal of Cognitive Psychology*, *21*, 581–598.

Glaser, W. R., & Düngelhoff, F. J. (1984). The time course of picture–word interference. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 640–654.

La Heij, W. (1988). Components of Stroop-like interference in picture naming. *Memory & Cognition*, *16*, 400–410.

La Heij, W., & van den Hof, E. (1995). Picture–word interference increases with target-set size. *Psychological Research*, *58*, 119–133.

Leck, K. J., Weekes, B. S., & Chen, M. J. (1995). Visual and phonological pathways to the lexicon: Evidence from Chinese readers. *Memory & Cognition*, *23*, 468–476.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1–75.

Lupker, S. J. (1979). The semantic nature of response competition in the picture–word interference task. *Memory & Cognition*, *7*, 485–495.

Lupker, S. J. (1982). The role of phonetic and orthographic similarity in picture–word interference. *Canadian Journal of Psychology*, *36*, 349–367.

Mahon, B. Z., Costa, A., Peterson, R., Vargas, K. A., & Caramazza, A. (2007). Lexical selection is not by competition: A reinterpretation of semantic interference and facilitation effects in the picture–word interference paradigm. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *33*, 503–535.

Melinger, A., & Koenig, J. P. (2007). Part-of-speech persistence: The influence of part-of-speech information on lexical processes. *Journal of Memory and Language*, *56*, 472–489.

Pechmann, T., Garrett, M., & Zerbst, D. (2004). The time course of recovery for grammatical category information during lexical processing for syntactic construction. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *30*, 723–728.

Pechmann, T., & Zerbst, D. (2002). The activation of word class information during speech production. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *28*, 233–243.

Perfetti, C. A., Liu, Y., & Tan, L. H. (2005). The lexical constituency model: Some implications of research on Chinese for general theories of reading. *Psychological Review*, *112*, 43–59.

Posnansky, C. J., & Rayner, K. (1978). Visual vs phonemic contributions to the importance of the initial letter in word identification. *Bulletin of the Psychonomic Society*, *11*, 188–190.

Rayner, K., & Springer, C. J. (1986). Graphemic and semantic similarity effects in the picture–word interference task. *British Journal of Psychology*, *77*, 207–222.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Roelofs, A., Meyer, A. S., & Levelt, W. J. M. (1996). Interaction between semantic and orthographic factors in conceptually driven naming: Comment on Starreveld and La Heij (1995). *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 246–251.

Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. (1975). Automatic semantic processing in a picture–word interference task. *Child Development*, *46*, 247–253.

Schriefers, H., Meyer, A. S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in language production: Picture–word interference studies. *Journal of Memory and Language*, *29*, 86–102.

Starreveld, P. A. (2000). On the interpretation of phonological context effects in word production. *Journal of Memory and Language*, *42*, 497–525.

Starreveld, P. A., & La Heij, W. (1995). Semantic interference, orthographic facilitation and their interaction in naming tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 686–698.

Starreveld, P. A., & La Heij, W. (1996a). The locus of orthographic–phonological facilitation: Reply to Roelofs, Meyer, and Levelt (1996). *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 252–255.

Starreveld, P. A., & La Heij, W. (1996b). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 896–918.

Starreveld, P. A., & La Heij, W. (2004). Phonological facilitation of grammatical gender retrieval. *Language and Cognitive Processes*, *19*, 677–711.

Weekes, B. S., Davies, R. A. I., & Chen, M. -J. (2002). Picture–word interference effects on naming in Chinese. In H. S. R. Kao, C. K. Leong, & D. -G. Gao (Eds.), *Cognitive neuroscience studies of the Chinese language* (pp. 101–127).: Hong Kong University Press.

Weekes, B. S., De Zubicaray, G., McMahon, K., Eastburn, M., Bryant, M., & Wang, D. (2005). Orthographic effects on picture naming in Chinese: A 4 T erfMRI study. *Brain and Language*, *95*, 14–15.

Zhang, Q., Chen, H. -C., Weekes, B. S., & Yang, Y. (2009). Independent effects of orthographic and phonological facilitation on spoken word production in Mandarin. *Language and Speech*, *52*, 113–126.

Zhang, Q., & Weekes, B. S. (2009). Orthographic facilitation effects on spoken word production: Evidence from Chinese. *Language and Cognitive Processes*, *24*, 1082–1096.

Zhou, X., & Marslen-Wilson, W. (1999). Phonology, orthography, and semantic activation in reading Chinese. *Journal of Memory and Language*, *41*, 579–606.