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The role of orthography in second-language spoken word production:
Evidence from Tibetan–Chinese bilinguals

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Abstract

Evidence suggests that spoken language production involves involuntary access to orthographic representations, both in languages with alphabetic and non-alphabetic scripts. An unexplored question is whether the role of orthography varies as a function of the language being native or non-native to the individual. Native (L1) and non-native (L2) languages differ in important aspects, i.e., lexical representations in L2 might be less well-established, but acquired at least partly via reading, and these unique features of non-native languages may contribute to a fundamental difference in how spelling and sound interact in production. We investigated an orthographic impact on spoken production with Tibetan-Chinese bilinguals who named colored line drawings of objects with Chinese adjective-noun phrases. Color and object names were orthographically related or unrelated. Even though none of the participants were aware of the orthographic manipulation, orthographic overlap generated a facilitatory effect. In conjunction with earlier findings from native speakers on the identical task (Qu & Damian, 2019), we conclude that orthographic information is activated in spoken word production regardless of whether the response language is native or non-native.

Keywords: spoken production; non-native spoken production; orthography; colored object naming task; Chinese; bilingualism

The role of orthography in second-language spoken word production:

Evidence from Tibetan–Chinese bilinguals

A growing body of evidence supports the claim that various subsystems involved in native language (i.e., semantic, syntactic, phonological, orthographic) are highly integrated, such that in a given task, various types of information are automatically activated even if not of primary relevance to the task. For instance, for literate individuals, orthographic information is activated in spoken word recognition (e.g., Seidenberg & Tanenhaus, 1979; Pattamadilok, Morais, Colin & Kolinsky, 2014; Qu & Damian, 2017, Ziegler & Ferrand, 1998, and others). This orthographic effect has been explained by assuming that listeners cross-activate orthographic information online whenever phonological codes are accessed, via bidirectional functional links between orthography and phonology (e.g., Chéreau, Gaskell, & Dumay, 2007; Pattamadilok, Perre, Dufau, & Ziegler, 2009). Alternatively, orthographic effects have elsewhere been explained in terms of the restructuring of phonological representations during literacy acquisition (e.g., Montant, Schön, Anton & Ziegler, 2011; Perre, Pattamadilok, Montant, & Ziegler, 2009). According to the restructuring view, the nature of phonological representations is altered during the process of learning to read and write, leading to “phonographic” representations that integrate orthographic knowledge.

From the substantial evidence on orthographic effects in spoken language recognition, one might predict parallel orthographic effects in spoken word production. Here, the findings are less consistent compared to speech perception, but a number of studies have also reported a role of orthography in speaking. A further and related issue is whether individuals, when producing in their non-native language, also show orthographic effects. This question is explored in the current study.

Orthographic effects in spoken production

Early studies on the role of orthography in spoken word production mostly used variants of the Stroop

task. For example, using a picture–word interference task in which the relation between picture names and distractor words was manipulated, Lupker (1982) demonstrated that orthographic similarity between picture names and distractor words (e.g., foot–boot) facilitated picture naming compared to unrelated distractor words. Lupker argued that the orthographic effect has its locus at some level of the name retrieval process of picture naming. However, such orthographically based effects are not conventionally interpreted as implying that spoken production *per se* involves access to orthographic codes. Rather, distractor words activate a cohort of orthographically related entries within the mental lexicon, among them the target, which is then produced faster than in the unprimed case. Related evidence comes from the Stroop color-naming task. Tanenhaus, Flanigan, and Seidenberg (1980) presented participants with target words printed in colors (“bread”) that were preceded by written or spoken orthographically related (“bead”) or phonologically related (“bed”) prime words, and found that orthographic and phonological prime words modulated the response latencies of color naming. However, as argued by the authors, even though the primary task involved spoken production, the orthographic effect in this study is probably best interpreted as mainly arising from word recognition and not from production.

Another widely used task in the relevant literature is the form preparation (or “implicit priming”) task, in which participants repeatedly produce words from among a small number of possible responses, and overlap between the words within a given set is manipulated. Word-initial overlap between spoken responses has a facilitatory effect on response latencies (Meyer, 1990, 1991). Damian and Bowers (2003) investigated whether this effect is affected by the orthographic properties of the spoken response words, and found that with English participants, priming disappeared when response words in a set began with the same phoneme but with different spelling (e.g., “coffee,” “camel,” and “kennel”). Because response words were spoken but their orthographic properties were not presented, this finding was taken to suggest that in word production,

speakers involuntarily activate orthographic codes. However, Roelofs (2006) did not replicate this pattern with Dutch speakers with an identical experimental task and design, and raised the possibility of languages with less consistent spelling-to-sound correspondence (e.g., English) being more prone to such effects than more consistent languages (e.g., Dutch). However, subsequent studies with French speakers also failed to find an orthographic effect (Alario, Perre, Castel & Ziegler, 2007), with French also having highly inconsistent sound-spelling mappings. Indeed, no orthographic effect was found with Chinese speakers (Bi, Wei, Janssen & Han, 2009; Chen, Chen & Dell, 2002; Zhang & Damian, 2012), a language in which sound and spelling are almost entirely dissociated from each other. In combination, these findings paint a complex picture, but because it has recently been highlighted that this task exhibits attentional constraints (O'Séaghdha & Frazer, 2014) it is probably not well-suited to investigate a potential involuntary activation of orthography in production.

Recently, novel word learning has opened up a new avenue for investigating the role of orthography in spoken word production. Rastle, McCormick, Bayliss, and Davis (2011) asked participants to associate novel objects with novel spoken words that could be spelled in a regular or irregular manner based on English spelling-sound relationships (e.g., /kisp/ can be spelled as “kisp” or “chisp”). On the next day, regular or irregular orthographic representations of the novel words were introduced. Orthographic regularity affected the subsequent spoken production of novel words, with faster responses to words with regular orthography-phonology mappings than to those with irregular mappings (similar results were found in perception tasks, but not in auditory shadowing), which reflects the activation of orthographic representations during spoken word production. Similar evidence for orthographic involvement in speech processing tasks comes from investigations of phonological variant processing via the novel word learning approach. Bürki, Spinelli, and Gaskell (2012) investigated the learning of novel French words containing consonant clusters that have two

variants, with schwa being either present or absent. Bürki et al. asked speakers to associate the spoken novel words with schwa being absent and novel objects, and then introduced the spelling of the novel spoken words, half of which were spelled with the letter schwa being present, and half with it being absent. In the subsequent naming tasks, participants produced more variants with the sound of schwa being present for those words that were spelled with the letter schwa. These and related findings (e.g., Han & Choi, 2015; Saletta, Goffman & Brentani, 2015) suggest that spelling constrains the way speakers represent and process words in spoken production, possibly via an offline restructuring of the phonological representations when speakers learn the spellings of novel words.

In recent work, we (Qu & Damian, 2019) developed a novel manipulation to explore potential orthographic effects in spoken production. The aim was to specifically explore the possibility that spelling and sound engage in on-line “cross-talk” during the preparation of spoken language. Hence, we avoided experimental contexts which might direct speakers’ attention and explicit awareness to an orthographic manipulation. Because it is difficult (although not impossible) to disentangle sound from spelling in alphabetic languages, we recruited Mandarin Chinese speakers, and asked them to name colored line drawings of simple objects with adjective-noun phrases (e.g., orange chair). Previous studies using the colored picture naming task have shown that when the color and object name are related in word form (e.g., when both words begin with the same sound, as in green goat, red rug), spoken responses are facilitated relative to a condition in which the same objects and colors are unrelated (green rug, red goat; e.g., Damian & Dumay, 2007, 2009 for English speakers; Qu, Kazanina, & Damian, 2012 for Chinese speakers, although only in EEG but not in behavioral results). In contrast to these earlier studies, in Qu and Damian (2019) we chose color-adjective combinations which were never phonologically related, but instead manipulated *orthographic* overlap. We found a significant facilitatory effect when color and object name shared an

orthographic radical (e.g., 橙梳子, /cheng2shu1zi/, orange comb), compared to the unrelated baseline condition. Speakers were throughout the experiment never explicitly exposed to the orthographic properties of the target words, and in postexperimental interviews reported no awareness of the orthographic manipulation. These findings suggest a clear involvement of orthographic codes in spoken production via “cross-talk” between phonological and orthographic codes, even when the task does not involve explicit and conscious orthographic processing. Because the study was conducted in a non-alphabetic language in which spelling and sound can be fully dissociated for a given set of materials, the orthographic effect was “pure” and not confounded with possible phonological overlap (as would be the case in most or all studies with alphabetic languages).

Orthographic effects in second-language processing

All studies reviewed so far explored language processing in individuals’ native languages. A related—and largely unexplored—issue is whether orthographic effects also arise in non-native language processing. Native and non-native language processing differ in interesting ways. For instance, a growing body of literature has demonstrated differences in emotionality and semantic sense between a native and foreign language, with weaker affective processing and semantic senses in L2 words than in L1 words. Proposed causes of such differences include proficiency, frequency of use, the automaticity of lexical access, and learning and use context (see Caldwell-Harris, 2015 for a review). More specifically with regard to the potential role of orthography in spoken language production and perception, there are several characteristics of non-native language processing that provided the motivation for our investigation. First, non-native languages are typically acquired much later in life than native languages, and often lack sufficient exposure, particularly in instructional classroom settings. This could render access to lexical representations of second languages less robust and automatic than for native representations. Second, native language phonology is

acquired very early in life whereas acquisition of literacy takes place much later in life. By contrast, non-native languages are typically acquired in both written and spoken format simultaneously. These unique characteristics of L2 (less robust representation, and joint acquisition of orthographic and phonological representations) may impact on the extent to which orthographic codes are cross-activated in phonologically based language tasks. However, predictions are difficult to make: on the one hand, less robust L2 representations might entail less opportunity to engage in irrelevant linguistic processing such as access to orthographic codes. On the other hand, because in L2 written and spoken codes are typically acquired at the same time, non-native orthography might be more prominent in L2 than in L1 lexical access.¹

In language comprehension, very few studies have explored this issue, but the limited evidence suggests that non-native listeners engage orthographic access to the same, or even a greater, extent than native listeners. For instance, Qu, Cui, and Damian (2017) presented Tibetan non-native Chinese speakers with two successive spoken Chinese words on a given trial, and participants were asked to judge whether or not the two words were semantically related. Pairs were either semantically related, orthographically related, or unrelated. Orthographic overlap induced a significant increase in response latencies. Compared to previous results for L1 listeners with an identical experimental task, materials, and procedure (Qu & Damian, 2017), the orthographic effect for L2 listeners was more pronounced, with a significant interaction between group and effect. Therefore, we argued that orthographic information is involuntarily accessed in native and non-native spoken word recognition alike and that it may play a more important role in the latter compared to the former (see also Mishra & Singh, 2014; Veivo & Järvisikivi, 2013; Veivo, Järvisikivi, Porretta & Hyönä, 2016).

¹ A related but non-overlapping issue is whether L2 speech production is influenced by the properties of second-language orthography. For instance, L2 English speakers sometimes erroneously add sounds which are represented in the orthographic forms, such as adding a [b] to the end of the word “comb” (Bassetti & Atkinson, 2015), or English-Spanish speakers producing the Spanish <v> as [v] because <v> represents /v/ in English (Zampini, 1994). Also, Italian-English speakers produce English consonant as longer when spelled with double consonant letters ([t] in “kitty”) than when spelled with a single consonant (“city”; Bassetti, 2017). Observations of this type are probably best accounted for by assuming that the phonological code of L2 words is affected by their orthographic properties, in a manner which is in line with the “restructuring” account highlighted above. By contrast, in the current work we explore “online” cross-activation of orthographic and phonological properties in L2 spoken production.

To our knowledge, to date few studies have investigated the role of orthography in non-native speech production (rather than perception). The current study aimed to fill this gap. We used the same colored object naming task featured in Qu and Damian (2019): participants were presented with colored objects, and they were asked to name colored objects with adjective-noun phrases. Color and object names were orthographically related or unrelated. However, whereas Qu and Damian (2019) tested native Chinese Mandarin speakers, here we tested a group of Tibetan non-native Chinese speakers who named the displays in Mandarin. Based on our previous findings with Chinese native speakers, if orthographic information is involuntarily activated in non-native spoken word production, we would expect that spoken naming latencies are modulated by orthographic relatedness. A comparison of this effect with the one reported in Qu and Damian (2019) for native speakers would provide further evidence about whether the effect is more or less pronounced, or similar, in native and non-native speakers.

Method

Participants

Twenty-eight Tibetan-Chinese bilinguals (17 females; mean age: 18.0 years, range: 17–20 years) from Affiliated National College of Hebei Normal University participated in the study. All of the participants reported normal hearing, normal or corrected-to-normal vision, and no history of neurological or language problems. All were unbalanced late bilinguals, with Tibetan² as their L1 and Mandarin Chinese as L2. They had begun learning Chinese at a mean age of 5.8 years (range: 2–9 years) and had been living in a Chinese-speaking area for an average of 5.0 years (range: 3–14 years). Self-evaluations of their proficiency levels (on a 7-point scale, with 1 representing "not at all familiar with Chinese" and 7 representing "extremely familiar with Chinese") suggested medium-to-high proficiency in Chinese (mean: 5, range: 3–6).

² Tibetan is a language spoken primarily in the high-plateau north of the Himalayas. The Tibetan writing system is derived from an Indian prototype. Tibetan is only very distantly related to Chinese in terms of its spoken and written properties.

Materials and Design

Materials and design were identical to Qu and Damian (2019, Experiment 2). Four colors (blue, brown, green, and orange) and 12 line drawings of objects with no canonical color (i.e., we avoided combinations such as “blue sky”) from the Snodgrass and Vanderwart (1980) picture set were used. All of the color names in Chinese were monosyllabic, and all of the object names were disyllabic. Each color was combined with 3 objects to form 12 *orthographically related* color–object pairings (i.e., color names shared an orthographic radical with the initial character of object names). Color and object names were recombined to form 12 *orthographically unrelated* pairings so that identical colors and objects were used for the related and unrelated conditions. Care was taken to avoid semantic or phonological overlap (in terms of onset, rhyme, and tone). Phonological overlap was also avoided in the Tibetan translation equivalents. As in English, adjectives precede nouns in Chinese (see Appendix). Besides 12 critical objects, a further 12 filler objects were included in order to reduce the percentage of related trials. As was the case for the critical objects, each filler object was paired with two colors, thus forming 24 filler trials.

Each participant was presented with 3 blocks of 48 trials (24 critical + 24 filler trials), with each color–object combination appearing once in each block, for a total of 144 trials. A new pseudo-random order of trials was generated for each participant and block, such that neither objects nor colors were repeated on consecutive trials.

Procedure

The experiment was run using DMDX (Forster & Forster, 2003), and vocal responses were recorded using a microphone connected to the computer. Participants were instructed that they would see objects in different colors presented on a computer screen, and their task was to name them with an adjective-noun combination as quickly and accurately as possible, e.g., 蓝椅子, /lan2yi3zi/, “blue chair.” Subsequently,

participants were asked to familiarize themselves with the experimental stimuli. Rather than presenting the expected object and color names in printed form (which is typical procedure in production experiments), here participants listened to corresponding names while viewing the stimuli on the computer screen. This was done to avoid participants being exposed to orthographic properties in the familiarization stage. Next, participants carried out a practice block consisting of 16 objects taken from the filler items, with each of the four colors occurring four times. Subsequently, the three experimental blocks were presented, separated by short breaks. On each trial, participants saw a fixation cross (500 ms), a blank screen (500 ms), and a target display (3,000 ms). The intertrial interval was 1,000 ms. The experimental session lasted approximately 20 minutes per participant.

Results

Naming latencies and errors were audiovisually identified using CheckVocal (Protopapas, 2007) by a research assistant who was blind to the design and rationale of the study. Filler trials were not analyzed. Data from critical trials with incorrect responses (6.0%) and responses faster than 200 ms or slower than 2,000 ms (3.2%) were excluded from further analysis. Results are shown in Table 1. Response latencies exhibited a substantial facilitatory effect (51 ms) of orthographic relatedness. Error scores were numerically identical in the related and unrelated condition (5.5%) and were therefore not statistically analyzed.

Latencies were analyzed using a linear mixed-effects model (Baayen, Davidson, & Bates, 2008; Bates, 2005). As was the case in the results reported by Qu and Damian (2019), preliminary data analysis suggested considerable variability among items in their naming times, with variability arising not only from the object, but also from the color adjective. To partial out the variance associated with colors, color was included as a fixed effect in all analyses, but the effect of color was not by itself considered to be of interest. We initially constructed a “maximal model” (Barr, Levy Scheepers & Tily, 2013) that contained the fixed factors

relatedness and *color*, as well as adjustments to intercepts and slopes for the random effects *participants* and *object names*. However, the model showed clear evidence of overparameterization via $r = 1.00$ (perfect correlations between intercept and slope adjustments for *participants*), and such a complex random effect structure was therefore not appropriate (Baayen, Davidson & Bates, 2008). When the random effect structure was reduced stepwise, the “most complex” model that did not suffer from overparameterization included slope adjustments only for *object names* and intercept adjustments for *participants* and *object names*. The comparison of the “most complex” model with the “maximal model” was not significant, suggesting that removing random slope adjustments for *participants* did not reduce the fit, $\chi^2(N = 1,830) = 0.33, p = .850$. Critically, the “most complex” model showed a significant effect of *relatedness*, $\beta = 54.4, SE = 21.6, F = 6.37, p = .034$, and *color*, $F = 7.84, p = .004$.

To further explore the effect of *relatedness* on response latencies, we conducted distributional analyses³ in two ways. First, we performed a Vincentized analysis (Ratcliff, 1979) by rank-ordering the response latencies for each participant and condition, dividing them into deciles (10% quantiles), and computing mean latencies for each decile. Figure 1 shows the averaged Vincentized cumulative distribution curves for the related and unrelated conditions, with latency on the horizontal axis and cumulative relative frequency on the vertical axis (cf. Luce, 1986, p. 101). The figure suggests faster latencies in the related than the unrelated condition throughout the entire latency range.

Second, we analyzed the response latencies via ex-Gaussian analysis (e.g., Heathcote et al., 1991; Spieler, Balota, & Faust, 1996; Yap & Balota, 2007). The ex-Gaussian function is a convolution of a Gaussian and an exponential distribution and characterizes a response latency distribution via three parameters: μ and σ (mean and standard deviation of the Gaussian distribution) and τ (reflecting the exponential distribution).

³ We would like to thank an anonymous reviewer for suggesting this additional analysis.

Estimating and analyzing μ and τ separately allows to determine whether an effect results in a distributional shift (indicated by μ), or in distributional skewing (reflected by τ). The parameters were estimated using QMLE (Brown & Heathcote, 2003) via the quantile maximum likelihood estimation method, using five quintiles for each participant and condition, and the effect of *relatedness* on each parameter was assessed separately via a *t*-test. The results revealed that the related and unrelated conditions differed in μ , $t(27) = -2.19$, $p = .038$; but neither in σ , $t(27) = -0.37$, $p = .714$, nor in τ , $t(27) = -0.38$, $p = .706$. Thus, the effect of relatedness emerged primarily in a distributional shift of the entire range of latencies.

In summary, the results showed a significant facilitatory effect on latencies when color and object name shared an orthographic radical. Postexperimental interviews revealed that none of the participants had recognized the orthographic relation between color and object names.

The results reported by Qu and Damian (2019) with an identical procedure but conducted on L1 speakers are also included for comparison in Table 1 (see also Figure 1 for cumulative response latency distribution curves). The orthographic effect was numerically larger in L2 (51 ms) than in L1 (39 ms), and a joint analysis of the results from both experiments tested for an interaction between group and relatedness. A model was specified in which group (L2 vs L1), relatedness (unrelated vs orthographically related), the interaction between group and relatedness, and color were included as fixed factors, and random by-participant and by-item intercept and slope adjustments were specified for relatedness (but not for the between-participants factor group; see Barr, 2013). However, this model exhibited overparameterization (perfect correlation between by-participant intercepts and slopes for relatedness). The simplified model without by-participant slopes showed a significant group effect, $b = 260.8$, $SE = 39.1$, $t = 6.68$, $p < .001$, and a significant relatedness effect, $b = 40.1$, $SE = 18.1$, $t = 2.22$, $p = .049$, but no group \times relatedness interaction, $b = 14.5$, $SE = 13.6$, $t = 1.07$, $p = .287$. Hence, the hypothesis that the orthographic effect was more pronounced

for L2 than for L1 speakers did not receive statistical support.

Discussion

As reviewed in the Introduction, existing evidence from alphabetic and non-alphabetic languages supports the notion that for literate individuals, spoken word production of native languages involves automatic access to orthographic information. A relevant but unexplored question is whether orthography is similarly relevant when bilingual speakers produce word in their non-native language. In the present study, we investigated whether Tibetan-Chinese bilinguals spontaneously access orthographic information while speaking in their non-native language (Mandarin Chinese). We used a task in which participants named colored line drawings of objects with adjective-noun phrases, and color and object names were orthographically related or unrelated. Even though none of the participants were aware of the fact that on some trials, color and object names were orthographically related, this orthographic overlap modulated spoken response latencies and generated a significant facilitatory effect. This finding constitutes clear evidence that orthography is involved in non-native spoken word production. In conjunction with the earlier findings from the same task carried out by native speakers (Qu & Damian, 2019), we conclude that orthographic information is activated in spoken word production regardless of whether the response language is native or non-native.

An interesting component of the current study is the direct comparison of native versus non-native language. As briefly summarized in the Introduction, in previous work we (Qu, Cui & Damian, 2017) compared effects of orthography in spoken Chinese word *perception* between Chinese monolinguals and Tibetan-Chinese bilinguals, and found that orthography affected perception more so for bilingual L2 listeners than monolinguals, as evidenced by a significant group x orthography interaction in a joint analysis. By contrast, in the present study the orthographic effect in spoken production was numerically somewhat larger

what we previously found for monolinguals (Qu & Damian, 2019) but the joint analysis did not show a significant interaction. The absence of a group x priming interaction might be attributed to insufficient statistical power (the comparison involved 28 L2 speakers and 27 L1 speakers). However, it is furthermore important to note that L2 speakers were substantially and significantly slower than L1 speakers on this task ($\Delta = 262$ ms). If the orthographic effect is expressed as facilitation relative to the unrelated baseline, then both groups showed an identical effect size of 4.5%. We tentatively conclude that speakers in L1 and L2 automatically access orthographic codes to a similar or identical degree, with the proviso that more sensitive future studies might be able to document larger orthographic effects in L2 than in L1 speakers.

How could spelling influence spoken production? As briefly noted in the Introduction (and expanded in more detail in Qu & Damian, 2019) a general distinction is between “online” and “offline” sources of potential effects, with the former reflecting direct processing “cross-talk” between spelling and sound, whereas the latter attributes effects of orthography to a restructuring of phonology during literacy acquisition. Bürki et al. (2012) recently suggested that to the extent that orthographic effects are found, they reflect “offline” restructuring of phonological representations during acquisition of literacy. However, we feel that the results reported here and in Qu and Damian clearly reflect “online” cross-activation between spelling and sound. At the same time, we currently lack sufficient insight into the topic to be able to specify a processing account of how exactly orthography impacts on phonological encoding. Given the dramatically different mappings between spelling and sound in alphabetic and non-alphabetic languages, the target language needs to be taken into account, as well as potentially whether the speaker operates in their native or non-native language. A promising avenue for future research would be to conduct EEG-based studies in which semantics, orthography, and phonology are independently manipulated, to examine at which point in time during phonological encoding orthography is accessed.

As reviewed earlier, based on inconsistent findings regarding orthography in spoken production generated via the form preparation paradigm, Roelofs (2006) suggested that orthographic effects might be related to the degree of orthography-to-phonology consistency in a given language, with less consistent languages (e.g., English) being more prone to such effects than more consistent languages (e.g., Dutch). Our finding that the orthographic effect is present in Chinese, a language with non-transparent mapping between orthography and phonology, is certainly consistent with this “cross-linguistic orthography transparency” hypothesis. To further examine this possibility, parallel studies to ours but conducted in languages with more consistent spelling would be necessary; this is of course very difficult because the more consistent the mappings between spelling and sound, the harder it is to disentangle the two dimensions. In other words, it will be very difficult to find materials for an experiment such as ours, but with speakers of a language with largely consistent mappings.

The present study also speaks to the architecture of orthographic representations of Chinese and thus provides suggestions for the manipulation of orthographic overlap in future studies. Chinese orthography incorporates at least five different levels: words, characters, radicals, logographemes, and strokes. Radicals are clearly important representational units in Chinese orthography, and evidence suggests that reading as well as writing Chinese characters involves independent radical processing (e.g., Ding, Peng & Taft, 2004; Qu, Damian, Zhang, & Zhu, 2011; Zhou & Marslen-Wilson, 1999). In the present study, we manipulated orthographic overlap in terms of a radical shared between color and object names, and our finding that this elicited a significant effect further highlights the relevance of radical representation in Chinese, for native as well as non-native speakers. To maximise the chances of detecting an effect of orthography in Chinese in future studies, the grain size of orthographic units clearly needs to be taken into account, and orthographic overlap should be manipulated at the radical or a higher level.

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Figure Caption

Figure 1. Vincentized cumulative distribution curves for the related and unrelated conditions for L2 speakers (Tibetan-Chinese bilinguals), as well as L1 (Chinese) speakers from Qu and Damian (2019).

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Table 1

Response latencies (in milliseconds) and errors (in percentages) for L2 speakers, and L1 speakers from Qu and Damian (2019). Standard deviations in parentheses.

	Orthographically related	Orthographically unrelated	Difference
L2 speakers			
Latencies	1089 (292)	1140 (307)	+51
Errors	5.6 (23.0)	5.6 (23.0)	0
L1 speakers			
Latencies	833 (214)	872 (248)	+39
Errors	5.2 (22.2)	5.5 (22.7)	+0.3

Appendix. Materials used in Experiment

Colour	Pinyin	English name	Related			Unrelated		
			Object	Pinyin	English name	Object	Pinyin	English name
绿	lǜ4	green	绳子	sheng2zi	rope	杯子	bei1zi	cup
绿	lǜ4	green	绵羊	mian2yang2	sheep	梳子	shu1zi	comb
绿	lǜ4	green	纺车	fang3che1	spinning wheel	梯子	ti1zi	ladder
蓝	lan2	blue	花朵	hua1duo3	flower	橡皮	xiang4pi2	rubber
蓝	lan2	blue	花瓶	hua1ping2	vase	枕头	zhen3tou2	pillow
蓝	lan2	blue	苍蝇	cang1ying	fly	椅子	yi3zi	chair
橙	cheng2	orange	杯子	bei1zi	cup	花朵	hua1duo3	flower
橙	cheng2	orange	梳子	shu1zi	comb	花瓶	hua1ping1	vase
橙	cheng2	orange	梯子	ti1zi	ladder	苍蝇	cang1ying	fly
棕	zong1	brown	橡皮	xiang4pi2	rubber	绳子	sheng2zi	rope
棕	zong1	brown	枕头	zhen3tou2	pillow	绵羊	mian2yang2	sheep
棕	zong1	brown	椅子	yi3zi	chair	纺车	fang3che1	spinning wheel

Figure 1

