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# The Role of Second Language Reading Proficiency in Moderating Second Language Word Recognition

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**Abstract:** Drawing upon the division of labor between orthographic and phonological information, this study investigated whether and how L2 reading proficiency moderates learners' reliance on phonological and orthographic information in retrieving word meanings. A total of 136 Chinese collegiate students who learned English as a foreign language (EFL) completed English reading proficiency tests and were divided into higher and lower reading proficiency groups using an extreme-group approach. Behavioral tasks were used to measure the participants' sensitivity to and processing skills of orthographic and phonological information. The analysis showed that the reliance on phonological and orthographic information differed significantly across L2 reading proficiency groups: The higher reading proficiency group was sensitive to both phonological and orthographic information within words, while the lower reading proficiency group was only sensitive to orthographic information; only orthographic processing skills significantly contributed to the word meaning retrieval of individuals in the higher reading proficiency group, while phonological processing skills were the only predictor for the lower reading proficiency group. These results suggest that the use of phonological and orthographic information vary as a function of L2 learners' English reading proficiency. Implications regarding the changing patterns of L1 influences and the language-universal and language-specific aspects of word recognition were discussed.

**Keywords:** word recognition; phonological information; orthographic information; cross-linguistic influences



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## 1. Introduction

It has been well established that first language (L1) influences affect second language (L2) reading. What remains less clear is how the L1 influences change as L2 learners become more proficient in the target language. Among different fields of L2 acquisition, visual word recognition is the cognitive process of recognizing the written word forms and retrieving the appropriate meaning of a printed word [1]. As a critical component in reading, the automaticity of word recognition is difficult to achieve for L2 learners [2]. The goal of this study is to examine how adult L2 learners, with a fully functional L1 word recognition system, recognize L2 words and how this process is jointly shaped by their L1 writing system features and L2 reading proficiency levels.

Previous studies [3–5] suggested that readers of alphabetic languages tended to rely more heavily on phonological information and their highly developed phonological skills for word recognition and reading. By contrast, readers of morpho-syllabic languages tended to rely relatively more on visual–orthographic information, while phonological information played a less essential role [6]. The established L1 reading habits transfer to L2 reading [7–9]. For example, under the influences of the L1 Chinese writing system, Chinese native speakers who learn English as a foreign language (EFL hereafter) are characterized by a heavier reliance on orthographic over phonological information in English word recognition and reading [10–12]. However, little is known about how the impacts of the L1 writing system change as learners become more experienced L2 readers [8]. In other words, it remains unclear whether Chinese EFL learners would develop a set of word recognition processes that are optimal for the English writing system as their reading proficiency in English increases. Two possibilities exist: with increasing reading proficiency, Chinese EFL learners may tune to the orthographic features of the English writing system. They may rely more heavily on the phonological information in English word recognition. Alternatively, learners may stick to the initial processing habits developed based on their L1 reading experience even as they become better English readers. This study examines these two possibilities by comparing the word recognition processes of Chinese EFL learners at different reading proficiency levels.

### 1.1. Comparing Chinese and English Word Recognition

As the foundation of reading [13], successful word recognition is characterized by retrieving the appropriate word meaning, a process that necessitates skillful processing of phonological and orthographic information [14,15]. The efficiency of processing the semantic, orthographic, and phonological information determines the extent to which word recognition becomes a seamless activation (see Lexical Quality Hypothesis) [14]. The seamless word recognition, in turn, provides the basis for reading development [13]. Thus, it is unsurprising that phonological sensitivity and processing skills have been found to have positive and even causal relationships with word recognition and reading performance among English speakers [16,17], bilingual children [18], and Chinese native speakers [19,20]. Similarly, orthographic sensitivity and processing skills are found to be significant predictors of reading performance in L1 and L2 reading research [5,21,22].

Despite the universal significance of phonological and orthographic information in word recognition, the weights of their respective roles vary by the properties of different writing systems [7,23,24]. One such difference is the degree to which phonological information is used to mediate the word meaning retrieval [15,25]. As an alphabetic writing system, the English language maps each graph (letter) onto a phoneme (e.g., the graph "k" represents the phoneme /k/). By contrast, Chinese is morpho-syllabic [26], wherein each Chinese graph (character) maps onto a morpheme and also holistically corresponds to a syllable. For example, the graph "猫" represents the morpheme associated with "cat" and the syllable /mao1/. Given this difference, phonology is activated immediately and incrementally as the readers decode English words [6,27,28]. In contrast, Chinese character phonology is activated in a holistic manner only when the readers reach the threshold for recognizing the character [6,27,29,30]. As a result, phonological information is less crucial in retrieving the word meaning in Chinese than in English.

In addition, Chinese word recognition primarily relies on the visual–orthographic processing and orthographic analysis [4,31,32] as a result of its graphic and visual complexity [33]. The Chinese writing system is visually more complex than English [6,34]. In effect, Chang and colleagues calculated the visual complexity of 131 writing systems. They found that Chinese characters were an outlier in terms of the average graph complexity among all the 131 writing systems [33].

Learning to read a visually complex writing system requires advanced orthographic processing skills and, in turn, strengthens this skill [35]. Moreover, the holistic and non-segmental phonological activation weakens the role of phonological information in Chinese word meaning retrieval. Therefore, compared with English readers, skilled Chinese readers are characterized by a stronger reliance on orthographic over phonological information in word meaning retrieval. Evidence supporting this conjecture comes from various studies. For example, several behavioral studies demonstrated that English readers were more sensitive to the unavailability of familiar phonological information in word recognition; on the other hand, Chinese native speakers were more dependent on orthographic information [28,36,37]. Using the semantic category judgment task, van Orden [28] found that English-speaking collegiate students were more distracted by similar phonological information than similar orthographic information in English word meaning retrieval. However, studies using the same paradigm did not find a higher false alarm rate to the phonologically similar items among Chinese native speakers, while the orthographic interference was still observed [38,39]. Similar findings have also been reported from computational modeling [40], neuroimaging [41,42], and eye-tracking studies [37].

Studies further showed that word recognition skills developed in L1 automatically transferred and affected how readers recognized words in L2 [1,43,44]. Therefore, the relative reliance on the phonological and orthographic information developed from Chinese reading affects how Chinese-speaking readers learn to read a second language. Compared with the alphabetic EFL learners and English native readers, Chinese-speaking English learners rely more heavily on orthographic information and less heavily on phonological information in English word recognition [10–12]. For example, using the semantic category judgment task, Wang et al. found that, compared with Korean counterparts, Chinese-speaking English learners made more false positives for orthographically similar stimuli than less orthographically similar ones [10]. The result suggested the more substantial effects of orthographic information in word meaning retrieval for these learners.

However, most studies provide only a cross-section of the learners' L2 word recognition processing at a given L2 proficiency level. The question remains regarding how the word recognition processes would change as the learners' reading experience in the target language accumulates, the answer to which is critical to understand the nature of L1 influences. The section below details two possible scenarios.

### *1.2. The Changing Patterns of L1 Influences on L2 Word Recognition*

There are different views on the roles of L1 impacts on L2 word recognition as learners become more proficient [8,43,45]. On the one hand, the increasing L2 reading proficiency may lead the learners to restructure how they recognize L2 words. In this scenario, the L1 impacts may gradually diminish, and L2 learners may adapt the features of the L2 writing system; alternatively, the restructuring process may not happen, and the L1 impacts may be persistent. In this case, L2 learners may be entrenched by their L1 processing habits in L2 word recognition.

According to the first view, L2 learners can make adjustments to their processing habits and adapt to L2 writing system features as they become more proficient. Thus, L1 influences may be true only at early stages of literacy development in a new language, and gradually diminish for highly proficient L2 readers. These readers could remold their transferred L1 reading habits and be tuned to the properties of the L2 writing system [43,46]. Similarly, Share proposed a novice-to-expert dualism of readers' word recognition performance [47]. In this dualism, reading experience is the key factor that determines how readers process visual words. The word recognition process of the highly proficient readers is characterized by the same automatic, effortless, and efficient processing regardless of their L1 backgrounds. According to this view, Chinese EFL learners may adjust according to the English orthographic features. They may rely more heavily on the phonological information and less so on orthographic information as they become more proficient.

Studies in support of this view have found a more native-like word recognition pattern and declining impacts of the L1 writing system among L2 learners with higher L2 proficiency [43,46,48–50]. For instance, Chikamatsu found that, among 34 English-speaking Japanese L2 college students, intermediate-level learners were more negatively affected by the lack of familiar orthographic information in Kana lexical decision task than their beginning-level counterparts [43]. The author contended that the participants with the higher L2 proficiency tended to use the orthographic information more strongly in syllabic Kana word recognition. This was similar to the patterns found from native Japanese readers. Using a longitudinal design, Yamashita [50] examined the changing contributions of orthographic and phonological processing skills to English lexical decision among Japanese-speaking EFL learners from Grade 9 to 11. The results demonstrated that the significant predictor of English word recognition gradually switched from orthographical processing to phonological processing skills. These findings indicate a declining role of L1-induced processing and emerging L2-based processing during the years of investigation.

By contrast, it is possible that the same, if not stronger, level of L1 impacts would remain and that L2 readers would still be affected by L1 literacy experience even at a very advanced L2 level in L2 word recognition [36,51–54]. As one of such arguments, the Linguistic Threshold Hypothesis contends that L1 reading skills cannot help learners in L2 reading until they reach a certain level of L2 knowledge; once the learners reach the critical threshold level, the L1 influence may continue increasing as L2 proficiency improves [53]. According to this view, L2 learners are not likely to attune to the L2 writing system in L2 word recognition. Even though the learners may become more efficient, their L2 word recognition is still affected by the L1 orthographic features.

Several empirical studies support this argument [36,52–54]. For instance, Akamatsu [36] examined how L2 reading proficiency altered the L1 orthographic impacts on L2 word naming. The author found that the higher and lower reading groups were adversely affected by case alternation to the same degree. The finding suggested that the impact of the non-phonological L1 writing systems on L2 word processing remained at the same level even when L2 learners became more proficient. Similarly, Komori [52] investigated the Kanji processing of Chinese-speaking Japanese learners at three proficiency levels. The results demonstrated that the high-proficiency group was able to make the strongest connection between Chinese and Japanese words while such a connection was not established for the lowest group. The results indicated that L1 impact was higher for the most competent L2 learners.

To sum up, controversy exists regarding how the L1 impacts on L2 word recognition differ for L2 learners at different proficiency levels. Discrepancies among these studies are hard to reconcile immediately as they vary largely in task demand, research scope, L1-L2 distance, learners' L2 proficiency, and context. On the one hand, L2 learners with two highly contrasting L1 and L2 writing systems, like Chinese and English, are more likely to experience the restructuring process. This is because the differences between the optimal L1 and L2 word recognition processes are sharper and thus make the L1 transfer harder and less available. However, it is also possible that such significant differences make the restructuring process more difficult and, therefore, unlikely to happen. The current rare and mixed studies necessitate more research efforts in understanding this question.

## 2. Materials and Methods

The present study is based on several findings established from the previous studies: first, compared with English L1 readers, Chinese L1 readers rely more heavily on orthographic over phonological information in word meaning retrieval; second, Chinese reading experience has cross-linguistic influences on Chinese EFL learners' behavior in recognizing English words. However, what remains unclear is how the cross-linguistic influences differ among L2 learners with various L2 reading proficiency levels. Therefore, this study examined whether the adult EFL learners could be tuned to the L2 writing system and restructure their word recognition processing by comparing their relative reliance on orthographic and phonological information in English word meaning retrieval.

Two sets of tasks were used to measure the participations' utilization of orthographic and phonological information in word meaning retrieval. First, the semantic category judgment task measured the participants' orthographic and phonological sensitivity. This task compared the extent to which the lack of familiar orthographic and phonological information interfered with the participants' word meaning retrieval. The larger negative impact implies the stronger sensitivity to the information. The second set of word recognition tasks measured the participants' orthographic processing skills, phonological processing skills, and word meaning retrieval to compare the relative contributions of the former two skills to the latter.

Correspondingly, there are two research questions:

(1) Do the Chinese EFL learners with higher and lower English reading proficiency differ in their sensitivity to phonological and orthographic information in English word meaning retrieval?
(2) Do the Chinese EFL learners with higher and lower English reading proficiency differ in their processing skills of phonological and orthographic information in English word meaning retrieval?

### 2.1. Participants

A total of 165 Chinese-speaking collegiate students who were English learners in a Chinese university took part in the experiment in 2021. By the time of the experiment, all participants were undergraduate students majoring in international education from a university in northern China. Students were recruited from the same major to minimize the impact of topic knowledge on L2 reading test. Six participants did not finish all the tasks, and 26 participants' oral responses in the phonological processing task were non-distinguishable due to technical issues or background noise. This resulted in 32 participants being excluded from the analysis. The remaining 133 participants, including 123 females and ten males (mean age = 20.53, *SD* = 2.53), were classified into two groups based on their scores in the reading proficiency test (see below for details).

These participants all reported normal cognitive ability without known dyslexia. Most students started learning English since grade one. No student had experience of living abroad for more than one month. And students were not fluent in languages other than Chinese and English. As reported by their instructor, students' English proficiency levels varied from intermediate–low to advanced according to the ACTFL proficiency standard. This relatively large range allowed us to capture the variance associated with the L2 proficiency levels in data analysis. This also provided the basis for categorizing the students into different L2 proficiency groups. As required by the university, students needed to pass College English Test (CET) Band 4 and 6 by the time of graduation. This test is organized by the Ministry of Education of the People's Republic of China. As a large national test, CET is regarded as a valid and reliable measure of Chinese college students' English proficiency [55].

### 2.2. Tasks

The participants completed two sets of tasks, which were designed to measure their phonological and orthographic sensitivity and processing skills in English word meaning retrieval, respectively. Their English reading proficiency was tapped by a standardized reading comprehension task. Their working memory was also measured.

#### 2.2.1. Reading Proficiency Test

The participants' reading proficiency was measured by a cloze test and a reading comprehension test with two passages. All the materials were adopted from retired versions of the CET-Band 4 and the CET-Band 6. There are 15 multiple-choice questions in the cloze test and the reading comprehension test, respectively. The questions addressed the participants' gist understanding, textual inferencing, and global inferencing. The participants were given 20 min to finish this test. The maximum score is 30. Cronbach's $\alpha$ = 0.72.

This study implemented an extreme-groups approach [56–58] to classify the participants. The participants were divided into thirds based on English reading proficiency scores. By dropping the participants who were in the middle one-third in the reading proficiency test, we classified the top and the bottom one-third of the participants into the higher (n = 47) and lower (n = 43) reading proficiency groups.

#### 2.2.2. Semantic Category Judgment Task

The semantic category judgment task was designed to measure the participants' sensitivity to orthographic and phonological information in English word meaning retrieval. Similar to the experiment conducted by Wang et al. [10], the participants in this task were first given a category name for 1500 ms and then a target stimulus for up to 3 s. They needed to judge whether the target stimulus was a member of the category by pressing the button "A" (yes) or "L" (no). The target stimulus was either orthographically or phonologically similar to a prototype word of that category. For example, "rose" is a prototype exemplar for the category "flower". Each stimulus thus fell into one of the four conditions: (1) O+P+: similarly spelled homophones (e.g., "meet" is orthographically and phonologically similar to "meat"); (2) O+P−: similarly spelled control (e.g., "melt" is orthographically similar but phonologically dissimilar to "meat"); (3) O−P+: less similarly spelled homophone (e.g., "rows" is phonologically similar but orthographically dissimilar to "rose"); (4) O−P−: less similarly spelled control (e.g., "robs" is both orthographically and phonologically different from "rose"). The stimuli were adapted from the work by Wang et al. [10]. There were nine items in each O+P+ and O+P− condition, seven items in each O−P+ and O−P− condition, and 35 fillers. The maximum score is 67. The Cronbach $\alpha$ of the task in this study is 0.80.

#### 2.2.3. Phonological Processing Task

The participants' phonological processing skills were measured by a standardized pseudoword naming task. In the task, the participants first saw a letter string for up to 3 s, followed by a 500-millisecond cross fixation at the center of the monitor. They were told to read aloud the letter string as rapidly and accurately as possible. The participants were encouraged to guess if they were uncertain. The stimuli were 33 regular and irregular pronounceable English pseudowords adopted from the Test of Word Reading Efficiency [59]. There were three practice trials to familiarize the participants with the task. The Cronbach $\alpha$ of the task in this study is 0.951.

#### 2.2.4. Orthographic Processing Task

The word-likeness judgment task was designed to measure the participants' orthographic processing skills. In this task, a string of letters was shown at the center of the monitor for up to 3 s, followed by a 500-milliseconds inter-trial cross fixation and a 500-milliseconds inter-trial interval. The participants were told that they would see some "made-up" words; and they needed to decide whether these "made-up" words looked like a real English word by pressing the button "A" (real) or "L" (not real). The participants were told to make decisions based on their English orthographic knowledge. The maximum response time was 3 s for each trial. The participants underwent three practice trials before the task.

The stimuli were adapted from the work by Massaro et al. [60] and were also used by Koda [61] and Martin [62]. They varied by the letter combination legality and positional frequency. Therefore, four sets of stimuli were created: legal pseudowords with high positional frequency, legal pseudowords with low positional frequency, illegal nonwords with high positional frequency, and illegal nonwords with low positional frequency. Each set had 20 items. The maximum score is 80. The Cronbach $\alpha$ of the task in this study is 0.948.

#### 2.2.5. Word Meaning Retrieval Task

The lexical category decision task was used to measure the participants' word meaning retrieval. In this task, the participants were first shown a category name for 1500 ms (e.g., "food") and then a target stimulus on the screen for up to 3 s (e.g., "bread"). They were asked to decide whether the presented stimuli belonged to the category as rapidly and accurately as possible by pressing the "A" (yes) or "L" (no) button. Twenty correct trails, 20 incorrect trails, and 34 fillers were included in this task. These 74 stimuli were derived from nine of the 27 most common categories reported in the work by Hebart et al. [63]. The authors in [62] sampled l,854 diverse object concepts systematically from concrete picturable and nameable nouns in the English language. Only high-frequency words were used to minimize the impact of vocabulary knowledge. The Cronbach $\alpha$ of the task in this study is 0.99.

### 2.2.6. Working Memory Test

A working memory span task was conducted to measure the participants' working memory [64]. The participants in this task saw a string of numbers on the screen for 1 s. They were asked to type the numbers into the input box based on their memory. There were 14 strings varying from 3 to 9 digits. The participants also completed three practice trials. The maximum response time was 7 s for each trial. The Cronbach $\alpha$ is 0.70.

### *2.3. Procedure*

The whole experiment was conducted online using Gorilla Builder Experimenter [65]. The whole experiment took about 60 min to finish. The tasks and the stimuli used in each task were randomized. The participants took the experiment individually online.

## 3. Results

### *3.1. RQ1: Do the Chinese EFL Learners with Higher and Lower English Reading Proficiency Differ in Their Sensitivity to Phonological and Orthographic Information in English Word Meaning Retrieval?*

All the data analyses were conducted using Stata [66]. The descriptive data of all measures were provided in Table 1. RQ1 measures the participants' phonological and orthographic sensitivity in English word meaning retrieval. For RQ1, the two groups' accuracy rates and response time in the semantic category judgment tasks were compared across the four conditions using mixed-factorial ANOVA. The section below presents the results of the accuracy scores and response time.

**Table 1.** Descriptive statistics of all the measures.

| Measures Mean (SD) | Lower Reading Proficiency Group (n = 43) | Higher Reading Proficiency Group (n = 47) | All Participants (n = 133) |
|---|---|---|---|
| Reading [1] | 12.77 (1.67) | 21.04 (2.30) | 17.17 (3.82) |
| WMR [2] | 64.44 (5.48) | 67.43 (4.56) | 66.62 (4.75) |
| WMR RT [3] | 1009.54 (136.09) | 1001.28 (156.04) | 1004.18 (139.25) |
| OP [4] accuracy | 54.05% (9.00%) | 57.67% (7.49%) | 55.48% (8.12%) |
| OP RT | 939.29 (319.75) | 1020.23 (244.46) | 996.43 (279.90) |
| PP [5] accuracy | 79.86% (15.17%) | 86.53% (9.13%) | 83.42% (11.71%) |
| PP RT | 3833.47 (1954.87) | 3310.96 (1281.47) | 3457.58 (1577.71) |
| Working memory | 10.09 (2.33) | 10.23 (1.94) | 10.22 (2.04) |
| SCT [6] O+P+ accuracy | 59.69% (22.22%) | 60.28% (19.93%) | 58.65% (20.16%) |
| SCT O+P+ RT | 1228.88 (244.51) | 1256.33 (254.48) | 1257.86 (248.39) |
| SCT O+P− accuracy | 55.56% (22.49%) | 73.25% (15.93%) | 63.13% (20.29%) |
| SCT O+P− RT | 1210.45 (200.86) | 1256.33 (154.48) | 1257.86 (248.39) |
| SCT O−P+ accuracy | 66.45% (19.44%) | 73.25% (15.93%) | 70.68% (18.70%) |
| SCT O−P+ RT | 1188.04 (245.77) | 1225.49 (245.14) | 1230.46 (273.61) |
| SCT O−P− accuracy | 71.10% (17.77%) | 79.60% (15.93%) | 75.08% (17.90%) |
| SCT O−P− RT | 1243.73 (227.83) | 1319.75 (307.05) | 1254.79 (260.04) |

[1] Reading: English reading proficiency scores. [2] WMR: word meaning retrieval scores. [3] RT: reaction time in milliseconds. [4] OP: orthographic processing skills. [5] PP: phonological processing skills. [6] SCT: semantic category judgment task.

### 3.1.1. Accuracy Rates

A 2 (orthographical similarity) by 2 (phonological similarity) by 2 (reading proficiency group) mixed-factorial ANOVA was conducted to compare the participants' accuracy rates in the semantic category judgment task. Orthographical similarity and phonological similarity were two within-subjects variables and reading proficiency was the between-subjects variable. The results show that the main effects of the two within-subjects variables and reading proficiency group were all significant: Phonological similarity ($F(1,88) = 4.645$, $p < 0.050$, partial $\eta^2 = 0.386$); Orthographic similarity ($F(1,88) = 55.325$, $p < 0.000$, partial

$\eta^2 = 0.050$); Reading proficiency group ($F(1,88) = 4.747$, $p < 0.050$; partial $\eta^2 = 0.051$). More interesting was the interaction between phonological similarity and reading proficiency group ($F(1,88) = 3.950$, $p < 0.050$, partial $\eta^2 = 0.043$). As Figure 1 shows, the post hoc simple effect tests demonstrated that the higher reading proficiency group (the right figure) performed significantly better in P− conditions regardless of orthographical similarity (O+: $t(46) = 2.312$, $p < 0.050$; O−: $t(46) = 2.300$, $p < 0.050$). By contrast, phonological similarity was found not to affect the lower reading proficiency group (the left figure) in either O+ or O− condition (O+: $t(42) = -1.199$, $p = 0.237$, O−: $t(42) = 1.615$, $p = 0.114$).

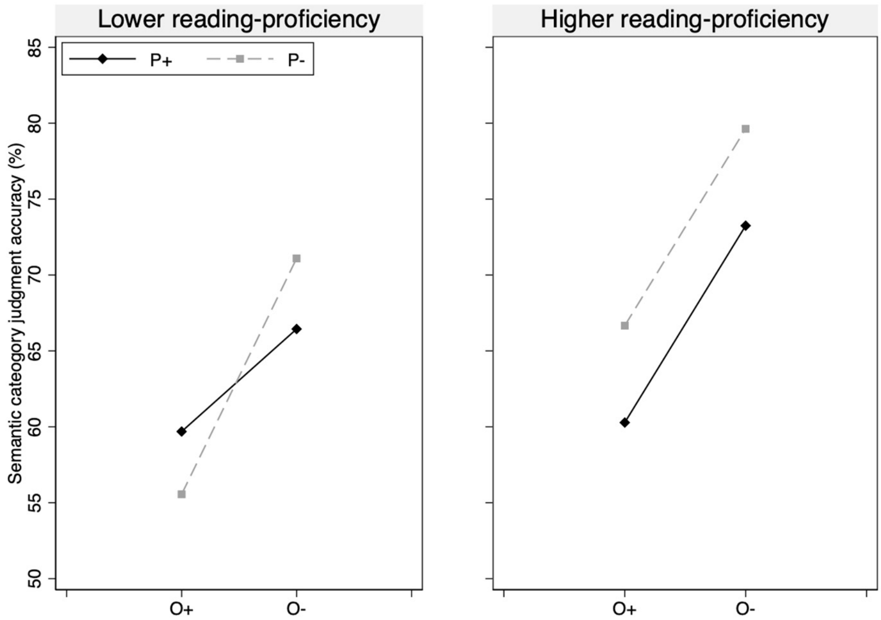


**Figure 1.** The higher and lower reading proficiency groups performed differently across the four conditions in the semantic category judgment task (O+: orthographically similar items; O−: orthographically different items; P+: phonologically similar items; P−: phonologically different items).

To sum up, first, orthographic similarity adversely affected the accuracy rates of both the higher and lower reading proficiency group ($F(1,88) = 55.325$, $p < 0.000$, partial $\eta^2 = 0.050$). Participants in both groups performed worse in O+ conditions than in O− conditions. All the participants were significantly distracted by the orthographically similar distractors in the task. This result indicated that the participants were highly sensitive to the orthographic information in word meaning retrieval, regardless of their English proficiency levels. Second, the interaction between phonological similarity and reading proficiency group indicated that phonological information played different roles between the two reading proficiency groups. The higher reading proficiency group performed worse in P+ conditions than in P− conditions. However, such a difference did not exist in the lower reading proficiency group. This result suggests that, while the higher reading proficiency group was negatively impaired by the phonologically similar distractors, the low reading proficiency group showed no effect of phonological interference. Taken together, the results suggest that, while both groups were sensitive to the orthographic information in word meaning retrieval, only the higher reading proficiency group was sensitive to the phonological information.

### 3.1.2. Reaction Time

Another 2 (orthographical similarity) by 2 (phonological similarity) by 2 (reading-proficiency group) mixed-factorial ANOVA was conducted to compare the participants' reaction time across the conditions. There was no main effect of orthographical similarity ($F(1,88) = 0.201$, $p = 0.655$). An almost significant main effect of phonological similarity ($F(1,88) = 3.880$, $p = 0.052$) was detected. There was a significant two-way interaction between orthographical similarity and phonological similarity ($F(1,88) = 4.275$, $p < 0.05$); across the two groups, the effect of phonological similarity was significant only when there was no orthographical interference (O+: $p < 0.01$; O−: $p = 0.821$). In addition, the reading proficiency group had no main effect on the participants' speed ($F(1,88) = 1.131$, $p = 0.290$), suggesting that the higher reading group was not faster than the other group. This result implies that learners' processing speed is difficult to improve despite their improved accuracy. It is also consistent with the previous observations that word recognition automaticity is hard to achieve for L2 learners [2].

### 3.2. RQ2: Do the Chinese EFL Learners with Higher and Lower English Reading Proficiency Differ in Their Processing Skills of Phonological and Orthographic Information in English Word Meaning Retrieval?

RQ2 examined the contribution of phonological and orthographic processing skills to word meaning retrieval in English. The binary correlations of these tasks are provided in Table 2.

**Table 2.** Binary correlations of the word recognition tasks (lower reading proficiency group below the diagonal; higher reading proficiency group above the diagonal).

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. |
|---|---|---|---|---|---|---|---|---|
| 1. WMR [1] scores | -- | −0.212 | −0.205 | 0.296 * | 0.239 | 0.167 | 0.023 | 0.203 |
| 2. WMR (RT [2]) | −0.031 | -- | −0.012 | −0.200 | 0.019 | −0.104 | 0.057 | −0.118 |
| 3. Reading [3] | 0.362 * | −0.110 | -- | −0.005 | −0.117 | 0.060 | −0.027 | −0.075 |
| 4. OP [4] accuracy | 0.120 | −0.122 | 0.139 | -- | 0.285 | 0.313 * | 0.058 | 0.225 |
| 5. OP RT | 0.184 | 0.066 | 0.052 | 0.621 *** | -- | 0.138 | −0.214 | 0.302 * |
| 6. PP [5] accuracy | 0.422 ** | −0.053 | 0.238 ** | 0.183 | 0.125 | -- | −0.182 | −0.306 * |
| 7. PP RT | −0.180 | 0.102 | −0.132 | −0.105 | −0.107 | −0.207 | -- | −0.070 |
| 8. Working memory | 0.351 * | −0.296 | 0.036 | 0.083 | 0.024 | −0.018 | −0.145 | -- |

[1] WMR: word meaning retrieval. [2] RT: reaction time in milliseconds. [3] Reading: English reading proficiency scores. [4] OP: orthographic processing skills. [5] PP: phonological processing skills. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.000$.

As Table 2 shows, when the participants were classified into the higher and lower reading proficiency groups, their word meaning retrieval had differential relationships with other variables. For the lower reading proficiency group (data presented below the diagonal in Table 2), word meaning retrieval scores were significantly correlated with reading proficiency ($r = 0.362$, $p < 0.05$), phonological processing accuracy ($r = 0.422$, $p < 0.01$), and working memory ($r = 0.351$, $p < 0.05$). No significant correlation was found between word meaning retrieval accuracy scores and any orthographic processing scores for this group. Their word meaning retrieval reaction time did not significantly correlate with any variables.

By contrast, the participants in the higher reading proficiency group exhibited a different pattern of relations (data presented above the diagonal in Table 2). Their word meaning retrieval accuracy was only significantly correlated with orthographic processing scores ($r = 296$, $p < 0.05$). Importantly, the significant correlation between word meaning retrieval accuracy and phonological processing accuracy detected in the lower reading proficiency group did not exist for the higher reading proficiency group. There was no significant correlation between word meaning retrieval reaction time and any measures for the higher reading proficiency group.

Two hierarchical regressions were conducted to examine what variables predicted word meaning retrieval accuracy for each group. For the lower reading proficiency group (Table 3), reading proficiency and working memory were entered into the model in Step 1 to control for any variances explained by them. Phonological processing accuracy was then entered in Step 2 to examine the unique variance it predicted. As Table 3 shows, reading proficiency and working memory together explained 24.4% of the variance in word meaning retrieval accuracy ($F(2,40) = 6.448$, $p < 0.01$). More critically, phonological processing accuracy explained an additional 15.5% of the variance of word meaning retrieval ($F(1,39) = 10.055$, $p < 0.000$) for the lower reading proficiency group. No interaction was found between any variables.

**Table 3.** Hierarchical regression results with word meaning retrieval accuracy as the dependent variable and working memory, reading proficiency accuracy, and phonological processing accuracy as the independent variables (lower reading proficiency group only; n = 43).

| Model | *R* | $R^2$ | $\Delta R^2$ | *B* | *SE* | *β* | *t* | *p* |
|---|---|---|---|---|---|---|---|---|
| Step 1 | 0.494 | 0.244 | 0.244 ** | | | | | |
| Working memory | | | | 0.782 | 0.324 | 0.336 | 2.444 | 0.019 * |
| Reading [1] | | | | 1.138 | 0.451 | 0.347 | 2.525 | 0.016 * |
| Step 2 | 0.632 | 0.399 | 0.155 ** | | | | | |
| Working memory | | | | 0.813 | 0.293 | 0.345 | 2.778 | 0.008 * |
| Reading | | | | 0.999 | 0.409 | 0.305 | 2.439 | 0.019 * |
| PP [2] | | | | 14.315 | 4.514 | 0.396 | 3.171 | 0.003 ** |

[1] Reading: English reading proficiency accuracy. [2] PP: phonological processing accuracy. * $p < 0.05$. ** $p < 0.01$.

In Table 4, orthographic processing accuracy was entered to examine their contribution to word meaning retrieval for the higher reading proficiency group. This process explained 8.8% of the variance of the word meaning retrieval accuracy for the higher reading proficiency group ($F(1,45) = 4.326$, $p < 0.05$).

**Table 4.** Hierarchical regression results with word meaning retrieval accuracy as the dependent variable and orthographic processing accuracy as the independent variable (higher reading proficiency group; n = 47).

| Model | *R* | $R^2$ | $\Delta R^2$ | *B* | *SE* | *β* | *t* | *p* |
|---|---|---|---|---|---|---|---|---|
| | 0.296 | 0.088 | 0.088 * | | | | | |
| OP [1] | | | | 0.180 | 0.087 | 0.296 | 2.080 | 0.043 * |

[1] OP: orthographic processing accuracy. * $p < 0.05$.

To sum up, the results from the two regression models (Tables 3 and 4) demonstrate that participants in the lower and higher reading proficiency groups relied differentially on phonological processing and orthographical processing skills. In the lower reading-proficiency group, phonological processing accuracy significantly contributed to word meaning retrieval accuracy after the variance associated with reading proficiency and working memory was controlled. By contrast, it did not significantly correlate with word meaning retrieval in the higher reading proficiency group. In addition, orthographic processing accuracy was not significantly correlated with the lower reading proficiency group, but it explained 8.8% of the variance of the word meaning retrieval among the higher reading proficiency group.

## 4. Discussion

There are two major findings obtained from the tasks. First, participants with the higher reading proficiency were sensitive to both the orthographical and phonological information in the semantic category judgment task, while the participants with the lower reading proficiency were only sensitive to the orthographic information. Second, participants with the higher reading proficiency primarily relied upon orthographic processing skills in English word meaning retrieval, whereas the lower reading proficiency group used phonological processing skills exclusively in the same task.

The results of the semantic category judgment task seem to suggest that the L1 influences were smaller among the learners in the higher proficiency group compared with their less proficient peers. Using the same task, van Orden [28] found that English native speakers showed a main effect of both orthographic and phonological interference. Likewise, the higher reading proficiency group showed the same main effects of orthographic and phonological similarity. By contrast, the participants with lower reading proficiency were only distracted by the lack of familiar orthographic information, a pattern detected from Chinese native speakers recognizing words in Chinese [38,39]. This finding indicates that Chinese EFL learners with higher L2 reading proficiency paid more attention and became sensitive to the phonological information within a word in word meaning retrieval, while their less proficient peers were still under the influence of the visually complex Chinese writing systems. In support of the declining L1 impacts, this finding suggests that the proficient adult Chinese EFL learners are capable of attuning to the English writing system in English word meaning retrieval.

Surprisingly, the results of the word meaning retrieval task show a seemingly different pattern: the lower reading proficiency group relied primarily on phonological processing skills, while the higher reading proficiency group used orthographic processing skills exclusively. This difference may be induced by the fact that the semantic category judgment task and the word meaning retrieval task entailed different processing strategies. Notably, in the semantic category judgment task, the participants had to be sensitive to the internal structure and the accurate spelling/pronunciation of the target stimuli. For example, the participants needed to notice that the word "rows" was not "rose." By contrast, the stimuli in the word meaning retrieval task were all high-frequency real English words in which the maximum processing efficiency could be achieved by holistic and automatic whole-word retrieval. For instance, Seidenberg [1,65] contended that words that were often exposed and familiar to the readers were recognized on a visual basis, whereas the less familiar and low-frequency words were processed via the phonological mediation. Therefore, the results may be explained by the fact that the better readers were also more flexible readers and were adept at adopting the most appropriate processing strategies in meeting the task demands: the higher proficiency group may use a direct orthography–semantics route to access the high-frequency real words and thus be able to read them holistically and "logographically" [47,65,66]. Thus, phonological information was less crucial and became insignificant in the word meaning retrieval task for them. By contrast, the less achieving readers were more analytical and relied more heavily on the phonological mediation to process high-frequency words [25,47]. Therefore, phonological processing skills primarily contributed to their word meaning retrieval. This pattern is similar to the developmental phases of English children learning to read words [66]. As their word recognition ability develops, children experience a pre-alphabetic phase in which they have barely any knowledge of English grapheme-to-phoneme correspondences. Then, in the partial alphabetic phase, they begin to grasp certain correspondences between letters and sounds. In the full alphabetic phase, they establish a full representation of grapheme-to-phoneme correspondence rules and utilize them in word recognition. Finally, when moving onto the consolidated alphabetic phase, children have more sight words and use larger orthographic units in word recognition. Likewise, the participants with higher reading proficiency had a larger size of sight words and used the orthographic units at the whole-word level to process the high-frequency English words.

To conclude, this study found that higher proficiency Chinese EFL learners in this study were sensitive to both phonological and orthographic information in word recognition. Their orthographic processing skills contributed exclusively to word meaning retrieval. In contrast, the lower proficiency group was only sensitive to the orthographic information, and they used phonological processing skills primarily in word meaning retrieval. Taken together, the results from the two sets of tasks indicate that Chinese EFL learners with higher reading proficiency were different from their less-achieving counterparts in the way they retrieved the meaning of the English words. Their word recognition processing was more similar to that of the native speakers, as they were sensitive to both orthographic and phonological information within words. They also used orthographic processing skills dominantly in processing high-frequency English words, seemingly suggesting their holistic and flexible word recognition process. Though tentative, the results tend to support a restructuring pattern of L2 word recognition, as the findings reveal qualitative differences in the sensitivity to and processing skills of phonological and orthographic information between L2 learners at different reading proficiency levels in L2 word meaning retrieval.

## 5. Conclusions, Implications, and Limitations

By comparing the sensitivity to and processing skills of the phonological and orthographical information at different L2 reading proficiency levels, we found that the better Chinese EFL learners recognized English words in different manners than their less proficient peers. Specifically, the higher reading proficiency group was sensitive to both phonological and orthographic information, whereas the lower reading proficiency group was only sensitive to the orthographic information in the semantic category judgment task. In addition, the higher reading proficiency group used orthographic processing skills in meaning retrieval of the high-frequency English words. In contrast, the lower reading proficiency group used phonological processing skills exclusively in the same task. The results suggest that better L2 readers are able to restructure their word recognition by attuning to the properties of the English writing system and using the processing skills optimal to task demands. Therefore, the results indicate that accumulated L2 reading experience and higher reading proficiency have the potential to restructure learners' English word recognition process, while the impacts of the L1 writing system may wane over time.

Given the characteristics shown by the higher reading proficiency group, we contend that the instructions that encourage the reconstruction of word recognition processing and flexible adoption of the optimal processing skills may benefit the L2 learners. Those practices may help the less-achieving L2 readers develop more efficient L2 word recognition processing and therefore facilitate their reading development. For this purpose, there is a need for the language instructors to promote the learners' metalinguistic awareness, especially among learners whose L1 and L2 are highly contrastive. In addition, the findings also emphasize the importance of expanding sight words. Frequent exposure to written words through reading may help learners to build high-quality word representation [14]. This will promote a larger size of sight words, and in turn efficient word recognition.

To better understand the L2 word recognition development, future studies will benefit from a longitudinal study design. In addition, the participants in this study were not beginners. They were categorized as intermediate–low to advanced learners by their instructors. Recruiting participants from a wider range of L2 proficiency will help us gain a more thorough understanding of the learners' behavior in L2 word recognition. Another limitation is that we did not measure the participants' performance of these tasks in their L1. Future studies may consider including comparable L1 measures in their experiment. Also, comparing the L2 learners with different L1 backgrounds may enable the researchers to compare the learners' L2 developmental trajectories and to what extent the trajectories are similar or different from each other. It may also be interesting to explore how L2 learners at different levels respond to different word recognition tasks. This direction will entail more nuanced online measures and techniques. These lines of research will not only illuminate our understanding of the language-universal and the language-specific constraints of the L2 reading process, but also bear important pedagogical implications on how to promote efficient L2 word recognition performance.

Word recognition plays a central role in L2 reading. Also, there has been long-standing research on the roles of L1 transfer in L2 acquisition. Considering the theoretical and pedagogical significance of these questions, we hope that this study can provide some evidence to further unpack the process of word recognition and shed some light on the roles of the L1 writing system in L2 reading.

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