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L1–L2 similarity and L2 word frequency effects in Chinese

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Research Article

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Abstract

Competing accounts have been proposed to explain why word frequency effects are often larger in second-language (L2) than in first-language (L1) reading. The lexical entrenchment hypothesis attributes this pattern to weaker lexical representations in L2 due to reduced exposure, whereas the language competition hypothesis predicts that cross-language interference from L1 modulates L2 lexical processing. To test these accounts, we conducted an eye-tracking study comparing native Chinese readers and L2 Chinese readers from alphabetic and Japanese L1 backgrounds. L2 readers exhibited larger word frequency effects than native readers. Critically, the magnitude of L2 word frequency effect did not differ between L1 backgrounds. These findings suggest that L2 word frequency effects are more consistent with differences in lexical entrenchment than with cross-language competition.

1. Introduction

Word frequency is one of the most important variables affecting lexical processing efficiency. Across languages and paradigms, high-frequency words are processed faster and more accurately than low-frequency words (for reviews, see Brysbaert et al., 2018; Rayner, 1998). Notably, numerous studies have reported that word frequency effects are typically larger in second language (L2) than in first language (L1; e.g., Cop et al., 2015; Mor & Prior, 2022). Although this pattern has been widely replicated, its underlying cognitive mechanisms remain debated. Two broad classes of accounts have been proposed to explain enlarged L2 word frequency effects. One attributes them to differences in lexical representations, whereas the other emphasizes that online co-activation of L1 and L2 lexical items introduces interference. Prior studies have mainly compared L1 and L2 within typologically similar alphabetic languages, making it difficult to disentangle these two accounts. Although a few studies have explored L2 word frequency effects in bilinguals with typologically distinct L1–L2 pairs (e.g., Mor & Prior, 2020, 2022; Sui et al., 2025), it remains unclear whether L1–L2 similarity modulates these effects to distinguish between the two accounts. The present study addresses this gap by examining whether L2 word frequency effects are modulated by L1–L2 similarity among L2 readers from alphabetic and Japanese L1 backgrounds.

1.1. Word frequency effect across native and L2 groups

Previous studies have shown that word frequency effects in L1 are modulated by language proficiency. Readers with lower language proficiency exhibit larger word frequency effects than skilled readers, as observed in both alphabetic languages (Ashby et al., 2005; Barnes et al., 2017; Cop et al., 2015; Gordon et al., 2020; Kuperman & Van Dyke, 2011, 2013; Lee et al., 2025; Taylor & Perfetti, 2016) and Chinese (Guan & Fraundorf, 2020; Liu et al., 2021; Zhang et al., 2022b). In alphabetic languages, word frequency effects are larger for younger children than older children (Ballot & Zesiger, 2024; Huestegge et al., 2009; Khelifi et al., 2019), in children compared to adults (Joseph et al., 2013; Khelifi et al., 2019; McArthur et al., 2024; Tiffin-Richards & Schroeder, 2015; Whitford & Joanisse, 2018), and in older adults compared to younger adults (Kliegl et al., 2004; McGowan et al., 2015; Rayner et al., 2006; Warrington et al., 2018; Whitford & Titone, 2017, 2019; Zhang et al., 2022a; but see Allen et al., 2011; McGowan et al., 2014). Similar patterns have also been observed in Chinese (Liu et al., 2020; Wang et al., 2018b; Zhang et al., 2022a; but see Wang et al., 2018a; Zang et al., 2016).

A growing number of studies have investigated word frequency effects in L2 reading using different tasks. Isolated word recognition studies using different tasks such as lexical decision have consistently shown larger word frequency effects in L2 than in L1 among bilinguals (Duyck et al., 2008; Mor & Prior, 2020), as well as larger effects in bilinguals compared to monolinguals (Brysbaert et al., 2017; Diependaele et al., 2013; Duyck et al., 2008; Gollan et al., 2011; Hamrick & Pandža, 2020; Lehtonen et al., 2012; Lemhöfer et al., 2008). Recent eye-tracking studies examining online lexical processing during natural reading have also reported converging evidence for larger word frequency effects in L2 than in L1. Studies of English–French, French–English and

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Dutch–English speakers consistently show amplified frequency effects in L2 across early and late eye movement measures in both adult and child bilinguals (Cop et al., 2015; Whitford & Joanisse, 2018; Whitford & Titone, 2012, 2017). Corpus-based analyses further demonstrate that L2 English learners from diverse L1 backgrounds exhibit larger frequency effects than native speakers during sentence reading (Berzak & Levy, 2023). Collectively, these findings indicate that word frequency effects are reliably larger in L2 than in L1 during isolated word recognition and natural reading.

However, most previous research has examined L1 and L2 within alphabetic language pairs (e.g., Cop et al., 2015; Whitford & Joanisse, 2018; Whitford & Titone, 2012), which may limit the ability to isolate the unique characteristics of L2 processing. In contrast, relatively few studies have explored word frequency effects in bilinguals with typologically distinct L1–L2 pairs, such as Hebrew–English (Mor & Prior, 2020, 2022), Chinese–English (Sui et al., 2025) and Chinese–Russian (Norkina et al., 2025). Studies examining typologically distinct L1–L2 pairs have reported similar patterns. For example, Hebrew–English bilinguals exhibit larger word frequency effects in L2 than in L1 in both lexical decision (Mor & Prior, 2020) and eye-tracking studies (Mor & Prior, 2022). Corpus-based eye-tracking research further demonstrates amplified L2 frequency effects among Chinese–English bilinguals during paragraph reading (Sui et al., 2025), and in Chinese–Russian bilinguals compared to Russian monolinguals during sentence reading (Norkina et al., 2025). Together, these findings suggest that larger L2 word frequency effects may generalize across script differences.

Prior studies have reported that word frequency effects in L2 are modulated by language proficiency. Bilinguals with lower L2 proficiency exhibit larger L2 word frequency effects (Berzak & Levy, 2023; Diependaele et al., 2013; Li et al., 2017, 2026; Mor & Prior, 2020, 2022; Whitford & Titone, 2012; Zhao et al., 2024). When L2 proficiency is sufficiently high or is controlled for, the difference in word frequency effects between bilinguals and monolinguals disappears (Berzak & Levy, 2023; Brysbaert et al., 2017; Diependaele et al., 2013). For example, Brysbaert et al. (2017) found larger word frequency effects in Dutch-English bilinguals compared to English monolinguals in a lexical decision task. Critically, when vocabulary size was considered, the differences between the word frequency effect in L1 and L2 became vanishingly small.

1.2. Theoretical accounts for larger L2 word frequency effect

Despite the robustness of larger L2 word frequency effects, their underlying cognitive mechanisms remain debated. Two prominent accounts have been advanced to explain this pattern (Diependaele et al., 2013): the lexical entrenchment hypothesis and the language competition hypothesis. The lexical entrenchment hypothesis attributes the word frequency effect to differences in the strength of lexical representations in memory. Words encountered more frequently develop more entrenched representations and are therefore processed more efficiently. Because bilinguals typically have lower cumulative exposure and proficiency in L2 than in L1, L2 lexical representations are assumed to be weaker, making lexical retrieval more effortful and leading to larger word frequency effects. Crucially, this account predicts that the magnitude of the L2 frequency effect should primarily reflect differences in representational strength and thus be relatively independent of the typological similarity between L1 and L2 (Diependaele et al., 2013).

In contrast, the language competition hypothesis emphasizes that bilingual lexical processing involves parallel activation of L1 and L2 representations and that larger L2 word frequency effects result from language competition. According to this view, L2 word recognition is influenced not only by the strength of L2 lexical representations but also by interference from co-activated L1 items. Bilinguals need to cope with greater competition among similar word form representations than monolinguals. Consequently, the magnitude of L2 word frequency effects may depend on the similarity between L2 and L1 lexical form representations, such that learners whose L1 is more similar to L2 may experience stronger interference and altered frequency effects. Importantly, unlike the lexical entrenchment hypothesis, this hypothesis predicts that the L2 word frequency effect increases as a function of L1–L2 similarity.

Although cross-language activation during word recognition is well established (e.g., cognate effects and cross-language neighborhood effects; de Groot et al., 2002; Gastmann et al., 2025; Whitford & Joanisse, 2021; Whitford & Titone, 2019), and the effects of L1–L2 distance on eye movements in L2 reading have been documented (Kuperman, 2025), few studies have directly tested whether L1–L2 similarity modulates L2 word frequency effects. Evidence from Chinese–English bilinguals (Sui et al., 2025) suggests that their observed patterns do not fully align with predictions from either the language competition or the lexical entrenchment hypotheses, particularly when L1 and L2 differ substantially in script. This indicates that the applicability of these accounts to cross-script bilinguals remains unclear.

In sum, the critical distinction between the lexical entrenchment and language competition hypotheses lies in whether L2 word frequency effects are driven by weaker lexical representations or by cross-language interference. Previous studies, however, have largely focused on alphabetic language pairs, where shared script may introduce close L1–L2 links through specific language exposure, lexical item overlap and transfer of underlying reading skills (Mor & Prior, 2020, 2022). These factors may mask processing differences that are purely attributable to L2 status. Although several studies have explored L2 word frequency effects in bilinguals with typologically distinct L1–L2 pairs (Mor & Prior, 2020, 2022; Norkina et al., 2025; Sui et al., 2025), it remains unclear whether L1–L2 similarity modulates word frequency effects.

1.3. Word frequency effects in L2 Chinese reading

While existing theoretical accounts of L2 word frequency effects have largely been developed based on alphabetic languages, Chinese, as a logographic language, provides a unique opportunity to test the predictions of the lexical entrenchment and language competition hypotheses, particularly through comparisons between L2 learners whose L1 is typologically similar versus dissimilar to Chinese.

Chinese is a logographic language with fundamental differences from alphabetic languages. Chinese words are composed of characters and are written without spaces to mark word boundaries. These characteristics pose challenges for L2 learners who often struggle to segment continuous character strings into words during reading (Li et al., 2025; Shen et al., 2012; Yao et al., 2025a, 2025b). Such segmentation difficulty may be especially pronounced for low-frequency words, whose boundaries are less predictable due to limited exposure, potentially resulting in larger word frequency effects in L2 learners compared to native readers.

To date, although many studies have examined word frequency effects in L2 Chinese (Jiang, 2005, 2006; Jiang et al., 2006; Zhang, 2008), direct comparisons between L1 and L2 Chinese readers remain scarce. To our knowledge, only Hao et al. (2024) and Lai and Jiang (2026) have included both groups. Hao et al. (2024)

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reported that Indonesian-speaking L2 learners exhibited word frequency effects in a lexical decision task, whereas native speakers did not. However, this lexical decision task may not reflect natural Chinese reading, where the lack of interword spaces demands simultaneous segmentation and identification (Li & Pollatsek, 2020), a process that cannot be captured in isolated word recognition (Sui et al., 2025). Recently, Lai and Jiang (2026) used eye-tracking and reported larger word frequency effects for alphabetic-L1 learners than for L1 readers during sentence reading. But with only one L2 group, the study leaves open the question of how L1–L2 similarity modulates the word frequency effect, specifically whether learners from typologically different L1 backgrounds show differential frequency effects. Answering this question is crucial because the lexical entrenchment hypothesis and the language-competition hypothesis make different predictions regarding the influence of L1–L2 similarity.

1.4. The present study

In the present study, we examined whether L2 word frequency effects in Chinese sentence reading are modulated by L1–L2 similarity. Specifically, we compared frequency effects in L2 Chinese learners from alphabetic-language backgrounds and Japanese L1 backgrounds using eye-tracking during sentence reading. Native Chinese readers were also included as a baseline group to establish the magnitude of word frequency effects in skilled native reading and to examine whether L2 readers exhibit larger word frequency effects than native readers. Our primary research question, however, concerned whether frequency effects differed between the two L2 groups as a function of their writing-system backgrounds. Whereas alphabetic languages share minimal orthographic and lexical overlap with Chinese, Japanese shares substantial orthographic and lexical similarity with Chinese, including the use of Chinese characters and a larger number of compound words in similar form and meaning. By contrasting these two learner groups, the present study provides a direct test of whether L2 word frequency effects are shaped by cross-linguistic similarity between L1 and L2, thereby adjudicating between accounts that attribute larger L2 word frequency effects to lexical entrenchment versus those emphasizing cross-language competition.

If L2 word frequency effects primarily reflect lexical entrenchment within the L2 lexicon, the magnitude of frequency effects should not differ between the two learner groups, assuming comparable L2 proficiency. In contrast, if L2 word frequency effects are driven by cross-language competition arising from shared orthographic and lexical representations, we would expect larger word frequency effects in learners with a Japanese L1 background, due to greater lexical representational overlap with Chinese.

2. Method

2.1. Participants

The sample analyzed in the present study comprised 150 participants: 50 native Chinese speakers (henceforth NS; 42 females; age range: 17–28 years; mean age: 21.1), 50 L2 learners of Chinese from alphabetic L1 backgrounds (henceforth L2-AL; 44 females; age range: 19–33 years; mean age: 24.0) and 50 L2 learners of Chinese from Japanese L1 backgrounds (henceforth L2-JL; 37 females; age range: 19–30 years; mean age: 22.3). The NS and L2-AL data were drawn from the dataset reported in Lai and Jiang (2026), which included 56 NS and 57 L2-AL participants. For the present study, 50 L2-AL participants were selected to match the newly recruited group of 50 L2-JL participants in Chinese proficiency. To maintain equal group sizes, 50 NS participants were randomly selected from the original NS sample. The L2-JL data were collected specifically for the present study using the same materials, equipment and experimental procedure as those used for the NS and L2-AL groups in Lai and Jiang (2026).

The recruitment target for the newly collected L2-JL group was set at 50 participants on the basis of feasibility, given the time-intensive nature of eye-tracking data collection and the limited availability of eligible participants. Because no previous eye-tracking study has directly compared word frequency effects in L2 Chinese reading among learners from different L1 backgrounds, no directly applicable estimate of the focal group-by-word-frequency interaction was available for a prospective power analysis. Following prior applications of simulation-based sensitivity analysis in bilingualism research (Washington & Wiley, 2023; Yow & Li, 2026), we conducted a sensitivity analysis on the fitted mixed-effects model using the simr package (Green & MacLeod, 2016). A simulation-based sensitivity analysis estimates the smallest effect that a given design can detect with a prespecified level of power. For each candidate effect size, data are repeatedly generated from the fitted model with the target effect set to that candidate value. The model is then refitted to each simulated data set, and power is estimated as the proportion of simulations in which the target effect is statistically significant. The analysis targeted the critical interaction between word frequency and L2 group (L2-AL versus L2-JL), which directly operationalizes our main research question. Total reading time on the target words was used as the dependent variable because this cumulative measure encompasses both initial processing and subsequent rereading and has been shown to be sensitive to word frequency effects in L2 reading (Lai & Jiang, 2026; Mor & Prior, 2022; Whitford & Titone, 2012, 2017). We first conducted a coarse scan across standardized interaction effects of d = 0.05, 0.10, 0.15 and 0.20 (step = 0.05), using 200 simulations per value. Given the fitted model's residual standard deviation of 0.510, these corresponded to interaction coefficients of b = 0.026, 0.051, 0.077 and 0.102 on the log scale. We then refined the search at d = 0.15, 0.16 and 0.17 (step = 0.01; b = 0.077, 0.082 and 0.087), using 1000 simulations per value (α = .05). The analysis indicated that the current design had approximately 80% power to detect an interaction of b = 0.077 or larger on the log scale, corresponding to the L2-AL group's ratio of low- to high-frequency reading times being approximately 8% larger than that of the L2-JL group.

The L2-AL group included learners from a range of alphabetic-language backgrounds (e.g., Vietnamese, Thai, Indonesian, Arabic, Russian, Korean, Spanish, French, Cape Verdean Creole, Mongolian and Burmese). Although some of these languages, particularly Vietnamese and Korean, contain Chinese loanwords or have historical contact with Chinese, their contemporary writing systems do not employ Chinese characters (logographs) as a primary orthographic component. In contrast, Japanese uses kanji as an integral component of its contemporary writing system and contains a substantial body of Sino-Japanese vocabulary. Thus, relative to the L2-JL group, the L2-AL group was operationally characterized as having lower average orthographic and lexical similarity to Chinese.

All L2 participants had passed HSK 5 or HSK 6 (Hanyu Shuiping Kaoshi, the standard Chinese language proficiency test for non-native speakers administered by the Ministry of Education of the People's Republic of China), which corresponds approximately to the B2 level of the Common European Framework of Reference for

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Languages (CEFR; Luo, 2017), indicating upper-intermediate proficiency in Chinese. All L2 participants completed a character recognition test (Hou & Jiang, 2022; Jiang & Liu, 2004) and a ClozCHI test (Cai et al., 2025). ClozCHI is a cloze test comprising three passages with varying levels of difficulty, in which participants fill each blank with one appropriate character or its Pinyin based on context (Cai et al., 2025). Compared with HSK level, which was obtained at varying time points prior to the experiment and may not accurately reflect participants' current proficiency, these two tests provide more fine-grained and up-to-date measures of L2 Chinese proficiency. The character recognition test scores were matched between L2-AL (M = 0.77, SD = 0.15) and L2-JL (M = 0.77, SD = 0.14), $t(98) = -0.29$, $p = .77$. The ClozCHI scores were also matched between L2-AL (M = 0.74, SD = 0.08) and L2-JL (M = 0.72, SD = 0.10), $t(98) = 1.06$, $p = .29$.

All participants had normal or corrected-to-normal vision. Informed consent was obtained from all participants, and monetary compensation was provided for their participation.

2.2. Materials

A total of 640 two-character words were selected as target words, comprising 320 high-frequency and 320 low-frequency words (see Table S1 in supplementary material). Word frequency data were obtained from the Chinese Lexical Database (CLD; Sun et al., 2018). Paired-samples t-tests indicated that high-frequency words (M = 92.34 occurrences per million, SD = 95.64) and low-frequency words (M = 1.44 occurrences per million, SD = 1.02) differed significantly in frequency, $t(319) = 16.98$, $p < .001$, and were matched on the frequency and number of strokes of both the first and second characters, as well as the total number of strokes of the two characters (ps > .10). Familiarity ratings, collected after the eye-tracking experiment on a 7-point scale (1 = very unfamiliar, 7 = very familiar), showed that the mean rating across all target words was 6.05 (SD = 0.92), with only three target words receiving a mean rating below 3. These results suggest that the target words were generally familiar to our L2 participants. The characteristics of target words are summarized in Table 1.

Target words were embedded in 160 sentence frames, each containing two high-frequency and two low-frequency words. Using two pairs of high- and low-frequency words within the same sentence frame can increase the number of target words and enhance the robustness and generalizability of the results by reducing item-specific bias. Each participant saw only one target word per frame, and each frame was presented only once per participant (i.e., no participant was exposed to repeated frames across trials).

Table 1. Characteristics of the target words

Characteristic	High-frequency	Low-frequency
Frequency (number of occurrences per million)	92.34 (95.64)	1.44 (1.02)
Frequency of first character	833.61 (1081.37)	758.04 (1049.20)
Frequency of second character	768.79 (986.61)	807.71 (1239.90)
Number of strokes	16.01 (4.54)	16.08 (4.46)
Number of strokes of first character	7.87 (3.04)	8.01 (3.09)
Number of strokes of second character	8.14 (3.11)	8.08 (3.19)

Note: Standard deviations are given in parentheses.

Table 2. Examples of sentences and target words

Target word	Example
High-frequency	小陈对她自己获得**礼物**这件事感到非常高兴。 Xiao Chen was very happy that she had received a **gift**.
	小陈对她自己获得**勋章**这件事感到非常高兴。 Xiao Chen was very happy that she had received a **medal**.
Low-frequency	小陈对她自己获得**奖状**这件事感到非常高兴。 Xiao Chen was very happy that she had received a **certificate**.
	小陈对她自己获得**高薪**这件事感到非常高兴。 Xiao Chen was very happy that she had received a **high salary**.

Note: Target words are indicated in bold.

Target words never appeared within the first or last four characters of a sentence. Sentences ranged from 18 to 31 characters and were displayed on a single line. Sentence plausibility was rated by 40 NS who did not take part in the main eye-tracking experiment, using a 7-point scale ranging from 1 (very implausible) to 7 (very plausible). Paired-samples t-tests indicated that plausibility ratings were matched between sentences containing high-frequency (M = 6.10, SD = 0.35) and low-frequency words (M = 6.06, SD = 0.35), $t(319) = 1.41$, $p = .16$. The predictability of each target word was assessed using a cloze task completed by another 10 NS, who read the sentence up to the target word and provided the next acceptable word. Paired-samples t-tests indicated that predictability was matched between high-frequency (M = 0.0009, SD = 0.01) and low-frequency words (M = 0.0003, SD = 0.01), $t(319) = 1.00$, $p = .32$. Examples of sentences and target words are presented in Table 2.

The experimental sentences were divided into eight lists, each list containing 80 experimental sentences (including 40 high-frequency words and 40 low-frequency words) as well as 40 filler sentences. Filler sentences were followed by yes/no comprehension questions. The mean frequency of high-frequency words did not differ significantly across the eight lists, $F(7, 312) = 0.64$, $p = .73$. Similarly, the mean frequency of low-frequency words was matched across lists, $F(7, 312) = 1.12$, $p = .35$. Sentences were counterbalanced across lists using a Latin square design and presented in a randomized order.

2.3. Apparatus

Participants' eye movements were recorded using an SR Research Eyelink 1000 plus eye tracker with a sampling rate of 1000 Hz. Stimuli were displayed on a 20-inch CRT monitor with a resolution of 1024 × 768 pixels and a refresh rate of 150 Hz. Sentences were presented in Song font in black on a white background, with each character subtending approximately 0.85° of visual angle. The first character of the sentence and the fixation point were positioned at 100 pixels from the left edge and 384 pixels from the top of the display. Participants were seated approximately 72 cm from the screen. Following a 3-point horizontal calibration and validation, the maximum gaze-position error was less than 0.5°. Viewing was binocular, but only the right eye was recorded.

2.4. Procedure

Participants were tested individually in the laboratory. The experiment started with a brief instruction and a standard horizontal 3-point grid calibration and validation. Each trial began with a

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fixation box presented at the left side of the screen, followed by the presentation of the target sentence. Participants were instructed to read sentences silently for comprehension and to answer occasional comprehension questions by pressing yes/no buttons. After reading, participants pressed a button to proceed. Prior to the formal experimental trials, participants completed four practice trials to familiarize themselves with the task and the eye-tracking equipment. The experiment lasted approximately 20 minutes for NS and 40 minutes for L2 Chinese learners.

Before the eye-tracking session, L2 Chinese learners completed the character recognition test and the ClozCHI test, which were not administered to NS.

2.5. Data analysis

Both global and local eye movement measures were analyzed. Specifically, sentence reading rate (SRR; characters per minute) was analyzed to reflect general reading efficiency (Rayner, 1998). Five eye movement measures on the target words were analyzed, including skipping rate (SR, the probability of a region being skipped during first-pass reading), first fixation duration (FFD, the duration of the first fixation in a region during first-pass reading, following a progressive saccade), gaze duration (GD, the sum of all first-pass fixation durations in a region before leaving it, following a progressive saccade), total reading time (TT, the sum of the durations of all fixations in a region), and regression path duration (RPD, the sum of the durations of all fixations in a region and any rereading to the left of it until it was passed to the right). While SR, FFD and GD reflect the early stages of processing, TT and RPD reflect the late stages of processing.

Linear mixed-effects models (LMMs) were employed to analyze log-transformed continuous variables (SRR, FFD, GD, TT, RPD), and generalized linear mixed-effects models (GLMMs) were used to analyze the binary variable (SR). Word frequency, group and their interaction were treated as fixed effects, and participants and items were treated as crossed random effects, including intercepts and slopes (Baayen et al., 2008). Word frequency and group were treated as categorical variables. For the group condition, three successive contrasts were set up to analyze differences between L2-AL and NS (Group 1), differences between L2-JL and NS (Group 2) and differences between L2-AL and L2-JL (Group 3). Specifically, contrast coding was employed to examine these contrasts. Two sets of models were fitted with different reference levels: the first model used NS as the reference level, yielding contrasts for L2-AL versus NS and L2-JL versus NS; the second model used L2-JL as the reference level, yielding the contrast for L2-AL versus L2-JL. Following Bates et al. (2015a), the random effects structure of the models was trimmed down from the maximal structure (i.e., random intercepts and slopes for all fixed effects, for both subjects and items) when the models failed to converge. Model comparisons were conducted using likelihood ratio tests and the Bayesian Information Criterion (BIC), and the more parsimonious model was selected when it did not significantly differ from the more complex model ($p > .05$). Data were analyzed in R (version 4.4.2; R Core Team, 2024) using the lme4 package (version 1.1.37; Bates et al., 2015b) and lmerTest package (version 3.1.3; Kuznetsova et al., 2017). Simple effects were tested using emmeans package (Lenth, 2018).

3. Results

Native speakers achieved a mean accuracy of 94% (range: 83%–100%). The L2-AL group achieved a mean accuracy of 85% (range: 70%–100%), and the L2-JL group achieved a mean accuracy of 86% (range: 70%–100%). The high comprehension accuracy rates indicate that participants attended to and successfully comprehended the sentences.

Fixations shorter than 80 ms or longer than 1000 ms (approximately 8.7% of all fixations) were excluded from the analysis. Trials were removed if (a) participants made more than three blinks or no fixations in the whole sentence (0.2% of trials); (b) participants blinked on the target words, pre-target words or post-target words (4.9% of trials) or (c) eye movement measures were above or below three standard deviations from the mean (1.4% of trials). This resulted in a loss of 6.5% of the trials. Excluding trials with blinks (a and b) is common practice in eye-tracking reading research (e.g., Inhoff & Rayner, 1986; Liu et al., 2014; Rayner et al., 2013; Yao et al., 2025b), since valid fixation data cannot be obtained during blinks. The exclusion rate due to blinks was relatively low and blinks occurred randomly, making them unlikely to systematically affect the validity of our results.

Table 3 presents the means and standard errors for each eye movement measure. Its note summarizes the number of observations retained per condition across the outcome measures, while the exact counts for every measure and Group × Frequency condition are reported in Table S2 of the supplementary material. Table 4 shows the results of the linear mixed-effects models/generalized linear mixed-effects models. The residuals of the linear mixed-effects models were approximately normally distributed.

Table 3. Means and standard errors for eye movement measures

	NS			L2-AL			L2-JL		
Measure	HF	LF	FE	HF	LF	FE	HF	LF	FE
SRR	639.69 (5.90)	634.45 (5.8)	−5.24	213.64 (2.22)	205.81 (2.08)	−7.83	287.85 (3.17)	280.65 (3.26)	−7.20
SR	0.32 (0.01)	0.29 (0.01)	−0.03	0.03 (0)	0.03 (0)	0	0.10 (0.01)	0.08 (0.01)	−0.02
FFD	236.87 (2.22)	243.75 (2.30)	6.88	293.88 (2.32)	305.77 (2.46)	11.89	288.01 (2.31)	299.68 (2.46)	11.67
GD	256.06 (3.12)	266.80 (3.22)	10.74	491.83 (6.16)	564.34 (6.99)	72.51	400.19 (5.39)	451.26 (6.17)	51.07
TT	326.79 (5.15)	346.48 (5.22)	19.69	705.66 (10.06)	849.48 (11.03)	143.82	582.00 (9.18)	691.27 (10.58)	109.27
RPD	341.09 (5.69)	354.78 (5.73)	13.69	614.29 (8.65)	718.06 (9.31)	103.77	499.88 (7.5)	565.61 (8.42)	65.73

Notes: Standard errors are given in parentheses. FE = Frequency effect; FFD = First fixation duration; GD = Gaze duration; HF = High-frequency; L2-AL = L2 Chinese learners from alphabetic L1 backgrounds; L2-JL = L2 learners from Japanese L1 backgrounds; LF = Low-frequency; NS = Native Chinese speakers; RPD = Regression path duration; SR = Skipping rate; SRR = Sentence reading rate; TT = Total reading time. The number of observations per condition across all measures ranged from 1314 to 1938 (M = 1715.75, SD = 188.61).

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Table 4. Results of the LMMs/GLMMs

Measure	Variable	*b*	*SE*	*t/z*	*p*
SRR	(Intercept)	5.73	0.03	218.26	<.001***
	Frequency	−0.03	0.01	−4.48	<.001***
	Group 1	−1.14	0.06	−18.05	<.001***
	Group 2	−0.85	0.06	−13.47	<.001***
	Group 3	−0.29	0.06	−4.57	<.001***
	Frequency × Group 1	−0.03	0.01	−1.89	.06
	Frequency × Group 2	−0.02	0.01	−1.78	.08
	Frequency × Group 3	−0.001	0.01	−0.09	.92
SR	(Intercept)	−2.70	0.11	−24.15	<.001***
	Frequency	−0.22	0.09	−2.60	.009**
	Group 1	−3.29	0.27	−12.14	<.001***
	Group 2	−1.97	0.24	−8.12	<.001***
	Group 3	−1.32	0.28	−4.80	<.001***
	Frequency × Group 1	−0.10	0.21	−0.47	.64
	Frequency × Group 2	−0.14	0.14	−1.01	.31
	Frequency × Group 3	0.04	0.23	0.18	.86
FFD	(Intercept)	5.57	0.01	522.94	<.001***
	Frequency	0.03	0.01	4.87	<.001***
	Group 1	0.22	0.03	8.64	<.001***
	Group 2	0.20	0.03	7.83	<.001***
	Group 3	0.02	0.03	0.77	.45
	Frequency × Group 1	0.02	0.02	0.99	.33
	Frequency × Group 2	0.02	0.02	1.00	.32
	Frequency × Group 3	−0.0004	0.01	−0.02	.98
GD	(Intercept)	5.84	0.02	329.60	<.001***
	Frequency	0.09	0.01	8.99	<.001***
	Group 1	0.65	0.04	15.26	<.001***
	Group 2	0.42	0.04	9.87	<.001***
	Group 3	0.23	0.04	5.33	<.001***
	Frequency × Group 1	0.10	0.02	4.12	<.001***
	Frequency × Group 2	0.08	0.02	3.49	<.001***
	Frequency × Group 3	0.02	0.02	0.68	.50
TT	(Intercept)	6.14	0.02	262.45	<.001***
	Frequency	0.15	0.01	10.77	<.001***
	Group 1	0.83	0.05	15.16	<.001***
	Group 2	0.58	0.05	10.72	<.001***
	Group 3	0.24	0.05	4.46	<.001***
	Frequency × Group 1	0.15	0.03	5.33	<.001***
	Frequency × Group 2	0.13	0.03	4.17	<.001***
	Frequency × Group 3	0.02	0.03	0.90	.37
RPD	(Intercept)	6.04	0.02	304.20	<.001***
	Frequency	0.11	0.01	9.31	<.001***
	Group 1	0.65	0.05	14.21	<.001***

(*Continued*)

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Table 4. (*Continued*)

Measure	Variable	*b*	*SE*	*t/z*	*p*
	Group 2	0.41	0.05	8.87	<.001***
	Group 3	0.25	0.05	5.36	<.001***
	Frequency × Group 1	0.13	0.03	4.89	<.001***
	Frequency × Group 2	0.09	0.03	3.35	<.001***
	Frequency × Group 3	0.03	0.03	1.30	.19

Notes: FFD = First fixation duration; GD = Gaze duration; Group 1 = L2-AL versus NS; Group 2 = L2-JL versus NS; Group 3 = L2-AL versus L2-JL; L2-AL = L2 Chinese learners from alphabetic L1 backgrounds; L2-JL = L2 learners from Japanese L1 backgrounds; NS = Native Chinese speakers; RPD = Regression path duration; SR = Skipping rate; SRR = Sentence reading rate; TT = Total reading time; **p < .01; ***p < .001; Results for Group 3 and Frequency × Group 3 were obtained from a separate model with L2-JL as the reference level.

3.1. Global measure

For SRR, there was a main effect of word frequency, indicating that SRR was slower for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting slower SRR than NS, and L2-AL exhibiting slower SRR than L2-JL. The interaction between word frequency and group was marginally significant for Group 1 (L2-AL versus NS) and Group 2 (L2-JL versus NS), but not for Group 3 (L2-AL versus L2-JL). Further simple effects analysis revealed that the word frequency effect was not significant for NS (t = 0.83, p = .41), but significant for both L2-AL (t = 3.50, p < .001) and L2-JL (t = 3.35, p < .001). These results indicate that the word frequency effect was larger for both L2 groups compared to NS, with no significant difference between L2-AL and L2-JL.

3.2. Early local measures

For SR, there was a main effect of word frequency, indicating that SR was lower for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting lower SR than NS, and L2-AL exhibiting lower SR than L2-JL. None of the other effects were significant.

For FFD, there was a main effect of word frequency, indicating that FFD was longer for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting longer FFD than NS. None of the other effects were significant.

For GD, there was a main effect of word frequency, indicating that GD was longer for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting longer GD than NS, and L2-AL exhibiting longer GD than L2-JL. The interaction between word frequency and group was significant for Group 1 (L2-AL versus NS) and Group 2 (L2-JL versus NS), but not for Group 3 (L2-AL versus L2-JL). Further simple effects analysis revealed that the word frequency effect was marginally significant for NS (t = −1.81, p = .07), but significant for both L2-AL (t = −7.99, p < .001) and L2-JL (t = −6.98, p < .001). These results indicate that the word frequency effect was larger for both L2 groups compared to NS, with no significant difference between L2-AL and L2-JL.

3.3. Late local measures

For TT, there was a main effect of word frequency, indicating that TT was longer for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting longer TT than NS, and L2-AL exhibiting longer TT than L2-JL. The interaction between word frequency and group was significant for Group 1 (L2-AL versus NS) and Group 2 (L2-JL versus NS), but not for Group 3 (L2-AL versus L2-JL). Further simple effects analysis revealed that the word frequency effect was significant for all groups (NS: t = −2.42, p = .02; L2-AL: t = −9.87, p < .001; L2-JL: t = −8.28, p < .001). These results indicate that the word frequency effect was larger for both L2 groups compared to NS, with no significant difference between L2-AL and L2-JL.

For RPD, there was a main effect of word frequency, indicating that RPD was longer for low-frequency words than high-frequency words. There was also a main effect of group, with both L2-AL and L2-JL exhibiting longer RPD than NS, and L2-AL exhibiting longer RPD than L2-JL. The interaction between word frequency and group was significant for Group 1 (L2-AL versus NS) and Group 2 (L2-JL versus NS), but not for Group 3 (L2-AL versus L2-JL). Further simple effects analysis revealed that the word frequency effect was marginally significant for NS (t = −1.87, p = .06), but significant for both L2-AL (t = −8.91, p < .001) and L2-JL (t = −6.69, p < .001). These results indicate that the word frequency effect was larger for both L2 groups compared to NS, with no significant difference between L2-AL and L2-JL.

It is worth noting that the interaction between word frequency and group was not significant for Group 3 (L2-AL versus L2-JL) across eye movement measures. Since Bayes factors can be used to determine whether non-significant results support a null hypothesis (Dienes, 2014), Bayes factor analyses were further conducted to assess the strength of evidence for this null effect, using the BayesFactor package in R (Morey et al., 2015). BF_{10} values ranging from 0.01 to 0.12 across eye movement measures provided moderate to very strong evidence in favor of the null hypothesis, indicating that L2 word frequency effects did not differ between L2-AL and L2-JL across eye movement measures.

Additionally, to examine whether sensitivity to word frequency varied as a function of L2 proficiency, correlations were conducted between L2 proficiency (character recognition and cloze test scores) and word frequency effects within each L2 group. The correlations were generally weak and non-significant across eye movement measures ($|r|$ = .01–.27, p = .06–.94).

To explore word frequency effects more broadly, correlation analyses were conducted between log-transformed word frequency and eye movement measures for all words in the sentences (excluding the first and last words of each sentence; Meng et al., 2020). Word frequency was significantly negatively correlated with reading times (FFD, GD, TT and RPD) and positively with SR ($|r|$ = .10–.35, ps < .001). Fisher's z-tests revealed that word frequency showed significantly stronger correlations with GD, TT and RPD in L2-AL ($|r|$ = .15–.35) than L2-JL ($|r|$ = .10–.28; ps < .001), and a significantly stronger correlation with SR (r = .28) in L2-JL than L2-AL (r = .25; p < .001).

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To summarize the main findings, word frequency effects were larger in both L2-AL and L2-JL than in NS in SRR, GD, TT and RPD. However, there was no significant difference in L2 word frequency effects between L2-AL and L2-JL across eye movement measures examined (SRR, SR, FFD, GD, TT and RPD).

4. Discussion

The present study examined word frequency effects in Chinese sentence reading among native Chinese readers and L2 Chinese learners from different writing-system backgrounds. More importantly, it investigated whether the magnitude of these effects varies as a function of L1–L2 writing-system similarity. The results showed that both L2 groups exhibited larger frequency effects than native readers, whereas the two L2 groups showed comparable frequency effects despite differences in writing-system background. These findings are more readily explained by differences in lexical entrenchment than by explanations based on cross-language competition.

The results revealed larger word frequency effects for L2 readers than for native Chinese readers in both global and local eye movement measures. Specifically, this pattern was observed in SRR, as well as in GD, TT and RPD, suggesting that lexical frequency exerted a stronger influence on both early and later stages of word processing in L2 than in L1 Chinese reading. These findings replicate a robust pattern in previous studies comparing L1 and L2 within alphabetic language pairs (Brysbaert et al., 2017; Cop et al., 2015; Diependaele et al., 2013; Duyck et al., 2008; Gollan et al., 2011; Lehtonen et al., 2012; Lemhöfer et al., 2008; Whitford & Joanisse, 2018; Whitford & Titone, 2012, 2017), and typologically distinct L1–L2 pairs (Mor & Prior, 2020, 2022; Norkina et al., 2025; Sui et al., 2025). Furthermore, the present study extended Lai and Jiang's (2026) eye-tracking findings of larger L2 word frequency effects in Chinese sentence reading, also observed in lexical decision tasks (Hao et al., 2024), to learners from typologically different L1 backgrounds. Thus, our results further demonstrated the robustness of larger L2 word frequency effects and their generalizability across L1 backgrounds.

The findings of larger word frequency effects in L2 than in L1 can be readily explained with the lexical entrenchment hypothesis (Diependaele et al., 2013). Under this hypothesis, frequency effects index the strength and quality of lexical representations. L2 lexical memory representations are weaker than those in L1 due to reduced exposure, thereby amplifying sensitivity to frequency differences. This may be particularly pronounced in Chinese, where words are written without spaces and readers must segment continuous character strings into words (Li et al., 2025; Shen et al., 2012; Yao et al., 2025a, 2025b). Weaker lexical representations make word boundaries less predictable and word identification more difficult, especially for low-frequency words, further amplifying word frequency effects in L2 readers. Conversely, for highly skilled native readers, extensive exposure to text leads to more robust lexical representations even for low-frequency words, thereby reducing processing differences between high- and low-frequency words.

However, stronger word frequency effects in L2 than in L1, by themselves, are insufficient to distinguish between the lexical entrenchment hypothesis and the language competition hypothesis (Diependaele et al., 2013). Importantly, this study showed that L2 word frequency effects did not differ between L2 learners from alphabetic-language and Japanese L1 backgrounds across eye movement measures. This absence of a reliable interaction provides a critical test of the competing accounts. Under the lexical entrenchment hypothesis, frequency effects primarily reflect the strength and automatization of lexical representations, which are determined by language experience and proficiency rather than by L1–L2 similarity (Diependaele et al., 2013). Because the two L2 groups were matched on Chinese proficiency, comparable frequency effects are what this account predicts. In contrast, the language competition hypothesis predicts that L2 learners from Japanese L1 backgrounds should exhibit larger L2 word frequency effects, given the substantial orthographic and lexical overlap between Japanese and Chinese (Diependaele et al., 2013). The absence of such modulation, supported both by non-significant interactions and by Bayesian evidence favoring the null model, suggests that competition-based accounts may not adequately explain L2 word frequency effects. In contrast, these findings are more readily accommodated by the lexical entrenchment hypothesis, which emphasizes the role of accumulated reading experience in shaping the strength of lexical representations.

Specifically, rather than reflecting dynamic cross-language interference, the larger L2 frequency effects observed here appear to index differences in lexical representational strength. This interpretation is consistent with converging theoretical accounts (e.g., Dijkstra & Van Heuven, 2002; Gollan et al., 2008, 2011; Perfetti, 2007). The weaker links hypothesis (Gollan et al., 2008, 2011) attributes larger L2 word frequency effects to reduced language exposure and divided language use, which weaken form–meaning connections. Similarly, the lexical quality hypothesis (Perfetti, 2007) proposes that lexical representations vary in the precision and integration of orthographic, phonological and semantic information. Lower proficiency entails lower lexical quality, leading to slower and more frequency-sensitive word recognition. Moreover, the bilingual interactive activation Plus model (BIA+; Dijkstra & Van Heuven, 2002) posits that L2 words generally have lower resting-level activations than do L1 words of the same corpus frequency, thus assuming larger word frequency effects in L2 than in L1. Relatedly, this interpretation is supported by converging evidence demonstrating the dominant role of language proficiency in word frequency effects, both in L1 (Ashby et al., 2005; Barnes et al., 2017; Gordon et al., 2020; Kuperman & Van Dyke, 2011, 2013; Lee et al., 2025; Zhang et al., 2022b) and in L2 (Berzak & Levy, 2023; Li et al., 2017, 2026; Mor & Prior, 2020, 2022; Whitford & Titone, 2012; Zhao et al., 2024). Furthermore, larger word frequency effects in L2 relative to L1 disappear when proficiency is controlled for (Brysbaert et al., 2017) or when it reaches a sufficiently high level (Berzak & Levy, 2023), even for bilinguals from different L1 backgrounds (Diependaele et al., 2013). Collectively, these theoretical accounts and empirical findings are consistent with the lexical entrenchment hypothesis (Diependaele et al., 2013).

According to the lexical entrenchment hypothesis (Diependaele et al., 2013), one may also expect a negative correlation between language proficiency and frequency effects in each L2 group. To evaluate this prediction, we conducted correlation analyses between L2 proficiency and word frequency effects within each L2 group across the eye movement measures. The analyses revealed weak and non-significant correlations ($|r|$ = .01–.27, p = .06–.94). One possible explanation is that the relatively restricted L2 proficiency range of our participants limited variability within the L2 groups, which may have reduced the likelihood of detecting correlations between L2 proficiency and frequency effects. In addition, by comparing words only at the extremes of the frequency continuum, our design may have overlooked the intermediate range, where group differences are likely to be most pronounced (Brysbaert et al., 2017, 2018). This interpretation is supported by Brysbaert et al. (2017), who reported a strong interaction between vocabulary size

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and word frequency in the middle frequency range, but not at the lower or higher ends of the frequency spectrum.

One potential concern is that the observed findings might be influenced by cognates, given the substantial lexical overlap between Japanese and Chinese. To address this issue, we conducted a supplementary analysis excluding cognates from the target word set. A total of 298 non-cognate words were included, comprising 123 high-frequency and 175 low-frequency items. The results remained largely consistent with the original analysis (see results on OSF for details), suggesting that the observed effects are unlikely to be explained by cognate status.

More broadly, by moving beyond comparisons within alphabetic writing systems to a cross-script contrast involving Chinese as a morphosyllabic writing system in L2 reading, the present study provides a more stringent test of whether L1–L2 similarity modulates L2 word frequency effects. However, while larger L2 word frequency effects in our study are consistent with prior studies comparing typologically distinct L1–L2 pairs (Mor & Prior, 2020, 2022; Norkina et al., 2025; Sui et al., 2025), the finding of comparable L2 word frequency effects across L2 learners from alphabetic and Japanese L1 backgrounds differs from Sui et al. (2025), who reported larger L2 word frequency effects in Chinese–English bilinguals with different L1–L2 scripts than Dutch–English bilinguals during paragraph reading. One possible explanation for this discrepancy lies in differences in the language pairs and writing systems involved. In Sui et al. (2025), the comparison involved English as the target language, where lexical processing is strongly dependent on alphabetic orthographic decoding. In contrast, the present study focused on Chinese reading, where lexical processing relies more heavily on character-level visual-orthographic and morphosyllabic information, which may reduce the impact of L1 script distance on word frequency effects.

This discrepancy may also be attributable to methodological differences. The present study employed an experimental design with controlled manipulation of frequency of target words and matching of key lexical variables (e.g., stroke number and word predictability), whereas Sui et al. (2025) adopted a corpus-based approach in which all words encountered during paragraph reading were analyzed, allowing for a broader range of lexical variability. We conducted a supplementary analysis including all words in the sentences, and the results provided support for this interpretation. Specifically, the result showed that word frequency showed stronger associations with reading times in L2-AL group than in L2-JL group, whereas the opposite pattern was observed for skipping rate (SR).

This dissociation across measures may reflect differences in online processing efficiency or reading strategies between the two L2 groups. Although the groups were matched on L2 Chinese proficiency based on character recognition and cloze test scores, these measures primarily assessed general L2 proficiency and may not have captured finer-grained differences in online processing efficiency during reading. Since Japanese shares greater orthographic and lexical similarity with Chinese than alphabetic languages, L2-JL readers may benefit from greater experience with logographic orthography, which could enhance online reading efficiency in reading Chinese, even when offline proficiency measures are comparable.

This interpretation is further supported by the group differences in our data: L2-AL readers showed longer reading times (SRR, GD, TT and RPD) and lower SR than L2-JL, a pattern consistent with Sui et al. (2025), who likewise found slower reading speeds in Chinese–English bilinguals than in Dutch–English bilinguals. In the analysis of all words (i.e., without controlling for other variables), the correlations between word frequency and reading times were stronger in the L2-AL group than in the L2-JL group. In contrast, the correlations between word frequency and skipping rate were stronger in the L2-JL group than in the L2-AL group. Because these correlations were derived from all words rather than experimentally controlled target items, they were likely modulated by factors such as character frequency, word length, contextual predictability and individual reading strategies. From this perspective, the stronger frequency–reading time correlations observed in the L2-AL group may reflect a more direct reliance on lexical decoding, whereas L2-JL readers may have relied more on contextual prediction and more efficient oculomotor strategies, which attenuated the linear relationship between frequency and reading times.

It should be noted that the L2-AL group was linguistically heterogeneous. Some learners came from languages such as Vietnamese and Korean, which contain substantial Chinese-derived vocabulary or historical links to Chinese. Although these languages lack the extensive character-level orthographic overlap with Chinese found in Japanese, such linguistic connections may have reduced the contrast between the two L2 groups, thereby attenuating group differences in word frequency effects. Similarly, Japanese is not a purely logographic system but a mixed writing system combining kanji and kana, which may also have weakened the distinction between the two groups. These factors may partly account for the absence of significant differences in L2 word frequency effects between the two groups. Nevertheless, Japanese remains substantially closer to Chinese than alphabetic writing systems because of its use of kanji. Thus, the contrast between Japanese and alphabetic-language learners of Chinese remains a meaningful and informative test of L1–L2 writing-system similarity.

It is also worth noting that the word frequency effect for native speakers was only marginally significant in some eye movement measures (e.g., gaze duration and regression path duration). One possible explanation is that word frequency effects in natural reading may be less pronounced than those typically observed in isolated word recognition tasks (Kuperman et al., 2013; Schilling et al., 1998; Xiong et al., 2023). In addition, the pattern of word frequency effects varied across individual eye movement measures in native speakers. This variability likely reflects differences in sensitivity across eye movement measures and the relatively small effect size of the frequency manipulation in native speakers.

Despite its contributions, the present study has several limitations. First, the alphabetic L1 group comprised learners from diverse native language backgrounds. Future research could examine more homogeneous alphabetic L1 groups with minimal historical and lexical overlap with Chinese to further clarify the role of cross-language similarity. Second, the L2 learners in the present study were relatively high in Chinese proficiency. It remains possible that cross-language competition effects are more likely to emerge at lower proficiency levels, when lexical representations are less entrenched. Future research including learners across a broader proficiency range would allow a more direct test of whether proficiency and cross-language competition modulate L2 word frequency effects. Third, we adopted a categorical manipulation of word frequency (high versus low), which limits the ability to capture the full shape of the frequency effect, particularly in the mid-frequency range where group differences may be most informative (Brysbaert et al., 2017, 2018). Future research should include words across a broader frequency range and apply non-linear analyses to provide a more fine-grained account of frequency effects across groups.

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5. Conclusion

In sum, the present study showed that L2 Chinese readers exhibited larger word frequency effects than native speakers, and critically, these effects did not differ between learners from alphabetic and Japanese L1 backgrounds. The absence of L1-related modulation suggests that the enlarged word frequency effects in L2 Chinese reading are more likely attributable to differences in lexical entrenchment rather than cross-language competition. These findings therefore highlight the important role of lexical representation strength in shaping L2 word recognition, even across typologically distinct L1 backgrounds.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S136672892610193X.

Data availability statement. The data that support the findings of this study are openly available at https://osf.io/yw9me/overview?view_only=5d0af8a6a774452eb4e1705eaeab4bcf.

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Ethics approval. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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References

Allen, P. A., **Bucur, B.**, **Grabbe, J.**, **Work, T.**, & **Madden, D. J.** (2011). Influence of encoding difficulty, word frequency, and phonological regularity on age differences in word naming. *Experimental Aging Research*, **37**(3), 261–292. https://doi.org/10.1080/0361073X.2011.568805

Ashby, J., **Rayner, K.**, & **Clifton, C.** (2005). Eye movements of highly skilled and average readers: Differential effects of frequency and predictability. *The Quarterly Journal of Experimental Psychology Section A*, **58**(6), 1065–1086. https://doi.org/10.1080/02724980443000476

Baayen, R. H., **Davidson, D. J.**, & **Bates, D. M.** (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, **59**(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Ballot, C., & **Zesiger, P.** (2024). Effects of word length and frequency on word identification in second- and fifth-grade children as a function of language skills. *Journal of Experimental Child Psychology*, **243**, 105912. https://doi.org/10.1016/j.jecp.2024.105912

Barnes, A. E., **Kim, Y.-S.**, **Tighe, E. L.**, & **Vorstius, C.** (2017). Readers in adult basic education: Component skills, eye movements, and fluency. *Journal of Learning Disabilities*, **50**(2), 180–194. https://doi.org/10.1177/0022219415609187

Bates, D., **Kliegl, R.**, **Vasishth, S.**, & **Baayen, H.** (2015a). *Parsimonious mixed models.* ArXiv. https://doi.org/10.48550/arXiv.1506.04967

Bates, D., **Mächler, M.**, **Bolker, B.**, & **Walker, S.** (2015b). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, **67**(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Berzak, Y., & **Levy, R.** (2023). Eye movement traces of linguistic knowledge in native and non-native reading. *Open Mind*, **7**, 179–196. https://doi.org/10.1162/opmi_a_00084

Brysbaert, M., **Lagrou, E.**, & **Stevens, M.** (2017). Visual word recognition in a second language: A test of the lexical entrenchment hypothesis with lexical decision times. *Bilingualism: Language and Cognition*, **20**(3), 530–548. https://doi.org/10.1017/S1366728916000353

Brysbaert, M., **Mandera, P.**, & **Keuleers, E.** (2018). The word frequency effect in word processing: An updated review. *Current Directions in Psychological Science*, **27**(1), 45–50. https://doi.org/10.1177/0963721417727521

Cai, J., **Han, Y.**, & **Jiang, X.** (2025). ClozCHI: A cloze test for measuring L2 Chinese proficiency from novice to advanced levels. *Behavior Research Methods*, **57**(12), 325. https://doi.org/10.3758/s13428-025-02834-9

Cop, U., **Keuleers, E.**, **Drieghe, D.**, & **Duyck, W.** (2015). Frequency effects in monolingual and bilingual natural reading. *Psychonomic Bulletin & Review*, **22**(5), 1216–1234. https://doi.org/10.3758/s13423-015-0819-2

de Groot, A. M. B., **Borgwaldt, S.**, **Bos, M.**, & **van den Eijnden, E.** (2002). Lexical decision and word naming in bilinguals: Language effects and task effects. *Journal of Memory and Language*, **47**(1), 91–124. https://doi.org/10.1006/jmla.2001.2840

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psychology*, **5**, 781. https://doi.org/10.3389/fpsyg.2014.00781

Diependaele, K., **Lemhöfer, K.**, & **Brysbaert, M.** (2013). The word frequency effect in first- and second-language word recognition: A lexical entrenchment account. *The Quarterly Journal of Experimental Psychology*, **66**(5), 843–863. https://doi.org/10.1080/17470218.2012.720994

Dijkstra, T., & **Van Heuven, W. J. B.** (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, **5**(3), 175–197. https://doi.org/10.1017/S1366728902003012

Duyck, W., **Vanderelst, D.**, **Desmet, T.**, & **Hartsuiker, R. J.** (2008). The frequency effect in second-language visual word recognition. *Psychonomic Bulletin & Review*, **15**(4), 850–855. https://doi.org/10.3758/PBR.15.4.850

Gastmann, F., **Poarch, G. J.**, & **Schimke, S.** (2025). Limitations of the cognate effect: How second language proficiency and stimulus frequency modulate adolescent learners' word recognition. *Applied Psycholinguistics*, **46**, e44. https://doi.org/10.1017/S0142716425100374

Gollan, T. H., **Montoya, R. I.**, **Cera, C.**, & **Sandoval, T. C.** (2008). More use almost always a means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language*, **58**(3), 787–814. https://doi.org/10.1016/j.jml.2007.07.001

Gollan, T. H., **Slattery, T. J.**, **Goldenberg, D.**, **Van Assche, E.**, **Duyck, W.**, & **Rayner, K.** (2011). Frequency drives lexical access in reading but not in speaking: The frequency-lag hypothesis. *Journal of Experimental Psychology: General*, **140**(2), 186–209. https://doi.org/10.1037/a0022256

Gordon, P. C., **Moore, M.**, **Choi, W.**, **Hoedemaker, R. S.**, & **Lowder, M. W.** (2020). Individual differences in reading: Separable effects of reading experience and processing skill. *Memory & Cognition*, **48**(4), 553–565. https://doi.org/10.3758/s13421-019-00989-3

Green, P., & **MacLeod, C. J.** (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, **7**(4), 493–498. https://doi.org/10.1111/2041-210x.12504

Guan, C. Q., & **Fraundorf, S. H.** (2020). Cross-linguistic word recognition development among Chinese children: A multilevel linear mixed-effects modeling approach. *Frontiers in Psychology*, **11**, 544. https://doi.org/10.3389/fpsyg.2020.00544

Hamrick, P., & **Pandža, N. B.** (2020). Contributions of semantic and contextual diversity to the word frequency effect in L2 lexical access. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, **74**(1), 25–34. https://doi.org/10.1037/cep0000189

Hao, Y., **Wu, C.**, & **Duan, X.** (2024). Processing mandarin Chinese compound words by native speakers and second language learners: Word frequency, semantic transparency, and word structure. *Sage Open*, **14**(2), 21582440241256249. https://doi.org/10.1177/21582440241256249

Hou, F., & **Jiang, X.** (2022). Interference effects of radical markings and stroke order animations on Chinese character learning among L2 learners. *Frontiers in Psychology*, **13**, 783613. https://doi.org/10.3389/fpsyg.2022.783613

Huestegge, L., **Radach, R.**, **Corbic, D.**, & **Huestegge, S. M.** (2009). Oculomotor and linguistic determinants of reading development: A longitudinal study. *Vision Research*, **49**(24), 2948–2959. https://doi.org/10.1016/j.visres.2009.09.012

Inhoff, A. W., & **Rayner, K.** (1986). Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception & Psychophysics*, **40**(6), 431–439. https://doi.org/10.3758/BF03208203

Jiang, X. (2005). 词的复现率和字的复现率对非汉字圈学生双字词学习的影响 [The effects of word frequency and character frequency on disyllabic word learning by foreign students from non-character-using countries]. *Chinese Teaching in the World* , **19**(4), 31–38.

Jiang, X. (2006). 外国人汉语双字词习得中的频率效应再探 [A further study on frequency effects of word and character on disyllabic word learning by CSL learners]. *Linguistic Sciences*, **5**(6), 70–78.

Jiang, X., & **Liu, Y.** (2004). 拼音文字背景的外国学生汉字书写错误研究 [A study of character writing errors by foreign learner using alphabetic writing]. *Chinese Teaching in the World*, **18** (1), 60–70.

Jiang, X., **Zhao, G.**, **Huang, H.**, **Liu, Y.**, & **Wang, Y.** (2006). 外国学生汉语字词学习的影响因素——兼论《汉语水平大纲》字词的选择与分级 [The factors affecting foreign students' learning of Chinese characters and words: A discussion on the selection and grading of characters and words in the HSK syllabus]. *Language Teaching and Linguistic Studies*, **26** (2), 14–22.

Joseph, H. S. S. L., **Nation, K.**, & **Liversedge, S. P.** (2013). Using eye movements to investigate word frequency effects in children's sentence reading. *School Psychology Review*, **42**(2), 207–222. https://doi.org/10.1080/02796015.2013.12087485

Khelifi, R., **Sparrow, L.**, & **Casalis, S.** (2019). Is a frequency effect observed in eye movements during text reading? A comparison between developing and expert readers. *Scientific Studies of Reading*, **23**(4), 334–347. https://doi.org/10.1080/10888438.2019.1571064

Kliegl, R., **Grabner, E.**, **Rolfs, M.**, & **Engbert, R.** (2004). Length, frequency, and predictability effects of words on eye movements in reading. *European Journal of Cognitive Psychology*, **16**(1–2), 262–284. https://doi.org/10.1080/09541440340000213

Kuperman, V. (2025). How does language distance affect reading fluency and comprehension in English as second language? *Studies in Second Language Acquisition*, **47**(3), 757–773. https://doi.org/10.1017/S027226312510065X

Kuperman, V., **Drieghe, D.**, **Keuleers, E.**, & **Brysbaert, M.** (2013). How strongly do word reading times and lexical decision times correlate? Combining data from eye movement corpora and megastudies. *The Quarterly Journal of Experimental Psychology*, **66**(3), 563–580. https://doi.org/10.1080/17470218.2012.658820

Kuperman, V., & **Van Dyke, J. A.** (2011). Effects of individual differences in verbal skills on eye-movement patterns during sentence reading. *Journal of Memory and Language*, **65**(1), 42–73. https://doi.org/10.1016/j.jml.2011.03.002

Kuperman, V., & **Van Dyke, J. A.** (2013). Reassessing word frequency as a determinant of word recognition for skilled and unskilled readers. *Journal of Experimental Psychology: Human Perception and Performance*, **39**(3), 802–823. https://doi.org/10.1037/a0030859

Kuznetsova, A., **Brockhoff, P. B.**, & **Christensen, R. H. B.** (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, **82**(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Lai, X., & **Jiang, X.** (2026). 汉语阅读中的词频效应:汉语母语者和不同水平二语学习者的眼动研究 [Word frequency effects in Chinese reading: An eye-tracking study of native Chinese readers and second language learners of different proficiency levels]. *Chinese Teaching in the World*, **40**(3), 398–414.

Lee, C. E., **Godwin, H.**, **Blythe, H. I.**, & **Drieghe, D.** (2025). Individual differences in skilled reading and the word frequency effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **51**(8), 1281–1302. https://doi.org/10.1037/xlm0001428

Lehtonen, M., **Hultén, A.**, **Rodríguez-Fornells, A.**, **Cunillera, T.**, **Tuomainen, J.**, & **Laine, M.** (2012). Differences in word recognition between early bilinguals and monolinguals: Behavioral and ERP evidence. *Neuropsychologia*, **50**(7), 1362–1371. https://doi.org/10.1016/j.neuropsychologia.2012.02.021

Lemhöfer, K., **Dijkstra, T.**, **Schriefers, H.**, **Baayen, R. H.**, **Grainger, J.**, & **Zwitserlood, P.** (2008). Native language influences on word recognition in a second language: A megastudy. *Journal of Experimental Psychology: Learning Memory and Cognition*, **34**(1), 12–31. https://doi.org/10.1037/0278-7393.34.1.12

Lenth, R. (2018). *Emmeans: Estimated marginal means, aka least-squares means* (R package version 1.1) [Computer software]. https://CRAN.R-project.org/package=emmeans

Li, L., **Ji, Y.**, **Li, S.**, **Liu, J.**, **Wang, S.**, **Gunn, S.**, & **Paterson, K. B.** (2025). Unpacking word segmentation processes by L2 Chinese readers: Evidence from eye movements. *Bilingualism: Language and Cognition*, 1–19. https://doi.org/10.1017/S136672892510076X

Li, X., **Li, H.**, **Liu, J.**, & **Bai, X.** (2017). 阅读水平和阅读任务对英语词频效应的影响: 来自非熟练汉—英双语者的眼动证据 [Effects of reading level and reading task on English word frequency: Evidence from eye movements for Chinese–English bilinguals during English reading]. *Studies of Psychology and Behavior*, **15**(4), 455–461.

Li, X., & **Pollatsek, A.** (2020). An integrated model of word processing and eye-movement control during Chinese reading. *Psychological Review*, **127**(6), 1139–1162. https://doi.org/10.1037/rev0000248

Li, X., **Sui, L.**, **Hyönä, J.**, & **Chen, B.** (2026). Saccade target selection in L2 reading: Evidence from Chinese-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **52**(10), 1863–1882. https://doi.org/10.1037/xlm0001572

Liu, N., **Wang, X.**, **Yan, G.**, **Paterson, K. B.**, & **Pagán, A.** (2021). Eye movements of developing Chinese readers: Effects of word frequency and predictability. *Scientific Studies of Reading*, **25**(3), 234–250. https://doi.org/10.1080/10888438.2020.1759074

Liu, P., **Li, W.**, **Han, B.**, & **Li, X.** (2014). Effects of anomalous characters and small stroke omissions on eye movements during the reading of Chinese sentences. *Ergonomics*, **57**(11), 1659–1669. https://doi.org/10.1080/00140139.2014.945492

Liu, Z., **Tong, W.**, & **Su, Y.** (2020). Interaction effects of aging, word frequency, and predictability on saccade length in Chinese reading. *PeerJ*, **8**, e8860. https://doi.org/10.7717/peerj.8860

Luo, L. (2017). 汉语分级测试与 CEFR 等级的连接研究 [A study on the relations of the Chinese placement test and CEFR]. *Applied Linguistics*, **26**(2), 110–118.

McArthur, A. W. D., **Whitford, V.**, & **Joanisse, M. F.** (2024). Event-related potential measures of visual word processing in monolingual and bilingual children and adults: A focus on word frequency effects. *Journal of Cognitive Neuroscience*, **36**(7), 1493–1522. https://doi.org/10.1162/jocn_a_02190

McGowan, V. A., **White, S. J.**, **Jordan, T. R.**, & **Paterson, K. B.** (2014). Aging and the use of interword spaces during reading: Evidence from eye movements. *Psychonomic Bulletin & Review*, **21**(3), 740–747. https://doi.org/10.3758/s13423-013-0527-8

McGowan, V. A., **White, S. J.**, & **Paterson, K. B.** (2015). The effects of interword spacing on the eye movements of young and older readers. *Journal of Cognitive Psychology*, **27**(5), 609–621. https://doi.org/10.1080/20445911.2014.988157

Meng, Z., **Lan, Z.**, **Yan, G.**, **Marsh, J. E.**, & **Liversedge, S. P.** (2020). Task demands modulate the effects of speech on text processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **46**(10), 1892–1905. https://doi.org/10.1037/xlm0000861

Mor, B., & **Prior, A.** (2020). Individual differences in L2 frequency effects in different script bilinguals. *International Journal of Bilingualism*, **24**(4), 672–690. https://doi.org/10.1177/1367006919876356

Mor, B., & **Prior, A.** (2022). Frequency and predictability effects in first and second language of different script bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **48**(9), 1363–1383. https://doi.org/10.1037/xlm0000927

Morey, R. D., **Rouder, J. N.**, & **Jamil, X.** (2015). *BayesFactor: Computation of Bayes factors for common designs* (Version 0.9.11) [Computer software]. http://bayesfactorpcl.r-forge.r-project.org

Norkina, M., **Chernova, D.**, **Alexeeva, S.**, & **Harchevnik, M.** (2025). Oculomotor behavior of L2 readers with typologically distant L1 background: The "Big Three" effects of word length, frequency, and predictability. *Journal of Eye Movement Research*, **18**(5), 58. https://doi.org/10.3390/jemr18050058

Perfetti, C. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading*, **11**(4), 357–383. https://doi.org/10.1080/10888430701530730

R Core Team (2024). *R: A language and environment for statistical computing* (Version 4.4.2) [Computer software]. R Foundation for Statistical Computing. https://www.r-project.org/

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, **124**(3), 372–422. https://doi.org/10.1037/0033-2909.124.3.372

Rayner, K., **Reichle, E. D.**, **Stroud, M. J.**, **Williams, C. C.**, & **Pollatsek, A.** (2006). The effect of word frequency, word predictability, and font difficulty

on the eye movements of young and older readers. *Psychology and Aging*, **21**(3), 448–465. https://doi.org/10.1037/0882-7974.21.3.448

Rayner, K., **Yang, J.**, **Schuett, S.**, & **Slattery, T. J.** (2013). Eye movements of older and younger readers when reading unspaced text. *Experimental Psychology*, **60**(5), 354–361. https://doi.org/10.1027/1618-3169/a000207

Schilling, H. E. H., **Rayner, K.**, & **Chumbley, J. I.** (1998). Comparing naming, lexical decision, and eye fixation times: Word frequency effects and individual differences. *Memory & Cognition*, **26**(6), 1270–1281. https://doi.org/10.3758/BF03201199

Shen, D., **Liversedge, S. P.**, **Tian, J.**, **Zang, C.**, **Cui, L.**, **Bai, X.**, **Yan, G.**, & **Rayner, K.** (2012). Eye movements of second language learners when reading spaced and unspaced Chinese text. *Journal of Experimental Psychology: Applied*, **18**(2), 192–202. https://doi.org/10.1037/a0027485

Sui, L., **Woumans, E.**, **Duyck, W.**, & **Dirix, N.** (2025). The word frequency effect in first- and second-language reading by Chinese and Dutch bilinguals. *Bilingualism: Language and Cognition*, **28**(1), 232–247. https://doi.org/10.1017/S136672892400035X

Sun, C. C., **Hendrix, P.**, **Ma, J.**, & **Baayen, R. H.** (2018). Chinese lexical database (CLD): A large-scale lexical database for simplified Mandarin Chinese. *Behavior Research Methods*, **50**(6), 2606–2629. https://doi.org/10.3758/s13428-018-1038-3

Taylor, J. N., & **Perfetti, C. A.** (2016). Eye movements reveal readers' lexical quality and reading experience. *Reading and Writing*, **29**(6), 1069–1103. https://doi.org/10.1007/s11145-015-9616-6

Tiffin-Richards, S. P., & **Schroeder, S.** (2015). Word length and frequency effects on children's eye movements during silent reading. *Vision Research*, **113**(Pt A), 33–43. https://doi.org/10.1016/j.visres.2015.05.008

Wang, J., **Li, L.**, **Li, S.**, **Xie, F.**, **Chang, M.**, **Paterson, K. B.**, **White, S. J.**, & **Mcgowan, V. A.** (2018a). Adult age differences in eye movements during reading: The evidence from Chinese. *The Journals of Gerontology: Series B*, **73**(4), 584–593. https://doi.org/10.1093/geronb/gbw036

Wang, J., **Li, L.**, **Li, S.**, **Xie, F.**, **Liversedge, S. P.**, & **Paterson, K. B.** (2018b). Effects of aging and text-stimulus quality on the word-frequency effect during Chinese reading. *Psychology and Aging*, **33**(4), 693–712. https://doi.org/10.1037/pag0000259

Warrington, K. L., **McGowan, V. A.**, **Paterson, K. B.**, & **White, S. J.** (2018). Effects of aging, word frequency, and text stimulus quality on reading across the adult lifespan: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **44**(11), 1714–1729. https://doi.org/10.1037/xlm0000543

Washington, P. N., & **Wiley, R. W.** (2023). The contributions of proficiency and semantics to the bilingual sentence superiority effect. *Bilingualism: Language and Cognition*, **26**(3), 516–526. https://doi.org/10.1017/S1366728922000748

Whitford, V., & **Joanisse, M. F.** (2018). Do eye movements reveal differences between monolingual and bilingual children's first-language and second-language reading? A focus on word frequency effects. *Journal of Experimental Child Psychology*, **173**, 318–337. https://doi.org/10.1016/j.jecp.2018.03.014

Whitford, V., & **Joanisse, M. F.** (2021). Eye movement measures of within-language and cross-language activation during reading in monolingual and bilingual children and adults: A focus on neighborhood density effects. *Frontiers in Psychology*, **12**, 674007. https://doi.org/10.3389/fpsyg.2021.674007

Whitford, V., & **Titone, D.** (2012). Second-language experience modulates first- and second-language word frequency effects: Evidence from eye movement measures of natural paragraph reading. *Psychonomic Bulletin & Review*, **19**(1), 73–80. https://doi.org/10.3758/s13423-011-0179-5

Whitford, V., & **Titone, D.** (2017). The effects of word frequency and word predictability during first- and second-language paragraph reading in bilingual older and younger adults. *Psychology and Aging*, **32**(2), 158–177. https://doi.org/10.1037/pag0000151

Whitford, V., & **Titone, D.** (2019). Lexical entrenchment and cross-language activation: Two sides of the same coin for bilingual reading across the adult lifespan. *Bilingualism: Language and Cognition*, **22**(1), 58–77. https://doi.org/10.1017/S1366728917000554

Xiong, J., **Yu, L.**, **Veldre, A.**, **Reichle, E. D.**, & **Andrews, S.** (2023). A multitask comparison of word- and character-frequency effects in Chinese reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **49**(5), 793–811. https://doi.org/10.1037/xlm0001192

Yao, P., **Jiang, X.**, **Chen, X.**, & **Li, X.** (2025a). Exploring the processing unit of L2 Chinese learners in on-line Chinese reading. *Second Language Research*, **41**(1), 3–19. https://doi.org/10.1177/02676583231202606

Yao, P., **Li, H.**, **Chen, X.**, & **Li, X.** (2025b). Processing strategy or representation difference? Investigating the word segmentation difficulty of second language learners of Chinese. *Bilingualism: Language and Cognition*, 1–13. https://doi.org/10.1017/S1366728925100643

Yow, W. Q., & **Li, X.** (2026). Theory-of-mind understanding in aging: Effects of early bilingual language experience. *Bilingualism: Language and Cognition*, **29**(1), 107–119. https://doi.org/10.1017/S1366728925000240

Zang, C., **Zhang, M.**, **Bai, X.**, **Yan, G.**, **Paterson, K. B.**, & **Liversedge, S. P.** (2016). Effects of word frequency and visual complexity on eye movements of young and older Chinese readers. *The Quarterly Journal of Experimental Psychology*, **69**(7), 1409–1425. https://doi.org/10.1080/17470218.2015.1083594

Zhang, J. (2008). 留学生汉语单字词识别的笔画数效应、词频效应和词素频率效应 [On the stroke effect, word frequency effect and morpheme frequency effect in the recognition of Chinese one-character word by foreign student]. *TCSOL Studies*, **8**(1), 22–29.

Zhang, J., **Warrington, K. L.**, **Li, L.**, **Pagán, A.**, **Paterson, K. B.**, **White, S. J.**, & **McGowan, V. A.** (2022a). Are older adults more risky readers? Evidence from meta-analysis. *Psychology and Aging*, **37**(2), 239–259. https://doi.org/10.1037/pag0000522

Zhang, M., **Hu, H.**, **Bian, H.**, **Li, F.**, **Zhang, Z.**, & **Zang, C.** (2022b). 中文阅读中快速读者与慢速读者的词频效应 [Word frequency effects in fast and slow readers during skilled Chinese reading]. *Studies of Psychology and Behavior*, **20**(3), 304–310. https://doi.org/10.12139/j.1672-0628.2022.03.003

Zhao, R., **Wei, H.**, & **Yao, Z.** (2024). The effects of L2 proficiency on L2 word reading strategies: Evidence from Chinese–English bilinguals. *Applied Psycholinguistics*, **45**(6), 1147–1164. https://doi.org/10.1017/S0142716424000432

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