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Inserting spaces before and after words affects word processing differently in Chinese: Evidence from eye movements

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Unlike in English, there are no spaces between printed words in Chinese. In this study, we explored how inserting a space before or after a word affects the processing of that word in Chinese reading. Native Chinese readers' eye movements were monitored as they read sentences with different presentation conditions. The results show that inserting a space after a word facilitates its processing, but inserting a space before a word does not show this effect and inhibits the processing of that word in some cases. Our results are consistent with the prediction of a word segmentation and recognition model in Chinese Li *et al.*, 2009, *Cognit. Psychol.*, *58*, 525. Additionally, we found that a space guides the initial landing position on the word: the initial landing position was further away from the space that inserted into the text, whether it was before or after a word.

Interword spaces play very important roles in most alphabetic writing systems, such as English, as they delimit word boundaries. When spaces are deleted or masked in English, reading speed decreases by 30–50% (Morris, Rayner, & Pollatsek, 1990; Pollatsek & Rayner, 1982; Rayner, Fischer, & Pollatsek, 1998; Spragins, Lefton, & Fisher, 1976; Winskel, Radach, & Luksanneeyanawin, 2009). Unlike in English, there are no explicit markers for word boundaries in the Chinese writing system. How readers segment words in Chinese reading is still unclear (Li, Liu, & Rayner, 2011; Li, Rayner, & Cave, 2009; Yan, Kliegl, Richter, Nuthmann, & Shu, 2010). If spaces are inserted between words like in English, will they aid word segmentation?

In English reading, interword spaces provide visual cues for word segmentation and facilitate word recognition and eye movement target selection in multiple ways. First, interword spaces mark the beginning and ending letters of words and provide low-level visual information, so that letters belonging to a word can be processed as a whole (McClelland & Rumelhart, 1981; Reicher, 1969; Wheeler, 1970). Second, interword spaces provide effective cues of word length, so that the number of possible word

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candidates is constrained (Juhasz, White, Liversedge, & Rayner, 2008; Rayner, 2009; Rayner, Slattery, Drieghe, & Liversedge, 2011). Finally, spaces can help saccade target selection so that a reader's eyes can land at the preferred landing positions (Rayner, 1979) to improve word perception efficiency (Morris *et al.*, 1990; Perea & Acha, 2009; Rayner *et al.*, 1998; Winskel *et al.*, 2009).

Spaces between words may be not as helpful in Chinese reading as they are in English reading. First, word length in Chinese is shorter in general than in English. More than 60% of Chinese words are made up of two characters, although some words consist of only one character and some consist of three or more characters (Chinese Lexicon, 2003). Second, Chinese readers do not always agree on where word boundaries are (Hoosain, 1992). When asked to segment a passage into words, Chinese readers often show substantial between-individual, as well as within-individual, variabilities (Hoosain, 1992; Peng & Chen, 2004). As a result, inserting spaces between words in Chinese text may not help Chinese reading as much as it does in English reading.

Indeed, previous studies have shown that Chinese readers do not benefit from interword spaces in texts in most situations (Bai, Yan, Liversedge, Zang, & Rayner, 2008; Inhoff, Liu, Wang, & Fu, 1997; Liu, Yeh, Wang, & Chang, 1974). Bai *et al.* (2008) found that inserting spaces between words did not shorten reading time compared with normal text.[1] Nevertheless, in cases of ambiguous or difficult sentences (Hsu & Huang, 2000a,b; Yang & Sun, 1994), interword spaces or other segmentation cues can play important roles in sentence comprehension. For example, without context, the string of characters '花生长' may be segmented as '花 生长' (means 'flower grows') or '花生 长' (means 'peanut grows'). Thus, inserting spaces between words may help distinguish between alternative meanings in some situations.

How do Chinese readers segment words without spaces? A word segmentation and recognition model proposed by Li *et al.* (2009) provides a potential solution to this question. This model adopts some assumptions of the Interactive Activation Model (McClelland & Rumelhart, 1981) and assumes that Chinese word recognition involves multiple levels of processing consisting of a visual perception level, a character recognition level, and a word segmentation and recognition level. Word segmentation and recognition are interactive processes. The model assumes that characters are processed in parallel at the character recognition level, while words are recognized serially. When some characters are partially activated, they feed forward to activate words at the word processing level. The activated words compete with each other, and finally a single word wins the competition and the word is recognized. When a word is recognized, it is also segmented from the rest of the sentence. The basic assumption of this model is that only one word can win the competition at a time, consistent with the assumptions of serial processing models. Those serial processing models usually assume that processing of one word does not start until processing of the previous word is complete (e.g., Henderson & Ferreira, 1990; Morrison, 1984; Pollatsek, Reichle, & Rayner, 2006; Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Rayner, & Pollatsek, 2003).

One implication of the word segmentation and recognition model is that when a word (word n) is recognized, word boundaries on both sides of the word are determined. As the right boundary of word n is also the left boundary of word $n + 1$, the left boundary of word $n + 1$ is also determined at the same time when word n is recognized. Hence, inserting a

[1] *Bai* et al. *(2008) noted that it was not surprising that interword spaces did not yield faster reading times compared with normal unspaced text, given that the subjects in the experiment had a lifetime of experience reading without spaces.*

space before word $n + 1$ does not provide any additional information about the left boundary of word $n + 1$. Therefore, it does not help readers to segment word $n + 1$ from the text. Furthermore, as the inserted space extends the distance between word $n + 1$ and word n, this may result in less preview benefit for word $n + 1$ compared to that in normal unspaced text. Hence, inserting a space before word $n + 1$ should have little facilitatory effect, and may even have an inhibitory effect on the processing of word $n + 1$. On the other hand, inserting a space after word n provides information about the right boundary of word n, which may help readers segment it from the text before recognizing it. Thus, inserting a space after a word may facilitate the processing of that word. In summary, the model proposed by Li *et al.* (2009) predicts that inserting a space before a word influences the processing of that word differently from inserting a space after it. We tested this prediction in this study.

Previous studies did not find any evidence that inserting spaces between words speed up Chinese reading (Bai *et al.*, 2008; Inhoff *et al.*, 1997; Liu *et al.*, 1974). The predictions that inserting a space before a word may have little facilitatory effect on the processing of that word and inserting a space after a word may facilitate the processing of that word may be consistent with these results. When spaces are inserted between words in Chinese reading, the processing of each word is influenced by the facilitatory and inhibitory effects. The potential benefits of adding spaces (word segmentation facilitation) may be negated by potential disadvantage of less preview benefit.

Therefore, in the present study, subjects were asked to read sentences in four presentation conditions depending on where the space was inserted relative to the target words, while their eye movements were monitored (see Figure 1). In *the normal unspaced* condition, text was presented without any spaces; in *the space before word* condition, a space was inserted before the target word; in *the space after word* condition, a space was inserted after the target word. In *the spaces around word* condition, there was a space before the target word and another space after it. Thus, the effect of inserting a

(a) Normal unspaced condition

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(b) Space before word condition

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(c) Space after word condition

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(d) Spaces around word condition

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Figure 1. Example of stimuli in the present experiment. English translation of the sentence is 'We need to learn more from these successful cases of International Corporations'. The target word region '案例' (i.e., cases) has been highlighted by bold font, and all spaces have been shaded here (but not during the actual experiment) for clarification.

space before a word and that of inserting a space after a word could be directly compared for the same word. As stated above, inserting a space after a word may facilitate the processing of that word, but inserting a space before a word may not. If this prediction is right, fixation duration on the target word should be shorter in the space after word condition than in the normal unspaced condition; and fixation duration on the target word should be similar or even longer in the space before word condition than in the normal unspaced condition. Similarly, the processing of target words should be influenced by both facilitatory and inhibitory effects in the spaces around word condition. Hence, fixation duration on such words may be similar or shorter than that in the normal unspaced condition.

Method

Subjects

Thirty-two native Chinese speakers (19 females) at universities in Beijing near the Institute of Psychology, Chinese Academy of Sciences, were paid to participate in the experiment. All of them had either normal or corrected-to-normal vision. All subjects were naïve regarding the purpose of the experiment.

Apparatus

Eye movements were recorded via an Eyelink 1000 eye tracker (SR Research, Osgoode, Canada). Viewing was binocular, but only the right eye was monitored. The materials were displayed on a 19-inch LCD monitor (resolution: 1,024 × 768 pixels; refresh rate: 60 Hz) connected to a Dell PC. All the materials were presented in white (RGB: 255, 255, 255) on a light grey (RGB: 91, 91, 91) background. Each sentence was displayed on a single line with Song 20-point font. The size of each space was 13 × 26 pixels in the spacing conditions. Subjects were seated at a viewing distance of 58 cm from the computer monitor. At this viewing distance, each character subtended a visual angle of approximately 0.7°.

Material and design

Eighty experimental sentences and 32 practice sentences were selected from an on-line corpus.[2] Both the target words and post-target words had two characters and were in the middle of sentences (i.e., not within the first five or last five characters of a sentence). All of the target words and post-target words in these sentences were listed as words according to the *Chinese Lexicon* (2003). Some of the sentences were revised slightly to prevent semantic ambiguities. Ten subjects were recruited to rate these sentences with a 7-scale naturalness rating ('1' indicated 'unnatural', and '7' indicated 'natural'). The average reported naturalness was 5.6. Sentences were 20–32 characters in length (M = 23.9, SD = 2.8). As stated above, there were four presentation conditions: normal unspaced condition, space before word condition, space after word condition and spaces around word condition (see Figure 1). The materials were presented in four blocks, with one condition in each block. Each block contained eight practice sentences and 20 experimental sentences. The orders of sentences were randomized within each block,

[2] *Center for Chinese Linguistics PKU, http://ccl.pku.edu.cn:8080/ccl_corpus/index.jsp?dir=xiandai*

and the orders of blocks were counterbalanced across subjects using a Latin square design. Each sentence was presented in one of the four presentation conditions for a quarter of the subjects.

Procedure

Subjects were tested individually. After subjects arrived at the lab, they were given instructions for the experiment and a description of the apparatus. At the start of the experiment, subjects performed a calibration procedure by looking at a sequence of three fixation points randomly displayed horizontally across the middle of the computer screen. Calibration error was smaller than 0.5° of visual angle. At the beginning of each trial, a white square (about 1° × 1°) appeared on the left side of the computer screen, which indicated the position of the first Chinese character in the sentence. Once the subject fixated on the white square successfully, a sentence was displayed. Subjects were instructed to read silently for comprehension and to press a button on a keypad when they finished reading the sentence. Comprehension questions were presented on the screen after 41% of the sentences. These yes/no questions required the subjects to have understood the meaning of the sentence and respond via a button press.

Results and Discussion

Comprehension accuracy was high (94%), indicating that subjects read and understood the sentences well. Trials in which there were blinks on the target words or post-target words were discarded prior to analyses (4.8% of trials). All fixations shorter than 80 ms or longer than 1,000 ms were excluded from our analyses (0.9% of total fixations).

Five standard eye movement measures (Rayner, 1998, 2009) on target words were examined (see Table 1): (1) *first fixation duration* (the duration of the first fixation on a word during first-pass reading), (2) *gaze duration* (the sum of all first-pass fixations on a word before moving to another word), (3) *total time* (the sum of all fixations on a word, including regressions), (4) *total number of fixations* (the number of all fixations on a word, including regressions), and (5) *initial landing positions* (the position of the first fixation in a word). A repeated measures analysis of variance (ANOVA) was carried out with presentation conditions (the normal unspaced condition, the space before word condition, the space after word condition, and the spaces around word condition) as one within-subject factor, and with subjects (*F*1) and items (*F*2) as random effects.

Table 1. Eye movement measures on the target word

Measure	Normal unspaced	Space before word	Space after word	Spaces around word
First fixation duration	283 (8.4)	292 (10.2)	250 (8.8)	266 (6.0)
Gaze duration	335 (12.5)	342 (13.5)	268 (9.9)	284 (8.2)
Total time	474 (19.7)	531 (34.3)	388 (21.6)	404 (18.1)
Total number of fixations	1.59 (.07)	1.76 (.12)	1.34 (.11)	1.40 (.07)
Initial landing position	.47 (.02)	.53 (.03)	.34 (.03)	.58 (.03)

Note. First fixation duration, gaze duration, and total time were measured in milliseconds. Standard errors are reported in parentheses.

Fixation times

As shown in Table 1, presentation condition had a significant effect on all fixation duration measures: for first fixation duration, $F1(3, 93) = 8.10$, $MSE = 1{,}390.47$, $p < .001$, $\eta_p^2 = .21$, $F2(3, 237) = 12.60$, $MSE = 2{,}596.17$, $p < .001$, $\eta_p^2 = .14$; for gaze duration, $F1(3, 93) = 17.35$, $MSE = 2{,}478.29$, $p < .001$, $\eta_p^2 = .36$, $F2(3, 237) = 21.96$, $MSE = 5{,}587.92$, $p < .001$, $\eta_p^2 = .22$; for total time, $F1(3, 93) = 12.38$, $MSE = 11{,}369.51$, $p < .001$, $\eta_p^2 = .29$, $F2(3, 237) = 26.30$, $MSE = 16{,}558.06$, $p < .001$, $\eta_p^2 = .25$. Follow-up contrasts indicated that first fixation duration, gaze duration, and total time in the space after word condition were significantly shorter than that in the normal unspaced condition (all $ps < .01$; see Table 2 for detailed statistics on fixation times). In addition, first fixation duration, gaze duration, and total time were significantly shorter in the spaces around word condition than those in the normal unspaced condition (all $ps < .05$). Total time was significantly longer in the space before word condition than in the normal unspaced condition in the items analysis ($p < .001$), but the difference was marginally significant in the subjects analysis ($p = .06$).

In summary, our results revealed that inserting a space before a word and after a word affects the processing of the target word differently. First fixation duration, gaze duration, and total time were all significantly shorter in the space after word condition

Table 2. Follow-up contrast results of the presentation conditions on eye movement measures

	Subjects analysis			Items analysis		
	*F*1	*MSE*	η_p^2	*F*2	*MSE*	η_p^2
First fixation duration						
After versus normal	18.17***	1,968	.37	15.39***	5,540	.16
Around versus normal	5.12*	1,788	.14	5.66*	3,977	.07
Before versus normal	.84			3.87	4,010	.05
Gaze duration						
After versus normal	28.68***	5,003	.48	30.84***	11,353	.28
Around versus normal	24.94***	3,264	.45	29.9***	7,486	.28
Before versus normal	.27			1.06		
Total time						
After versus normal	13.16**	18,221	.30	15.3***	29,300	.16
Around versus normal	17.33***	9,171	.36	17.27***	2,354	.18
Before versus normal	3.68$^+$	28,215	.11	14.29***	37,383	.15
Total number of fixations						
After versus normal	6.14*	0.32	.17	16.13***	0.29	.17
Around versus normal	9.89**	0.12	.24	10.21**	0.31	.11
Before versus normal	2.94$^+$	0.30	.09	7.70**	0.37	.09
Initial landing position						
After versus normal	11.19**	0.05	.27	11.64**	0.08	.13
Around versus normal	8.04**	0.05	.21	10.47**	0.10	.12
Before versus normal	3.43$^+$	0.04	.10	4.48*	0.10	.05

Note. For the subjects analysis, the degrees of freedom were (1, 31); and for the items analysis, the degrees of freedom were (1, 79).

Normal, normal unspaced condition; before, space before word condition; after, space after word condition; around, spaces around word condition.

***$p < .001$; **$p < .01$; *$p < .05$; $^+.05 < p < .10$.

than in the normal unspaced condition, suggesting that inserting a space after a word facilitates the processing of that word. Moreover, the total time on target words was significantly shorter in the normal unspaced condition than in the space before word condition in the items analysis, suggesting that inserting a space before a word does not facilitate, but instead inhibits the processing of that word. These results are consistent with the prediction of the word recognition and segmentation model proposed by Li *et al.* (2009).

Total number of fixations

As is seen in Table 1, manipulation of presentation condition also influenced total number of fixations on the target word, $F1(3, 93) = 7.27$, $MSE = 0.16$, $p < .001$, $\eta_p^2 = .19$, $F2(3, 237) = 18.55$, $MSE = 0.17$, $p < .001$, $\eta_p^2 = .19$. Follow-up contrasts indicated that total number of fixations was significantly less in the space after word condition and the spaces around word condition than in the normal unspaced condition (all *ps* $< .05$, see Table 2 for the detailed statistics). Moreover, total number of fixations was numerically greater in the space before word condition than in the normal unspaced condition. The effect was significant in the items analysis ($p < .01$), but marginally significant in the subjects analysis ($p = .10$). No other follow-up contrasts yielded reliable effects. These results showed that subjects tended to have more fixations on the target word in the space before word condition, but fewer fixations in the space after word condition relative to the normal unspaced condition.

Initial landing position

Interword spaces aid eye movement and targeting during reading in most alphabetic languages. We sought to explore how inserting space at a word boundary position affects the initial landing position during Chinese reading. ANOVA analyses showed that presentation condition had a significant effect on the initial landing position, $F1(3, 93) = 12.64$, $MSE = 0.03$, $p < .001$, $\eta_p^2 = .39$, $F2(3, 237) = 16.57$, $MSE = 0.05$, $p < .001$, $\eta_p^2 = .17$. Follow-up contrasts showed that initial landing position in the space after word condition was significantly closer to the beginning of the target word than that in the normal unspaced condition (all *ps* $< .01$; see Table 2 for the detailed statistics). In addition, initial landing positions were significantly closer to the beginning of the target words in the normal unspaced condition than that in the spaces around word condition ($p < .01$). Furthermore, initial landing positions were significantly closer to the beginning of target words in the normal unspaced condition than that in the space before word condition in the items analysis ($p < .05$). This difference was only marginally significant in the subjects analysis ($p = .07$).

In summary, compared with the normal unspaced condition, mean initial landing position was further away from the space when space was inserted near the target word. The initial landing position was significantly closer to the beginning of the word in the space after word condition than in the normal unspaced condition. Additionally, the spaces before words guided the readers' eyes further away from the beginning of words in the space before word condition than in the normal unspaced condition. This suggested that the initial landing position was further away from the referential position of spaces in the space before word condition and the space after word condition relative to that in the normal unspaced condition.

General Discussion

In the present study, we examined how inserting spaces before and after words affects word recognition and eye movement guidance in Chinese reading. Our results show that inserting a space before a word and inserting one after a word affect the processing of that word differently. Relative to the normal unspaced condition, first fixation duration, gaze duration, and total time were shorter and the total number of fixations on a word was fewer when a space was inserted after the word. On the other hand, total time was longer and the total number of fixations on a word was greater when a space was inserted before it compared with the normal unspaced condition. Additionally, our results also show that inserting a space before or after a word also affects the guidance of eye movement to that word. Inserting a space before a word made the initial landing position further away from the word beginning. In contrast, inserting a space after a word made the initial landing position closer to the word beginning. In both cases, inserting a space in a sentence shifts the initial landing position further away from the space relative to that in the normal unspaced condition.

The findings that inserting a space before and after a word affects Chinese reading differently are consistent with the predictions of the word segmentation and recognition model (Li *et al.*, 2009). According to the model, word recognition and word segmentation are not distinguishable. Most importantly, the model assumes that only one word can win the competition at a time, indicating that words are processed serially. When a Chinese word is recognized, its boundaries on both sides are known. As the right boundary of word n is also the left boundary of word $n + 1$, inserting a space after word n marks the right boundary of word n, but does not offer helpful boundary information for word $n + 1$. Furthermore, the space interferes with the processing of word $n + 1$ as indicated by our data on total time. Thus, a space after word n may facilitate word segmentation and recognition, but a space before word n may not have any facilitatory effect for the word or may even hinder its processing.

It is noteworthy that total time in the space before word condition was longer than in the normal unspaced condition, suggesting that inserting a space before a word interferes with its processing. A possible explanation is that the target word was less likely to be processed with parafoveal vision, thus resulting in longer fixation times. However, the effect was not seen for first fixation duration and gaze duration. Hence, lack of parafoveal processing cannot fully explain this effect. Another possible explanation is that this may be caused due to an effect on landing position. As shown in the initial landing position analyses, readers tended to land further away from the inserted space in the space before word condition, so they fixated on the first character less often and on the second character more often than they did in the normal unspaced condition. Previous studies have shown that word recognition is less efficient when the eyes fixate more on the second character than on the first character of a 2-character word (Li, Gu, Liu, & Rayner, *in press*; P. P. Liu & X. S. Li, unpublished data). Thus, more time may be needed to process the word in the space before word condition relative to the normal unspaced condition. However, we acknowledge that the mechanism for the interference effect in the space before word condition is not completely clear and needs to be investigated further.

In addition, inserting spaces between words may decrease lateral inhibition (Brysbaert & Nazir, 2005; Perea & Acha, 2009; Perea, Moret-Tatay, & Gomez, 2011; Rayner *et al.*, 1998). Lateral inhibition is a very common property of visual sensory systems. Letters can be recognized more easily when they are presented against an empty background than when they are embedded within other letters (Blakemore, Carpenter, & Georgeson, 1970). Moreover, the outer letters of words could be easier to process than inner letters because the initial and final letters are laterally inhibited by only one adjacent letter in most alphabetic languages (Bouma, 1973). As a result, inserting a space around a word may make the perception of outer characters easier due to less lateral inhibition. However, Winskel, Perea, and Ratitamkul (2012) failed to find the effect of lateral inhibition on the coding of letter position by manipulation spacing in Thai text, suggesting that the magnitude of the effect of lateral inhibition may be small or negligible.

Although inserting spaces between words could reduce lateral inhibition, the different effects of inserting a space before and after a word are unlikely to be caused mainly by reduction in lateral inhibition. If inserting a space before or after a word reduces lateral inhibition, the amount of reduction in lateral inhibition should be similar in the space before word condition and space after word condition. In addition, several prior studies have indicated that word beginning is usually more informative than other parts of a word (Broerse & Zwaan, 1966; Brysbaert & Nazir, 2005; Li & Pollatsek, 2011; O'Regan, Lévy-Schoen, Pynte, & Brugaillère, 1984; White, Johnson, Liversedge, & Rayner, 2008). As a result, we should expect that inserting a space before a word would facilitate its processing based on the decrease in lateral inhibition for the word-beginning letters. However, our results indicate that this is not the case. Thus, the difference in the space before word condition and the space after word condition is not probably caused by lateral inhibition.

In this study, we were mainly focused on understanding how inserting spaces between words affects word segmentation and word recognition. However, inserting spaces between words may introduce other effects as well. As mentioned in previous studies, the unfamiliar format of interword spaces may hinder Chinese reading. Interword spaces also lengthen the spatial layout of sentences relative to normal unspaced text (Bai *et al.*, 2008; Inhoff *et al.*, 1997; Liu *et al.*, 1974). Additionally, readers' eyes may land on these spaces because of their novelty, which may result in mislocated fixations (Nuthmann, Engbert, & Kliegl, 2005). Together, these effects may reduce the potential benefits of interword spaces on word segmentation facilitation.

In short, interword spaces can have both facilitatory and inhibitory effects on the processing of words in Chinese. The combination of these effects of interword spaces may result in negligible facilitation in Chinese sentence reading and no improvement in global sentence reading. These results are consistent with the findings of previous studies (Bai *et al.*, 2008; Inhoff *et al.*, 1997; Liu *et al.*, 1974).

Our results also suggest that presentation conditions affect saccade target selection in Chinese reading. As noted above, we found that the initial landing position was further away from the space inserted in Chinese text, regardless of whether it was before or after a word. We suspect that word perception efficiency and perceptual span in Chinese reading may account for this phenomenon. Due to visual acuity limitations, readers need to change the landing positions where their eyes fixate to extract useful information from different materials (Rayner, 1998, 2009). To process words effectively, readers may fixate on Chinese characters more often than on spaces or punctuations in the spacing conditions. Additionally, in Chinese, the perceptual span of Chinese readers extends 1 character to the left of fixation to 2 or 3 characters to the right of fixation (Inhoff & Liu, 1998). Hence, Chinese readers do not need to fixate on the neighbouring character of a space.

In the space before word condition, there was one space before the target word. It would be less efficient if readers chose to fixate near the space in this condition as they would extract little helpful information to the left of fixation. To improve perceptual efficiency, subjects' eyes needed to land further away from the space in the space before word condition relative to other conditions. The same logic could be used in the space after word condition in which there was one space after the target word. It would also be less efficient if readers chose to fixate near the space in this condition as they would extract little information to the right of fixation. To process information to the right of fixation more effectively, it would be better for subjects to fixate at positions further away from the spaces. Our results may indicate that the strategy for eye movement control of Chinese readers is rather flexible and can be adjusted for efficient word recognition despite unfamiliar presentation conditions.

In summary, consistent with the prediction of the word segmentation and recognition model in Chinese reading (Li *et al.*, 2009), the present study demonstrated that while inserting a space after a word reduces its processing time, inserting a space before a word lengthens its processing time. Furthermore, we found that presentation conditions affect saccade target selection in Chinese reading.

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