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Encoding the target or the plausible preview word? The nature of the plausibility preview benefit in reading Chinese

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Abstract

Previous studies have shown that a plausible preview word can facilitate the processing of a target word as compared to an implausible preview word (a plausibility preview benefit effect) when reading Chinese (Yang, Wang, Tong, & Rayner, 2012; Yang, 2013). Regarding the nature of this effect, it is possible that readers processed the meaning of the plausible preview word and did not actually encode the target word (given that the parafoveal preview word lies close to the fovea). The current experiment examined this possibility with three conditions wherein readers received a preview of a target word that was either (1) identical to the target word (identical preview), (2) a plausible continuation of the pre-target text, but the post-target text in the sentence was incompatible with it (initially plausible preview), or (3) not a plausible continuation of the pre-target text, nor compatible with the post-target text (implausible preview). Gaze durations on target words were longer in the initially plausible condition than the identical condition. Overall, the results showed a typical preview benefit, but also implied that readers did not encode the initially plausible preview. Also, a plausibility preview benefit was replicated: gaze durations were longer with implausible previews than the initially plausible ones. Furthermore, late eye movement measures did not reveal differences between the initially plausible and the implausible preview conditions, which argues against the possibility of misreading the plausible preview word as the target word. In sum, these results suggest that a plausible preview word provides benefit in processing the target word as compared to an implausible preview word, and this benefit is only present in early but not late eye movement measures.

Keywords

plausibility preview benefit; eye movements; Chinese

During reading, the processing of a word starts when it is to the right of fixation in parafoveal vision (see Rayner, 1998, 2009, Schotter, Angele, & Rayner, 2012 for reviews). That is, when readers fixate on word n, they are able to get information from word n+1 to

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the right of fixation (parafoveal word), and then use it to identify word n+1 when it is later fixated. Therefore, fixation times on word n+1 are shorter when it was visible than when it was masked during the previous fixation on word n (e.g., McConkie & Rayner,1975; Rayner, 1975; also see Rayner 1998, 2009, Schotter et al., 2012 for reviews). This effect has been referred to as preview benefit. During the reading of alphabetic languages, it has been demonstrated that preview benefit can be due to: (1) orthographic or partial word information, (2) word length information, and (3) phonological information (see Schotter et al., 2012). Regarding preview benefits at higher linguistic levels in reading alphabetic languages, the results seem to be dependent on languages and experimental designs. For example, several studies have indicated that preview benefits do not extend to morphological (Lima, 1987; Inhoff, 1989, Kambe, 2004,) and semantic codes in reading English (Rayner, Balota, & Pollatsek, 1986; Rayner & Morris, 1992; Altarriba, Kambe, Pollatsek, & Rayner, 2001). In contrast, Deutsch and colleagues (Deutsch & Frost, Pollatsek, & Rayner, 2005, Deutsch, Frost, Pelleg, Pollatsek, & Rayner, 2003) have observed that word processing in Hebrew significantly benefits from having a parafoveal preview of a words' morphological root. Furthermore, Hohenstein, Laubrock, and Kliegl (2010) and Hohenstein and Kliegl (2013) found a semantic preview benefit for readers of German, and recently, Schotter (2013) showed that semantic preview benefit can be observed in English when the preview and target are synonyms (while she replicated the lack of semantic preview benefit from semantically related items that do not share the same meaning with the target).

The nature of preview processing in reading Chinese, a logographic script that is formed by strings of equally spaced box-like symbols called characters, is somewhat different from that in reading alphabetic languages (for details about how Chinese is different from alphabetic script in many aspects, see Yang, Wang, Xu, & Rayner, 2009; Yang, Wang, Chen, & Rayner, 2009). On the one hand, preview benefit can also be due to orthographic and phonological information in reading Chinese, as in reading alphabetic languages. For example, Liu, Inhoff, Ye, and Wu (2002) found that an orthographically dissimilar but phonological similar preview and an orthographically similar but phonologically dissimilar preview yielded shorter gaze durations (the sum of all fixations on the target word prior to leaving it) on the target character than an unrelated preview. Moreover, Tsai, Lee, Tzeng, Hung, and Yen (2004) found that phonological coding of a preview character can occur at the sublexical level. That is, phonological information could be obtained from a phonetic radical of a character that provides a cue to the pronunciation of the whole character. Yan, Richter, Shu, and Kliegl (2009) also reported robust orthographic preview benefit for integrated characters which consist of crossed strokes that are inseparable.

On the other hand, in contrast with the findings from English that preview benefit from a higher linguistic level was only observed with synonyms (Schotter, 2013), preview benefit has also been found to be due to morphological and semantic information in reading Chinese, similar to the morphological preview benefit reported in Hebrew (Deutsch et al., 2003, 2005) and the semantic preview benefit in German (Hohenstein et al., 2010; Hohenstein & Kliegl, 2013). Specifically, Yen, Tsai, Tzeng, and Hung (2008) found that Chinese readers obtained morphological preview information from a component character of a two-character target word. There were three types of two-character string previews with

the same first character as the target word: (1) same morpheme preview - its first character shared the meaning with the first character of the target word, (2) different morpheme preview - its first character had a different meaning from the first character of the target word, and (3) pseudoword preview. For example, given a target word "戒烟 (to quit smoking)", the three types of previews were: 戒除 (to give up a habit), 戒备 (to guard against), and 戒料 in the same morpheme, different morpheme, and pseudoword preview conditions, respectively. The results indicated that target words with the pseudoword preview had the longest gaze duration, with the different morpheme preview being intermediate, and the same morpheme shortest, suggesting that the first character of the preview stimulus was processed within the context of the two-character string.

Regarding semantic preview benefit in reading Chinese, Yan et al. (2009) reported such an effect for integrated characters (a semantically related preview character led to shorter fixation durations on the target character as compared to a semantically unrelated preview character). Following this experiment, Yan, Zhou, Shu and Kliegl (2012) further demonstrated that semantic information can be extracted from compound preview characters, as well as from the semantic radical (which may represent the meaning of the whole character) of a compound character (that is, a transparent semantic radical, which provides a clear guide to the meaning of the character it belongs to, yielded a larger preview benefit than an opaque semantic radical, the meaning of which is unrelated to the meaning of the character it belongs to). On the other hand, Yang, Wang, Tong and Rayner (2012, Experiment 1) failed to find semantic preview benefit when the semantically related and unrelated preview words did not fit in the sentence context (the semantically related words in Yan et al.'s studies did not fit in the sentence context either). However, when the semantically related and unrelated preview characters were modified to fit in the sentence (so that the preview was plausible) in Experiment 2, Yang et al. found a semantic preview benefit in single fixation duration (the time spent on the initial fixation on the word given that the reader made only one fixation on the target word on the first pass reading of the word). Comparing the results of Experiment 2 to Experiment 1, Yang et al. suggested that plausibility information affected the presence of semantic preview benefit. Moreover, they found a robust plausibility preview effect in Experiment 2; that is, plausible preview words led to shorter fixation durations than implausible preview words in all early eye movement measures (also see Wang, Tong, Yang, & Leng, 2009).

Furthermore, Yang (2013) recently demonstrated plausibility preview benefit with two-character **transposed words** (which have the order of their component characters reversed, but are still words). There were two kinds of transposed words: (1) synonymous-transposed (ST), in which the meaning remains when the order of the component characters is reversed, such as 合适 (suitable) and 适合 (suitable); and (2) different-transposed (DT), in which the meaning changes when the order of the component characters is reversed, such as 人情 (favor) and 情人 (lover). Yang found that readers obtained a similar amount of preview benefit from a reverse character order preview as from the identical, correct character order preview for ST target words (which always fit into the sentence context after reversing their character order), and for DT target words as long as the transposition fit into the sentence

context. When the transposition preview of DT target words did not fit into the sentence, there were significantly longer fixation durations on the target word than the identical preview. In addition, Yang found that a plausible control preview (a totally different word from the target) yielded larger preview benefit than an implausible control preview, again, showing a plausibility preview benefit. Compared with the previous experiments on plausibility preview benefit in reading Chinese (Wang et al., 2009; Yang et al., 2012), Yang kept the orthographic changes between a plausible and an implausible preview word relatively small (as the plausibility manipulation was achieved by reversing the character order within a transposed word). The experiment also excluded possible influences from different orthographic properties between the plausible and implausible preview words and served as a strong test for the plausibility preview benefit.

As discussed above, although the presence of semantic preview benefit was inconsistent across experiments (Yan et al., 2009, 2012, Yang et al., 2012), the plausibility preview benefit[1] has been replicated in several studies. Logically, this inconsistency is not easy to explain because plausibility processing is presumably a higher level of processing than semantic processing. While semantic preview benefit occurs at a lexical level, plausibility preview benefit occurs at an integration level, which requires readers to integrate semantic information of the preview word with context. Yan and his colleagues (see Yan, Risee, Zhou & Kliegl, 2012; Zhou, Kliegl & Yan, 2013) suggested that the inconsistent patterns of semantic preview benefit can be explained by the extent of activation of the non-identical previews (e.g., the semantically related preview word) across experiments: the higher the activation of the non-identical preview word, the more interference to the processing of the target word and thus less preview benefit. Factors, such as the duration of the fixation on the pretarget word (the word prior to the target word) and the predictability of the target word (how likely readers can predict the target word given the first part of the sentence up to the target word) could both affect the competition between the target word and preview word and thus affect the presence of semantic preview benefit. On the other hand, Yang et al (2012) suggested that the failure to observe semantic preview benefit in their Experiment 1 does not necessarily mean that Chinese readers can't obtain semantic information from a preview word. Thus, for example, if the semantic information from a preview word does not help readers to understand the sentence (it is implausible in the context), the semantic priming effect from a semantically related preview word in relation to a semantically unrelated preview word could be washed out by its implausibility. That is, whether or not a preview word fits into the context has a bigger effect than whether its meaning is related to the target word.

While the above explanations are possible, they are based on the assumption that a plausible preview word can facilitate the reading of a target word which has a different meaning from the preview word. However, this assumption is open to test. Given the fact that a two-character Chinese word is short and the two characters are quite close together, a two-character word to the right of fixation would lie quite close to the fovea. Moreover, it has

[1]Plausibility preview benefit was based on the difference between the plausible and implausible preview condition. It may actually reflect a penalty from the implausible preview word, instead of a benefit from plausible preview word for the processing of the target word. We still refer it "benefit" to be consistent with the literature.

been demonstrated that Chinese readers use a relatively diffuse strategy for processing words and context (Chen, 1992). Hence, readers may be likely to encode the plausible preview word without actually encoding the target word (even if they fixated on the target word, their attention could shift to the word next to the target word; see Reichle, Pollatsek, Fisher, & Rayner, 1998 for how attention is separated from eye movements during reading in the E-Z Reader model). If this is true, the nature of the "plausibility preview benefit" is different from other kinds of preview benefits, as the other kinds of preview benefit refer to how the coding of the preview word facilitates the coding of the target word.

The current experiment was thus designed to examine if the plausibility preview benefit is similar in nature to other preview benefits. In other words, we tried to exclude the possibility that Chinese readers process the meaning of a plausible preview word without actually encoding the target word. There were three types of previews: (1) identical to the target word, (2) initially plausible, which was a plausible continuation of the pre-target text (however, the post-target text in the sentence was incompatible with it), and (3) implausible, which was not a plausible continuation of the pre-target text, nor compatible with the post-target text. Therefore, the main difference between the current experiment and previous experiments (Yang, 2013; Yang et al., 2012; Wang et al., 2009) was in the initially plausible `condition`. Therefore, the main difference between the current experiment and previous experiments (Yang, 2013; Yang et al., 2012; Wang et al., 2009) was in the initially plausible condition. From the prior experiments it is unclear whether Chinese readers process the meaning of a plausible preview word or the target word (as both of them were plausible in the sentence). Thus, in the current experiment, the effects of processing the meaning of the initially plausible preview word, but not the target word, should be reflected in inflated reading times on the second part of the sentence (which was incompatible with the initially plausible preview word).

We anticipate there are several possible results. In first pass reading, in an extreme situation, if readers processed the initially plausible preview word without encoding the target word (even after the display change has occurred and the eyes have landed on the target word) and understood the prior context with the plausible preview word, there shouldn't be a difference between these two conditions. But, more likely, readers would spend less time fixating the target word in the identical condition than in the other two preview conditions that were different from the target word (this would reflect the typical preview benefit effect). Moreover, this typical preview benefit would suggest that readers did encode the target word. Furthermore, if the preview benefit effect from a plausible word is robust across experiments, we should observe preview benefit from the initially plausible preview word as compared to the implausible preview word.

However, if readers processed the meaning of the initially plausible preview word and did not actually encode the target word, in addition to the fact that first pass reading time should not differ between the identical and the initially plausible preview condition, eye movement measures reflecting later processing should show a difference between the initially plausible and implausible preview conditions (given that the post-target context was inconsistent with the initially plausible word). For example, there should be more regressions back and longer second pass reading times to the target word location (which was occupied by a preview

word initially) and pre-target context when readers get to the second part of the sentence (after the target word), and longer total reading time in the post-target context because they would encounter conflicts between the post-target context with the initially plausible preview word. Similar effects have been reported in English when readers initially misread a target word (Johnson, 2009; Slattery, 2009). We will refer to this effect as *preview misreading*. If readers understood the sentence with the target word and did not actually integrate the meaning of the initially plausible preview word with context, there should be no difference in the late eye movement measures between the initially plausible and the implausible preview condition.

Method

Subjects

Thirty-nine undergraduate students from the South China Normal University, who were all naïve concerning the purpose of the experiment, participated in the eye movement portion of this experiment. All subjects were native speakers of Chinese, had normal or corrected to normal vision, and received either cash or course credit as compensation for their time.

Materials

Forty-two two-character words were selected and embedded into 42 sentence frames as target words. They were always in the middle of the sentence, with at least 4 characters from the beginning and 3 characters from the end of the sentence. Each target word was paired with an initially plausible and an implausible preview word. Given a target word 讲演 (speech), the sentence and its English translation (the boundaries for meaning units corresponding to English words are marked by *), with the target word and its initially plausible and implausible preview words being underlined, were:

李*教授*的*讲演/护照/功率*受到*听众的*热烈*欢迎*。

(Li* Professor* of* *speech/passport/power** passive form* audience's* warmly* welcomed*.)

Professor Li's speech/passport/power was warmly welcomed by his audience.

The initially plausible preview word 护照(passport) was a plausible continuation of the pre-target text (from the beginning of the sentence to the character prior to the target word), but it turned out to be implausible in the sentence when readers got to the second part of the sentence. The implausible preview word 功率 (power, which is only used for in the context of an electric appliance in Chinese, and hence implausible for Chinese readers), was not compatible with the pre-target text, nor the post-target text. Lexical properties, including word frequency, character frequency of the component characters, and number of strokes of these two kinds of preview words were closely matched with the target word. There were no significant differences regarding these properties across the three conditions, Fs <1. Table 1 presents the stimulus characteristics. Moreover, to avoid any orthographic and homophonic benefit from the initially plausible and the implausible preview words, such similarities between these preview words and the target words were controlled.

By counterbalancing the sentences in the experiment, three material sets were created, each containing 42 experimental sentences, with 14 sentences in each preview condition. In addition, 78 filler sentences with no display changes were added into the material set. Totally, each participant read 9 practice sentences followed by the 120 sentences in a random order.

Apparatus

An SR Eyelink 1000 eye-tracking system was used to track eye movements at the rate of 1000Hz. The eye-tracker monitored movements of the right eye, although viewing was binocular. A Dell 19-inch SVGA monitor was used to display the stimuli. The monitor was set to a refresh rate of 150 Hz. The delay in detecting an eye movement crossing the boundary and changing the display averaged 9 ms. All stimuli were presented in white on a black background on the computer monitor. All characters were printed in Kai-Ti font. The size of each character was $0.95\times0.95cm^2$, with 0.25cm between individual characters. Each character subtended approximately 1 degree of visual angle with the subject's eyes being 64 cm away from the monitor. For each experimental trial, the sentence always appeared in the center of the screen and the crucial word also appeared in the middle of the sentence.

Procedure

Subjects were tested individually and randomly assigned to one of three stimulus sets (which were divided into two blocks). The experiment consisted of a calibration phase and an experimental phase. In the calibration phase, each subject performed a 3-point calibration procedure to make sure that the eye-tracker recordings were accurate. The experimental phase then followed, with recalibration as needed.

Before reading each sentence, subjects were first asked to fixate on a dot at the left corner of the computer screen that indicated the position of the first character of the sentence. Once they fixated on the dot, the sentence was displayed. The eye movement contingent boundary technique (Rayner, 1975) was used to vary parafoveal preview information (see Figure 1). Upon initiation of the sentence, the word presented in the target location was either the identical, initially plausible, or implausible preview. When the readers' eyes crossed the invisible boundary, which was located at the end of the character preceding the target word, the preview was changed to the target word. Subjects read each sentence at their own pace and then pressed a button to terminate the trial. One-third of the sentences were immediately followed by a true-false comprehension question to ensure that subjects were not merely skimming the sentences. Subjects answered the question based on the information from the previous sentence by pressing an appropriate button. The answer to a question of an experimental sentence was identical in the three preview conditions. Nine practice sentences were presented at the beginning of the experiment to familiarize subjects with the procedure; they were informed that they could take a break whenever they needed one. The whole experiment lasted about 40 min.

Normative data

All of the target words and preview words were highly familiar to readers (overall mean = 4.2), according to a familiarity norming study in which 10 subjects were asked to rate the

familiarity of the target words and their two kinds of preview words on a 5-point scale (where 1 means “extremely unfamiliar” and 5 means “extremely familiar”). There were no significant differences across conditions (*F*s < 1). Also, the predictability of the target word and the preview word was low as indicated by a predictability norming study in which eight undergraduate students were given the first part of the experimental sentence up to (and including) the character to the left of the target word and asked to provide the next word in the sentence (i.e., predict the target word). All target words and preview words, as well as the first component character of these words (note that all of the target words and their preview words were two-character words) were predicted less than 5% of the time by these subjects (with no differences across the three conditions.)

More importantly, each sentence was normed for plausibility in two ways. First, fifteen subjects read the 42 complete sentences in one of the three preview conditions offline and rated on a scale of 1 to 5 how well each target word or its preview word fit within its sentence frame (1 = highly implausible; 5 = highly plausible). Sentences were counterbalanced so that every subject saw each sentence frame only once, and a third of the sentences with the target word, a third of them with an initially plausible preview word, and a third with an implausible preview word. The results showed that there was a significant effect of plausibility, $F(2,82) = 89.91$, $p < .001$. Sentences with the target words were rated more plausible (M = 3.6, SD = .62) than those with *initially plausible* previews (M = 2.4, SD = 58.), and those with *implausible* previews (M = 2.3, SD = .55.), *t*s > 12.0, *p*s < .001. There was no significant difference between the latter two conditions, *p*s > .2.

A second plausibility rating study was conducted on the first part of the sentences. Another 15 subjects were presented the first part of the sentences up to (and including) the target word or its preview words and were asked to rate the plausibility of the sentence fragment (assuming that the sentence did not end there) on a 5-point scale (where 1 = highly implausible; 5 = highly plausible). The plausibility of the sentences with the target word, *initially plausible*, and *implausible* previews averaged 3.70 (SD = .81), 3.51 (SD = .88), and 2.38 (SD = .64), respectively. The main effect of plausibility was significant, $F(2,82) = 44.73$, $p < .001$. Sentences with the target words and the initial-plausible preview words were rated more plausible than those with *implausible* preview words, *t*s > 6.9, *p*s < .001. There was no significant difference between the target words and the initially plausible conditions, *ts* < 1.5, *ps* > .15.

All subjects in these rating studies were undergraduate students from the South China Normal University. They did not participate in the main experiment and they only participated in one of these rating studies.

Results

All subjects scored 80% or better in response to the questions, averaging 91%. Trials in which readers blinked or fixated longer than 800 ms in a single fixation on the target word or two characters on either side of it were discarded from analyses. In addition, extremely short (less than 60 ms) fixations were pooled with the fixation adjacent to them (or on the same character), and any isolated extremely short fixations were removed from the data.

Moreover, trials in which the display change occurred during a fixation were excluded. No subjects lost more than 30% of the trials and in total, 14% of the data were lost, including track losses, and data loss was evenly distributed across the three conditions.

Several standard eye-movement measures reflecting early processing (Rayner, 1998; 2009), were computed to assess the influence of preview manipulation on the two-character target word. These measures include (1) *skipping probability* (the probability of skipping the target word on first pass reading), (2) *the probability of a single fixation* (the probability of making only one fixation on the target word), (3) *first fixation duration* (the amount of time a reader spends on the initial fixation on the target word regardless of the total number of fixations made on it), (4) *single fixation duration* (the time spent on the initial fixation on the target word given that the reader made only one fixation on the target word on the first pass reading of the word), and (5) *gaze duration* (the sum of fixations on the target word before moving to another region).

Go-past time (the amount of time that the reader looked at the target word and any time spent rereading earlier parts of the sentence before moving ahead to inspect new parts of the sentence), which reflects integration processes, was also computed. Moreover, three measures that represent later processing which occurs after the reader has left the area of interest on their first pass reading of the text were computed to assess the possibility that readers had encoded only the preview word. They were: (1) *second pass time* (the time spent on the target word after going past it or during the second reading of the region, including zero times when a region is not refixated), (2) *regressions-in* (the percentage of regressions made back into the target word after leaving it) and (3) *regressions-out* (the percentage of regressions made out from the target word to an earlier portion of the sentence). For completeness, total reading time (the sum of all fixations in the target word, both forward and regressive movements) are reported.

Statistical analyses on the various eye movement measures were performed using Linear mixed models (LMM) for durations and generalized linear mixed models (GLMM) for binary dependent variables (skipping and regressions), specifying subjects and items as crossed random effects. These analyses were carried out using the lmer program of the *lme4* package (Bates & Maechler, 2009) in R, an open-source programming language and environment for statistical computation (R Development Core Team, 2009). We report regression coefficients (*b*s, effects relative to the intercept, which indicate effect sizes in milliseconds for durations, and change in log odds for binary dependent variables), standard errors (*SE*s), *t* values (for durations, a t-value of greater than 2 indicates statistical significance; Baayen, 2008), *z* values (for binary dependent variables), and corresponding *p* values for *z* values. For all LMMs, we started with a model that included random intercepts and random slopes for all fixed effects. We then iteratively removed effects that did not significantly increase the model's log-likelihood and report the statistics output by the largest model justified by the data. Random participant and item slopes were not justified by the data for all models and we report the simplest models without them.

Two sequential contrasts were set up: (1) *identical preview* vs. *initially plausible preview* to examine the typical preview benefit that an identical preview provides larger preview

benefit than a non-identical preview, and (2) *initially plausible* vs. *implausible* to examine the plausibility preview effect. We will report the eye movement measures reflecting the first pass and later processing separately below. Subject means as a function of preview on the target word are shown in Table 2.

Early Eye Movement Measures

Skipping probability—Given that the target region had two characters, readers were very unlikely to skip it. Skipping averaged about .04 across the three preview conditions, with no significant effects by the two contrasts, *p*s > .1. We will not discuss this ceiling effect further.

Probability of a single fixation—Readers were more likely to make a single fixation in the identical preview condition (.71) and less likely in the implausible preview condition (.55), with the initially plausible condition being intermediate (.65); for identical vs. initially plausible, $b = .31$, $SE = .14$, $z = 2.13$, $p < .05$, and for initially plausible vs implausible, $b = .42$, $SE = .14$, $z = 3.01$, $p < .01$. The more likely it is that readers make a single fixation, the easier the processing is. This pattern of data suggested a typical preview benefit and a plausible preview benefit.

Fixation times[2]—The difference between the identical and initially plausible preview conditions was not significant in first fixation duration (both were 262 ms) or single fixation duration (271 ms vs. 267 ms), *t*s < 1. However, gaze duration on the target word in the identical condition was shorter than in the initially plausible condition (321 ms vs. 346 ms), $b = 24$, $SE = 10.4$, $t = 2.3$, as the target word in the initially plausible condition received more refixations. The pattern wherein the difference between the identical and plausible preview condition was only significant in gaze duration but not in first fixation duration and single fixation replicated the finding by Yang et al. (2012). As outlined in the Introduction, these results suggest that: (1) the initially plausible preview word, which was different from the target word in orthography, did not provide as much facilitation as the identical preview word to the processing of the target word, and (2) readers did not misread the initially plausible preview word as the target word and then understand the sentence meaning based on the initially plausible preview.

A significant plausibility preview effect was observed in all measures as fixation durations were longer in the implausible preview condition than in the initially plausible preview condition: first fixation duration (278 ms vs. 262 ms), $b = 15$, $SE = 5.9$, $t = 2.52$; single fixation duration (292 ms vs. 267 ms), $b = 15$, $SE = 7.3$, $t = 2.11$; and gaze duration (374 ms vs. 346 ms), $b = 27$, $SE = 10.4$, $t = 2.61$. These results are consistent with previous studies showing plausibility preview benefit (implausible previews yield longer fixation durations than plausible ones: Yang et al, 2012; Yang, 2013).

[2]We also did analyses on log transformed fixation durations. However, log transforming the fixation duration variables did not change the pattern of effects. We prefer to report the analyses on un-transformed data so that the effects are more transparently mapped onto the observed data (i.e., so that the b estimates of the LMMs are in milliseconds and can be compared to the raw means)

Late Eye Movement Measures

Go-past time, second pass time, and total time on the target word were longer in the initially plausible condition than in the identical condition: for go-past time (400 ms vs. 357 ms), b = 42, SE = 14.6, t = 2.85; for second pass time (95 ms vs. 68 ms), b = 27, SE = 12.0, t = 2.27; and for total time (457 ms vs. 400 ms), b = 57, SE = 14.6, t = 3.89. Moreover, readers made more regressions into the target word (22 vs. 16%), b = .43, SE = .17, z = 2.48, p < .05, and marginally significant more regressions out from the target word to the earlier part of the sentence, (10 vs. 6%) b = .49, SE = .26, z = 1.88, p = .061 in the initially plausible condition than in the identical condition. Regarding the comparison between the implausible and initially plausible conditions, except for the fact that go-past time was marginally longer in the implausible preview condition than in the initially plausible preview condition (430 ms vs 400 ms,) b = 28, SE = 14.7, t = 1.90 (which is probably due to longer gaze durations in the implausible condition than the initially plausible preview condition), there was no difference between these two conditions in second pass reading time (92 ms vs. 95 ms), total time (482 ms vs. 457 ms), the percentage of regressions-in (21% vs. 22%), and the percentage of regressions-out (11% vs. 10%) t/zs <1.6. In short, the differences between the identical and the initially plausible preview condition, but not the difference between the initially plausible and implausible preview condition, were significant in all analyzed late eye movements on the target word.

Pre-target and post-target region/text—In order to further examine which word (the identical or the initially plausible preview word) readers actually integrated with the sentence, eye movement measures were analyzed for regions other than the target region in the sentence (see Table 3). For example, if the reader processed the incorrect meaning of the target word, such as the initially plausible preview word, they should have longer second pass reading times and more regressions into the early portion of the sentence, such as the pre-target region (the two characters prior to the target word) when they got to the second part of the sentence. In addition, they might have longer go-past times and more regressions out from the later portion of the sentence, such as the post-target region (the two characters following the target word).

For the pre-target region, the second pass times were 41 ms, 63 ms, and 59 ms, regressions in were 9, 15 and 17% in the identical, initially plausible, and implausible preview conditions, respectively. The difference between the identical and the initially plausible preview conditions was significant in second pass reading time, b = 21, SE = 8.6, t = 2.50, and in the percentage of regressions-in, b = .43, SE = .17, z = 2.48, p < .01. The differences between the implausible and initially plausible condition were not significant, t/z <1.

Second pass time and the percentage of regressions-in were also analyzed for the pre-target text (from the beginning of sentence up to but not including the target word). The second pass times were 85 ms, 105 ms, and 101 ms, regressions-in were 15, 22 and 23% in the identical, initially plausible, and implausible preview conditions, respectively. Statistical analysis revealed the same pattern of results in the pre-target text as in the pre-target region and we will not report the statistical data.

Moreover, gaze durations were analyzed on the pre-target region to examine parafoveal-on-foveal effects (see Rayner, 2009 for discussion). These effects occur when the characteristics of the word to the right of fixation influence the processing of the currently fixated word (see Yang, Wang, Xu, & Rayner (2009) for such an effect in reading Chinese). Surprisingly, fixation durations in the identical preview condition were longer than the initially plausible preview condition (291 ms vs. 273 ms), $b = 18$, $SE = 8.7$, $t = 2.10$, suggesting a parafoveal-on-foveal effect. We are not sure what can be made this effect and will return to it in the Discussion. There was no significant difference between the initially plausible condition and the implausible condition (275 ms vs. 273 ms), $ts < 1$.

For the post-target region, go-past times were 363 ms, 411 ms, and 401 ms, regressions-out were 12, 19 and 18% in the identical, initially plausible, and implausible preview conditions, respectively. Similar to the pattern for the pre-target region, significant differences were only found between the identical and the initially plausible preview conditions: for go-past time, $b = 47$, $SE = 18.7$, $t = 2.50$, for regressions-out, $b = .52$, $SE = .21$, $z = 2.50$, $p < .05$. Similarly, total time and the percentage of regressions out were analyzed for the post-target text (i.e., the rest of the sentence after the target word which did not allow for the calculation of go-past time). These analyses showed the same pattern of effects as the go-past time and regressions-out for the post-target region. Total times were 1271 ms, 1313 ms, and 1296 ms, regressions-out was 22, 30 and 28% in the identical, initially plausible, and implausible preview conditions, respectively.

In addition, gaze duration was analyzed for the post-target region to examine the spill-over effect from the target word; the means were 289 ms, 301 ms, and 299 ms in the identical, initially plausible, and implausible preview conditions, respectively. Although the numerical difference between the identical and the initially plausible condition was 12 ms, it was not significant, $t < 1.3$ (nor was the difference between the initially plausible and the implausible condition, $t < 1$). For completeness, the probability of skipping and total time for the pre-target and post-target region are also presented in Table 3. However, we do not discuss these measures further.

Supplementary analyses

When the two-character pre-target region was skipped, fixations on the target region must be launched from a further distance. In this situation, readers may not get enough preview information to show as strong of preview effects as when the pre-target region was fixated. To maximize the chance of observing the influence of the preview words, we excluded the cases when the pre-target region was skipped (about 11% of the trials) and only analyzed the data on the target region when the fixations on this region were launched from the pre-target region. These results showed exactly the same pattern as the full analyses. We will therefore not report the statistics from these LMM analyses. Subject means as a function of preview for the target region when the pre-target region was fixated are presented in Table 4.

Discussion

The current experiment examined whether a plausible preview word would yield a preview misreading effect such that readers encoded the plausible preview word and thus misread the

word in the target location using three kinds of preview words: (1) identical, (2) initially plausible, and (3) implausible. Consistent with the findings from previous experiments (e.g., Yang et al., 2012, Wang et al., 2009; Yang, 2013), a robust effect of plausibility was reflected by significantly longer first fixation durations and gaze durations in the implausible condition than in the initially plausible condition on the target word. Moreover, readers were more likely to make a single fixation on the target region in the initially plausible preview condition than the implausible preview condition. More importantly, gaze duration in the initially plausible preview condition was longer than in the identical preview condition, which indicated a typical preview benefit, as well as the inference that readers did not integrate the initially plausible preview word into the sentence (instead, they encoded the target word). Note that the pattern of data wherein a preview effect was significant in gaze duration but not in first fixation duration is not uncommon in the literature on reading Chinese. For example, Yan et al (2009) observed a phonological preview benefit in gaze duration but not in first fixation, and Yang, Wang, Xu, and Rayner (2009) found evidence for preview benefit from the second word (word n+2) in the parafovea in gaze duration but not in first fixation duration. Since gaze duration reflects relatively later processing (due to refixations on the target word) in comparison to first fixation duration (and single fixation duration), the preview effect is stronger in gaze duration than in first fixation duration. This preview benefit was also reflected by the finding that readers made more single fixations in the identical condition than the initially plausible condition.

Another important finding in current experiment is reflected by late eye movement measures. While readers were more likely to regress back to the target word and made longer second pass reading time on it in the initially plausible preview condition than in the identical preview conditions (which was consistent with the pattern in gaze duration and again against the possibility of preview misreading), there were no statistical differences between the initially plausible and the implausible conditions for these two late measures. These results imply that the penalty from a non-identical preview (initially plausible and implausible preview in the current experiment) could last to second pass reading. Moreover, the comparison in late eye movement measures between the initially plausible and implausible preview condition provides evidence for the question we asked in the current experiment. That is, whether readers were more likely to encode a plausible preview than an implausible one and process the meaning of a plausible preview word but not actually encode the target word. The answer seems to be no. If they did, they should encounter more conflict when they got to the second part of the sentence and thus be more likely to regress back to the target word in the initially plausible condition than in the implausible preview condition. But the data in the late eye movement measures did not show any difference between these two conditions. This result was confirmed by the supplementary analyses on the target words when the pre-target region was fixated (which maximized the chance to obtain information from the preview word). Moreover, the difference between the identical and the initially plausible preview condition was also reflected by late eye movement measures in the pre-target region: readers had longer second pass reading times and more regressions back to the pre-target region in the initially plausible condition than in the identical condition. There were no significant differences between the initially plausible

condition and the implausible condition in all measures in the pre-target/text and post-target region/text.

In short, the present results suggest that the plausibility preview benefit is a consistent effect across different experiments, and this effect is not because of a misreading of the plausible preview word as the target word. Instead, the plausible preview benefit, as other kinds of preview benefit, is due to the fact that the processing of the preview word can facilitate the processing of the target word when the target word was later fixated on. That is, the nature of plausibility preview benefit is similar to other kinds of preview benefits in reading Chinese. Yang (2013) proposed two potential explanations for the underlying mechanism of the plausibility effect. One is that Chinese readers get partial semantic information from a plausible preview word which allows them to get a rough estimation of whether the preview word is a possible continuation of the current context. If it is, processing will go smoothly; in contrast, if the preview word is not a possible continuation of the pre-context, reading will slow down (as when drivers see a highway construction or maintenance sign). While this account involves semantic processing, the second account doesn't. The second, alternative account suggests that the plausibility effect may reflect the likelihood of co-occurrence of the pre-target word and the preview word. In other words, a plausible preview word is more likely to co-occur with the pre-target word than an implausible preview word (also see Wang, Pomplun, Ko, Chen, & Rayner, 2010) for the effect of transitional probability in reading Chinese). These two explanations for the plausibility preview benefit effect cannot be ruled out by the current study and further experiments are needed to test the feasibility of each alternative.

Finally, the current study showed a parafoveal-on-foveal effect as the initially plausible preview yielded shorter gaze durations than the identical preview word on the pre-target region. This is consistent with the finding from Yang et al. (2012) that an unrelated and plausible preview word (which is similar to the initially plausible preview word in the current experiment) yielded shorter gaze durations than an identical preview word. However, other eye movement studies on reading Chinese showed inhibitory parafoveal-on-foveal effects if there were such effects. For example, Yen, Radach, Tzeng, Hung, and Tsai (2009) found that gaze duration on the pre-target word was longer when the preview word was masked than when it was visible during the first 140 ms of a fixation on the pre-target word. Yang, Wang, Xu, and Rayner (2009) found shorter gaze durations in the pre-target region in the identical preview condition than the different preview condition. The inconsistent findings across experiments regarding parafoveal-on-foveal effects in reading Chinese is puzzling, as in reading English (see Schotter et al., 2012). On the one hand, parafoveal-on-foveal effects could be explained by the mislocated fixation account that they result from saccadic undershoots of word n+1 (parafoveal word) on word n (foveal word). On the other hand, we speculate that these effects are related to how attention is distributed to the foveal and the parafoveal word, which needs to examine with further studies. As the main purpose of the current experiment was not on parafoveal-on-foveal effects, we will not discuss these effects further.

In conclusion, in addition to replicating the results of previous experiments (Yang et al., 2012; Wang, et al., 2009; Yang, 2013) in demonstrating that there is a robust plausibility

preview effect in reading Chinese, the current experiment identified that the nature of the plausible preview benefit was not due to a misreading effect from taking the plausible preview word as the target word (based on the findings that there were significant difference between the identical and the initially plausible preview condition in gaze durations and other late eye movement measures, and no significant difference between the initially plausible and implausible preview conditions). As with other kinds of preview benefit (such as phonological and orthographic preview benefit), the plausibility preview benefit was due to the fact that information obtained from a preview word facilitated the processing of the target word. We also discussed the two potential explanations for the nature of this plausibility effect proposed by Yang (2013): (1) readers obtain partial semantic information from the preview words and decide whether it is a possible continuation of the pre-context, and (2) it is actually due to the likelihood of co-occurrence of the pre-target word and the preview word. Further studies are needed to test these two hypotheses.

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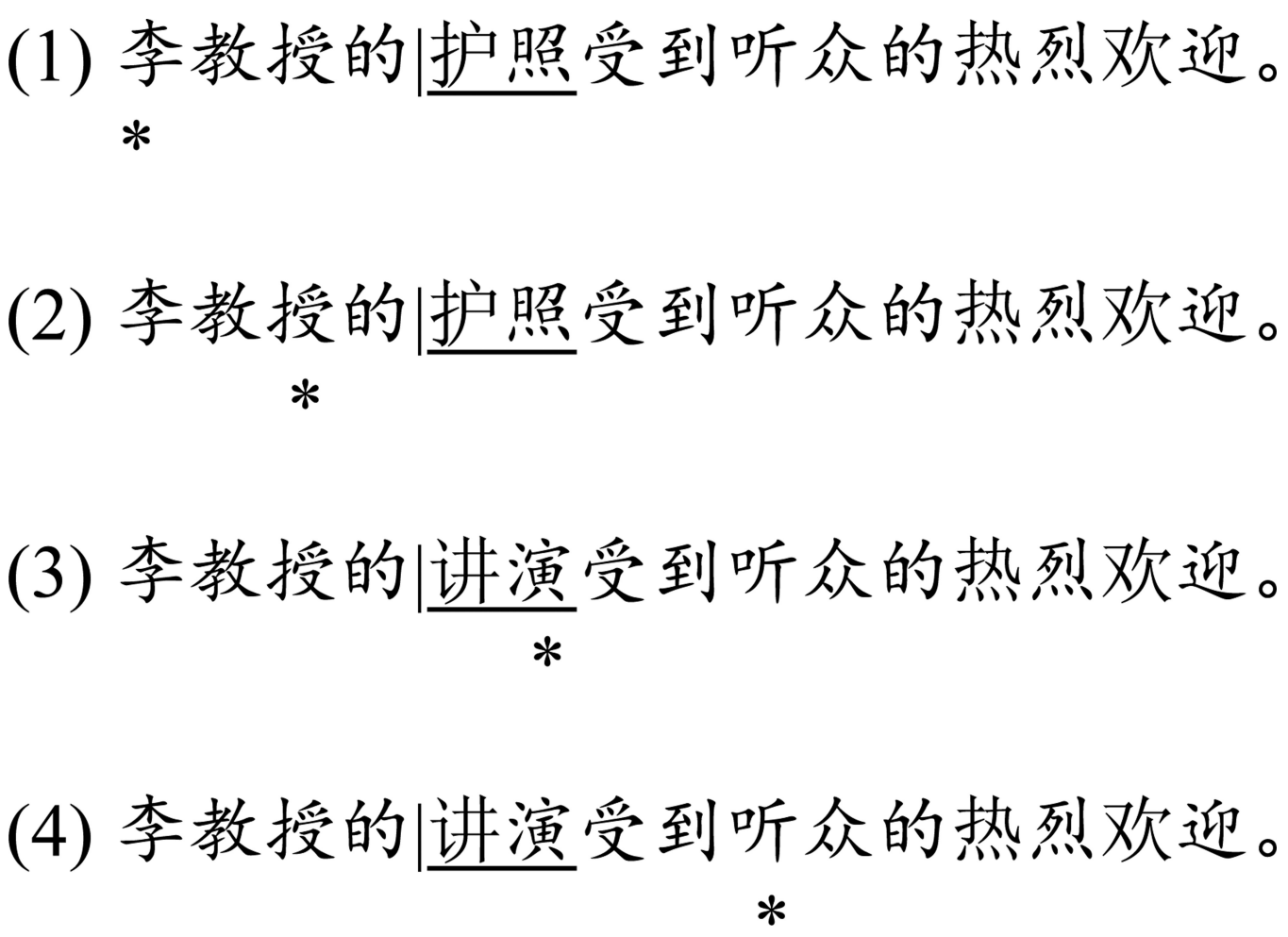

Figure 1. Example of the boundary display change paradigm with Chinese

Note: In the line (1) to (2), the initially plausible preview (" 护照, passport", which was underlined) is initially displayed in the target location. When the reader's eyes crossed the invisible boundary location (|) located just to the left of the target word, the preview is replaced by the target word (" 讲演, speech", which was underlined), see line (3) and (4). The asterisks represent the fixation locations.

The English translation of this sentence is: *Professor Li's speech was warmly welcomed by his audience*.

Table 1

Lexical properties of different preview conditions

Preview	Identical	Initial-plausible	implausible
Word frequency	22 (40)	24 (43)	22 (39)
Log word frequency	0.64 (.94)	0.83 (0.78)	0.63 (0.98)
Character frequency			
1st character	794 (1305)	802 (1345)	817 (1117)
2nd character	794 (1305)	772 (1390)	769 (1275)
Log character frequency			
1st character	2.47 (.69)	2.48 (0.67)	2.55 (0.62)
2nd character	2.47 (.69)	2.49 (0.59)	2.48 (0.64)
Number of strokes			
1st character	9.3 (3.5)	9.2 (3.0)	8.9 (3.1)
2nd character	9.3 (3.5)	9.4 (3.3)	9.1 (3.5)

Notes: Numbers in parentheses are standard deviations. Frequency is measured as character/word per million from a Chinese Dictionary (Corpus from China Daily, 1998).

Table 2

Subject means (and standard error) as a function of preview on the target word.

Preview	Identical	Initially plausible	Implausible
	Early measures		
Probability of skipping	0.04(0.01)	0.03(0.01)	0.06(0.02)
Probability of single fixation	0.71(0.03)	0.65(0.03)	0.55(0.03)
First fixation duration (ms)	262(6)	262(6)	278(7)
Single fixation (ms)	271(7)	267(8)	292(10)
Gaze duration (ms)	321(12)	346(13)	374(13)
	Late measures		
Go-past time (ms)	357(15)	400(16)	430(17)
Second pass (ms)	68(9)	95(11)	92(14)
Total time (ms)	400(17)	457(19)	482(21)
Regressions in (%)	16(2)	22(2)	21(2)
Regressions out (%)	6(1)	10(1)	11(2)

Table 3

Subject means (and standard error) as a function of preview on the pre-target and post-target region.

Preview	Identical	Initially plausible	Implausible
	Pre-target region		
Probability of skipping	0.11(0.02)	0.11(0.02)	0.11(0.02)
Gaze duration (ms)	291(11)	273(8)	275(9)
Second pass time (ms)	41(7)	63(10)	59(8)
Regressions in (%)	9(1)	15(2)	18(2)
Total time (ms)	339(14)	351(15)	350(13)
	Post-target region		
Probability of skipping	0.18(0.03)	0.17(0.02)	0.15(0.02)
Gaze duration (ms)	289(9)	301(10)	299(10)
Gopast time (ms)	363(15)	411(18)	401(15)
Regressions out (%)	12(2)	19(2)	18(2)
Total time (ms)	357(12)	384(13)	378(15)

Table 4

Subject means (and standard error) as a function of preview on the target word when the pretarget region was fixated.

Preview	Identical	Initially plausible	Implausible
	Early measures		
Probability of skipping	0.05(0.02)	0.03(0.01)	0.07(0.02)
Probability of single fixation	0.73(0.03)	0.66(0.03)	0.57(0.03)
First fixation duration (ms)	265(7)	262(7)	281(7)
Single fixation (ms)	270(7)	267(8)	294(10)
Gaze duration (ms)	325(13)	346(13)	377(14)
	Late measures		
Gopast time (ms)	342(14)	391(17)	426(17)
Second pass (ms)	65(9)	103(12)	91(14)
Total time (ms)	394(16)	459(20)	481(21)
Regressions in (%)	16(2)	24(3)	22(2)
Regressions out (%)	4(1)	8(1)	9(2)