to longer fixation
osodic boundary informa-
aradigm to manipulate the
disambiguating position.
reduced the reading time
the prosodic boundary cue was
eporter interviewed the squatter and the policeman" may
e an event with two objects. But if a break is heard between

squatter and and, the listener may expect a second event with the policeman as its agent or patient and may feel that the sentence is incomplete after hearing only the policeman. In this case, prosodic information is used to guide the syntactic parser (Snedeker & Yuan, 2008) and to help predict upcoming information with respect to the syntactic structure (Kerkhofs, Vonk, Schriefers, & Chwilla, 2007), and hence to facilitate sentence comprehension. However, although there is ample evidence showing that prosodic information can be immediately perceived and used to help syntactic parsing and semantic integration of phrases preceding the boundary, it is unknown whether and how this rapid process affects the processing of upcoming lexical information. The main purpose of the present study was therefore to explore how information about the prosodic structure of a sentence affects the processing of lexical items right after the occurrence of prosodic boundary.

In speech, a prosodic boundary is usually characterized by preboundary lengthening, pause and pitch declination, followed by pitch reset upon crossing the boundary (de Pijper & Sanderman, 1994; Li & Yang, 2009; Wang, Lü, & Yang, 2004). Considered as a signal for when to close off a clause or phrase (Nicol, 1996), a prosodic boundary helps to organize speech into phrases and to indicate syntactic segmentation of the sentence (Cutler, Dahan, & van Donselaar, 1997; Li & Yang, 2009; Snedeker & Yuan, 2008). In the case of temporary ambiguity, prosodic boundary informa-

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pated in Experiment 1. They all were native speakers of Chinese and had normal or corrected-to-normal vision.

Materials and design. Each ambiguous sentence was paired with three types of speech melody, forming three experimental conditions. For the condition with an early prosodic boundary, the P2[(v)9(is)4(io)-1((5(.)]TJ /CS1-113i)-6(g12.5455)3(p)-1149.88u588.36

2)

from a linear mixed model for durations and landing positions and a generalized linear mixed model for percent regressions and skipping rates, with crossed random effects for participants and items, via the lmer program of the lme4 package (Bates, Maechler, & Dai, 2008) in the R environment for statistical computing (R Development Core Team, 2008). Analyses for untransformed and log-transformed durations yielded the same pattern of significance; thus statistics are reported for log-transformed durations. Estimates larger than 2 standard errors (i.e., absolute t values greater than 2) sslute 2) 2 gaze duration: 308 and 310 ms; second-pass reading times: 423 and 432 ms, respectively). In contrast, the landing positions into this region for sentences with an early pause were numerically the shortest (0.91 character) among the three conditions.

Region 3. As shown in Table 2, sentences without pauses had longer gaze durations (316 ms) than sentences with a pause (298 ms for those with an early pause and 305 for those with a late pause; $b = 0.020$, $SE = 0.008$, $t = 2.6$). The second-pass reading times were also longer for sentences without pauses (473 ms) than for the other two types of sentences (415 ms for sentences with an early pause, 402 ms for sentences with a late pause; $b = 0.051$, $SE = 0.022$,
t Tw 0.387 0 Td [(lj /TT3 1i Tw 1.147 0 Td)6Tj 0.007 Tc -0.007 Tw 0.267 0 Td (2lj /TT3 [(no

between prosody and parsing strategy in a particular experimental condition (depending on the strategy used). For instance, if the reader used a minimal attachment strategy (Frazier, 1978; Frazier & Rayner, 1982), the postboundary Region 2 and Region 3-(modifier + NP3) would be taken as a copatient by the strategy. Then on both Region 1 and the postboundary regions the conflict between parsing strategy and prosody would engender longer reading times. It is clear from Table 2 that although this was the case for Region 1, it was not for Region 2 and Region 3. On the other hand, if the reader used an early closure strategy, then the reading times on Region 1 should be longer for the sentences with a late pause than for the sentences with an early pause because of the conflict in the former condition. Again, the data in Table 2 speak against this suggestion.

Experiment 2

Experiment 1 showed that prosodic boundary information in a speech melody can be projected onto visually presented sentences and gives rise to longer durations on preboundary regions, possibly because of a wrap-up process. Moreover, inconsistent with the preparation account, Experiment 1 showed that reading times on the postboundary regions were not shorter or were even longer than reading times on the words without a boundary preceding them. In Experiment 2, we focused more on postboundary regions and sought to examine whether the processing of prosodic boundary information would facilitate or interfere with the processing of the upcoming, postboundary lexical information. To this end, we adopted the gaze-contingent boundary paradigm (Rayner, 1975) and examined how prosodic boundaries and parafoveal preview would jointly influence the processing of the words right after and before the prosodic boundary.

Figure 3. Exemplar sentences and interest regions in Experiment 2. (A) The sentence presented before the fixation crossed the invisible boundary between NP2 and hé in identical preview condition. (B) The sentence presented before the fixation crossed the invisible boundary between NP2 and hé in mask preview condition. (C) The sentence presented after the fixation crossed the invisible boundary. Translations: “Doctor Wang bid farewell to her parents and her newly married husband, and went to the East Sea to examine the oil fields.” / “Doctor Wang bid farewell to her parents, and went to the East Sea to examine the oil fields with her newly married husband.” NP = noun phrase; VP = verb phrase.

The modifier had one or two words, with the first word serving as the target word. Given that the modifiers (Region 2) in Experiment 1 were often short (i.e., two to three characters) and the head nouns had different syntactic roles in different conditions, the processing of the modifiers may potentially be affected by the parafoveal processing of the head nouns (i.e., the parafoveal-on-foveal effect). Hence the prosodic boundary effect on Region 2 could be confounded with the parafoveal-on-foveal effect. To minimize this potential confound, we used only long modifiers with four or five characters.

All sentences were assessed for syntactic ambiguity by 20 participants who did not participate in the eye-tracking experiment or in the norming for Experiment 1. Participants selected the early prosodic boundary reading for 49.5% (ranging from 40% to 65%) of these sentences and selected the late prosodic boundary reading for 50.5% (ranging from 35% to 60%).

The same speaker from Experiment 1 read these sentences according to instructions. This sentences were filtered according to the same procedure, yielding 160 pieces of speech melody, 80 with the early pause (the mean duration of the pause was 421 ms; SD = 72) and 80 with the late pause (the mean duration was 455 ms; SD = 74). These pieces were paired with the 80 visually presented sentences, respectively.

A Latin square design was used to assign the sentences and the paired speech melodies to four test lists, with each list having 20 sentences for each experimental condition. The same filler items as in Experiment 1 were used.

Apparatus. The same equipment used in Experiment 1 was used here. The font Song-22 was used, with one character subtending 0.6° of visual angle. Other parameters were the same as in Experiment 1.

Procedure. Figure 3 illustrates the sequence of display changes during one trial. When a sentence was initially presented, the target location in preview (i.e., the first character of the target word) was occupied by either an identical character (see Figure 3A) or a pseudocharacter that was created by reversing the left and the right part of the original character via the Microsoft TrueType program (see Figure 3B). The pseudocharacter was used to prevent participants from extracting lexical information before fixating upon the target word. An invisible vertical boundary was located between NP2 and hé. When a saccade crossed this invisible boundary, the previewed character was replaced by the target character (see Figure 3C). The sentence remained in this final form until the end of the trial. After the eye-tracking system had detected the crossing of the boundary, display changes were accomplished with a mean time of 7.3 ms, ranging from 2 to 13 ms. Participants read 116 sentences, including 80 experimental sentences and 36 filler sentences. For half of the sentences in each category, a comprehension question was presented after the stimulus sentence, and the participant had to decide, by pressing a response button, whether the meaning of the question sentence was congruent or incongruent with a proposition encoded in the stimulus sentence. To detect whether participants used the prosodic boundary cue to parse the sentences, two of the 58 question sentences were directly related in meaning to the interpretation of the ambiguous sentences.

After the completion of the test, participants were asked to report whether and how often they had noticed anything unusual during sentence reading. Twenty-five out of 38 participants reported seeing “flashes” on the screen, and the number of flashes noticed ranged from one to four, with a mean of 1.6. However, they could not report anything specific for the flashes. In addition, all participants except three reported that they noticed the early and the late pauses in speech melodies. Those three participants showed similar patterns of eye movements as the other participants and were included in the data analysis.

Data analysis. Two regions were selected as regions of interest, as shown in Figure 3. Region 1 contained NP2 (i.e., word n), composed of two to three characters. Region 2 (i.e., word n + 2) contained part of the modifier for the head noun in NP3, composed of two to four characters (i.e., newly married in the figure). Trials with either first-fixation duration less than 60 ms or greater than 800 ms or gaze duration less than 60 ms or greater than 1,000 ms (2% of all fixations) were eliminated. Trials in which the display change was inappropriately initiated during fixations on n + 1 or n + 2 were also excluded. Results from six participants were further discarded because the inappropriate display change occurred in more than 40% of the trials. For the remaining 32 participants, 77% of all the fixations were entered into the analyses of duration and landing position.

Similar to Experiment 1, estimates are from a linear mixed model for durations and landing positions and a generalized linear mixed mode

Figure 4. Exemplar sentences in Experiment 3. (A) A sentence with an

A 69AsA4A 0.02TJ 0c 0.011 395(e)]TA 0 2t T 0 aw 9 4330 6 (e92g)TJ 0 Tc 0 Tw ( )T(Tc 0.01m 60esc77n0.01150.011 Tc50295(e)]TJ 0 2)22ententAA 0 00.

region. Although the interaction between preview type and prosodic boundary was not reliable ($b = 0.049$, $SE = 0.031$, $t = 1.6$), the pattern was nevertheless similar to that in Experiment 2: The difference between gaze duration in sentences with the early pause (337 ms) and those with the late pause (308 ms) in identical preview was numerically larger than the difference in mask preview (322 vs. 313 ms).

Region 2.

Parafoveal preview

Experiment 3, the preview benefit for postcomma words was significant even when the comma was present.

Previous research on the effect of prosodic boundary in sentence reading has commonly used punctuation to convey the (implicit) prosodic structures in the sentences. However, this kind of manipulation introduces at least two confounds: (a) the unbalanced visual complexity for the target regions between the conditions with and without a comma and (b) an increased distance between the pre and postcomma words when a comma is present. Both confounding factors have been found to influence the pattern of eye movements during sentence reading (Drieghe, Brysbaert, & Desmet, 2005; Rayner, Fischer, & Pollatsek, 1998; White, 2008). To avoid this confound, we used speech melody to convey the prosodic boundary information and observed not only the effect of wrap-up process on the prebounda2008)n of1(c)11(t)5(of)20(e(s)9(e)11(k(f)20()11(a)11(som)12(m)25((oun)14(d t)5(of)20(e11(om)(of

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