



“Who” should be focused? The influence of focus status on pronoun resolution

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Abstract

Focus is assumed to be able to enhance the salience of a focused constituent and thereby facilitate the interpretation of a pronoun that refers to a focused antecedent relative to an unfocused antecedent. To assess how discourse-based focus structure influences the interpretation of a pronoun and whether this process is modulated by the grammatical role of the antecedent, we conducted an ERP study in which the focus status of a pronoun's potential antecedents was manipulated by means of a *wh*-question-answer structure. We found that, relative to those in the focused position, pronouns referring to antecedents in the unfocused position evoked enhanced positive responses in both early (180–230 ms) and late time windows (400–800 ms). Moreover, while a larger positivity was evoked by object-referring pronouns compared to subject-referring pronouns in the 400–800 ms time window over the right hemisphere, there was no effect of grammatical role in the 180–230 ms time window. These findings indicate that, while the initial stage of pronoun resolution is modulated by focus information assigned via a *wh*-question structure, integration of the pronoun and its antecedent into a coherent discourse representation at the later stage could be constrained by various factors, including the focus status and possibly the grammatical role of the antecedent.

Descriptors: Focus, *Wh*-question structure, Grammatical role, Pronoun resolution, ERPs

Focus is an information structural primitive that determines which part of an utterance contributes to new or contrastive information (Filik, Paterson, & Sauermaun, 2011; Halliday, 1967; Jackendoff, 1972; Kiss, 1998; Rooth, 1992). The focus of an utterance can be signaled prosodically (e.g., via changes in pitch, loudness, etc.; Johnson, Clifton, Breen, & Morris, 2003; Stolterfoht, Friederici, Alter, & Steube, 2007) or syntactically (e.g., by using *cleft* structure; “It was the king who led the troops”). Moreover, focus can also be realized or modified by discourse-based contextual information (Chomsky,

1971; Cowles, Kluender, Kutas, & Polinsky, 2007; Sauermaun, Filik, & Paterson, 2013). One frequently used strategy is the use of *wh*-question structure. A *wh*-question sets the background for an answer, which in turn determines the focus of the answer. As illustrated in Example 1, below, the noun “Lisa,” which is asked for by a *wh*-question sentence, is the focus of the answer as it conveys new information, whereas “John” was previously mentioned and therefore was treated as background information.

1. *Who did John see yesterday?*
John saw Lisa yesterday.

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Focused information receives more attention than unfocused information and thus could be more accessible for a subsequent referential form (e.g., pronoun) to refer to. Thus, if a pronoun is resolved toward an unfocused antecedent but not the focused one, it would engender topic shift and disrupt sentence/discourse coherence. The main purpose of the current study is to investigate the relationship between focus processing and pronoun resolution. Specifically, we examine whether and how the focus status of a referent assigned through a *wh*-question structure exerts neural modulation on the interpretation of a subsequent pronoun during discourse comprehension. Before we move to our experimental design, we first briefly review the existing findings related to the issue.

Behavioral evidence from a variety of paradigms shows that entities in the focus position receive more attention and are processed more deeply, whereas information in a nonfocus position receives less attention and is thus processed less elaborately (Almor, 1999; Bredart & Modolo, 1988; Reichle, 2014; Sturt, Sanford, Stewart, & Dawydiak, 2004; Wang, Bastiaansen, Yang, & Hagoort, 2011, 2012). Studies using electrophysiological recording demonstrate that the contextual prediction generated by *wh*-question structure can exert neural modulation on the early stage of sentence processing (Bornkessel, Schlesewsky, & Friederici, 2003; Cowles, Kluender et al., 2007; Johnson et al., 2003). Bornkessel et al. (2003), for example, investigated how contextual predictions in terms of question-answer pairs modulate online sentence processing in German. A critical constituent (the initial NP [noun phrase]) in the answer sentence, which functioned as either a subject or an object, was either focused or unfocused by a preceding *wh*-question context. It was found that, relative to the unfocused constituent in a neutral context, the focused constituent evoked a larger positivity in the 280–480 ms time window irrespective of whether the focused element was a subject or an object. This finding suggests that the *wh*-question focus structure can modulate sentence processing, with the focus expectation sufficing to override the effect of the grammatical role of a constituent. A similar pattern was reported by Johnson et al. (2003) for auditorily presented question-answer pairs, with a larger positivity for focused constituents relative to unfocused constituents, although this effect was a little delayed (500–700 ms). In another line of ERP studies, Wang et al. (2011, 2012) examined how semantic and syntactic processing were modulated by focus status assigned via *wh*-question context. They found that both the N400 effect elicited by semantic anomaly and the P600 effect evoked by syntactic violation were enhanced when the anomalies were presented in a focus position relative to a nonfocus position, suggesting that focus assignment can exert neural modulation on sentence-level semantic as well as syntactic processing.

The ERP studies cited above consistently show that focused information, irrespective of whether they are semantically or grammatically congruent with the sentence/discourse context, can be processed more deeply than unfocused information. However, these studies sought only to deal with how focused information itself is processed; they told us little about how focus status influences the establishment of a long-distance dependency, for example, a co-referential relation between a focused constituent and a subsequent referential expression (i.e., anaphor/pronoun). Previous studies have revealed that a number of constraints, including both word-level and discourse-level, can influence the online referential processing and thereby affect the establishment of a coherent discourse representation. For example, if a pronoun is consistent with the verb's implicit causality bias ("Linda praised David, because *he* . . ."), discourse coherence is easier to achieve (e.g., a reduced P600 response is observed; Van Berkum, Koornneef, Otten, & Nieuwland, 2007). Moreover, if the coherence relations across clauses are made explicit by discourse conjunctions (e.g., causal marker *because*), both referential interpretation and discourse coherence become easier to achieve (Cozijn, Noordman, & Wonk, 2011; Koornneef, & Van Berkum, 2006; Millis & Just, 1994; Traxler, Bybee, & Pickering, 1997; Van Berkum et al., 2007; Xu, Jiang, & Zhou, 2015). Particularly relevant to the current study are the ERP experiments showing that topic structure, another type of information structural device, can significantly increase the salience of a topical referent in discourse and thereby facilitate the interpretation of an anaphor and the establishment of a coherent discourse representation (Xu, 2015; Xu & Zhou, 2016).

For the issue concerning focus information and anaphor resolution, there are only a few behavioral attempts (Almor, 1999; Foraker, 2004; Foraker & McElree, 2007). Using a cross-modal naming task, Cowles, Walenski, and Kluender (2007) investigated how the interpretation of a pronoun is influenced by the focus status of the potential referents in an auditory discourse context, as in Example 2. The authors reported faster responses to a visual probe, which was potentially related to either a prominent (focused) or a less prominent (unfocused) antecedent, immediately presented at the offset of the potentially ambiguous pronoun ("she") when it referred to the preceding focused referent ("Anne") relative to an unfocused referent ("Sarah"). This finding is consistent with the idea that focus structure can increase the cognitive salience of potential referents, and this increased activation of the referent can be detected when the subsequent pronoun is presented.

2. *A new movie opened in town.*

It was Anne who called Sarah.

But later that night she couldn't go to the movie after all.

Colonna, Schimke, and Hemforth (2012) investigated how pronoun interpretation is influenced by *it*-cleft focus structure as well as the grammatical role of potential antecedents in German and French. They asked participants to report their interpretation of an ambiguous pronoun, which can potentially refer to an antecedent in either the subject or object position. For German speakers, the pronoun is preferred to refer to the subject antecedent regardless of whether the subject or object was focused, revealing an overall subject preference. For French speakers, however, focus seems to have a reverse effect on pronoun resolution; that is, the pronoun is more likely to be interpreted as referring to the unfocused rather than focused constituents. The effect of focus on pronoun resolution is apparently modulated by cross-linguistic differences.

Although the above studies provided evidence for the relation between focus processing and pronoun resolution, they are not able to reveal the time course of how focus status modulates the interpretation of a pronoun. According to psycholinguistic models of anaphoric resolution, the interpretation of a pronoun may include at least two processing stages (Garrod & Sanford, 1994; Garrod & Terras, 2000): an initial process to reactivate/retrieve the potential antecedents (bonding), followed by a process of evaluating the activated antecedents for the degree of fit with the pronoun and the whole discourse (resolution). The initial process is driven mainly by the superficial cues such as lexical or morphological features; structural constraints and discourse-based constraints (e.g., information structure) are assumed to be available only at the later stage of processing.

Using online eye-movement measures, Foraker and McElree (2007) found that, relative to the unfocused antecedent, the focused antecedent assigned by a cleft structure speeded up the late processing (e.g., the *second-pass reading time*, the *regression path time*) of integrating the pronoun-antecedent bond into the discourse (Garrod & Terras, 2000); however, measures for the early processing (e.g., the *first-pass reading time*, the *first-pass regressions out*) failed to show any processing facilitation. Using a visual-world eye-tracking paradigm, Kaiser (2011) investigated how focus assignment influences the resolution of an ambiguous pronoun and whether this process is modulated by the antecedent's grammatical role in the English *it*-cleft structure.

Results showed a marginal interaction between focus status and grammatical role in a late time window (1,502–2,000 ms), with a stronger subject preference in the focused subject condition relative to the focused object condition. Data for the early time window, however, failed to show clear facilitation of focus assignment, although there was an overarching subject preference across all conditions. The authors argued that focus only facilitates the resolution stage (the integration of the pronoun and antecedent into discourse) of pronoun processing; moreover, focus contributes less than subjecthood in determining the referent for the pronoun.

To our knowledge, there has been only one ERP study on how the interpretation of a coreferential relation is affected by focusing, although nominal anaphora rather than pronoun was adopted in this study (Cowles, Kluender et al., 2007). Cowles, Kluender et al. (2007) recorded brain responses to a target noun in the *it*-cleft sentence (the target sentence), which was paired with a prior *wh*-question context (Example 3a). The focus assignment to a critical word by the *it*-cleft structure in the target sentence could be either congruent (3b) or incongruent (3c) with the focus expectation triggered by the preceding *wh*-question context.

3. (a) Set up context: *A queen, an advisor, and a banker were arguing over taxes. Who did the queen silence with a word, the banker or the advisor?*
- (b) Congruent target: *It was the **banker** that the queen silenced.*
- (c) Incongruent target: *It was the **queen** that silenced the banker.*

It was found that the cleft referential noun “banker” (in 3b) in the focus-appropriate sentence elicited more positive responses in the 200–500 ms window than its counterpart “queen” (in 3c) in the focus-inappropriate condition, suggesting that focus assignment via *wh*-question context can exert fast modulation on the moment-by-moment sentence processing. However, it should be noted that, in this study, anaphora, rather than antecedent, was focused by the focus structure; it provides us with limited insights on how anaphora resolution is influenced by the focus status of the antecedent.

The Present Study

The main purpose of this study was to examine the neural correlates underpinning focus processing and pronoun resolution. Unlike previous behavioral studies adopting a syntactic approach (e.g., *it*-cleft structure) to assign focus information, the focus status in this study was manipulated in terms of *wh*-question structure, a type of focus structure that can be naturally assigned to constituents in either subject or object position in Chinese (Lambrecht, 1994; Reichle, 2014; Saueremann, Filik, & Paterson, 2013).

A *wh*-question sentence sets the background for an answer and determines what information should be focused in that answer. However, although both Chinese and English use *wh*-questions to assign focus information, Chinese *wh*-question structure differs from its English counterpart in the location of the *wh*-element, as the *wh*-question element (i.e., “Who”) in Chinese is *in situ*. That is to say, whereas *wh*-question elements in English usually rise at the beginning of the sentence (from “Fengkui abandoned Liufei” to “Whom did Fengkui abandon?”), *wh*-question elements in Chinese occupy the same structural position in a sentence as their declarative counterparts do (e.g., the equivalent question in Chinese is

“Fengkui abandoned whom?¹”). Thus, when the *wh*-word appears at clause-initial (subject position), as illustrated in Sentence (4a/5b) in Table 1, then the focus of the answer will be the subject (“Fengkui”). On the other hand, when it appears at clause-final (object position), as in Sentence (4b/5a), the focus of the answer will be the object (“Liufei”). Finally, the *because* clause at the end of the sentence (see Table 1) introduces a pronoun that may refer to either the subject or the object; fully crossing the focus structure of the answer (two levels: focused subject vs. focused object) and the reference of the following pronoun (two levels: subject vs. object) yields four experimental conditions. Given that the position of a *wh*-element and its corresponding focused constituent was structurally parallel (a clause-initial *wh*-element places focus on the initial position of a clause, i.e., subject, whereas a clause-final *wh*-element places focus on the final position of a clause, i.e., object), the present study could eliminate the confound induced by structural variations (e.g., position and distance) and more directly gain insights into the relationship between focus processing and pronoun resolution.

Previous ERP studies on focus processing generally revealed a larger early positivity for the focused constituent (the target word) than for the unfocused constituent (around 200 ms postonset of the target word; e.g., Bornkessel et al., 2003; Cowles, Kluender et al., 2007). Different from these studies, the ERP waveforms in this study were not time-locked to the antecedent but to a subsequent long-distance pronoun, which occurs outside the *wh*-question focus structure. Thus, the earlier findings do not necessarily lead us to expect a larger positivity for the focus-consistent pronoun relative to the focus-inconsistent pronoun.

Instead, our predictions are mainly based on the existing studies of pronoun resolution. According to the psycholinguistic model of anaphora resolution, different stages of pronoun resolution are associated with different ERP effects (Callahan, 2008; Silva-Pereyra, Gutierrez-Sigut, & Carreiras, 2012). The resolution stage is consistently manifested by a late positivity effect (P600 effect). For instance, a larger P600 response has been repeatedly observed for pronouns that are interpreted to refer to a less prominent antecedent (e.g., nontopic antecedent, long-distance antecedent) rather than a prominent antecedent (e.g., topic antecedent, short-distance antecedent; Hammer, Jansma, Lammers, & Münte, 2008; Hirofani & Schumacher, 2011; Hung & Schumacher, 2012; Qiu, Swaab, Chen, & Wang, 2012; Xu, 2015; Xu & Zhou, 2016). Thus, we predicted that the focus-inconsistent pronoun would elicit enlarged late positive responses (P600) compared to the focus-consistent pronoun. Specifically, if focus status plays a dominant role in determining the interpretation of a pronoun, then the focus-inconsistent pronoun should evoke larger positive deflections than the focus-consistent pronoun regardless of the grammatical role of its antecedents.

The predictions for the bonding stage were less obvious, due to the inconsistent ERP findings in previous studies. Li and Zhou (2010) found that ERP responses to a (reflexive) pronoun were more positive when its referent was less accessible (because of a long distance between the pronoun and the antecedent) compared to the more accessible one (i.e., short

1. While this type of question is also possible in English, it is only felicitous with contextual support (e.g., in a situation where the listener wants the speaker to repeat the answer, either because the listener did not hear the answer clearly or because she is surprised by it). In Chinese, however, this is the default, unmarked question structure.

Table 1. *Experimental Conditions and Exemplar Sentences with Translations*

Condition	Examples
Subject-consistent (subject focused)	<p>4(a) 谁/抛弃了/刘菲, 是/冯奎/还是/别人? 冯奎/抛弃了/刘菲, 因为/他/染上了/严重的/毒瘾。 <i>Shui/paoqile/Liufei_{fem}/, shi/Fengkui_{male}/haishi/bieren?</i> <i>Fengkui_{male}/paoqile/Liufei_{fem}, yinwei/ta_{male}/ranshangle/yanzhongde/duyin.</i> Who/abandon/Liufei_{fem}, is/Fengkui_{male}/or/someone else? <i>Fengkui_{male}/abandon/Liufei_{fem}, because/he/addict to/serious/heroin.</i> <i>Who abandoned Liufei_{fem}, Fengkui_{male} or someone else?</i> <i>Fengkui_{male}/abandoned/Liufei_{fem}, because/he/was seriously/addicted to/heroin.</i></p>
Subject-inconsistent (object focused)	<p>4(b) 冯奎/抛弃了/谁, 是/刘菲/还是/别人? 冯奎/抛弃了/刘菲, 因为/他/染上了/严重的/毒瘾。 <i>Fengkui_{male}/paoqile/shui, shi/Liufei_{fem}/haishi/bieren?</i> <i>Fengkui_{male}/paoqile/Liufei_{fem}, yinwei/ta_{male}/ranshangle/yanzhongde/duyin.</i> <i>Fengkui_{male}/abandon/whom, is/Liufei_{fem}/or/someone else?</i> <i>Fengkui_{male}/abandon/Liufei_{fem}, because/he/addict to/serious/heroin.</i> Whom did Fengkui_{male} abandon, Liufei_{fem} or someone else? <i>Fengkui_{male}/abandoned/Liufei_{fem}, because/he/was seriously/addicted to/heroin.</i></p>
Object-consistent (object focused)	<p>5(a) 冯奎/抛弃了/谁, 是/刘菲/还是/别人? 冯奎/抛弃了/刘菲, 因为/她/染上了/严重的/毒瘾。 <i>Fengkui_{male}/paoqile/shui, shi/Liufei_{fem}/haishi/bieren?</i> <i>Fengkui_{male}/paoqile/Liufei_{fem}, yinwei/t_{fem}/ranshangle/yanzhongde/duyin.</i> <i>Fengkui_{male}/abandon/whom, is/Liufei_{fem}/or/someone else?</i> <i>Fengkui_{male}/abandon/Liufei_{fem}, because/she/addict to/serious/heroin.</i> Whom did Fengkui_{male} abandon, Liufei_{fem} or someone else? <i>Fengkui_{male}/abandoned/Liufei_{fem}, because/she/was seriously/addicted to/heroin.</i></p>
Object-inconsistent (subject focused)	<p>5(b) 谁/抛弃了/刘菲, 是/冯奎/还是/别人? 冯奎/抛弃了/刘菲, 因为/她/染上了/严重的/毒瘾。 <i>Shui/paoqile/Liufei_{fem}, shi/Fengkui_{male}/haishi/bieren?</i> <i>Fengkui_{male}/paoqile/Liufei_{fem}, yinwei/t_{fem}/ranshangle/yandongde/duyin.</i> Who/abandon/Liufei_{fem}, is/Fengkui_{male}/or/someone else? <i>Fengkui_{male}/abandon/Liufei_{fem}, because/she/addict to/serious/heroin.</i> <i>Who abandoned Liufei_{fem}, Fengkui_{male} or someone else?</i> <i>Fengkui_{male}/abandoned/Liufei_{fem}, because/she/was seriously/addicted to/heroin.</i></p>

Note. Condition labels indicate which noun the pronoun refers to. The subject noun or the object noun could be focused by the structure of the preceding *wh*-question (“谁” who/whom). Consistency refers to whether the pronoun is referring to the focused element.

distance between the pronoun and the antecedent), not only in the late time window (450–750 ms) but also in the early time window (300–400 ms). Another line of ERP studies, however, failed to show clear early ERP effects on pronoun resolution (Silva-Pereyra et al., 2012; Xu, Jiang, & Zhou, 2013). We tentatively predicted that the effect of context-based focus information on pronoun resolution occurs not only at the resolution stage, as suggested by the eye-tracking studies (e.g., Foraker & McElree, 2007; Kaiser, 2011), but also at the bonding stage, as suggested by the electrophysiological studies of focus processing (Bornkessel et al., 2003; Cowles, Kluender et al., 2007; Johnson et al., 2003) and pronoun resolution (Li & Zhou, 2010).

Method

Participants

Twenty-eight native Chinese speakers (seven males, age ranging from 18 to 26 years with mean age of 23.8 years) were recruited from Nanjing Normal University and were paid for their participation. All of them were right-handed, neurologically healthy, and had normal or corrected-to-normal vision. This study was carried out in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the School of Psychological and Cognitive Sciences, Peking University.

Materials and Design

We constructed 136 question-answer passages (see examples in Table 1). Each consisted of an answer sentence (target sentence) and a preceding *wh*-question sentence, which established a context that assigned focus information for the subsequent answer sentence. The answer sentence consisted of two clauses, a main clause and a subsequent subordinate clause. The main clause described an event or behavior involving two protagonists of different genders, introduced by proper names (“小刚/Xiaogang,” a typical boy’s name, and “小兰/Xiaolan,” a typical girl’s name), acting as subject and object, respectively. The subordinate clause described the reason behind the occurrence of the events or behaviors described in the main clause, which began with a conjunction “因为/because” and was immediately followed by a pronoun (“他/he” or “她/she”) that can be interpreted as referring to a protagonist acting as subject or object of the main clause. To test the gender stereotypes of the selected proper names, a norming study (with 40 students) was conducted. It showed that more than 98.0% of the NP1 names and 98.2% of the NP2 names can be unambiguously indicated as male or female, respectively, and there was no difference between these two types of proper names, $t < 1, p > .1$. The gender of the first and second protagonists was counterbalanced, making sure that a gender-marked pronoun could refer either to the close or the distant antecedent. In each condition, only one protagonist was a syntactically plausible antecedent of the pronoun, because of the

unambiguous gender cue. Previous studies concerning verb-based implicit causality and pronoun resolution have demonstrated that the implicit causality effect on pronoun resolution is limited to NP2-biased but not NP1-biased verbs (e.g., Long & De Ley, 2000). We hence here used only NP1-biased verbs for our critical stimuli in order to minimize the potential influence from verb-related implicit causality. However, if the implicit causality encoded in NP1-biased verbs does play a role in pronoun resolution, the use of only NP1-biased verbs would contaminate the potential effect of grammatical role (i.e., the subject preference effect) in pronoun resolution (see Discussion).

As described above, the preceding *wh*-question context can make the pronoun's potential antecedents either focused or unfocused. To ensure that each referent was mentioned equally often in the context, the *wh*-question clause was immediately followed by an alternative question, which presented the alternative protagonist plus someone else not mentioned in the context (e.g., “冯奎抛弃了谁, 是刘菲还是别人/Whom did Fengkui abandon, was it Liufei or someone else?”). The alternative protagonist could be the answer to the preceding *wh*-question, that is, the same as the subsequent focused constituent (e.g., “Liufei”). In this way, a 2×2 factorial design was created, with focus status (focus vs. nonfocus) and grammatical role (subject vs. object) being manipulated, resulting in four experimental conditions. For the convenience of description, we defined the four conditions according to whether the pronoun was referring to the subject noun or the object noun: subject-consistent (subject focused), subject-inconsistent (object focused), object-consistent (object focused), and object-inconsistent (subject focused; see Table 1).

Besides the critical sentences, a total number of 272 filler sentences were constructed to make the characteristics of the critical materials less transparent to the participants. Among them, 68 fillers had a similar question-answer structure, but neither subject nor object but the verb of the initial clause was focused by a preceding *wh*-question structure.² The other 204 filler sentences also had similar *wh*-question-answer structures: 40 sentences in which a third person (who would not be mentioned again subsequently) was questioned in the alternative question, 60 sentences in which the NP2-biased, rather than NP1-biased, verbs were adopted, and 104 sentences in which the *wh*-question clause was not followed by an alternative question and with a different *wh*-question element (e.g., “哪里/where,” “何时/when,” etc.).

The 136 quartets of critical stimuli were distributed into four test lists according to a Latin square procedure, with each list containing 34 passages per condition. The filler sentences were then added to each list, and materials in each list were pseudorandomized, with the restriction that no more than three consecutive passages were of the same condition. Participants were randomly assigned to one of the four lists.

Prior to the selection of the final set of sentences, the potential materials underwent two sentence-completion pretests. The first test was used to choose the NP1-biased verbs in order to constrain the potential influence of verb-related semantic biases on pronoun interpretation. Thirty-two participants were asked to write a meaningful continuation to each fragment of 320 target sentences (i.e., the fragment without the subordinate clause, as in “冯奎抛弃了刘菲, 因为.../Fengkui abandoned Liufei, because ...”). Participants were encouraged to begin the continuation with a pronoun (*he* or

Table 2. Mean Percentage and Standard Deviation for Using Pronoun Only (and Pronoun + Names) in Each Focus Context

	Pronoun only		Pronoun + names	
	NP1	NP2	NP1	NP2
Focus	0.631 ± 0.049	0.347 ± 0.044	0.797 ± 0.024	0.548 ± 0.035
Nonfocus	0.347 ± 0.038	0.114 ± 0.019	0.452 ± 0.035	0.203 ± 0.024

she) or with a repetition of a name (e.g., “冯奎/Fengkui” or “刘菲/Liufei”) presented in the main clause. On the basis of this pretest, only NP1-biased sentences were selected for the ERP experiment. Over the finally selected critical sentences, the percentage of NP1 reference was 67.24% (including both name and pronoun). The purpose of the second test was to examine how the use of a pronoun was influenced by context-based focus information and grammatical role. In this test, the same uncompleted target sentences were preceded by a *wh*-question context, with either subject or object being focused. Another 35 participants were asked to write a meaningful continuation to each of them. We examined the percentage of each antecedent being chosen for the continuation, as a function of condition (see Table 2). The repeated measures analysis of variance (ANOVA; with use of pronoun only) showed significant main effects of grammatical role, $F(1,34) = 60.42$, $p < .001$, and focus status, $F(1,34) = 36.81$, $p < .001$. The two-way interaction was also significant, $F(1,34) = 11.36$, $p < .005$. Because the differences between conditions were great (see the mean values in Table 2), the resolution of the interaction showed that the effect of focus status can be observed regardless of the antecedent's grammatical role (for subject: $t(34) = 6.35$, $p < .001$; for object: $t(34) = 5.58$, $p < .001$); and the effect of grammatical role (i.e., subject preference) was also observed regardless of the antecedent's focus status (for focused condition: $t(34) = 8.20$, $p < .001$; for unfocused condition: $t(34) = 6.96$, $p < .001$), suggesting that focus status and grammatical role have separable effects during pronoun processing.

Procedure

The participants were seated comfortably in a dimly lit sound-attenuating and electrically shielded booth. They were instructed to read each sentence attentively. All the stimuli were displayed in black against a gray background. Each trial began with a fixation point (+) at the center of the screen for 500 ms, followed by a blank screen for 500 ms. Then, the whole *wh*-question context was presented on the screen. After reading the *wh*-question context, the participant pressed the space bar to initiate the main clause of the target sentence (presented as a whole). After reading the main clause, they were required to press the space bar again to initiate the subordinate clause, which was presented segment by segment at the center of the screen. Each segment was presented for 400 ms followed by a 400-ms blank screen. The final segment of each subordinate clause was followed by a yes/no comprehension question that probed the understanding of the passages. The assignment of left/right hand to yes/no response was counterbalanced across participants. In order to reduce the participants' strategy of focusing only on the coreferential relation, 60% of the comprehension questions were designed to probe the understanding of segments other than the antecedent or the pronoun.

Each participant performed a practice block of 24 sentences, which had similar structures as the test stimuli. The test stimuli

2. Some researchers argued that, in this situation, the whole answer sentence, rather than a specific sentence constituent, is focused (Stolterfoht et al., 2007).

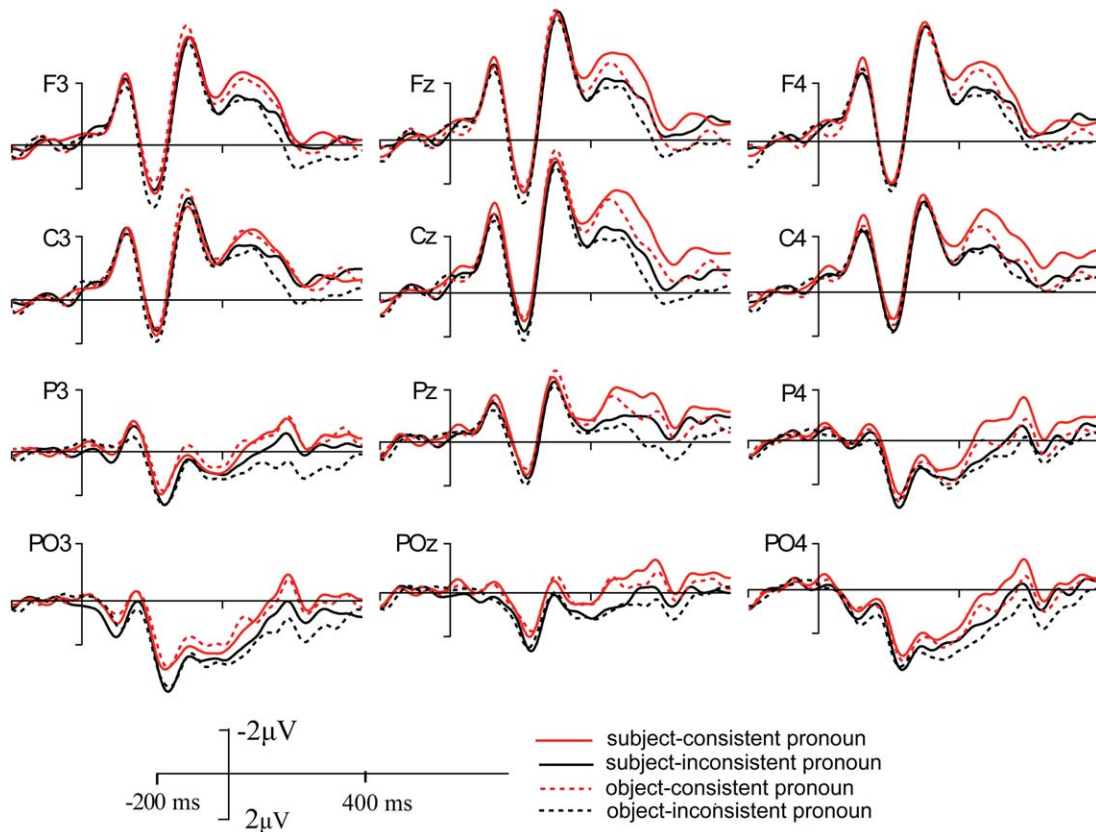


Figure 1. Grand-averaged ERPs time-locked to the critical pronoun for the subject-consistent pronoun, subject-inconsistent pronoun, object-consistent pronoun, and object-inconsistent pronoun, respectively.

were divided into five blocks, and the participant had a break of at least 3 min between each block. The test of each participant lasted about 2.5 h, including electrode preparation.

EEG Recording and Analysis

EEG activity was recorded from 63 electrodes in a secured elastic cap (Electro-Cap International). The EEGs were referenced online to the tip of nose and rereferenced offline to the algebraic average activity measured in the left and right mastoids (TP9 and TP10). The vertical electrooculogram (VEOG) was monitored from an electrode located above the right eye and the horizontal electrooculogram (HEOG) from one at the outer canthus of the left eye. Electrode impedances were kept below 5 k Ω . EEG signals were filtered using a band-pass of 0.016–70 Hz, and digitized at a sampling rate of 500 Hz.

For each target sentence, the ERP epoch was extracted from the pronoun in the subordinate clause with a prestimulus baseline of 200 ms and the ERP response to the pronoun for 800 ms. Trials with incorrect responses, or with EEG maximal amplitude exceeding $\pm 60 \mu\text{V}$, were eliminated from data analysis. Trials were also screened for drift artifacts. The mean number of trials included for EEG analysis was 28.7 for the subject-consistent pronoun, 28.9 for the subject-inconsistent pronoun, 28 for the object-consistent pronoun, and 27.3 for the object-inconsistent pronoun. Based on previous relevant studies (Xu, 2015; Xu, Jiang, & Zhou, 2013; Xu & Zhou, 2016) as well as the visual inspection of ERP responses, two time windows, namely, 180–230 ms (P2) and 400–800 ms (P600),

were selected for statistical analysis. To improve the signal-to-noise ratio of measurement and avoid component overlap, for the early effect (P2), a peak-based approach was adopted, whereas for the late time window a mean amplitude approach was used. ANOVAs were performed on the peak amplitude or the mean amplitude in each region of interest (ROI), with focus status (focused vs. unfocused), grammatical role (subject vs. object), and topographical factors as within-participant variables. For the mid-line analysis, the topographic factor was region with three levels: anterior (Fz and FCz) versus central (Cz and CPz) versus posterior (Pz and POz). For the lateral analysis, the topographic factors were region with three levels (anterior vs. central vs. posterior) and hemisphere with two levels (left vs. right). The region and hemisphere were crossed, resulting in six ROIs: left anterior (F1, F3, F5, FC1, FC3, FC5), left central (C1, C3, C5, CP1, CP3, CP5), left posterior (P1, P3, P5, PO3, PO7), right anterior (F2, F4, F6, FC2, FC4, FC6), right central (C2, C4, C6, CP2, CP4, CP6), and right posterior (P2, P4, P6, PO4, PO8). Mean amplitudes, based on the electrodes involved, were calculated for the ROIs before they were entered into statistical analysis. The Greenhouse–Geisser correction was performed when appropriate.

Results

Behavioral Results

The mean proportion of correct responses to probe questions for each experimental condition was more than 92.8%, indicating that participants had attended to the materials. An ANOVA with focus

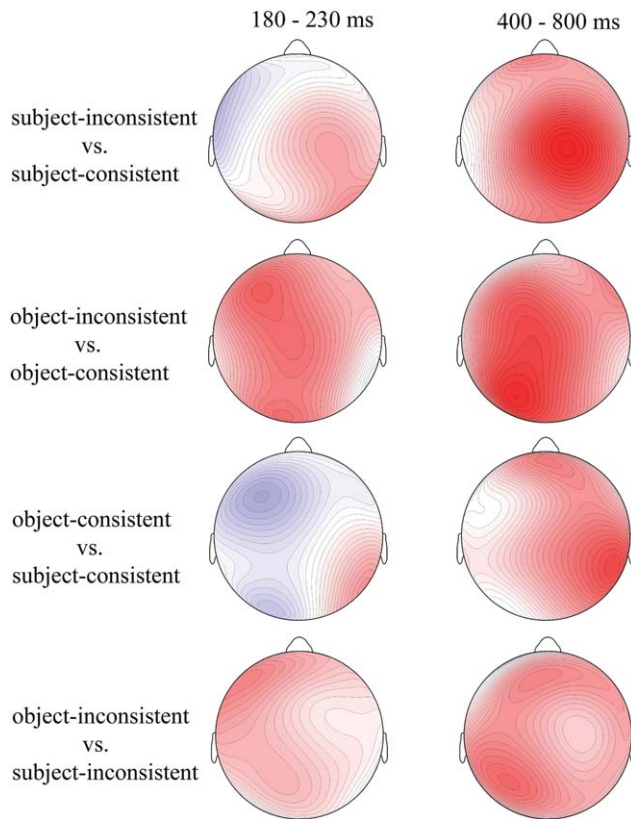


Figure 2. Topographic maps for difference waves on the pronoun between subject-inconsistent pronoun and subject-consistent pronoun, between object-inconsistent pronoun and object-consistent pronoun, between object-consistent pronoun and subject-consistent pronoun, and between object-inconsistent pronoun and subject-inconsistent pronoun in 180–230 ms window (the left column) and 400–800 ms window (the right column), respectively.

status and grammatical role as within-subject factors showed neither a main effect of focus status, $F < 1$, nor grammatical role, $F < 1$, although there was a marginal significant interaction between focus status and grammatical role, $F(1,23) = 3.83$, $.05 < p < .1$. We do not address this effect further because the probes were mainly focused on sentential contents other than the critical coreferential relation, as indicated earlier.

Electrophysiological Results

ERP responses in the 180–230 ms time window. Repeated measures ANOVA involving focus status and grammatical role, region, and hemisphere in the lateral analysis showed a significant three-way interaction between grammatical role, pronoun consistency, and hemisphere, $F(2,27) = 8.36$, $p < .01$, although neither the main effect of focus status or grammatical role nor the interactions with region reached significance, $ps > .1$. Further analyses were conducted for the left and right hemispheres separately to resolve the three-way interaction. For the left hemisphere, there was a significant interaction between focus status and grammatical role, $F(1,27) = 4.0$, $p < .05$, although neither the main effect of focus status nor grammatical role was significant, $F_s < 1$. Follow-up analyses showed that object-inconsistent pronouns evoked larger positivities than object-consistent pronouns, $F(1,27) = 4.76$, $p < .05$, whereas there was no difference between subject-inconsistent pronouns and subject-consistent pronouns, $F < 1$. For

the right hemisphere, there was a significant main effect of focus status, $F(1,27) = 4.52$, $p < .05$, but no interaction with grammatical role, $F < 1$, indicating that focus-inconsistent pronouns, including both object-referring and subject-referring pronouns, evoked larger positivities than focus-consistent pronouns (see Figure 1). No other effects of interest reached significance in the lateral analyses. The midline analysis revealed only a marginally significant main effect of focus status, $F(1,27) = 3.83$, $.05 < p < .1$. Thus, in the early time window, while the more positive responses for focus-inconsistent pronouns, relative to focus-consistent pronouns, were observed for the object-referring pronouns over the whole scalp (Figure 1), this effect for the subject-referring pronouns was mainly observable in the right hemisphere (see the topographic maps in Figure 2).

It should be noted that an alternative analysis with a poststimulus baseline (0–100 ms), to correct for early differences in the waveform that are visually apparent over some channels, yielded the same outcomes. Additionally, the mean amplitude measurement, which is less sensitive to early modulation, showed similar result patterns as well, though the effects were less robust.

ERP responses in the 400–800 ms time window. A repeated measures ANOVA showed a significant main effect of focus status, $F(1,27) = 12.82$, $p < .005$ in the midline and $F(1,27) = 6.78$, $p < .05$ in the lateral, with larger P600 positivity for focus-inconsistent pronouns than for focus-consistent pronouns. The main effect of grammatical role was marginally significant, $F(1,27) = 2.75$, $.05 < p < .1$ in the midline and $F(1,27) = 3.29$, $.05 < p < .1$ in the lateral, with larger positivity for object-referring pronouns than for subject-referring pronouns. Importantly, there was a three-way interaction between focus status, grammatical role, and hemisphere in the lateral lines, $F(1,27) = 6.03$, $p < .05$, although the two-way interaction between focus status and grammatical role was not significant, $F < 1$. Further analyses were carried out for the left and right hemispheres, separately. For the left hemisphere, there was only a significant main effect of focus status, $F(1,27) = 5.02$, $p < .05$, with larger P600 positivity for focus-inconsistent pronouns than for focus-consistent pronouns. For the right hemisphere, however, there were significant effects of both grammatical role, $F(1,27) = 5.40$, $p < .05$, and focus status, $F(1,27) = 7.69$, $p < .01$, with larger positivities for the object-referring pronouns than for the subject-referring pronouns, and for the focus-inconsistent pronouns than for the focus-consistent pronouns, respectively (see Figure 1). The interaction between grammatical role and focus status was not significant in either hemisphere, $F_s < 1$. There was no interaction between experimental condition and region (including both lateral and midline analyses), $ps > .2$.

Collapsing Data Across Subject and Object

To eliminate the potential influence of grammatical role (as well as mention order) and to measure more clearly the effect of focus status on pronoun resolution, the EEG data were collapsed across subject and object for the focused and unfocused conditions, respectively. The repeated measures ANOVA with focus status and topographic factors as within-subject factors showed a significant effect of focus status, with larger positivities for focus-inconsistent pronouns than for focus-consistent pronouns in the early and the late time windows: the early window, $F(1,27) = 3.87$, $.05 < p < .1$, (marginally significant) for the lateral, and $F(1,27) = 5.23$, $p < .05$, for the midline; the late time window, $F(1,27) = 6.78$, $p < .05$ for the lateral, and $F(1,27) = 12.82$, $p < .005$ for the midline. These

results demonstrated again the focus effects in the early and late time windows.

Discussion

In this study, we found that pronouns referring to antecedents in a nonfocus position evoked more positive responses than pronouns referring to antecedents in a focus position in both the 180–230 ms and the 400–800 ms time windows. In the early P2 time window (180–230 ms), there was only a significant effect of focus status, with a larger positivity for focus-inconsistent pronouns than for focus-consistent pronouns, although this effect appeared over the whole scalp for object-referring pronouns but mainly in the right hemisphere for subject-referring pronouns (see Figure 2). In the late time window (400–800 ms), however, there was a significant effect of grammatical role in addition to the effect of focus status, with larger positivities for object-referring pronouns than for subject-referring pronouns (see Figure 1), suggesting that both focus status and grammatical role contribute to the later stage of pronoun resolution. These findings indicate that focus information assigned via *wh*-question structure can exert fast neural modulation on the activation of the potential antecedents. Moreover, it suggests that the process of integrating the subsequent pronoun with the antecedent to form a coherent discourse representation is modulated by constraints from both focus status and grammatical role.

Early Positivity

The early positivity (P2) has traditionally been found to be associated with the allocation of attentional resources (Donchin, 1984; Hillyard, 1984), with larger positivity for stimuli occurring less frequently, reflecting the increased attentional engagement for processing unfamiliar stimuli. For referential processing, Heine, Tamm, Hofmann, Hutzler, and Jacobs (2006) found that a pronoun referring to a less frequent (i.e., less activated) antecedent elicited a larger positivity peaking around 300 ms postonset (named P300 by the authors), suggesting that increased attentional resources are needed to reactivate the unfamiliar word and link it with the pronoun. For focus processing during pronoun resolution, the observation of an early ERP effect in response to an inappropriate focus assignment could be related to the requirement of more attentional resources for reactivating the unfocused entity (relative to the focused entity).

The finding of the early focus effect (e.g., larger early positivity) on pronoun interpretation is consistent with previous studies on the processing of focus itself (e.g., Bornkessel et al., 2003; Cowles, Kluender et al., 2007). These studies, by using the *wh*-question structure, revealed enlarged positivities (around 200 ms) postonset of the focused words (with appropriate focus information) either relative to the focus-incongruent words (with inappropriate focus information; Cowles, Kluender et al., 2007) or to the neutral words (with no focus information; Bornkessel et al., 2003; Hruska, Alter, Steinhauer, & Steube, 2000). However, although early neural modulations were observed in both cases, there are major differences between these two lines of research. Firstly, while an enhanced positivity was evoked by the appropriate focus relative to the inappropriate focus or the no-focus condition in previous studies (e.g., Bornkessel et al., 2003; Cowles, Kluender et al., 2007), an enlarged positivity was evoked by inappropriate focus relative to appropriate focus in the present study. Secondly, the ERP effects in previous studies were commonly elicited by the focused constituents, whereas the ERP effect in the present study was not generated by the

focused constituents themselves but, instead, were evoked by an unfocused constituent, namely, a long-distance pronoun, which was coreferential with the focused constituent. In other words, what was focused here is a pronoun-antecedent referential relation. It should be noted that retrieving/activating focused information (i.e., antecedent) from a dependency relation (processing a pronoun-antecedent referential relation) is different from retrieving/activating focused information from a nondependency relation (i.e., processing a focused constituent itself; e.g., Bornkessel et al., 2003). The former was additionally modulated by a number of constraints such as the pronoun-antecedent distance and the agreement rules (e.g., gender/number information, etc.).

As can be seen from the topographic map (Figure 2), the focus effect, as manifested by a larger positivity effect, was broadly distributed (both hemispheres) for the object-referring pronouns, whereas focus effect was mainly distributed to the right hemisphere for the subject-referring pronouns. This distributional difference may be associated with the different referential preference status of subject entity versus object entity. Firstly, a pronoun generally has a preference to refer to subject entity over object entity (the so-called subject preference; Gelormin-Lezama & Almor, 2011; Gordon, Grosz, & Gilliom, 1993; Kaiser, 2011). Secondly, the subject-biased verbs (e.g., “abandon”) used in the critical sentences, could also make the subject a more likely antecedent than the object for the subsequent pronoun. These combined forces might have promoted the prominent status of subject antecedent (relative to object antecedent) and thereby led to different P2 distribution patterns between the subject-referring condition and the object-referring condition. As previously addressed (Donchin, 1984; Heine et al., 2006; Hillyard, 1984), the early positivity could reflect the deployment of the attentional effort for dealing with the focus assignment (e.g., whether the presence of a pronoun is consistent with the top-down expectation generated by *wh*-question focus structure); processing an inappropriate focus assignment in the object-referring condition requires more attentional effort than in the subject-referring condition, and as a consequence the former requires the engagement of more extensive brain areas than the latter. More studies are needed to further elucidate the relationship between focus processing and P2 topographic distribution.

Late Positivity

Different from the early positivity, the late positivity (P600) showed sensitivity not only to the focus status but also to the grammatical role of the antecedent, although the two resources worked somehow independently (see Figure 1, 2). This finding is consistent with the offline sentence-completion tests (see Table 2), which showed that both focus status and subjecthood could make an antecedent more accessible for the pronoun. The P600 has generally been observed in cases where the establishment of a coreferential relation between a pronoun and the potential antecedent was impossible (e.g., because of gender/number mismatch; Molinaro, Kim, Vespignani, & Job, 2008; Nieuwland, 2014; Osterhout & Mobley, 1995; Xu, 2015; Xu, Jiang, & Zhou, 2013) or difficult (e.g., because of referential ambiguity or topic shift; Van Berkum et al., 2007; Xu & Zhou, 2016). The P600 was interpreted as reflecting the difficulty of integrating the pronoun and the antecedent into discourse representation (Li & Zhou, 2010; Xu, Jiang, & Zhou, 2013). In a similar vein, the P600 effect generated by inappropriate focus may reflect the difficulty of integrating the pronoun and the inappropriate focus information into discourse. However, although the context-based focus information plays a dominant role

in the process of activating the potential antecedents in the earlier process, focus is not the sole factor in determining pronoun resolution in the later process. Rather, the integration of focus information and pronoun-antecedent relation into discourse is modulated by both the information status and the grammatical role (but see later discussion) of the potential antecedents.

A pronoun has a preference to refer to the subject antecedent relative to the object antecedent (Gelormin-Lezama & Almor, 2011; Gordon et al., 1993; Kaiser, 2011), and to refer to the focused antecedent relative to the unfocused antecedent, because both subjecthood and focus status are strategies that can attract readers'/listeners' attention to that part of utterance and therefore make the antecedent in the subject or focus position more accessible for pronoun resolution. In particular, when the two strategies work in concert, it would lead to a most pronounced subject preference effect (Reichle, 2014), as demonstrated by the largest P600 difference between the object-inconsistent pronouns and the subject-consistent pronouns (see Figure 1 for the black dot line vs. the red solid line). Nonetheless, the observed subject preference effect (larger P600 effect) could also be associated with the verb-based implicit causality, since NP1-biased verbs were adopted here. These combined forces made the subject a more likely antecedent than the object for the subsequent pronoun. Further studies are needed to gain more insight into the potential relations between processing focus information and grammatical role during pronoun resolution, and how this potential interaction is modulated by the verb-based implicit causality.

The finding of enhanced brain activities (both larger P2 and P600) in response to unfocused versus focused coreferential relation is consistent with the findings from previous behavioral studies (Almor, 1999; Foraker & McElree, 2007), which showed that the NP anaphors referring to unfocused antecedents were processed more slowly than NP anaphors whose antecedents were in focus. Both lines of evidence support the argument that focusing can enhance the accessibility of the focused entities and therefore facilitate the process of pronoun/anaphor interpretation. The present results, however, are only partially consistent with the results from two relevant eye-movement studies (Foraker & McElree, 2007; Kaiser, 2011), in which the authors failed to reveal an early modulation of focus, although a late effect was observed. The observation of facilitation for focused versus unfocused antecedents from the late measures led the authors to argue that focus aids only later-stage integration processing (Foraker & McElree, 2007). However, the failure to find early modulation could be due to the critical stimuli adopted by the studies. In Foraker and McElree's (2007) study, the use of pronoun + verb rather than pronoun alone as the critical region would probably weaken the focus effect, as the measurement included both focused (pronoun) and unfocused (verb) constituents. As for Kaiser's (2011) study, given that two gender-matched antecedents were simultaneously available for the subsequent pronoun (e.g., "The maid scolded the bride . . . She . . ."), the absence of a surface cue (i.e., gender) may lead to difficulty in observing the focus effect in the bonding stage processing.

Contextual Focus Information and the Psycholinguistic Model of Pronoun Resolution

The pattern of ERP results observed at different time windows can be interpreted within the framework of two-stage models of pronoun resolution (Callahan, 2008; Garrod & Terras, 2000). According to this model, pronoun resolution can be divided into two main processes. The first stage involves the activation/retrieval of

potential antecedents and the second involves evaluating the activated potential antecedent for the degree of fit with the pronoun and the whole discourse in order to establish a coherent discourse representation (Callahan, 2008; Li & Zhou, 2010; Silva-Pereyra et al., 2012). While the initial process is mainly constrained by the superficial cues such as lexical or morphological features (e.g., gender/number/case features), the later process is modulated by a number of constraints including semantic, syntactic, as well as discourse-based pragmatic information. However, given that the superficial cues for the pronoun and antecedent were identical across the focused and the unfocused conditions in the current study, the only possible explanation of the early positivity is the expectation triggered by the preceding *wh*-question focus structure, which led to stronger activation of focused entities than unfocused entities. Similar to the present finding, Bornkessel et al. (2003) found that, relative to the neutral condition (with no focus assignment over the target word), the grammatical mismatch (i.e., case violation) in the focused condition (via *wh*-question structure) evoked a larger early positivity, regardless of whether the focused constituent was in subject or object position, suggesting that contextual prediction can lead to faster detection of case mismatch, and the focus expectation is able to override the effect of the grammatical role of a constituent. Chen et al. (2016) found that if the final character (i.e., target word) of a Chinese poem line is incongruent with the rhyme expectation generated by the preceding poem line, this incongruence, induced by the top-down prosodic expectation, would lead to a larger P2 effect (100–300 ms). As for anaphor resolution, Li and Zhou (2010) found that ERP responses to reflexive pronouns were more positive in long-distance reference compared to short-distance reference in both the early (300–400 ms) and late time windows (450–750 ms). The early positivity was interpreted as reflecting the detection of incongruence between mental representation based on syntactic constraint of Principle A (i.e., the reflexive pronoun has a preference to refer to the local antecedent) and mental representation based on the verb's semantics (the implicit semantic bias of the verb making the pronoun resolved toward the distant antecedent). Consistent with Bornkessel et al. (2003), Chen et al. (2016), as well as Li & Zhou (2010), the early positivity in the present study may reflect the detection of the incongruence between an expectation of a gender-marked pronoun (e.g. *she*) generated by the contextual *wh*-question structure and the actually presented pronoun (e.g., *he*). This incongruence reduced the reactivation (or retrieval) of the antecedent entities and thereby led to difficulty in bonding stage processing, regardless of the grammatical role of the pronoun's actual antecedents.

More specifically, the focus effect was robust in both the subject and the object position and in both the late and the early time windows, indicating that focus can exert a fast and long-lasting effect on pronoun resolution. This finding is in line with previous studies concerning topic information and pronoun resolution (Xu, 2015; Xu & Zhou, 2016), which also revealed an effect of information structure on pronoun resolution. However, different from topic status, which only affects the resolution stage of pronoun resolution (as manifested by a P600 effect), focus status shows sensitivity to both the bonding and resolution stages of pronoun resolution. The discrepancy underpinning these two aspects of information structures (i.e., focus vs. topic) is likely due to the different ways of pre-activating (or predicting) the antecedent entities: focus status was assigned via context-based expectation triggered by *wh*-question structure (top-down), whereas topic status was structurally assigned within the same sentence/clause (bottom-up). We speculate that the presence (vs. absence) of a top-down prediction could explain the

differential ERP modulations in the initial stage of pronoun resolution.

Different from the focus information, the grammatical role showed an effect (mainly in the right hemisphere) only in the later stage of pronoun resolution. This echoes the previous studies showing that grammatical role (subject/topic vs. object) and linear order (e.g., SVO vs. SOV) of the antecedent impact pronoun resolution at a relatively late process (e.g., after 500 ms postonset of the pronoun; Callahan, 2008; Foraker & McElree, 2007; Kaiser, 2011; Xu, 2015; Xu & Zhou, 2016). These findings fit well with the two-stage model of pronoun resolution, implicating that structurally based constraints typically influence pronoun resolution at the later processing stage, such as integrating the pronoun-antecedent bond into the discourse representation.

However, although there is a modulation of grammatical role on the later stage of pronoun resolution, the present design does not allow us to draw firm conclusions with regard to the effect of grammatical role on focus processing, because NP1-bias verbs, rather than no-bias verbs, were adopted in this study. It is plausible that the verb-based causality interacts with grammatical role to influence pronoun resolution. It had contributed to the subject preference effect observed in this study because the NP1-biased implicit causality also biased the interpretation of the pronoun toward the subject. However, it is also plausible that the verb-based implicit causality exerts no significant effect on grammatical role. These two possibilities require further clarification. Relative to grammatical role, verb-based implicit causality could have little influence on focus effect. Previous studies concerning topic status and pronoun resolution (Xu, Chen, & Ni, 2016; Xu & Zhou, 2016) have found that topic-inconsistent pronouns evoked larger P600 than topic-consistent pronouns irrespective of whether NP1-bias or NP2-bias verbs were used. Similar to topic information, the larger P600 evoked by focus-inconsistent pronouns relative to focus-consistent pronouns should show no sensitivity to verb-based implicit causality either. Further studies may be conducted to pit the subject preference against the verb-based implicit causality and examine the

effect of grammatical role and its potential interaction with focus in pronoun resolution.

Taken together, according to the two-stage model of pronoun resolution, if the pronoun is initially linked to a less activated entity (i.e., the unfocused constituent) rather than the expected, more activated one (i.e., the focused constituent), this incongruence would disrupt the construction of a coherent coreferential relation, resulting in an early positive deflection. A reinterpretation process is immediately initiated, as manifested by a late positivity, to resolve the inappropriateness and to find an appropriate alternative. Different from the initial bonding process, the resolution process shows sensitivity not only to focus status but also to other structural and discourse differences such as grammatical role, although the two sources of constraints somehow work independently (see Figure (1 and 2)).

Conclusion

This study was conducted to examine how pronoun resolution is modulated by the antecedent's focus status and grammatical role. Although larger positive responses were elicited by the focus-inconsistent pronouns compared to the focus-consistent pronouns, the amplitude of the positivities showed different sensitivity to focus status and grammatical role during different temporal processes. In the earlier time window (180–230 ms), there was only an effect of focus status, whereas in the late time window (400–800 ms), both focus status and grammatical role exerted modulations on pronoun interpretation, although the effect of the grammatical role could have been contaminated by other factors, such as mention order or verb-based implicit causality. These findings suggest that focus expectation in terms of a *wh*-question structure can exert neural modulation on the initial stage of pronoun resolution and that the integration of the pronoun and antecedent into the discourse representation can be constrained by various factors, including the focus status and possibly the grammatical role of the antecedent.

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