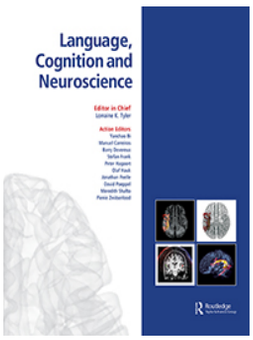

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Gender interference in processing Chinese compound reflexive: evidence from reading eye-tracking

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REGULAR ARTICLE

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ABSTRACT

In Chinese, the compound reflexive *ta-ziji* ("him/her-self") has the gender marking pronoun *ta*, hence presenting a good test case for interference effects from structurally illicit antecedents predicted by cue-based retrieval models. Using reading eye-tracking, we manipulated the gender of *ta-ziji* that (mis)matches that of matrix- and local-subject. Results showed no interference whatsoever when *ta-ziji* matched local subjects. Only when *ta-ziji* mismatched local subjects did we find an *inhibitory* interference on first fixation duration and gaze duration at the verb immediately preceding *ta-ziji*, but a *facilitatory* interference on gaze duration at *ta-ziji*. Furthermore, at *ta-ziji*, total reading times were longer for gender-mismatching local subjects than for gender-matching ones. These findings are partially predicted by the standard cue-based retrieval model, but are mostly consistent with the structure-favoring cue-based retrieval model, suggesting that the structural cue plays a dominant role in the antecedent retrieval process, with interference occurring only in highly constrained situations.

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Cue-based retrieval; interference; Chinese; ta-ziji; eye-tracking

1. Introduction

In parsing sentences, a reader needs to identify, construct and complete non-local syntactic dependencies between linguistic elements. One such dependency is the reflexive-antecedent dependency, as in "*John knows Tom believes himself.*" where upon encountering the reflexive *himself*, the reader will trigger a search process for the appropriate antecedent. A purely structure-based account, based on Principle A of Chomsky's (1981) Binding Theory (henceforth BT-A), would posit that the parser only considers the noun within a local governing domain, which in this case must be the local subject *Tom*. Note however, that the matrix subject *John*, though outside the governing domain of the reflexive, shares the gender feature with the reflexive and the local subject. Then a question immediately arises: Compared to the sentence "*Mary knows Tom believes himself*" where the matrix subject *Mary* does not share the gender feature, will the gender-matching noun *John* be considered as an antecedent candidate, thereby interfering in the retrieval process of the local noun *Tom*?

To address this question, various parsing models have been proposed, and some might be subsumed under one influential framework, namely cue-based memory retrieval (Jäger et al., 2017; Lewis & Vasishth, 2005). One essential claim is that upon encountering a reflexive (or more generally, an anaphor), the parser necessarily initiates a retrieval process from working memory that is content-addressable, searching for its appropriate antecedent (McElree et al., 2003; Van Dyke & McElree, 2006). Memory representations with features that match relevant properties of the reflexive (called retrieval cues) can be directly accessed. As a result, there can be more than one candidate antecedent, among which the best one is selected depending on the strength of activation. This cue-based retrieval framework has obtained ample evidence from psycholinguistic experiments and computational modelling on reflective-antecedent dependency and other linguistic dependencies as well (for a comprehensive review, see Jäger et al., 2017).

While the structural cue (i.e. BT-A) is clearly important in the antecedent retrieval process, it remains unclear whether and how it interacts with other retrieval cues. One variant of cue-based retrieval models, known as the structure-favoring account (Dillon et al., 2013; Frazier et al., 2015; Parker & Phillips, 2017), posit that

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the structural information has priority over other cues in the retrieval process of antecedents. In contrast, the standard cue-based retrieval account (Jäger et al., 2017; Lewis & Vasishth, 2005) contends that all cues – structural (e.g. BT-A) and nonstructural (e.g. gender, number, focus-position) – are treated equally, jointly guiding the antecedent-search process for reflexive resolution. Thus, while both accounts agree that a structurally illicit noun that matches the reflexive in nonstructural features may be (mis)retrieved as a candidate antecedent, leading to the so-called interference effect, they differ in how and when the interference effect appears.

Given that the structure-favoring cue-based retrieval model views BT-A as a primary cue in retrieving the antecedent of a reflexive, a structurally illicit candidate will minimally interfere in the retrieval of the structurally licit antecedent. Rather, interference from a structurally illicit candidate, if any, would only be observed in highly constrained situations, especially when the structurally licit antecedent fails to match any non-structural cue(s). Perhaps the earliest evidence for the structure-favoring cue-based retrieval model comes from Sturt (2003), who, using materials as in (1), manipulated gender congruence between the reflexive and the matrix subject (*Jonathan*/*Jennifer*), with the local subject (*the surgeon*) being a stereotypical male or female.

(1) Jonathan (Jennifer) was pretty worried at the City Hospital. He/she remembered that the surgeon had pricked himself (herself) with a used syringe needle. There should be an investigation soon.

Sturt (2003) found that at the reflexive, sentences with gender-mismatching local subjects (i.e. *surgeon … himself*) were read longer than sentences with gender-matching local subjects (i.e. *surgeon … herself*), as reflected in first fixation duration, gaze duration, and second-pass reading time, suggesting that BT-A was immediately applied in antecedent search. The interference from the gender-matching matrix subject was only observed on second-pass reading time.

Using similar stimuli, Cunnings and Sturt (2014) replicated the early (i.e. gaze duration) effect of gender congruence between the reflexive and the local subject, but failed to replicate the late interference effect. Instead, they only found a gender congruence effect of local subjects on the second-pass reading time, indicating that reflexive resolution in English is strongly biased towards the local subject, with little interference from matrix congruence.

In addition to the gender cue, recent evidence has shown that the structural constraint can override other non-structural cues as well. In Dillon et al. (2013), prolonged reading times were observed at the reflexive when it mismatched in number with the structurally licit antecedent, regardless of the number feature of structurally illicit antecedents. Similarly, while Parker and Phillips (2017) found interference from the (structurally illicit) matrix subject when the reflexive mismatched the local subject in both gender and animacy, this interference disappeared when the reflexive matched the local subject in either feature. Taken together, these results suggest that the structural cue plays a dominant role in antecedent search for reflexives in English. Only in cases where the reflexive-antecedent dependency cannot be completed by the structural cue alone would non-structural cues play a role.

In contrast, the standard cue-based retrieval model assigns an equal status to the structural cue as other cues, and makes the following predictions: When a perfectly matched antecedent is available, its activation would be reduced in the presence of a structural illicit antecedent that matches one or more non-structural cue(s) (e.g. gender, number, or animacy) due to activation spreading from the retrieval cue to both antecedents, leading to a slowdown in retrieval latencies or increased reading times (*inhibitory interference*, also known as *similarity-based interference* or *cue overload*). When a perfectly matched antecedent is unavailable, that is, the structurally licit candidate mismatches a certain non-structural cue, then a candidate antecedent matching in that non-structural cue would race with the structurally licit candidate until the one with a higher activation is retrieved, resulting in a speed-up in the average retrieval latencies or decreased reading times (*facilitatory interference*) (Logačev & Vasishth, 2016).

In addition, while the standard cue-based retrieval model also predicts a main effect of local congruence (i.e. a penalty of violation of the locality constraint), the underlying reason is motivated by faster decay of activation of non-local versus local antecedents, without even using the structural cue (Jäger et al., 2015, p. 11).

Evidence for interference effects has been reported in English reflexives, but the results are mixed (Badecker & Straub, 2002; Kwon & Sturt, 2014; Parker & Phillips, 2017; Sturt & Kwon, 2015). Using self-paced reading, Badecker and Straub (2002) found inhibitory interference effects in the post-reflexive region when a perfectly matched local subject was available, reflected by longer reading times when the reflexive matched the matrix subject (*John thought that Bill owed himself another opportunity to solve the problem*) than when *John* was

replaced by *Jane*. In contrast, in a Bayesian meta-analysis of 30 published studies (eye-tracking and self-paced reading) on reflexive/reciprocal-antecedent dependency, Jäger et al. (2017) found no interference when a perfectly matched antecedent was available, but inhibitory (instead of *facilitatory*) interference when the structurally licit antecedent candidate mismatched the nonstructural cue.

Despite a wealth of research on English reflexive processing, few studies have focused on reflexive processing in Chinese. Reflexives in Chinese can take either bare (*ziji*, "self") or compound (*ta-ziji*, "himself/herself") forms, with the latter requiring its antecedent to match the pronoun *ta* in gender and number features (Huang et al., 2009). While the bare reflexive *ziji* has long been known to allow long-distance binding from antecedents in a matrix clause, the compound reflexive *ta-ziji* is claimed by theoretical linguists to strictly obey BT-A (Huang et al., 2009). Previous work on reflexive processing in Chinese has mainly focused on *ziji*, with converging results verifying the theoretical claims that *ziji* can be affected by nonstructural information and be bound by a non-local antecedent. Specifically, using reading eye-tracking, Jäger et al. (2015) found an inhibitory interference from the structurally illicit antecedent (i) when *ziji* mismatched the local antecedent in animacy (Experiment 1), and (ii) when *ziji* matched the local antecedent if an additional memory load was enforced on the participants (Experiment 2). In addition, specific referential properties of local verbs, which may serve as nonstructural cues in processing, can also directly affect how the bare reflexives *ziji* are interpreted (Jin, 2003; Li & Zhou, 2010).

Given that *ta-ziji* resembles English reflexives more closely than *ziji* (Huang et al., 2009), one might assume that its online resolution process should be more likely to follow BT-A. To our knowledge, only a few experimental studies have investigated real-time processing of *ta-ziji*. Using self-paced reading, Dillon et al. (2016) compared *ziji* with *ta-ziji* using complex sentences as in (2a-b), where the animate feature of reflexives matched with either the local/head noun (*seamstress*) or the distant/embedded noun (*Mrs. Zhang*) of a prenominal relative clause.

(2) Sample stimulus set from Dillon et al. (2016)

(a) 媒体报道的那个女裁缝上个星期把她自己（自己）不小心弄 伤了。

Media/ report-on/ that/ seamstress/ last-week/ BA/ *ta-ziji* (*ziji*)/ carelessly/ harm.

The seamstress that the media reported on carelessly harmed herself last week.

(b) 张太太经常光顾的那个时装店上个星期把她自己（自己）不小心弄伤了。

Mrs. Zhang/ often/ visit/ that/ boutique/ last-week/ BA/ *ta-ziji* (*ziji*)/ carelessly/ harm.

The boutique that Mrs. Zhang often visits carelessly harmed herself last week.

Dillon et al. (2016) found that reflexives were read longer when their animacy features matched with the distant/embedded noun (2b) than with the local/head noun (2a), and the effect size (i.e. the difference in reading times between the two types of sentences) was larger for *ziji* than *ta-ziji* in the spillover region (不小心 "*carelessly*"). They took these findings as evidence for *ta-ziji* being less subject to the locality constraint than *ziji*, and attributed this difference in the parsing profile of the two reflexives to the presence of an additional retrieval cue *ta* in *ta-ziji* that encoded human, number and gender features. This suggests that when the local antecedent does not match with the reflexives in animacy, *ziji* will undergo a stronger inhibitory interference from the distant animacy-matching antecedent than *ta-ziji*. Note, however, in (2b) the distant noun phrase "Ms. Zhang" is actually the only appropriate antecedent for both *ziji* and *ta-ziji*, making its status as a "distractor" less clear in the cue-based retrieval theories.

In a self-paced reading experiment, Qian and Wu (2016) manipulated gender congruence of *ta-ziji* with the local subject and the matrix subject in sentential complement sentences as in (3). All proper nouns are typical Chinese names for males (e.g. *Lijun*) or females (e.g. the matrix subject *Limei* or the local subject *Huwei*). The verbs in the subordinate clauses were eqoperWu

were longer when *ta-ziji* mismatched the local subject than when it matched the local subject, regardless of the gender congruence between *ta-ziji* and the matrix subject. Only at the fourth word following *ta-ziji* (i.e. *qita* "other") did they find longer reading times when *ta-ziji* mismatched the matrix subject than when *ta-ziji* matched the matrix subject. These results were largely analogous to the finding from English reflexives (Cunnings & Sturt, 2014), suggesting that Chinese compound reflexive is governed by BT-A, with potential interference from the matrix subject taking effects in such a delayed fashion as to be negligible. Note however, that self-paced reading is less fine-grained than reading eye-tracking in temporal resolution (Cunnings & Felser, 2013; Cunnings & Sturt, 2014; Jäger et al., 2015; Sturt, 2003). Thus, it might not be surprising that they failed to detect early interference effects from the matrix subject.

Building on Qian and Wu (2016), we aim to further investigate potentially early interference effects in Chinese compound reflexive processing, using reading eye-tracking. According to the structure-favoring cue-based retrieval account, we would expect to observe (i) a main effect of gender congruence when *ta-ziji* matches the local subject, reflected by prolonged reading time on eye movement measures in local incongruence conditions than local congruence conditions, and (ii) a potential interference effect from the matrix subject that would be shown only when *ta-ziji* mismatches the local subject. In other words, interference from gender-matching matrix subjects is predicted to occur only in ungrammatical conditions where no structurally licit antecedent is available, with the condition containing gender-matching matrix subjects being processed faster (i.e. facilitatory interference or "illusionary grammaticality") than the condition containing gender-mismatching matrix subjects. According to the standard cue-based retrieval model, however, since both structural and (non-structural) gender cues are assigned equal weight, we would expect to observe an interaction depending on the availability of a perfectly matched antecedent, specifically, (i) an *inhibitory* interference from the gender-matching matrix subject relative to the gender-mismatching matrix subject when *ta-ziji* matches the local subject, and (ii) a *facilitatory* interference from the gender-matching matrix subject when *ta-ziji* mismatches the local subject.

In addition, we expect to see early interference effects prior to the reflexive region, given the strong parafoveal-on-foveal effect reported in the literature on Chinese reading (Tsai et al., 2012; Yan et al., 2010; Yan & Sommer, 2015; Yan, Zhou, et al., 2012; Yang et al., 2009; Yen et al., 2008). The perceptual span in Chinese reading extends from 1 character on the left of the fixated character to up to 4 characters on its right (Inhoff & Liu, 1998; Pan et al., 2017; Yan et al., 2010, 2015), depending on the frequency (Yan et al., 2010) and predictability (Zang et al., 2016) of parafoveal words. Given that *ta* and *ziji* are highly frequent (11853.78 words/million for masculine ta, 6600.96 words/million for feminine *ta*, and 1728.29 words/million for *ziji*; Cai & Brysbaert, 2010) and that these two words form natural collocations (i.e. *ta-ziji*), the early congruence effect(s) on processing *ta-ziji* might be detected when the eyes are fixated to the local verb preceding the reflexive.

2. Method

.1. i i

Forty-five undergraduate and graduate students (18 males; age range: 19–25 years) from Peking University participated in this experiment. They were all native speakers of Chinese and had normal or corrected-to-normal vision. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the School of Psychological and Cognitive Sciences, Peking University.

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Adapting the experimental design of Qian and Wu (2016), we created 48 sets of experimental stimuli with a compound reflexive *ta-ziji* embedded in the subordinate clause. The structure of each sentence was "NP_1 + V_1 + NP_2 + ADV + V_2 + *ta-ziji* + CONJ + NP_3 + VP_3", as shown in Table 1. The matrix subject (NP_1) and the local subject (NP_2) are proper names with stereotypical gender (See *Norming tests* below), each consisting of two characters. The matrix verb (V_1) is always mono-morphemic *shuo* ("say"). A verb phrase follows NP_2, consisting of a two-character adverb (e.g. "already", ADV) and a two-character local verb (V_2). The local verb (V_2) is always transitive with an equal bias towards the matrix or local subject as the patient (see *Norming tests* below). The local verb (V_2) takes an embedded clause, consisting of *ta-ziji* (three characters), a two-character conjunction phrase *yiji* ("and"; CONJ), and a collective noun referring to a group of people (four characters; NP_3), followed by a predicate structure (VP_3) having four to six characters.

We manipulated gender congruencies of *ta-ziji* to the matrix subject NP_1 and to the local subject NP_2, yielding four conditions: (1) *ta-ziji* matched both NP_1 and NP_2 (Local-match, Matrix-match), (2) *ta-ziji* matched NP_1

Table 1. Experimental conditions, exemplar sentences and interest regions.

Condition	Example Matrix subject		Local subject		Local verb	Compound reflexive	Conjunction			
Matrix-match, local-match	李美 Lijmei	说 says	胡薇 Huwei	早就 already	推荐 recommended	她自己 herself	以及 and	其他 other	干部 officials	参加辩论赛。 participate in the debate competition.
Matrix-mismatch, local-match	李骏 Lijun	说 says	胡薇 Huwei	早就 already	推荐 recommended	她自己 herself	以及 and	其他 other	干部 officials	参加辩论赛。 participate in the debate competition.
Matrix-match, local-mismatch	李骏 Lijun	说 says	胡薇 Huwei	早就 already	推荐 recommended	他自己 himself	以及 and	其他 other	干部 officials	参加辩论赛。 participate in the debate competition.
Matrix-mismatch, local-mismatch	李美 Limei	说 says	胡薇 Huwei	早就 already	推荐 recommended	他自己 himself	以及 and	其他 other	干部 officials	参加辩论赛。 participate in the debate competition.

Translation: *Limei (Lij n) sa s H ei has alread recommended herself (himself) and o her officials o par icipa e in he deba e compe i ion.*

only, but mismatched NP_2 (Local-mismatch, Matrix-match), (3) *ta-ziji* matched NP_2 only, but mismatched NP_1 (Local-match, Matrix-mismatch), and (4) *ta-ziji* mismatched both NP_1 and NP_2 (Local-mismatch, Matrix-mismatch). Within each set of experimental stimuli, NP_2 was identical across all four conditions. Half of the NP_2 were feminine names, and the other half were masculine names, with comparable visual complexity as indexed by the number of strokes ($t_{(47)} = 0.75$, $p = 0.457$). Half of the materials contained "他自己" ("himself"), and the other half contained "她自己" ("herself").

Experimental sentences were assigned into four lists, using Latin-square procedure, such that each list had 48 sentences, 12 from each condition. Another 92 sentences were added into each list as fillers. All filler sentences were well-formed with a variety of syntactic structures. Stimuli in each list were pseudo-randomized such that the first five sentences were fillers and no more than three sentences from the same condition appeared consecutively.

2.3.1. Gender stereotypicality of proper names

The proper names used for NP_1 and NP_2 were assessed for gender typicality to ensure the strength of the manipulation of gender congruence. We created 304 proper names consisting of a common Chinese family name (1 character) and a given name (1 character) which typically contained the gender information. Eight participants who did not participate in the eye-tracking experiment were asked to rate on a 5-point scale how typical these Chinese names were associated with a particular gender (1 for extremely masculine and 5 for extremely feminine). Based on the mean ratings, 144 names were selected for the experimental stimuli, half being masculine (mean = 1.72, $SD = 0.28$, all lower than or equal to 2.5), and the other half being feminine (mean = 4.59, $SD = 0.23$, all higher than or equal to 3.88).

2.3.2. The property of local verb phrases (VP)

To ensure that only gender and syntactic features of antecedents were relevant in interpreting *ta-ziji*, we conducted a norming test for selectional properties of verb phrases.

Twenty-six participants who did not participate in the eye-tracking experiment were asked to finish a multiple-choice cloze test consisting of 108 items. Each item consisted of an embedded clause taken from the experimental stimuli, with the direct object missing, as in "NP_2 (proper name) + ADV + V_2 + [BLANK] + CONJ + NP_3 + VP_3". Participants were instructed to read the sentence and to fill in the blank by choosing one of the three options: "*ta-ziji*", "*A proper name other than NP_2 (e.g. Wangyao)*", or "*Both*". Participants were told that they should choose "*Both*" only when they believed that both *ta-ziji* and *Wangyao* were acceptable to fill in the blank. The three choices were encoded as 0 for *Both*, 1 for *ta-ziji*, and −1 for *Wangyao*. Averaging across participants, an acceptability score close to zero would mean both *ta-ziji* and a proper name other than NP_2 were acceptable. In the end, 48 pairs of adverb and verb were selected with acceptability scores close to zero (mean = −0.03, $SD = 0.23$), and one-sample *t*-test further indicated that the acceptability scores were comparable to zero ($t_{(27)} = -0.93$, $p = 0.357$). These 48 verb phrases consisting of adverb and verb (VP) pairs were then used to construct experimental stimuli. Of these 48 pairs, 20 verbs were used twice each (paired with two different adverbs), and 8 verbs were used only once.

Eye-movements were recorded with an Eyelink 2 K system at a sampling rate of 2000 Hz. Each sentence was presented in one line at the middle vertical position of a 21-inch CRT screen (1024*768 resolution; frame rate 120 Hz). The font Song-28 was used, with each character subtending 1 degree of visual angle. Participants read