Multiple constraints modulate the processing of Chinese reflexives in discourse

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This study investigates the real-time processing of Chinese reflexives *ziji* and *ta-ziji* in discourse when multiple constraints are involved. Our primary goal is to examine the time course of syntactic and non-syntactic constraints in reflexive resolution. The Syntactic Filter Hypothesis argues that syntactic cues are prioritized at the early stages of processing, in contrast to the Multiple Constraints Hypothesis which posits that at this stage all streams of information can be recruited. The results of two self-paced reading experiments show that in neutral contexts where no antecedent is discourse-prominent, syntactic locality and verb semantics immediately impact real-time processing of *ziji* and *ta-ziji*. Crucially, participants' processing patterns are also influenced at an early stage by the discourse topical status of the non-local antecedents. Overall, these findings suggest that syntax, verb semantics, and discourse prominence all play important roles at an early stage.

1. Introduction

Real-time resolution of referentially dependent expressions like reflexives poses a challenge to comprehenders as they need to weigh different factors to identify the intended referent or antecedent. In reflexive resolution, a comprehender needs to not only keep track of the semantic/pragmatic properties of potential antecedents, but also to consider their structural positions. This paper investigates the interplay of syntactic, semantic, and pragmatic information on the interpretation of two reflexives in Chinese, *ziji* ('self') and *ta-ziji* ('s/he-self').

Previous psycholinguistic research suggests that not all linguistic cues guide antecedent retrieval at the same speed. In prior work on reference resolution, one influential claim is that structural or syntactic information is prioritized and that syntactically unlicensed antecedents are "filtered" out at early stages of processing (e.g. Cunnings & Sturt, 2014; Nicol & Swinney, 1989; Sturt, 2003; Xiang et al., 2009). We refer to this view as the *Syntactic Filter Hypothesis*. On this view, at least during the initial stages, antecedent retrieval is guided more by syntactic than by semantic or pragmatic information. The syntactic constraint that this paper focuses on is the locality constraint or Principle A of the Binding Theory (Chomsky, 1981) which requires that a reflexive be bound by an antecedent in the local domain (often a tensed clause).

However, the claim that syntactic information is privileged faces counterevidence from other studies suggesting that comprehenders show immediate sensitivity to non-syntactic cues, including, but not limited to, animacy, gender, and verb-based cues in antecedent retrieval (e.g. Badecker & Straub, 2002; Chen et al., 2012; Han et al., 2015; Jäger et al., 2015; Kaiser et al., 2009; Patil et al., 2016; Runner et al., 2006; Xu & Runner, 2019). These studies are more compatible with a *Multiple Constraints Hypothesis*, according to which both syntactic and non-syntactic constraints can guide the earliest moments of reference resolution. In sum, opinions diverge on whether syntactic constraints categorically block antecedents in structurally inaccessible positions, particularly in the early stages of processing.

While the Syntactic Filter Hypothesis has gained support from studies on the English reflexives *himself/herself* (e.g. Cunnings & Sturt, 2014; Sturt, 2003), the situation becomes less clear once we look at Chinese, where the *perspective-sensitive* reflexive *ziji* can be readily exempt from Principle A (e.g. Charnavel et al., 2017; Huang & Liu, 2001; Huang et al., 2009; Pan, 1997; 2001), as in (1a,b). Native-speaker judgments concerning the binding possibilities in (1a,b) indicate that long-distance binding of *ziji* is allowed and even preferred when *verb semantics* and *discourse context* favor the non-local antecedent.

(1)   a.   Yuehan$_i$ shuo Bier$_j$ bangjia-le   ziji$_{i/j}$.
             John   say   Bill   kidnap-ASP self
             'John$_i$ said that Bill$_j$ kidnapped self$_{i}/_{j}$.'

b. Yuehansen$_i$ zai chengshi yiyuan-li xiande shifen jiaolü. Ta$_i$ jide
Jonathan at city hospital-in look very worried. He recall
waikedaifu$_j$ yong zhentou zha-le ziji$_{i/j}$.
surgeon with needle prick-ASP self
'Jonathan$_i$ was pretty worried at the City Hospital. He$_i$ remembered that the surgeon$_j$ had pricked self$_{i/j}$ with a syringe needle.'

Example (1a) illustrates the effect of verb bias: 'kidnap' is an *other-directed* verb, as the action of kidnapping is most plausibly interpreted as directed towards someone other than the agent of the kidnapping action, in contrast to a *self-directed* verb like 'shave', where the action tends to be interpreted as directed towards the agent of that verb (see e.g. Haiman (1983) on verb directedness). Consequently, the most natural reading of (1a) is one where *ziji* is bound by the non-local antecedent *John,* in line with verb semantics. Example (1b) illustrates the effect of topic prominence: the more felicitous antecedent for *ziji* is the discourse topic *Jonathan*, the subject of the first sentence. This can be attributed to *Jonathan* being more prominent in the discourse than the local antecedent 'surgeon' (see Section 2). Given these observations, it is debatable whether local antecedents might still be prioritized in the real-time processing of *ziji* when semantic and discourse-level constraints are involved.

In addition to *ziji*, the present work probes the processing of *ta-ziji* which exhibits different linguistic properties. While *ziji* is clearly subject to non-structural constraints (e.g. Huang & Liu, 2001; Huang et al., 2009), the case of the bi-morphemic *ta-ziji* is controversial. This reflexive consists of the personal pronoun *ta* ('s/he') and the reflexive *ziji* ('self') and is typically thought to strictly obey the locality constraint (e.g. Battistella & Xu, 1990; Cole & Sung, 1994; Huang, 1983; Huang & Tang, 1991; Li, 1993). However, it has been noticed in the literature that LD binding of *ta-ziji* is possible if the local antecedent is inanimate, as in ex.(2) (Pan, 1998; Pan & Hu, 2002):

(2) Yuehan$_i$ shuo zhe-zhang zhaopian$_j$ shanghai-le ta-ziji$_{i/*j}$-de mingyu.
John say this-CL picture damage-ASP he-self-DE reputation
'John$_i$ said this picture$_j$ damaged he-self$_{i/*j}$'s reputation.'

Using a constraint-based Optimality theoretic (OT) approach, Pan and Hu (2002) argue that LD binding of *ta-ziji* is only licensed when the prominence constraint (animacy prominence of antecedents) outranks locality. In this paper, we explore whether another type of prominence constraint – discourse topic prominence – can impact online reflexive resolution of *ta-ziji* to further examine the Syntactic Filter Hypothesis.

Note that the difference between *ziji* and *ta-ziji* in terms of LD binding is related to their linguistic properties. LD *ziji* is often treated as a *logophoric reflexive* (Huang & Liu, 2001; Huang et al., 2009) or an "exempt anaphor" (Charnavel et al., 2017) governed by discourse-pragmatic

conditions, as opposed to regular *anaphoric reflexives* such as *ta-ziji* which is largely constrained by locality. It is widely agreed that logophoric reflexives typically refer to perspective holders or empathy loci (e.g. Charnavel, 2020; Charnavel & Zlogar, 2015; Oshima, 2007) – we discuss these notions more below – in contrast to regular anaphoric reflexives which are bound by local antecedents and show no perspective-sensitivity.

Despite these differences, the online processing patterns of *ziji* and *ta-ziji* often show a locality bias, observed with various methods including cross-modal priming (Gao et al., 2005), self-paced reading (Dillon et al., 2016; Lyu et al., 2022; Qian & Wu, 2016; Wang, 2017a), eye-tracking (Chang et al., 2020; Jäger et al., 2015; Wang, 2017b), and ERP (Li & Zhou, 2010). The locality bias for *ziji* is particularly interesting, because in these studies, the non-local matrix subject is often a Source – a semantic role argued to license logophoric LD binding of *ziji* (e.g. Huang & Liu, 2001). The fact that *ziji* strongly prefers local antecedents, like *ta-ziji* does, even in contexts where a non-local Source antecedent is available, could suggest that local search driven by the locality constraint might be a default parsing strategy in real-time reflexive resolution.

However, most experimental studies on *ziji* and *ta-ziji* only used isolated sentences. Thus, it is not yet known whether local search characterizes reflexive resolution in connected discourse as well. One exception is Lyu and Kaiser (2021), who tested *ziji* in discourse-topic-biasing contexts. However, they did not directly manipulate the presence/absence of a discourse topic, because their focus was on testing the blocking effect, i.e., whether the 1st-person perspective is prioritized compared to 3rd-person perspectives during reflexive resolution. (The term *blocking effect* refers to the observation that an intervening first-person element impacts whether *ziji* can be bound by a non-local antecedent.)

Most relevant for the purposes of the experiments in this paper is that, to our knowledge, prior work has not systematically tested the impact of topic prominence on the processing of *ta-ziji*. Thus, this work builds on and goes beyond Lyu and Kaiser (2021) by asking whether the locality constraint is prioritized for *ziji* and *ta-ziji* in neutral vs. biased discourse contexts, and whether *ziji* and *ta-ziji* differ in this regard. Furthermore, as we saw in (1a), verb bias can influence the interpretation of *ziji*. However, few prior studies have probed the effect of verb bias in online and offline interpretation of *ta-ziji*, and its effects are poorly understood even from a linguistic perspective, with one study suggesting that, in the case of *ta-ziji*, the locality bias trumps verb semantics in offline judgment (Lu, 2011).

To address these psycholinguistic and linguistic questions, we report antecedent judgment and self-paced reading experiments on *ziji* and *ta-ziji*. We are especially interested in how *ziji* and *ta-ziji* are processed in contexts with and without discourse topics. This allows us to explore the limits of the Syntactic Filter Hypothesis which to our knowledge has not yet been widely tested in connected discourse (but see Cunnings & Sturt, 2014; Sturt, 2003), and to assess the

validity of the Multiple Constraints Hypothesis which posits that both syntactic and non-syntactic constraints can guide even the earliest moments of reference resolution.

2. Connecting core linguistic concepts to sentence processing

2.1 Perspective-sensitivity of *ziji*

Below, we review the core concepts of perspective-sensitivity, topic prominence and verb bias, and discuss how they are likely to impact reflexive resolution in Chinese given prior linguistic and psycholinguistic work. We first introduce the perspective-sensitivity property of *ziji* as this provides an important foundation for considering topic prominence.

As mentioned above, *ziji* is often seen as a logophoric reflexive due to its perspective-sensitivity. Logophoric pronouns are typically coreferential with the sentence-internal subject whose speech or mental state is reported (e.g. Clements, 1975; Hagège, 1974) – the person whose speech/thoughts/perspective is being conveyed. Sells (1987) applied the notion of logophoricity to languages that allow LD reflexivization and outlined three primitive roles for antecedents of logophoric reflexives:

(3)   a.   Source: one who is the intentional agent of communication
        b.   Self: one whose mental state or attitude the content of the proposition describes
        c.   Pivot: one with respect to whose (space-time) location the content of the proposition is evaluated

The antecedent of *ziji* has been argued to exhibit all three properties (e.g. Huang & Liu, 2001), as LD binding of *ziji* can be licensed by antecedents in Source, Self, and Pivot roles. In the following sentences adapted from Huang and Liu (2001, p. 314), *John* is an intentional speaker or Source in (4a). Example (4b) involves backward binding, where the antecedent *John* does not structurally dominate (i.e. c-command) *ziji*. But binding is licensed because the psychological predicate 'very happy' makes *John* the Self. Ex.(4c) describes the situation that John is in with respect to a specific time and location, which makes *John* the Pivot.

(4)   a.   Yuehan$_i$ shuo Bier$_j$ xihuan ziji$_{i/j}$.
             John   say   Bill   like   self
             'John$_i$ said that Bill$_j$ liked self$_{i/j}$.'

        b.   Bier$_j$ hui   bangzhu ziji$_{i/j}$ rang Yuehan$_i$ hen gaoxing.
             Bill   would help   self   make John   very happy
             'That Bill$_j$ would help self$_{i/j}$ made John$_i$ very happy.'

        c.   Dang Bier$_j$ zai jiaoji de deng ziji$_{i/j}$ de shihou Yuehan$_i$ hai mei chu men.
             when Bill   at anxious DE wait self   DE time   John   still not exit door
             'When Bill$_j$ was anxiously waiting for self$_{i/j}$, John$_i$ had not left the house yet.'

In the linguistic literature, various terms have been used to refer to the phenomena of logophoricity and perspective-sensitivity in (4a–c). For example, Sells (1987, fn.15) and Huang and Liu (2001) argue that Pivot, Source, and Self involve "empathy" with the antecedent. In this context, "empathy" refers to the "speaker's identification with a person/thing that participates in an event or state" (Kuno, 1987, p. 206). It typically involves taking on an event participant's perspective or point-of-view (Huang & Liu, 2001; Iida, 1992; Kuroda, 1965; Kuno & Kaburaki, 1977; Oshima, 2007; Sells, 1987). In this paper, when we use the term "empathy" in discussing prior work on some occasions, it can be construed as synonymous with "perspective-taking." Thus, in (4a–c), if John is construed as the antecedent of *ziji*, he is the *perspective center*: the reader assumes John's perspective and views the event from his point of view. In fact, some researchers argue that LD binding of *ziji* necessarily involves perspective-taking (Huang & Liu, 2001; Huang et al., 2009; Pan, 1997; Wang & Pan, 2015; but also see Charnavel et al. (2017) for a review of alternative approaches).

Note that the perspective-sensitivity property attributed to *ziji* differs sharply from the morphologically complex form *ta-ziji*. It is generally agreed that, unlike *ziji*, *ta-ziji* is not perspective-sensitive. LD binding is highly restricted for *ta-ziji* and seems to be allowed only when the local NP is inanimate (e.g. Pan, 1998; Pan & Hu, 2002). Whenever the local antecedent is animate, LD binding is deemed impossible as in 'Zhangsan$_i$ knows Lisi$_j$ likes *ta-ziji*$_{*i/j}$' (Pan, 1998, p. 781). This coreference pattern contrasts sharply with the logophoric use of *ziji* shown above. To illustrate the difference, we replaced *ziji* in (4a–c) with *ta-ziji*. As can be seen in (5a–c), LD binding by Source, Self, or Pivot is highly degraded according to native-speaker judgment.

(5) a. Yuehan$_i$ shuo Bier$_j$ xihuan ta-ziji$_{*i/j}$.
         John   say   Bill   like   self
         'John$_i$ said that Bill$_j$ liked he-self$_{*i/j}$.'

     b. Bier$_j$ hui   bangzhu ta-ziji$_{*i/j}$ rang Yuehan$_i$ hen gaoxing.
         Bill   would help   he-self   make John   very happy
         'That Bill$_j$ would help he-self$_{*i/j}$ made John$_i$ very happy.'

     c. Dang Bier$_j$ zai jiaoji   de deng ta-ziji$_{*i/j}$ de shihou Yuehan$_i$ hai mei chu
         when Bill   at anxious DE wait he-self   DE time   John   still not exit
         men.
         door
         'When Bill$_j$ was anxiously waiting for he-self$_{*i/j}$, John$_i$ had not left the house yet.'

2.2 Topic prominence and *ziji/ta-ziji*

As shown above, LD *ziji* is sensitive to perspective-taking. We now consider how topic prominence can play a role in the processing of *ziji*. According to the *Topic Empathy Hierarchy* (Kuno, 1987),

given an event involving two participants A and B such that A is a discourse topic, it is easier to take the perspective of A than B. Although Kuno's work is not based on Chinese *ziji*, it makes clear predictions. Suppose we have two participants in a discourse as in (6), 'chairman' and 'Director Li'. The first sentence introduces 'chairman' in subject position and describes an event about him. He can be easily construed as the discourse topic. Thus, the Topic Empathy Hierarchy predicts that readers should prefer the perspective of 'chairman', and thus the perspective-sensitive *ziji* should tend to be interpreted as referring to the perspective center 'chairman' (rather than 'Director Li'). In the rest of this paper, we refer to this phenomenon as the *topic prominence/topicality effect*. Building on Kuno's work on the link between *topics* and *empathy/perspective*, we assume that any potential topic prominence effects displayed by *ziji* are related to its perspective-sensitivity.

(6) Dongshizhang$_i$ zhuchi-le jintian zaochen de huiyi. Hui-shang, ta$_i$ zhuyi-dao
     chairman   host-ASP today morning DE meeting meeting-on he notice- ASP
     Li zhuren$_j$ yizhi   tiji   ziji$_{i/j}$ de guanli   caineng.
     Director Li constantly mention   self   DE management skill
     'The chairman$_i$ hosted the meeting this morning. In the meeting, he$_i$ noticed that Director
     Li$_j$ constantly mentioned self's$_{i/j}$ management skills.'

What about non-perspective-sensitive *ta-ziji*? The claims of the Topic Empathy Hierarchy are not relevant for *ta-ziji* since it shows no signs of perspective-sensitivity in (5a–c). But recall that Pan and Hu (2002) noticed that, in certain contexts, *ta-ziji* can be LD-bound. Most relevant for us, they argue that this is due to *ta-ziji* being sensitive to a *prominence* constraint. In their terminology, "prominence" refers specifically to the grammatical role and the animacy of the antecedent. However, in light of a large amount of work showing that grammatical role and animacy are only two of the many factors that influence the prominence of referents, it seems reasonable to hypothesize that *ta-ziji* may be sensitive to topic prominence as well. Thus, in this work, we ask the following question: do Chinese speakers consider LD binding of *ta-ziji* when the non-local antecedent is prominent at the discourse level?

2.3 Verb bias

We have so far sidestepped an important factor: verb semantics. Example (6) uses the verb *tiji* ('mention') in the second sentence. But if the verb is changed to a self-directed verb like *xuanyao* ('brag'), the sentence becomes more ambiguous. Now, it is more plausible that Director Li brags about his own skills as opposed to the chairman's skills. Thus, when *ziji* or *ta-ziji* occurs with a self-directed verb like *xuanyao* ('brag'), the verb's lexical semantics, locality, and topic prominence push in different directions (towards the local antecedent 'Director Li' or the discourse topic 'chairman'). Faced with this dilemma, how do Chinese speakers interpret *ziji* or *ta-ziji*? In other words, how are different kinds of information (syntactic, semantic, and pragmatic) prioritized?

We explore the role of verb semantics by testing the effects of verb directedness. *Self-directed* verbs (or "introverted" verbs) describe actions that "one generally performs upon one's self" and *other-directed* verbs (or "extroverted verbs") denote actions that one "usually performs towards others" (Haiman, 1983, p. 803; also see e.g. Gast, 2006; König & Siemund, 2000). There are also *neutral* verbs which are ambiguous regarding whom the action is directed at. Verb bias has been frequently used in previous studies on *ziji* to push comprehenders to construct local or non-local dependencies (He, 2014; Li & Zhou, 2010; Schumacher et al., 2011). However, these studies do not speak directly to the question of whether verb effects interact with a potential topic prominence constraint and the locality constraint in the processing of *ziji/ta-ziji*.

Prior work by Lu (2011) on Taiwan Mandarin Chinese suggests that a conflict between verb semantics and the locality constraint as in (7) does not always lead to processing difficulty. Lu tested sentences with triple-clause structures where *ziji* or *ta-ziji* occupies the position of the subject of the most embedded third clause. As shown in (7), the semantics of the verb after *(ta-)ziji* biases either towards the "local" antecedent ('receive' biasing 'public') or towards the non-local antecedent ('deliver' biasing 'mailman'). It is worth mentioning that the verb bias manipulated by Lu (2011) is more about real-world plausibility than verb-directedness.

(7) $Youchai_i$ xuancheng $minzhong_j$ zong huaiyi $(ta-)ziji_{i/j}$ meiyou anshi
        mailman claim   public   always suspect (he-)self   not   on-time
        shoudao/toudi   youjian.
        receive/deliver   mail
        'The $mailman_i$ claimed that the $public_j$ always suspects that $(he)-self_{i/j}$ does not $receive_{public}$/ $deliver_{mailman}$ the mail on time.'

Given what we know from earlier research, we can have the following expectations for (7). As the locality constraint pushes *(ta-)ziji* to look for a structurally closer antecedent but a LD-compatible verb such as 'deliver' pushes for the matrix subject 'mailman', one would expect a clash of the structural constraint and semantic bias at the disambiguating verb. Interestingly, Lu (2011) found that these kinds of clashing configurations elicited reading slowdowns with *ta-ziji* but not with *ziji*. Lu's account of this asymmetry largely boils down to different degrees of sensitivity to the locality constraint (*ziji* is less sensitive to locality than *ta-ziji*, under this view). Lu's other finding is that participants preferred local antecedents for *ta-ziji* even with 'receive', suggesting locality is more important for *ta-ziji* than verb bias, which we will assess further in this study.

3. Aims of the present work

We report two sets of experiments aiming to enrich our understanding of the cognitive and linguistic constraints that impact reflexive interpretation in Chinese, and to contribute to the debate between the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis. We have two main aims.

First, we address linguistic questions concerning people's final interpretation of *ziji* and *ta-ziji* by using offline experiments, to lay the foundation for our online experiments. In addition to showing that *ziji* is sensitive to discourse topicality and verb bias, we ask (i) whether the prominence constraint for *ta-ziji* can be extended to the discourse level and (ii) whether locality is a stronger constraint than verb semantics for *ta-ziji*. The first question has direct consequences for the online experiment on *ta-ziji,* because testing the Multiple Constraints Hypothesis would be uninformative if *ta-ziji* turns out to be insensitive to topic prominence. The second question is an attempt to take a closer look at verb semantics and *ta-ziji* given Lu's prior work.

Second, we examine from a psycholinguistic perspective the dynamic interaction of syntactic and non-syntactic constraints in online reflexive resolution. We are especially interested in the role of discourse topicality in the real-time processing of *ziji* and *ta-ziji*. Despite extensive research investigating the effects of discourse-level information on the resolution of cross-sentential pronouns, studies on whether discourse-level information modulates online reflexive resolution are still relatively scarce. Thus, building on the offline experiments, we aim to clarify the influence of discourse-level information to the real-time processing of *ziji* and *ta-ziji*.

Experiments 1a and 1b test the offline and online processing of *ziji*, respectively, while Experiments 2a and 2b test the offline and online processing of *ta-ziji*, respectively.

4. Experiment 1: Processing of *ziji*

Experiment 1 has two parts. Experiment 1a is a forced-choice task which tests whether the self- vs. other-directed verbs used in Experiment 1b (self-paced reading) are indeed effective in biasing participants' final interpretations of *ziji*. Experiment 1b taps into real-time processing to assess whether *ziji*'s locality bias, observed in contexts without clear discourse topics (e.g. Dillon et al., 2016; Wang, 2017a, 2017b), persists when the non-local referent is a discourse topic, and to explore whether discourse-level topicality plays a role in modulating comprehenders' real-time interpretations.

4.1 Materials and design for Experiments 1a and 1b

Experiments 1a and 1b used the same materials and design. The factors *context* (neutral/biased) and *verb bias* (self-directed/other-directed) were crossed in a 2x2 factorial design. The label *neutral context* refers to a context that lacks a clear discourse topic (see (8a,b)). In neutral contexts, no individual character is mentioned in the first sentence, and thus no referent is established in prior discourse as topical. We contrast this with *biased contexts* where the first sentence establishes the non-local antecedent (e.g. 'chairman') as the discourse topic (see (8c,d)) by introducing it in subject position and providing information about it. We refer to this context manipulation as a discourse topic manipulation. Note that in biased contexts, the matrix subject of the critical

sentence starts with the pronoun *ta* to avoid incurring a repeated name penalty (e.g. Almor, 1999; Gordon et al., 1993; Garrod et al., 1994).

(8)   a.   **Neutral context/Self-directed verb**

Dasha-li	zhengzai	juxing	yi-ge	zhongyao	de	huiyi.	Hui-shang,
building-in	in-progress	have	one-CL	important	DE	meeting	meeting-in

dongshizhang	zhuyi-dao	Li zhuren	yizhi	*xuanyao*	ziji	de
chairman	notice-ASP	Director Li	constantly	*brag*	self	DE

guanli	caineng.
management	skill

'There was an important meeting in progress inside the building. In the meeting, the chairman noticed that Director Li constantly **bragged about** self's management skills.'

b.   **Neutral context/Other-directed verb**

Dasha-li	zhengzai	juxing	yi-ge	zhongyao	de	huiyi.	Hui-shang,
building-in	in-progress	have	one-CL	important	DE	meeting	meeting-in

dongshizhang	zhuyi-dao	Li zhuren	yizhi	*chuipeng*	ziji	de
chairman	notice-ASP	Director Li	constantly	*flatter*	self	DE

guanli	caineng.
management	skill

'There was an important meeting in progress inside the building. In the meeting, the chairman noticed that Director Li constantly **flattered** self's management skills.'

c.   **Biased context/Self-directed verb**

Dongshizhang	zhuchi-le	jintian	zaochen	de	huiyi.	Hui-shang,	ta
chairman	host-ASP	today	morning	DE	meeting	meeting-in	he

zhuyi-dao	Li zhuren	yizhi	*xuanyao*	ziji	de	guanli	caineng.
notice-ASP	Director Li	constantly	*brag*	self	DE	management	skill

'The chairman hosted the meeting this morning. In the meeting, he noticed that Director Li constantly **bragged about** self's management skills.'

d.   **Biased context/Other-directed verb**

Dongshizhang	zhuchi-le	jintian	zaochen	de	huiyi.	Hui-shang,	ta
chairman	host-ASP	today	morning	DE	meeting	meeting-in	he

zhuyi-dao	Li zhuren	yizhi	*chuipeng*	ziji	de	guanli	caineng.
notice-ASP	Director Li	constantly	*flatter*	self	DE	management	skill

'The chairman hosted the meeting this morning. In the meeting, he noticed that Director Li constantly **flattered** self's management skills.'

The critical sentence contains either a self-directed verb (e.g. 'brag') that biases the local reading of *ziji* or an other-directed verb (e.g. 'flatter/praise') that biases the non-local reading. The verbs were initially selected based on native-speaker judgment, but the verbs' self- vs. other-directed biases were confirmed in Experiment 1a. We used *ziji* in possessive position (*ziji de* in (8)) because

this is the most frequent grammatical position in which *ziji* occurs (in the Lancaster Corpus of Mandarin Chinese; Jia, 2020).

Half of the local and non-local antecedents were male, and half were female. Ten different verbs ('notice', 'hear', 'say', etc.) were used as the matrix verb in the critical sentence. Twenty sets of target items were created and distributed into 4 lists in a Latin Square design. Thus, each participant only saw a particular item once, and saw 5 targets in each of the 4 conditions over the course of the experiment. In the self-paced reading Experiment 1b, the critical region is the reflexive *ziji*, preceded by the biased verb and followed by three spillover regions: DE, a modifier, and an NP.

Twenty fillers were interleaved with targets such that each target was followed or preceded by a filler. The fillers all contained non-reflexive pronouns. On filler trials in Experiments 1a and 1b, comprehension questions asked about the non-reflexive pronoun to ensure that participants paid attention.

4.2 Experiment 1a: Forced-choice judgment

4.2.1 Participants

Forty-five adult Chinese native speakers participated via the internet. All had normal or corrected-to-normal vision. Studies reported in this paper have all been reviewed and approved by the Institutional Review Board (IRB) at the University of Southern California.

4.2.2 Procedure

The experiment was run using Qualtrics (Qualtrics, Provo, UT). Participants answered comprehension questions after each sentence. On target trials, the questions probed the antecedent of *ziji*. For example, the question for (8) was 'Who has management skills?'. On each trial, the context sentence was displayed first. The critical sentence was shown on the next screen. This was done to match the presentation set-up in the self-paced reading Experiment 1b. After reading the target sentence, participants answered the comprehension question displayed on the same screen, by selecting one of two answer choices. The top-bottom orientation order of antecedent choices (e.g. 'chairman'/'Director Li') was counterbalanced.

4.2.3 Predictions

If the verb bias manipulation is successful, participants should prefer local antecedents with self-directed verbs (e.g. 'brag') and non-local antecedents with other-directed verbs (e.g. 'flatter'). Additionally, if topic prominence influences the interpretation of *ziji*, we expect a main effect of *context*: when the non-local antecedent is the discourse topic in a biased context, the bias for non-local choices should be stronger relative to the neutral context.

4.2.4 Data analysis

Statistical analyses were conducted in R (R Core Team, 2018). For the two factors *context* and *verb bias*, we fit two contrasts (biased context: 0.5, neutral context: –0.5; other-directed verb bias: 0.5, self-directed verb bias: –0.5). Participants' answers to comprehension questions (i.e., antecedent choices) were analyzed using mixed-effect logistic models with the *glmer* function, implemented by the R package *lme4*. Statistical models were first fit with random intercepts and random slopes. If the model failed to converge, we simplified the model following the procedures in Bates et al. (2015). A simpler model was always preferred if it did not differ significantly from a more complex model, as indicated by model comparison. Following Matuschek et al. (2017), we chose an alpha value of 0.2 rather than 0.05 for model comparisons. (Note that the choice of 0.2 vs. 0.05 does not impact the data patterns reported below or our conclusions.)

4.2.5 Results

Figure 1 shows participants' mean preference of selecting the *local* referent as the antecedent of *ziji*. For statistical analysis, see **Table 1**. The mixed-effect logistic model indicates a main effect of *verb bias* (p < 0.001). As **Figure 1** shows, when the verb is self-directed, participants preferred local NPs as antecedents (63% in the biased context and 82% in the neutral context), but when the verb is other-directed, they overwhelmingly chose non-local NPs (85% in the biased context and 77% in the neutral context). Context modulates participants' choices as well,
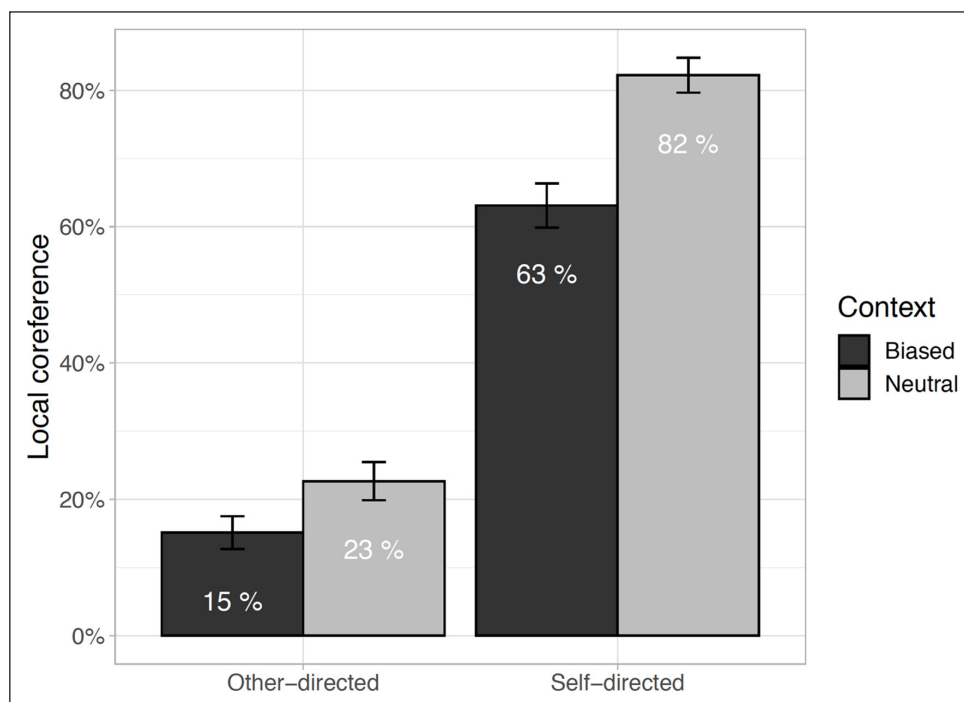

Figure 1: Mean percentages of local coreference in Experiment 1a on *ziji*.

as critical sentences preceded by biased contexts made participants less likely to select local NPs as antecedents (p < 0.001). There is no significant *context* x *verb bias* interaction.

Table 1: Summary of statistics for Experiment 1a (*: <0.05).

	β	SE	t-value	*p*-value
Context	–0.92	0.18	–5.01	<0.001*
Verb	–3.01	0.21	–14.67	<0.001*
Context x Verb	0.35	0.36	0.97	0.33

Model structure: glmer(Answer ~ Context * Verb + (1|Subject_ID) + (1|Item_ID), data, family = binomial).

Overall, these patterns suggest that (i) the verb bias manipulation is effective: self-directed and other-directed verbs guide the interpretation of *ziji* in expected directions, and (ii) discourse-level information modulates Chinese speakers' antecedent choices: participants are more likely to select the non-local referent when it is a discourse topic. In other words, these two kinds of non-structural cues influence participants' offline antecedent choices for *ziji*. Next, we turn to Experiment 1b to assess the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis.

4.3 Experiment 1b: Self-paced reading

4.3.1 Participants

Seventy-nine adult Chinese native speakers with normal or corrected-to-normal vision participated via the internet. No participant had participated in Experiment 1a.

4.3.2 Procedure

The study was run on Ibex Farm (Drummond, 2013). Participants first saw a screen displaying the context sentence in its entirety. They then pressed the spacebar to see the critical sentence on a new screen presented word by word, except for the first region which is an adverbial phrase presented as a single unit. Each key press revealed the next region and at the same time masked the previous region with a dash. Once participants had finished reading the critical sentence, they pressed the spacebar again to see a comprehension question with two answer choices. Twelve questions out of the 20 questions for the target items probed the antecedent of *ziji*, and the answer choices consisted of the two candidate antecedents.[1] The remaining 8 questions asked

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[1] These questions ensured that participants paid attention and provided a secondary measure of people's late-stage interpretations of *ziji* and *ta-ziji*. (See also Chen et al. (2012), Jäger et al. (2015), and Lyu & Kaiser (2021), which also

about the context sentence, with answer choices consisting of a factually correct and a factually incorrect choice. Participants' responses to these 8 questions and the questions about fillers were used to calculate comprehension accuracy. The order of answer choices was randomized.

4.3.3 Predictions

We now consider the predictions of the Syntactic Filter Hypothesis and Multiple Constraints Hypothesis for reading times (RTs) at the critical reflexive and/or the preceding verb region.

Our linking hypothesis between RTs and preference for local/non-local antecedents is as follows: when there exists a clearly preferred antecedent (whether local or non-local), RTs are relatively fast; when there is no clear preference for any one antecedent, RTs are relatively slow. In other words, the stronger the preference for an antecedent (whether local or non-local), the faster the RTs. Furthermore, if the strength of the preference for a local antecedent in one condition is comparable to the strength of the preference for a non-local antecedent in another condition, those RTs should also be similar.

In what follows, we include the preceding verb region in our predictions because a prior study on *ziji* by Lyu and Kaiser (2021) with a similar verb bias manipulation and a similar target-filler ratio found that the predicted effects can already occur at the *verb*, before the reflexive. The effects presumably emerge already at the verb because participants are actively predicting upcoming reflexives (see e.g. Lyu & Kaiser, 2021, for discussion). Such anticipatory effects are not unexpected, given that humans are known to engage in anticipatory/predictive processing during real-time sentence comprehension (e.g. DeLong et al., 2014; Kuperberg & Jaeger, 2016).

As mentioned above, although *ziji* can be LD-bound, prior work has frequently shown a locality bias for *ziji*, suggesting that local search may be a default parsing strategy (e.g. Chen et al., 2012; Dillon et al., 2014; 2016; Gao et al., 2005; Jäger et al., 2015; Li & Zhou, 2010; Lyu et al., 2022; Wang, 2017a). We follow existing work in assuming that syntactic locality is one of the factors that can guide antecedent retrieval.[2] Thus, according to the Syntactic Filter Hypothesis, participants should initially consider local binding. According to a strong version, no verb bias effects should appear at the earliest moments because verb semantics is inaccessible to the parser. But as this strong view has met with substantial counterevidence (e.g. Boland et al., 1990; Garnsey et al., 1997; Trueswell et al., 1993), we consider a weaker version which admits

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included questions probing reflexives' antecedents.) However, they are not a key part of our predictions. Indeed, as statistics with 12 target items are underpowered (3 per condition), we do not focus on these results, but our sentence-final judgment results mirror the patterns of Experiment 1a and 2a.

[2] An anonymous reviewer asks whether syntactic locality and discourse topicality could be viewed as two opposite ends of the same constraint. While we think it is feasible to unify these two different types of prominence, we keep them separate in our predictions and hypotheses because they play distinct roles in reference resolution.

immediate recruitment of verb semantic information (but not discourse-level information). This weaker version predicts a main effect of *verb bias* such that other-directed verbs should lead to reading slowdowns in both neutral and biased contexts due to a clash between verb semantics and the locality constraint, but it does not predict an early effect of topic prominence or a *context* x *verb bias* interaction, given that topicality is a discourse-level factor.

The Multiple Constraints Hypothesis, in contrast, allows for early effects of locality, verb bias and discourse topic prominence. In neutral contexts, this hypothesis, just like the Syntactic Filter Hypothesis, predicts reading slowdowns for the other-directed verb condition relative to the self-directed verb condition. In biased contexts with discourse topics, however, the Multiple Constraints Hypothesis predicts verb bias effects to differ from those observed in neutral contexts, due to the influence of the discourse topic. More specifically, this account predicts a *context* x *verb bias* interaction. We emphasize that we make no specific predictions regarding the details of this interaction in the present paper. Here, our aim is simply to test *whether such an interaction exists*, as this would be a key piece of evidence in favor of the Multiple Constraints Hypothesis.

However, in what follows we sketch out some possible ways that the interaction could play out – in particular, how things might look in the biased conditions if topic prominence kicks in early on, as predicted by the Multiple Constraints Hypothesis.

First, if the three constraints – locality, verb bias, topic prominence – have equal weights, then the self-directed and other-directed verb conditions should result in similar RTs at the verb and/or critical reflexive region in the biased conditions. This is because with both self- and other-directed verbs, we have a clear "two-against-one" situation: we have a configuration where one antecedent is favored by two constraints and the other antecedent is favored by only one constraint: with other-directed verbs, topic prominence and other-directedness favor the non-local antecedent, only locality favors the local antecedent. With self-directed verbs, self-directedness and locality favor the local antecedent, only topic prominence favors the non-local antecedent. Thus, in biased contexts, the strength of participants' expectations – and hence their RTs – for (i) local binding with self-directed verbs and (ii) non-local binding with other-directed verbs should be similar.

Alternatively, if topic prominence has more weight than locality, biased contexts should yield a clearer antecedent preference (and faster RTs) with other-directed verbs than with self-directed verbs. This is because with other-directed verbs, we again have a clear "two-against-one" situation: *both* topic prominence and verb bias favor the non-local antecedent. However, with self-directed verbs, although both self-directedness and locality favor the local antecedent, they face stiff competition from topic prominence which favors the non-local antecedent. These tensions among constrains may cause RT slowdowns with self-directed verbs relative to other-directed verbs.

Note that topic prominence could be weighted differently with *ziji* and *ta-ziji* since *ziji* is perspective-sensitive but *ta-ziji* is not. Our study only takes initial steps to investigate whether discourse-pragmatic factors can have an immediate effect on the processing of *ziji/ta-ziji*. Work on the exact weights of these constraints is beyond the scope of this paper. What's crucial for our purpose is simply that the Multiple Constraints Hypothesis predicts a *context* x *verb bias* interaction while the Syntactic Filter Hypothesis does not.

Finally, we also predict a global main effect of *context*, due to reasons unrelated to our research questions. Critical sentences preceded by biased contexts may be easier to process overall, compared to neutral context conditions, because previous studies showed that perspective shift incurs processing costs (e.g. MacWhinney, 2005; MacWhinney & Pleh, 1988). In biased contexts, after a character (e.g. 'chairman') has been encountered in the context sentence, participants might assume that character's perspective. This means transitioning to the second sentence with a coreferential pronoun *ta* ('s/he') is easy as the perspective is maintained. In contrast, in neutral contexts, participants only encounter the non-local character (e.g. 'chairman') in the critical sentence. The switch of perspective from their own (in the context sentence) to that of the non-local antecedent (in the critical sentence) could lead to reading slowdowns. Thus, a *context* main effect is expected but not central for our aims.

4.3.4 Data analysis

Before data analysis, we decided that any participant with mean accuracy below 75% on the comprehension questions would be excluded, which resulted in the removal of 6 participants. The remaining 73 participants had a mean accuracy of 94%. RTs shorter than 100 ms or longer than 3000 ms were excluded. Then RTs more than 2.5 standard deviations away from the mean by region and condition were also removed. This resulted in the removal of 2.71% of the original data. Statistical analyses were conducted over both log-transformed RTs and raw RTs using mixed-effect linear models implemented by the *lme4* package in R. In this paper, we mainly focus on log-transformed RT analyses but accompany those with raw RT analyses in the text. In almost all cases, the two sets of analyses yield consistent results.

4.3.5 Results

The reading times are in **Figure 2**. The critical region is Region 7, *ziji*. Visually, it's clear that, first, words in biased context conditions are processed faster compared to the neutral contexts. Second, verb-related differences within each context type appear at the verb, prior to the reflexive *ziji*. At the reflexive itself, RTs are faster in biased contexts than in neutral contexts, but there appears to be no effect of verb bias.

These observations are confirmed by statistical analysis (**Table 2**).[3] First, the *context* main effect is significant across all regions except Region 1 (ps < 0.005), showing that target sentences preceded by biased contexts were read faster. This is not relevant for our main claims and is expected under a perspective-shift account.
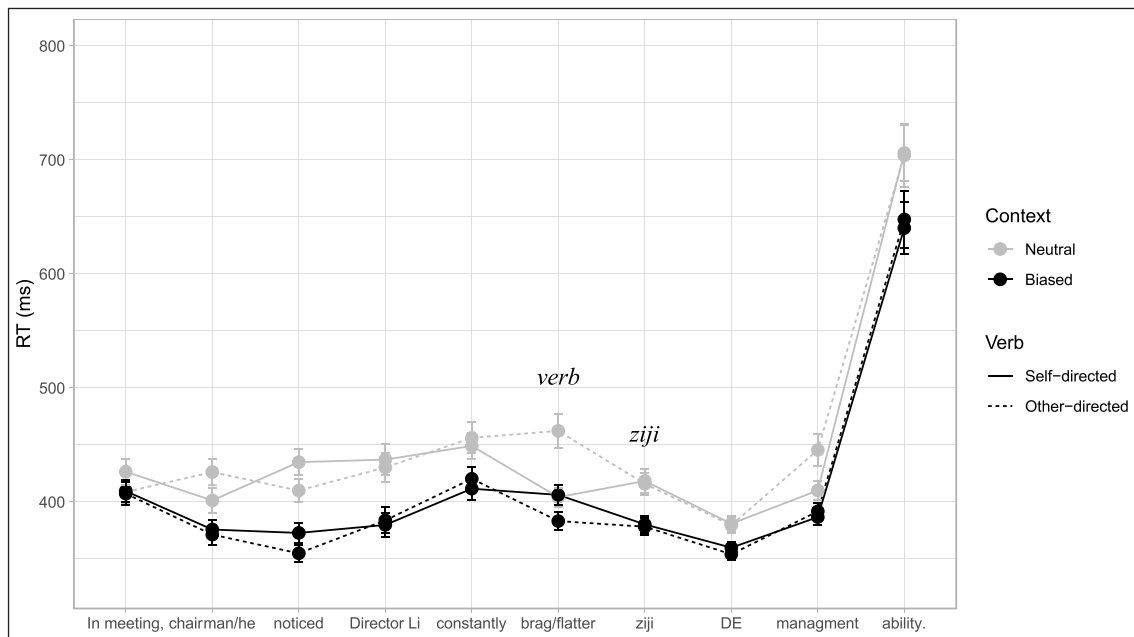

Figure 2: Mean RTs (ms) across regions in the target sentence in Experiment 1b.

At the verb region, in addition to the *context* main effect (p < 0.001; raw RT analysis: β = 37.08, SE = 8.68, t = 4.27, p < 0.001), we found a *context* x *verb bias* interaction (p < 0.001; raw RT analysis: β = –76.02, SE = 17.34, t = –4.38, p < 0.001). This shows that verb bias has different effects in neutral and biased contexts. Pairwise comparisons revealed that in neutral contexts, other-directed verbs lead to RT slowdowns relative to self-directed verbs (log-transformed RT analysis: β = –0.08, SE = 0.02, t = –3.08, p = 0.002; raw RT analysis: β = –56.56, SE = 14.44, t = –3.92, p < 0.001). This is predicted by both the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis (given prior work showing that reflexive-related effects can occur on the preceding verb). However, in the biased context, self-directed verbs caused longer RTs than other-directed verbs (log-transformed RT analysis: β = 0.0, SE =

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[3] We also ran analyses including RTs from previous regions as predictors. These yield the same overall data pattern, with only minor differences at some spillover regions. These changes do not impact our conclusions. See supplementary materials for details.

Table 2: Summary of statistics for log-transformed RTs in Experiment 1b (*: <0.05).

Region	Context				Verb				Context x Verb			
	β	SE	t-value	p-value	β	SE	t-value	p-value	β	SE	t-value	p-value
In meeting	0.01	0.02	0.67	0.50	0.005	0.02	0.29	0.77	0.03	0.03	0.77	0.44
chairman/he	0.08	0.02	4.34	<0.001*	−0.03	0.02	−1.72	0.09	−0.06	0.03	−1.76	0.08
noticed	0.12	0.03	4.88	<0.001*	0.03	0.02	1.61	0.13	0.02	0.03	0.67	0.50
Director Li	0.11	0.02	5.99	<0.001*	−0.001	0.02	−0.07	0.94	−0.0001	0.04	−0.002	0.99
constantly	0.07	0.02	3.84	<0.001*	−0.01	0.02	−0.72	0.47	0.03	0.04	0.74	0.46
verbed	0.06	0.02	2.72	0.01*	−0.02	0.02	−0.84	0.40	−0.12	0.03	−3.73	<0.001*
ziji	0.08	0.01	5.39	<0.001*	0.002	0.01	0.02	0.87	−0.02	0.03	−0.53	0.60
DE	0.05	0.01	4.20	<0.001*	0.008	0.01	0.65	0.51	−0.005	0.02	−0.21	0.84
management	0.06	0.01	4.34	<0.001*	−0.03	0.01	−1.79	0.07	−0.03	0.03	−0.98	0.32
skills	0.08	0.02	3.12	0.002*	0.01	0.02	0.46	0.64	0.03	0.05	0.53	0.60

The final models for the biased verb, reflexive, and post-reflexive regions are as follows:

Verb region: lmer(logRT ~ Context * Verb + (1 + Context + Verb|Subject_ID) + (1 + Context|Item_ID), data).

Reflexive region: lmer(logRT ~ Context * Verb + (1|Subject_ID) + (1|Item_ID), data).

Post-reflexive region: lmer(logRT ~ Context * Verb + (1|Subject_ID) + (1|Item_ID), data).

0.02, t = 2.13, p = 0.03; raw RT analysis: β = 20.75, SE = 9.37, t = 2.21, p = 0.03). This is the opposite of what the Syntactic Filter Hypothesis predicts and fits better with the Multiple Constraints Hypothesis.

For the critical region *ziji* and the three spillover regions, we only found main effects of *context* (ps < 0.001) in the log-transformed RT analysis. However, analysis of raw RTs for the second spillover region ('management') reveals a main effect of *verb bias* (β = –21.27, SE = 8.08, t = –2.63, p < 0.01) and a marginal *context* x *verb bias* interaction (β = –28.25, SE = 16.08, t = –1.76, p = 0.08). Pairwise comparisons indicate that while there is no verb bias effect in biased contexts (β = –6.11, SE = 7.56, t = –0.81, p = 0.42), other-directed verbs lead to slowdowns in neutral contexts (β = –36.69, SE = 14.04, t = –2.61, p < 0.01), pointing to a locality bias. No other effects at the spillover regions are significant.

4.3.6 Discussion

Experiments 1a and 1b investigate how locality bias, verb semantics and discourse-level information guide the offline and online processing of *ziji* in bi-clausal contexts with local and non-local candidate antecedents. The data we collected regarding offline interpretations provides a foundation that helps us assess the self-paced reading times.

Offline data

Experiment 1a shows that Chinese speakers have a clear preference to choose antecedents that match the verb's semantic bias. This is consistent with prior work on *ziji* (He, 2014; Lu, 2011; Lyu & Kaiser, 2021). Although our findings may appear to diverge from those of Jäger et al. (2015, pre-test in Exp. 1) which shows that Chinese speakers prefer local antecedents despite semantic incongruence (animacy), we do not think our findings conflict with theirs. We attribute the divergence to differences in syntactic structures (non-local antecedents in Jäger et al. (2015, Exp. 1) do not c-command *ziji*) and to the different types of semantic information tested (animacy vs. verb bias). Future work should look more into how different types of semantic information compete with syntactic locality.

Reading times

To assess two competing accounts of how different kinds of information guide online resolution of *ziji* – the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis – we measured word-by-word reading times. According to the Syntactic Filter Hypothesis, discourse-level information does not guide the early moments of reference resolution, which are determined by structural information. According to the Multiple Constraints Hypothesis, information from different levels of representation (syntactic, lexical, and discourse levels) can play an immediate role during reference resolution.

The reading time results go against the Syntactic Filter Hypothesis and are more compatible with the Multiple Constraints Hypothesis, because we found a *context* x *verb bias* interaction at the verb (and later on as well). As mentioned above, our key aim in this work was simply to test whether such an interaction exists, as this provides an important piece of evidence in favor of the Multiple Constraints Hypothesis. More speculatively, if we look at the direction of the effects, we can make some preliminary observations about the relative weights of the different factors.

In neutral contexts without a discourse topic, other-directed verb conditions elicited longer RTs than self-directed verbs, which we interpret as reflecting the clash of two constraints, verb semantics and locality. This is expected as previous studies repeatedly found longer RTs when the locality bias and semantic cues (e.g. gender, animacy) clash (e.g. Dillon et al., 2016; Jäger et al., 2015; Wang, 2017a, 2017b), and does not speak directly to the Syntactic Filter vs. Multiple Constraints issue.

In biased contexts with a discourse topic, the direction of the RT slowdown flipped: self-directed verb conditions elicited longer RTs than other-directed verb conditions. This fits with the speculative prediction we sketched out in 4.3.3 about topic prominence playing an important role: if the topic prominence constraint carries more weight than the locality constraint, we expect self-directed verbs in biased contexts to elicit longer RTs than other-directed verbs. This is due to the conflict in the self-directed verb conditions between (i) a heavily weighted topic prominence constraint favoring the non-local antecedent and (ii) both the locality and verb bias constraints favoring the local antecedent. Our finding that self-directed verbs lead to slowdowns is compatible with the idea that topic prominence (perspective-taking) for *ziji* is weighted more heavily than syntactic locality.

However, we emphasize that our main aim here was simply to test for the *presence* of an interaction, thereby distinguishing the Syntactic Filter and Multiple Constraints Hypotheses. Future work is needed to assess the constraint weights in a more systematic way.

Recall also that, as foreshadowed in 4.3.3, our finding that the *context* x *verb bias* interaction already emerged at the verb region is in line with the findings of Lyu and Kaiser (2021) who found that the verb bias effect can appear at the verb region (their Exp. 2b) or at the reflexive (their Exp. 2c). When the distance between *ziji* and the matrix subject is long – spanning over 6 words in their Exp. 2b, similar to our Experiment 1b – the effect appeared earlier, possibly because participants have more time to anticipate the upcoming *ziji*. When the distance is shorter, the effect appeared at the reflexive region, presumably because participants did not have ample time to make predictions. As linguistic prediction is a fundamental component of human sentence processing (e.g. Kuperberg & Jaeger, 2016), we do not find the earlier-than-expected effect to be surprising.[4]

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[4] Post-hoc analyses on the first vs. second half of the trials show that the verb bias effect emerges at the verb region already during the first half of the study (see supplementary material), indicating that this is not a late-emerging learning effect. Furthermore, results of other studies (e.g. Chen et al., 2012; Jäger et al., 2015; Lyu & Kaiser, 2021)

5. Experiment 2: Processing of *ta-ziji*

So far, we have focused on the interpretation and processing of *ziji*. In Experiments 2a and 2b, we turn to *ta-ziji* ('s/he-self'). Experiment 2a uses an offline forced-choice task to test whether *ta-ziji* is influenced by verb bias and topic prominence like *ziji*. Experiment 2b uses the self-paced reading method to replicate the locality bias observed for *ta-ziji* in prior work when the matrix subject is not a discourse topic (e.g. Chang et al., 2020; Dillon et al., 2016; Qian & Wu, 2016) and to examine whether discourse topicality modulates real-time processing patterns of *ta-ziji*. Moreover, as we saw in (5a–c), *ta-ziji* contrasts with *ziji* in being perspective-insensitive. Looking closer at these two reflexive forms may offer initial insights into how a topicality manipulation influences perspective-sensitive vs. -insensitive reflexive forms.

5.1 Materials and design for Experiments 2a and 2b

The materials used in Experiment 2 are identical to Experiment 1, except *ziji* was replaced by *ta-ziji*.

5.2 Experiment 2a: Forced-choice judgment

5.2.1 Participants

Forty-six adult Chinese native speakers participated. They had normal or corrected-to-normal vision. None had participated in Experiments 1a or 1b.

5.2.2 Procedure

The procedure is the same as in Experiment 1a.

5.2.3 Predictions

If the interpretation of *ta-ziji* is similarly impacted by verb bias and topic prominence like *ziji*, we expect the same antecedent choice pattern as in Experiment 1a. However, *ta-ziji* could yield different results, for at least two reasons. First, Lu (2011) found that *ta-ziji* shows a locality bias in an offline judgment task even when the verb biases towards the matrix subject. It is possible that we might not find a *verb bias* main effect. Second, as shown by (5a–c), *ta-ziji* shows no sign of perspective-sensitivity and it is assumed to be anaphoric (e.g. Pan, 1998). If effects of topic prominence found in Experiments 1a and 1b are inherently tied to perspective-sensitivity, we may find no main effect of *context* for *ta-ziji*. On the other hand, in light of claims by Pan and Hu

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suggest that these effects at the verb can emerge with different participants and methods. As suggested by an anonymous reviewer, the verb bias effects at the pre-critical region may be related to our design (high target-filler ratio) and could be due to other reasons in Chen et al. (2012) and Jäger et al. (2015). We gratefully acknowledge this point and would like to examine this possibility closely in our future work. For our predictions, whether the effect is at the verb or at the reflexive is not crucial.

(2002) that *ta-ziji* is sensitive to certain aspects of antecedent prominence, we may find a topic prominence effect in Experiments 2a.

5.2.4 Data analysis

Data analysis was identical to Experiment 1a.

5.2.5 Results

As can be seen in **Figure 3**, participants' antecedent choices are modulated by verb bias as well as context. See **Table 3** for statistics. Participants preferred non-local binding when the verb is other-directed (Biased context: 81%; Neutral context: 75%) and local binding when the verb is self-directed (Biased context: 77%; Neutral context: 82%). Therefore, we found different antecedent choice results than Lu (2011) regarding *ta-ziji*. (We come back to this in the discussion.) Instead, we find – in line with our Experiment 1a on *ziji* – that verb bias is a stronger cue in offline judgment than syntactic locality in guiding antecedent choices with *ta-ziji*. The *context* main effect is also significant ($p < 0.05$). This novel finding indicates that the previous claim that *ta-ziji* is sensitive to antecedent prominence (Pan, 1998; Pan & Hu, 2002) seems applicable to the discourse level. If the non-local antecedent is the discourse topic and thus more prominent, LD binding is more accessible, relative to when the non-local antecedent is not a discourse topic.
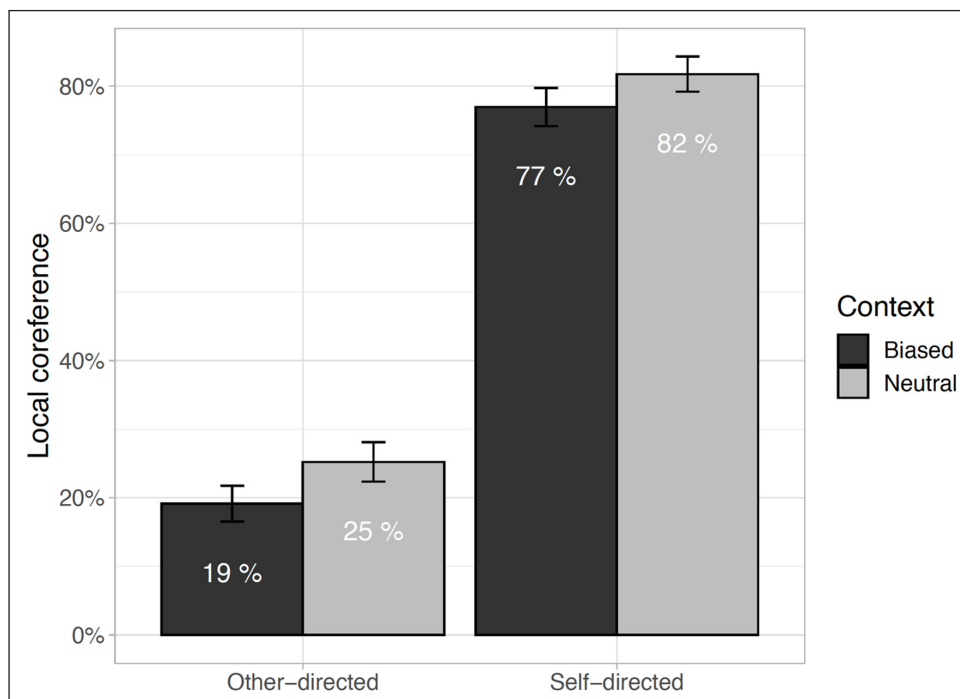

Figure 3: Mean percentages of local coreference in Experiment 2a.

Table 3: Summary of statistics for Experiment 2a (*: <0.05).

	β	SE	t-value	*p*-value
Context	–0.42	0.18	–2.38	0.017*
Verb	–3.13	0.20	–15.34	<0.001*
Context x Verb	–0.26	0.35	0.46	0.46

Model structure: glmer(Answer ~ Context * Verb + (1|Subject_ID) + (1|Item_ID), data, family = binomial).

Comparing Experiment 1a (ziji) and Experiment 2a (ta-ziji)

A visual comparison of Experiments 1a and 2a (**Figures 1** and **3**) seems to suggest that although both forms are sensitive to context manipulation, *ziji* exhibits a stronger topicality effect. In particular, in biased contexts, *ziji* seems to elicit higher percentages of *non-local* antecedent choices than *ta-ziji*. To assess the differences between *ziji* and *ta-ziji* statistically, we included *reflexive type* as a between-participant predictor (contrast coding: *ta-ziji* = 0.5, *ziji* = –0.5). If *ta-ziji* and *ziji* show different sensitivities to the context manipulation, we expect a *context* x *reflexive type* interaction.

Table 4: Summary of statistics from mixed-effect modeling comparing the context effect shown by *ziji* and *ta-ziji* (*: <0.05).

	β	SE	t-value	p-value
Context	–0.68	0.13	–5.26	<0.001*
Verb	–3.08	0.14	–21.37	<0.001*
Reflexive	0.31	0.14	2.20	0.027*
Context x Verb	0.01	0.26	0.05	0.96
Context x Reflexive	0.51	0.25	2.01	0.045*
Verb x Reflexive	–0.09	0.25	–0.37	0.71
Context x Verb x Reflexive	–0.59	0.50	–1.17	0.24

Model structure: glmer(Answer~Context*Verb*Reflexive+(1|Subject_ID)+(1|Item_ID), data, family = binomial).

As summarized in **Table 4**, the main effect of *reflexive type* is significant ($p < 0.05$), suggesting that participants preferred non-local antecedents more with *ziji* than with *ta-ziji*. Crucially, the *context* x *reflexive type* interaction is also significant ($p < 0.05$). Pairwise comparisons suggest that *ziji* tends to refer to non-local antecedents more than *ta-ziji* does in biased contexts ($\beta = 0.59$, SE $= 0.18$, t $= 3.20$, p $= 0.001$) but not in neutral contexts ($\beta = 0.06$, SE $= 0.18$, t $= 0.32$, p $= 0.75$). This means that, although both forms show sensitivity to discourse topicality, the interpretation of *ta-ziji* is less sensitive to discourse-level prominence than *ziji*. We next turn to Experiment 2b to examine whether this difference has consequences for online processing.

5.3 Experiment 2b: Self-paced reading

5.3.1 Participants

Eighty-three adult Chinese native speakers participated via the internet. No participant had participated in any of the previous experiments.

5.3.2 Procedure

The procedure is the same as in Experiment 1b.

5.3.3 Predictions

If the processing of *ta-ziji* is guided by verb bias, topic prominence, and locality, then the predictions for the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis are the same as for Experiment 1b. Similarly, given the results of Experiment 1b and a study on *ta-ziji* (Chang et al., 2020), we expect potential effects of our manipulation to arise on the verb and/or the reflexive. As in Experiment 1b, we also expect to see global main effects of *context*, which is not central to our main aims.

5.3.4 Data analysis

Data analysis was done as in Experiment 1b. Nine participants were excluded because their comprehension accuracies fell below the 75% threshold. The remaining 74 participants had a mean accuracy of 92%. Following the same guidelines as Experiment 1b, 3.00% of the original data was removed.

5.3.5 Results

The reading times are in **Figure 4**. The critical region is Region 7, *ta-ziji*. As we will see below, in contrast to Experiment 1b, we found no effects on the verb,[5] and thus we focus on the reflexive

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[5] In both Experiment 1b and Experiment 2b, participants saw one type of reflexive only. This high within-experiment frequency could lead one to expect similar verb bias effects at the verb region. However, unlike *ziji*, *ta-ziji* is low

region. Before the critical region, the main effect of *verb bias* reaches significance at the matrix subject (e.g. 'chairman/he') and the embedded subject ('Director Li'), respectively (ps < 0.05). We believe these effects are spurious because the biased verbs have not yet been encountered.
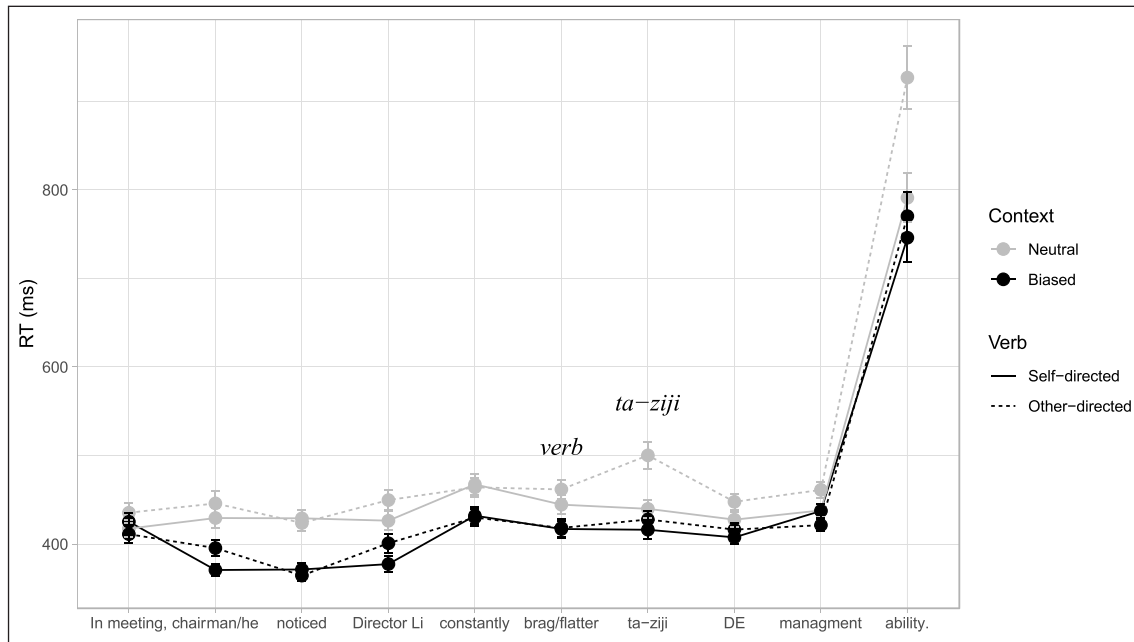

Figure 4: Mean RTs (ms) across regions in the target sentence in Experiment 2b.

There are three major findings. First, as predicted, there is a *context* main effect in all regions except Region 1 (ps < 0.001, see **Table 5**). Second, at *ta-ziji*, other-directed verb conditions are read more slowly than self-directed verb conditions (main effect of *verb bias*, p < 0.001; raw RT analysis: $\beta = -38.51$, SE = 9.20, t = -4.19, p < 0.001), but this is modulated by a *context* x *verb bias* interaction that reaches marginal significance in the log-transformed RT analysis (p = 0.08) and significance in the raw RT analysis ($\beta = -49.33$, SE = 18.55, t = -2.66, p < 0.01). Pairwise comparisons in log-transformed RT analysis and in raw RT analysis show that self-directed and other-directed verbs differ in the neutral context as RTs are longer for other-directed verbs (log-transformed RT analysis: $\beta = -0.09$, SE = 0.02, t = -3.99, p < 0.001; raw RT analysis: $\beta = -64.45$, SE = 14.66, t = -4.40, p < 0.001), but not in the biased context (log-transformed RT analysis: $\beta = -0.04$, SE = 0.02, t = -1.61, p = 0.11; raw RT analysis: $\beta = -13.31$, SE = 11.06, t = -1.20, p = 0.23). The finding that, in the neutral context, other-directed verbs elicited

in relative frequency in native speakers' language exposure. Indeed, a search in the Center for Chinese Linguistics Corpus (Zhan et al., 2003) with over 700 million characters shows that *ziji* is 17 times more frequent than *ta-ziji*. Thus, *ta-ziji* might be more difficult to predict and retrieve due to lower frequency, which could explain the verb bias effect at the critical region in Experiment 2b.

Table 5: Summary of statistics for RTs in Experiment 2b (*: <0.05).

Region	Context				Verb				Context x Verb			
	β	SE	t-value	p-value	β	SE	t-value	p-value	β	SE	t-value	p-value
In meeting	0.02	0.02	1.10	0.27	0.0005	0.02	0.034	0.97	−0.049	0.03	−1.54	0.12
chairman/he	0.08	0.02	5.02	<0.001*	−0.04	0.02	−2.21	0.03*	0.016	0.03	0.47	0.64
noticed	0.13	0.02	8.50	<0.001*	0.002	0.02	0.14	0.89	−0.009	0.03	−0.28	0.77
Director Li	0.12	0.02	7.11	<0.001*	−0.05	0.02	−2.81	0.005*	−0.02	0.03	−0.46	0.65
constantly	0.07	0.02	3.99	<0.001*	−0.004	0.02	−0.26	0.80	−0.004	0.03	−0.12	0.92
verbed	0.09	0.02	5.29	<0.001*	−0.03	0.02	−1.70	0.09	−0.04	0.03	−1.19	0.23
ta-ziji	0.10	0.02	5.92	<0.001*	−0.06	0.02	−3.93	<0.001*	−0.06	0.03	−1.74	0.08
DE	0.05	0.01	3.53	<0.001*	−0.03	0.01	−2.32	0.02*	−0.02	0.03	−0.70	0.49
management	0.04	0.01	3.01	0.003*	−0.005	0.01	−0.38	0.70	−0.07	0.03	−2.85	0.005*
skills	0.09	0.03	3.50	<0.001*	−0.08	0.03	−2.87	0.005*	−0.1	0.05	−1.83	0.07

The final models for the biased verb, reflexive, and post-reflexive regions are as follows:

Verb region: lmer(logRT ~ Context * Verb + (1|Subject_ID) + (1|Item_ID), data).

Reflexive region: lmer(logRT ~ Context * Verb + (1 + Context +Verb|Subject_ID) + (1|Item_ID), data).

Post-reflexive region: lmer(logRT ~ Context * Verb + (1 + Context|Subject_ID) + (1|Item_ID), data).

longer RTs than self-directed verbs replicates Experiment 1b at the verb. However, in contrast to Experiment 1b, we found no differences between self- and other-directed verbs in the biased contexts with discourse topics, suggesting local and non-local binding are equally probable to participants in real-time parsing.

Finally, the verb bias effect in neutral contexts carries over to the spillover regions. In log-transformed RT analyses, the *context* x *verb bias* interaction reaches significance at region 9 ('management', $p = 0.005$) while in raw RT analyses, the interaction is significant at both region 9 ('management') ($\beta = -41.25$, $SE = 12.45$, $t = -3.31$, $p < 0.001$) and region 10 ('skills') ($\beta = -122.99$, $SE = 52.79$, $t = -2.33$, $p < 0.05$). Pairwise comparisons in log-transformed RT analyses suggest that for both regions, other-directed verbs caused reading slowdowns in the neutral context only (Region 9: $\beta = -0.04$, $SE = 0.02$, $t = -2.22$, $p < 0.05$; Region 10: $\beta = -0.12$, $SE = 0.04$, $t = -3.19$, $p = 0.001$), which matches the raw RT analyses (Region 9: $\beta = -24.52$, $SE = 9.51$, $t = -2.58$, $p = 0.01$; Region 10: $\beta = -144.47$, $SE = 39.18$, $t = -3.69$, $p < 0.001$).

5.3.6 Discussion

Experiment 2 probes the influence of verb bias and topic prominence on the interpretation of *ta-ziji* in online and offline tasks. We are also interested in examining whether the reflexive resolution patterns are similar for *ta-ziji* and *ziji*.

Offline data

Participants' antecedent choices revealed effects of both verb bias and topic prominence. First, we find that Chinese speakers prioritize verb bias semantics over the locality constraint in the interpretation of *ta-ziji*, which is inconsistent with the results in Lu (2011), where Taiwanese Mandarin speakers prioritized local antecedents. This difference could be due to the different types of verbs used. The verb bias in Lu's study is more about real-world plausibility than verb directedness, and the verbs are not inherently biased (e.g. anyone can 'deliver' or 'receive' their own or others' packages). This differs from our study where it is inherently odd to 'brag' about other people's achievement. Our data also suggest that Chinese speakers consider the non-local antecedent more when it is a discourse topic. This means that *ta-ziji* is sensitive to discourse-level prominence, in addition to animacy prominence as posited by Pan and Hu (2002).

Despite this, our results show that *ta-ziji* is less sensitive to discourse topicality than *ziji*. We explain the weaker context effect in Experiment 2a as follows. As ex.(5a–c) shows, *ta-ziji* is not sensitive to perspective centers or empathy loci, consistent with the standard assumption that *ta-ziji* is an anaphoric reflexive (e.g. Pan, 1998). Therefore, the different sizes of the context effect could boil down to the different discourse-level mechanisms underlying the LD

binding of *ziji* and *ta-ziji*. The idea that different referential forms can exhibit different levels of sensitivity to different factors has been put forth by Kaiser et al. (2009) for English pronouns and reflexives and by Kaiser and Trueswell (2008) for Finnish cross-sentential anaphors, in their Form-Specific Multiple Constraints approach. With our data, it could be that *ziji* is more sensitive to discourse topicality than *ta-ziji*. More specifically, with *ziji*, topicality-related perspective-taking could be a stronger discourse-level cue that prompts participants to consider non-local antecedents, compared to non-perspective-related topic prominence in the case of *ta-ziji*. These two phenomena, though firmly grounded in prior work on Chinese, should be investigated more systematically in future research.

Reading times

An influence of discourse context was again observed in reading times in Experiment 2b. If context had no effect, we would expect other-directed verbs to yield equally long RTs in both neutral and biased contexts. However, this is not what we found: instead, reading times in biased contexts for self- and other-directed verb conditions did not differ. This null effect specifically in biased contexts suggests that both local and non-local interpretations were considered equally likely at the early stages of processing, which is compatible with the predictions of the Multiple Constraints Hypothesis but not the Syntactic Filter Hypothesis.

According to the predictions outlined in Sections 4.3.3 and 5.3.3 for the Multiple Constraints Hypothesis, in neutral contexts, when verb bias semantics and the locality bias conflict, reading slowdowns occur because of the tension of coreference; in the biased context, when all three constraints – topic prominence, locality, verb bias – have similar weights, local interpretations with self-directed verbs (locality + self-directedness > topic prominence) and non-local interpretations with other-directed verbs (topic prominence + verb bias > locality) are equally probable due to the "two-against-one" situation. The absence of the verb bias effect in biased contexts is compatible with the idea that discourse topic prominence carries the same weight as verb semantics and syntactic locality but contrasts with the finding in Experiment 1b on *ziji* where discourse topic prominence seems to be more heavily weighted. The finding that discourse topic prominence plays a weaker role for *ta-ziji* than *ziji* in online processing aligns with the comparative analysis results for the two offline experiments in Section 5.2.5. Overall, the *context* x *verb bias* interaction Experiment 2b on *ta-ziji* is again consistent with the Multiple Constraints Hypothesis.

6. General discussion
6.1 Summary of results

This work has two main goals. The *linguistic* goal is to test whether *ta-ziji* is sensitive to (i) verb bias semantics and (ii) discourse topic prominence, like *ziji*. Gaining knowledge about these fundamental linguistic patterns is meaningful from a linguistic perspective and also lays the

foundation for evaluating sentence processing hypotheses. Our *psycholinguistic* goal is to examine the effects of non-syntactic constraints on the processing of *ziji* and *ta-ziji* in discourse, to evaluate the Syntactic Filter Hypothesis and the Multiple Constraints Hypothesis. By comparing *ziji* and *ta-ziji*, we can also assess whether the offline and online processing patterns of these two reflexive forms are different.

We created local and non-local semantic dependencies by manipulating verb directedness. In neutral contexts where neither of the antecedents is mentioned prior to the critical sentence, a tension between verb semantics and the locality constraint is created when the verb is other-directed. This manipulation allows us to replicate the previous finding that *ziji* and *ta-ziji* are both subject to a locality constraint despite the option of LD binding for *ziji* (e.g. Dillon et al., 2016; Gao et al., 2005; Jäger et al., 2015; Lyu et al., 2022; Wang, 2017a). The two biased verb conditions in neutral contexts also serve as a baseline for the conditions in biased contexts, where the non-local antecedent is a discourse topic. Any change in the processing pattern should thus be ascribed to the change of the context. The Syntactic Filter Hypothesis predicts a main effect of *verb bias* in neutral and biased contexts for *ziji* and *ta-ziji*, but the Multiple Constraints Hypothesis predicts a *context* x *verb bias* interaction for these two forms.

Experiment 1 investigated the interpretation of *ziji*. In the forced-choice Experiment 1a, Chinese speakers clearly preferred antecedents congruent with verb semantics: when the verb is self-directed, they preferred local dependencies; when the verb is other-directed, they preferred non-local dependencies. Moreover, biased contexts made Chinese speakers more likely to consider the non-local antecedent which is a discourse-topic, relative to neutral contexts where no antecedent is topically prominent. This finding fits with prior claims that one tends to take the perspective of a discourse topic (Kuno, 1987) and that *ziji* is perspective-sensitive (e.g. Charnavel et al., 2017; Huang & Liu, 2001; Huang et al., 2009; Pan, 1997; 2001; Wang & Pan, 2015).

Experiment 1b (self-paced reading) investigated the processing of *ziji*. At the embedded verb, we observe that, in the neutral context, participants showed reading slowdowns when the verb is other-directed. In contrast, in the biased context, the pattern flipped, because now self-directed verbs elicited reading slowdowns. (As discussed earlier, this effect at the verb region is also seen in prior work and potentially related to participants' anticipatory processing behavior; online processing is known to be highly anticipatory.) Critical for our purposes, the *context* x *verb bias* interaction supports the Multiple Constraints Hypothesis but not the Syntactic Filter Hypothesis.

Experiment 2 explored similar issues in the processing of the complex reflexive *ta-ziji* to assess whether *ta-ziji* is strictly local in offline and real-time interpretations. In the forced-choice Experiment 2a, participants again based anaphoric interpretations on verb bias semantics: they mostly chose local antecedents when the verb is self-directed and non-local antecedents when the verb is other-directed. Intriguingly, participants preferred non-local readings of *ta-ziji* more in biased contexts than in neutral contexts, suggesting that topic prominence indeed impacts the

processing of *ta-ziji*. Nevertheless, this main effect of *context* is weaker than what has been found for *ziji*, attributable to the different linguistic properties of *ziji* and *ta-ziji*. These kinds of form-specific asymmetries have also been observed in other languages (see e.g. Kaiser & Trueswell, 2008, Kaiser et al., 2009 on form-specific effects).

Experiment 2b (self-paced reading) found immediate sensitivity to both verb bias and discourse structure with *ta-ziji*. In the neutral context, the critical region *ta-ziji* was read more slowly when the preceding verb was other-directed as opposed to self-directed. This is expected due to the clash of verb bias and the locality constraint. In the biased context, no processing differences were observed between the two verb types, suggesting that local and non-local readings were equally probable in real-time reference resolution. The absence of a verb bias effect with *ta-ziji* in biased contexts contrasts with the verb bias observed with *ziji*. These findings fit with our suggestion that topic prominence may have a stronger influence on *ziji* than *ta-ziji*. At any rate, the *context* x *verb bias* interaction at the reflexive *ta-ziji* (significant in the raw RT analysis, marginal in the log-RT analysis) is consistent with the predictions of the Multiple Constraints Hypothesis, and echoes what we found with *ziji*.

Taken together, our results suggest that Chinese speakers recruit multiple sources of information – structural and non-structural – at early stages of reference resolution. However, the offline data suggest that, over time, discourse-level and syntactic constraints may decay, as participants largely based their sentence-final antecedent choices on verb semantics. Another important finding is that discourse topicality seems to impact the processing of *ziji* and *ta-ziji* differently. We discuss the broader implications of our findings below.

6.2 Long-distance binding of *ta-ziji*

Regarding *ta-ziji*, we found that this form is sensitive to verb semantics and topic prominence. These findings have implications for linguistic theories.

When verb semantics biases non-local antecedents (e.g. 'flatter'), Chinese speakers strongly preferred non-local antecedents with *ta-ziji* in Experiment 2a. This novel finding seems inconsistent with Lu (2011), who found that local readings were strongly preferred with *ta-ziji* when context-dependent verb bias information (e.g. 'delivering' biasing non-local 'mailman') conflicts with the locality constraint. This difference may stem from the different aspects of the verb information being tested. Consequently, the impact of verb semantics in our study is stronger than the context-dependent verb effects in Lu (2011).

Another key finding is that topic prominence impacts the offline and online resolution of *ta-ziji*, similar to what we see with *ziji*. Construed superficially, this means that the Prominence Constraint (Pan, 1998; Pan & Hu, 2002) should include topic prominence, in addition to grammatical prominence and animacy prominence. But perhaps more importantly, the fact that local and non-local readings in biased contexts are equally probable in Experiment 2b suggests

that LD binding of *ta-ziji* (an "exempt" reading) was considered by participants even if the local antecedent is a viable animate binder. This finding may seem surprising, especially given the linguistic behavior of exempt anaphors in languages like English, where local binding is preferred when an animate referent is available in the local domain (see picture NP reflexives in Cunnings & Sturt, 2014).

Traditionally, it has been suggested that in English, syntactic reflexives subject to Principle A and exempt reflexives licensed extra-syntactically are in complementary distribution (Pollard & Sag, 1992; Reinhart & Reuland, 1991; 1993). Under this view, the exempt LD reading of *himself* in *John said that the newspaper published a picture of himself* is allowed because the reflexive does not have an animate clausemate antecedent. But if *himself* has a viable clausemate antecedent, some claim that it must be locally bound. This is summarized by Reuland's (2001; 2011) Rule L: when a viable local antecedent exists, an exempt reading is impossible, as this kind of extra-syntactic reading is computationally more costly.

However, given our finding that LD binding of *ta-ziji* in biased contexts is possible and that LD binding does not lead to extra processing effort relative to local binding, a categorical Rule L seems too strong. Indeed, even prior work on English reflexives (Kaiser et al., 2009; Runner et al., 2006) and on the Korean complex reflexive *caki-casin* (Kim & Yoon, 2020) indicates that exempt readings are possible when the local antecedent is animate. In fact, in an unpublished study (Lyu & Kaiser, 2023), we found that logophoric properties of non-local antecedents – source vs. perceiver status (see e.g. Culy, 1994; Kaiser, 2022; Kaiser et al., 2009; Sloggett, 2017) – impact the online and offline interpretation of *ta-ziji*, further indicating that exempt reflexives (e.g. *ta-ziji*) are not necessarily in complementary distribution with syntactic reflexives.

As a whole, our findings suggest that, to capture the behavior of *ta-ziji*, we may want to extend Pan and Hu's (2002) claims about prominence, so that semantic, syntactic, and discourse-pragmatic prominence can all impact LD binding of *ta-ziji*. However, instead of a monolithic prominence constraint outranking locality, we hypothesize that different types of prominence should be considered separately, and suggest that with *ta-ziji*, discourse topic prominence competes with, but does not outrank, syntactic locality.

6.3 Towards a unification of modular and constraint-based approaches

Now we turn to some of the broader implications from a psycholinguistic perspective. We interpret the self-paced reading results as supporting the Multiple Constraints Hypothesis.[6] However, other studies present evidence that sometimes syntactic cues are accessed first, before non-structural

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[6] An anonymous reviewer asks how this work contributes to our understanding of the cue-based memory retrieval in reference resolution. Although detailed discussion is beyond the scope of this paper, we would like to briefly mention that the early accessibility of discourse-level information – when conceptualized as retrieval cues – aligns with the predictions of the cue-based retrieval model (e.g., Jäger et al., 2015; Lewis & Vasishth, 2005).

cues (e.g. animacy, gender), supporting a modular account (e.g. Chang et al., 2020; Cunnings & Sturt, 2014; Nicol & Swinney, 1989; Sturt, 2003). In this section, we explore whether these results can be reconciled.

Support for the Syntactic Filter Hypothesis largely comes from work on the Binding Theory and c-command (e.g. Felser & Cunnings, 2012; Kazanina et al., 2007; Kush et al., 2015; Sturt, 2003). Conceivably, these constraints are "hard," as opposed to "soft" constraints (see e.g. Kush et al., 2017; Felser & Drummer, 2017). This distinction is extensively used in natural language processing (e.g. Eisner & Smith, 2010) and has also been used to characterize human sentence processing (e.g. Cunnings et al., 2014; Dillon et al., 2013). While there is no clear consensus on whether "hard" constraints are inviolable or merely very highly-ranked/heavily-weighted, the basic intuition is that there are (at least) two kinds of constraints: hard constraints, whose violation incurs steep penalties and which may even be inviolable, and soft constraints, which have lower weights but whose violation still incurs a penalty (see e.g. Cunnings et al., 2014; Dillon et al., 2013; Parker & Phillips, 2017, for discussion).

The distinction between hard and soft constraints is supported by prior work. For example, Kush et al. (2017) showed that in a strong crossover configuration (9a) which involves a potential violation of Principle C (a hard constraint), structurally inaccessible distractors (here, 'maintenance man') have no effect on pronoun resolution (as predicted by the Syntactic Filter Hypothesis). This fits with Principle C being a hard constraint, strong enough to block the distractor. Now consider a weak crossover configuration (ex.9b). Here, Principle C is irrelevant and only the weak crossover constraint, hypothesized to be a soft constraint, is at play. Now, the distractor *does* interfere with pronoun processing, contrary to the Syntactic Filter Hypothesis. In sum, this difference is captured if Principle C is a *hard* constraint, and the weak crossover constraint is a *soft* one. This suggests that the Syntactic Filter Hypothesis can predict the behavior of hard constraints but *not* soft constraints.

(9)   a.   Jane asked which maintenance man/lunch lady$_i$ it appeared that **he** already spoke with t$_i$ regarding the food fight in the cafeteria.
        b.   Jane asked which maintenance man/lunch lady$_i$ it appeared that **his** boss already spoke with t$_i$ regarding the food fight in the cafeteria.

We suggest that the locality, semantic and topic prominence constraints that we tested are *soft* constraints (though probably with somewhat different weights), and thus do not pattern as predicted by the Syntactic Filter Hypothesis and instead fit better with the Multiple Constraints Hypothesis. Our findings thus open the door for future investigations that more systematically compare the interaction of constraints with varying weights.

Another question we leave for future work is how the hard vs. soft distinction should be modeled in accounts of language processing. There are (at least) two ways. One is using a rank-based system like the classical OT (Kager, 1999; Prince & Smolensky, 1993) or stochastic OT (Boersma, 1997; Boersma & Hayes, 2001). On this view, hard constraints (e.g. hard structural constraints) would be ranked above other constraints (e.g. non-structural constraints) à la Stevenson and Smolensky (2006). Alternatively, we could adopt a weight-sensitive system similar to Harmonic Grammar (e.g. Pater, 2009; Potts et al., 2010), the spirit of which is found in the work of Parker and Phillips (2017). Here, hard constraints would be assigned more weight than soft constraints, assuming that language comprehenders do not lose attention, use shallow parsing strategies (Barton & Sanford, 1993; Ferreira et al., 2002), or confuse structural and semantic cues (Jäger et al., 2015).

However, unifying multiple-constraint approaches and modular approaches is not without challenges. Even if we distinguish hard vs. soft structural constraints, there is still no consensus whether hard constraints (e.g. Principles A and C) are prioritized in early-stage processing (see e.g. Dillon, 2014; Drummer & Felser, 2018; Jäger et al., 2020; Kaiser et al., 2009; Patil et al., 2016; Runner et al., 2006). These divergent findings may stem from methodological differences or from statistical power (see e.g. Jäger et al., 2020; Patil et al., 2016 for discussion). Therefore, although unifying the modular account and the multiple constraints account is conceivable, we first need a better understanding of the nature of these constraints and more empirical evidence. We regard this as a valuable direction for future work.

7. Conclusion

Experiments 1a and 1b provide evidence that native Chinese speakers show immediate sensitivity to both syntactic and non-syntactic cues in the processing of the monomorphemic reflexive *ziji*. In Experiments 2a and 2b on the bi-morphemic reflexive *ta-ziji*, we found that participants similarly used syntactic and non-syntactic cues effectively. Thus, broadly speaking, our results support the Multiple Constraints Hypothesis over the Syntactic Filter Hypothesis. However, the processing patterns of *ziji* and *ta-ziji* differ, pointing to form-specific differences. We suggest that the reading time patterns observed for *ziji* are related to the Topic Empathy Hierarchy and its property of perspective-sensitivity, while the patterns found for *ta-ziji* are due to a general topicality effect unrelated to perspective-taking.

Abbreviations

ASP – aspect marker; CL – classifier; DE – a marker in noun phrases denoting a modification relation

Data accessibility

The data, analyses, and the supplementary material are available at https://www.doi.org/10.17605/OSF.IO/CZ32N.

Ethics and consent

These internet-based studies involving human subjects were reviewed and approved by the Institutional Review Board at the University of Southern California. Due to the nature of the experiments, the Institutional Review Board determined that written consent was not needed.

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Competing interests

The authors have no competing interests to declare.

Author contributions

JL: conceptualization, methodology, formal analysis, visualization, investigation, data curation, validation, writing – original draft, writing – review and editing. EK: conceptualization, supervision, formal analysis, writing – original draft, writing – review and editing

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