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The interpretational preferences of null and overt pronouns in Chinese[1]

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We report three reading comprehension experiments investigating the interpretational preferences and processing of *pro* and overt pronouns in Chinese, a 'discourse-oriented' *pro*-drop language (Huang 1984). Our offline rating experiments showed that both *pro* and overt pronouns were subject-based, but the preference for the subject antecedents was stronger with *pro* than with overt pronouns. In addition, these different levels of subject biases were confirmed in a self-paced reading experiment; a processing penalty was incurred with object antecedent interpretation regardless of the pronominal type, but the penalty was bigger for *pro* than for overt pronouns. These experimental results are consistent with Accessibility theory that less specific anaphoric expressions (e.g. *pro*) were less likely than more specific anaphoric expressions (e.g. overt pronouns) to refer to a less prominent antecedent (e.g. syntactic object).

KEYWORDS: anaphoric biases, Chinese, overt pronouns, *pro*, referential resolution

1. Introduction

Languages differ in their inventories of pronominal elements. While English only has overt pronouns (see Haegeman & Ihsane 2001), languages such as Spanish, Italian, and Chinese have both null and overt pronouns. Given that the anaphoric resolution is based on the interplay of various sources of structural, semantic, and pragmatic information, the availability of two pronominal forms in one language motivates an investigation of the differences in the usages and interpretations of these forms. Thus, in this paper, we examine and compare interpretational biases and processing patterns of null and overt pronouns in Chinese. In particular, we focus here on intra-sentential anaphoric resolution.

Investigation of different forms of anaphoric expression is not a recent topic in theoretical linguistics. For example, Chomsky (1981) claimed that zero anaphora

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(e.g. *pro*, PRO, or zero topic) is preferred over overt pronouns where possible (i.e. Avoid Pronoun Principle). This is consistent with (1), which illustrates that in neutral contexts, PRO is allowed to refer to John while an unstressed overt pronoun (*his*) is not.

(1) John$_i$ would much prefer [PRO$_i$/*his$_i$ going to the movie].

On the other hand, Ariel (1990, 1994) emphasized the role of extra-grammatical factors and took a pragmatic approach to anaphoric expressions, arguing that cognitive motivations underlie their uses and interpretations. According to this proposal, referential forms are ranked in the 'accessibility marking scale' shown in (2) below such that a particular referential form is directly correlated with the degree of mental accessibility of its referent (Accessibility theory; see also Givón 1983, Gundel, Hedberg & Zacharski 1993). Note that the high accessibility marker, zero, in this hierarchy includes various types of linguistic elements without phonetic realization such as *pro* and *wh*-trace.

(2) *Accessibility Marking Scale*
zero < verbal person inflections < cliticized pronouns < unstressed pronouns < stressed pronouns < stressed pronouns + gesture < proximal demonstrative (−NP) < distal demonstrative (−NP) < proximal demonstrative + NP < distal demonstrative + NP < proximal demonstrative + modifier < distal demonstrative + modifier < first name < last name < short definite description < long definite description < full name < full name + modifier
(Ariel 2001: 31)

Various factors have been argued to play a role in determining the mental accessibility of an antecedent. Putting details aside, one factor of particular relevance for the current paper is the concept of 'topichood'. According to Ariel (1990), if a topic in a given discourse has high mental accessibility, it is more likely to be referred to with a high accessibility marker. The proposal is consistent with the observations that in English sentences, the most accessible antecedents such as discourse or sentential topics are more likely to be referred to with an unstressed overt pronoun rather than with a full name, which is typically dispreferred for such cases, as shown in (3).

(3) Geraldine Ferraro has been an active Democrat for quite a few years.
But she/??Geraldine Ferraro ran for Vice-Presidency only in 1984.
(Ariel 1988: 69)

On the other hand, the degree of mental accessibility of a referent could also correlate with its structural position, with the subject position having higher mental accessibility than the non-subject position (see PROMINENCE in Centering Theory: Grosz, Joshi & Weinstein 1983, 1995; Walker, Joshi & Prince 1998). Under this account, it is predicted that an antecedent in the subject position is more likely to be referred to with a high accessibility marker than a low accessibility marker. Thus, the proposal is also consistent with the results of psycholinguistic investigations of

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anaphoric expressions. For example, examining reading times of sentences involving a pronoun and a full NP anaphor, Garrod & Sanford (1982) showed sentences with a pronoun were read faster than those with a full NP when an antecedent occurred in the subject position as in (4).

(4) *Antecedent in the subject position*
The engineer repaired the television set.
It had been out of order for two weeks.
Target sentence: He/the engineer took only five minutes to repair it.

Conversely, they found that when an antecedent occurred in the object position a few sentences away from its anaphoric expression as in (5), sentences with a full NP were read faster than those with a pronoun.

(5) *Antecedent in the object position*
The mother picked up the baby.
She had been ironing all afternoon.
Target sentence: The baby/it had been crying nearly all day.

Garrod & Sanford (1982) took these results to suggest that the subject position is associated with focused representation in our memory, which is more easily accessed with an anaphoric pronoun than with a full NP.

Similarly, in languages with *pro*, Accessibility theory makes a prediction that *pro*, the highest accessibility marker, is likely to refer to the most salient antecedent (e.g. the subject of a sentence), while an overt pronoun, being a lower accessibility marker than *pro*, is likely to refer to a relatively less salient antecedent (e.g. a non-subject NP such as an object). These predictions are compatible with the studies of Indo-European *pro*-drop languages, which are more closely related to the current study. In Italian, for example, Carminati (2002) showed different interpretational biases of different forms of anaphoric expressions. In this study, native Italian-speaking participants were asked to read Italian ambiguous sentences involving *pro* and overt pronouns as in (6) and to choose the preferred interpretations of the two potential ones, such as those in (6a) and (6b) (the underlined parts in the examples in this paper indicate the potential referents of the pronoun).

(6) Marta scriveva frequentemente a Piera quando Ø/lei era negli Stati Uniti.
'Marta wrote frequently to Piera when Ø/she was in the United States.'
(Carminati 2002: 45)

(a) Quanto Marta era negli Stati Uniti.
'When Marta was in the United States.'
(b) Quando Piera era negli Stati Uniti.
'When Piera was in the United States.'

The results showed that participants chose the interpretation (a) 81% of the time for the null pronoun condition, while they chose the interpretation (b) 83% of the time for the overt pronoun condition. In addition, these different interpretational biases were

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further supported in online experiments. Reading times were shorter when *pro* referred to the subject than when it referred to the object. On the other hand, reversed reading time patterns were found for the overt pronouns, with shorter reading times obtained for the overt pronouns referring to the object NP than those referring to the subject NP. These results suggest that different referential forms are associated with a different level of mental accessibility, which in turn correlates with a particular structural position (Grosz et al. 1983, 1995; Ariel 1994; Walker et al. 1998). Based on the results, Carminati (2002) proposed the Position of Antecedent Strategy (PAS):

(7) *Position of Antecedent Strategy*
The null pronoun prefers an antecedent which is in the Spec IP position, while the overt pronoun prefers an antecedent which is not in the Spec IP position.
(Carminati 2002: 33)

The Position of Antecedent Strategy basically argues that there is a division of labor between *pro* and overt pronouns, with *pro* more likely to refer to subject NPs and overt pronouns more likely to refer to non-subject NPs. Similar experimental results were further obtained in other *pro*-drop languages such as Spanish (Alonso-Ovalle et al. 2002, Filiaci, Sorace & Carreiras 2014), Catalan (Mayol & Clark 2010) and Greek (Papadopoulou et al. 2015).

On the other hand, studies of Korean, Japanese, and Chinese showed slightly different results. For example, in Korean, Kwon & Polinsky (2011) found a subject bias for both *pro* and overt pronouns (see also Kim, Theres & Schafer 2013; for Japanese, see Ueno & Kehler 2016). Likewise, Yang et al. (1999) found similar interpretational biases for *pro* and overt pronouns in Chinese in a series of self-paced reading time experiments (see also Li 2014, Li, Mak & Sanders 2016, Simpson, Wu & Li 2016). Of particular interest are Yang et al.'s Experiments 2–4, where the authors manipulated discourse contexts in addition to the anaphor type, as shown in (8) (the gloss DE indicates modifying marker occurring at the end of a prenominal modifier).

(8) *Sample target sentences in Yang et al. 1999*
(p. 732 Experiment 3 and 4)
Lead-in sentence

大兴	告诉	小荣	花园	里	应	种	蔬菜
Daxing	tell	Xiaorong	garden	in	should	plant	vegetable
而不	种	花。					
not	plant	flowers.					

'Daxing (male name) told Xiaorong (female name) that vegetables, instead of flowers, should be planted in the garden.'

(a) **Critical sentence of the Continue condition**

大兴/他/Ø	认为	蔬菜	比	花	还要
Daxing/ he/Ø	think	vegetable	compare	flower	should
实用。					
useful					

'Daxing/He/(He) thought vegetables are more useful than flowers.'

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(b) **Critical sentence of the Shift condition**

小荣/她/Ø 却 认为 蔬菜 和 花
Xiaorong/she/Ø however think vegetable and flowers
都 要 种。
all should plant
'Xiaorong/She/(She) thought, however, that both vegetables and flowers should be planted.'

Final sentence

花园 的 使用 及 规口 是 很 大 的 学问。
garden DE utility and rule be very big DE knowledge
'The usage and planning of a garden are both worth studying.'

In these experiments, the discourse topic was manipulated to either continue, (8a), or to be shifted, (8b), in a target sentence such that successful interpretation of the sentences would require the anaphoric expressions to refer to the subject (e.g. Daxing) in (8a) or the object (e.g. Xiaorong) in (8b) of the preceding sentence.

Yang et al. (1999) compared the processing of repeated full NPs and overt pronouns in Experiment 2 and overt pronouns and *pro* in Experiments 3 and 4 based on this discourse manipulation. Predictions relevant to the current study are that if an anaphoric expression has an object bias, then the Shift condition (b) should elicit faster reading times than the Continue condition (a). On the other hand, if an anaphoric expression is more likely to refer to the subject, then the Continue condition (a) is predicted to incur faster reading times than the Shift condition (b). That is, if there is a clear division of labor between *pro* and overt pronouns in Chinese as in Italian, the reading times should differ for *pro* and overt pronoun sentences with different discourse contexts. However, the results of these experiments showed that the Continue condition elicited shorter reaction times than the Shift condition regardless of the pronominal type (*pro*: Experiments 3 and 4; overt pronoun: Experiment 2). This suggests that both *pro* and overt pronoun sentences were subject-biased. However, although this was not explicitly discussed by the authors, the results also showed that *pro* sentences in the Shift condition, where *pro* preferentially referred to the NP in the object position (Experiment 4, Figure 3 in Yang et al. 1999), elicited longer reading times than overt pronouns sentences. This suggests that while both *pro* and overt pronouns were subject-biased, *pro* was less likely than overt pronouns to refer to object NPs despite the authors' argument that the two types of anaphoric expressions contribute equally to discourse coherence (see also Yang et al. 2001).

However, the experimental results in Yang et al. are based on whole-sentence reading times in inter-sentential contexts. Therefore, various factors could have obscured potential differences at the critical region. Thus, in this study, we aim to better understand the interpretational biases of *pro* and overt pronouns in Chinese by systematically controlling pragmatic and structural factors and by examining the reading times at a critical target region. To this aim, we examined the

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interpretational biases of these anaphoric expressions in pragmatically neutral contexts in Experiment 1 and in pragmatically-biased contexts in Experiment 2. Finally, in Experiment 3, we used a self-paced reading time method to investigate how interpretational biases of *pro* and overt pronouns constrained their processing during online sentence processing.

2. Experiment 1

Experiment 1 was designed to investigate the interpretational biases of *pro* and overt pronouns in contextually neutral sentences. As illustrated in (9), the experimental sentences were created to be globally ambiguous such that the subject (e.g. Li Gang$_m$) and the object (e.g. Wang Qiang$_m$) could both potentially be an antecedent for the pronoun (e.g. *pro* or an overt pronoun). (The subscript $_m$ indicates 'male' name bias; in later examples, the subscript $_f$ is used to indicate 'female' name bias.)

(9) *A sample sentence of Experiment 1*

(a) ***Pro* condition**

李刚	给	王强	打电话	的	时候,	Ø	还
Li Gang$_m$	give	Wang Qiang$_m$	call	DE	when		still

在 办公室。
in office.
'When Li Gang$_m$ called Wang Qiang$_m$, he was in the office.'

(b) **Overt pronoun condition**

李刚	给	王强	打电话	的	时候,	他	还
Li Gang$_m$	give	Wang Qiang$_m$	call	DE	when	he	still

在 办公室。
in office.
'When Li Gang$_m$ called Wang Qiang$_m$, he was in the office.'

That is, in (9) the event 'Li Gang$_m$ being in an office' is just as plausible as the event 'Wang Qiang$_m$ being in the office'.

Given the results of previous studies of languages with *pro*, it was predicted that *pro* was likely to refer to the NP in the subject position. This is consistent with Accessibility theory (Ariel 1990), in that as the highest accessibility marker, *pro* refers to a discourse antecedent with high mental accessibility. On the other hand, the prediction for the overt pronoun was less clear. Studies of Italian and Spanish, for example, showed division of labor between *pro* and overt pronouns with a clear object bias for the overt pronoun and a subject bias for *pro* (Alonso-Ovalle et al. 2002, Carminati 2002, Filiaci et al. 2014). This is also consistent with Accessibility theory because as a lower accessibility marker, an overt pronoun was predicted to refer to an antecedent with lower mental accessibility, such as an NP in the object position in our experiment. However, previous studies of Chinese (as well as of those of Korean and Japanese) suggest a subject bias both for *pro* and overt

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pronouns, even though Yang et al. (1999, 2001), in fact, claimed that there was no need to distinguish *pro* and overt pronouns in Chinese in the way that they contributed to discourse coherence. Thus, given these previous studies, we predicted that overt pronouns would also show subject bias similarly to *pro*. However, given the results of Experiment 4 of Yang et al. (1999) and the predictions of Accessibility theory, which had been supported by studies of Italian and Spanish, we also predicted that the degree of the subject bias would be stronger for *pro* than for overt pronouns.

2.1 *Method*

2.1.1 *Participants*

Twenty native speakers of Mandarin participated in Experiment 1 (six males; average age: 19 years). At the time of the study, they were enrolled at a university in China. The participants were born and raised in China and had never lived abroad. No one reported a native-like proficiency in a language other than Chinese.

2.1.2 *Materials*

Thirty-two sets of complex sentences consisting of a main clause, preceded by a subordinate clause similar to those in (9) were constructed. Pronominal elements (*pro* or overt pronouns) occurred in the main clause. The subordinate clause contained two same-gender referents appearing respectively in the subject and object positions. These same-gender referents were equally distributed between males and females using typical Chinese proper names such as Li Gang_m and Ding Lan_f. To make sure that all the names we used were clear in their associated gender, we first ran a norming study. Ten college students (five males; average age: 19 years) who did not take part in other experiments rated 90 Chinese names for their implied gender on a scale from 1 (clearly male) to 5 (clearly female). Based on the results, we identified 84 names (42 male names) that received average ratings of lower than 2 (likely to be male) or higher than 4 (likely to be female) and used only those names in the following experiments (see Appendix). Two lists were created based on the Latin Square design such that a participant would see only one condition from each pair. The 32 experimental items were combined with an additional 60 fillers. Fillers consisted of two clauses containing one or two referents involving *pro*, overt pronouns, or reflexives, as shown in (10) (the gloss LE indicates currently relevant state of the example).

(10) *A sample filler sentence*

李梅	下班	的	时候,	Ø	找	不到	自行车	了。
Li Mei_f	off work	DE	when		find	not	bike	LE

'When Li Mei_f was off work, she couldn't find her bike.'

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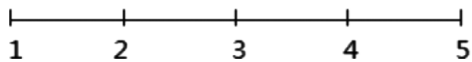
Thus, each list contained 92 sentences that were pseudo-randomized such that experimental items from the same condition would not appear in the same row. Every sentence in a list was followed by two choices, where the pronominal element in a sentence was interpreted as referring to the NP in the subject or object position, as shown in (11) below.

(11) Which is the preferred explanations of the sentence you have just read?
A. 李刚在办公室。
'Li Gang$_m$ was in the office.'
B. 王强在办公室。
'Wang Qiang$_m$ was in the office.'

The order of the choices was counterbalanced such that the subject antecedent appeared as option A for half of the items and as option B for the remaining half.

In addition, participants were required to rate how confident they were of their choices on a Likert scale from 1 (very unsure) to 5 (absolutely certain), as shown in (12).

(12) How confident were you of your choices?



very unsure absolutely certain

Since anaphoric resolution in our experiment is an issue of preference but not of grammaticality, confidence rating is an important indicator of the participants' gradient difference when they make a forced choice between two readings (see Christianson et al. 2001, Carminati 2002).

2.1.3 *Procedure*

The experiment was carried out in a group in a classroom. Participants were given questionnaires along with written instructions with examples. There was no time limit.

2.1.4 *Data analysis*

Two experimental items were removed from analyses, as they contained transfer-of-possession verbs whose tense could bias the interpretation of ambiguous pronouns (see Rohde 2008). For the remaining 30 sets of experimental stimuli, we first analyzed choice responses using a generalized Linear Mixed Effect (LME) model with a binomial distribution (Baayen, Davidson & Bates 2008). The models included the experimental condition (Pronoun type: *pro* vs. overt) as a fixed effect and crossed random effects for participants and items. They were built to have maximum random effects and were only simplified in cases of non-convergence (Barr et al. 2013). Random slope parameters included in the model are reported in

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the 'slope' column of Table 2 below, along with coefficients, standard errors and *z*-values for the fixed effects. We calculated *p*-values with Monte Carlo Markov Chaining (pvals.fnc function, Bates & Maechler 2010). In addition, confidence ratings were analyzed based on Linear Mixed Effect Regression (LMER) (Baayen 2008, Baayen et al. 2008, Jaeger 2008), using the *lme4* R package (Bates et al. 2015; version 1.1-8). The experimental conditions (Pronoun type: *pro* vs. overt pronouns) and Choice response (subject vs. object), in addition to their interactions, were included as fixed effects. For random effects, intercepts for subject and item as well as by-subject and by-item random slope for both effects were included. The analysis yielded coefficients, standard errors, and *t*-values for each fixed effect and interaction. For the linear models, the coefficient was considered significant at $\alpha = 0.05$ if the absolute value of *t* exceeded 2 (Baayen 2008).

2.2 *Results and discussion*

Experimental results are summarized in Table 1 and Figure 1, and statistical analysis results are presented in Tables 2 and 3. The results showed that there were more subject choices (448 out of 600 total responses; 74.7%) than object choices (152 responses; 25.3%) regardless of the pronominal type. However, while both pronominal types showed subject bias, the Overt pronoun condition elicited a higher number of object responses (104 out of 300 total responses) than the *Pro* condition (48 out of 300 total responses). These observations were confirmed with a significant main effect of the Pronoun type ($p < 0.0001$), suggesting that the subject antecedent preference was stronger for *pro* (84% of the total responses) than for overt pronouns (65.3%).

Similarly, analyses of confidence ratings showed a significant main effect of the Pronoun type, suggesting that participants were more confident about their interpretations of *pro* (4.26 out of 5) than about those of overt pronouns (3.95) ($t = 3.424$). There was also a main effect of Choice, indicating that participants were more confident when they responded with the subject antecedent interpretation than the object antecedent interpretation ($t = 3.256$). Finally, even though there was no significant interaction between the Pronoun type and the Choice, we ran planned paired comparisons using the Tukey test (glht function of multcomp package: Hothorn, Bretz & Westfall 2008; version 1.4-1) in R (R Core Team 2018).

	Pro condition		Overt pronoun condition	
	Subject	Object	Subject	Object
Choice	252	48	196	104
Rating	4.42 (1.005)	4.10 (1.115)	4.14 (1.144)	3.75 (1.406)

Table 1
Antecedent choice responses and mean confidence ratings (standard deviation in parentheses) in Experiment 1.

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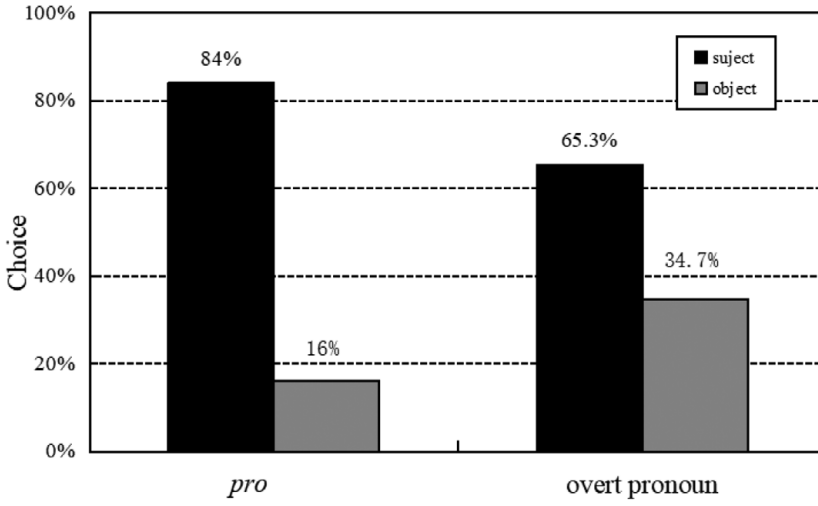

Figure 1
Percentage of antecedent choices.

	Estimate	SE	*z*	*p*	Slope
(Intercept)	1.8540	0.4178	4.437	9.12e-06	
Pronoun type	−0.8988	0.2090	−4.301	1.70e-05*	(p)

Table 2
Generalized linear mixed effects results for antecedent choices in Experiment 1. The asterisk indicates that the effect is significant at $p < .05$ (based on the $|t| > 2$ criterion).

	Estimate	SE	*t*	Slope
(Intercept)	4.107	0.182	23.017	
Pronoun type	0.139	0.054	3.424*	
Choice	0.155	0.052	3.256*	
Pronoun type × Choice	0.021	0.045	0.332	

Table 3
Linear mixed effect model results for confidence ratings in Experiment 1. The asterisk indicates that the effect is significant at $p < .05$ (based on the $|t| > 2$ criterion).

The results showed that with the subject antecedent interpretation, the *Pro* condition received significantly higher confidence ratings than the Overt pronoun condition ($p = .01$). In contrast, with the object antecedent interpretation, there was no difference between *Pro* and Overt pronoun conditions (n.s.).

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Overall, both *pro* and overt pronouns displayed a subject preference. This is consistent with previous studies of discourse-oriented languages such as Korean (Kwon & Polinsky 2011, Kim et al. 2013) and Japanese (Ueno & Kehler 2016) but not with the studies of Spanish (Alonso-Ovalle et al. 2002, Filiaci et al. 2014), Italian (Caminati 2002), Catalan (Mayol & Clark 2010) or Greek (Papadopoulou et al. 2015). In addition, these results are consistent with our observation of Yang et al.'s data (their Experiment 4) discussed in Section 1 above (see also Li 2014, Li et al. 2016). Figure 3 in Yang et al. suggests reading times were faster for the Overt pronoun condition than for the *Pro* condition when the pronoun referred to the object NP. Similarly, our results showed that the Overt pronoun condition was more likely to refer to the object NP than the *Pro* condition was even though both pronominal types were subject-biased. These results suggest that while both *pro* and overt pronouns were subject-biased in Chinese, *pro* had a stronger subject bias and/or a stronger dispreference to refer to a non-subject NP than overt pronouns did.

To summarize, the results of Experiment 1 showed that both *pro* and overt pronouns were subject-biased in semantically neutral contexts. However, this subject bias was stronger for *pro* than for overt pronouns. In Experiment 2, we investigated the interpretational preferences of *pro* and overt pronouns in semantically biasing contexts.

3. Experiment 2

Experiment 1 showed clear subject bias both for *pro* and overt pronouns in semantically neutral contexts. In Experiment 2, we examined the interpretational biases of *pro* and overt pronouns in semantically biasing contexts using a naturalness rating task. Thus, by comparing the results of Experiment 2 with those of Experiment 1, we aimed to examine the role of sentential contexts in referential resolution of *pro* and overt pronouns in Chinese.

As illustrated in (13), the sentences in Experiment 2 consisted of a main clause and a preceding subordinate clause (the gloss PFV indicates perfective aspect marker).

(13) *A sample sentence of Experiment 2*

(a) **Subject NP-biased *Pro* condition**

吴军	给	周斌	打电话	的	时候,	Ø
Wu Jun$_m$	give	Zhou Bin$_m$	call	DE	when	
拨	错	了	号码。			
dial	wrong	PFV	number			

'When Wu Jun$_m$ called Zhou Bin$_m$, he dialed a wrong number.'

(b) **Subject NP-biased Overt pronoun condition**

吴军	给	周斌	打电话	的	时候,	他
Wu Jun$_m$	give	Zhou Bin$_m$	call	DE	when	he
拨	错	了	号码。			
dial	wrong	PFV	number			

'When Wu Jun$_m$ called Zhou Bin$_m$, he dialed a wrong number.'

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(c) **Object NP-biased *Pro* condition**
吴军 给 周斌 打电话 的 时候, Ø
Wu Jun$_m$ give Zhou Bin$_m$ call DE when
很久 才 接。
long time answer
'When Wu Jun$_m$ called Zhou Bin$_m$, he answered the phone after a long time.'

(d) **Object NP-biased Overt pronoun condition**
吴军 给 周斌 打电话 的 时候, 他
Wu Jun$_m$ give Zhou Bin$_m$ call DE when he
很久 才 接。
long time answer
'When Wu Jun$_m$ called Zhou Bin$_m$, he answered the phone after a long time.'

The main clause contained either *pro* or an overt pronoun, and the subordinate clause contained two potential antecedents of the same gender. Crucially, the sentences were devised such that the antecedent of a pronominal element would be semantically signaled in a given sentence. For example, in (13a) and (13b), 吴军 'Wu Jun$_m$' is the person who makes a call and is also likely to be the person making a mistake in the process. Thus, *pro* in (13a) and 他 'he' in (13b) are likely to refer to the subject NP (i.e. 吴军 'Wu Jun$_m$'). On the other hand, in (13c) and (13d), as 周斌 'Zhou Bin$_m$' is the person who receives a phone call, he is likely to be the person who answers the phone with some delay. Thus, *pro* in (13c) and 他 'he' in (13d) are likely to refer to the object NP (i.e. 周斌 'Zhou Bin$_m$').

Given the results of Experiment 1, we predicted that the subject bias of *pro* and overt pronouns would interact with sentential contexts. Thus, sentences would sound more natural when the sentential contexts coincided with the interpretational biases of a pronominal than when the contexts conflicted with them. Given that both *pro* and overt pronouns were subject-biased, it was predicted that sentences with subject-biased contexts ((13a) and (13b)) would sound more natural than sentences with object-biased contexts ((13c) and (13d)). In addition, given that *pro* had a stronger subject bias than overt pronouns, for the subject-biased context conditions, sentences with *pro* would sound more natural than sentences with overt pronouns. On the other hand, for the object-biased contexts, we predicted the reverse to be true; sentences with overt pronouns would sound more natural than sentences with *pro*.

3.1 *Method*

3.1.1 *Participants*

Twenty undergraduates (eight males; average age: 19 years) enrolled in a university in China were paid to participate in Experiment 2. They were all native speakers of Mandarin Chinese and did not participate in any other experiment in this study.

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3.1.2 *Materials*

Thirty-two sets of target sentences similar to those in (13) above were created. As in Experiment 1, every sentence was followed by two questions. First, participants were asked to select their preferred interpretation for each sentence. For example, sentences (13a) and (13b) were followed by statement (14), while sentences (13c) and (13d) were followed by statement (15).

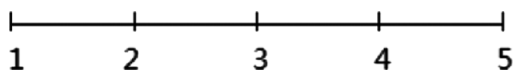
(14) *Interpretations given for sentences (13a) and (13b)*
A. 吴军拨错了号码。
'Wu Jun$_m$ dialed the wrong number.'
B. 周斌拨错了号码。
'Zhou Bin$_m$ dialed the wrong number.'

(15) *Interpretations given for sentences (13c) and (13d)*
A. 吴军很久才接。
'Wu Jun$_m$ answered after a long time.'
B. 周斌很久才接。
'Zhou Bin$_m$ answered after a long time.'

In order to prevent an order effect, we balanced the number of the subject (e.g. Wu Jun$_m$) and object NP (e.g. Zhou Bin$_m$) occurring as option A or B. Thus, for half of the sentences, the subject NP and object NP were presented as option A and B respectively; for the remaining half of the sentences, the order was reversed.

Participants were also asked to rate the naturalness of the sentences given their interpretation of choice using the Likert scale from 1 (very awkward) to 5 (absolutely natural), as shown in (16).

(16) Please rate the naturalness of the sentence.



very awkward absolutely natural

Four lists were created based on the Latin square design such that a participant would see only one condition from the same item in a given list. In addition, sixty filler sentences were added to the lists. Fillers consisted of two clauses containing one or two different-gender referents and involved *pro*, an overt pronoun or a reflexive, as shown in (17).

(17) *A sample filler sentence*
王艳 表扬 孙强 的 时候, 她 是 认真的。
Wang Yan$_f$ praise Sun Qiang$_m$ DE when she is serious
'When Wang Yan$_f$ praized Sun Qiang$_m$, she was serious.'

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These 92 sentences in each list were displayed in a pseudo-random order, preventing two experimental sentences from the same condition from appearing successively.

3.1.3 *Procedure*

The procedure of this experiment was the same as that in Experiment 1.

3.1.4 *Data analysis*

Interpretational preference was analyzed using a generalized Linear Mixed Effect (LME) model with a binomial distribution, and naturalness ratings were analyzed using a Linear Mixed Effect Regression (LMER) analysis (Baayen 2008, Baayen et al. 2008, Jaeger 2008). The models incorporated the pronoun type and contextual bias, as well as their interaction, as fixed factors and crossed random effects for participants and items. The remaining analysis procedures were the same as the ones reported in Experiment 1.

3.2 *Results and discussion*

The results of Experiment 2 are summarized in Table 4 and Figure 2 below, and the results of statistical analyses are presented in Tables 5 and 6 below. Overall, our predictions were partially confirmed.

For the analysis of preferred interpretations, we coded whether the intended interpretation was selected for a given context. The results showed the significant main effect of the Contextual bias ($p = 0.001$). Thus, although both *pro* and overt pronouns were interpreted to refer to the subject or object NP depending on semantic manipulation, participants accepted the intended referents more readily in the Subject-biased context condition than in the Object-biased context condition (subject: 315 vs. object: 299 out of 320 responses each) (Table 4 and Table 5). This means that there was a stronger bias for subject interpretation than for object interpretation. On the other hand, there was no significant main effect of the

	Subject-biased contexts		Object-biased contexts	
	Pro	Overt pronoun	*Pro*	Overt pronoun
Intended interpretation%	98.13 (157)	98.75 (158)	95 (152)	91.88 (147)
Naturalness ratings	4.49 (0.87)	4.48 (0.96)	3.66 (1.43)	4.12 (1.08)

Table 4
Selection rate of the intended interpretations (raw counts in parentheses) and naturalness rating of Experiment 2 (standard deviations in parentheses).

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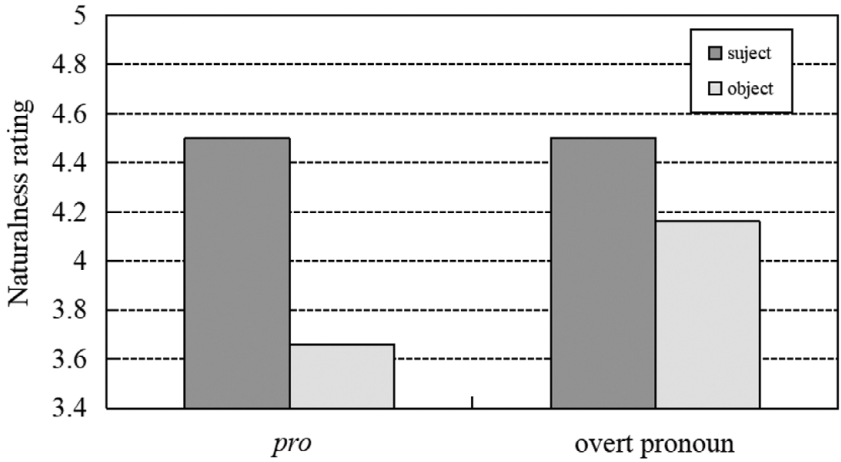

Figure 2
Naturalness ratings across all conditions.

	Estimate	SE	*z*	*p*	Slope
(Intercept)	0.741	0.268	2.763	0.006	
Pronoun type	−0.234	0.258	−0.905	0.365	
Contextual bias	3.473	0.289	11.998	0.001*	
Pronoun type × Contextual bias	0.027	0.258	0.106	0.915	

Table 5
Results of statistical analyses of preferred interpretation of Experiment 2. The asterisk indicates that the effect is significant at $p < .05$ (based on the $|t| > 2$ criterion).

	Estimate	SE	*t*	Slope
(Intercept)	4.186	0.119	35.13	
Pronoun type	−0.114	0.055	2.09*	
Contextual bias	0.298	0.071	4.19*	
Pronoun type × Contextual bias	0.117	0.051	2.30*	(p, i)

Table 6
Linear mixed effect model results for naturalness rating. The asterisk indicates that the effect is significant at $p < .05$ (based on the $|t| > 2$ criterion).

Pronoun type, suggesting that sentences were created equally acceptable for *Pro* and Overt pronoun conditions.

For the naturalness ratings, we initially predicted that the Subject-biased context condition would receive higher naturalness ratings than the Object-biased context

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condition, as *pro* and overt pronouns both showed subject bias in Experiment 1. This prediction was confirmed with a significant main effect of the Contextual bias (Table 6). Sentences were rated to be more natural when a pronominal element referred to the subject NP (4.49) than to the object NP (3.89) regardless of the pronominal type.

There was also a main effect of the Pronoun type, with higher naturalness ratings for the Overt pronoun condition (4.3) than for the *Pro* condition (4.08) (Figure 2). However, this was due to the naturalness rating results in the Object-biased context condition, as indicated by a significant interaction of the Contextual bias and the Pronoun type. We predicted that the *Pro* condition would receive higher naturalness ratings than the Overt pronoun condition for the Subject-biased context condition but that ratings would be reversed for the Object-biased context condition. However, as shown in Figure 2, our prediction was confirmed only for the Object-biased context condition, not for the Subject-biased context condition. Indeed, post-hoc pairwise comparisons showed the *Pro* condition received significantly lower naturalness ratings than the Overt pronoun condition only in the Object-biased context condition ($p = 0.044$). In the Subject-biased context condition, these two conditions did not differ (n.s.).

The results of Experiment 2 confirmed the subject bias of both *pro* and overt pronouns found in Experiment 1, which is also consistent with Yang et al. (1999, 2001), Li (2014), Li et al. (2016) and Simpson et al. (2016). However, contrary to the argument in Yang et al. that *pro* and overt pronouns did not differ in their processing mechanisms, the results of Experiment 2 showed different interpretational mechanisms for *pro* and overt pronouns in Chinese. These results are compatible with the results of Experiment 1, suggesting that *pro* had a stronger preference for the subject NP antecedent and/or a stronger dispreference for an object NP antecedent than overt pronouns did.

Given these results, Experiment 3 investigated whether interpretational biases of *pro* and overt pronouns constrained the processing of these pronominal elements during online sentence processing.

4. Experiment 3

Experiments 1 and 2 yielded consistent results that both *pro* and overt pronouns were subject-biased. However, the results also suggest that overt pronouns had weaker subject bias and were more likely to refer to object NPs than *pro* was. In Experiment 3, we examined online processing of Chinese *pro* and overt pronouns using a self-paced reading time method.

The experimental sentences involved either *pro* or an overt pronoun at the subject position of the main clause (R5) (R is short for Region, thus R followed by a number was used to indicate different regions in Experiment 3), and gender-biased Chinese names in the subject (R1) and the object (R3) position of the

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preceding subordinate clause, as seen in (18) (e.g. 孙兰 'Sun Lan$_f$' and 刘军 'Liu Jun$_m$').

(18) *A sample sentence of Experiment 3*

(a) **Subject NP-biased *Pro* condition**
孙兰$_{R1}$ / 离开$_{R2}$ / 刘军$_{R3}$ / 之后$_{R4}$, / Ø 不久$_{R6}$ /
Sun Lan$_f$ leave Liu Jun$_m$ after soon
就成 了$_{R7}$ / 一名$_{R8}$ / 芭蕾舞女$_{R9}$ / 而不是$_{R10}$ /
become-PFV a CL ballerina rather than
电影$_{R11}$ / 明星$_{R12}$。
film star
'After Sun Lan$_f$ left Liu Jun$_m$, she soon became a ballerina rather than a film star.'

(b) **Subject NP-biased Overt pronoun condition**
孙兰$_{R1}$ / 离开$_{R2}$ / 刘军$_{R3}$ / 之后$_{R4}$, / 她$_{R5}$ 不久$_{R6}$ /
Sun Lan$_f$ leave Liu Jun$_m$ after she soon
就成 了$_{R7}$ / 一名$_{R8}$ / 芭蕾舞女$_{R9}$ / 而不是$_{R10}$ /
become-PFV a CL ballerina rather than
电影$_{R11}$ / 明星$_{R12}$。
film star
'After Sun Lan$_f$ left Liu Jun$_m$, she soon became a ballerina rather than a film star.'

(c) **Object NP-biased *Pro* condition**
刘军$_{R1}$ / 离开$_{R2}$ / 孙兰$_{R3}$ / 之后$_{R4}$, / Ø 不久$_{R6}$ /
Liu Jun$_m$ leave Sun Lan$_f$ after soon
就成 了$_{R7}$ / 一 名$_{R8}$ / 芭蕾舞女$_{R9}$ / 而不是$_{R10}$ /
become-PFV a CL ballerina rather than
电影$_{R11}$ / 明星$_{R12}$。
film star
'After Liu Jun$_m$ left Sun Lan$_f$, she soon became a ballerina rather than a film star.'

(d) **Object NP-biased Overt pronoun condition**
刘军$_{R1}$ / 离开$_{R2}$ / 孙兰$_{R3}$ / 之后$_{R4}$, / 她$_{R5}$ / 不久$_{R6}$ /
Liu Jun$_m$ leave Sun Lan$_f$ after she soon
就成 了$_{R7}$ / 一 名$_{R8}$ / 芭蕾舞女$_{R9}$ / 而不是$_{R10}$ /
become-PFV a CL ballerina rather than
电影$_{R11}$/ 明星$_{R12}$。
film star
'After Liu Jun$_m$ left Sun Lan$_f$, she soon became a ballerina rather than a film star.'

Accordingly, the referent of the overt pronoun could be inferred at the main clause subject position (R5) based on the disambiguating gender information of the

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overt pronouns. The referent of *pro*, however, stayed ambiguous until R9, where such information became available based on gender stereotypes. For example, 芭蕾舞女 'ballerina' at R9 in (18) indicates that the pronoun in the subject position is likely to be a female, referring to the subject in (18a) and (18b) and the object in (18c) and (18d).

Thus, the critical regions of our interest were R5 for the Overt pronoun condition and R9, 芭蕾舞女 'ballerina', for all the conditions. We predicted that the reading times of these regions would be modulated as a function of the interpretational bias of *pro* and overt pronouns. Specifically, given that both *pro* and overt pronouns were subject-biased in Chinese, it was predicted that reading times of the overt pronoun at R5 and 芭蕾舞女 'ballerina' at R9 in (18a) and (18b) would be shorter than those in (18c) and (18d). In addition, given that the subject bias was stronger or the dispreference of an object antecedent was stronger for *pro* than for overt pronouns, the reading times of the *Pro* condition (18a) would be shorter than those of the Overt pronoun condition (18b) for the subject NP-biased conditions at R9. On the other hand, for the object NP-biased condition, the *Pro* condition (18c) would be read more slowly than the Overt pronoun condition (18d). Thus, it is predicted that there would be a main effect of the antecedent type and an interaction of the antecedent type and the pronoun type at R9.

4.1 *Method*

4.1.1 *Participants*

Thirty-six native speakers of Mandarin (eight males; average age = 19 years) attending a university in China were paid to participate in the experiment. They were born and raised in China and none of them participated in the other experiments in this study. No participants reported a native-like fluency in a language other than Chinese.

4.1.2 *Materials and design*

Thirty-six items similar to the sentences in (19) were constructed. As in Experiments 1 and 2, four lists were created based on the Latin Square design. In addition, 108 fillers of similar length and complexity were constructed and added to the lists. Fillers consisted of two clauses containing those Chinese names and nouns appearing at R9 that were not strongly gender-biased.

4.1.3 *Procedure*

Experiment 3 was run individually in a quiet room using Linger (Doug Rohde MIT). Participants silently read sentences for comprehension, which were presented phrase by phrase in a non-cumulative moving-window fashion. A yes/no comprehension question was presented after each sentence. Comprehension

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questions did not probe the resolution of the pronouns, as we did not want participants to develop strategic processing. For example, a sentence like those in (18) above was followed by question equivalent to (19).

(19) Did anybody become a film star?

There were six practice trials. The experiment lasted approximately 30 minutes.

4.1.4 *Data analysis*

The mean comprehension accuracy for the experimental items was 91.2%. The reading time analyses reported below included both correctly and incorrectly answered trials. Reading times that were three standard deviations beyond the mean were excluded from further analyses. Overall, 4.73% of data were removed before analysis. Reading time data were then analyzed with Linear Mixed Effect Regression models (Baayen 2008, Baayen et al. 2008, Jaeger 2008). The experimental conditions (Pronoun type: *pro* vs. overt pronoun) and Antecedent (subject vs. object), in addition to their interaction, were included as fixed effects. For random effects, intercepts for subject and item as well as by-subject and by-item random slope for both effects were included. The remaining analysis procedures were analogous with those reported in Experiment 1.

4.2 *Results and discussion*

There was no reliable main effect or interaction in any region in the first subordinate clause (R1 through R4). The reading results of the main clause (R5 through R12) are summarized in Table 7 and Figure 3, and the results of statistical analyses are presented in Table 8 and Table 9.

Our prediction at R5 was not confirmed. As discussed already, from R5 to R8, we only focused on the Overt pronoun condition, as disambiguating gender information was not yet available for the *Pro* condition. There were no reliable effects in any of these regions, however, as can be seen from Figure 3 and Table 8. Thus, reading times at R5 did not confirm the subject bias of overt pronouns found in Experiments 1 and 2.

On the other hand, the analyses of reading times at R9 confirmed our predictions. We predicted that the subject NP-biased condition would be read faster than the object NP-biased condition, as both *pro* and overt pronouns displayed a subject preference. This was confirmed with a main effect of Antecedent at R10 ($t = -3.09$), at R11 ($t = -2.49$) and R12 ($t = -2.03$). In all these regions, the reading times of the subject NP-biased condition were shorter than those of the object NP-biased condition regardless of the pronominal type. Also, as we predicted, there was a significant interaction of the Pronoun type and Antecedent at R9 ($t = -2.06$) and R10 ($t = -2.41$). Post-hoc pairwise comparisons at these positions showed that the reading times of the *Pro* condition were significantly longer than those of the Overt

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	R5	R6	R7	R8	R9	R10	R11	R12
	pro/overt	soon	become	a	ballerina	rather than	film	star
Pro-subject		516 (12)	466 (10)	470 (9)	523 (15)	472 (9)	459 (8)	693 (24)
Pro-object		543 (15)	491 (12)	457 (11)	615 (24)	543 (14)	498 (10)	748 (27)
Overt pronoun–subject	499 (12)	475 (11)	450 (10)	448 (10)	517 (14)	478 (9)	466 (8)	634 (17)
Overt pronoun–object	511 (15)	466 (10)	461 (11)	450 (10)	515 (15)	499 (12)	475 (9)	676 (21)

Table 7
Average reading times (standard deviations) for each region in the main clause, by condition.

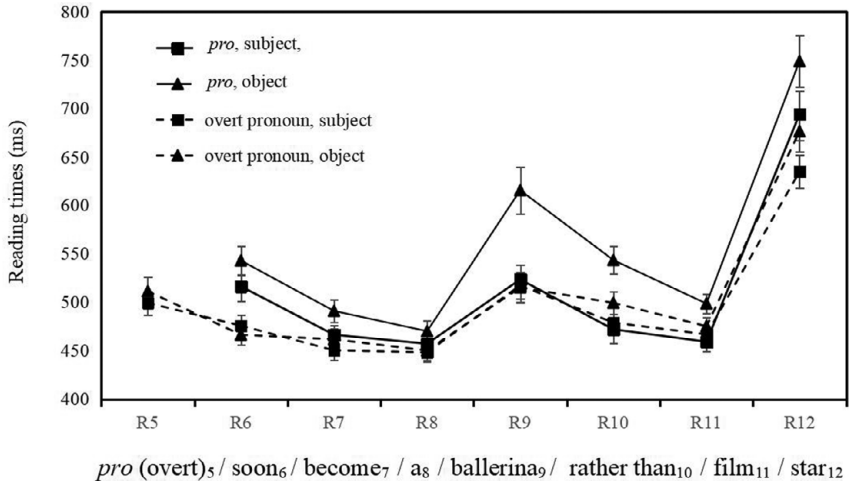

Figure 3
Mean reading times of the main clause across all conditions. The error bars represent standard error above/below the mean of the participant mean.

		Estimate	SE	*t*	Slope
R5					
	(Intercept)	6.146	0.044	141.16	
	Antecedent	−0.005	0.012	−0.45	(p, i)
R6					
	(Intercept)	6.140	0.043	142.62	
	Antecedent	−0.004	0.008	−0.43	(p, i)
R7					
	(Intercept)	6.079	0.044	138.25	
	Antecedent	−0.014	0.008	−1.70	(p, i)
R8					
	(Intercept)	6.060	0.043	141.42	
	Antecedent	−0.005	0.009	−0.60	(p, i)

Table 8
Linear Mixed Effects results for reading times from R5 to R8.

pronoun condition for the object NP-biased conditions ($p < .05$). For the subject-biased condition, however, the reading times of these two conditions did not differ (n.s.).

Although the effects were slightly delayed, which is common in self-paced reading time experiments (see Chow, Lewis & Phillips 2014), the overall results are compatible with our offline experiments. Both *pro* and overt pronouns were subject-biased, with *pro* displaying a stronger dispreference for the object antecedent than overt pronouns.

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		Estimate	SE	*t*	Slope
R9					
	(Intercept)	6.178	0.056	111.3	
	Pronoun type	0.027	0.014	1.90	
	Antecedent	−0.021	0.013	−1.66	
	Pronoun type × Antecedent	−0.024	0.012	−2.06*	(p, i)
R10					
	(Intercept)	6.144	0.044	139.88	
	Pronoun type	0.014	0.008	1.60	
	Antecedent	−0.032	0.010	−3.09*	
	Pronoun type × Antecedent	0.020	0.008	−2.41*	(p, i)
R11					
	(Intercept)	6.112	0.037	163.58	
	Pronoun type	0.005	0.007	0.65	
	Antecedent	−0.025	0.010	−2.49*	
	Pronoun type × Antecedent	0.016	0.009	−1.85	(p, i)
R12					
	(Intercept)	6.413	0.050	127.01	
	Pronoun type	0.029	0.012	2.39*	
	Antecedent	−0.029	0.015	−2.03*	
	Pronoun type × Antecedent	−0.009	0.013	−0.68	(p, i)

Note: Coefficients, standard errors, and *t*-values are reported for the main effect of Pronoun type and Antecedent, as well as for the interaction of these two factors.

Table 9

Linear Mixed Effects results for reading times from R9 to R12. The asterisk indicates that the effect is significant at $p < .05$ (based on the $|t| > 2$ criterion).

5. General discussion and conclusion

In this study, we examined the interpretational biases of *pro* and overt pronouns in Chinese during offline and online sentence processing. Overall, the experimental results suggest that both *pro* and overt pronouns were subject-biased. In semantically neutral contexts, both *pro* and overt pronouns were judged as more likely to refer to subject NPs than object NPs, although this tendency was stronger for *pro* (Experiment 1). The subject bias of *pro* and overt pronouns was also confirmed in semantically biased contexts (Experiment 2). Despite context manipulation, there was a stronger preference for the subject antecedent interpretation than for the object antecedent interpretation regardless of the pronominal type. In addition, naturalness ratings were higher with the subject interpretation than with the object interpretation regardless of the pronominal type. The results of Experiment 2 also showed that naturalness ratings were lower for sentences with *pro* than for those with overt pronouns when the referential expressions referred to the object NP, suggesting that dispreference of object antecedents was stronger for *pro* than for overt pronouns. Finally, the results of Experiment 3 confirmed that these interpretational biases constrained the processing of *pro* and overt pronouns during online sentence processing. Thus, sentences were easier to process with the subject

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antecedent interpretation than with the object antecedent interpretation regardless of the pronominal type. In addition, with the object antecedent interpretation, sentences were more difficult to process with *pro* than with overt pronouns. While these results showed certain similarity between *pro* and overt pronouns in Chinese, both online and offline results suggest that the mechanisms that underlie the interpretation of null and overt pronouns were not the same. The results thus provided strong evidence against the argument by Yang et al. (1999) that *pro* does not differ from overt pronouns in Chinese in the way that it contributes to discourse coherence.

Overall, our results converge with previous results of discourse-oriented *pro*-drop languages (Korean: Kim et al. 2013, Kwon & Polinsky, 2011, Japanese: Ueno & Kehler 2016, Chinese: Yang et al. 1999, 2001; Li 2014; Li et al. 2016; Simpson et al. 2016) in that both *pro* and overt pronouns were subject-biased. The results are also consistent with Accessibility theory (Ariel 1990, 2001), which argues for the form-function correlations on the accessibility marking scale such that referring expressions signal a specific degree of mental accessibility. According to the proposal, the highest accessible marker (e.g. *pro*) is more likely to be used to refer to the most salient entity (e.g. the subject) than a lower accessibility marker (e.g. overt pronoun) is. This was confirmed by a stronger subject preference of *pro* in our findings. Although overt pronouns in Chinese also showed a subject bias similarly to *pro*, they were still more likely to refer to an object antecedent than *pro* was.

Our results, however, diverge from those of other *pro*-drop languages with rich verbal inflection such as Spanish (Alonso-Ovalle et al. 2002, Filiaci et al. 2014), Italian (Carminati 2002), Catalan (Mayol & Clark 2010) and Greek (Papadopoulou et al. 2015), which showed a clear division of labor between *pro* and overt pronouns. A remaining question is how to account for these cross-linguistic differences in anaphoric resolution. One possibility is that different levels of accessibility are associated with pronominal elements in different languages (Ariel 1990). That is, the relative differences in degree of accessibility between referring forms along the accessibility marking scale may not be exactly the same across different languages. Therefore, even formally-equivalent referring expressions from different languages might refer to antecedents with different degrees of accessibility in each language (Ariel 1990, Filiaci et al. 2014). We argue that the relative difference between *pro* and overt pronouns in discourse-oriented languages is smaller than in Indo-European *pro*-drop languages. Thus, *pro* and overt pronouns share more similarity, both favorably referring to the subject antecedent.

Related to this is the argument that cross-linguistic differences in anaphoric resolution could be due to different levels of sensitivity to different sources of information in different languages (Kwon & Sturt 2013). That is, in a discourse-oriented language such as Chinese, Korean, or Japanese (Huang 1984), discourse cues could take priority over other cues such as morpho-syntactic information. Indeed, examining the processing of *pro* in Korean, Kwon & Sturt (2013) showed that *pro* interpretation was more sensitive to discourse manipulation such that when the referential ambiguity of *pro* was resolved through a discourse topic NP, the

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parser did not evaluate additional morpho-syntactic cues when they became available. This was different from English, where referential ambiguity resolution of overt pronouns was equally sensitive to discourse as to morpho-syntactic cues (Liversedge & Van Gompel n.d.). These results suggest that referential resolution is guided by different levels of sensitivity to different cues in a given language such that an interpretation of an anaphoric expression based on a cue of greater importance is preferred over one that is based on a cue of less importance. If so, the strong subject bias of *pro* and overt pronouns of Chinese found in this study (also in studies of Korean and Japanese) could be due to the prominence of topic as a cue in Chinese (Li & Thompson 1981), given that the subject position is likely to be associated with a discourse topic. In fact, this account of the results is also consistent with Accessibility theory, which argues that discourse salience as well as grammatical functions of antecedents affects their mental accessibility. That is, according to Accessibility theory, a (global or local) discourse topic is argued to maintain a higher degree of accessibility and thus is more likely to be referred to with a high accessibility marker (e.g. *pro*) than a nontopical NP is (Ariel 2001). Thus, the effect of discourse salience on mental accessibility should be further investigated. For example, it is an empirical question whether *pro* will show as strong a dispreference to refer to a topical object NP as it does to refer to a non-topical object NP. It is unlikely, given that Chinese is a discourse-oriented language. However, we leave this to a future study.

Various other factors may also contribute to different levels of anaphoric biases. Kaiser & Truswell (2008) argued that different forms of anaphoric expression could be subject to different kinds of cues after finding that Finnish pronouns and demonstratives showed different sensitivity to features of antecedents. Likewise, Ueno & Kehler (2016) reported that in Japanese, *pro* was primarily regulated by grammatical role whereas overt pronouns were more sensitive to verb aspect. In addition, different historical origins of pronouns in different languages might contribute to cross-linguistic variations of anaphoric resolution (Carminati 2002, Filiaci et al. 2014). For example, different historical origins of Spanish pronouns and Italian pronouns may lead to different levels of anaphoric biases. The frequency of referring expressions used in a specific language may also affect the anaphoric biases. In Chinese, overt pronouns are widely used, almost as frequently as *pro*. (e.g. Tai 1978, Chen 1986, Tomlin & Pu 1991, Tao 1996, Christensen 2000). Therefore, the overt pronoun might be the standard, unrestricted form and therefore used to refer to both subject and object, while *pro* is restricted to refer to the subject only. Likewise, our experimental results align with frequency results reported in previous studies. For example, using the Chinese version of the pear stories, Chen (1986: 129) showed that a preverbal subject/topic NP was more likely to be referred to by *pro* (50%) than by overt pronouns (30%) or full NPs (20%). Conversely, an object NP was more likely to be referred to by full NPs (45%) than by overt pronouns (35%) or *pro* (25%). Wang & Liang (2020) also reported similar results based on BCC Corpus (Beijing Language and Culture University Corpus Center, a corpus of 15 billion Chinese words). They showed that a subject NP was

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overwhelmingly referred to by *pro* (n = 231) rather than by overt pronouns (n = 29) or full NPs (n = 4), while a non-topic object was more likely to be referred to by full names (n = 34) than by overt pronouns (11) or *pro* (n = 0).

Several questions remain unanswered. First, while we mainly discussed the relation between referring expressions and antecedents in terms of mental accessibility, previous studies have shown relevance of other factors such as animacy, thematic roles, etc. (see Christianson & Cho 2009 for a related discussion of *pro* in Odawa in the context of Optimality Theory). This calls for systematic investigations of potential interactions among these different factors. Second, our study was restricted to intra-sentential reference and thus it is an empirical question whether the findings would extend to inter-sentential reference. According to the Accessibility theory (Ariel 1990, 2001), the relation between an antecedent and a referring expression is tighter within a unit (e.g. within a clause, sentence, paragraph) than across boundaries (e.g. across clauses, sentences, paragraphs), so the degree of accessibility of relevant mental representations is correspondingly higher in the former than the latter. Thus, we predict greater overall use of overt pronouns for inter-sentential reference, although the choice of *pro* vs. overt pronouns will still be affected by discourse salience as well as grammatical functions of antecedents. We leave this question to a future study.

In conclusion, both *pro* and overt pronouns in Chinese showed a strong subject bias during offline and online sentence processing. They were both more likely to refer to a subject NP than to an object NP. However, the bias was stronger for *pro*, which showed a stronger dispreference for object NP antecedents than overt pronouns did. Our data are compatible with Accessibility theory in that less informative anaphoric expressions were less likely to refer to less accessible antecedents than more informative anaphoric expressions were. We also argue that anaphoric resolution across languages may be sensitive to cues of different importance in a given language, such as discourse topic.

APPENDIX

Male names and female names

Male names are set in bold to distinguish them from female names. The numbers correspond roughly to the associated gender rating, with 1 = clearly a male name; 5 = clearly a female name.

Name	Rating	Name	Rating	Name	Rating
王大壮	1	**韩建国**	1.1	田 美	4.9
周宏伟	1	**李 雄**	1.1	林瑶瑶	4.9
高 强	1	**丁 魁**	1.1	姜 茜	4.9
何振东	1	**刘毅翔**	1.1	赵 嫣	4.9
冯智勇	1	**刘子浩**	1.2	赵凤娇	5

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许大兵	1	**张 亮**	1.2	陈爱萍	5
孙浩民	1	**孙 盛**	1.2	朱爱玲	5
崔栋梁	1	**黄海波**	1.3	刘雪莹	5
杨威武	1	**宋康博**	1.3	郭丽丽	5
李小龙	1	**高明灏**	1.3	于婷婷	5
孙浩宇	1	**肖擎宇**	1.3	袁姗姗	5
王子豪	1	**孙金祥**	1.4	邓伊妍	5
薛 奎	1	**石 海**	1.5	蔡红霞	5
郭卫健	1	**柴 昊**	1.7	贾小娥	5
陈国庆	1	林玉荷	4.6	贾丽娟	5
王 虎	1	王晓娅	4.7	杜婉茹	5
吕庆柱	1	张 婵	4.7	余娇娇	5
李 军	1.1	张丽珍	4.8	李薇薇	5
唐 刚	1.1	周小芸	4.8	陈美燕	5
沈华健	1.1	董俊妮	4.8	董小妹	5
潘兴军	1.1	付爱英	4.8	郭小菊	5
薛海江	1.1	谭玉芳	4.8	杨娅楠	5
乔 伟	1.1	崔玉环	4.8	秦文莲	5
张 斌	1.1	徐秀敏	4.9	沈梦露	5
陆海涛	1.1	林媛媛	4.9	李雪儿	5
赵小川	1.1	韩丽娜	4.9	丁 兰	5
苏泽凯	1.1	罗翠翠	4.9	魏倩倩	5
张 震	1.1	薛文静	4.9	孙巧儿	5

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