

THE EFFECTS OF VERB BIAS, CONTEXT AND TASKS
ON MANDARIN CHINESE REFLEXIVES

BY

HSIN-YI LU

DISSERTATION

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Doctoral Committee:

Associate Professor Susan M. Garnsey, Director of Research
Associate Professor Chilin Shih, Chair
Professor Jerome Packard
Professor Hye Suk James Yoon

ABSTRACT

The interpretation of Mandarin reflexives can be ambiguous, especially if there are multiple possible antecedents mentioned in the context prior to the reflexives. Misunderstanding between speakers and listeners can happen if listeners misinterpret the referent of the reflexives that speakers intended. For example, in English sentence “John knew that Peter likes himself”, the antecedent for ‘himself’ must be Peter. In the Mandarin equivalent, the antecedent of the reflexive could be either Peter or John. Thus, there is more ambiguity about the antecedents of reflexives in Mandarin than in English. Theoretical frameworks have been devoted to explain how multiple antecedents is allowed in Mandarin; however, it is not clear how people interpret Mandarin reflexives from a processing perspective. This study investigated the issue from such perspective, exploring people’s preferences for interpreting Mandarin reflexives. The study focused on how factors like verb subcategorization (i.e. verb biases, properties that a verb tends to take a direct object more than a sentential complement or vice versa) or context information influence such interpretation by using off-line and on-line reading times and event-related potential measurements. Time courses of when such decision was made were also investigated.

Two self-paced reading experiments used sentences containing two possible antecedents for Mandarin reflexives *ziji* and *taziji* to examine whether verb bias properties influence the antecedent selection. It is found that whether there was any antecedent preference depended on the structural bias of the verb preceding the reflexive. For bare reflexive *ziji*, the distant antecedent was preferred after a verb that usually takes direct objects, but after a verb that usually takes embedded clauses, no preference was observed. For complex reflexive *taziji* which is thought to co-refer more to the local antecedent, it is found that local antecedents were indeed preferred, but only for verbs that take embedded clauses. After verbs that usually take direct objects, the distant antecedent was still preferred. These results were interpreted to mean that readers expected sentences to end soon after DO-bias verbs so they chose the most prominent available antecedent, which was the distant main clause subject. In contrast, after Clause-bias verbs they expected a longer sentence so they waited for further disambiguating information, causing prominence to have less impact. Consistent with this interpretation, in another self-paced reading study with a context sentence preceding the same target sentences, there was again an antecedent preference only after Clause-bias verbs, but the preference was for whichever of the possible antecedents was made more prominent by mentioning it in the context sentence.

Two off-line completion tasks and forced-choice tasks were used to investigate people's antecedent preferences for both Mandarin bare and complex reflexive interpretations given no time constraint. The results of the completion task for bare reflexive were consistent with native speakers' intuition as described in the literature, whereas the forced-choice task results were similar to what was found in the reading time experiments. Both off-line results for complex reflexive showed that there was a strong tendency for complex reflexive to co-refer to local antecedents; however, this tendency was only observed in sentences with SC-bias verbs. After DO-bias verbs, people were affected greatly by the presence of long distance antecedents, suggesting that long distance nouns attracted people's selections even for complex reflexive *taziji*, which is usually thought to be locally bound in the literatures. The findings of on-line and off-line studies were taken together to show that verb biases and context have a great influence on the antecedent selection and the time courses of the reflexive resolution. Readers might choose to resolve or not to resolve the reflexive ambiguity on-line, depending on the on-line and off-line task demands.

ERPs evoked by the disambiguating verb showed more negativity in a 300-500ms window over frontal scalp regions when sentences were disambiguated toward local antecedents than when they were disambiguated toward distant antecedents. This was taken to suggest that people might in general have more difficulty integrating disambiguating verbs consistent with local antecedents during reflexive resolution. If people take distant antecedents as the default interpretation of the reflexive, when the meaning of the disambiguating verb suggests otherwise, they have to switch to the local antecedent, resulting in more frontal negativity from integration difficulty and increased ambiguity about the antecedent of the reflexive.

To My Parents and Sister

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CHAPTER 1: INTRODUCTION

Anaphors are linguistic tools that allow people to refer back to earlier-mentioned referents and thereby create a coherent discourse. Determining which previously-mentioned entity a particular anaphor refers back to is called anaphor resolution, and this has become one of the central issues in language comprehension. Linguistic theories have been developed to define constraints on co-reference relationships for different kinds of anaphors, including pronouns and reflexives. For example, Chomsky's Government and Binding Theory (1981, 1986) set up principles to explain why the anaphors in the English sentences in (1) below selected different antecedents. In (1a), the antecedent of the reflexive *himself* must be Peter because a reflexive should be bound with an accessible subject in its governing category, according to the Binding Principle A. The governing category of a reflexive refers to a minimal phrase that contains the reflexive, a head of a lexical category as the governor of the reflexive, and a subject that c-commands the governor. For example, in '*Peter likes himself*', the whole sentence is a governing category that contains the reflexive, in which the verb '*like*' is a lexical head that functions as the governor, and the noun '*Peter*' is the accessible subject that c-commands the governor. In contrast, the antecedent of the pronoun *him* in (1b) must NOT be Peter according to Binding Principle B (Chomsky 1981).

- (1) a. *John thinks that Peter likes himself.*
b. *John thinks that Peter likes him.*

Reflexives behave somewhat differently in Mandarin and thus present challenges to Chomsky's Government and Binding Theory. Inconsistent with Binding Principle A, the

Mandarin reflexive *ziji* can have a long-distance subject as its antecedent. For instance, in (2), a Mandarin example with similar structure as the English sentence in (1a), the reflexive *ziji* can co-index with either the local subject *Lisi* or the long-distance subject *Zhangsan*. If *ziji* co-indexes with the local subject as in English, then the sentence has the interpretation of ‘*Zhangsan thinks that Lisi likes Lisi*’. If the reflexive co-indexes with the long-distance subject ‘*Zhangsan*’, then the sentence would have the meaning of ‘*Zhangsan thinks that Lisi likes Zhangsan*’.

- (2) 張三_i 認為 李四_j 喜歡 自己
Zhangsan_i renwei lisi_j xihuan ziji_{ij}
 Zhangsan think Lisi like self
 ‘Zhangsan_i thinks that Lisi_j likes self_{ij}.’

A number of syntactic or pragmatic explanations have been developed to account for the long-distance binding properties of Mandarin reflexives (Battistella 1989, Cole, Hermon & Sung 1990, 1994, Huang and Tang 1991, Huang Yen 1994 Liu 1999 Pan 1995, Pollard & Xue 1998, 2001, Sell 1987, Tang 1989, Xu 1993, 1994, Yu 2000, Zribi-Hertz 1989 among others). Some syntacticians have argued that long-distance binding in Mandarin can be best explained in terms of LF movement (Cole, Hermon and Sung 1990, 1994, Battistella 1989 for LF head movement, and Huang and Tang 1991 for IP adjunction). On this account, the featureless bare reflexive *ziji* undergoes LF head-to-head movement from INFL to COMP to INFL to get features, which explains why long-distance subjects become accessible to the reflexive. Other researchers endeavor to explain the long-distance binding properties of *ziji* from a pragmatic perspective. Sells (1987) proposed that long-distance binding can be explained by logophoricity such as the SOURCE, the SELF and the PIVOT. According to Sells, the source of the report (source),

the person (self) that made the report and the person's point of view (pivot) of making the report are the three elements that interact and contribute to logophoricity, and interpretation of anaphora should take such discourse information into account. Other researchers have suggested that unified accounts that are purely syntactic or purely pragmatic are problematic, and it is better to have a non-unified analysis of reflexives (Pollard and Xue 1998, 2001, Liu 1999). They argue that there are two kinds of reflexives, syntactic and non-syntactic reflexives, which are subject to different binding principles. The syntactic reflexives abide by purely syntactic rules such as Chomsky's Binding Principle A, which explains the cases where the reflexive is bound locally. In contrast, reflexives with long-distance binding are explained as non-syntactic reflexives which are subject to pragmatic principles.

The theoretical accounts described above are concerned with explaining how local and long-distance binding are both possible for Mandarin reflexives, but they do not provide a ready explanation for the processes people go through in order to interpret reflexives. When there are multiple candidate antecedents in a sentence, how and when do people decide which is correct? Do they have general preferences, or do syntactic, semantic or pragmatic factors determine their decisions? The goal of this study is to try to answer these questions about Mandarin reflexive processing, with a focus on the time course of the use of different kinds of cues and on the ambiguity resolution of the reflexives.

CHAPTER 2: ANAPHOR PROCESSING, ANTECEDENT ACTIVATION AND VERB SUBCATEGORIZATION BIASES

2.1 Anaphor Processing Models

Two opposing kinds of processing models have generally been proposed in the sentence comprehension literature. According to serial or syntax-first models such as the Garden-Path Model (Frazier and Fodor 1978, Ferreira and Clifton 1986), a parsing stage first builds syntactic structure based on major word categories in the input and the syntactic rules of the language, independently from other kinds of information. Semantic and other non-syntactic information come into play at a later stage where early syntactic decisions can be revised if they turn out to be inconsistent with subsequent information. The other class of models, often called constraint-based models, argued that various sorts of information interact throughout sentence processing, and are thus said to be interactive rather than serial (e.g Trueswell and Tanenhaus 1994).

Garrod and colleagues (Garrod & Sanford, 1994; Garrod & Terras, 2000) have developed a two-stage model specifically for English pronoun interpretation. In their model, there is an initial binding stage in which possible antecedents are activated subject to structural constraints. Then in a second resolution stage, other cues are evaluated and integrated in order to arrive at a final interpretation (See Nicol & Swinney, 1989 for a similar account). Sturt (2003a, 2003b) has labeled this view the “binding-as-initial-filter” account because syntactic constraints function like a filter that rules out all the impossible antecedents. Sturt (2003a, 2003b) also brought up three additional possible hypotheses about the time course of the use of binding constraints. The second hypothesis is the “binding-as-late-filter” account, which predicts that syntactically impossible antecedents

get activated initially but then are filtered out when the binding constraints are applied later. The third alternative is a weaker version of the “binding-as-initial-filter” account, in which binding principles are applied at the earliest processing stage but can be overridden later when other kinds of information become available. In two eye-tracking experiments Sturt (2003a) tested sentences like (3). In these sentences, the reflexives himself/herself should refer to the syntactic antecedent ‘the surgeon’, but there are also possible logophoric antecedents (Jonathan/Jennifer) present in the sentences. The gender of the reflexive is also manipulated to match or mismatch the stereotypical gender of the syntactic antecedent ‘the surgeon’. This gender stereotype manipulation is taken as the earliest point where the binding Principle A is applied in the experimental design, because this kind of gender stereotype violation can be quickly detected.

- (3)
- a. Jonathan was pretty worried at the City Hospital. He remembered that the surgeon had pricked himself with a used syringe needle. There should be an investigation soon.
 - b. Jennifer was pretty worried at the City Hospital. She remembered that the surgeon had pricked himself with a used syringe needle. There should be an investigation soon.
 - c. Jonathan was pretty worried at the City Hospital. He remembered that the surgeon had pricked herself with a used syringe needle. There should be an investigation soon.
 - d. Jennifer was pretty worried at the City Hospital. She remembered that the surgeon had pricked herself with a used syringe needle. There should be an investigation soon.

In such a design, there should not be any effects of gender mismatch for the logophoric antecedents under the ‘binding as initial filter’ view. If “binding as late filter” is correct, then there should be gender mismatch effects on both syntactic and logophoric

antecedents at the earlier stage and effects on syntactic antecedents only for a later stage. The weaker “binding as initial filter” view would predict gender effects on syntactic antecedents but not on logophoric antecedents at the early stage; however, the effects would emerge later on logophoric antecedents. Sturt (2003a) calculated first fixation duration (the duration of the first fixation of a region) and first-pass reading times (which is the sum of fixations in a region between the time when the gaze first enters the region from the left, to the time when the gaze exits that region), and the results showed that the first fixation duration and first pass reading times were faster when the gender of the anaphor matched the stereotype of the syntactic antecedents than when they mismatched, and there were no reliable differences on the logophoric antecedents. This suggests that the binding constraints are applied pretty fast at an early stage, so the “binding as late filter” view was not supported. The results on the second pass reading times (i.e. the sum of fixations made on a region after that region has already been exited for the first time) showed that gender effects were still found on the syntactic antecedents as before, but the reading times were longer when there was a gender mismatch for the syntactic antecedents while the logophoric antecedents were gender matched to the reflexives. This was taken as an evidence that logophoric antecedents have an influence on processing in a later stage. They therefore argued that binding principles operated at the very earliest stages of processing, so antecedents that were ruled out by the binding principles did not affect early processing but did influence people’s final interpretation. There is a fourth hypothesis about pronoun resolution based on constraint-based models (e.g. MacDonald et al. 1994, Spivey and Tanenhaus 1998), in which all relevant constraints are applied in parallel from the start, and the extent to which they influence processing depends on their relative strengths.

2.2 Accounts of Antecedent Activation and Selection

The hypotheses described above are primarily concerned with the timing of the application of syntactic constraints during sentence processing. Another approach has been taken by researchers who have investigated other factors that influence antecedent activation and selection. In Crawley et al.'s (1990) two experiments, one with a self-paced reading task (where people were asked to read the passages and then answer comprehension questions) and the other with an assignment task (where people were asked to read sentences and then make decisions on the assignment of ambiguous pronouns), they found out that people were more likely to assign a pronoun to an antecedent occupying the grammatical subject position than to an antecedent in the object position. For example, each of the passages contained an ambiguous sentence like (4), and in the assignment task, people more frequently selected the subject (Sarah) as the antecedent of the ambiguous pronoun (her), and subject-antecedent interpretations were made faster than object-antecedent interpretations.

(4) Sarah visited Cathy at home and Charles rang her at work.

Gernsbacher and colleagues (Gernsbacher & Hargreaves, 1988; Gernsbacher, 1989, Gernsbacher et al. 1989) also found that first-mentioned antecedents tended to be more activated than second-mentioned antecedents using probe recognition tasks. In these tasks, participants would read word-by-word sentences about two participants and after each sentence, participants verified whether a probe had occurred in the sentences they just read by pressing one of the 'yes' or 'no' response keys. They found that probes were

responded to faster if they were the names of the first mentioned participants as opposed to second-mentioned ones.

Thus, with regard to anaphor selection, one hypothesis is that people generally prefer to assign pronouns to first-mentioned antecedents and/or to antecedents occupying the grammatical subject position. Alternatively, one might hypothesize that there could initially be unselective activation for all of the possible antecedents and then later selection of the proper antecedent when more cues become available. Corbett and Chang (1983) argued for this view based on priming effects in a memory probe paradigm. After reading sentences that either did or did not include a pronoun as in (5), one of the names from the sentence (Gary or Marvin) was presented as probes and people decided whether it had appeared in the sentence.

(5) Gary was interviewed by Marvin but (Gary/he) would not answer many questions.

In the sentence containing the pronoun he, Gary is the more plausible antecedent given the content of rest of the sentence. However, recognition times were faster and more accurate for the Marvin probe when the sentence contained a pronoun than when it did not. This was taken as an evidence that the ultimately less plausible antecedent was initially activated when the pronoun was encountered.

In Corbett and Chang's studies, the test probe was always presented at the end of the sentence. Greene et al. (1992) used the same paradigm but presented test probes at various sentence positions, including immediately before or after critical pronouns or at the end of the sentence, to try to tap into the time course of pronoun processing. Their test examples are presented in (6). The test words are 'Mary', 'John' and 'dishes', in which

'Mary' is the referent, 'John' is the non-referent and 'dishes' is the control. The numbers indicate the positions of the test words.

- (6) Mary and John were doing the dishes after dinner.
One of them was washing while the other dried.
Mary accidentally scratched John with a knife
and then ₁ she dropped ₂ it on the counter. ₃

Their assumption was that if the referents are the only ones that would be activated when reading a pronoun, then we would expect to see the recognition advantages only for referent probes, not for non-referent probes in some of the positions. They found a recognition advantage of referent over non-referent probes for a pronoun, but only when the sentences were presented slowly and when the task was manipulated to be very easy and encourage identification (i.e. by asking comprehension questions)., They argued that people do not always identify a unique referent for a pronoun since there was no advantage of referent over non-referent under some conditions.

Gordon and Scarce (1995) did two self-paced reading time experiments to look at how discourse structure and world knowledge influence English pronoun interpretation. In one of their studies, readers read passages frame by frame like (7). In these passages, the third sentence (frame (e)) contained a pronoun or a full name that continued the subject or shifted from the subject of the previous two sentences, and frame (f) would semantically disambiguate the pronoun. They predicted that based on several structural factors such as primacy, subject-assignment and parallel syntactic structure, pronouns in the critical sentences (frame e) would be more likely to be interpreted as the subject of the preceding sentences. Moreover, such interpretation would have to be purely based on

structural information, because there was no other source of disambiguating information until frame (f), where the meanings of the verbs sent/received provided disambiguation.

- (7) (a) Bill wanted John to look over (b) some important papers.
(c) He had to mail him (d) the documents by Monday.

CONTINUE

- (e) Unfortunately, he/Bill (f) never sent the papers.

SHIFT

- (e') Unfortunately, he/John (f') never received the papers.
(g) As a result, the whole deal (h) fell behind schedule.

The results showed that people read slower when the sentence disambiguated toward the non-subject antecedent (i.e. the shift condition was read slower), and this effect only showed up for the pronoun conditions, not for sentences with full names. They also found sentences with repeated names were read slower than those with pronouns in the Continue condition. They took this pattern of results as evidence against Greene et al. (1992), and argued that readers do come up with an initial identification of the pronoun referent, and that their initial default interpretations were based on the local discourse structure, with those interpretations later confirmed or overridden later by knowledge-based processes.

Taken together, the findings of studies on anaphor resolution suggested that several factors affect anaphor processing. Syntactic constraints like binding principles and structural antecedent biases such as a preference for subjects or first-mentioned nouns as antecedents have all been found to influence in anaphor resolution.

2.3 Verb Bias and Reflexive Processing

In order to understand a sentence, readers have to know word meanings, and in addition to that, they also need to know the intrinsic properties of verbs and the structural information provided by the verbs to figure out the relationship between verbs and nouns in a sentence. Implicit causality (Garvey and Caramazza 1974), for instance, is a property of verbs that affects ambiguous pronoun interpretation. For example, the pronoun ‘he’ in (8) is ambiguous since it could refer to either John or Bill. However, it is more likely for people to choose John as the antecedent for the pronoun in (8a), and choose Bill as the antecedent in (8b). These biases were mainly from the implicit causality marked by the verb ‘telephone’, and readers could make use of such information to generate the appropriate causal relationship between the nouns, and that, in turn, determined the possible referent of the ambiguous pronoun. Compare this to (8c) where readers are more likely to take the second noun as the antecedent of the pronoun because of the verb ‘punish’. So, verbs like ‘telephone’ and ‘punish’ naturally differ in their implicit causality relationships.

- (8) a. John telephoned Bill because he wanted some information.
b. John telephoned Bill because he withheld some information.
c. The mother punished her daughter because she broke an antique vase.

Caramazza et al. (1977) investigated this ‘implicit causality’ property of verbs by using sentences like (8a and 8b) above. They found that people would name the referent of the pronoun faster when the semantic relations in the subordinate clause were consistent with the direction of pronoun assignment established by the main verb ‘telephone’, and slower

if the semantic relations were inconsistent with the causality relations (i.e. faster responses for (8a) than for (8b)). Thus, the implicit causality of verbs helps readers to determine coreference of ambiguous anaphoric pronouns during comprehension.

Another potentially important property of verbs is their subcategorization, which determines the possible syntactic structures of sentences containing the verb, including how many nouns will be required. In addition, verbs vary in the relative frequency with which they are used in their different allowed syntactic structures. For example, many verbs that can take either direct objects or sentential complements may be much more likely to take one or the other. Several previous studies (e.g., Trueswell et al. 1993, Garnsey et al. 1997) have reported that verb subcategorization preferences (termed as “Verb Bias” from now on here) have robust effects on ambiguity resolution in temporarily ambiguous sentences like (9) in English. These sentences are temporarily ambiguous because the noun following the verb ‘warned’ could be either its direct object, as in (9a), or the subject of an embedded clause, as in (9b).

- (9) a. The referees warned the spectator against heckling the other team.
b. The referees warned the spectator would probably get too rowdy.
c. The bus driver worried the passengers were starting to get annoyed.

The verb ‘warned’ in (9a, 9b) tends to be used in sentences where it takes a direct object more often than in sentences where it takes sentential complements, so it will be called a ‘Direct Object bias (DO-bias) verb’. In contrast, the verb ‘worried’ in (9c) is a Sentential Complement bias (SC-bias) verb because it tends to take sentential complements more often than direct objects. Both self-paced moving window task and eye-tracking studies have shown the effects of verb bias on sentence reading (e.g., Trueswell et al. 1993,

Garnsey et al. 1997). In sentences with DO-bias verbs (e.g., warned), people slowed down when an auxiliary verb made it clear the temporarily ambiguous noun phrase was the subject of an embedded clause rather than a direct object, but the same did not happen when the sentences contained SC-bias verbs (e.g., worried) . Thus, people use verb biases quite rapidly to aid them in predicting what is likely to come next in a sentence.

Mandarin sentences like the English examples in (9) have the same kind of temporary ambiguity about whether a noun phrase following the main verb is its object or the subject of a sentential complement. In English, if the noun phrase following the main verb is a reflexive, there is no such ambiguity because reflexives are morphologically marked to indicate whether they are subjects or objects. However, Mandarin reflexives have no similar morphological marking, so their role remains ambiguous. In addition, *ziji* can refer to either a long-distance subject or the local governing subject or even sometimes both, making both the syntactic role of the reflexive and its antecedent ambiguous. A final difference between English and Mandarin is that English sentences containing embedded sentential complements can be rendered unambiguous by including the complementizer ‘that’, while there is no complementizer in Mandarin.

Mandarin Chinese has the same basic Subject-Verb-Object (SVO) word order that English has. Thus, in both languages the verb comes early enough in the sentence that its subcategorization preferences could be useful in predicting what might come after it in the sentence. It seems highly likely that Mandarin speakers learn about verbs’ structural biases and use them predictively, just as English speakers do. Thus, verb bias preference information might be useful in constraining Mandarin reflexive processing. If people make use of verb bias in processing temporarily ambiguous sentences in Mandarin as they do in English, it could also influence their resolution of ambiguous reflexives, given

sentences with the right kinds of properties. In example (10) below, differences in reading time on the post-verbal reflexive itself or on the word following it could be used to diagnose readers' preferred interpretation of the reflexive.

(10) 機長 要求 乘客 要 相信 自己 一定 能 平安的 搭乘 飛機 到 目的地
jizhang yaoqiou chengke yao xianxin ziji yiding neng pingande dacheng feiji dao mudidi
pilot ask passenger need believe self definitely can safely ride plane to destination
'The pilot asks the passengers to believe him/themselves that they definitely can ride the plane safely to the destination.'

In this example, there are two possible antecedents for the reflexive *ziji*, which occurs after a verb whose argument structure options include both direct objects and sentential complements. Thus there is a temporary ambiguity about whether *ziji* functions as a direct object or as the subject of an embedded sentential complement. If Mandarin speakers use their knowledge about particular verbs' argument structure preferences similarly to the way English speakers do during sentence comprehension, then they might expect the sentence to end soon after a verb that usually prefers to take direct objects, in contrast to expecting more information after a verb prefers to take sentential complements. Such expectations might influence the processing times for the reflexive itself. The prediction is that a post-verbal reflexive will be read more slowly after a verb that prefers to take direct objects because people expect the sentence to end soon but the sentence so far has not included sufficient information to disambiguate the reflexive's antecedent. In contrast, when the reflexive follows a verb that prefers to take sentential complements, then people may not slow down on the reflexive because they expect the sentence to continue and to provide disambiguating information. This is one way in

which verb biases could influence reflexive processing in Mandarin. Another way in which verb biases are predicted to influence reflexive resolution is on the time course of antecedent selection and also on what antecedent is selected. If people use verb biases to predict what the upcoming syntactic structures are, they would expect more information to come soon in the SC-bias condition but not in DO-bias condition. Because people expect to read more disambiguating information when SC-bias verbs are read, it is possible that they do not need to resolve the ambiguity right away when the reflexive is encountered, but rather, people wait until disambiguating information is available. If this assumption is correct, then we predict that people would not make the antecedent selection right after reading the reflexive after a SC-bias verb, and that there would thus be no reading time differences when the disambiguating region is consistent with one but not the other possible antecedent of the reflexive because they would not have chosen between the possible antecedents yet. However, we would then expect to see reading time differences at the disambiguating region in sentences with DO-bias verbs because people would go ahead and choose an antecedent for the reflexive sooner because they would not expect to receive much more information, so they would have to interpret the reflexive with the currently available cues. If they make the antecedent selection soon after reading the reflexive, then they will be surprised and read slowly if the disambiguation turns out to be inconsistent with their original antecedent choice. Therefore, we predict that verb biases would have an effect on when the reflexive referent is determined (later for SC-bias /earlier for DO-bias conditions).

2.4 Anaphor Resolution in Mandarin

Several researchers have investigated whether the factors described above also play a role in Mandarin anaphor resolution. Chen et al. (2000) conducted three reading time studies to examine how the order of antecedents and semantic context affect the resolution of temporarily ambiguous Chinese pronouns. They found that people read faster when the disambiguating phrases made it clear that the pronoun referred back to the first-mentioned antecedent, regardless of the thematic roles of the possible antecedents. However, this order effect was eliminated when a biasing context preceded the pronouns. They concluded that Chinese pronoun interpretation depends on both contextual and structural factors, in that first-mentioned antecedents are preferred in a semantically neutral condition, but this preference can be overridden by semantic context. Yang et al. (1999, 2001, 2003) have done a series of studies on repeated names, pronouns and zero anaphor processing in Mandarin. They investigated the contributions of different types of referring expressions (i.e. full names or pronouns), different sentence structures (i.e. active or passive sentences), genders of the referring expressions, and discourse context on pronominal processing. Yang et al. (1999) reported that in Mandarin, pronouns that refer back to the antecedents in the subject position (but not antecedents in the object position) were read faster than matched sentences containing repeated names, similar to the repeated name penalty observed in English (Gordon et al. 1993). Like Chen et al. (2000), by comparing active and passive sentence structures, Yang et al. (2003) also found that it is syntactic prominence (grammatical subjects/objects) rather than thematic roles, that is the primary factor in the processing of pronoun co-reference in Chinese.

2.5 Reflexive Processing in Mandarin

The previous studies described above shed some light on Mandarin pronoun resolution, but there have not been many studies specifically addressing Mandarin reflexive processing. Dillon et al. (2009) investigated how different word order and locality properties impact antecedent search for Mandarin bare and complex reflexives. Their stimuli were all in SOV word order, which was accomplished by using the BA-construction in Mandarin, illustrated in example (11). In the BA-construction, the object appears before the verb instead of after it, and the pragmatic consequence of using the construction is an emphasis on the affectedness of the object.

(11) a. [anim] N1 + [anim] N2: [*Zhang-taitai jingchang guanggu _ de*] *na-ge nü-caifeng...*

Mrs. Zhang often visit DE that seamstress
“The seamstress that Miss Zhang often visits...”

b. [inanim] N1 + [anim] N2: [*Meiti baodao guo _ de*] *na-ge nü-caifeng...*

Media report DE that seamstress
“The seamstress that the media reported on...”

c. [anim] N1 + [inanim] N2: [*Zhang-taitai jingchang guanggu _ de*] *na-ge shizhuangdian...*

Mrs. Zhang often visit DE that boutique
“The boutique that Miss Zhang often visits...”

d. [inanim] N1 + [inanim] N2: [*Meiti baodao guo _ de*] *na-ge shizhuangdian...*

Media report DE that boutique
“The boutique that the media reported on...”

continuation: ... *shang-ge-xingqi ba {ziji / ta-ziji} nongshang-le.*

last week BA self/himself hurt

... carelessly harmed {ziji / ta-ziji} last week.”

In these sentences, the bare or complex reflexive appeared right after BA word and

functioned as its object. There were two nouns in each sentence prior to the reflexive. One appeared as the head noun of a relative clause ('seamstress' and 'boutique') and the other as the embedded head of the relative clause ('Mrs. Zhang' and 'the media') that modifies the head noun. The animacy of these two nouns was manipulated to test whether there is a preference for Mandarin reflexives to refer back to animate referents. In two self-paced reading studies, they found that the reflexive region was read faster in sentences with the bare reflexive *ziji* if there was an animate head noun (9a, 9b) than when the head noun was inanimate (9c, 9d), but the same was not true for the complex *taziji*. For *taziji*, people read sentences that contained an inanimate head noun plus an animate embedded noun (9c) just as fast as sentences containing animate head nouns (9a, 9b). They argued that the complex reflexive *taziji* can immediately access embedded antecedents while the bare reflexive *ziji* cannot. They concluded that neither recency nor locality were responsible for targeted subject search in Mandarin reflexive resolution, and word order did not matter much since readers did not need predicate information to interpret the reflexive.

While Dillon et al's (2009) interpretation is a reasonable explanation of their results, another possibility is that readers were given no options but to access a remote (animate) antecedent in the complex reflexive *taziji* condition because the head noun is an implausible/inanimate antecedent. It is also possible that people had different processing strategies or preferences for their sentences because of their non-canonical word order. Since the reflexive preceded the verb in their sentences, verb information was not yet available at the reflexive, so readers may have relied more on the animacy information to make decisions on reflexive antecedents since that was all that was available so far. A different approach to testing reflexive antecedent preferences would be to present

sentences in the canonical SVO order and make both antecedents animate and plausible for the reflexive. Thus, the experimental sentences in our studies were designed to have a canonical SVO word order and have both referents accessible and plausible to the reflexives, to rule out the possibility that readers favor one of the antecedents over the other because the other one is less plausible.

Mandarin reflexive processing has not yet being fully explored. Many questions remain unanswered, such as whether Mandarin reflexive processing is similar to Mandarin pronoun processing. For example, is there a similar bias for the anaphor to refer to first-mentioned entities or subjects? Is Mandarin reflexive resolution influenced by syntactic constraints, semantic context and discourse coherence just as pronouns are? If so, what is the time course of the contributions of these factors during reflexive processing? The goal of this dissertation is to find answers to four questions about Mandarin reflexive processing. First, whether there are general preferences for reflexive antecedents will be tested. Second, the roles of structural factors such as verb bias and semantic factors such as context during reflexive interpretation will be examined, along with the time course of the usage of these different information sources. Third, whether and how people interpret reflexives when they only have partial information will be addressed. And fourth, both offline and online tasks will be used to probe processing at different times to map out the time course of reflexive processing, and different kinds of processing measures will be collected to determine whether they tap into the same or different aspects of reflexive processing. The questions are articulated more specifically below:

Research questions:

- 1) Preferences for interpreting Mandarin reflexives
 - a. Which antecedent will be preferred or selected? (Distant vs local nouns?)
 - b. What is the time course of such selection? (right at/after reflexive or not until a disambiguating region that comes later in the sentence?)
- 2) The effect of Verb Bias and Context on reflexives
 - a. Will verb bias influence the decision? (Do people have preferences for different antecedents based on the bias of the verb preceding the reflexive?)
 - b. How do verb biases play a role in the time course of the selection?
 - c. How does contextual information influence reflexive resolution?
- 3) Can people resolve Mandarin reflexives with only partial information available?
 - a. Would different amounts of information affect reflexive resolution differently?
- 4) Do offline or online tasks tap into reflexive processing at different points?
- 5) Do Event-Related Potential (ERP) responses measured during Mandarin reflexive processing provide useful information?
 - a. Which ERP components are involved? N400 at the disambiguating region because it's less predicted and harder to integrate? Or Anterior Negativity caused by co-referential difficulties? Or other ERP components?
 - b. Which sentence regions will these components be observed in? (In the reflexive region or disambiguating verb region?)

2.6 Hypotheses about Antecedent Selection in Reflexive Resolution

Based on the different theoretical analyses of the Mandarin reflexive described above, there are at least three possibilities for how people interpret Mandarin reflexives. One could take the view that interpreting Mandarin reflexives involves searching back for feature-matched antecedents in a serial manner until all possible feature-matched antecedents are found. The assumption is that such a search back would start from where reflexives are encountered, since it is not known until the reflexive appears that there a need to search back for all possible antecedents. It might be hypothesized that local

antecedents would be favored since these are found soonest during such a search and thus have a recency advantage. This will be termed as Hypothesis A.

Hypothesis B follows the accounts for anaphor activation and selection in English, and proposes that because first-mentioned nouns and grammatical subjects are more prominent, they will be preferred as antecedents for reflexives, as they are for pronouns. Under this hypothesis, people would prefer the first-mentioned noun (usually the grammatical subject) as the default interpretation of an ambiguous reflexive, regardless of what syntactic constraints or other semantic cues might indicate.

Alternatively, a third possibility is that people have no consistent preferences about reflexive antecedents at the earliest stages of processing. It could be the case that people do not try to disambiguate an ambiguous reflexive when they first encounter it, but rather wait for more information as the sentence unfolds before making a decision. Therefore, it is possible that at early stages of processing, people do not have any antecedent preferences, and then later make use of all of the relevant available cues for reflexive interpretation.

CHAPTER 3: BARE AND COMPLEX REFLEXIVE RESOLUTION

In Chapters 3 and 4, two self-paced reading time experiments, a sentence continuation judgment task and several off-line norming studies will be reported. They were conducted to investigate whether people have a general preference for one of the possible antecedents of a reflexive, and also whether within-sentence syntactic cues such as the structural bias of a verb preceding the reflexive influence reflexive resolution in isolated Mandarin sentences. Another self-paced reading time experiment was also conducted to investigate how cross-sentence context information would affect the resolution of the bare reflexive.

3.1 Experiment 1: Resolution of Bare Reflexive *ziji* in Isolated Sentences

An experiment was conducted using the self-paced reading paradigm to answer two questions: whether people have preferences for Mandarin reflexive *ziji*'s antecedents and if so, what those preferences are, and whether structural information like verb bias has immediate effects on Mandarin reflexive processing.

Method

Participants

Forty-eight native Mandarin speakers from National Taiwan University in Taiwan (22 males, mean age 21) participated in this study. All interactions between the researcher and participants were conducted in Mandarin throughout the session.

Materials

Participants were asked to read sentences like those in (12) below.

(12) DO-bias verbs, Local antecedent

a. 報童 宣稱 訂戶 會 喜歡 自己 今天 訂閱 的 報紙
baotong xuancheng dinghu hui xihuan ziji jintian dingyue de baozhi
Newsboy alleged subscriber will like self today subscribe DE newspaper

‘The newsboy alleged that the subscriber will like the newspaper self (he) subscribed today.’

DO-bias verbs, Distant antecedent

b. 報童 宣稱 訂戶 會 喜歡 自己 今天 送達 的 報紙
baotong xuancheng dinghu hui xihuan ziji jintian songda de baozhi
newsboy allege subscriber will like self today deliver DE newspaper

‘The newsboy alleged that the subscriber will like the newspaper he delivered today.’

SC-bias verbs, Local antecedent

c. 郵差 宣稱 民眾 總 懷疑 自己 沒有 按時 收到 郵件
youchai xuancheng mingzhong zhong huaiyi ziji meiyou anshi shoudao youjian
mailman allege the public always doubt self not on time receive mail

‘The mailman alleged that the public always doubts that they do not receive mails on time.’

SC-bias verbs, Distant antecedent

d. 郵差 宣稱 民眾 總 懷疑 自己 沒有 按時 投遞 郵件
youchai xuancheng mingzhong zhong huaiyi ziji meiyou anshi toushi youjian
mailman alleged the public always doubt self not on time deliver mail

‘The mailman alleged that the public always doubts that he does not deliver mails on time.’

All of the experimental sentences began with a main clause consisting of a noun (e.g., newsboy or mailman) plus a verb (e.g., alleged), which was then followed by an embedded clause that began with another noun (e.g., subscriber or public) followed by another verb (e.g., like or doubt). This second verb was always one that could take either a Direct Object (DO) or a Sentential Complement (SC) as an argument, and it was strongly biased toward one or the other of those structures, as determined by corpus counts. The second verb was immediately followed by the reflexive *ziji*. Crucially, two nouns that were both possible antecedents for *ziji* preceded it in the sentence (e.g., newsboy and subscriber or mailman and public). One was the first-mentioned noun in the

sentence and was the more distant possible antecedent (e.g., *newsboy or mailman*) and the other was a more local possible antecedent (*'subscriber' or 'public'*). The rest of the sentence following *ziji* was semantically biased to force the interpretation of the reflexive toward either the local antecedent (12a, 12c) or the distant one (12b, 12d). Semantic bias was manipulated by using different verbs following the reflexive (*'subscribe'* and *'deliver'* in 12a and 12b, and *'receive'* and *'deliver'* in 12c and 12d). Within each verb bias condition, the two sentences with different semantic disambiguation were identical except for the disambiguating words. The goal of this manipulation was to avoid any disambiguating cues until after the reflexive and then use reading times at the post-reflexive disambiguating verb to diagnose antecedent choice. If people have a preference for one of the possible antecedents, they should slow down on a verb that indicates that the other possible antecedent is the correct one. So, if people have a default preference for the local subject as antecedent as they search back for possible referents, reading times on the disambiguating verb region should slow down if that verb points to the long-distance antecedent for *ziji*. In contrast, if people have a default preference for the long-distance subject as *ziji*'s antecedent due to the prominence of matrix subjects, then they should slow down on the disambiguating verb region when that verb points to the local possible antecedent instead. The mismatch of people's expectation enables us to understand whether people have predetermined preferences for the antecedents. If the reaction times in the two disambiguation conditions do not differ, it might suggest that people do not make decisions prior to the disambiguation region. They just hold all possible antecedents in mind and make the decision after more information is disclosed at the disambiguation region. So this semantic bias manipulation enables us to see if people have preferences about reflexive antecedents.

Pretests

21 undergraduate students from National Taiwan University rated the acceptability of the experimental stimuli on a 1-7 (unacceptable to acceptable) scale. Only those stimuli that were rated above 5 were included in the self-paced reading time experiment. Another 30 undergraduate students from National Taiwan University were asked to provide coreference information about the reflexive after reading the experimental stimuli. They were directly asked to provide their interpretations about the reflexive for each sentence. This pretest was to make sure that our disambiguating verbs were indeed biased to our target referents. Stimuli that were agreed upon by about 70% by the participants were selected for the self-paced reading study. Furthermore, the end-of-sentence judgments in the self-paced reading time experiment also showed that people interpreted *ziji* consistently with the semantic bias of the disambiguating verb 82% of the time.

The disambiguating verbs were matched for number of strokes (21 (DO) vs 21 (SC) on average). Another 23 undergraduate students participated in a lexical decision experiment, to determine that there were no reading time differences for the disambiguating verbs in isolation (677 ms (DO) vs 670ms (SC), $t < 1$). Verb subcategorization biases were determined by using the Chinese Gigaword Corpus, which is a written corpus including articles from newspapers and magazines. (See a more detailed description of the corpus in Hong & Huang 2006). Fifty samples were randomly selected from the corpus for each target verb, and the subcategorization preferences were hand-coded. Overall, the DO-bias verbs chosen for this study were used in the corpus with direct objects 90% of the time on average, and SC-bias verbs were used with sentential complements 86% of the time.

Procedures

128 sentences (80 experimental (40 DO-bias, 40 SC-bias) + 48 fillers) were used in this self-paced reading study. Words were presented centrally on the screen of a HP Pavilion laptop computer, and participants were asked to make true/false responses to a paraphrase of the sentence after each sentence. All the comprehension questions were constructed to identify the antecedent of the reflexive.

Results and Discussion

Participants' mean reading times are shown in Figure 1. There were no differences across conditions in the reading times for the reflexive itself, but reading times on the region immediately following the reflexive were influenced by verb bias. The word immediately following *ziji* (e.g., 'today') was read more slowly overall in sentences with DO-bias verbs than sentences with SC-bias verbs ($F(1,47) = 10.25, p < .01$). Presumably, this is because DO-bias verbs led people to expect sentence endings and thus they felt obliged to figure out an interpretation of the reflexive at that point since it was likely that there would be no clear disambiguating information coming given that the sentence would probably end soon. In contrast, SC-bias verbs led people to expect the sentence to continue with an embedded clause that could provide more information relevant to disambiguation, so they did not need to resolve the ambiguity so soon. It is not surprising that this effect did not show on the reflexive itself but only on the following word, since effects are often delayed a word in the self-paced reading paradigm.

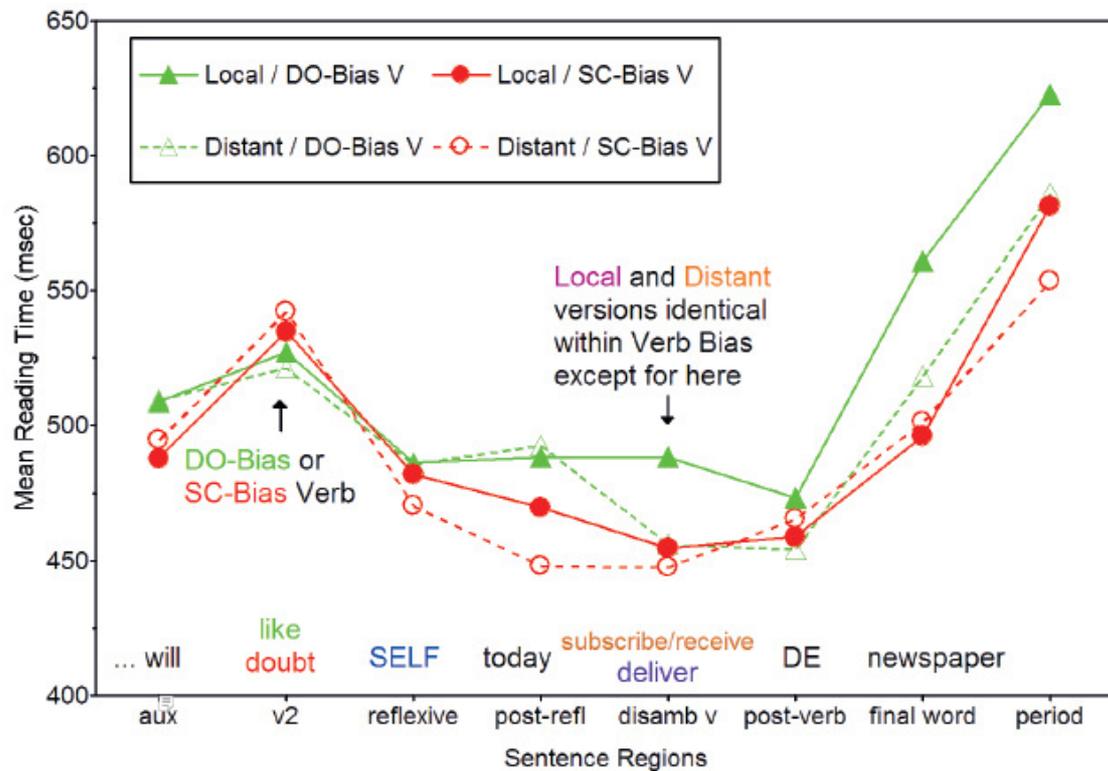


Figure 1. Word-by-word Reading Times for Target Sentences in Experiment 1

At the disambiguating verb region and throughout the rest of the sentence, sentences with DO-bias verbs continued to be read more slowly only when they were semantically disambiguated by the embedded verb toward the Local antecedent ($F(1,44) = 6.28$, $p < .05$). There was no effect of antecedent disambiguation in sentences with SC-bias verbs. The interaction between verb bias and antecedent disambiguation did not reach significance, even though the disambiguation effect was significant for sentences with DO-bias verbs but not for sentences with SC-bias verbs ($F(1,44) = 6.32$, $p < .05$).

Reading times at the disambiguating region suggest that people had an expectation for the reflexive to refer to the long-distance (first-mentioned) noun rather than the local noun when reading sentences that contain DO-bias verbs. No similar pattern was observed in sentences with SC-bias verbs. Thus, DO-bias verbs seem to have led readers

to select an interpretation of the reflexive earlier than SC-bias verbs did. This is probably because DO-bias verbs predicted that the sentence would end soon, and such time pressure forced people to come up with a decision based on the currently available information, whereas SC-bias verbs predicted that the sentence would continue with an embedded clause, which allowed people to wait for more information to interpret the reflexive and thus they were not surprised by either disambiguation provided by the embedded sentences.

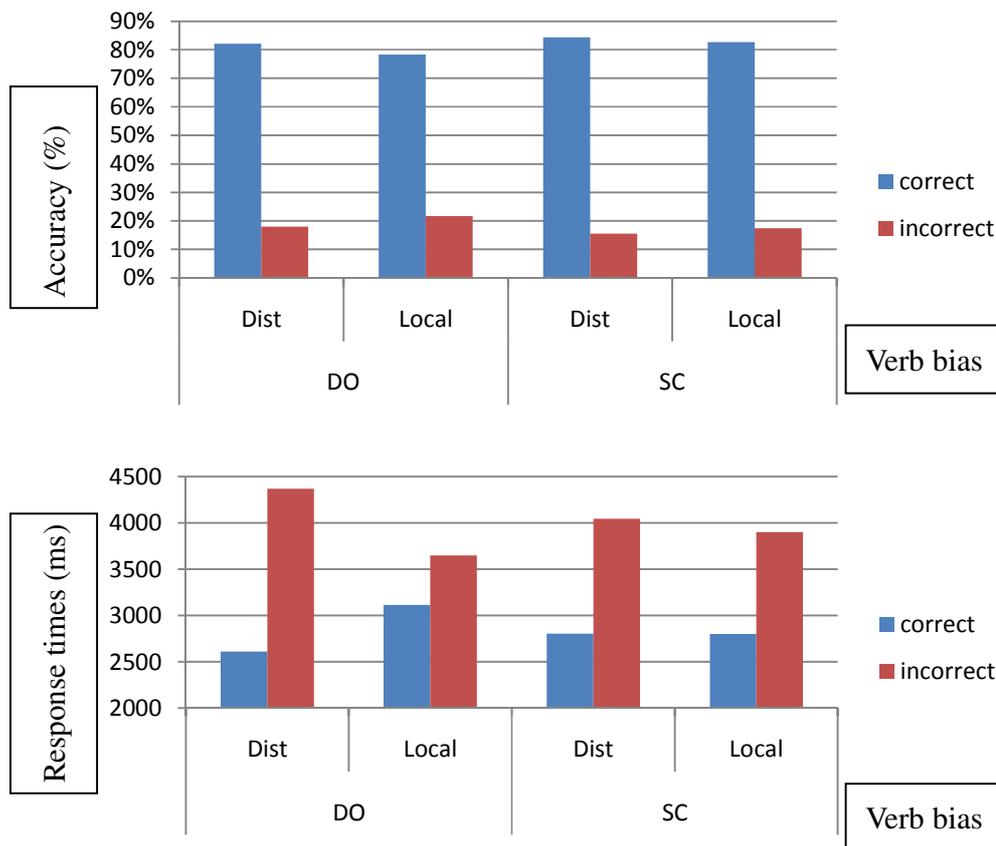


Figure 2. Experiment 1 Accuracy (upper panel) and Response Times for Comprehension Questions

Figure 2 shows the accuracy rate and response times for the comprehension

questions. The question response results were consistent with the sentence reading times, in that the responses to questions were both slower and less accurate after sentences with DO-bias verbs where *ziji* was disambiguated toward the local antecedent (3114 ms (DO_LOCAL noun) vs ~2611 ms (DO_DIST noun) and 78% vs ~82% correct), whereas the response times and accuracy of the comprehension questions for sentences with SC-bias verbs did not differ (around 80% correctness and ~2800ms response times).

Finding that readers had a preference for the long-distance noun as the antecedent for *ziji* after DO-bias verbs is consistent with previous studies of pronouns suggesting that first-mentioned and grammatical subject nouns are the preferred antecedents for pronouns (Chen et al. 2000). There is another possible explanation, however, which is specific to reflexives. People may have a preference for a distant antecedent for *ziji* because a less ambiguous complex reflexive *taziji* ‘himself’ could be used to refer back to a local antecedent. Thus, when speakers produce sentences with two possible antecedents for a reflexive, they might tend to use the bare reflexive *ziji* if it refers to the distant antecedent and to use the complex reflexive *taziji* if it refers to local antecedent. This possible explanation was investigated in Experiment 2.

Returning to the hypotheses laid out at the end of the introduction, Hypothesis A was not supported by our results, since when there was an antecedent preference, it was for the distant noun. Thus, antecedent recency did not seem to be the basis for the observed bias. Hypothesis B proposed that the relative prominence of first-mentioned and subject nouns might lead to a preference for them as reflexive antecedents, and it was partially supported by the finding that when there was a preference it was for the distant noun. However, a preference was shown only in sentences containing DO-bias verbs, suggesting that antecedents were not always selected prior to the disambiguating region,

partially consistent with Hypothesis C. Thus, the findings suggest that the selection of reflexive antecedents is a complex process that cannot be simply explained by another the proposed hypotheses. Hypotheses B and C were both partially supported, depending on the bias of the verb in the sentence. Overall, the findings suggest that readers built and modified their interpretations based on available cues in the sentences during processing, so antecedent interpretation and selection may be constantly updated as sentences unfold.

To sum up, the finding that people read the post-verbal reflexive and the word following it slower after DO-bias verbs suggested that they were working to resolve the antecedent of the reflexive in those sentences but waited for more information in sentences with SC-bias verbs. When they did resolve the reflexive, they preferred the distant antecedent, but there was not a strong general preference for one antecedent over the other. The preference for the distant antecedent when there was a preference is consistent with some previous findings on pronoun resolution in English and in Mandarin (Gordon and Scearce 1995, Chen et al. 2000).

3.2 Experiment 2: Resolution of Complex Reflexive *taziji* in Isolated Sentences

Mandarin Chinese has other types of reflexives in addition to the bare reflexive *taziji*. There are also complex reflexives such as *woziji* ‘ourselves’, *niziji* ‘yourselves’, or *taziji* ‘himself’, where the bare reflexive *ziji* is preceded by pronoun *wo* ‘I’, *ni* ‘you’ or *ta* ‘he/she’. The pronouns that precede *ziji* can also be marked for number, so the complex reflexives are generally less ambiguous than the bare form. In the case of *taziji* ‘himself’, a different character is written for the pronoun component depending on the gender of the referent, but there is no accompanying difference in pronunciation. It is generally

suggested in the literature that the bare reflexive *ziji* can be bound either locally or long-distance, but that the complex reflexive *taziji* tends to be more locally bound (Huang and Tang 1991, see Yu 1998, 2000 for arguments that all Mandarin reflexives can be locally-bound, long-distance-bound or even free). It could be argued that the distant antecedent preference we found in the first experiment was driven by this. It could be the case that people preferred distant referents as reflexive antecedents because the bare reflexive *ziji* was used. Using the bare reflexive rather than the complex reflexive might be taken as a cue for the distant antecedent, since the complex reflexive should have been used for the local antecedent. In order to investigate this possibility, another self-paced reading time experiment was conducted. The experimental stimuli were identical to those used in Experiment 1 except that the bare reflexive *ziji* was replaced by the complex reflexive *taziji*. We predict that if the complex reflexive *taziji* is more likely to be locally bound, then we would expect to find that people in general prefer local antecedents over distant ones regardless of verb biases manipulations. On this view, whether the sentences contain DO-bias or SC-bias verbs should not influence people's antecedent preferences, and the reading times should be slower on the disambiguating verb region whenever it disambiguates toward the distant noun.

Method

Participants

32 native Mandarin speakers were recruited at the University of Illinois (11 males, mean age 26) to participate in this study.

Materials & Procedures

All the procedures were the same as in Experiment 1, and the stimulus sentences

were identical to Experiment 1 except for the replacement of *ziji* with *taziji*.

Results and Discussion

The reading time results are presented in Figure 3. As in Experiment 1, there was a main effect of verb bias at the region immediately after the reflexive which was read more slowly after DO-Bias verbs than after SC-bias verbs ($F(1, 31) = 24.14, p < .001$). In both RT studies, reading times for the region after the reflexive suggested that readers adopted different strategies for resolving the reflexives based on verb bias. They tried to resolve the antecedent of the reflexive immediately only when verb bias suggested the clause might end soon.

Also as in Experiment 1, there were no significant main effects of verb bias or semantic disambiguation at the disambiguating verb region, but unlike Experiment 1 the interaction reached significance ($F(1,31)=10.88, p < .05$) for this region. The interaction arose because there was still a preference for the distant antecedent in sentences with DO-bias verbs, but the preference was reversed in sentences with SC-bias verbs (when sentences were semantically biased to local antecedents, $F(1,31)=14.20, P < .01$). Given differences in how *ziji* and *taziji* tend to be used, together with results of Experiment 1, there were two predictions that were not confirmed by this pattern of results. It was predicted that there would again be no antecedent preference in sentences with SC-bias verbs, but in fact there was a preference for local antecedents. This preference for local antecedents was at least in the direction that would be expected from how *taziji* tends to be used. However, in sentences with DO-bias verbs, the preference was for distant antecedents, just as it was in Experiment 1 for *ziji*, which was not expected.

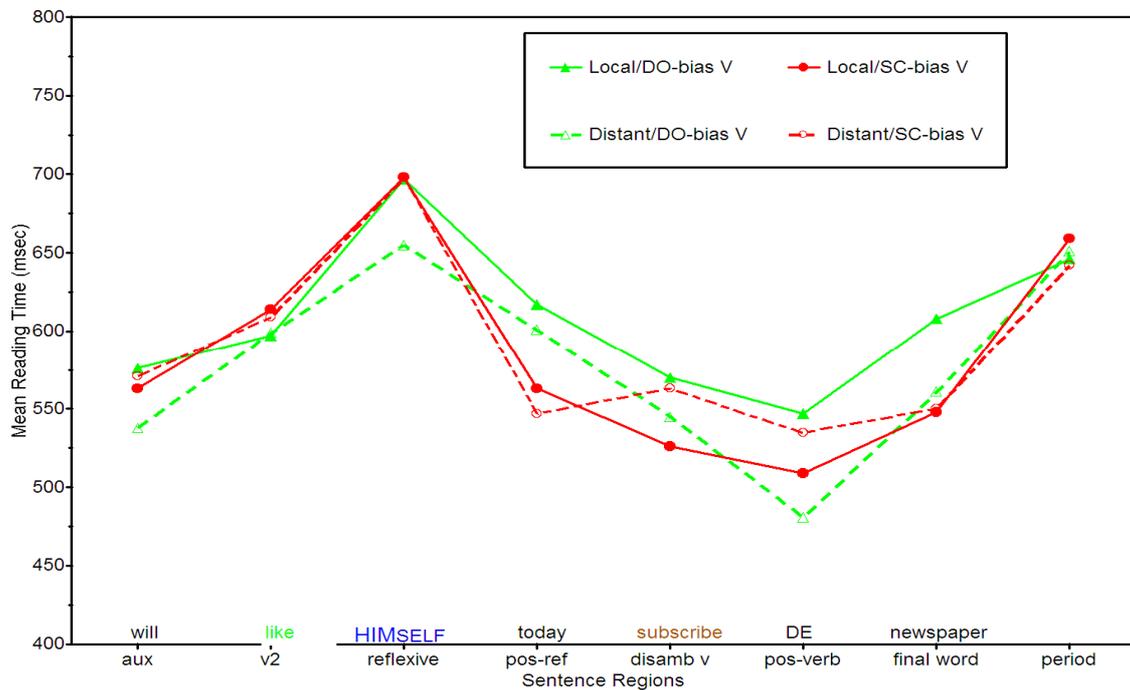


Figure 3. Word-by-word Reading Times for Sentences with the Complex Reflexive *taziji*

The disambiguating verbs in the SC-bias verb condition were read faster when the meanings of the disambiguating verbs biased the interpretation of the reflexive toward the local antecedent. This portion of the results confirms native speakers' intuitions, as described in the linguistics literature, that the complex reflexive prefers local antecedents. However, there was the opposite preference in sentences containing DO-bias verbs, which is not consistent with native-speaker intuitions. The results reported here suggest that the local antecedent is not always the default selection for the complex reflexive. Depending on the verb bias information available earlier in the sentence, people have different preferences for antecedents. In the discussion of Experiment 1, it was argued that DO-bias verbs led people to resolve the bare reflexive quickly, and in those cases they chose the distant antecedent, while SC-bias verbs led them to hold off and wait for more information. It was expected that they would again resolve the complex reflexive

quickly in sentences with DO-bias verbs in this study but that their choice would be the local antecedent, based on native speaker intuition. They did indeed again resolve quickly, but contrary to expectation they chose the distant antecedent for the complex reflexive just as they had for the bare reflexive in Experiment 1. Maybe when readers feel they need to resolve the antecedent of a reflexive quickly, their initial choice is whichever of the possible antecedents is most prominent in working memory, which is typically the first-mentioned one. In that case, if they hold off on resolving the antecedent of the reflexive after SC-bias verbs, then the pattern across the two studies is consistent with native speaker intuitions. According to those, *ziji* can be bound either locally or long-distance, while *taziji* is much better when bound locally. Consistent with that, the reading times in sentences with SC-bias verbs showed no preference for *ziji* and a local antecedent preference for *taziji*.

The end-of-sentence judgment times and accuracy showed that people had a preference for the complex reflexive to refer to the local antecedent regardless of verb biases (Figure 4). People answered 80% of the comprehension questions incorrectly for both DO-bias and SC-bias sentences when those sentences were disambiguated toward distant antecedents, indicating that they thought the complex reflexive should refer back to local antecedent. This matches native speaker intuitions about the complex reflexive but not the pattern of reading times at the disambiguating region of the sentences. For both the end-of-sentence comprehension questions and for native speaker intuitions reported in the literature, the response is a deliberative one made upon seeing the whole sentence. The fact that the pattern was different in online word-by-word reading times suggests that the decision reached by the end of the sentence differs from the first one entertained while reading the sentence. The response times for answering the

comprehension questions provides some support for this idea in that they patterned similarly to the online reading times. When people answered the comprehension correctly, they were slower after sentences with SC-bias verbs where *taziji* was disambiguated toward the distant antecedent (3897 vs 3229 ms), and slower after sentences with DO-bias verbs they were slightly slower if the sentences disambiguated toward local nouns (3287 vs 3225ms). This pattern suggests that they may have still needed more time to revise their initial choice of the distant antecedent in sentences with DO-bias verbs of the reflexive, but that they successfully did so eventually.

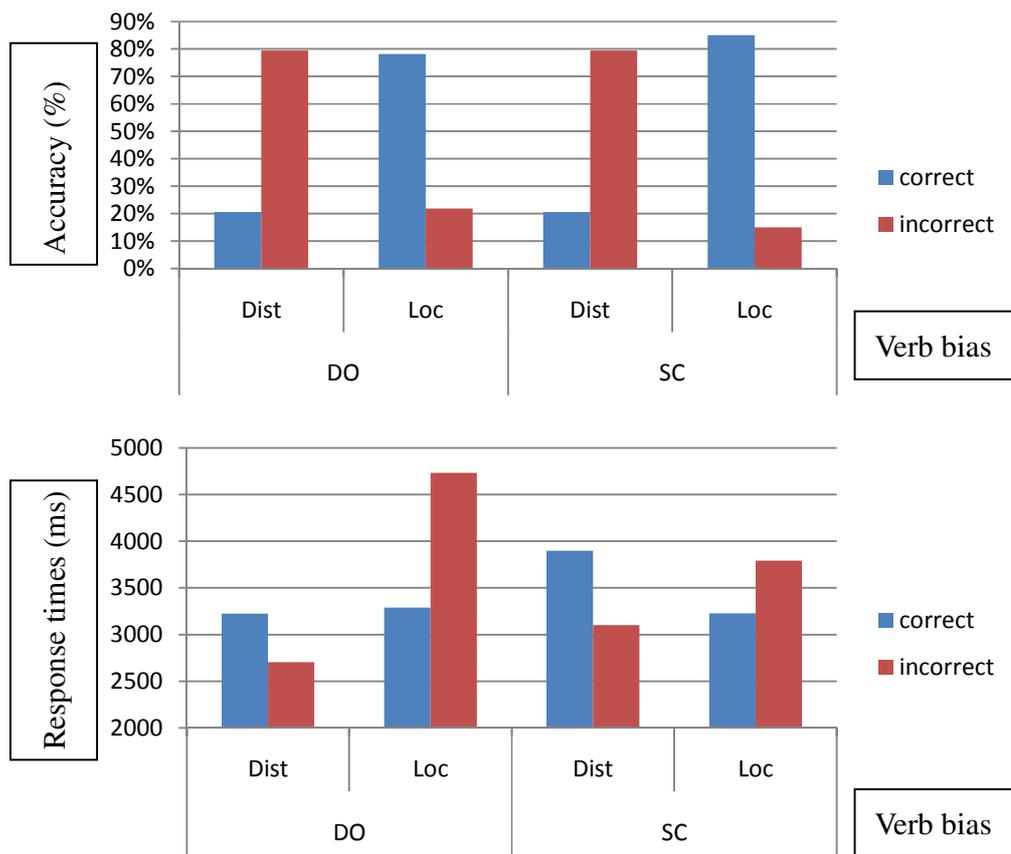


Figure 4. Experiment 2 Accuracy (upper panel) and Response Times for Comprehension Questions

The pattern of results across Experiments 1 and 2 suggest that the distant noun preference found for the bare reflexive *ziji* in the DO-bias condition in Experiment 1 was not due to the availability of another more locally bound complex reflexive *taziji* in the language, since the same preference was found for the complex reflexive in Experiment 2. It would appear that readers feel they have to resolve the reflexive quickly after DO-bias verbs because the clause is likely to end soon, and that under those circumstances they choose the distant antecedent for both the bare and complex reflexives, presumably because its first-mentioned status makes it more prominent in working memory. In sentences with SC-bias verbs, readers seem to wait for more disambiguating information to come, and under those circumstances they have no preference for one antecedent over the other for the bare reflexive, but prefer the local antecedent for the complex reflexive. The pattern in sentences with SC-bias verbs matches both the accuracy and response times for the end-of-sentence comprehension questions in both studies, as well as native speaker intuitions about antecedent preferences.

To further explore the different patterns of results found for the word-by-word reading times and question responses in Experiments 1 and 2, as well as how they might relate to the native speaker intuitions reported in the literature, several offline studies were conducted using the same stimuli and those are reported in the next section.

CHAPTER 4: REFLEXIVE RESOLUTION WITH PARTIAL INFORMATION AND WITH CROSS SENTENCE CONTEXTS

4.1 Experiment 3: Reflexive Resolution with Partial Information

In Experiments 1 and 2, the meaning of the last verb in the embedded clause was manipulated to see whether people have antecedent preferences for interpreting bare and complex reflexives in Mandarin. There were some mismatches between the word-by-word reading times and responses to the end-of-sentence comprehension questions, suggesting that readers' interpretation of reflexives evolved over time. The next set of studies ask how the partial information available at different points in the sentences used in Experiments 1 and 2 constrain the evolving interpretation of the reflexive, using both offline and partially online sentence completion paradigms as well as forced choice judgment tasks.

4.1.1 Sentence Completion Task with Bare and Complex Reflexives

In the sentence completion task, people were asked to complete sentence fragments containing either the bare reflexive *ziji* or complex reflexive *taziji*, illustrated in example (13) below. The assumption was that if people had consistent antecedent preferences by then in the sentence, they would write continuations consistent with those preferences. 80 experimental stimuli were divided into 4 lists. Each participant created 30 sentences (20 experimental items and 10 fillers). 72 undergraduate students (42 males, mean age = 21.9) from National Taiwan University participated in this task with the bare reflexive. Another group of 30 undergraduate students from National Cheng-chi University (23 females, mean age = 21.4) completed the task with the complex reflexive. Each of them completed

the whole 80 experimental stimuli and 15 fillers.

(13) 報童 宣稱 訂戶 會 喜歡 自己/他自己_____

—
baotong xuancheng dinghu hui xihuan ziji / taziji
 newsboy claim subscriber will like SELF/himself
 ‘The newsboy claimed that the subscriber will like self/himself.....’

Participants’ sentences were coded into 3 categories. Answers were classified into continuations that disambiguated the reflexive toward the distant noun or toward the local noun, or continuations that did not clearly disambiguate the reflexive. Results are shown in Table 1. There was no overall preference for either antecedent for the bare reflexive *ziji*, but there were preferences when the sentences were divided up according to verb bias. People were more likely to continue the fragments with the distant noun as the antecedent of the reflexive if the sentence had a DO-bias verb (46%), but with the local noun as the reflexive antecedent if the sentence had a SC-bias verb (54%).

	Distant noun %	Local noun %	Ambiguous %
Overall percentage	42	42	16
DO-bias verbs	46	29	25
SC-bias verbs	38	54	8

Table 1. Percentages of Continuations with Each Antecedent in a Sentence Completion Task for *ziji*

The continuation patterns in the sentences with DO-bias verbs were consistent with the reading time findings in Experiment 1, in that people showed a preference in both studies for the distant antecedent. In sentences with SC-bias verbs, however, people had not yet chosen an antecedent for the reflexive when they reached the disambiguating verb in the

word-by-word reading study, but when they were forced to make a choice in order to write a continuation, they showed a preference for the local antecedent. Perhaps when they had not already chosen the distant antecedent for the reflexive, as they apparently had for sentences with DO-bias verbs, they found it easier to come up with a continuation using the most recent noun, i.e., the local antecedent.

	Distant noun %	Local noun %	Ambiguous %
Overall percentage	36	43	19
DO-bias verbs	36	35	28
SC-bias verbs	38	52	10

Table 2. Percentages of Continuations with Each Antecedent in a Sentence Completion Task for *taziji*

The sentence completion results for the complex reflexive *taziji* are shown in Table 2. Overall people completed sentences with more local noun continuations (~43%). When sentences were divided up according to verb biases, it became clear that the overall effect was carried entirely by fragments containing SC-bias verbs. Consistent with both the on-line reading time data in Experiment 2 and with native speaker intuitions, there was a preference for *taziji* to refer to the local antecedent. However, inconsistent with the online reading times, there was no antecedent preference in fragments with DO-bias verbs. This could actually be taken as additional evidence for a preference for distant antecedents in sentences with DO-bias verbs, on the following logic. Given the purported local antecedent preference of the complex reflexive *taziji*, one would expect to see more continuations with local antecedents. The fact that just as many fragments were completed with disambiguation toward the distant antecedent suggests that the distant antecedent had substantial influence.

4.1.2 Forced-choice Task on Bare and Complex Reflexives

In the off-line sentence completion task, a substantial number of the fragment completions remained ambiguous. To get around that, another two forced-choice off-line studies were conducted. In the first forced-choice task, people were asked to choose all the antecedents that they think were possible for the given sentence fragments. The same sentence fragments were used, but participants were given four choices were provided, as illustrated in (14). The 80 experimental stimuli were divided into 2 lists and each person read 50 items in total (with 40 experimental items and 10 fillers). 62 undergraduate students from National Taiwan University (39 male, mean age= 21.9) performed the forced choice task with the bare reflexive *ziji*, and another 57 graduate students from National Normal University or National Jiao-Tong University (42 females, mean age=30) performed the task with the complex reflexive *taziji*. Results are shown in Tables 3 and 4.

(14) Sentence fragments:

報童 宣稱 訂戶 會 喜歡 自己/他自己.....

baotong xuancheng dinghu hui xihuan ziji... /taziji.....

Newsboy claim subscriber will like SELF/HIMSELF.....

‘The newsboy claimed that the subscriber will like self/himself.....’

Choices:

1)報童 2)訂戶 3)兩者皆是 4)其他
newsboy subscriber both others/neither

Overall there was a preference for distant noun antecedents, but this effect was driven entirely by the sentences with DO-bias verbs, which had a preference for the distant antecedent. In sentences with SC-bias verbs, there was no preference. The pattern of results matches that found for reading times in Experiment 1 quite closely. In both studies,

people did not consistently choose one antecedent over the other in sentences with SC-bias verbs, but they did in sentences with DO-bias verbs and what they chose then was the distant antecedent.

	distant noun %	local noun%	both %	Other/Neither %
Overall percentage	55	42	3	0.2
DO-bias verbs	62	36	4	0.1
SC-bias verbs	49	48	3	0.3

Table 3. Percentages of Antecedent Selection in a Forced-choice Task for *ziji*

Comparing the results for the bare reflexive across the online reading time study and the offline sentence continuation and forced choice tasks, there was always a preference for the distant antecedent. However, in sentences with SC-bias verbs, there was either no antecedent preference (self-paced reading and forced choice task) or a preference for the local antecedent (sentence continuation task). So it was only when participants had to come up with a sentence continuation that they consistently chose an antecedent for the reflexive. It may be that they chose the local antecedent in that circumstance because it was easier to construct a sentence using it.

	distant noun %	local noun%	both %	Other/Neither %
Overall percentage	39	54	6	0.35
DO-bias verbs	45	48	7	0.44
SC-bias verbs	34	61	5	0.26

Table 4. Percentages of Antecedent Selection in a Forced-choice Task for *taziji*

The results of the forced-choice task on antecedent selection for complex reflexive *taziji* are shown in Table 4. The pattern was the same as that found in the completion task for

these reflexives, i.e. no antecedent preference in sentences with DO-bias verbs and a preference for the local antecedent in sentences with SC-bias verbs. Unlike for *ziji*, this pattern does not match the pattern in self-paced reading times for these sentences, which showed a preference for distant antecedents after DO-bias verbs and no preference after SC-bias verbs.

4.1.3 Self-paced Sentence Continuation Decision Task on the Bare Reflexive

The four off-line studies presented so far suggest that there is sufficient information in the sentence fragments up through the reflexive to lead people to consistent preferences for one antecedent over the other at least some of the time. However, these offline studies did not directly tap into the time course of people's decisions. Therefore, a self-paced reading experiment was conducted to investigate people's decision making and reading times on sentences fragments containing the bare reflexive. Sentences fragments up through the post-reflexive region and then two verbs were presented and participants had to choose which was the better next word. The two verbs that were given as alternative continuation choices were the verbs that were used in the full sentences presented in Experiment 1 to disambiguate toward either the distant or the local antecedent. If people had a preference for one antecedent over the other, they should choose the alternative consistent with that preference

Method

Participants

30 native Mandarin speakers recruited from Taipei Municipal University of Education in Taiwan (29 females, mean age 19.7) were recruited to participate in this study.

Materials & Procedures

In this continuation selection task, people were asked to read sentence fragments like (15a). These experimental sentences were all taken from Experiment 1. The only difference was that fragments that ended after the post-reflexive region were presented and then followed by a 2-choice forced choice task. Each fragment was presented all at once on the screen. Participants read the whole fragment then pushed a button to get the two verbs to choose between. As soon as they pressed the button, two alternatives were presented simultaneously on the screen, as illustrated in (15b).

(15) a) Sentence fragment:

報童 宣稱 訂戶 會 喜歡 自己 今天
baotong xuancheng dinghu hui xihuan ziji jintian
newsboy claim subscriber will like SELF today

“Newsboy claimed that the subscriber will like (self) today...”

b) Alternatives:

1) 訂閱 2) 送達
dingyue ‘subscribe’ *songda* ‘deliver’

These alternatives were verbs that disambiguated toward either to the distant noun or the local noun as the antecedent of the reflexive, and were the verbs used for that purpose in Experiments 1 and 2. Which verb was on the left and which on the right was counterbalanced. Each participant read 128 sentences (48 fillers) in total, the same as in Experiments 1 and 2.

Results and Discussion

Table 5 summarizes participants’ verb choices. The pattern was similar to that found in the offline sentence completion task, in that people were more likely to select verbs

that disambiguated toward distant nouns in sentences with DO-bias verbs, and verbs that disambiguated toward local nouns in sentences with SC-bias verbs. They also responded faster on the trials where their responses followed that pattern, as shown in Figure 5.

Vbias	Disambiguate to Distant noun	Disambiguate to Local noun
DO	55%	45%
SC	45%	55%

Table 5. Percentages on the Selection of the Alternatives for Bare Reflexive in the Continuation Decision Task

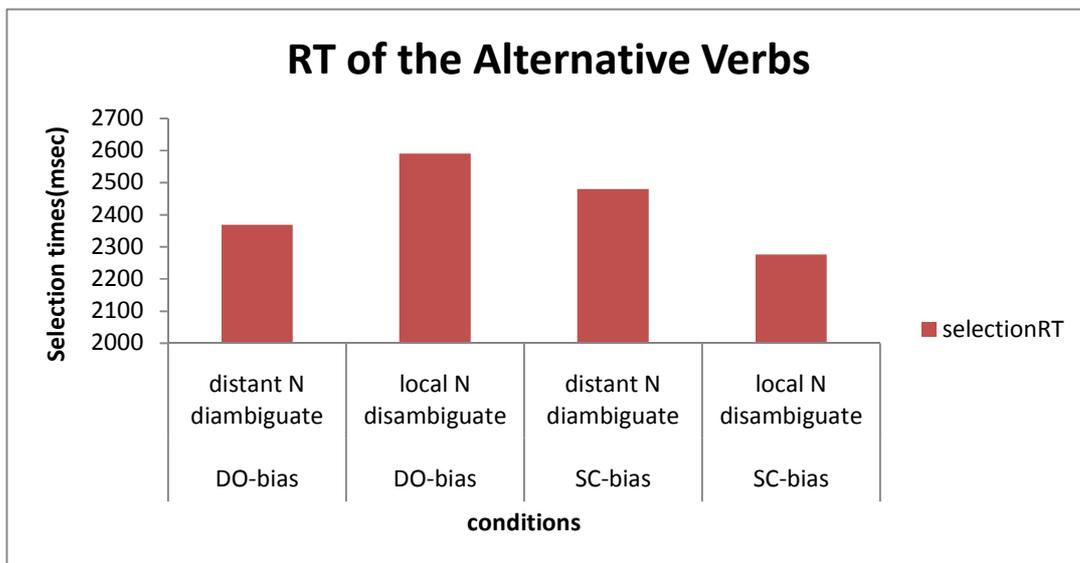


Figure 5. Selection Times for the Alternative Disambiguating Verbs for the Continuation Decision Task

The main effects of verb bias ($F(1,29)=4.58, p<.05$) and the interaction of verb bias and which antecedent the verb disambiguated toward ($F(1,29)=4.37, p<.05$) were both significant in the time measure. In general, people were slower in responding in the DO-bias conditions, and they were slower when they chose the verb that was less often chosen in that condition.

4.1.4 General Discussion of Online Reading Time Studies and Offline Studies

In this chapter, sentence fragments were used to investigate whether people can make use of available information to process reflexives, or instead wait for disambiguating information. For the bare reflexive *ziji*, the results of the offline sentence completion task patterned with the on-line sentence continuation decision task, in that distant nouns were preferred in sentences with DO-bias verbs and local nouns were preferred in sentences with SC-bias verbs. The offline forced-choice task, however, patterned with the reading times in Experiment 1, with a preference for distant antecedents in sentences with DO-bias verbs and no antecedent preference in sentences with SC-bias verbs. Thus, across all of the experiments there was always a preference for the distant antecedent in sentences with DO-bias verbs, but whether there was a preference in sentences with SC-bias verbs varied across tasks. No preference was found in the online reading times or in the forced choice tasks and a preference for the local antecedent was found in the sentence completion and forced-choice completion tasks. For the complex reflexive *taziji*, the results of the two off-line tasks patterned similarly, with a preference for local antecedents after SC-bias verbs but no preference after DO-bias verbs. However, this pattern was different from that found in the online reading study, where there was a preference for the distant antecedent after DO-bias verbs. The different response patterns might come from the nature of the on-line and off-line tasks. In the self-paced reading task, all the information was not immediately available for readers. Rather, readers received information piece by piece as they controlled their reading speed with button presses. By doing so, they were more likely to experience the time pressure of updating their mental representation of the sentence so far. They had to make decisions on every word about whether to press the button to go on to next word and they could not

look back to reread earlier words. The off-line tasks did not have similar time constraints. People got all the sentence information at once, and they could read back and forth as many times as they wanted. The decisions could be made later in the off-line tasks. Maybe the reason for a preference for the distant antecedent for both the bare and complex reflexives in the two reading time studies is because of these properties of the online reading task. Perhaps the time pressure imposed by the on-line task plus the expectation that sentences with DO-bias verbs would end soon led people resolve the reflexive to the antecedent that was most prominent in working memory, which would usually be the distant antecedent because it was first-mentioned and a subject. Because readers expected more to come in the sentences with SC-bias verbs, there was less pressure to make choice and they waited.

The off-line norming results also suggested that people applied verb bias information in reflexive resolution fairly quickly, and whether or not people were given sentence fragments or complete sentences, the antecedent preferences were generally consistent across experiments. People did not wait to interpret the reflexives, but rather used currently available information such as verb bias in interpreting the reflexives. This is consistent with Dillon et al. (2009)'s argument that readers did not necessarily rely on predicate information in order to interpret the reflexives in non-canonical SOV structures in Mandarin.

Verb bias seemed to influence both selection of the antecedents of reflexives and the time course of those selections. People tried to resolve the reflexives sooner after DO-bias verbs than after SC-bias verbs. When there were preferences about antecedents, they were affected by verb bias. For the bare reflexive *ziji*, the subject of the matrix clause was preferred after DO-bias verbs, while there was no particular preference after

SC-bias verbs. For the complex reflexive *taziji* there was a local antecedent preference after SC-bias verbs. In the cases where no preference was observed, it is still an open question whether people simply had not yet tried to disambiguate the reflexives yet, or did resolve them but were not consistent enough across sentences for any preference to emerge. In order to investigate this question, in Experiment 4 one-sentence contexts were added before the target sentences that contained reflexives.

4.2 Experiment 4: Reflexive Resolution with One Context Sentence

The self-paced reading time studies and offline surveys reported above investigated the contributions of within-sentence structural and semantic factors in processing Mandarin reflexive sentences in isolation. Since the Mandarin reflexive *ziji* can take a referent outside the local clause as its antecedent (i.e. people may have to search back to earlier sentences to find possible antecedent nouns), contextual information may influence how *ziji* is interpreted. As previously stated, Chen et al. (2000) have found that the preference for subjects as antecedents for pronouns in Mandarin can be overridden by context. Gordon and Scearce (1995) used sentences with semantic disambiguation information before the critical pronoun. For example, people would read passages like (7) which is repeated below, but the critical sentence now read “After sending the papers, he/Bill began more work”, where the action of sending clearly disambiguates the pronoun to be the agent of the passage prior to where the pronoun is encountered.

- (7) (a) Bill wanted John to look over (b) some important papers.
(c) He had to mail him (d) the documents by Monday.

CONTINUE

- (e) Unfortunately, he/Bill (f) never sent the papers.

SHIFT

- (e') Unfortunately, he/John (f') never received the papers.
(g) As a result, the whole deal (h) fell behind schedule.

With such a design, they still found that local discourse structure continues to influence English pronoun interpretation even when the semantic information limited the interpretations before the critical pronoun. Findings in these pronoun studies suggested that the discourse structure is influential in language comprehension and readers evaluate multiple cues at the same time to derive interpretations. Therefore, in Experiment 4, we examine how discourse context influences Mandarin reflexive interpretation, including how discourse context interacts with the within-sentence structural and semantic context factors and when these cues come into play during processing. The prediction is that whichever potential antecedent is mentioned in the context will be more prominent and thus become the preferred antecedent for the reflexive.

Method

Participants

Thirty-four native Mandarin speakers from National Taiwan University in Taiwan (22 females, mean age 20.5, all right handed) participated in this study.

Materials

Critical target sentences were the ones used in Experiment 1. Each target sentence (see example (12a, 12b) repeated below) was preceded by one context sentence that

mentioned either the **Distant** (first-mentioned) noun (as in (16a)) or the **Local** noun (as in (16b)) in the target sentence.

(16) Context examples for **DO-bias** verbs

a. Context sentence mentioned the **Distant** noun

報童 受雇 於 一家 很有名的 報社。
baotong shougu yu yi jia hen youmingde baoshe
 newsboy was hired by one CL very famous newspaper (company)

‘The **newsboy** was hired by a very famous newspaper (company).’

b. Context sentence mentioned the **Local** noun

訂戶 正 打算 填寫 意見表 去 投訴。
dinghu zheng dasuan tianxie yijianbiaoqu tousu
 subscriber is plan fill out survey go complain

‘The **subscriber** is planning to fill out a survey form to make a complain.’

(12)

DO-bias verbs, **Local** antecedent

a. 報童 宣稱 訂戶 會 喜歡 自己 今天 訂閱 的 報紙
baotong xuancheng dinghu hui xihuan ziji jintian dingyue de baozhi
 Newsboy alleged subscriber will like self today subscribe DE newspaper

‘The **newboy** alleged that the **subscriber** will like the newspaper **self** (he) **subscribed** today.’

DO-bias verbs, **Distant** antecedent

b. 報童 宣稱 訂戶 會 喜歡 自己 今天 送達 的 報紙
baotong xuancheng dinghu hui xihuan ziji jintian songda de baozhi
 newsboy allege subscriber will like self today deliver DE newspaper

‘The **newboy** alleged that the **subscriber** will like the newspaper **he** **delivered** today.’

The context sentences mentioned one or the other of the possible reflexive antecedents in the target sentences, but the topic of the context sentences and of the target sentences were not the same. Coherent topics were intentionally avoided because it is hard to quantify the degree of coherence between the context and target sentences and to make sure it is matched for the two different context sentences. Another reason for not using coherent topics was to prevent readers from developing strong expectations about the contents of the target sentences. The goal was to determine whether simply mentioning a possible reflexive antecedent in the context was sufficient to influence antecedent choice.

A norming study was conducted to try to make sure that the acceptability of the target sentences following the context sentences did not differ across conditions. 33 undergraduate (all right-handed, 22 females, mean age = 20.45) students from National Taiwan University were asked to rate the acceptability of the target sentences when preceded by the context sentences on a 1-7 scale. Overall, people rated the target sentences as better continuations in the filler items than in the experimental items (rating mean: fillers=5.09 vs experimental items = ~3.5). Crucially, within the experimental items the ratings were not differ significantly between disambiguation verbs that biased to the **Local** noun or **Distant** noun (mean rating= 3.49 vs 3.57, $t < 1$), between **DO-bias** and **SC-bias** verbs (mean rating= 3.55 vs 3.50, $t < 1$), and between contexts that mentioned the distant and the local nouns (mean rating = 3.57 vs 3.48, < 1).

Procedures

The procedure was the same as in Experiments 1 and 2. 128 sets of sentences (80 experimental sets, 48 fillers) were used. Each context sentence was presented all together on the screen, and participants pressed a button when they were ready for the next sentence, which was then presented word by word as participants pushed a button to see each next word. Immediately after they finished reading the word-by-word target sentences, participants made yes/no response to comprehension questions. Unlike Experiments 1 and 2, only half of the comprehension questions in the current study specifically asked about the reflexive interpretations. The idea was to make sure participants were paying attention to the context sentences by asking about them on half of the trials.

Results and Discussion

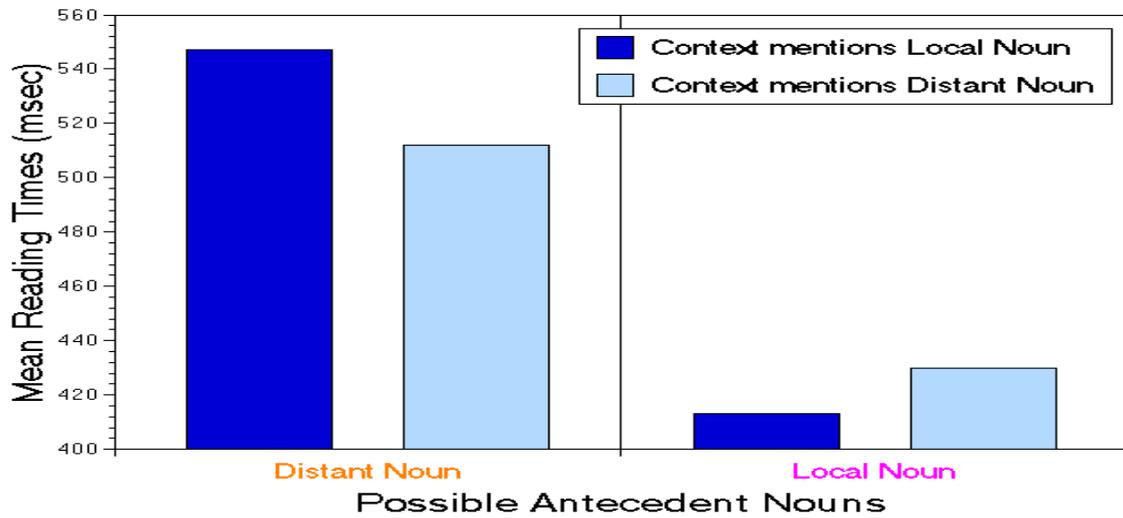


Figure 6. Reading Times on Possible Antecedent Nouns in the Target Sentences

Figure 6 shows the reading times on the two possible antecedent nouns themselves in the target sentences. For both nouns, there was a main effect for contextual bias at (Distant noun: $F(1,33) = 22.18$, $p < .001$, and for Local noun: $F(1,33) = 5.79$, $p < .001$). Thus, faster reading times were found for whichever of these nouns had been mentioned in the context sentence. Reading times were slower overall on the Distant Noun simply because it was the first word in the target sentence and reading times are usually slow on sentence-initial words.

Figure 7 shows the reading times for all conditions at the disambiguating verb region. At this position, the only thing that reached significance was the three-way interaction for context, verb bias and semantic disambiguation ($F(1,33) = 5.57$, $p < .01$). Contrary to the Experiment 1 results, there were no differences between conditions after DO-bias verbs. Thus, people did not have preferences for either antecedent for sentences after DO-bias verbs, and no effect of which noun was mentioned in the context. On the other hand, post hoc analyses showed that for sentences with SC-bias verbs, the

interaction between context and semantic disambiguation was significant ($F(1,33)=4.65$, $p<.01$). This interaction arose for the sentences with SC-bias verbs because reading times were faster whenever the reflexive *ziji* was resolved toward the antecedent noun that was mentioned in the context. If the semantic disambiguation guided people to a noun that was not consistent with the noun mentioned in the context, then the reading times were slower. There was a robust preference for *ziji* to refer to whichever antecedent that was mentioned in the Context.

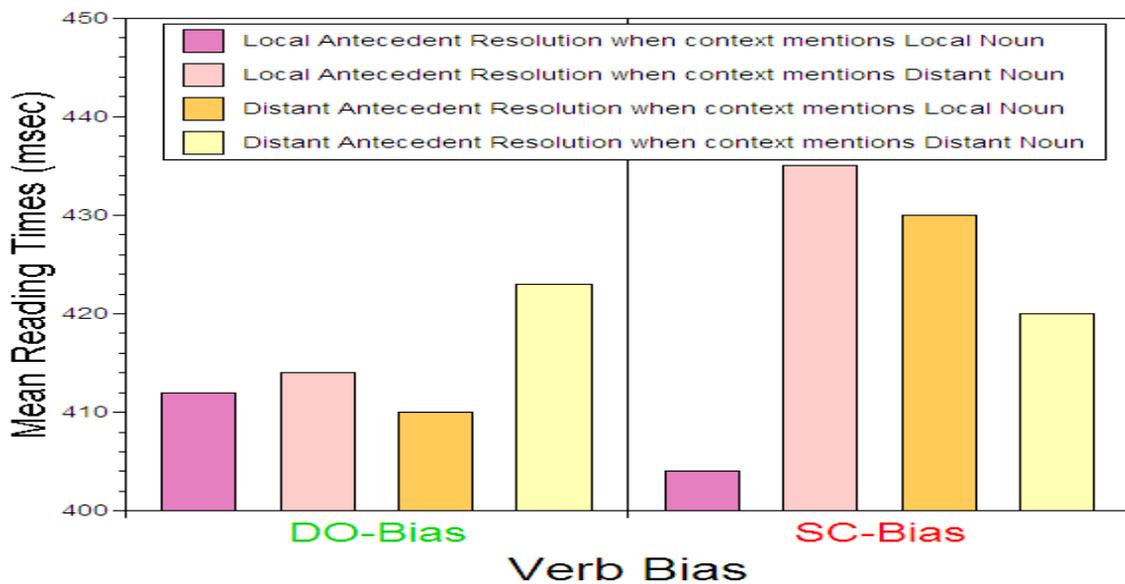


Figure 7. Reading Times on the Disambiguating Verbs in Experiment 4

In Experiment 1, it was argued that people tried to resolve *ziji* immediately after DO-bias verbs, but that they did not do so for sentences with SC-bias verbs because more disambiguating information could be coming. The same processing strategy could explain the results for the 2-sentence discourses used in Experiment 4. If people still tried to resolve *ziji* quickly after DO-bias verbs, there may not have been enough time for them to

successfully integrate the context and target sentences, which would explain the absence of a context effect in those sentences. The work they were still doing to integrate the two sentences may also have affected the relative prominence of the two possible reflexive antecedent nouns in the target sentence, with the result that there was no consistent antecedent preference at all for these sentences. Although there were no significant differences in the sentences with DO-bias verbs, numerically the condition where the context mentioned the distant antecedent and the disambiguating verb also disambiguated toward that distant antecedent was the slowest condition, when that might have been expected to be the fastest, given that there was a preference for distant nouns in sentences with DO-bias verbs in Experiment 1 and the context also promoted the distant noun here. Perhaps the repeated name penalty that has been observed for pronouns is having an effect here. Perhaps readers found it odd when the noun mentioned as the subject in the context sentences was repeated as the subject of the target sentence because it would be better to use a pronoun in the second sentence to refer to that entity, and that interfered with their resolution of *ziji*.

If readers waited for more information before trying to resolve *ziji* in this study as they did in Experiment 1, there may have been enough time to integrate contextual information so that it played a role in resolving *ziji*, since reading times on the disambiguating verb were faster whenever it disambiguated toward the antecedent mentioned in the context sentence.

As the explanations given above make clear, longer reading times can be due to various kinds of difficulty arising from different sources or with different time courses. It could be useful to employ a different kind of measure of processing difficulty to help sort out the various possible explanations for the patterns in the reading time studies. Toward

that end, an experiment was done using event-related brain potentials (ERPs) to monitor processing in sentences containing the bare reflexive *ziji*. As will be described in the next section, different components of ERP waveforms are sensitive to different kinds of processing difficulty, so it may be helpful to see which components are observed in response to sentences containing *ziji*.

CHAPTER 5: EVENT-RELATED POTENTIAL RESPONSES FOR BARE REFLEXIVE *ZIJI*

Reading time studies and off-line measures provided us with some understanding about the selection of reflexive antecedents, but one disadvantage of those measurements is that they might not be very sensitive to the time courses of the effects that we were interested in. For example, we manipulated local semantic information on the disambiguating verb to see whether people have any antecedent preferences. We found that people encountered some processing difficulties that resulted in longer reading times at that region, but many factors could have contributed to that. We were not sure if it was indeed the wrong expectancy about the reflexive antecedent that caused longer reaction times, or some other kind of processing difficulty that people might have had during reading. One possibility is that verbs that tend to take sentential complements are syntactically harder to process than verbs that tend to take direct object because embedded clauses are involved. Comparing across the online reading studies and the various offline studies also made it clear that task-related demands influenced reflexive resolution. It is possible that the requirement to push a button for each word in the reading times studies may have affected reflexive antecedent resolution, since it requires making a decision on every word about whether to go on to the next word yet. If that is true, it would be good to use a processing measure that does not require word-by-word decisions but still provides word-by-word data. Event-related potentials (ERPs) have that property, and they also provide a more multidimensional measure, with different components sensitive to different aspects of language processing.

ERPs are the subset of ongoing electroencephalographic activity (EEG) that are in response to some stimulus. EEG is measured using electrodes placed on the scalp. By

averaging across trials and across subjects, tiny voltage changes that are time-locked to stimulus events are revealed. Many studies have applied this technique to study various aspects of language processing (see Callahan 2008 for a review of ERP studies of anaphor processing). There are several advantages of using this technique. First, it records responses to words in sentences without requiring any overt behavioral responses to the words. Given that task demands have been shown to influence reflexive resolution processes in the studies reported here, that is an important advantage. Second, EEG can be measured continuously throughout a sentence and thus may be able to provide finer processing time course information than a technique collecting just one measure per word. Third, it is already established that there are different components of the ERP that are sensitive to different aspects of language processing, which may allow the teasing apart of different contributions to processing difficulty. A final advantage of ERPS that is not exploited here is that similar responses can be obtained for both written and spoken language

5.1 ERP Components

Several ERP components, including the N400, the P600, and the LAN (Left Anterior Negativity), have been observed across a wide variety of language studies. The names of ERP components typically reflect their polarity (positive, negative) and often their characteristic peak latency in milliseconds (N400, P600), and sometimes their scalp distribution (LAN). For example, the N400 ERP component is described as a negative-going voltage deflection peaking approximately 400ms (300-500ms) after the onset of the stimulus that evokes it, and it has centro-parietal maximum scalp distribution but is observed across much of the head. The P600 component is a positive-going voltage

deflection with a much more variable peak latency and a similar scalp distribution as the N400. The N400 ERP component is primarily sensitive to the ease of processing a meaningful stimulus, which often includes integrating it with a context, but it is also observed in response to isolated words. Kutas and Hillyard (1980) originally observed a larger N400 in response to a semantically anomalous word at the end of a sentence, but anomaly is not required to evoke the N400. Its amplitude has been found to reflect the degree of contextual constraint on words that are perfectly plausible (Kutas & Federmeier 2001,) the degree of predictability of a word from context, both in sentences and in word lists (cloze probability, Kutas and Hillyard 1984, Federmeier and Kutas 1999, semantic priming in word lists, Holcomb 1993, Misra et al, 2003), word frequency (smaller N400 for high frequency words, Van Petten and Kutas, 1990, 1991), and word repetition (smaller N400 for repeated words, Nagy et al. 1989, Rugg 1990, Van Petten et al., 1991). These studies suggest that N400 is related to several dimensions of semantic processing in language.

In contrast to N400, P600 has been found to be sensitive to aspects of form processing. It was originally observed in response to syntactic anomalies in sentences (Neville et al., 1991, Osterhout & Holcomb 1992). P600 can be elicited by grammatical violations such as tense, gender, number, case agreement as well as by phrase structure violations (Kaan & Swaab 2003) and garden-path sentences (Osterhout & Holcomb 1992). P600 has been argued to be an index of the reanalysis of sentence structures (Kaan & Swaab 2003), and/or the degree of effort required in building syntactic structure (Hagoort 2003a 2003b, Hagoort, Brown, & Groothusen 1993).

A third ERP component observed in response to sentences is the LAN, which is thought to be associated with increased demand on working memory and/or competition

between alternative structures or interpretations when there is ambiguity. The LAN was first observed by Kluender & Kutas (1993 a, b), who found increased negativity at left anterior electrode sites 300-500 msec after the onset of words that either began or ended some kind of long-distance dependency in a sentence. Subsequent studies on working memory (Munte, Schiltz, and Kutas 1998) and relative clause processing in English (King & Kutas 1995, Muller, King & Kutas 1997) found that the amplitude of the LAN was modulated by individual differences in working memory capacity. So the LAN seems to reflect the engagement of working memory in processing long-distance dependencies in sentences, but more evidence is needed to clarify whether and how the LAN is related to other frontally distributed negativities in the same time range but without the lateralized scalp distribution (Kutas et al. 2007), such as the Nref, which is a widely distributed negative deflection that has been observed when there is ambiguity about the referent of a referential word (see Van Berkum et al. 2007 for a review). When reading passages like (17) below, the noun phrase ‘the girl’ is referentially ambiguous in the last sentence in the (b) version because the context mentioned two possible referents whose gender matched the anaphoric noun, while it was unambiguous in the (a) version because only one of the two referents mentioned earlier in the context matched the noun anaphor in gender. Nref is observed at the anaphor in (17b) compared to (17a). Nref has also been found in response to pronoun anaphors whose antecedents are ambiguous, as in (18).

- (17) a. David had asked the boy and the girl to clean up their room before lunchtime. But the boy had stayed in bed all morning, and the girl had been on the phone all the time. David told the girl that had been on the phone to hang up.
b. David had asked the two girls to clean up their room before lunchtime. But one of the girls had stayed in bed all morning, and the other had been on the phone all the time. David told the girl that had been on the phone to hang up.

- (18) a. David shot at Linda as he jumped over the fence.
b. David shot at John as he jumped over the fence.

Van Berkum et al. (2007) have argued that Nref reflects something about establishing reference rapidly with respect to the situation model that readers build along comprehension. It is unclear at this point whether Nref and the LAN are different ERP components.

5.2 ERP Responses to Mandarin Reflexives

Li and Zhou (2010) investigated ERP responses to the Chinese bare reflexive *ziji*. In the sentences in their study, *ziji* was the sentence-final word and it was preceded by two possible antecedents. The meaning of the verb that immediately preceded *ziji* disambiguated it to either the local or the distant referent, or did not disambiguate so that the sentence remained ambiguous, as shown in (19).

- (19) Local reference: xiaoli/ asked / Xiaozhang/ not/ disguise /*ziji*
 “Xiaoli asked Xiaozhang not to disguise himself.”
- Long-distance reference: xiaoli/ asked/ Xiaozhang/ not/ embroil /*ziji*
 “Xiaoli asked Xiaozhang not to embroil himself.”
- Ambiguous reference: xiaoli/ asked/ Xiaozhang/ not/ scare /*ziji*
 “Xiaoli asked Xiaozhang not to scare himself.”

They found that ERP responses to the sentence-final reflexive were significantly more positive 300-750ms after word onset in the long-distance reference condition. They divided this up into two time windows, one 300-400 ms and the other 450-750 ms, which

they called P300 and P600, respectively. They argued that these were two separate effects based on which conditions patterned together during the different time windows and also based on differences in scalp distribution of the effects in the two time windows. In the earlier time window the distant referent condition was more positive than both the local referent and ambiguous referent conditions, which did not differ from each other, and this effect was widely distributed over the head, though largest at posterior electrode sites. In the later time window, however, it was the distant and ambiguous referent conditions that patterned together and both were more positive than the local referent condition, and this effect was more restricted to posterior sites. They suggested that the earlier effect could reflect the detection of incongruence between the mental representation based on binding principle A and the representation built on processing the local verbs, whereas the later effect could be associated with a second-pass integration of the reflexive and the matrix subject.

It is interesting that the ERP effects found by Li and Zhou were posterior positivities, seeming to indicate structural processing difficulty and reanalysis, rather than frontal negativities, which would indicate referential ambiguity and increased working memory load. Some aspects of their explanation of the pattern of results seem unlikely. First, while the positivities found in the Long distance binding condition could indicate the detection and integration of binding principle A and the mental representation built by the verbs as Li and Zhou (2010) suggested, it was not clear why the same level of the waveform amplitudes was not found in the ambiguous condition, where both long distance and local antecedents were possible. In ambiguous condition, both nouns were possible antecedents because the semantic of the verbs did not rule either one out. Since the long distance noun was also a possible interpretation of the reflexive created by the

local verbs, the same type of integration difficulties should be observed. Moreover, the mental representation created by the ambiguous verbs contained two nouns that need to be integrated. This was presumably a harder thing to do, compared to the integration difficulties that the other two conditions had (where the semantic of the verbs already limited down the possible antecedents, thus only one antecedent left to be integrated).

Another question was that they did not find other ERP components related to referential processing (i.e. Nref component in Van Berkum et al. 2007) in processing of Mandarin reflexives. Li and Zhou (2010) argued that no Nref was found in Mandarin because Van Berkum et al's stimuli remain ambiguous, whereas the Mandarin stimuli they used were consider less ambiguous comparing to Van Berkum et al's. Readers in the Mandarin study could build a mental representation based on the referent they selected for the reflexive, therefore no Nref was observed. However, this argument may require further investigation, since the reflexive *ziji* appeared sentence finally and there was no disambiguating information downstream, one could never be sure that readers did select a referent for the reflexive. Moreover, even if no Nref is observed in local and long distance conditions in Li and Zhou (2010), it should be observed in their ambiguous condition, since this type of sentences should remain referentially ambiguous and never had been resolved.

A third question was that all the critical word (the reflexive) was in the sentence final position. It has been established in several ERP studies that elements in the sentence final position may not only elicit a combination of a local ERP effect but also a global effect due to sentence wrap-up responses (Hagoort et al. 1993, Hagoort 2003b, Osterhout & Holcomb 1992). Such effects would make the findings harder to interpret, because one could not be sure that the less positive amplitudes found in the ambiguous condition was

due to ambiguous sentences eliciting more negative waves prior to the final word and thus made the waveform less positive, or because these ambiguous sentences were just easier to integrate and thus being less positive in the waveforms.

In our ERP study, we tried to avoid the possible sentence wrap-up effect by using the same sets of sentences used in the self-paced reading studies reported earlier, with the critical reflexive word appearing in non sentence-final position, and with a disambiguating point after the reflexive in the later part of a sentence. Having a disambiguating point had the advantages of allowing us to see whether people have preferences for antecedents and disambiguating the reflexive, because different ERP responses could be observed when people's selection is incongruent with the disambiguation. In addition, if people have decided a referent for the reflexive before reaching disambiguating verbs, sentences should be less ambiguous at the disambiguating region. By comparing among different conditions that disambiguate to different antecedents, we have a chance to better understand how Mandarin reflexive is processed.

5.3 Experiment 5: ERP Responses of Processing Bare Reflexive *ziji*

In experiment 5, bare reflexive resolution was revisited by using ERP measurement. There were several ERP components expected to be observed at different sentence regions. Based on Vos & Friederici (2003), positive deflections were observed if there was an assumed reanalysis process involved. If this is so, and if processing Mandarin reflexive involves constructing a simple mental representation first, and when this representation turned out to be wrong at the disambiguating region later, we should be able to see positive waveforms at the disambiguating region for different verb biases.

This is in accord with Li & Zhou's (2010) arguments that people built a representation based on the binding principle A first, so that the integration of long distance antecedents was more difficult and elicit more positive waveforms. However, we predict that with our current design, people first build a structure based on verb bias information, then sentences in the DO-bias conditions should be more positive than sentences in the SC-bias conditions at the region immediately following the reflexive. This is because people first build a direct object sentence structure after reading DO-bias verbs, and when it turned out to be wrong and sentences continued with an embedded clause, more positive waves should be observed, signaling a reanalysis process for the wrong structure. On the other hand, sentence with SC-bias verbs would be less positive compared to sentences with DO-bias verbs, because there is no need to reanalyze the sentence structure when sentences continued with clause structure that is the same as the SC-bias verbs predict. Thus, we should be able to find a reanalysis process for DO-bias verbs not for SC-bias verbs in the post-reflexive region.

According to Li & Zhou (2010), reflexive that had long-distance interpretations was more positive than the other conditions. We could compare this result with the data at our disambiguating region where sentences were disambiguated toward one of the referents. We would expect to see sentences disambiguating toward the long-distance nouns in our studies were also more positive than those disambiguate toward local nouns. If verb biases had an effect on reflexive processing, as we found in our previous reading time studies, we might expect to see some interaction between verb biases and disambiguation as well. Previously we found a Distant antecedent preference for DO-bias verbs, suggesting that people found local antecedents harder to process, and thus resulted in longer reading times. Therefore, ERP responses toward different antecedent

disambiguation within the DO-bias verb condition should be different at the disambiguating verb region, given that the unexpected local antecedent disambiguation is harder to integrate than the preferred distant nouns. Such effect is expected to be larger after DO-bias verbs than after SC-bias verbs, because no antecedent preference was observed after SC-bias verbs and the incongruence between people's preferred antecedents and disambiguation should be less.

Li and Zhou (2010) did not find other ERP components to be relevant to reflexive processing and argued that the positivity they observed is related to reanalysis process and long-distance coreference. Nevertheless, it is possible that syntactic reanalysis is not the only aspect of reflexive processing that could be observed. With our design, reflexive processing might as well be involved with semantic processing such as matching the intended antecedents with the disambiguating information. The incongruence might instead elicit semantic related ERP components like N400 or anterior negativities. For example, N400 could be found at the disambiguating verb region. In that region, verb meanings were manipulated to resolve the reflexive toward one of the possible antecedents. If people have expectancies about certain antecedents, then they would be surprised when they read the verbs that biased them toward the other antecedent, and this violation in expectancy would also result in a larger N400. If we find N400 at this disambiguate verb region, it might be an indication that people have a preference for antecedents prior to the disambiguation.

It is also possible to find LAN in our design, if LAN indexes dependencies processing difficulties. The more distant antecedents are supposedly to be associated with more processing load because they are far away from the reflexive compared to local antecedents. Although the current design is not testing filler-gap dependencies where

LAN is observed, it is a type of long-distance dependency that requires people to search back. We expect to find these negativities at the disambiguating verb region in conditions where the interpretations were semantically biased toward long-distance anaphors, because it might index difficulties of integrating verbs to an anaphor that is far away.

We might also be able to observe Nref (Van Berkum et al. 2007) that are found in processing referential ambiguous phrases. It is possible that we can observe Nref in the reflexive region of the SC-bias verb condition because following what our previous behavioral results suggested, people might not have decided the exact referent yet for the reflexive, and the reflexive is referential ambiguous at this point. Alternatively, we could find it at the disambiguating region of the SC-bias verb condition. If people do not resolve the reflexive because they expect to get more information in the SC-bias verb condition, then the reflexive will remain ambiguous at the disambiguating region. So, it is possible that we observe a sustained negativity that reflects such referential ambiguity in both post-reflexive and disambiguating verb regions for the SC-bias verb condition. Since people are likely to already select an antecedent for the reflexive after DO-bias verbs and the reflexive is not ambiguous under that circumstance, we will not expect to see DO-bias verb conditions to be more negative than SC-bias verb conditions.

Method

Participants

19 native Mandarin speakers were recruited in Taiwan (16 females, mean age 21.5) for their participation. All of them were right-handed, had normal or corrected-to-normal vision and no history of any neurological brain damage or cognitive disorders.

Design and Materials

The 160 experimental stimuli were identical to those used in our previous self-paced reading studies. There were 40 DO-bias and 40 SC-bias verbs. For each verb, two sentences were created, one sentence disambiguated toward local antecedents and the other toward distant ones. These two versions of sentences were exactly the same, except the disambiguating verb. So the design is 2x2 (verb bias x disambiguation). These 160 experimental stimuli were divided into 2 lists. Each participant read 80 experimental sentence plus 66 fillers (146 sentences in total). We increased the amount of the fillers to include various different sentence structures and anomalous sentences for the purpose of finding a baseline for component like N400. Also, we created another 2 lists in order to counter balance the yes/no comprehension questions. Sentences in these 2 new lists were identical to the original lists, the new lists just differ in the yes/no answers of the comprehension questions. So previously ‘yes’ answers in the original lists would become ‘no’ answers in the new lists and vice versa. The 146 sentences in each list were divided into 3 blocks, with the first 2 blocks containing 49 sentences and the last one 48 sentences.

Procedures

Each sentence was presented word by word at the center of a computer monitor, in white font against black background. In each block, participants first saw a text “READY #”, where # was the trial number for each block, at the center of the screen for 1000ms. This was functioning as a fixation point. After it disappeared, experimental trials started. Each word was presented for 500ms with a 150ms inter-stimulus interval (ISI) between words. The last word of each trial is a period mark to signal the ending of the

experimental sentence. Right after the period was presented, a comprehension question showed up on the screen until participants made a yes/no judgment or for 8 seconds, whichever came first would terminate the trial. Participants then got feedback for their responses or no response. If participants did not make a judgment within 8 seconds, a “TOO SLOW” feedback in Mandarin would be presented as a feedback for their no response, and it terminated the trial to proceed to the next. If participants made either yes/no judgment within 8 seconds, the feedback they received did not reveal any correctness information. They received a message like “SELECTED” instead. No substantial correctness information feedback was offered because all the comprehension questions were implicitly directed to test participant’s selection of the antecedents. The accuracy of their answers was based on our intended disambiguation, but participants might not agree. In order not to bias participants’ reflexive interpretations, we decided not to reveal their accuracy of answering the questions in the feedback. After the feedback was given, trial proceeded to the next. All the ISI between trials were set to be 500ms. So it was a 500ms wait between the end of the feedback and the “READY #” fixation of the next trial.

Participants was instructed to silently read sentences in Mandarin that were presented word by word on screen, and responded to the comprehension questions by clicking the left mouse button for ‘yes’ answers and right mouse button for ‘no’ answers afterwards. In order to avoid eye movements as much as possible, participants were instructed not to blink too much during the word by word presentation. They could blink at the “READY” fixation or blink freely after the period mark was presented. They were given a practice session containing 5 sentences to familiarize themselves with the procedures before the experimental blocks started. Experimenters communicated with

participants through microphone between blocks, and experimenters who were outside the data collection room during data collection monitored participants' conditions via a video camera. The entire EEG data collection session, starting from electrode application to removal, approximately lasted about 2 to 2.5 hours.

EEG Recordings

Participants were seated in a sound-attenuated and electrically shielded room, with a viewing distance of 1m to the monitor. The electroencephalogram was recorded from 64 sintered Ag/AgCl electrodes mounted on an electrode cap (QuickCap, Neuromedical Supplies, USA). The location of the electrodes followed the International 10-20 system, in which 2 supra- and infra-orbital electrodes (VEOG channel) were placed above and below participants' left eye to monitor vertical eye movements like blinks. Horizontal eye movements were monitored by another 2 electrodes placed at the outer canthi (HEOG channel). There were also 2 electrodes placed on the right and left mastoid and all the signals were on-line referenced to the bilateral mastoid. The electrodes were localized at the following positions: FP1, FPZ, FP2, AF3, AF4, F7, F5, F3, F1, FZ, F2, F4, F6, F8, FT7, FC5, FC3, FC1, FCZ, FC2, FC4, FC6, FT8, T7, C5, C3, C1, CZ, C2, C4, C6, T8, M1, TP7, CP5, CP3, CP1, CPZ, CP2, CP4, CP6, TP8, M2, P7, P5, P3, P1, PZ, P2, P4, P6, P8, PO7, PO5, PO3, POZ, PO4, PO6, PO8, CB1, O1, OZ, O2, CB2, HEOG, VEOG, GFP, REF. Electrode impedances were controlled to be below 5k Ω . The EEG signals collected through the cap were then amplified by two 16bit AC amplifiers (Synamp) by NeuroScan with a band-pass at 0.1-30Hz. The EEG was continuously recorded and digitized at a rate of 200Hz.

EEG Analysis

The EEG data were re-referenced to the average of the left and right mastoid again off-line for analysis. Then, ERPs were computed for each participant over an epoch starting from 100 ms before the stimulus onset to 1000 ms after, and used the 100ms pre-stimulus interval for baseline correction. Artifact rejection was performed in two stages. First, epochs contaminated with eye blinks that had voltage variations larger than $\pm 100\mu\text{V}$ in the HEOG and VEOG channels were rejected. In the second artifact rejection stage, any voltage variation that was larger than $\pm 100\mu\text{V}$ in the rest of the channels other than HEOG and VEOG were rejected. All the rejected trials were not included in the following analysis. The overall rejection rate was less than 25% per condition. After artifact rejection, data were then band-pass filtered between 1~30Hz (FIR filter, zero phase shift mode, 12 dB/oct).

Based on the visual inspection of ERP waveforms and the time windows of potential effects, ERPs in the 200–400, 300–400, 300–500, 500–700, 600–800, 700–900 and 500–900 ms time windows were all selected for statistical analyses. Statistical analyses on these windows were aimed at capturing the early negative (LAN and N400) and late positive potentials that we predicted to find based on previous literatures. Although data were collected through 64 channels, only the data from the following 28 channels (AF3, AF4, F7, F3, FZ, F4, F8, FT7, FC3, FC4, FT8, T7, C3, CZ, C4, T8, CP3, CP4, P7, P5, P3, PZ, P4, P6, P8, PO7, PO8, OZ) were used for statistical analyses. These 28 channels included electrodes located at various sites, which were thought to be able to capture the whole head brain wave activities as well. Repeated-measures ANOVA were performed on these 28 sites with respect to verb biases by disambiguation by 28 channels (2x2x28 levels). All the reported *p* values in statistical analyses were adjusted with the

Greenhouse–Geisser correction for nonsphericity.

Results

Comprehension Questions Behavioral Data

Patterns of the accuracy and the response times for the end of sentence judgment showed that overall accuracy was 78%, meaning that people agreed with our intended referent disambiguation most of the times. People were more accurate and their response times were faster when sentences were disambiguated toward distant antecedents (figure 8). Under each verb bias condition, sentences with distant antecedent disambiguation were more accurate (DO_DIST:81% vs DO_LOC: 65% and SC_DIST: 79% vs SC_LOC: 70%) and were responded faster (DO_DIST: 2084 ms vs DO_LOC: 2248 ms, and SC_DIST: 2301 ms vs SC_LOC: 2361 ms).

Results observed here showed that it was harder for people to make the judgment when sentences were disambiguated toward local nouns regardless of verb biases. They took longer time to decide the local referents were the right disambiguation for the reflexive (i.e. they were slower to make “yes” responses), and they were more likely to take the Distant Noun as the reflexive antecedent for sentences that were intended to have local antecedent disambiguation (so they answered more “no” responses for sentence that actually had local antecedent disambiguation). The patterns were consistent with the EEG data discussed in the next section.

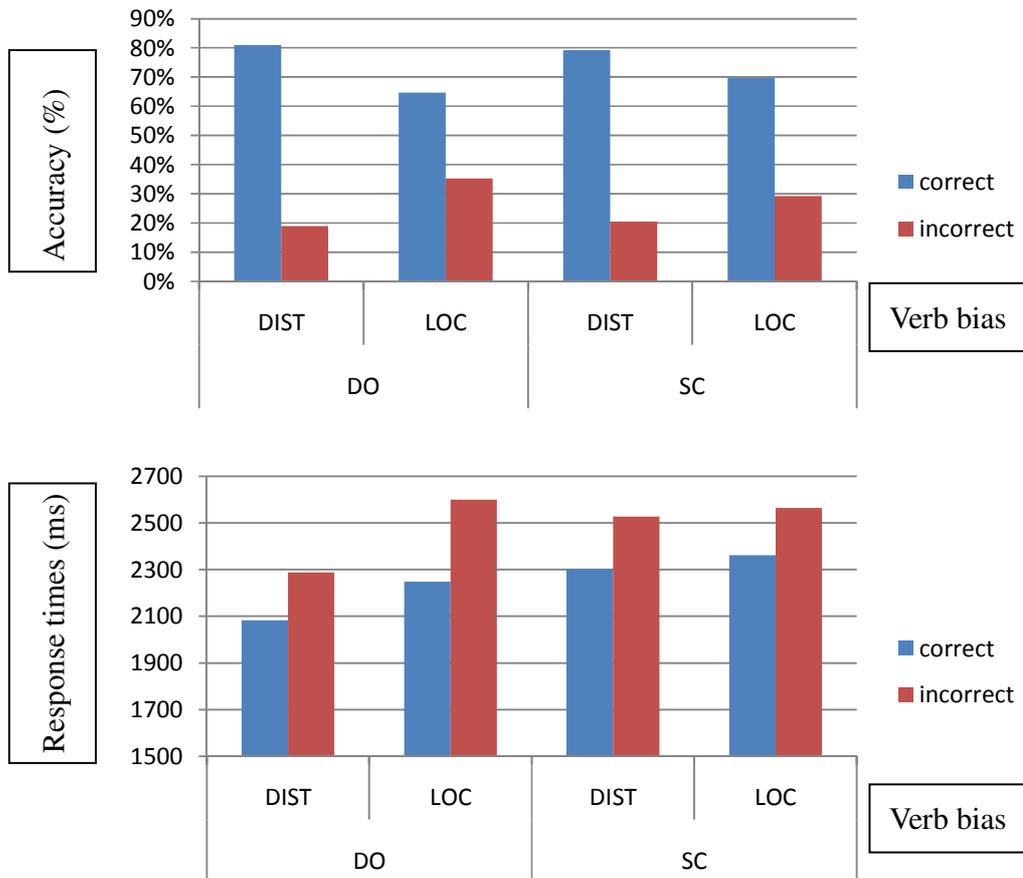


Figure 8. Accuracy (upper panel) and Response Times of Comprehension Questions for ERP Experiment

ERP Data

ERPs were time-locked respectively to 4 positions in the target sentences, at the reflexive, post-reflexive, disambiguating verb and the post-disambiguating verb region for statistical analyses and visualization. Statistical analyses were done on the mean amplitude of each time windows described in the previous section, but no main effects of verb bias, disambiguation, or interaction of verb bias by disambiguation turned out to be significant in window 200-400, 500-700, 600-800, 700-900 or 500-900ms when the ERPs were time-locked to the verb region. Therefore those were dropped from discussion.

Statistical results on window 300-400 and 300-500ms were similar, so our discussion would focus only on the 300-500ms time window.

ERPs time-locked to the disambiguating verb with an epoch of -100 pre-stimulus onset to 1000 ms after the verb onset were shown in figure 9. Data were collapsed over verb biases in the figure, because no significant main effect of verb bias was found. The figure plotted the amplitude of the waveforms (x-axis) across time (y-axis). Red line represented sentences that were disambiguated to local referents and blue line the distant antecedents. In the 300-500ms window, a significant main effect of semantic disambiguation was found ($F(1,1)=9.309$, $p<.01$), with sentences having local antecedent disambiguation to be more negative than sentences that were disambiguated toward distant antecedents. No other effect reached significant level at the verb region, nor did we find any other significant effect when ERPs were time-locked to the reflexive or the post-disambiguating verb region, although there was a significant interaction of disambiguation and channel ($F(1,27)=3.9$, $p<.01$) at the post-disambiguating verb region in this 300-500ms time window.

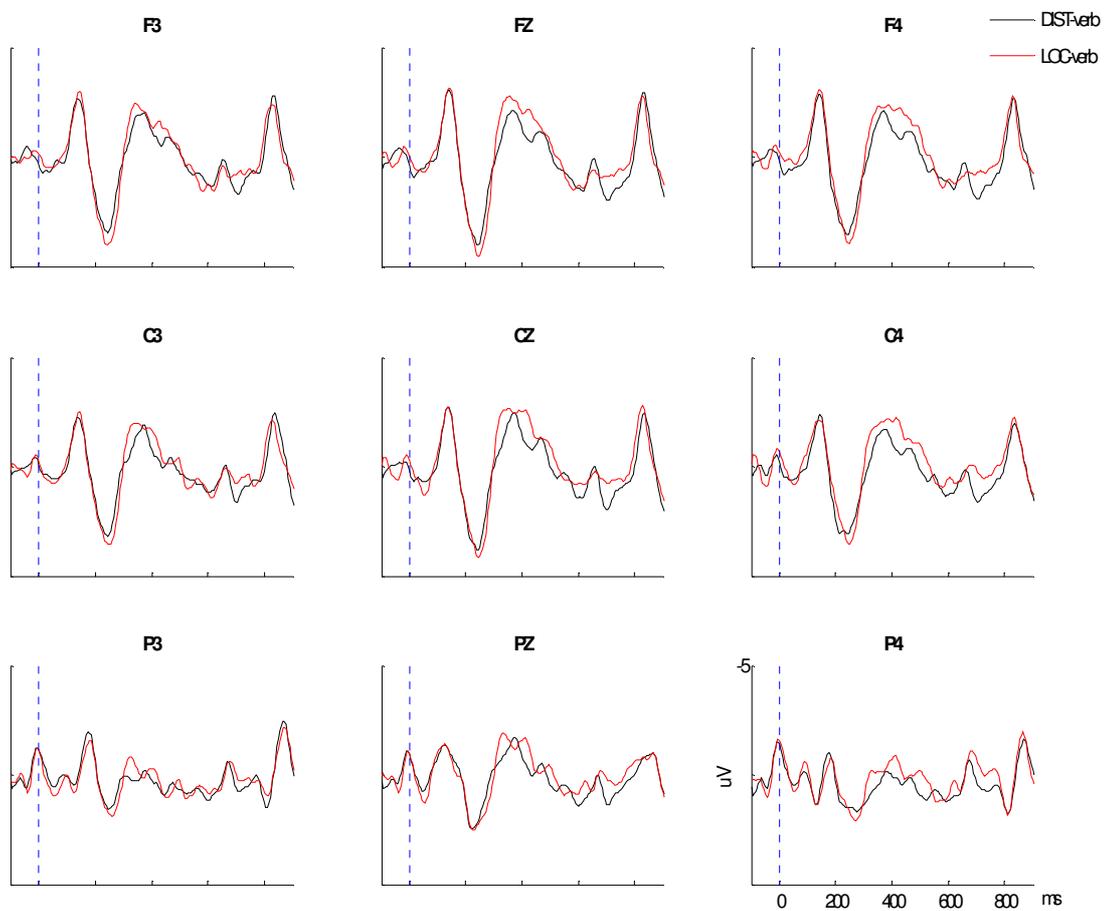


Figure 9. Grand average ERP waveforms on 9 exemplar electrodes in experiment 5 on the disambiguating verb region. Data Epoch was from -100 pre-stimulus to 900 ms after the onset of the verb. Baseline corrected by using the EEG activity in the 100 ms pre-stimulus interval.

Discussion

From the mean amplitude analysis in the 300-500ms window at the disambiguating verb region, it is observed that verb bias did not have an effect. Within each verb bias, sentences that were disambiguated toward local antecedents were more negative comparing to those disambiguated to distant antecedents. In a sense, this finding is

similar to what Li and Zhou (2010) found, that sentences disambiguated toward distant anaphors were more positive than sentences disambiguated toward local antecedents, although the designs of these two studies were different in several aspects. First, there was no pure ambiguous condition in our design. All the experimental sentences in our study were intended to be disambiguated to one of the referents at the disambiguation verb, though at our reflexive region, it was assumed that both antecedents were possible if people did not resolve the ambiguity at that time, thus the interpretation of the reflexive remained ambiguous. So, unless verb biases information carried by the verbs that preceded the reflexive had an influence on antecedent selection, then we would expect the reflexive to be resolved earlier; otherwise the reflexive was supposed to be ambiguous until the disambiguating region. Second, the disambiguating region in our study was the last verb that appears after the reflexive, rather than on the reflexive itself as in Li and Zhou's design (2010). Despite that the two studies were not comparable due to so many differences in sentence structures and experimental designs, findings in both studies seem to suggest that sentences having local disambiguation were more negative than sentences having long distance disambiguation.

Li and Zhou (2010) argued that what they observed was a positivity that indicated the detection of the mismatch between binding principle A and the already built mental representation. However, it is skeptical that why the same degree of mismatch did not show up in their ambiguous condition. Since that condition is ambiguous, that means people know there are two antecedents that the reflexive refers back to, not just the local antecedents. So, once people built a mental representation for the long-distance antecedent in the sentence, shouldn't a mismatch to binding principle A be always expected to occur as long as there was a mismatch between the mental representation and

the binding principles? The authors argued that the reason why their ambiguous condition results were in between the other two conditions was that the ambiguous condition was not always staying ambiguous. Based on their post-experiment questionnaire, the authors found that only 25% of the ambiguous sentences remained ambiguous. Most of the time, people still tried to resolve the reflexive ambiguity by selecting one of the referents among the two possibilities. So the results observed in their ambiguous condition were a combination of long distance antecedent disambiguation, local antecedent disambiguation and still ambiguous condition. It would be interesting to see the ERP responses of the “true” ambiguous items in their data, so that we could ascertain that the positivity was about the binding principle mismatch.

Instead of arguing that sentences with long distance antecedent disambiguation being more positive than sentence with local antecedent disambiguation, we nevertheless argued that what we observed in our study was an anterior negativity. Though widely distributed, this negativity seemed to be larger over the frontal part of the head, which did not have the usual distribution of a typical N400. Moreover, we thought it could be a negative deflection that involved semantic processing since it was semantic information that was manipulated at that region where the negativity was observed. We manipulated the semantic meanings carried by the verb to bias people resolve the ambiguity, so the responses toward it could be semantic in nature. Furthermore, we did not find any effect in the later time windows, where possible syntactic reanalysis might occur. Lacking of evidence for syntactical reanalysis or integration, the responses we found could just be an indication of processing difficulties of integrating multiple referents. It is also questionable that Mandarin Reflexive processing indeed involves reanalysis when sentences were disambiguated to distant anaphors. Li & Zhou (2010) argued that the

observed positivities were the results of violating binding principle A and thus reanalysis was required for sentences have long distance binding. This is based on the assumption that Mandarin reflexive processing also follows what English binding principle A predicts, so there is a reanalysis process if long distance binding takes place. But what if Mandarin binding principle for bare reflexive *ziji* doesn't work the way as English binding principles do, and long distance binding is actually the default? The interpretation and interpretation of that could change completely. We will turn back to this point in the General Discussion in the next chapter.

This negativity could be an index of how likely it is to accept local nouns as the reflexive resolution. The more negative the waveforms are, the harder it is to accept the local noun interpretation. For example, if people already took long distant referents as the default interpretation of the reflexive during processing, then it would be harder to accept local nouns as the resolution especially when sentences turned out to indicate local referents are the correct interpretations. Sentences with long distance disambiguation elicit smaller negativities because disambiguating verbs confirmed their default interpretation, and thus there is no need to revise their selections or to integrate local antecedents. Therefore, this frontal negativity found in sentences with local antecedent disambiguation could represent that there was a conflict between people's original selection and sentence disambiguation. It might also represent the integration and processing difficulties that people encountered when trying to revise their original assumptions and incorporate the correct interpretations of the reflexives.

Other than signaling integration or processing difficulties, this frontal negativity may be an Nref response, which indicates the referential ambiguity created by having both referents activated in mental representation at the same time. For instance, if people have

long distance referents as the default interpretation for the reflexive, then when sentences are disambiguated toward local antecedents, this means these local referents are now competing with people's default selections in their mental representations and thus makes those conditions become more referential ambiguous. Nref was smaller in sentences with long distance antecedent disambiguation because disambiguating verbs confirmed that their default selection were correct. Local antecedents under those conditions were not selected at the beginning and were not introduced again by the disambiguating verbs, therefore local antecedents were less referentially influential in sentences that had long distance antecedent disambiguation, and Nref was less obvious in those conditions.

Based on the reasons above, we propose that the effects found in our study were more about processing difficulties of semantic integration and referential ambiguities. The negativities we saw might reflect the efforts of integrating local interpretations into the current mental representation. Local interpretations could be harder to integrate were also evident from our self-paced reading study on bare reflexive, where we found a preference for distant antecedents for DO-bias verbs but no preference for SC-bias verbs. At least for DO-bias verbs, local antecedents were harder to process because they were less preferred. Therefore, the negativities in the local antecedent disambiguation conditions in our ERP study could be an indication of difficulties in integrating local antecedents. Moreover, from the behavioral data of this ERP study, people responded faster and more accurate to sentences that were disambiguated to distant nouns regardless of verb bias, which also suggested that people in the ERP studies preferred distant disambiguation and had more difficulties in processing local disambiguation. The more negative waveforms in the local disambiguation confirmed such processing difficulties as well. Therefore, we argued that the effects we found in the disambiguating verb region

were instead related to semantic integration of local antecedents. The negativities were reflecting difficulties of integrating a less expected antecedent or reflecting the mismatch between preferred distant antecedent and the semantic disambiguation offered by the verbs. Moreover, the anterior negativity might also be an indication of referential ambiguity due to local referents came into play and were competing with people's default selections of distant referents.

Our ERP data showed that people responded to DO-bias and SC-bias verbs in the same way. They only responded differently when sentences were disambiguated toward different antecedents. Previously we predicted that we would find different ERP responses at the reflexive or post-reflexive region, if people used the structural information carried by the verb-bias verbs to predict what was coming up during reading. They would be surprised by getting more information after DO-bias verbs when they predicted sentences were going to end soon. They wouldn't be surprised that much after SC-bias verbs. However, we did not find any of these effects in the ERP data. The experimental stimuli used in the ERP and self-paced reading studies were the same, so we hoped to replicate what we found before, that the bare reflexive processing would be influenced by verb bias. Both the self-paced reading and ERP studies showed that when people processed Mandarin bare reflexive *ziji*, they seemed to have a general preference for distant anaphors. We found that the distant antecedent preferences was modulated by verb biases in the reading time study (preferences were found only after DO-bias verbs), but not in the ERP experiment (people just overall had more difficulties when sentences had local disambiguation). We speculated that such differences were from the demands of different tasks. In self-paced reading task, people seemed to be more actively engaged in reading because they were the ones that had the control over sentence presentation.

Self-paced reading participants processed the information at their own speed, took relatively longer time to think over if they need to, or advanced the sentences as fast as possible by skipping over some simple words until they got to more important words that conveyed more information. It is possible that in the reading time task, people make decisions on every word (i.e. about when to proceed, how much information they need to predict or understand the sentences), and they quickly built up mental representations and frequently updated them as they controlled the timing of the appearance of the information. The ERP measurement, on the contrary, is a more passive reading task. Participant simply read through words prompt on the screen with a fixed presentation rate (every 650ms for one word in our case, which is a rather slow rate, comparing to our self-paced reading times, which people usually made responses ranged from 400ms to 550ms). They could not skip a word even though they already finished reading it, and there was no way for them to make information showed up faster. Participants were not required to do anything during the presentation in the ERP experiment, until a comprehension question showed up and they made a judgment on that. So in a sense, people did not need to resolve the ambiguity as quickly as they did in the self-paced reading task. In the ERP experiment, people could just wait until all the words were presented and then made a decision. If that's true, the resolution process in the ERP task might happen later, more like a recall process. Or, it could be that people just developed a good enough processing strategy during the ERP experiment, that they did not bother to resolve the reflexive while encounter it, but only did so when they were asked to later. This is also probably why people overall preferred distant referents in the ERP study, because if they selected referents in a recall manner, it is likely that they answered questions with whatever referent they could remember, and discourse and syntactic

prominent matrix sentence subjects seemed to be good candidates under that circumstances.

In next Chapter, we will return to the questions we asked at the beginning of this study. We will discuss the results and implications of our studies with regard to the questions we brought up. Then some future direction will be discussed.

CHAPTER 6: GENERAL DISCUSSION

We began this study in the hope of finding out how Mandarin reflexives are processed, how are they being resolved when they are ambiguous, and what are the time courses of resolving them. There are perhaps numerous factors that may influence the answers to the above questions, whether it be syntactic (morphologically or sentential), semantic, or pragmatic. In order to begin the investigation with somewhat more straightforward factors, we chose to look at the effects of verb bias and the amount of information available (partial information or pre-target context sentences) on Mandarin reflexives. We used off-line norming tasks, self-paced reading times and ERP measurement to investigate people's intuition, on-line responses of the resolution and the time courses of the resolution.

We found that both verb biases and context influenced reflexive resolution and the time course of the resolution. People's preferences of antecedents were modulated by verb bias. There was a distant antecedent preference for bare reflexive *ziji* but only after verbs that usually takes direct objects. For complex reflexive *taziji*, local antecedents were indeed preferred, but only for verbs that take embedded clauses. After DO-bias verbs, distant antecedent still appeared to be an appealing resolution for the complex reflexive. We argued that such preferences were developed from people's knowledge about the verb subcategorization structures. When they applied that knowledge to predict what was coming up, they strategically developed a preference for certain antecedents. Verb biases also affected the time course of the resolution. When people predicted that sentence would end soon, they made the resolution happened earlier, otherwise they did not disambiguate until some later disambiguating points. Context was another factor that

contributed to reflexive resolution. People did not necessarily need complete sentence information to process reflexives. With only partial information, people could still make selections based on the available information. When more information was provided, the antecedent preference was now favoring for whichever of the possible antecedents that was made more prominent by context. However, such preference was only developed when there was no time pressure of making an antecedent selection. This is perhaps because people relatively have more time to take context into consideration given no time pressure. Under that situation, we observed an interaction between verb bias and context. When people thought there was a time pressure of processing sentences and making decisions, they did not take context into account. They only did so when they thought they have more time, thus context effects were only on the SC-bias verbs. We also observed different patterns from off-line and on-line measurements. We believed that the differences came from different task demands (such as time constraint between off-line and on-line studies, or the active or passive reading strategies that people applied). Finally, ERP results suggesting that people were having more difficulties in processing sentences with local antecedent disambiguation, which could be taken as a consistent evidence for that people in general preferred distant antecedents when processing bare reflexive *ziji*. The anterior negativity or Nref we found in the study may indicate such processing/integration difficulties and referential ambiguity in sentences with local antecedent disambiguation.

In this chapter, we will focus on several questions that were being raised or observed along the way of our investigation and that are worth to be discussed in details, including topics like the time courses of reflexive processing, reflexive antecedent activation and selection, effects of different tasks and measures, and Mandarin Binding Principles. We

will conclude the chapter with some future directions and implications of this study.

6.1 Time Course of Reflexive Processing

One of the important questions for Mandarin reflexive processing is when the ambiguity is resolved. Is it resolved as soon as the reflexive is encountered? Or people do not always try to resolve it? Our self-paced reading data suggested that people tried to resolve the reflexive as soon as possible only if they thought there was a time pressure of doing so. We found that even if the resolution did not happen right after reading the reflexive, people resolved the ambiguity at least at some point prior to the disambiguating verb for DO-bias verbs. They tried to resolve the reflexive by selecting one of the antecedents, and preferably the distant antecedents, and then they slowed down when they found out the disambiguating verb indicating the other referent was right. So the self-paced reading results supported the idea that people resolve the ambiguity before sentences revealed all the information. Our ERP data, on the other hand, was ambiguous to interpret. If we believe that the negativities in the 300-500ms window indicated the mismatch between people's expected antecedents and the semantic disambiguation, then this meant that people resolved the reflexive earlier than the disambiguating verb appeared, similar to the arguments made for self-paced reading results. However, if the negativity we found was simply an indication of integrating local nouns into the representation, then we knew little about the time courses of when the reflexive was being resolved. There might be another evidence from the ERP results suggesting that people might not resolve the reflexive earlier, and the resolution happened later at the comprehension question answering stage, as a post-hoc rescue. In our ERP results, we did

not find an effect of verb bias. If we believe verb bias affected the time courses of when antecedent was being selected, then we should see that people have different antecedent preferences based on different verb biases: distant antecedent preference after DO-bias verbs, but no preferences for SC-bias verbs (or local antecedent preference from the off-line sentence completion norming). Our ERP data did not have that dissociation between antecedent selection and verb bias, but rather there was an overall preference for distant nouns. This distant noun preference could come from that people do not resolve the ambiguity in the ERP experiment fast enough. People probably just take the perspective of the first mentioned noun, and thus encountered greater difficulties when they have to incorporate local nouns at the disambiguating verb region. So this could be an evidence for people did not always resolve the reflexive as fast as possible. Greene et al. (1992) also found that people preferred referent over non-referent only under a slow presentation rate, indicating that people did not resolve the pronoun on-line in other cases. Thus, it was possible to think that people did not resolve Mandarin reflexive on-line in the ERP experiment, and the difficulties observed in the verb region was not about resolution but about updating and integrating another referent into the mental representation that people built before.

Due to the above findings, we believe that the time courses of antecedent selection could be a late process in the ERP and other tasks. People did not resolve the ambiguity unless they had to. In the self-paced reading study, people only resolve it after DO-bias verbs, because they assumed a sentence ending. They did not do it after SC-bias verbs, where there was no obvious need to resolve the reflexives. Similar things happened in our ERP study, that people probably did not resolve the ambiguity due to the passive nature of the task. They perhaps did the resolution when they were asked to answer the

comprehension questions about the resolution, and the resolution might actually base on a recollection of possible antecedents. So people were both faster and more accurate to answer questions about distant nouns, because distant nouns were syntactically, pragmatically or discourse-wise more prominent to be recalled later.

6.2 Reflexive Antecedent Activation and Selection

Another important question about reflexive processing is how reflexive antecedent is selected. Does it involve serial search back of the possible antecedents, so that one referent will be available before another before selection? Or all the antecedents are activated at the same time and then being ruled out or selected by other constraints? If it is a serial searching process, then we could assume that people select local antecedents first because when people start searching back after reading a reflexive, local antecedents will be the first possible antecedent in the back searching. There will be a recency advantage for local antecedents. However, it is also possible that people initiate the searching from the first encountered noun, and then search forward (i.e. downstream of a sentence) for possible antecedents. In this forward searching, local antecedents will not have a recency advantage. If antecedents are activated in a parallel manner, we would expect all the antecedents to be available at the same time at first, and some of them being ruled out later. Our data did not seem to support the serial back searching model, because we did not find a recency effect for local antecedents. If local antecedents were selected at the beginning because of its recency advantage, we should see people prefer local antecedent after both DO-bias and SC-bias verbs. People should read faster when the disambiguating verbs referred back to local antecedents. Instead, we found no

preference after SC-bias verbs and distant antecedent for DO-bias verbs, suggesting that recency was not an influential factor, and local antecedents were not selected and preferred.

So, did it mean that reflexive antecedents were all activated at the same time? Somehow it did not seem to be the case either. If all the antecedents were activated and available, then we shouldn't observe any slow down in reading times at the disambiguating region, because both referents were ready to be matched to the disambiguation. The fact that there was a slow down in the verb region, suggesting that one of the referent was more activated than another. So, when the disambiguation indicated otherwise, the slow down in reading times might represent the reactivation time of the unselected referent. In sum, it seems that the forward searching for antecedents, starting with the first mentioned noun to other nouns downstream, was observed from our ERP data. Regardless of verb bias, people's selection begins with the first mentioned referent and when sentences indicate otherwise, they try to incorporate the new referents found downstream, and thus causing processing difficulties and referential ambiguity.

As for what factors influenced antecedent selection, we proposed that it was the prominence (of the matrix subject) that influenced the selection most. The matrix subject is prominent in several aspects: it is the first mentioned noun and it is a "pure" subject syntactically. Although the subject in the embedded clause is also a subject, it also has the status of being a part of the object complement of the matrix sentence. The matrix subject is higher in syntactic structure and bears the discourse prominence of being first mentioned, which makes it more likely to be selected among the possible choices.

6.3 Effects of Off-line and On-line Measures

In this study, we applied several off-line and on-line measurements on the same experimental material. One would think we would be able to find systematic results by replicating the findings again and again. It was in general true, that most of the times we were able to get some consistent findings across studies, but at the same time we obtained different results between studies that needed explanations. We argued that the difference results we got across studies on reflexive antecedent selection and the time courses of the resolution were from the time constraints that different measurements imposed on participants, and from different task demands. Off-line studies did not require people to respond in a fast and accurate manner, while on-line task measures accuracy and response times. Because of having such time pressure in making responses, people's performance and strategies of doing the task varied. We think that is why we found different antecedent preferences between on-line and off-line measures.

Other than the time pressure differences between tasks, task requirements for each measurement were different as well. Off-line studies allowed people to get all the information at the same time. They could read back and forth, where as self-paced reading did not have such luxury. People only get one piece of information at a time, and they can't go back once they make a response. Even in on-line tasks like self-paced reading and ERP differ in task demands. ERP is a more passive task whereas self-paced reading gives people more control over the reading speed and the timing of getting the right and necessary information. All these influence people's decision and responses during reflexive processing.

6.4 Mandarin Binding Principles

What exactly are the binding principles in Mandarin is a topic of debate. Here our goal is not to propose new binding principles for Mandarin, but rather to discuss how it influences the interpretations of our results if people take different views on what Mandarin binding principle would be. According to Li and Zhou (2010), the early positive ERP responses they found reflecting detection of the violation of the binding principle A. This suggested that they assumed Mandarin binding principles were basically applied like the binding principles in English. Long-distance binding was a sort of violation of the initial local binding, and therefore more difficult to process. This view seemed to fit Li and Zhou's arguments quite well. For example, in their local antecedent disambiguation condition, the reflexive co-referred to local antecedents. Binding principles were not violated therefore less positivities were observed. Long distance binding in this condition was somehow blocked or not necessary, since the long distance head had been ruled out by the verb meaning.

However, the above view did not seem to capture the modified Mandarin binding principles, proposed by various linguists. One could argue that Mandarin binding principle in fact has a larger governing category, so long distance binding is no longer a violation under the revised view. This view would have a great impact on Li and Zhou's explanation, because what they thought to be a violation was not a real violation, and it was not necessary to do the reanalysis if both long distance binding and local binding were acceptable structures. It is possible that their positivity signals the complexity of the structure of long-distance binding. But then, explanations should be provided for why ambiguous sentences containing both local and long-distance binding was not a more

complex structure than other conditions that had only one structure being the correct interpretation.

In our view, we thought that Mandarin binding principles have a larger governing category, so long distance binding is not a violation. Under this larger governing category, both referents that c-command the reflexive (like the two possibilities in our design) would be okay according to the binding principle. Our data seemed to be consistent with this view. For example, the antecedents in our design did not violate the Mandarin binding principles, therefore no syntactic related ERP component (ie P600) was observed. Also, it could be the case that because Mandarin reflexive has a larger governing category and the matrix subject is a more prominent candidate inside this category, the matrix subject is easier to be integrated. Therefore, we observed the anterior negativity at the disambiguating verb region when people had to integrate the less prominent local antecedents into their mental representation.

6.5 Implications and Future Studies

Reflexive Processing in Mandarin is influenced by many factors. We started to look at this issue from some factors we thought to be simple, and yet so many questions remain unanswered. Questions that worth to be investigated including but not limited to testing Mandarin binding principles. We made assumptions on how Mandarin binding principles work in the reflexive resolution, but our current experiments were not designed to directly test the binding principles, therefore did not provide strong evidence for how Mandarin binding principles constrain the reflexive resolution. A new design that has both accessible and inaccessible antecedents maybe a good way that allows us to see how

binding principles are applied in reflexive resolution.

Another possibility is to look at how individual difference such as working memory capacity or the abilities of inhibition affects reflexive processing. Working memory capacity has been found to influence sentence processing (Just & Carpenter 1992, MacDonald et al. 1992), and ERP measurement has been applied to investigate the issue. Friederici et al. (1998) collected ERP responses from high and low memory span readers reading German subject and object relative sentences to evaluate the influence of working memory capacity on ambiguity resolution. Sentence complexity (simpler subject relative clause vs. more complex object relative clauses) and length of the ambiguous region (where sentences remained ambiguous toward the end or could be disambiguated at two earlier positions) were manipulated. Their results showed that high memory span readers had more positive deflections at the disambiguating region in object relative clause condition than in subject relative clause conditions. Low memory span readers did not have this pattern. They argued that the positive waves reflected the reanalysis process for objective relative clauses because the structure was first build as a subject relative, and thus need revision. Also testing German subject and object relative clauses, Vos et Friederici (2003) investigated the influence of working memory and context cues on processing different types of clauses. Their English-translated examples were presented in (20).

There were four types of target sentences, with subject/object relative clauses and subject/object complement clauses. Each target sentence was be preceded by one of the 'lead-in' sentences that biased toward either subject, object or no bias, and followed by a comprehension question that ask about either the subject or the object. The 'lead-in' sentences were presented frame by frame, divided by the comma. Participants self-paced

read through the lead-in sentences. Then target sentences were presented word by word (300 ms per word, 200 ms ISI) centrally. Finally, each comprehension question was presented all at once on the screen until subjects made a yes/no response.

(20) Lead-in sentences: (a) Neutral bias:

The spectator asked himself, what has happened?

(b) Bias to subject-first structure:

The spectator asked himself, who distracted the producers?

(c) Bias to object-first structure:

The spectator asked himself, who(m) the producers distracted?

Target sentences: (a) Relative clause, subject-first:

He found out that it was the actress who distracted the producers.

(b) Relative clause, object-first:

He found out that it was the actress who the producers distracted.

(c) Complement clause, subject-first:

He found out that the actress distracted the producers

(d) Complement clause, object-first:

He found out that the actress was distracted by the producers.

Comprehension questions: (a) Was the actress distracted?

(b) Were the producers distracted?

The behavioral results on the comprehension questions showed that in the neutral bias condition, they basically replicated previous findings, in that low span readers, rather than high span readers, had more difficulties in reading object relative clauses. Such effect disappeared when biased information was provided. For reading complement clauses, the two span groups did not differ: both had more difficulties in comprehending object complement clauses, and this was observed for both neutral and bias conditions. The ERP results at the disambiguating region showed that only high span readers had a P600 for object clauses compared to subject clause, regardless context biases. This P600

effect was also observed in Friederici et al. (1998) and was believed to reflect reanalysis process. They explained that it could be that high span readers were efficient so that they only construct one representation for simple structure and thus garden-pathed for complex structures. Moreover, high span group may have more resources for reanalysis whereas low span group do not. So, low span reader did not show a P600, but instead displayed a context bias effect in both complement and relative clauses by having a slow frontal negativity in the neutral bias condition. They argued that this slow frontal negativity may reflect integration difficulties in the neutral condition.

Based on these findings, we would expect to see working memory have an effect on Mandarin reflexive processing. Reflexive processing, like pronoun processing, involves long-dependencies (i.e. searching antecedents that occurred before or after, and which might be outside of the local clause), building mental representations for referents, and integration processes. People with different working memory span may differ in all these aspects. High span readers may have less difficulties in integrating new referents, can be more efficient in comprehension by only constructing simple mental representations first (but prone to suffer from reanalysis later), or they may have more resources to process long-dependencies and other referential ambiguities, so less processing difficulties they might have. People may also differ in how they interpret the Mandarin reflexive. People with larger working memory span might be able to hold and process more information at the same time and might prefer distant noun (not only because they have more resources to hold distant anaphors, but also because they are more efficient in processing and will be able to use multiple cues such as prominence to make the decision making procedures faster), whereas people with smaller span would only be able to attend the local information and thus show a preference for local antecedents.

Another individual differences measurement, the Stroop task, is thought to be a good measurement of individual differences. This task involves selectively attending to some feature while inhibiting other features. If a feature that needs to be inhibited is an automatic process (like the retrieval of word meanings), then it is not easy to inhibit, because the more automatic processing will interfere with less automatic processing. (Macleod 1991). So, using Stroop task, we could measure people's ability of inhibition, which might also be an index of how people can suppress the competitions of multiple possibilities of the referents. For example, if people are better in inhibiting, they might be able to select antecedents faster (since they are good in inhibiting other choices). Or, these people might be good or faster at using verb bias information (to help them inhibit other possibilities), and if this is so, we might expect the verb bias effect to be stronger for these people. People with good inhibition abilities may also be more prone to suffer from doing reanalysis processes if they rapidly select a wrong interpretation by inhibiting other possibilities. We therefore can have a better understanding on how people with different capacities process reflexives, and which antecedent they prefer.

In this study, we examined both behavioral and ERP data on reflexive processing. The behavioral data enables us to build up a general expectation about Mandarin reflexive, and the ERP data would allow us to find out the neural correlates with reflexive processing as well as to identify the possible processing difficulties, time course and the nature of processes involved in the resolution. Having done several different off-line and on-line measurements, we found that reflexive resolution is not only influenced by linguistic factors, it could also be task dependent. By investigating various within and cross-sentence factors that might affect reflexive processing, we also make contribution in understanding antecedent selection and be able to put up a temporal profile for when or

which cues that play a central role in reflexive interpretation. The results could also provide some evidence for Mandarin anaphor resolution in general.

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