

L2 LEARNERS' PROCESSING OF RECONSTRUCTION IN  
ENGLISH: A MINIMALIST ACCOUNT<sup>1</sup>

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**Introduction**

In this introduction, I will first address anaphoric relations and Binding Theory. Then I will discuss reconstruction (sentences with a reflexive inside a fronted noun phrase that involves overt movement of a *wh*-element) from the perspective of Chomsky's (1993, 1995) Minimalist program, and how reconstruction presents a logical problem of language acquisition for Chinese EFL learners. Finally I will review psycholinguistic accounts regarding processing sentences with a fronted *wh*-phrase and second language research on sentence processing.

*Anaphoric relations and Binding Theory*

Anaphoric relations refer to referential properties of anaphors. Anaphors refer to two referentially-dependent NP types: reflexives (e.g., himself) and reciprocals (e.g., each other).

- (1) John<sub>i</sub> hates himself<sub>i</sub>.
- (2) They<sub>i</sub> hate each other<sub>i</sub>.

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Just as *himself* in (1) is referentially dependent on *John*, *each other* in (2) is on *they*. The convention to show that two expressions co-refer is to assign them the same "index" in the subscript. The fact that *John* and *himself* in (1) and *they* and *each other* in (2) refer to the same person(s) is shown by giving them both the index *i*.

A reflexive is a type of noun phrase (NP). It differs from two other types of noun phrase: pronouns and referring / referential expressions (R-expressions). Reflexives need a local antecedent, i.e., a local NP on which a reflexive is dependent for its interpretation; pronouns may have an antecedent, but cannot have a local one; R-expressions cannot refer to some other element in the sentence. The following are examples illustrating the differences among three types of NPs:

- (3) Mary<sub>*i*</sub> thinks Jane<sub>*j*</sub> likes herself<sub>*i/j*</sub>.
- (4) Mary<sub>*i*</sub> thinks that Jane<sub>*j*</sub> likes her<sub>*i/\*j*</sub>.
- (5) Nancy<sub>*i*</sub> likes her<sub>*i\**</sub>.

The reflexive *herself* in (3) must have the local NP *Jane* as antecedent. The pronoun *her* in (4) cannot have *Jane* as its antecedent; it has to refer to either *Mary* or someone else. The R-expression *Nancy* in (5) cannot refer to *her*. The use of the asterisk (\*) in the front of an index means that the two expressions cannot co-refer. The fact that *herself* and *Mary* in (3), *her* and *Jane* in (4), and *her* and *Nancy* in (5) do not co-refer is shown by using the asterisk before an index *i* or *j*. The principles that govern the interpretations of these NPs are referred to as Binding Theory (Chomsky, 1981):

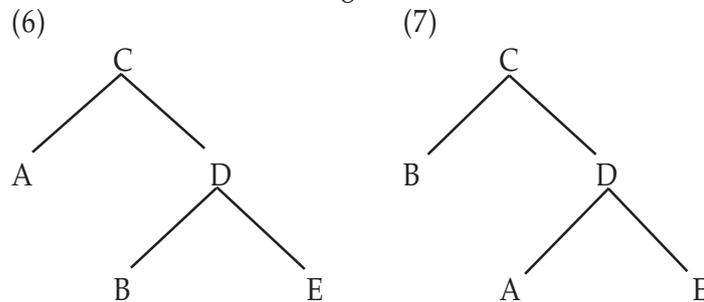
#### Binding Theory

Principle A: An anaphor (e.g., *herself*, *each other*) must be bound in a local domain.

Principle B: A pronoun (e.g., *he*, *she*, *him*, *her*) must be free in a local domain.

Principle C: An R-expression (referring expression; e.g., *Mary, the child*) must be free.

"Bound" means coindexed with a c-commanding antecedent. "C-command" means A c-commands B if and only if the first branching node dominating A also dominates B (and A does not dominate B). To illustrate, let us look at the following:



In (6), A c-commands B because the first branching node which dominates A, i.e., C, also dominates B (and A does not dominate B). In (7), however, A does not c-command B, because the first branching node which dominates A, i.e., D, does not dominate B (Ouhalla, 1994). "Free", on the other hand, means not co-indexed with a c-commanding antecedent.

### *Reconstruction*

Reconstruction refers to a syntactic phenomenon in which an anaphoric element is moved out of the c-command domain of its antecedent (Barss, 1994).

(8) John<sub>i</sub> wonders which pictures of himself<sub>i/j</sub> Bill<sub>j</sub> likes *t*.

In (8), an anaphor is contained inside a moved NP which leaves a trace (symbolized by *t*) in its original site. Reconstruction typically involves movement of a *wh*-phrase (e.g., *which pictures of himself* in (8)). The

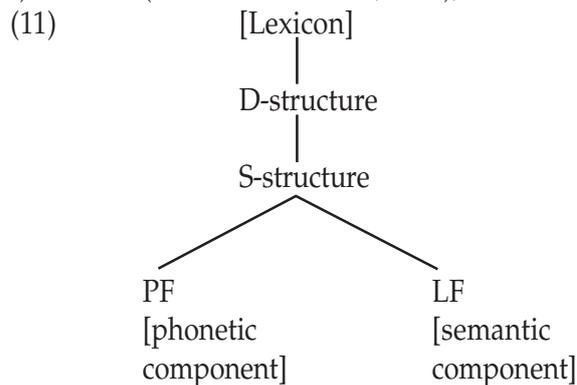
relevance of reconstruction to Binding Theory is that such fronting "places the anaphor out of the c-command domain of its understood antecedent, with no loss of grammaticality" (Barss, 1986, p. 17). What makes reconstruction particularly interesting is that reconstruction gives rise to ambiguity of antecedence which is not present in sentences without reconstruction. Compare (9) with (10):

- (9) Mary<sub>i</sub> wonders which pictures of herself<sub>i/j</sub> Nancy<sub>j</sub> likes.  
 (10) Mary<sub>i</sub> wants to know whether Nancy<sub>j</sub> likes those pictures of herself<sub>i/j</sub>.

In (9) herself can be bound by either the matrix subject Mary or the embedded subject Nancy. But herself in (10) can only have the embedded subject Nancy but not the matrix subject Mary as antecedent.

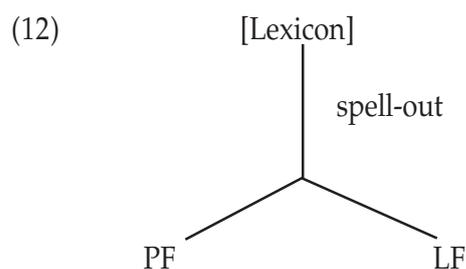
#### *GB Theory and the Minimalist Program*

The standard GB (government-binding) theory has four levels of representation: D-structure, S-structure, Logical Form (LF) and Phonological Form (PF). These combine to form the well-known (upside down) T-model (Cook and Newson, 1996), as shown in (11).



The minimalist program questions whether all these levels of representation are necessary. Chomsky (1993, 1995) argues that, since

language is a mapping between sound and meaning, the only absolutely necessary representations are the interfaces of meaning and sound components of the linguistic system. So, in the minimalist framework, only LF and PF are necessary and there are no specific levels of D-structure and S-structure. In other words, instead of the four levels of representation in the GB model, the minimalist program has two interface levels, LF and PF, LF interfacing between syntax and semantics and PF between syntax and articulatory-perceptual system, in addition to a point, called "Spell-out", which determines which movements will affect the pronunciation of a sentence - those that occur before Spell-Out – and which ones won't - those that occur after Spell-Out, on the way to LF (Marantz 1995). This is shown in (4).



#### *A Minimalist Account of Reconstruction*

In the spirit of minimalist framework, Chomsky (1993) proposes two options with respect to reconstruction. One option assumes that at LF only *which* adjoins to *wh*. As a consequence, the non-*wh*-material which is overtly moved along with a *wh*-element, as in (13a), is placed back into its original position and only *wh*-elements undergo covert movement to *wh*-positions at LF. This yields (13b), which is interpreted in (13c):

(13a) John wondered [which pictures of himself] [Bill saw *t*].

(13b) John wondered [<sub>wh</sub> which<sub>i</sub>] Bill saw [<sub>wh</sub> *t*<sub>i</sub> pictures of himself].

(13c) John wondered [which  $x$  [Bill saw [ $x$  pictures of himself]]].

With this option, *himself* seeks the embedded subject *Bill* as its antecedent.

The other option assumes that *which pictures of himself* adjoins to *wh*, as in (14a). Then complementary portions are deleted from the fronted phrase and its copy. This yields (14b), and it is interpreted in (14c):

(14a) John wondered [<sub>wh</sub> which pictures of himself] Bill saw [<sub>wh</sub> which pictures of himself ]].

(copy)

(14b) John wondered [which pictures of himself]<sub>i</sub> Bill saw [<sub>wh</sub> <sub>t<sub>i</sub></sub>]

(14c) John wondered [which  $x$ ,  $x$  pictures of himself] [Bill saw  $x$ ].

With this option, *himself* can seek the matrix subject *John* as its antecedent. The available two options at LF explain why *himself* in (8) can have either the matrix subject *John* or the embedded subject *Bill* as its antecedent.

### *The Logical Problem of Language Acquisition*

The logical problem of language acquisition (Hornstein & Lightfoot, 1981) or the projection problem (Baker, 1979) refers to the problem of accounting for adults' knowledge of properties of language not available directly from input. Reconstruction in English which typically involves *wh*-movement presents the logical problem for Chinese learners because sentences of this type are not available directly from input in Chinese:

(15)

*Najizhang	taziji <sub>i/j</sub> de zhaopian	Zhangsan <sub>i</sub> shuo Lisi <sub>j</sub> xihuan?
WHICH	HIMSELF 'S PICTURES	ZHANGSAN SAID LISI LIKE

'Which pictures of himself<sub>i/j</sub> did Zhangsan<sub>i</sub> say that Lisi<sub>j</sub> liked?'

(15) involves the overt movement of a *wh*-element, *najizhang* "which". The sentence is ungrammatical because Chinese does not allow overt *wh*-movement (Huang, 1982).

#### *Psycholinguistic Accounts*

In the psycholinguistic literature the relationship between the *wh*-element and its argument position (the subject or object position) has been called a *filler-gap* dependency, *wh* being the *filler*, its original argument position the *gap* (i.e., the empty position). Over the past 20 years a great deal of attention has been paid to processing of sentences with a fronted *wh*-element in the psycholinguistic literature (e.g., Fodor, 1978; Frazier and Flores D'Arcais, 1989; Gibson, 1994), although sentences with a fronted *wh*-phrase that contains a reflexive (i.e., reconstruction) have attracted little attention. Several psycholinguistic accounts have figured prominently with respect to the assignment of fillers to gaps. The first account is known as the "Active Filler Strategy". It says: "Assign an identified filler as soon as possible; i.e., rank the option of a gap above the option of a lexical noun phrase within the domain of an identified filler" (Frazier & Flores D'Arcais, 1989, p. 332). In other words, given the option of postulating a gap or waiting to see a lexical complement appear, the parser (the mental program that analyzes sentence structure during sentence comprehension, Pinker, 1994, p. 107) prefers to posit a gap. Thus in (16),

(16) Who did John see \_\_\_\_?

the parser would initially try to assign *who* to the subject position. This attempt needs to be abandoned immediately upon receiving the noun phrase *John*. The parser will then postulate a gap following the verb *see*. The second account, "Gap as Last Resort", adopts the strategy of delaying positing a gap until forced to. That is, instead of postulating a gap at the first opportunity, the parser waits for structural information

that unambiguously identifies the true gap site (e.g., the end of the sentence) (Fodor, 1978):

(17) Who<sub>i</sub> did Tom ask Meg to persuade Jill to inform Ted that Bob had spoken to *t*<sub>i</sub>?

As shown by the index of (17), the parser would delay postulating a gap until the end of the sentence.

*L2 research in sentence processing*

Second language research in sentence processing has typically examined L2 learners' processing strategies (e.g., Heilemann and McDonald, 1993; Kilborn and Ito, 1989; Liu, Bates and Li, 1992; McDonald and Heilemann, 1991; Sasaki, 1991; Vaid and Pandit, 1991; Wulfeck, et al, 1986) within the framework of the competition model (e.g., Bates and MacWhinney, 1989; Bialystok, 1994; MacWhinney, 1987a, 1987b), the use of L1 strategies in L2 sentence processing (e.g., Kilborn, 1989; Kilborn and Coorman, 1987; Gass, 1987; Harrington, 1987; MacWhinney, 1992; Miao, 1981) and the use of cues in L2 sentence interpretations (e.g., Harley, Howard and Hart, 1995; Kail, 1989; Kilborn, 1994).

Only recently have ambiguous sentences been gaining the attention of L2 researchers. Harley et al (1995) investigated how both older and younger ESL learners interpret ambiguous sentences. The ambiguous sentences in their study typically involved manipulating sentence subjects and predicates, as shown in (18) and (19):

(18) *The new teacher's watch* has stopped.

(19) *The new teachers watch* baseball on TV.

The researchers first recorded two sentences separately. They then edited the tape so that the italicized part of sentence (18) replaced that of sentence (19), creating a prosodic contour in the stimulus sentence

(19) that competed with the sentence syntax. Thus the ambiguities of these sentences actually resulted from "sentence manipulations" (Harley, et al., p. 50). Manipulations of this kind are particularly obvious with Harley et al.'s examples (5) and (6), cited here as (20) and (21) (p. 51):

(20) *Almost all* young children like to eat cake.

(21) *When they are* young, children like to eat cake.

Harley and her colleagues argued that the ambiguity of the sentences resulted from the stress's falling prior to the end of the subject NP, as the italicized part of sentence (20) replaced that of sentence (21). Their results showed that "the older ESL learners were found to be just as likely as the younger ones to attend to prosody rather than syntax" (p. 44).

A potential drawback with such manipulations, as discussed in Ying (1996), arose when the participants often became "confused" and "surprised" on learning after the experiment that the target sentences were ambiguous.

Juffs and Harrington (1996) investigated Chinese learners' interpretation of garden path sentences such as

(22) After Bill drank the water proved to be poisoned.

This sentence first led the parser down a "garden path" to a (momentarily) incorrect analysis (i.e., the noun phrase (NP) *the water* was wrongly analyzed as the object of the verb *drank*); then the parser had to go back to reanalyze the sentence (i.e., the NP *the water* was reanalyzed as the subject of the verb *proved*). They argued that sentences like (22) were structurally similar to sentences with *wh*-subject extraction:

(23) Who does Jane expect *t* to fire the manager?

The subjects were predicted to first analyze *who* in (23) as the object of *expect*, only to find that *who* is also the subject of *fire*. Thus in both cases, the subjects were predicted to spend a longer time processing the embedded or second verb. The results confirmed their predictions.

Ying (1996) examined adult ESL learners' interpretation of ambiguous sentences with ambiguously attached prepositional phrases such as

(24) The spy saw the cop with binoculars,

where the prepositional phrase *with binoculars* can be attached to either the verb *saw* or the NP *the cop*. The experimental results indicated multiple constraints (i.e., lexical, prosodic, syntactic, and semantic constraints) on processing ambiguous sentences.

None of the studies on L2 sentence processing that I am aware of have looked at how EFL learners interpret reconstruction in terms of current linguistic and parsing theories. This article aims to fill this gap.

#### *Research Questions*

In the light of linguistic and psycholinguistic explanations, the main research questions are the following:

1. Do Chinese EFL learners have linguistic knowledge of reconstruction in English?
2. Do Chinese EFL learners actively search for a gap or delay postulating a gap until the end of a sentence when they process reconstruction?

## Experiment 1

### *Participants*

The participants were 60 Chinese learners of English and 20 native speakers of English. The Chinese learners were all college students learning English as a foreign language in Shanghai, China. The native speakers of English were students at a major research institution in the United States.

### *Instruments and Rationale*

The experimental materials were 16 sentences with reconstruction (Appendix A):

(25) John<sub>i</sub> wonders which pictures of himself<sub>i/j</sub> Bill<sub>j</sub> admires.

In sentences like (25), the reflexive *himself* can be bound by either the embedded subject *Bill* or the matrix subject *John*. In addition, the experimental materials also included 16 fillers.

If Chinese EFL learners have knowledge of reconstruction in English, they should exhibit the possibility of potential ambiguity of antecedence for the reflexive. In other words, they should bind the reflexive to either the embedded or matrix subject. Since the reconstructed sentences involve the filler-gap dependency, the Active Filler Strategy would predict that the parser would initially try to assign *which pictures of himself* to the subject position in (25). This hypothesis will need to be abandoned upon receiving the noun phrase *Bill*. The parser will then postulate a gap following *admires*. The Gap-as-last-resort strategy would predict that the parser would delay postulating a gap until the end of the sentence. Thus, despite different predictions, the two psycholinguistic accounts claim a structure dependency between the *gap* (the empty position) and the *filler* (the fronted *wh*-phrase) and suggest that the parser would seek binding of the reflexive to the embedded subject for reconstruction in English.

*Procedure*

Before the experiments, the Chinese students were first asked to complete a language history survey. Information about their age and years of English learning is reported in Table 1.

**Table 1:** Age and years of English learning

	Mean	SD	Range
Age (N=60)	20.42	1.41	18-23
Years of English Learning (N=60)	8.15	1.02	6-11

Information about their English entrance exam scores is reported in Table 2.

**Table 2:** English entrance exam scores (n= 60)

	Mean	SD	Range
English scores (maximum 150 points)	113.93	7.88	98-139

The English entrance exam in China is a required test for high school students who wish to go to college. The minimum score for entering a college varies from school to school. Table 2 shows that the students' English proficiency levels varied a great deal at the time when they were admitted as college students. The survey also indicated that none of the students had ever traveled to an English-speaking country or been taught by a native speaker of English.

After the survey, they were asked to take a simplified version of the TOEFL test. The test consists of 25 questions on English Structure, and 25 questions on Reading Comprehension. The test did not include the listening comprehension questions because this study was not aimed

at testing the subjects' listening comprehension ability. But a basic understanding of English sentence structure and an ability to make inferences were important for this study, because the experiments not only dealt with single sentences; they also involved making inferences using contextual cues. Thus the test included two sections of the TOEFL test, the Structure section (25 points) and the Reading Comprehension section (25 points). The test began with written instructions and examples. The students were asked to identify and circle one out of the four given choices. The purpose of the test was to measure the students' English proficiency and to group them according to their English proficiency levels. Thomas (1993) administered a simplified Michigan test, which also included 50 test items, each with one point. In her study the low level comprised subjects with scores between 19 and 31, the mid level had scores between 32 and 40, and the high level had scores between 41 and 50. In this study, the low level comprised students with scores between 20 and 30, the mid level had scores between 31-39, and the high level had scores between 40 and 48. The low level started with 20, since that was the lowest score of the test, and ended with 30 rather than 31, since 30, 60% of the total score, is traditionally considered a passing grade. The mid level ended with 39 instead of 40, because 40, 80% of the total score, appears to be a score that characterizes a high proficiency level. The high level ended with 48 instead of 49, because this was the highest score of the test. The original pool consisted of 27 freshmen, 28 sophomores and 26 juniors. The subjects were regrouped according to the test results, with each level having 20 students. The results of the test at each level are reported in Table 3.

**Table 3:** TOEFL test results

	Mean	SD	Range
Low	26.50	2.57	20-30
Mid	36.05	3.07	31-39
High	43.95	2.46	40-48

Then the students participated in the experiment. They were given instructions and examples before the experiment. The instructions specified that experimental sentences had the following format:

(26) John thinks that Bill likes himself.

Who is referred to by himself?

a) John    b) Bill    c) someone else    d) none of the above

They were instructed to identify, as quickly as possible, who himself refers to in the sentence by circling one of the four choices marked (a), (b), (c) or (d). They were instructed NOT to go back and make any changes after they had made a choice.

## Results

As shown in Table 4, the low-level Chinese Group (C-Group 1) showed a strong preference for binding the reflexive to its matrix subject (M=12.1 for the matrix subject vs. M=3.9 for the embedded subject). The mid-level Chinese Group (C-Group 2) showed a similar preference for the matrix subject binding (M=12.3 for the matrix subject vs. M=3.7 for the embedded subject). The high-level Chinese group (C-Group 3) patterned like other Chinese groups with respect to their preferences for the matrix subject binding (M=12.7 for the matrix subject vs. M=3.3 for the embedded subject). In fact, Chinese learners of English were comparable with native speakers of English, who also showed a very strong preference for the matrix subject binding (M=14.7 for the matrix subject vs. M=1.3 for the embedded subject).

**Table 4:** Performance on 16 sentences with reconstruction by Chinese learners of English and native speakers of English (NSs).

	C-Group 1 (low level) (N=20)		C-Group 2 (mid level) (N=20)		C-Group 3 (high level) (N=20)		US-Group (NSs) (N=20)	
	M	SD	M	SD	M	SD	M	SD
Embedded subject	3.9	2.5	3.7	2.8	3.3	1.6	1.3	1.2
Matrix Subject	12.1	2.1	12.3	2.8	12.7	1.6	14.7	1.2

## Discussion

Instead of showing the possibility of binding the reflexive to either the embedded or matrix subject, Chinese EFL learners showed a strong preference for the matrix subject binding. The low-level Chinese students bound the reflexive to the matrix subject 75.3%, the mid-level Chinese students 76.9%, and the high-level Chinese students 79.7%. Interestingly, native speakers of English also showed a strong preference for binding the reflexive to the matrix subject (91.9%). These findings may very well be due to the nature of a multiple-choice task, where the set of choices is supplied in the form of a list of potential antecedents. Recall that the subjects in this experiment were instructed to QUICKLY identify one answer out of the four choices given. When the subjects were asked to identify an antecedent for the reflexive, they chose the matrix subject, because the reflexive can be interpreted immediately. On the other hand, if they identified the embedded subject as the antecedent of the reflexive, the reflexive cannot be interpreted immediately; it has to be placed back to its original movement site and to be interpreted there. In other words, not associating the reflexive to the left imposes a load on the processor, which must "remember" that there is an antecedent to be found (Barss, personal communication).

The result regarding the matrix subject binding for reconstruction appears to support "the Economy Principle" (Chomsky, 1993) in the minimalist framework. This principle refers to a general requirement that all representations and derivations [processes used to derive them] be subject to a certain form of "least effort" condition and be as minimal or economical as possible (Cook and Newson, 1996). The Chinese EFL learners' (and the native speakers') binding of the reflexive to the matrix subject consumes minimal effort, because the matrix subject binding imposes no extra processing load on the processor.

The finding regarding Chinese learners' preference for the matrix subject binding of the reflexive for reconstruction in English indicates that Chinese EFL learners did not appear to actively search for a gap; nor did they wait until the end of the sentence when they interpreted such sentences, for either of the two strategies would have resulted in the parser seeking the embedded subject as the antecedent for the reflexive. This suggests that pure *wh*-gap sentences (e.g., *Who did John see \_\_\_?*) are likely to differ from *wh*-gap sentences with reflexives (i.e., reconstruction). With pure *wh*-gap sentences, links between the gap and the filler are made eventually. Regarding *wh*-gap sentences with reflexives, links between the gap and the filler are not necessarily made, because the moment the reflexive appears, the parser would seek an antecedent to bind it. Since the matrix subject is a current antecedent (i.e., an antecedent that has just been processed), the parser would take it as the binder for the reflexive. This interpretation is more "minimal" or "economical" than the interpretation based on "actively searching for a gap" or "waiting until the end of the sentence". The latter interpretation involves more costly computations because the parser has to, first of all, suspend the immediate links between the reflexive and its current antecedent, and then establish new links between the reflexive and the new antecedent.

Chinese EFL learners' matrix subject binding of the reflexive left unanswered the question of whether Chinese learners have knowledge of potential ambiguity of antecedence for the reflexive in reconstruction. Experiment 2 investigated such knowledge.

## Experiment 2

### *Participants*

Experiment 2 included the same participants as Experiment 1.

### *Instruments and Rationale*

The experimental materials were the same 16 sentences as in Experiment 1, but they were preceded by a context favoring the embedded subject binding<sup>2</sup>.

(27) Bill has lots of his own pictures. John does not think that Bill admires all of them. John wonders which pictures of himself Bill admires.

Given the contextual information favoring the embedded subject binding of the reflexive in this experiment, I predicted that the matrix subject binding of the reflexive for sentences with reconstruction in Experiment 1 would be greatly reduced. In other words, the participants would exhibit the embedded subject binding of the reflexive.

### *Procedure*

The experiment was conducted one week after Experiment 1. The students were given instructions and examples before the experiment. The instructions specified that the experimental sentences had the same format as they did the previous week, but these sentences occurred in a task context. Namely, there were two semantically related sentences in each set of sentences. Their task was to read the sentences carefully and identify an answer by circling one of the four choices marked (a), (b), (c) and (d), as in (28):

(28) William had lots of his own portraits. Richard did not think that William admired all of them. Richard wondered which portraits of himself William would admire.

Who is referred to by *himself*?

- (a) William (b) Richard (c) someone else (d) none of the above

## Results

**Table 5:** Performance on 16 sentences with reconstruction by Chinese learners of English and native speakers of English (NSs) in a discourse context.

	C-Group 1 (low level) (n=20)		C-Group 2 (mid level) (n=20)		C-Group 3 (high level) (n=20)		US-Group (NSs) (n=20)	
	M	SD	M	SD	M	SD	M	SD
Embedded subject	11.4	2.4	11.1	2.8	13.3	2.2	14.2	1.3
Matrix Subject	4.6	2.4	4.9	3.3	2.7	2.2	1.8	1.3

Table 5 indicates that Chinese students and native speakers of English showed a preference for the embedded subject binding of the reflexive for reconstruction in a referential context. The low-level Chinese Group showed a preference for binding the reflexive to the embedded subject (M=11.4 for the embedded subject vs. M=4.6 for the matrix subject). A correlated groups t-test compared the mean of C-Group 1's embedded subject binding in NP fronted sentences in a referential context (M=11.4) with the mean of the embedded subject binding in the same type of structure without a referential context in Experiment 1 (M=3.9). The differences were found to be statistically significant,  $t(19) = -10.97$ ,

$p < .0001$ , indicating the influence of contextual cues on the low-level Chinese students' interpretation of NP fronted sentences.

The mid-level Chinese Group also showed a preference for the embedded subject binding of the reflexive ( $M=11.1$  for the embedded subject vs.  $M=4.9$  for the matrix subject). A correlated groups t-test compared the mean of C-Group 2's embedded subject binding of the reflexive in a referential context ( $M=11.1$ ) with the mean of the embedded subject binding in the same type of structure without a referential context in Experiment 1 ( $M=3.7$ ). It was found to be statistically significant,  $t(19) = -8.1$ ,  $p < .001$ , illustrating the effect of contextual cues on the mid-level Chinese students' interpretation of NP fronted sentences.

The high-level Chinese group showed a strong preference for the embedded subject binding ( $M=13.3$  for the embedded subject vs.  $M=2.7$  for the matrix subject). A correlated groups t-test compared the mean of C-Group 3's embedded subject binding of the reflexive in a referential context ( $M=13.3$ ) with the mean of the embedded subject binding in the same type of structure without a referential context in Experiment 1 ( $M=3.3$ ). It was found to be statistically significant,  $t(19) = -17.1$ ,  $p < .0001$ , showing that contextual cues influenced the high-level Chinese students' interpretation of NP fronted sentences.

Native speakers of English showed a very strong preference for the embedded subject binding ( $M=14.2$  for the embedded subject vs.  $M=1.8$  for the matrix subject). A correlated groups t-test compared the mean of their embedded subject binding of the reflexive in a referential context ( $M=14.2$ ) with the mean of the embedded subject binding of the reflexive in the same type of structure without a referential context in Experiment 1 ( $M=1.3$ ). It was found to be statistically significant,  $t(19) = -31.48$ ,  $p < .0001$ , indicating the influence of contextual cues on native speakers' interpretation of NP fronted sentences.

## Discussion

The results of this experiment confirmed the prediction regarding the effect of contextual information. Chinese learners of English showed a strong preference for the embedded subject binding of the reflexive for NP fronted sentences in a referential context favoring binding the reflexive to the embedded subject.

Recall that in the sentence interpretation task of reconstruction without a referential context in Experiment 1, the Chinese students showed a strong preference for the matrix subject binding. Taken together, these data indicate that the Chinese learners of English had knowledge of potential ambiguity of antecedence of *himself/herself* in reconstruction, despite the fact that such information with the movement of *wh*-elements is not present in Chinese. In other words, given the appropriate context, they would bind the reflexive to either the embedded or matrix subject.

The combined results of Experiments 1 and 2 on sentences with reconstruction suggest that Chinese learners of English appeared to "know" two options at LF. As discussed earlier in the introduction, Chomsky (1993, 1995) proposed two options at LF to account for ambiguity of antecedence of a reflexive in reconstruction:

(29) John wondered [which photographs of himself] [Bill saw *t*].

One option assumes that at LF only *wh*-material is in *wh*-positions. As a result, the non-*wh*-material that is overtly moved along with a *wh*-element, as in (25), is placed back into its original position and only *wh*-elements undergo covert movement to *wh*-positions at LF. Under this option, *himself* takes the embedded subject *Bill* as antecedent. The Chinese learners' preference for the embedded subject binding of the reflexive in this experiment appeared to derive from their tacit knowledge of this option at LF.

The other option assumes that *which pictures of himself* adjoins to *wh*. Then, *wh* is deleted from the fronted phrase, whereas the phrase adjoined to *wh* is deleted from the copy. Under the second option, *himself* takes the matrix subject *John* as antecedent. The Chinese learners' preference for the matrix subject binding of the reflexive in Experiment 1 appears to derive from their tacit knowledge of this option at LF. Thus the combined findings of Experiments 1 and 2 appear to indicate that Chinese EFL learners have knowledge of reconstruction in English.

In Experiment 2, the parser appeared to wait until the end of the sentence in their interpretation of reflexives. This is not unexpected, given the robust effect of contextual cues reported in Altmann & Steedman (1988) and Ying (1996). In other words, when confronted with input allowing more than one interpretation, the parser would make use of available pragmatic information to help make a parsing decision. Thus seeking a local antecedent for the reflexive in these contexts is "minimal" in nature, because the preceding context helped the parser identify the local antecedent as the plausible interpretation without having to infer at length which of the two interpretations to choose, thus sparing more costly computations.

The results of the two experiments also argue for two types of parser - a modular parser and an interactive processor (Nicol, 1996, p. 1) in language processing. A modular parser undergoes grammar's direct influence because it makes parsing decisions based on grammar using, for example, "the Economy Principle" (Chomsky, 1993). In Experiment 1, the Chinese EFL learners bound the reflexive to the matrix subject under the syntactic constraint that focuses on the notion of economy, insisting on an interpretation that does not impose an extra processing load on the processor. Although grammar directly influences parsing decisions made by a modular parser, an interactive processor interacts with grammar to ensure the well-formedness of incoming strings of words and makes parsing decisions using pragmatic information. That is, parsing "could be interactive not just architecturally

but de facto as well: Pragmatic information is accessible in time for it to have an influence on ambiguity resolution, if the structure of the system permits it to do so" (Fodor, et al., 1996, p. 48). Experiment 2 provided evidence for this: Interactive with grammar that "specifies the class of available sentence structures" (Ritchie and Bhatia, 1996, p. 20), the interactive processor made use of the available pragmatic information (contextual cues) to bind the reflexive to the embedded subject. The preceding discourse context helped the parser identify the embedded antecedent as the plausible interpretation without having to infer at length which of the two interpretations to choose, thus sparing more costly computations. Thus, it appears that "human processors employ grammatical information about a single sentence *flexibly*, at some points suspending word-by-word application of that information to consult information about prior discourse" (Sag, 1991, p. 76, italics added). In other words, language processing involves the interface of syntactic and pragmatic information which produces "the integrated understanding of what has been said in a given context of utterance" (Kasher, 1991, p. 579).

## Conclusion

This article is among the first to examine L2 sentence processing from the perspective of Chomsky's (1993, 1995) minimalist program. It investigated Chomsky's minimalist proposal that ambiguity of antecedence of a reflexive in reconstruction derives from two options at LF. The two experiments reported in this study produced evidence that Chinese EFL learners have knowledge of two options at LF. Chinese EFL learners bound the reflexive predominantly to the matrix subject in a null context, but they bound the reflexive predominantly to the embedded subject in a referential context. In processing reconstruction in a null context, Chinese EFL learners appeared to obey neither the "Active Filler Strategy" nor the "Gap as Last Resort" strategy, because they did not bind the reflexive predominantly to the embedded subject,

as suggested by the two strategies. In processing reconstruction in a referential context, Chinese EFL learners made use of contextual information and bound the reflexive to the embedded subject. Processing reconstruction in both contexts appears to be constrained by "the Economy Principle" proposed by Chomsky in his minimalist program. The Chinese EFL learners' binding of the reflexive to the matrix subject in a null context consumes "minimal" effort, because the matrix subject binding imposes no extra processing load on the processor. Identifying the embedded subject as antecedent for the reflexive in a referential context is "minimal", too, because the preceding context helped the parser identify the appropriate antecedent without having to infer at length which of the two interpretations to choose, thus sparing more costly computations. Thus "the Economy Principle" in the minimalist framework appears to provide a plausible account for Chinese EFL learners' processing of reconstruction in English.

### Notes

- 1 This article is a revised version of a paper presented at the Annual Meeting of the American Association of Applied Linguistics (AAAL) in Orlando, Florida in March, 1997. I would like to thank Andy Barss, Janet Nicol, Douglas Adamson and the participants at the meeting for their helpful comments on earlier drafts
- 2 For the use of a similar preceding context, see Altmann and Steedman (1988), and Ying (1996).

### References

- Altmann, G. & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, 30, 191-238.
- Baker, C. (1979). Syntactic theory and the projection problem. *Linguistic Inquiry*, 10, 533-581.
- Barss, A. (1986). *Chains and anaphoric dependence*. Ph.D. dissertation, MIT.

- Barss, A. (1994). *Anaphora and the timing of dependency formation*. Unpublished manuscript, University of Arizona, USA.
- Bates, E. & MacWhinney, B. (1989). Functionalism and the Competition Model. In B. MacWhinney and E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 3-73). Cambridge: Cambridge University Press.
- Bialystok, E. (1994). Towards an explanation of second language acquisition. In G. Brown, K. Malmjaer, A. Pollitt, & J. Williams (Eds.), *Language and understanding* (pp. 115-138). Oxford: Oxford University Press.
- Chomsky, N. (1981). *Lectures on government and binding*. Dordrecht: Foris.
- Chomsky, N. (1993). A minimalist program for linguistic theory. In K. Hale & J. Kester (Eds.), *The view from Building 20: Essays in honor of Sylvain Bromberger* (pp. 1-52). Cambridge, MA: The MIT Press.
- Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: The MIT Press.
- Cook, V. & Newson, M. (1996). *Chomsky's Universal Grammar: An introduction* (2nd ed.). Oxford: Blackwell.
- Fodor, J. (1978). Parsing strategies and constraints on transformation. *Linguistic Inquiry*, 9, 427-474.
- Fodor, J., Ni, W, Crain, S. & Shankweiler, D. (1996). Tasks and timing in the perception of linguistic anomaly. *Journal of Psycholinguistic Research*, 25, 25-57.
- Frazier, L. & G. Flores D'Arcais (1989). Filler driven parsing: A study of gap filling in Dutch. *Journal of Memory and Language*, 28, 331-344.
- Gass, S. (1987). The resolution of conflicts among competing systems: A bi-directional perspective. *Applied Psycholinguistics*, 8, 329-350.
- Gibson, E. (1994). Processing empty categories: A parallel approach. *Journal of Psycholinguistic Research*, 23, 381-405.
- Harley, B. Howard, J. & Hart, D. (1995). Second Language processing at different ages: Do younger learners pay more attention to prosodic cues to sentence structure? *Language Learning*, 45, 43-71.

- Harrington, M. (1987). Processing transfer: Language-specific processing strategies as a source of interlanguage variation. *Applied Psycholinguistics*, 8, 351-377.
- Heilemann, L. & McDonald, J. (1993). Processing strategies in L2 learners of French: The role of transfer. *Language Learning*, 43, 507-557.
- Hornstein, N. & Lightfoot, D. (Eds.) (1981). Explanations in linguistics: The logical problem of language acquisition. London: Longman.
- Huang, C-T. James (1982). *Logical relations in Chinese and the theory of grammar*. Ph.D. dissertation, MIT.
- Juffs, A. & Harrington, M. (1996). Garden path sentences and error data in second language sentence processing. *Language Learning*, 46, 283-326.
- Kail, M. (1989). Cue validity, cue cost, and processing types in sentence comprehension in French and Spanish. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 77-117). Cambridge: Cambridge University Press.
- Kasher, A. (1991). Pragmatics and the modularity of mind. In S. Davies (Eds.), *Pragmatics: A reader* (pp. 567-582). Oxford: Oxford University Press.
- Kilborn, K. (1989). Sentence processing in a second language: The timing of transfer. *Language and Speech*, 32, 1-23.
- Kilborn, K. (1994). Learning a language late: Second language acquisition in adults. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 917-944). New York: Academic Press.
- Kilborn, K. & A. Cooreman. (1987). Sentence interpretation strategies in adult Dutch-English bilinguals. *Applied Psycholinguistics*, 8, 415-431.
- Kilborn, K., & Ito, T. (1989). Sentence processing strategies in adult bilinguals. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 257-291). Cambridge: Cambridge University Press.
- Liu, H., Bates, E. & Li, P. (1992). Sentence interpretation in bilingual speakers of English and Chinese. *Applied Psycholinguistics*, 13, 451-484.

- MacDonald, M. (1993). The interaction of lexical and syntactic ambiguity. *Journal of Memory and Language*, 32, 692-715.
- McDonald, J. & Heilemann, L. (1991). Determinants of cue strength in adult first and second language speakers of French. *Applied Psycholinguistics*, 12, 313-348.
- MacWhinney, B. (1987a). Applying competition model to bilingualism. *Applied Psycholinguistics*, 8, 315-327.
- MacWhinney, B. (1987b). Cues, competition, and learning. In J. Miller (Eds.), *Wisconsin papers on language development*. Madison, Wisconsin: University of Wisconsin Press.
- MacWhinney, B. (1992). Competition and transfer in second language learning. In R. Harris, (Eds.), *Cognitive processing in bilinguals* (pp. 371-390). Amsterdam: North-Holland.
- Miao, X. (1981). Word order and semantic strategies in Chinese sentence comprehension. *International Journal of Psycholinguistics*, 8, 23-33.
- Nicol, J. (1996). Introduction. *Journal of Psycholinguistic Research*, 25, 1-3.
- Ouhalla, J. (1994). *Introducing transformational grammar*. London: Edward Arnold.
- Pinker, S. (1994). *The language instinct*. New York: Harper Perennial.
- Ritchie, W. & Bhatia, T. (1996). Second language acquisition: Introduction, foundations, and overview. In W. Ritchie & T. Bhatia (Eds.), *Handbook of second language acquisition* (pp. 1-46). New York: Academic Press.
- Sag, I. (1991). Linguistic theory and natural language processing. In E. Klein & F. Veltman (Eds.), *Natural language and speech* (pp. 69-83). Berlin: Springer-Verlag.
- Sasaki, Y. (1991). English and Japanese interlanguage comprehension strategies: An analysis based on the Competition Model. *Applied Psycholinguistics*, 12, 47-73.
- Thomas, M. (1993). *Knowledge of reflexives in a second language*. Amsterdam: John Benjamins.
- Vaid, J. & Pandit, R. (1991). Sentence interpretation in normal and aphasic Hindi speakers. *Brain and Language*, 41, 250-274.

- White, L. et al. (1997). The researcher gave the subject a test about himself: Problems of ambiguity and preference in the investigation of reflexive binding. *Language Learning*, 47, 145-172.
- Wulfeck, B., Juarez, L., Bates, E., & Kilborn, K. (1986). Sentence interpretation strategies in healthy and aphasic bilingual adults. In J. Vaid (Ed.), *Language processing in bilinguals: Psycholinguistics and neurological perspectives* (pp. 199-219). Hillsdale, NJ: Lawrence Erlbaum.
- Ying, H. (1996) Multiple constraints on processing ambiguous sentences: Evidence from adult L2 learners. *Language Learning*, 46, 681-711.

APPENDIX: EXPERIMENTAL SENTENCES

1. John wonders which pictures of himself Bill admires.
2. Mary wondered which posters of herself Nancy admired.
3. Tom wonders which portraits of himself David likes.
4. Susan wondered which photographs of herself Cindy liked.
5. Lisa wondered which drawings of herself Jennifer loved.
6. Jack wonders which photographs of himself Mark hates.
7. Jane wondered which posters of herself Alice hated.
8. Richard wondered which portraits of himself William would admire.
9. Wendy wondered which pictures of herself Nancy would admire.
10. Peter wondered which drawings of himself Max would love.
11. Helen wondered which posters of herself Lucy would love.
12. Robert wondered which portraits of himself John would like.
13. Cathy wondered which photographs of herself Nancy would like.
14. Steve wondered which pictures of himself Paul would love.
15. Rebecca wondered which posters of herself Alice would love.
16. Lisa wondered which drawings of herself Helen admired.