

**PROCESSING CHINESE EMPTY
CATEGORIES**

By

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Abstract

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This study investigates empty category (or ‘gap’) interpretation by native Mandarin Chinese speakers. Two research methods (sentence completion and self-paced reading) and four experiments were employed to examine the strategy adopted to assign a reference (or a ‘filler’) to an identified empty category in real-time sentence comprehension. The sentences tested included main clause, clausal subject, clausal object, and relative clause constructions, all of which contained an empty category in subject position (*pro*, PRO or trace, according to the construction).

There are three pertinent research questions:

- I) When a gap is identified before its filler is, does the parser adopt the first candidate filler, or does it wait to see whether a better filler may subsequently appear?
- II) How does empty category interpretation interact with structural ambiguity resolution?
- III) Is local interpretation of a gap (as generic in reference) preferred over association with a filler elsewhere in the sentence?

Re Question I: The data indicate that the parser adopts the first available filler. This candidate filler may be in the already parsed segment of the sentence, or the first plausible filler encountered in subsequent words.

Re Question II: The results show that the parser, when facing a combined structural and empty category ambiguity, is willing to sacrifice a preferred structural analysis in order to obtain an optimal reference for an empty category.

Re Question III: For the empty subject within a clausal subject, the parser can either locally assign a generic interpretation or else search for an overt filler in the sentence. The data show that the parser prefers the latter strategy, and takes a generic interpretation as the last resort if no filler is found.

These findings can be integrated into a comprehensive parsing strategy (an ‘Active Gap Strategy’) for on-line empty category interpretation in Chinese. This strategy is proposed as a universal strategy, alongside Minimal Attachment and others.

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CHAPTER 1

Introduction

1.1 Background

This study investigates the processing of empty categories in Mandarin Chinese by native speakers. An ‘empty category’ is a syntactic constituent which has no phonological realization. In some linguistic and psycholinguistic discussions it may also be called a gap, or a zero pronoun, or a null anaphor, or a null subject or object, depending on its structural position and role in the sentence or discourse. The principle of Full Interpretation (Chomsky, 1995) requires every syntactic constituent, even if phonologically null, to be interpreted at the conceptual-intentional (semantic) interface. The nominal that provides an interpretation to an empty category may be called its antecedent, its controller, its binder, or the filler for the gap, or a co-referent. In what follows, I will lean toward the most neutral terminology, since the focus of this dissertation is the on-line interpretation, rather than the syntactic status, of an empty category.

In essence, then, an empty category is phonetically null and is referentially dependent on another linguistic or non-linguistic element. Whether or not it does indeed have syntactic reality depends on the linguistic theory that is assumed.¹ If it does not, the term “empty category” is a misnomer, but in this dissertation I will continue to use it for convenience without prejudice to the important theoretical issues that lie behind it. In either case, there is an understood element in the semantic representation (or logical

¹ See section 3.1.3 for discussion of the psychological reality of empty categories, and the arguments over whether an empty category is a syntactic or semantic element.

form) of the sentence. In the linguistics literature, especially Government-Binding theory and its more recent developments, an empty category is often represented as an element in the syntactic structure of example sentences, as *pro* or PRO or *t* (a movement trace), or more neutrally as *e*. Matched subscripts on it and another element in the sentence or discourse indicates a coreferential reading of these two elements.

The distribution of empty categories (which is a matter of how they are licensed) and the recovery of their referents (which is a matter of how they are identified) have been approached from different perspectives. The present study looks at these issues from the perspective of sentence processing, with the focus of the investigation on how an empty category is assigned a referent in a sentence that is unfolding in real-time. In sentence processing, the presence of either a filler or a gap in a sentence can disrupt the basic process of phrase structure assignment to a word string. Structure assignment is not complete until every filler has been linked with a gap, and every gap has been linked with a filler. In a filler-gap dependency, the filler depends on the gap for its thematic role, if it is a fronted phrase in a non-argument position that carries no thematic role of its own. For example, in an English *wh*-question like *Who_i did Mary believe that John insulted e_i yesterday?* the word *who* is a fronted item that cannot be assigned a thematic role in its surface structural position. It therefore needs to be co-indexed with another element in the sentence which does have a thematic role, from which it can acquire its thematic role at second hand. On the other hand, a gap is typically a thematically assigned element but it lacks a referential interpretation. As a result, it needs to acquire a reference through co-indexation with an overt element elsewhere in the sentence or discourse. These mutual

requirements of thematic role assignment for fillers and referential interpretation for gaps underpin a filler-gap dependency. (See Fodor, 1978; Pritchett, 1992; among others.)

Some previous sentence processing studies have shown evidence of an *active* filler-gap parser, which tries to complete a filler-gap dependency as soon as it can. (See more discussion in section 3.1.1.) Note that processing of a filler-gap association can be driven either by the filler or by the gap. In this dissertation, the former type is called *filler-driven* filler-gap dependencies, and the latter type is called *gap-driven* filler-gap dependencies. Typically, a filler linearly (temporally, in real-time sentence processing) precedes the gap in a filler-driven dependency, and a gap linearly (temporally) precedes the filler in a gap-driven dependency. However, in some instances, the component that motivates initiation of establishing a filler-gap dependency may actually be received later than the other component. For example, if no gap has yet been encountered and an item that is linguistically a potential filler is in a thematically assigned position, the parser would have no reason at that point to identify it as a filler; a filler search would be instigated, presumably, only when a gap is subsequently encountered. I will call this kind of dependency gap-driven, even though the filler is encountered first, because it is the gap that drives the completion of the dependency. Control constructions and passive constructions in English exhibit this kind of gap-driven filler-gap dependency. (See examples and discussion in sections 3.1 and 3.2.) On the other hand, it is also possible that a gap which precedes a filler is not recognized as a gap when it is encountered, so that it is only the subsequent appearance of a filler that drives the parser to create a gap in the previous segment of the sentence.² An example is the adjunct relative clause

² This is presuming that the parser would prefer not to posit a gap unless there is clear evidence that it is necessary. This has not been studied in Chinese. For English, there is a curious finding that suggests that

construction in Chinese discussed in section 2.3. Mazuka et al. (1989; discussed in Mazuka, 1991) have investigated the processing of this kind of filler-gap dependency in Japanese, and did not find a significant processing cost when the parser backtracks and posits an empty category in the parsed segment of the sentence.³

The present study focuses on the processing of gap-driven filler-gap dependencies, which has received much less research effort so far than filler-driven dependencies. Chinese is the language of investigation. Empty categories occur in many constructions in Chinese, thereby creating test materials rich in empty category ambiguities. This makes it possible to observe the parser's preferences in processing empty categories. Chinese also has sentence patterns that permit experimental comparison of different gap-filling strategies. Among the various structural positions that an empty category can occur in, this study focuses on empty categories in subject position. The subject position can remain null in more constructions than other structural positions in Chinese. Consequently, there is the widest possible range of constructions that can be employed to test gap-filling strategies. In addition, this allows comparison of

the parser does not refrain from positing a gap even when it is not required by the grammar. What little psycholinguistic evidence there is on the *visiting relatives* ambiguity suggests that there is no strong preference for the adjective+noun analysis over the verb+noun analysis though the former has no empty category but the latter does. An early study by Mehler and Carey (1967) implied a fairly strong preference for the verb+noun reading. However, this was in the context *They are recurring mistakes / They are describing events*, where the preference could be due to interpreting *they are* as subject+progressive auxiliary. A recent study by Mani (2004) tested item fragments such as *Frying eggs are... / Frying eggs is...* and found no difference in response time to *are* or *is* following the first two words (presented auditorily), suggesting the two interpretations were equally preferred. This is perhaps surprising, but possibly it can be explained as due to the greater frequency of *-ing* in English as verbs than as adjectives. This will not be discussed in this dissertation; Chinese does not have this ambiguity.

³ One type of experimental sentence in Mazuka et al. contained a subject noun phrase that is ambiguous as to being the subject of an adverbial clause, or being the subject of a main clause. The subject noun phrase, which resides at the beginning of the sentence, is likely to be initially read as the subject of the adverbial clause. But when the matrix verb, which occurs at the end of the sentence, is encountered, it becomes obvious that the noun phrase is the subject of the main clause, and an empty category with a referent different from the main clause subject has to be posited as the subject of the adverbial clause. Mazuka et al. found that the per-character whole-sentence reading times of this type of sentence were not significantly different from those of the baseline sentence, which was a plain complex sentence with an adverbial clause.

the findings of this study with studies on other languages which have few or no null elements other than null subjects.

Some basic assumptions about the operations of the human sentence parsing mechanism underlie the current project. This study assumes serial incremental parsing and full attachment. Based on these assumptions, the parser processes a sentence incrementally, which means it tries to attach each word, as soon as it encounters it, into the partial phrase structure it is constructing for the sentence. In the case of ambiguity, the parser prefers to attach the incoming word rather than leave it unattached and wait for more information to resolve the ambiguity. (See Frazier and Rayner, 1982; among others.)

On encountering an ambiguity, a serial parser selects and follows only one analysis. It reanalyzes that analysis as necessary later, only if and when the incoming material is incompatible with the current analysis (Lewis, 2000).⁴ This is in contrast to a parallel parser, which can maintain more than one analysis at the same time; it may eventually select the most probable analysis and give up on others, depending on the amount and quality of evidence that supports one analysis (Gibson & Pearlmutter, 2000).

A parser that abides by a principle of Full Attachment tries to build all the dominating nodes over each word as it receives it. The implication of this is that the parser would prefer to guess, if necessary, the maximal phrasal projection of an incoming word, rather than creating orphan nodes that are unattached to the current partial phrasal

⁴ That is, this study assumes the principle of Revision-as-Last-Resort (Fodor & Frazier 1980), in the sense that the parser's current analysis will not be revised unless there are no legitimate means to attach the incoming material into it. It is possible, however, given that ambiguities are ubiquitous in Chinese, that the parser may be more ready to consider alternative analyses than in languages where ambiguities are less common (cf. the discussion of parsing Japanese by Fodor and Inoue, 2000). This openness to reanalysis may permit some revisions in Chinese to occur with little processing cost.

marker. For example, if it encounters *John* at the beginning of a sentence, it not only assigns the lexical category ‘noun’ to the word, but also constructs a maximal phrasal structure to accommodate the word, for example, [IP [NP John]....].

Full attachment is generally assumed to be an efficient parsing strategy for head-initial languages like English (e.g., Frazier & Rayner, 1988). No studies seem to have investigated whether a Chinese parser obeys full attachment. But evidence from other languages is telling. Inoue and Fodor (1995) argue that even in a head-final language like Japanese, where the verb that assigns the argument structure resides at the end of a clause, decisions on the attachment of an ambiguous phrase are made long before the crucial information that guides the attachment becomes available. This stands in contrast to a bottom-up parser that may assign the lexical category to a word, but delay decisions on the higher nodes that dominate the word. In addition, Frazier (1987a) presents experimental evidence to argue that in a mixed-headed language like Dutch, whose main clause is head-initial but subordinate clause head-final, the assignment of phrase structure begins before the head is processed. Chinese is also a mixed-headed language, with basic SVO word order but strictly head-final noun phrases. If evidence in general supports full attachment for languages with different headedness features, it is reasonable to assume that full attachment applies to on-line Chinese sentence processing.

1.2 General parsing strategies

One of the most influential accounts of syntactic ambiguity resolution is the garden-path model (e.g., Frazier 1987b), which embraces two general parsing strategies. The first is the principle of Minimal Attachment, and the other is the principle of Late Closure. These

two strategies are argued to guide the parser to select an analysis when a structural ambiguity is identified. Minimal Attachment is defined as: Do not postulate any potentially unnecessary nodes. In other words, when more than one analysis is available for a phrase, a structurally simpler analysis is preferred over a structurally more complex analysis. Structural simplicity is generally defined as incorporating an ambiguous phrase into the currently parsed structure with the least number of nodes. For example, the fragment *Mary admitted the mistake...* permits two analyses: *the mistake* as the direct object of *admit*, or as the subject within an object complement clause. The direct object analysis is structurally simpler than the object complement clause analysis, and hence, the former is preferred on-line on that basis. If the sentence turns out to be *Mary admitted the mistake was hers*, the initial direct object analysis will need to be revised. A higher processing load may be associated with the reanalysis.

Late Closure is defined as: If grammatically permissible, attach new items into the clause or phrase currently being processed (i.e., the phrase or clause postulated most recently). For instance, in *Mary said John will leave yesterday*, the phrase *yesterday* is preferred to be attached to the subordinate clause, the currently processed clause, rather than the main clause. However, it is incongruous with the meaning of the clause, thereby causing processing difficulty.

The present study assumes Minimal Attachment in on-line sentence processing. Late Closure is not relevant to the target sentences of this study, but constitutes one of the future research interests; see section 5.3.

1.3 Relevant properties of Chinese

This section discusses some linguistic properties of Chinese that are relevant to the present study. It focuses on the specific constructions tested in the experiments, and the properties of the subject gap within these constructions. The most relevant constructions are: main clause, clausal subject, clausal object, and relative clause.

The basic word order of Chinese is subject-verb-object. Thus, the order of major constituents within a main clause or subordinate clause in Chinese is identical to that in English. But there are four relevant linguistic properties of Chinese that are different from English. First, Chinese is a ‘*pro-drop*’ language that allows the subject to remain phonologically null as long as its reference can be recovered from the discourse. (See more discussion in section 2.1.) Second, Chinese does not have a complementizer like English *that* that marks the left edge of a clause. A finite clausal subject in English must be introduced by *that*, as in *That John insulted his boss surprised Mary*, and a complementizer is at least optional in an English sentence that contains a clausal object, for instance, *Mary believed (that) John insulted his boss*. In Chinese neither subject nor object clauses are morphologically signaled in this fashion. Third, Chinese lacks rich morphology, and even the distinction between finite and non-finite verbs is not clearly marked. (See the discussion in section 2.2.1.) This deprives the parser of essential information that would differentiate on-line between a main and a subordinate clause, or would distinguish among different types of subordinate clause. Fourth, Chinese is a mixed-headed language. Even though its basic clausal word order is SVO, Chinese noun phrases are strictly head-final; even relative clauses are pre-nominal. There are also no relativizers like the English *who* or *that* in Chinese that portend a relative clause.⁵ In the

⁵ A relative clause may be disambiguated at its very beginning by preceding demonstratives and classifiers, both of which are typical components of a noun phrase. For example, the structure of a Chinese noun

typical case, the onset of a relative clause in Chinese is not flagged in any way, and it may not be recognizable on-line as a relative clause until its end, where it is followed by *de*, a function word that marks a preceding constituent as a modifier of the head noun that follows. Note that this morpheme *de* also follows all other kinds of modifiers of a noun, including nominal and adjectival phrases.

These properties of Chinese conspire to create abundant local ambiguities, which include not only structural ambiguities, but also ambiguities concerning the referent of a gap. For example, a sentence fragment that begins with a verb implies the presence of a subject gap. This *e Verb* fragment is four-ways ambiguous between a main clause, a clausal subject, a relative clause, and an adjunct clause analysis, as illustrated by the sentences in (1). (The gloss CAU in (1b) below indicates the word is a causative marker.)

(1) a. Main clause

e wuru laoban.
insult boss
'(Someone) insulted the boss.'

b. Clausal subject

[*e_i wuru* laoban] ling John_i shiqu-le zhege jinsheng jihui.
insult boss CAU John lost this promotion opportunity
'Having insulted the boss made John lose this promotion opportunity.'

phrase can be: demonstrative + classifier + relative clause + *de* + noun. If the demonstrative and classifier are incongruous with the first components of the relative clause (e.g., the classifier does not match with the subject within the relative clause), it hints at the presence of a relative clause within the noun phrase. However, there are studies that have shown that classifiers may not be an efficient disambiguator for relative clauses on-line. This is discussed in section 3.3.1.

c. Relative clause

[*e*_i **wuru** laoban] de tongshi_i shiqu-le zhege jinsheng jihui.
 insult boss DE colleague lost this promotion opportunity
 ‘The colleague who insulted the boss lost this promotion opportunity.’

d. Adjunct clause

[*e*_i **wuru** laoban yihou], John_i shiqu-le zhege jinsheng jihui.
 insult boss after John lost this promotion opportunity
 ‘After insulting the boss, John lost this promotion opportunity.’

All the sentences in (1) begin with a null subject and the same verb, but as the sentence unfolds, it becomes clear that the beginning fragments must be assigned different structural analyses. The sentence in (1a) is a main clause, the referent of whose null subject is likely to be recovered from the prior discourse (not shown above). The sentence in (1b) contains a clausal subject with a null subject that is co-indexed with a noun phrase in the main clause predicate. The sentence in (1c) contains a relative clause with a subject gap, whose filler is the head noun that follows the relative clause. The sentence in (1d) contains an adjunct clause with a null subject, whose referent is provided by the main clause subject. Adjunct clauses are not the focus of the present investigation, and will not be discussed beyond this section. Nonetheless, the existence of such a structural analysis for an initial fragment will occasionally be relevant to discussions below.

Note that structural ambiguity interacts with gap interpretation ambiguity at the beginning of these sentences. If the *e Verb* fragment is a main clause, the gap is likely to refer to some discourse referent. On the other hand, if the fragment is assumed to be in a

subordinate clause, as in (1b-d), the referent is likely to appear later, in the main clause that follows.

There are also substantial structural ambiguities when an *e Verb* segment occurs after a matrix verb. It may require a clausal object analysis as in (2a), a relative clause analysis as in (2b), or a complex analysis as a clausal subject inside a clausal object as in (2c).

(2) a. Clausal object

Mary_i dasuan [*e_i* **wuru** laoban].

Mary plan insult boss

‘Mary planned to insult the boss.’

b. Relative clause

Mary chize [*e_i* **wuru** laoban] de tongshi_i.

Mary scorn insult boss DE colleague

‘Mary scorned the colleague who insulted the boss.’

c. Clausal subject (inside a clausal object)

Mary_i jianchi [[*e_i* **wuru** laoban] ling ta_i shiqu-le zhege jinsheng

Mary insist insult boss CAU her lost this promotion

jihui.

opportunity

‘Mary insisted that having insulted the boss made her lose this promotion opportunity.’

These ambiguities concerning a clausal structure subordinate to a preceding matrix clause may in some cases be disambiguated in advance by the type of matrix verb. For example,

dasuan ‘plan’ in (2a) is a verb that is subcategorized for a clausal object,⁶ while *chize* ‘scorn’ in (2b) is a verb that is subcategorized for an object noun phrase. The verb *jianchi* ‘insist’ in (2c) is subcategorized for a clausal object, but it may take either a simple clausal object (such as in English *Mary insisted on leaving*) or a clausal object with a clausal subject embedded in it as in (2c) above. Thus, when an *e Verb* fragment occurs after a matrix clause, the matrix verb may function as a disambiguator or it may sustain the ambiguity.

Note that the filler-gap dependencies in (1) and (2) are all gap-driven. In the sentences in (1b-d) and (2b), the gap linearly precedes the filler. In the sentences in (2a,c), the gap follows the filler. But because the filler is thematically assigned, it is not recognized as a filler when it is encountered, and it seems reasonable to suppose that only when the gap is identified would the parser start to look for a filler to complete the dependency. Therefore, these dependencies also belong to the gap-driven type. In all these sentences except (1a), the filler and gap are in the same sentence. The filler for the gap in (1a) is likely to be found in the prior discourse. (See section 2.5 for more discussion.)

1.4 Research questions

This study investigates how the human sentence comprehension mechanism ranks the options in processing a gap-driven filler-gap dependency. To anticipate the outcome: The ranking of these options can be subsumed under an Active Gap Hypothesis, parallel to the Active Filler Strategy, which was first proposed by Frazier (1987b) and depicts an

⁶ This is unlike English *plan*, which can take a clausal object or a noun phrase object (as in *Mary was planning her wedding*). Here, and in many places in discussion below, the closest translations of Chinese words into English do not adequately reveal their selection properties.

active parser that keenly searches for the gap after a filler is identified. When it encounters a potential gap position, an Active Filler parser immediately posits the gap there rather than waiting to see if the next element in the sentence could fill the position and/or a better gap position will become available later. (See section 3.1.1 for more details.) In the case of a gap-driven filler-gap dependency, it is the gap that initiates the search for the filler to complete the dependency. In this case, an active parser may keenly seek out the filler and assign the first candidate filler to the gap rather than waiting to see if a better filler will become available later.⁷ In order to investigate the various filler-gap configurations in a gap-driven dependency, and how the parser ranks the options in each, I formulate three research questions.

First research question: When a gap is identified before its filler is, does the parser adopt the first candidate filler, or does it wait to see whether a better filler may subsequently appear?

The fundamental question here is how eager the parser is to complete a dependency, as opposed to remaining non-committal and thereby avoiding the risk of having to reanalyze later. If the parser prefers to fill a gap as soon as possible, it would presumably adopt the first candidate filler that is available for the gap. On the other hand, if it prefers to play safe and avoid the risk of subsequent revision, it would delay gap interpretation until the end of the sentence, or at least until the last possible point at which a filler might appear, so that it can be sure it has the best filler for the gap.

⁷ A filler could be better than another for two reasons. First, the grammar may insist that only one is the real filler. In the case of Chinese, grammar dictates the head noun to bind a preceding gap in the relative clause. The other reason could be related to plausibility, e.g., a filler is more likely to be the doer of an action than another.

The option to adopt the first candidate filler has two aspects. First, when a gap is identified, a potential filler may be available in the already parsed segment of the sentence or discourse. Will the parser adopt it immediately, or will it still look for a subsequent filler? Alternatively, when a gap is identified, it may be that no potential filler is already available. Then, in searching for the filler, will the parser adopt the first available candidate, or will it wait in case a better filler appears later? A number of sentence patterns in Chinese can be employed to test these two alternative strategies; some examples are shown in (3) and (4).

- (3) Xiaofen shu-le zhechang bisai yihou, *e* piping...
 Xiaofen lost this competition after criticize
 ‘After Xiaofen lost this competition, (someone) criticized...’

Main clause: ..., *e* piping caipan de shuiping.
 criticize judge DE standard
 ‘she criticized the judges’ standard.’

Clausal subject: ..., *e_i* piping caipan shi ta-de jiaolian_i weiyi neng zuo de
 criticize judge is her coach only can do DE
 shi.
 thing
 ‘criticizing the judges was the only thing her coach
 could do.’

Relative clause: ..., *e_i* piping ta duishou de ren_i dou yaquewusheng.
 criticize her opponent DE people all silent
 ‘the people who had criticized her opponents were all
 silent.’

When the gap (empty subject of *piping* ‘criticize’) is identified in the sentence fragment in (3), the subject of the preceding subordinate clause *Xiaofen* is a potential filler. Hence, if the parser is eager to complete the filler-gap dependency, it would presumably adopt this subject as the filler. But if the parser is more concerned to avoid subsequent revision of the gap interpretation, it would wait to make sure no better filler appears later. The latter option is especially appropriate for a conservative parser given the structural ambiguity of the fragment that contains the empty category. The fragment in (3) can be analyzed as a main clause, as a clausal subject, or as a relative clause. In the case of a main clause, the filler for the gap is likely to be the subject of the preceding adjunct clause *Xiaofen*. In the case of a clausal subject or a relative clause, the grammar requires that the filler follows the gap. Thus, an active gap parser would adopt the only potential filler *Xiaofen* when the gap is encountered, while a conservative parser would remain neutral until the structure of the sentence becomes clear, and potential fillers are revealed.

The fragment in (4) tests the parser’s gap-filling strategy in another way.

- (4) [e Shu-le zhechang bisai] ling Xiaofen...
 lost this competition CAU Xiaofen
 ‘Having lost this competition made Xiaofen...’

When the gap (subject of *shu-le* ‘lost’) is identified in (4), there is no potential filler available. Thus, the parser needs to look for a filler in the incoming material. In the search process, it may adopt the first candidate, which would be *Xiaofen* in (4). But because Chinese noun phrases are head-final, *Xiaofen* might be only a modifier of a head

noun that follows, for example, *Xiaofen de tongshi* ‘Xiaofen’s colleague.’ In this case, *Xiaofen* cannot be the filler, but *tongshi* ‘colleague’ is.⁸ Hence, an active parser would assign Xiaofen to the gap rapidly, but a conservative parser would be more likely to wait in order to avoid gap revision, given that the head-final features of Chinese mean that a potential filler may be overridden by what follows.

**Second research question: How does empty category interpretation
interact with structural ambiguity resolution?**

As noted in section 1.3 above, structural ambiguity in Chinese may interact with gap ambiguity. This often happens when a subject gap is encountered at the beginning of a structurally ambiguous clause. In this case, the filler of the gap (or the range of its possible fillers) depends on the clause type. It is imaginable that the parser first establishes the clause type and then selects the filler on that basis. Alternatively, the parser might first seek an optimal filler, and adopt a structural analysis on that basis. Informal observation suggests that the latter can happen: the ease of obtaining an interpretation for the gap may affect the preferred analysis for the clause. Relevant examples are presented in (5).

- (5) Xiaofen guli [*e* piping...
 Xiaofen encourage criticize...

⁸ In Chinese, it is possible in some cases for the modifier instead of the head noun to be the filler. See the explanation in footnote 74 in Chapter 4.

Clausal object: Xiaofen guli [*e* piping caipan de shuiping].
 Xiaofen encourage criticize judge DE standard
 ‘Xiaofen encouraged (someone) to criticize the judges’
 standard.’

Relative clause: Xiaofen guli [*e* piping caipan] de duizhang.
 Xiaofen encourage criticize judge DE team-captain
 ‘Xiaofen encouraged the team captain who criticized the
 judges.’

In (5), the subordinate clause (beginning at *piping*) is ambiguous between a clausal object and a relative clause analysis. The clausal object is likely to be preferred over the relative clause analysis on the basis of Minimal Attachment, which favors the simplest structural analysis for an ambiguity. But the clausal object analysis creates a gap interpretation problem. The gap is unlikely to refer to the matrix subject, given that the matrix verb *guli* ‘encourage’ dampens such a possibility. (Though not impossible, it is unlikely that Xiaofen is encouraging herself.) Also, there is no preceding discourse that could provide a referent for the gap. Thus on the clausal object structural analysis, the gap in the subordinate clause remains uninterpreted (except as a pro-form with new reference). In contrast, the relative clause analysis can resolve the interpretation problem for the gap. Chinese relative clauses are pre-nominal, which means that the head noun will follow, and will bind the gap. Even if the parser doesn’t yet know what the head noun will be, it can be confident that there will be one and hence that there will be a referent for the gap. Thus, on pure structural grounds, the clausal object analysis could be preferred over the relative clause analysis, but on pure gap interpretation grounds, the relative clause analysis may be the preferred analysis. Hence, at the ambiguity, the parser needs to

evaluate the trade-off between an optimal structural analysis and an optimal gap interpretation. If the parser ultimately chooses the clausal object analysis, that will indicate that the preference for a simpler structure trumps the gap interpretation problem. If the parser's ultimate choice is the relative clause analysis, that will indicate that finding a good filler for a gap can outweigh Minimal Attachment.⁹

Third research question: Is *local* interpretation of a gap (as generic in reference) preferred over association with a filler elsewhere in the sentence?

In English as well as Chinese, a subject gap within a clausal subject can be interpreted in two ways. It can be co-referential with a nominal in the main clause predicate that follows. Alternatively, it can be interpreted generically, in which case there is no need to associate it with an overt filler. These two interpretive options are illustrated in (6).

- (6) a. [*e*_i Piping caipan] shi Xiaofen_i de xiguan.
criticize judge is Xiaofen DE habit
'Criticizing the judges is Xiaofen's habit.'
- b. [*e* Piping caipan] bu neng gaibian bisai de jieguo.
criticize judge not can change competition DE result
'Criticizing the judges cannot change the result of the competition.'

⁹ The clausal object analysis has an additional advantage over the relative clause analysis. The former does not include a syntactic chain in the construction but the latter does. In a relative clause, the head noun is assumed to move out of the relative clause, leaving behind a gap in the original position. The two positions are linked in a chain, indicating their structural and semantic interdependency. According to the Minimal Chain Principle, a chain should be avoided if possible. For more discussion of this principle, and of relative clause structure in Chinese, see sections 3.1.1, and 2.3.1 respectively.

In (6a), the gap is co-indexed with *Xiaofen*, meaning that Xiaofen is the person who criticizes the judges. In (6b), the sentence does not offer any overt filler for the gap, and the gap may be interpreted generically: *Whoever* criticizes the judge, it cannot change the result. Thus, when the gap is identified at the beginning of the sentence, the parser has two options: it might either assign a generic referent to the gap immediately, or it might opt for establishing a gap-filler relationship, in which case it must search for a subsequent filler. The former option results in speedy gap resolution but may require gap revision if a likely filler appears later in the sentence. The latter option delays commitment to a gap interpretation; like any ‘delay’ strategy, it reduces the risk that revision will be needed later. The parser’s prioritization of these two options was studied in an experiment that will be reported in Chapter 4.

1.5 Summary of Methods

The experiments reported here employed two methods for the investigation: a paper-and-pencil sentence completion questionnaire; and self-paced word-by-word reading. In paper-and-pencil questionnaires, participants were provided with the beginning of a sentence, and were required to continue the fragment to make a complete sentence. All the critical fragments (interspersed among filler items) were structurally ambiguous. The way they were continued by the participants reveals which structure was assigned during processing of the fragments.

The on-line reading task presented complete sentences, one word at a time, on a computer screen. Each frame contained only one word of a sentence, centered on the screen; the appearance of each word replaced the preceding word on the screen so that

there was no opportunity for look-back to an earlier portion of the sentence. The presentation pace was controlled by the participant, and the computer registered the reading time of each word. Longer reading time, compared with the baseline, is standardly interpreted as signaling processing difficulty at that portion of the sentence (Mitchell, 2004).

1.6 Preview of Results and Implications

This dissertation reports four experiments. The first experiment consisted of two sentence completion tasks, intended to tap into the structural preference of Chinese speakers for the ambiguous fragment *e Verb*, examples of which are shown in (1) above. The results showed that the clausal subject and the main clause analyses were preferred over the relative clause analysis. The main clause analysis has the advantage of being the structurally simplest analysis, and the clausal subject analysis has the advantage of being able to provide a referent for the empty category in the later part of the sentence. Both of them beat out the relative clause analysis, which, though it can also provide a filler for the gap, is structurally more complex than the clausal subject. This finding suggests that gap interpretation can be a significant factor in structural ambiguity resolution. In addition, when a potential referent for the gap was provided in a clause preceding the *e Verb* fragment, as illustrated by the fragments in (3), the proportion of main clause continuations increased significantly. This indicates that, when a gap is identified, the parser will favor an already available potential filler to interpret the gap. Once the gap is interpreted, the structurally simplest main clause is the most preferred analysis.

The second, third and fourth experiments employed self-paced reading. The test materials of the second experiment were like the sentence in (5), which includes a subordinate clause that is temporarily ambiguous between a clausal object and a relative clause. The matrix verb was manipulated (e.g., *refuse* versus *ridicule*) so that the matrix subject was either a plausible filler or an implausible filler for the subject gap. The results show that the clausal object analysis was preferred when the matrix subject was a plausible filler for the embedded gap, but the relative clause analysis was preferred when the matrix subject was not a plausible filler. This finding, once again, suggests that the lack-of-referent problem for a gap may drive the parser to adopt a more complex structural analysis, which implies that gap interpretation is indeed a factor in structural ambiguity resolution.

The third experiment investigated whether the parser, in its search for a filler for a detected gap, adopts the first available candidate. The test materials were like the sentence in (4), and are illustrated more clearly in (7) below. Each sentence contains either a plausible decoy filler (e.g., *Xiaofen*) or an implausible decoy filler (e.g., *tushuguan* ‘library’), both followed by the real filler; the plausible decoy condition has *Xiaofen de tongshi* ‘Xiaofen’s colleagues,’ while the implausible decoy condition has *tushuguan de tongshi* ‘library’s colleagues.’

- (7) [e Shu-le zhechang bisai] ling Xiaofen / tushuguan de tongshi...
 lost this competition CAU Xiaofen library de colleague
 ‘Having lost this competition made Xiaofen’s / library’s colleague...’

The data showed faster reading times at the beginning of the complex noun phrase, but slower times at the latter part of the noun phrase, for the plausible decoy sentences, relative to the implausible decoy sentences. This suggests that the plausible decoy filler was initially adopted as the filler, and the subsequent appearance of the real filler led to gap revision, and therefore, a reading slowdown. In contrast, the implausible decoy filler would cause surprise to the parser, leading to a reading slowdown at that point. But because no link was established between the decoy filler and the gap, the subsequent appearance of the real filler did not require gap revision, so processing was easier at that point. Overall, the finding supports an active parser that fills a gap with the first candidate filler.

The fourth experiment addressed the option of generic interpretation of a gap, avoiding any search for a filler. It also provided additional data concerning the rapid adoption of a potential filler for a detected gap. The experimental sentences were like the sentence in (8), which contain a clausal subject with a subject gap followed by a predicate that contains either a specific filler (e.g., *Xiaofen*), or a generic filler, that is, *ren* ‘people’ in Chinese.

- (8) a. [e_i Meitian kan xinwen] shi Xiaofen_i liaojie shishi.
 Every-day watch news CAU Xiaofen understand current-affair
 ‘Watching news everyday makes Xiaofen understand current affairs.’
- b. [e_i Meitian kan xinwen] shi ren_i liaojie shishi.
 Every-day watch news CAU people understand current-affair
 ‘Watching news everyday makes people understand current affairs.’

The results showed processing difficulty in only the generic filler sentences, implying that the generic interpretation is not initially adopted; for otherwise, the subsequent encounter with a generic filler should facilitate rather than impede processing. Why the generic filler is not favored is unclear; see section 4.4.4 for some speculation. For instance, it might be that the parser, upon giving up a local generic interpretation, is looking for a [-generic] filler.

In addition, a sentence like (8) can be embedded in a clause that either provides a potential filler for the gap (e.g., *Lili fouren [e meitian kan xinwen ...* ‘Lili denied that watching news every day...’) or that does not provide a potential filler (e.g., *Hen mingxian [e meitian kan xinwen ...* ‘It is clear that watching news every day ...’). In the former case, the parser is likely to adopt the potential filler (i.e., *Lili*) on-line before encountering another filler later in the sentence. In the fourth experiment, the materials were designed so that the later filler was in fact a better filler, so the initial gap interpretation would be incorrect. The data showed a reading slowdown on the final predicate of the sentences with a prior potential filler, compared to those without. This result provides additional evidence to support the rapid adoption of an available filler when a gap is identified.

The findings of the four experiments bear out an Active Gap Hypothesis. When a gap is encountered, the parser will adopt the first plausible filler available. That is to say, it will first look for the filler in the parsed segment of the sentence or discourse. If no potential filler is found there, it will seek out the filler in the incoming material of the rest of the sentence. In the process, when facing a structural and empty category ambiguity, it will evaluate the complexity of alternative structural analyses and the ease of gap

interpretation in each analysis. Should a forward search for a filler for an identified gap become necessary, it will adopt the first candidate filler. Finally, if no overt filler is found anywhere in the sentence, the gap may be assigned a generic interpretation.

This dissertation is organized thus: Chapter 2 examines more closely the various syntactic/semantic constructions in Chinese that are central to this study, and the factors that affect the interpretation of the subject gap within these constructions. Chapter 3 reviews psycholinguistic evidence on the processing of the subject gap within relevant constructions in English, Chinese, and a number of other languages. Chapter 4 reports the materials, design, procedures and findings of the four experiments. Chapter 5 summarizes the findings and draws together some general implications for models of the human sentence parsing mechanism.

CHAPTER 2

Chinese empty categories

This chapter reviews the linguistic theories that offer an account of the interpretation of an empty category in subject position in Chinese. Psycholinguistic research on empty categories was most active in the 1980's, and the linguistic theory that informed it was Government and Binding (GB) Theory (Chomsky, 1981, 1986), as well as some work in alternative theories of the time such as Lexical Functional Grammar (Bresnan, 1982) and Head-Driven Phrase Structure Grammar (HPSG) (Pollard & Sag, 1994). There has been much interesting new analysis of empty category constructions since then, particularly with respect to the copy theory of movement (e.g. Hornstein, 1999) and new approaches to deletion phenomena (Chomsky, 1995). The descriptive terms of GB Theory are appropriate for the early psycholinguistic research and will suffice in most cases for more recent experimental work also, and they will be employed throughout this thesis except where indicated to the contrary.

Section 2.1 presents an overview of GB Theory of empty categories. The rest of the chapter examines interpretive preferences for null subjects within the Chinese constructions that are most relevant to the present experimental study. Section 2.2 explores the various approaches to null subject interpretation within object complement clauses. Section 2.3 looks at the structure and frequency of subject-extracted Chinese relative clauses. Section 2.4 considers the reference of the null subject within subject complement clauses. Finally, section 2.5 examines empty subjects within a main clause.

2.1 Types of empty category and their properties

Government and Binding Theory distinguished four types of empty category: NP-trace, *pro*, *wh*-trace and PRO. Haegeman (1994, p. 453) has presented a summary of their properties and overt counterparts in a table format, shown here as Table 2.1.

Table 2.1: Typology of NPs

Type	Overt	Non-overt
[+Anaphor, -Pronominal]	anaphors	NP-trace
[-Anaphor, +Pronominal]	pronouns	<i>pro</i>
[-Anaphor, -Pronominal]	R-expressions	<i>wh</i> -trace
[+Anaphor, +Pronominal]	-----	PRO

In establishing empty categories, GB theory mostly endorsed those with properties parallel to overt nominal expressions observed in natural language. (PRO does not have an overt counterpart but its presence in a language is supported by its semantics whereas its distribution is constrained by its syntax.) Thus, even though empty categories are phonologically empty and unobservable in speech or writing, they inherit their distribution and properties from their overt counterparts.

As shown, each empty category type is composed of a feature matrix. The feature specification [+Anaphor] on an item signifies that it is subject to Binding Principle A.¹⁰ This includes NP-trace, and its overt counterpart, an anaphor such as *herself* in English or *ziji* ‘self’ in Chinese. (PRO also carries the [+Anaphor] feature, and Binding Principle A

¹⁰ Binding may include a structural and an interpretive component. Structurally, ‘ α binds β if α c-commands β and α , β are coindexed’ (Chomsky, 1995, p. 93). Semantically, a coindexation of two elements signifies a referential interdependency. Chomsky (1995) writes ‘If the index of α is identical to the index of β , then α is the antecedent of β or β is the antecedent of α ’ (p. 96).

should apply to it. However, it is special, since its features entail conflicting properties; see below.) Binding Principle A states that an NP with the feature [+Anaphor] must be bound in its governing category. There have been debates over what constitutes a governing category, thereby producing many definitions. One definition offered by Chomsky (1995) is: The governing category (GC) of α is the minimal clause containing α and a governor of α (p. 101).¹¹ NP-trace is the trace of local movement which associates elements in argument positions. The example in (1) shows an NP-trace in a raising construction.

- (1) [_{IP} Susan_i [_{VP} appeared [_{IP} e_i to regret her decision]]].

The NP-trace in (1) (the empty category e_i) is a product of raising: *Susan* is raised from the embedded subject position to the matrix subject position, leaving a trace at its original position. A chain is thereby created, which links the two positions. The governing category of the trace is the matrix Inflectional Phrase (IP), which is the minimal clause containing the trace and its governor. The matrix verb *appeared* is the governor because it c-commands the trace in the subordinate clause. (See footnote 11 for the definition and properties of government.) Because *Susan* binds the trace, they are co-indexed and referentially interdependent.

Items with the feature [+Pronominal] include overt pronouns, together with their covert counterpart *pro*. (Once again, PRO is a special case; see below.) These are subject

¹¹ The concept of government rests on the concept of c-command. Chomsky (1995) defines government as ‘ α governs β if α c-commands β and there is no category γ that “protects” β from government by α ,’ (p. 79) and c-command as ‘ α c-commands β if α does not dominate β and every γ that dominates α dominates β ,’ (p. 35) gamma has always been defined by Chomsky as the first maximal projection.

to Binding Principle B, which requires that a pronoun must be free in its governing category. In other words, the antecedent of a pronominal should be outside of its governing category. *Pro* is not found in English but it occurs in a number of European languages such as Spanish and Italian, and East Asian languages such as Korean and Chinese.¹² The languages that have this type of empty category are often called ‘*pro*-drop languages.’ The subject of a tensed clause in these languages can be phonologically null.

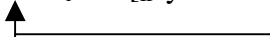
- (2) a. [_{IP} *pro* ha mangiato il spinacio ieri].
 has eaten the spinach yesterday
 ‘(Someone) ate the spinach yesterday.’
- b. [_{IP} Teresa_i ha detto [_{CP} che [_{IP} *pro*_i ha mangiato il spinacio ieri]]].
 Teresa has said that has eaten the spinach yesterday
 ‘Teresa said that (someone) ate the spinach yesterday.’
- c. [_{IP} Teresa_i said [_{CP} [_{IP} Maria_j asked her_{i/*j} to eat the spinach yesterday]]].

The subject of the Italian sentence in (2a) can be left empty. The governor of *pro* is the INFL (inflection). The governing category of the empty category is the IP, where the pronominal remains free as its antecedent is not present within the governing category. The empty category can be interpreted through the agreement features of the verb that follows, or through inference from the discourse. The sentence in (2b) shows that *pro* can be bound (in this case, by the matrix subject), but the binder must be outside the subordinate IP, which is also the governing category. The English sentence (2c) shows an

¹² It is not clear whether the properties of *pro* are identical in these two groups of languages. See the discussions in Jaeggli and Safir (1989) and Newmeyer (2005) for the linguistic properties of these languages concomitant with their null subject feature.

overt pronoun. (English does not have the empty category *pro*; overt pronominals are used instead.) In this sentence, *her* cannot be bound by *Maria* because it resides within the governing category of the pronoun, which is the subordinate IP.

Items that are both [-Anaphoric] and [-Pronominal] cannot be bound by an argument at all; in other words, they must be (argument-)free everywhere, in accord with Binding Principle C. This class of items includes overt referential expressions and *wh*-traces. The former have independent reference and do not need to be bound; the latter must be bound, but necessarily by a binder in a non-argument position. A chain relating *wh*-trace and its overt *wh*-NP antecedent is shown in (3).

- (3) [CP What_i did [IP you see *e_i*]]?
- 

The *wh*-trace in (3) is in the object position of the verb *see*; the overt *wh*-item *what* is in the Specifier position of the Complementizer Phrase (CP), a non-argument position.

Finally, PRO has the features of both anaphors and pronominals. The [+Anaphor] feature requires it to be bound in its governing category but the [+Pronominal] feature requires it to be free in its governing category. Since these two features cannot be reconciled, it must be the case that PRO is not governed, so that it does not have any governing category, and thus does not violate either Principle A or Principle B. This is called the PRO Theorem. It explains why PRO can appear only as the subject of a non-finite clause, a non-governed position. PRO can nevertheless establish a co-reference relation with a nominal through what is called ‘control.’

- (4) Tom_i tried [_{CP} [_{IP} PRO_i to fix the car]].

For instance, in the sentence in (4), the empty subject of the subordinate clause is ungoverned (because the embedded verb is non-finite, and due to the presence of the CP, *try* cannot govern into the embedded clause). The empty subject is thus PRO, and it is controlled by and therefore co-referential with the matrix subject *Tom*. It is a lexical fact about the verb *try* that it permits subject control.

There are two types of control: obligatory control, as in (4), and non-obligatory control, as in (5) (Williams, 1980). In the former type of control, PRO must be c-commanded by and co-indexed with an overt nominal (i.e., the antecedent) in the sentence. In the latter type of control, PRO needed not be c-commanded by an antecedent present in the sentence. For example, in (5), the empty category is not c-commanded by any nominal element, and no potential antecedent is present in the sentence. In this case, PRO may be interpreted as arbitrary in reference,¹³ that is, as encompassing any (relevant) individual. Note, however, that in (5) there is an implicit identification of the eater and the person for whom it is fun.

- (5) *e* Eating spicy food is fun.

The concept of control has no counterpart for overt nominals and has not always been well understood. Attention to these constructions has persisted in the development of linguistic theory since Rosenbaum (1967) raised questions about the interpretation of

¹³ In section 1.4, I briefly discussed the generic interpretation in sentences like (5). I will examine the difference between an arbitrary and a generic interpretation in section 2.4.

the missing subject within some of the English predicate complement constructions. GB theory posited a separate module (Control Theory) to handle the phenomenon, and the missing subject is conventionally represented by PRO. The earlier version of Control Theory relegated PRO to an ungoverned position, as the subject position within a non-finite clause, and PRO's reference is determined by its co-indexed antecedent (Chomsky, 1981). A recent version of the theory has argued for a movement theory of control. Hornstein (1999) argued that obligatory control PRO is indeed an NP-trace, and the 'controller' is moved from the trace position. On this account, a non-obligatory control PRO, as in example (5), is reanalyzed as *pro*, and it can be licensed by the *ing* or *to* of a non-finite verb in English. In response to Hornstein (1999), Culicover and Jackendoff (2001), following the HPSG theory of complement control set out in Sag and Pollard (1991), claimed that the intricacy of control in various nominal and verbal forms of the control construction cannot be captured by any syntax-based account, such as Hornstein's. Instead, the thematic properties of the verb in selecting the complement must play a considerable role in the selection of the controller; the controller is likely to be an implicit Source argument in the argument structure or conceptual structure rather than an item in a specific syntactic position. The Culicover and Jackendoff approach shares some similarity with the earlier lexico-semantic approach by Xu (1985-86) to control in Chinese sentences, which is discussed in section 2.2.1 below.

The rest of this chapter focuses on Chinese empty categories. Chinese exhibits massive use of empty categories. In C.-T. J. Huang's (1984a) words, it is a very 'cool' language, in the sense that active audience participation is required in the communication process to fill in aspects of meaning that are not overtly lexically signaled. Chinese does

not have *wh*-movement in overt syntax (though it may at Logical Form), but empty categories other than *wh*-trace occur in Chinese in both subject and object positions, and in main as well as subordinate clauses. Since the focus of the present study is on empty categories in subject position, the literature that I will review in this chapter is also confined to previous research on empty subjects.

2.2 Subject gaps within object complement clauses

This section explores subject gaps within object complement clauses. The syntactic and semantic properties of this type of gap have attracted the attention of researchers from different domains of linguistic theory. Section 2.2.1 reviews syntactic and lexical approaches, section 2.2.2 explores a pragmatic approach, and section 2.2.2 examines a mixed approach.

Descriptively, a null subject is often allowed in Chinese object complement clauses, and sometimes it is obligatory.

- (6) a. John_i shefa [*e_i*/*ta/*ziji/*Mary chuban zheben shu].
 John try he/self/ Mary publish this book
 ‘John tried to publish this book.’
- b. John_i shuo [*e_{i/j}*/ta_{i/j}/ziji/Mary yijing chuban-le zheben shu].
 John say he/ self/Mary already published this book
 ‘John said he himself/someone/Mary had already published this book.’

In (6a), an empty subject in the subordinate clause must refer to the matrix subject, and no overt subject is allowed in that position. In (6b), however, the empty category may or

may not refer to the matrix subject and overt noun phrases are allowed in that position. An overt noun phrase there (such as *ta* ‘he’ or *ziji* ‘self’) can refer to the matrix subject, or can refer to some discourse referent (e.g., *ta* can refer to someone other than John), or a lexical NP there can explicitly introduce a new referent such as *Mary*.

2.2.1 Syntactic and lexical approaches

C.-T. J. Huang has greatly influenced thinking on this topic. His theoretical analysis has evolved over the years. In his 1982 dissertation, he argued that the empty category in (6a,b) can be an empty topic, a *pro*, or a PRO. If the empty category refers to the matrix subject, it is *pro* or PRO. If the empty category does not refer to the matrix subject, it is a trace bound by an operator in the CP projection. The operator is coindexed with a topic in discourse. The referent of the topic need not be linguistically present in the discourse; it could be deictically determined. For example, the subject of a sentence or a clause may be omitted entirely if the speaker points to an adjacent object while she speaks.

If the empty category refers to the matrix subject, it may be a *pro*, which according to Binding Principle B (section 2.1), must be free in its governing category. Huang further invoked the *Pro*-drop Principle to restrict the reference of *pro* in Chinese. The *Pro*-drop Principle requires that a *pro* must be identified by its closest SUBJECT. The SUBJECT is the most prominent nominal element of a given domain (Huang 1982; p. 258 in 1998). In the case of a matrix clause followed by a complement clause, the SUBJECT is likely to be the matrix subject. Alternatively, the empty category may be a PRO if it is obligatorily controlled by the matrix subject and no overt pronoun is allowed in the empty category position. To support the distinction he drew between *pro* and PRO

in this 1982 analysis, Huang maintained that PRO can only occur in non-finite clauses, as in English and other languages. Since Chinese does not have overt tense morphology, the distinction between finite and non-finite clauses is not very robust, but Huang gave some diagnostic criteria for finiteness, for example, the presence of modals and aspectual markers in the embedded clause. However, these criteria have often been controversial.¹⁴

According to this analysis, the empty category in (6a) is a PRO because it must be controlled by the matrix subject, and no overt pronouns are allowed in the subject position. The complement clause is an infinitival clause, and no modals and aspectual markers usually occur in the subordinate clause. On the other hand, the empty category in (6b) is a trace if it refers to a discourse referent, and is a *pro* if it is co-referential with the matrix subject; in either case, the complement clause is finite, and perfective markers like *le* can be attached to the subordinate verb.

The analysis in Huang (1982) sparked a decade-long debate on the properties of null subjects within Chinese complement clauses. C.-T. J. Huang (1984a, 1984b, 1987) continued to argue that the matrix verb in (6a) is a control verb, whereas the matrix verb in (6b) is not but is what he called a *say-type* verb. A control verb dictates co-reference between the matrix and embedded subjects. In other words, the matrix subject obligatory controls the embedded null subject, and excludes overt NPs in subject position of the complement clause. For a *say-type* verb, by contrast, control is possible but not obligatory, and overt embedded subjects are acceptable. This issue of matrix verb types interacts with the issue of the finiteness of the subordinate verb, which is never a simple issue in Chinese. As noted above, Chinese does not have tense inflections; hence there is

¹⁴ Hu, Pan, and Xu (2001) have reviewed some of those arguments, and concluded that they are problematic. For example, modal verbs and aspectual markers may occur in clauses considered to be non-finite.

no really decisive way to establish the finiteness of a verb. C.-T. J. Huang (1982) and Li (1990) insisted on the existence of both finite and non-finite verbs in Chinese but Xu (1985-86) and Hu et al. (2001) rejected the finiteness / non-finiteness distinction for Chinese. As we have seen, the arguments over finiteness bear on the type of empty category that appears as the subject argument of the clause. If there are finite and nonfinite verbs in Chinese, the distinction of PRO and *pro* is meaningful. Otherwise, as Xu (1986) points out, the empty subject of the complement clause must be regarded as a free empty category that does not fit neatly into the empty category paradigm of GB Theory.

To further complicate the issue, there appears to be no clear-cut distinction between control and non-control verbs, but considerable variation in the strength of the tendency for the matrix and embedded null subjects to co-refer. The sentence in (6a) shows obligatory co-reference while (6b) shows possible but not obligatory co-reference. There are also verbs for which coreference is optional but which strongly lean in one direction or the other. For example, the semantics of verbs such as *jinzhi* ‘prohibit’, *fandui* ‘object-to,’ and *yunxu* ‘allow’ bias them strongly toward disjoint reference between the matrix and embedded subjects. In such cases it is much more likely, on pragmatic grounds, that there are two distinct agents in the matrix and embedded clauses.

Prompted by these facts, Xu (1985-86) proposed a lexical-thematic approach to control in Chinese. Xu maintained that Chinese verbs impart a varying degree of control force, ranging from strong control verbs like *shefa* ‘try’ to weak control verbs like *jinzhi* ‘prohibit.’ At one end, the strong control verbs can be marked with features like [+obligatory coreference], and [+preferable coreference], and at the other end, the weak

control verbs can be marked with features like [-obligatory coreference], and [-preferable coreference]. Between the two ends are verbs that carry other combinations of the binary values of the features. These so-called control selection features can be specified for verb entries.

This account eliminates the difference between PRO and *pro*, as well as the difference between finite and non-finite clauses. Xu further invoked an Obligatory Controlled Empty Category Principle (OCECP) to exclude the presence of overt subjects in obligatory control clauses. The principle requires that an NP whose control is assigned on the basis of the feature [obligatory coreference] must be empty. It therefore excludes overt embedded subjects in sentences like (6a). NPs controlled on the basis of the feature [preferable coreference] are optionally overt or empty, which accounts for the optional overt realization of the embedded subject in (6b). Xu compares OCECP to the Avoid Pronoun Principle¹⁵ and calls it “the lexically stereotyped Avoid Pronoun Principle” (Xu 1985-6, p. 367).

By 1989, C.-T. J. Huang had accepted the confluence of PRO and *pro* in Chinese but still maintained a syntax-based approach for control theory (Huang 1989). He put forward the Generalized Control Rule (GCR), which requires that an empty pronominal is controlled in its control domain (if it has one). The control domain is the minimal category that: i) is the lowest S¹⁶ or NP which contains the empty category, or the minimal maximal category containing the empty category; and ii) contains a SUBJECT accessible to the empty category. A *pro* or PRO without a control domain need not be

¹⁵ Chomsky (1981) originated the principle of ‘Avoid Pronoun,’ which “might be regarded as a subcase of a conversational principle of not saying more than is required” (p. 65). Fernández Soriano (1989) defines Avoid Pronoun Principle as: *pro* is obligatory when it is licensed and fully identified (p. 55).

¹⁶ The examples given by Huang suggest that S is intended to include both finite and non-finite clauses.

controlled in this way; it may be subject to arbitrary or discourse-based interpretation. However, one problem clearly arises: the control domain of the sentences in (6a,b) is the matrix clause, because that is the lowest S that contains the empty category and a SUBJECT (i.e., the matrix subject or Agr), but yet the null subject in (6a) must be controlled while that in (6b) need not be controlled. Because of this, Huang argued that the verbs that exercise obligatory control subcategorize for an S' complement, whereas the verbs that exercise optional control subcategorize for an NP that subcategorizes for an S'. In line with this analysis, the control domain of the empty category in (6a) is the matrix clause, and the controller is the matrix subject. By contrast, the empty category in (6b) does not have a control domain because there is not a SUBJECT within the embedded S or the NP under VP. (The NP under VP is the highest category where a control domain can be established because, according to GCR, it is the lowest NP that contains the empty category and the embedded S', which is the minimal maximum category.) This approach, unlike Xu's, avoids lexical specifications and accounts for the difference between the obligatory control and the optional control construction, while eradicating the difference between PRO and *pro*.

Summarizing to this point: There is at least some agreement that the matrix verb can influence antecedent assignment to a null subject within a complement clause. The difference between Huang's and Xu's approaches mainly lies in the mechanism through which the matrix verb exercises its influence. Huang subsumes control under the GCR and verb subcategorization, while Xu includes control into a lexical-thematic theory.

With this in hand, it is possible to ask whether there is a preference for one antecedent or another when more than one is acceptable, particularly when the matrix

verb is not strongly biased toward either a coreferent or a non-coreferent interpretation. For instance, in (6b), the matrix verb *shuo* ‘say’ is fairly neutral with respect to whether John said he himself or someone else had already published the book. In that case, how is the reference of the empty category resolved? This is obviously important for a psycholinguistic account of how ambiguous empty categories are typically interpreted on-line. There are syntax-based accounts that speak to this issue, but where the language of investigation is not Chinese. The studies investigating this in Chinese adopt other approaches and will be reviewed in section 2.2.2.

A few studies have investigated the interpretation of null subjects in Italian and Spanish when the matrix verb does not determine the control relationship. Carminati (2002, 2005) has proposed the Position of Antecedent Hypothesis (PAH) to explain the distribution of overt and covert pronouns in Italian. The PAH for intra-sentential anaphors (her revised version, p. 109) says that a null pronoun prefers an antecedent in the highest Spec IP position, while an overt pronoun prefers an antecedent which is not in the SpecIP position. This means a null pronoun is more likely to be coindexed with the matrix subject while an overt pronoun is less so. To support her claim, Carminati employed questionnaires testing referential, dative and expletive subjects in Italian as potential antecedents for a *pro* in a complement clause. Examples are given in (7).

(7) a. Referential Subject

Gregorio ha detto che Ø / lui sarà presente al matrimonio di Maria.
 Gregorio has said that he will-be present at-the wedding of Maria
 ‘Gregorio has said that he will be present at the wedding of Maria.’

b. Dative Subject

Poichè a Giovanni non piace affatto Enzo, Ø / lui cerca di evitarlo.
 because to Giovanni not please Enzo he tries to avoid-him
 ‘Because Enzo does not like Giovanni, he tries to avoid him.’

c. Expletive subject

Adesso che c’è Gianna disoccupata, Ø / lei non fa altro che lamentarsi.
 now that there-is Gianna unemployed she not do other but complain
 ‘Now that Gianna is unemployed, she does nothing but complain.’

Results of the questionnaires pointed to a strong preference for coreference of the matrix subject with a null subject rather than with an overt pronoun in subject position. However, if the matrix subject was put in a post-verbal position,¹⁷ as is allowed in Italian (e.g. *È arrivato Marco* ‘Has arrived Marco’), its advantage as the antecedent to the null embedded subject disappeared.

Alonso-Ovalle, Fernández-Solera, Frazier, and Clifton (2002) tested Carminati’s PAH in Spanish. They employed several written questionnaires to investigate intra-sentential and inter-sentential anaphoric preferences. The results were generally consistent with the PAH: *pro* is preferred to refer to the antecedent in the subject [Spec, IP] position, regardless of whether this position is in the same or previous sentence. Alonso-Ovalle et al. argue that the reason for why the null subject prefers to link to a prominent antecedent is because *pro* is always in a topical position, which is also a prominent position.

¹⁷ Following Burzio (1986), Carminati assumed the standard account that post-verbal subjects in Italian are co-indexed with a null expletive in the Spec IP position. Post-verbal subjects are either base-generated (when the verb is unaccusative), or moved from a pre-verbal position (when the verb is unergative or transitive).

Chinese also seems to exhibit a general preference for co-reference between a null embedded subject and the matrix subject, when the matrix verb does not bias against it. For example, in (6b), despite the neutrality of the matrix verb with respect to the plausibility of coreference, the null subject still preferentially co-refers with the matrix subject, at least according to informal intuitions of native speakers I consulted. This could be due to the structural prominence of the subject position, as proposed by Carminati.¹⁸ In that case, both Italian and Chinese (though their empty categories differ in some other respects) show a similar interpretational preference: the null subject within a complement clause preferentially refers to the matrix subject.

The theoretical issues outlined here concerning the underlying phonological, syntactic, semantic and pragmatic properties of what are known as ‘control constructions’ are important though also difficult to resolve. But out of the theoretical discussions there emerges one clear fact. In a nutshell: there seems to be a general agreement that in Chinese the semantic properties of the matrix verb affect the permissibility of, and the degree of preference for, coreference or non-coreference between a matrix subject and the null subject within an object complement clause. In addition, it emerges that the syntactic (or information-prominence) position of a potential antecedent may affect its ability to serve as the antecedent for an embedded empty subject. Whether there is a real difference between PRO and *pro*, and whether there is a real difference between finite and non-finite embedded clauses in Chinese, does not seem to play a major role in these

¹⁸ Carminati hints at the similarity between Italian and Chinese in null subject interpretation. She writes, citing studies by Yang et al. (1999, 2001), that “the antecedent bias of the null pronoun is the same in the two languages,” (i.e., Italian and Chinese) (p. 330) and that some *pro*-drop languages appear to be similar in displaying “a special affinity for a prominent antecedent” (p. 333). Yang et al. (2003) still appeal to syntactic prominence to account for the tendency for a higher subject to antecede a pronominal in Chinese, but they add that syntactic prominence is in fact sensitive to structural relations rather than grammatical functions; for example, a movement of the object to preverbal position could increase its prominence in Chinese.

anaphoric preferences. Thus, the disagreements are mostly confined to the theoretical status of the empty category, rather than the descriptive facts concerning permissible and preferred interpretations. I will now consider some other perspectives on this issue of the interpretation of null subjects within a complement clause, which put less emphasis on the syntactic status of the null element.

2.2.2 A pragmatic approach

Many pragmatics-based studies have examined anaphors in discourse. These investigations are more related to studies of null subject interpretation within main clauses, and they will be reviewed in section 2.5. The present section focuses on one study that examines intra-sentential interpretation of null subjects.

Y. Huang (1992, 1994, 2000) applied the neo-Gricean pragmatic framework to investigate the interpretation of zero anaphors and other anaphors (such as pronouns and reflexives) in Chinese. He argues that no syntactic or lexical theories can convincingly account for all the facts concerning null subjects in Chinese. This is because the phenomenon is partially a pragmatic one. To explain the various situations where felicitous anaphora occurs in Chinese, he invokes an array of pragmatic and interpretational principles and constraints. Since some of the experimental materials of the present study are similar to the construction in (6b), only information relevant to this construction in Huang's account will be discussed here.

The null subject in (6b) is preferentially co-referential with the matrix subject, as noted above. Carminati (discussed in last section) attributes this preference to the syntactic prominence of the matrix subject position, which, as a result, tends to antecede

a null subject. Huang believes, instead, that pragmatic rules are at work. He argues that the interpretation of zero anaphors is subject to the I-principle,¹⁹ which favors a local referent. He then formulates the rigid *I-heuristic*, as in (8), to account for antecedent assignment for a zero anaphor.

- (8) An antecedent search procedure for zero anaphors
- In a structure of the sort $[s_2[s_1 \emptyset]]$, where $\emptyset$ is a zero anaphor, $\emptyset$ is interpreted as referentially dependent according to the following preference order:
- (i) $\emptyset$ is referentially dependent on the local subject; failing which:
 - (ii) $\emptyset$ is referentially dependent on the local object; failing which:
 - (iii) $\emptyset$ is referentially dependent on both the local subject and the local object (split antecedents); failing which:
 - (iv) (i)-(iii) is recursively applied to the next, higher clause until an antecedent is found; failing which:
 - (v) find the nearest antecedent in the discourse, preferably a topic; failing which:
 - (vi) settle for an ‘arbitrary’ interpretation.

Huang also agrees with Xu (1985-86) about the role that the lexical semantics of the matrix verb plays in antecedent assignment.²⁰ The procedure outlined above is therefore operated on the condition of ‘other things being equal.’

¹⁹ From the speaker's perspective, the I-principle is to say as little as necessary, and from the recipient's perspective it is to amplify the informational content of the speaker's utterance. At the level of reference, “the smaller the number of possible state-descriptions which are compatible with a proposition, the more informative the proposition,” and at the level of logical form, “the fewer existential commitments, the more informative the proposition” (Huang, 2000, p. 216).

²⁰ However, Huang maintains that the lexical semantics of the matrix verb only provides a set of possible controllers. The determining factor in the selection of the controller is the I-principle, consistent with context and/or world knowledge.

The *I-heuristic* is generally consistent with the intuition of native Chinese speakers in the co-reference preference of the null subject within complement clauses. But there are still two issues that need further clarification. First: why is it more likely for the local subject than the local object to attract the reference of a zero pronoun? One straightforward answer is subjects, by default, are more salient than objects. But Huang is ambivalent about the rationale involved in shaping the anaphoric preferences. On the one hand, he seems to invoke a structural notion to explain saliency. He says information saliency is reflected in the structural hierarchy of implicatures, such that “implicatures due to higher constructions may take precedence over implicatures due to lower constructions” (i.e. ‘matrix wins’), and “implicatures to coreference may be preferred according to the saliency of antecedent in line with the following hierarchy: topic > subject > object, etc”. (Huang 1994, p. 145) In addition, ‘a c-commanding antecedent is in general preferred to a non-c-commanding one’ (Huang 2000, p. 237). Thus, Huang’s notions of information saliency and ‘matrix wins’ seem to be structural based, and thus similar to Carminati’s idea of structural prominence discussed in the last section. On the other hand, while stressing that more research needs to be done to untangle the notion of ‘locality,’ Huang also notes that “there seems to be a lot of evidence to indicate that ‘locality’ in Chinese is primarily of a pragmatic nature.” (p. 284)

A second concept that needs elucidation is the notion of an arbitrary interpretation. Huang does not further clarify what an arbitrary referent is. Is it an unspecified individual like ‘someone,’ or a generic reference like ‘everyone?’ Section 2.4 will discuss the difference between generic and arbitrary reference, both of which are often called ‘*arb*’ in the literature.

Y. Huang's heuristic on antecedent assignment is similar to the Accessibility Marking Scale of Ariel (1994), though the latter is based on psychological principles. Ariel argues that the degree of Accessibility of an anaphoric expression is linked to the addressee's memory at the point when the expression is encountered. Two factors affect whether an antecedent is still active in the memory by the time an anaphor is processed. The first is the prominence of the antecedent. The more prominent an antecedent is, the longer it stays active. The second factor is the nature of the relation between the antecedent and the potentially anaphoric expressions (i.e. the Givenness marker). For example, the longer the distance between the antecedent and the anaphor, the less accessible the antecedent is. Moreover, if the anaphor and the antecedent enter into some kind of structural relation, the antecedent becomes more accessible. For instance, two clauses entering a subordination relation are more closely linked than two clauses entering a coordination relation. Hence, the antecedent in the former is more accessible to an anaphor than the antecedent in the latter. Among different referring expressions on the Accessibility Marking Scale, the zero pronoun is the least accessible category, and therefore is likely to link to the most immediate antecedent. While it is clear that Ariel's approach considers the issue more from the cognitive perspective, and Huang's is more from the communicative perspective, both approaches make a similar prediction about the reference of a zero anaphor in an embedded clause: it is likely to refer to some element in the matrix clause.

To sum up, Huang's *I-heuristic* provides a specific testable paradigm for the interpretation of Chinese zero anaphors, which must be subject to empirical scrutiny. The present study is interested in the plausibility of a coreference between the matrix and

embedded subject. Of particular importance is that the syntactic, lexico-semantics and pragmatics approaches generally agree that the matrix verb can control anaphoric preferences. When the matrix verb does not discourage a disjoint reference, the embedded null subject tends to co-refer with the matrix subject. This can be explained by Carminati's structural prominence or Huang's information saliency, both of which claim that elements higher in the structural hierarchy are inclined to pass down their meaning to referentially dependent elements lower in the structural hierarchy.

2.2.3 A mixed approach

A mixed approach draws on resources from different disciplines to offer a unified approach to empty category resolution. Pan and Liang (2002) employ the framework of Optimality Theory in their study; they rank six relevant constraints in accordance with their violability, in selecting a nominal as the subject of a sentence in Chinese. This ranking is shown in (9). (The / sign in (9) indicates the two constraints are ranked equally in their violability, and the > sign indicates the preceding constraints are ranked higher than the following ones.)

- (9) compatibility constraint / subcategorization constraint >
 parallel constraint / topic constraint >
 locality constraint / part of speech constraint

Constraints in Optimality Theory need not be restricted to one linguistic domain, for example, syntax or pragmatics. Also, every constraint is violable. The ranking only indicates some constraints are more important than others, in the sense that a violation of

a lower-ranked constraint is less serious than a violation of a higher-ranked one. A number of candidates are evaluated against the constraints and the optimal outcome is the one which violates the least number of highest-ranked constraints. In the theoretical analysis, the ranking of the constraints is based on empirical data which reveal which constraint wins out when they are in competition. The optimal candidate is predicted to be the one actually evidenced in the language.

The *compatibility constraint* and *subcategorization constraint* in (9) require that a subject should be compatible with the semantic and subcategorization requirements of the predicate. The *parallel constraint* says that the same phrase is preferred to be the subject in a similar structural position in two clauses. In order to satisfy the *topic constraint*, the comment in a topic-comment construction should have a semantic or syntactic gap that allows the topic to be related to it. The *locality constraint* entails that a linearly closer candidate is preferred over a more distant candidate. For example, among several nominals that are candidates to antecede an empty category, only the closest one does not violate this constraint. Finally, the *part of speech constraint* expresses a preference for first and second person pronouns to be the subject, rather than other pronouns, which in turn are preferred over non-pronominals, and non-interrogative pronouns over interrogative pronouns.

The sentences in (10) illustrate how this ranking and evaluation mechanism works in Chinese:

- (10) a. Ta lingdao ai.
He/him²¹ leaders like

²¹ Chinese pronouns are not case-marked.

b. $Ta_i, lingdao\ ai\ e_i.$

c. $Ta_i, lingdao_j, e_i\ ai\ e_j.$

Both *ta* ‘he’ and *lingdao* ‘the leaders’ in (10a) can be the subject or object of the verb *ai* ‘like.’ This sentence could mean ‘the leaders like him,’ as in (10b), or ‘he likes the leader,’ as in (10c). Using Pan and Liang’s evaluation matrix, both arguments satisfy the *compatibility constraint* and the *subcategorization constraint*. The *compatibility constraint* warrants semantic compatibility of the subject and the predicate, and the *subcategorization constraint* controls for the number of arguments for a head. The *parallel constraint* is not relevant because the sentence in (10) has only one clause. As for the *topic constraint*, either *ta* is the topic as in (10b), or both *ta* and *lingdao* are topics as in (10c). In either case, there are gaps in the comment clause for the argument. Thus, both (10b) or (10c) satisfy the *topic constraint*. (10b), however, violates the *part of speech constraint* because, according to Pan and Liang, pronominals are better subjects than non-pronominals. On the other hand, (10c) violates the *locality constraint* because it has the more distant nominal as the subject. But since the *part of speech constraint* and the *locality constraint* are not ranked, candidates that violate either of them once are not different in optimality. Hence both (10b) and (10c) are predicted to be equally good candidates for (10a). This matches the informal intuitions of native speakers.

This approach can account for the facts concerning the reference of the null subject in sentences like (6b). First, it emphasizes the importance of compatibility. Even though Pan and Liang mention the semantic compatibility only of the subject and the

predicate, an extension of this constraint can include the semantic compatibility of an embedded null subject and the matrix verb in the sentence. For instance, if the matrix verb in (6b) is *jinzhi* ‘prohibit,’ a co-reference between the two subjects leads to semantic incompatibility because it is unlikely for John to prohibit himself from publishing the book. This echoes a theme of the analysis discussed in the previous two sections: the lexico-semantics of an matrix verb can influence antecedent assignment.

Second, if the matrix verb in a construction like (6b) is neutral with respect to a co-reference between the matrix subject and the embedded null subject, there is still such a preference, because of the *parallel constraint*. This is because the same referent would be the subject in the same structural position in two clauses. Hence this framework captures and ranks the two important rules governing empty subject interpretation within object complement clauses in Chinese. First, the *compatibility constraint* excludes candidates where the matrix verb and the antecedent of the null subject are semantically incompatible. Second, if the *compatibility constraint* is not violated, the *parallel constraint* deters disjoint reference between the matrix subject and the embedded null subject.

To conclude section 2.2, I may summarize the basic outcomes. Studies drawing on resources of different linguistic subfields have generally come to agree on two facts regarding null subject interpretation within object complement clauses in Chinese. First, the matrix verb can strongly bias conjoint or disjoint reference between the matrix subject and an embedded null subject. As suggested by Xu (1985-86), there is a spectrum of co-reference possibilities, such that *shefa* ‘try’ strongly suggests co-reference, but *jinzhi* ‘prohibit’ strongly suggests disjoint reference. Second, when the matrix verb is neutral

with regard to this preference, such as the verb *shuo* ‘say,’ the embedded subject is preferentially interpreted as co-referential with the matrix subject. The experimental sentences of the present study contain biased matrix verbs that hold sway over how the embedded empty subject might be interpreted. The experiments are neutral with respect to the reasons behind the observed facts. They neither presuppose nor support any particular linguistic analysis.

2.3 Subject gaps within relative clauses

Chinese relative clauses can be divided into three types: argument relatives, as in (11a), adjunct relatives, as in (11b), and gapless relatives, as in (11c). An argument relative contains a null argument within the relative clause. The null argument can be the subject or the object. In the sentence in (11a), the subject within the relative clause is null and its meaning is retrieved through co-indexation with the head noun. The structure of an adjunct relative is like that of an argument relative but it has a gap that is an adjunct. A gapless relative, as the name indicates, has no gap. The relative clause and the head noun enter an aboutness relation; for example, in (11c), the principle is about Mary’s handling affairs.

- (11) a. [RC e_i lai kaihui] de tongshi_i dou meiyou zhunbei.
 come meeting DE colleague all not-have prepare
 ‘The colleagues who came to the meeting were all unprepared.’

- b. [RC Mary zhunbei kaoshi e_i] de fangfa_i hen zhide women xuexi.
 Mary prepare exam DE method very deserve us learn
 ‘The way Mary prepared for the exam deserves our learning.’
- c. [RC Mary zuoshi] de yuanze ling ren peifu.
 Mary handle-affairs DE principle CAU people respect
 ‘The principle of Mary’s handling affairs gains respect from other people.’

The present study investigates only the processing of the subject gap within a relative clause. Thus, the discussion here is limited to argument relatives.

Like English, the gap within a relative clause in Chinese is referentially dependent on the head noun. But Chinese relative clauses differ from their English counterparts in two respects. First, relative pronouns like *who* and *what* do not exist and therefore are never present in the relative construction. Instead, the morpheme *de* usually follows the relative clause and precedes the head noun. Second, the gap created always is to the left of the head noun. Chinese noun phrases are strictly head-final; the head noun always occurs at the end of a noun phrase, so the relative clause (and all other nominal-modifying elements) precedes the head noun in linear word order. For instance, the head noun *tongshi* ‘colleague’ in (11a) follows the empty category in surface word order.

How is a Chinese argument relative clause derived? Section 2.3.1 reviews two recent studies within generative-transformational theory to investigate this issue. Section 2.3.2 discusses corpus studies that survey the frequency of different types of relative clause in Chinese usage.

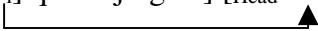
2.3.1 Relative clause formation

One well-regarded account is that proposed by Simpson (2002), who follows Kayne's (1994) proposal that a relative clause is the complement of a determiner. According to Simpson, *de* in Chinese is the head of a Determiner Phrase (DP), which selects a CP as its complement. The head noun and the relative clause follow *de* in underlying word order. (12a,b), taken from Simpson (2002), depict the derivations schematically. The head noun *ren* is first raised to SpecCP (specifier position of complementizer phrase), creating a trace in the IP, which is the relative clause. The whole IP is then raised to SpecDP. The link between the empty category inside the relative clause and the head noun constitutes a movement chain. (12c) shows the final configuration with *de* being the head of the DP, the relative clause in SpecDP, and the head noun being the complement of *de*. *De*, in this analysis, is a determiner, rather than a complementizer like the English *that*.

- (12) a. [de [CP ren_i [IP t_i qu Beijing]]]
- ▲
- b. [[IP t_i qu Beijing]_k [de [CP ren_i] t_k]]
- ▲
- c. [DP [IP t_i qu Beijing]_k [D de [CP ren_i] t_k]]
- go Beijing DE person
- ‘the person who went to Beijing’

By contrast, Aoun and Li (2003) argue, based on facts concerning coordination and scope reconstruction, that Chinese relative formation involves adjunction. Rather than being a complement to a determiner, the relative clause is a CP adjoined to the NP that contains the relativized head noun. (The NP can be a copy of an NP inside the CP.)

An argument raises from within the relative clause to the head position. The phrase that contains the relative clause in Chinese, unlike English, is an NP instead of a DP. (13) illustrates a Chinese relative construction derived from adjunction.

$$(13) \quad [_{NP} [_{CP} [_{NP} t_i] \text{ qu Beijing de}] [_{Head} \text{ ren}]_i]$$


Summarizing: Chinese relative clauses are prenominal, with the gap always preceding the antecedent. From a processing point of view, the most significant aspect of the relative clause construction is that a gap is identified before its antecedent is. One of the research questions of the present study is how the parser's search for a filler (an antecedent) for a gap that it has already identified might affect ambiguity resolution tendencies. On the other hand, the present study is neutral with respect to the derivation processes by which relative clauses are generated, as long as they accurately capture the linear order of the gap and antecedent in the input to the sentence processor, which creates the ambiguity-resolution tasks that the sentence processing routines must contend with.

2.3.2 Relative clause frequency

This section reviews studies that consider the frequency of different types of relative clause in Chinese. The present study specially investigates relative clauses with a subject gap. This is relevant because difficulties in processing this construction might conceivably be due to low frequency of this type of relative clause. In fact, this is far from the case.

Pu (2007) examined the distribution of different types of Chinese relative clauses in oral and written narratives. She found first, that relative clauses in general were much more frequent in written discourse than in oral discourse; and second, that the frequency ranking of the four types of relative clause is: 1) a subject-extracted relative clause modifying a subject (SS relative); and 2) a subject-extracted relative clause modifying an object (OS relative); and 3) an object-extracted relative clause modifying an object (OO relative); and 4) an object-extracted relative clause modifying a subject (SO relative).²² The reason for the overall high frequency of the SS relative clause is, she argues, pragmatic/semantic: a human referent tends to be coded as a subject,²³ which in turn is naturally modified by a subject-extracted relative clause. The SS relative clause therefore can retain humanness in the two subject positions. Moreover, her data showed that a new referent in discourse is likely to be a grammatical subject, and subject relative clauses can help ground new referents into the discourse.

Tao (2002) studied ten Chinese oral narratives of the Pear Stories,²⁴ and found a preponderance of relative clauses that modify a human head noun.²⁵ She shared the viewpoint of Pu that grounding a human character into the story is one of the functions of this kind of relative clause.

²² Wu, Kaiser, and Andersen (2009) analyzed the occurrence of relative clauses in the Chinese Treebank 5.0 corpus (507,222 words) and found a frequency ranking of the four types of relative clause: SS > OS > SO > OO. Hence, the SS relative was once again found to be the most frequent relative construction, although the ranking of other relative constructions was somewhat different from Pu (2007).

²³ Pu (1997) corroborates this assertion. In the 75 pages of Chinese narrative texts that she studied, 94.2% of the subjects coded human referents.

²⁴ 'The Pears Stories' is a six-minute silent film that features a farmer who harvests pears, which are stolen by a boy. The film was designed by Wallace Chafe (Chafe 1980), who employed it to collect narratives of the story by the viewers after they see the film.

²⁵ Unlike Pu (2007), Tao (2002) did not distinguish the grammatical position of the gap in the relative clause and the grammatical position of the relative clause itself in the sentence. But most of the examples she gave are subject-extracted relative clauses.

To summarize, the subject-extracted subject relative clause is found to be the most frequent among other types of relative clause, in both oral and written materials. In addition, a human referent tends to occupy the subject position of a Chinese sentence. The significance of the combination of these two findings to the present study is that the subject-extracted relative clause modifying a subject is common in Chinese. This has two important implications for the experimental studies reported here. First, in a structurally ambiguous sentence fragment where this type of relative clause is a potential analysis, any dispreference for it in the competition with other analyses is not likely to be due to low frequency of usage. A second and more specific consequence is that when the head noun of a noun phrase is human, it significantly increases its chance of being the subject within a relative clause that modifies it.²⁶ This finding is important to Experiment 2 reported below, as will become clear in the discussion of the experimental design in Chapter 4.

2.4 Subject gaps within subject complement clauses

Apart from the object complement and relative clause constructions discussed in sections 2.2 and 2.3, there is one more type of construction that is central to the present study: the subject complement clause. This section considers its structure and gap interpretation.

In Chinese, the internal structure of a subject complement clause and an object complement clause is identical; both have basic SVO word order. But when they have a subject gap, its antecedent assignment can be very different. The studies discussed in section 2.2 show that for an object complement clause, the matrix verb can influence

²⁶ The data in Pu (2007) show that in the oral and written narratives combined, the chance for a human to be the subject head of a relative clause is 75%, and the chance for a nonhuman is 25%.

antecedent assignment of the subject gap, and there is a general preference for co-reference between the matrix subject and the embedded gap. In a subject complement clause, by contrast, the antecedent may follow the gap, as illustrated in (14a), where the empty subject is interpreted as *Mary*, or else the gap is interpreted generically or arbitrarily (often called ‘*arb*’) when no antecedent is present in the sentence, as in an example like (14b). (See the discussion below on the difference between the generic and the arbitrary interpretation.)

- (14) a. [e_i meitian he shui] dui Mary_i de jiankang you haochu.
 every-day drink water to Mary DE health have advantage
 ‘Drinking water every day is good for Mary’s health.’
- b. [e meitian he shui] hen zhongyao.
 every-day drink water very important
 ‘Drinking water every day is important.’

In sentences such as these in (14), obligatory control does not apply. In (14a) the antecedent *Mary* is embedded in a noun phrase; therefore, it can never c-command the empty category.²⁷ In (14b) the controller is not even in the sentence; the gap is usually understood as people in general, unless an appropriate antecedent is provided in the preceding (or following) sentence. Hornstein (1999) maintains that sentences like those in (14) involve non-obligatory control and that the empty categories are *pro*. Landau (2001) calls these empty subjects logophoric anaphors, which he claims can only refer to antecedents that are sources or targets of mental/communicative reports.

²⁷ Hornstein (1999) points out seven characteristics associated with obligatory control, as opposed to non-obligatory control. One is that the antecedent must c-command the anaphor in obligatory control.

It is generally agreed that in a non-obligatory control construction, such as these sentences, the empty category is interpreted in the pragmatic domain, for example, on the basis of who is likely to do what. In (14a), since *Mary* is the only one mentioned in the sentence, she becomes the one who would be most likely to drink water. In (14b), no animate individual is mentioned, and the empty category tends to assume a generic reference, meaning ‘everyone.’

At this point, it is important to look more closely at the difference between a generic and an arbitrary reference, in the discussions of subject gaps within subject complement clauses. As discussed above, in a sentence that contains a clausal subject with a null subject, the antecedent for the subject gap could appear in the main clause predicate that follows the clausal subject. But if there is no overt filler in the sentence, the null subject will then be interpreted generically. While this interpretive restriction is not in doubt, there is some theoretical uncertainty as to how to describe it. Is the interpretation *generic*, in the true sense of the term? Or is it what has been called *arbitrary*? The GB literature often uses ‘*arb*’ to refer to the implied referent of this type of null subject (e.g., Chomsky, 1986; Manzini, 1983; Williams, 1980). But in this dissertation, the implied referent is called a generic referent. Two questions then arise: Is a generic referent different from an arbitrary referent, and if so how?

According to Egerland (2003), a generic referent “denotes a quasi-universal set of individuals, and is roughly equivalent to ‘people’ (in some cases ‘everyone’ or ‘anyone,’)” whereas an arbitrary referent “refers to a non-specific group of individuals, close to ‘some people,’ unspecified ‘they,’ or ‘someone’” (p. 76). Sigurðsson and Egerland (2009) clarify by noting that a generic referent potentially includes the speaker

and the hearer, while an arbitrary referent probably excludes the speaker and the hearer. They note that a comparable distinction can be found in other works, notably Cinque (1988), under other terminology. See also Holmberg, Nayudu and Sheehan (2009).

For a clausal subject with a null subject, the implied referent of the subject gap can be either generic or arbitrary, depending on the meaning of the sentence. For example, in a sentence like *e Reducing the property tax would help the financially squeezed homeowners*, the null subject is likely to refer to the government, the body that controls the tax rate. This referent is like an arbitrary ‘someone’ and its identity is understood through the context. But in a sentence like *e Exercising every day is good for the health*, the null subject is likely to refer generically, to everyone who does the exercising.

In Chinese, the word *ren* ‘people’ (one of the fillers used in the test sentences of Experiment 4) is generic, denoting people in general including the speaker and the hearer. Chinese does also have expressions with an arbitrary referent, such as *tamen* ‘they,’ or *mouren* ‘someone,’ an unspecified group or individual. In this dissertation, the generic referent is more relevant to the experimental materials. In the sentence completion study of Experiment 1, the implied referent of the null subject within the clausal subject continuations that participants created was most often generic rather than arbitrary. Moreover, in Experiment 4, in order to compare two gap-filling strategies, a generic filler *ren* ‘people’ was used to contrast with a specific filler as the preferred referent for a subject gap. (The details of these experiments will be discussed in Chapter 4.) This is why the term ‘generic’ is used more frequently in this dissertation than ‘arbitrary,’ even though the null subject within a clausal subject can in principle assume either

interpretation. To my knowledge, there is no reason to believe that either the fact or the terminology can affect the general conclusions about parsing that have been drawn here. The descriptive claims relevant to the present research issues could be couched in terms of either generic or arbitrary without significantly altering their substance.

In sum, it appears that where there is no obligatory control, pragmatics plays an important role in the interpretation of a subject gap within subject complement clauses in Chinese. If an appropriate referent is available in the predicate, it is often adopted as the antecedent. But if this condition is not met, the gap usually assumes a generic or arbitrary reference. Note that Y. Huang (1994) claims, among others, that arbitrary reference is the least preferred antecedent for the subject gap within object complement clauses in Chinese. (See section 2.2.2.) But for the subject gap within subject complement clauses, arbitrary or generic reference is more readily available. This descriptive point is important to the present study, as the adoption of an arbitrary reference for the subject gap within object complement clauses may invoke a high processing cost, and an accessible generic/arbitrary reference for the subject gap within subject clauses may decrease the parser's drive to look for a specific referent in the predicate. Details will be discussed in Chapter 4.

2.5 Subject gaps within main clauses

Subject gaps within main clauses are largely referentially dependent on discourse topics.

Either in speech or in a text, such a gap can be a member of a topic chain.²⁸ Since the

²⁸ Li (2004) defines a topic chain as 'a chain of clauses starting with an identical topic that occurs overtly once in one of the clauses. All other clauses are linked to the chain by zero NPs coreferential anaphorically or cataphorically with the topic' (p. 41). This definition covers topic chains on the discourse level, not on the syntactic level.

present study only investigates processing at a single sentence level, this type of gap is of less relevance than other types discussed in previous sections. However, in the two sentence completion experiments employed by this study, some fragments were continued as main clauses. Thus, some understanding of this type of gap is still essential to interpreting the findings of these experiments.

The referent of this type of gap in Chinese has been discussed in many studies. The earlier studies include Li and Thompson (1979) and Chen (1984). The former invoked conjoinability to explain the distribution of zero (null) pronouns in Chinese. It was claimed that the preference for the omission of an argument in a clause corresponds to the degree of conjoinability of the clause, which is defined as the speaker's perception of the degree of 'connection' between clauses in discourse. The higher the degree of connection between clauses, the more likely a zero pronoun is used. Factors affecting conjoinability include, for instance, a continuation versus a switch of background and foreground information. Conjoinability is impaired if there is an adverbial expression such as a time phrase, or a contrastive morpheme in the second clause, or the two clauses are spoken by different participants.

Chen (1984) put forward the Predictability and Negligibility Conditions. The former states that a zero pronoun is used when the identification of the reference in the context can be easily predicted; the latter requires that a zero pronoun is not preferred when the identity of the reference needs to be emphasized.²⁹

Later studies are in general agreement with the observations of the previous studies. Taking the pragmatic approach, Y. Huang (1994) (also discussed in section

²⁹ Chu (1998) provides a brief summary of three analyses of anaphora distribution in Mandarin discourse. These analyses take a slightly different approach, but derive similar conclusions. Details are omitted here.

2.2.3) maintains that the use of a more prolix pronoun when a zero anaphor could occur implies a contrast in reference. In other words, a zero anaphor suggests co-reference with a salient referent whereas an overt pronoun suggests disjoint reference. The sentence in (15), cited in Huang (1994), illustrates this. When the zero pronoun is used in the second clause, the person who closed the door is usually understood as Xiaoming. But when an overt pronoun is used, it is likely to be a person other than Xiaoming who closed the door.

- (15) Xiaoming yi jin wu, Ø/ta jiu ba men guan shang le.
 Xiaoming as soon as enter room, he immediately BA door close up PART³⁰
 ‘As soon as Xiaoming_i entered the room, he_{i/Ø} closed the door immediately.’

Yang et al. (1999, 2001, and 2003) look beyond a single sentence in their investigation of the distribution of zero pronouns in Chinese, and conclude that a zero pronoun tends to facilitate co-reference with a nominal in the same structural position of the preceding sentence. They employed passages like (16) (for reader’s convenience, only the English translation of the Chinese sentences is presented here) in sentence-by-sentence self-paced reading experiments.

- (16) Xiaoming told Xiaolin that the community here is not safe.
 Xiaoming/He/Ø warned Xiaolin/her to always keep alert.
 To keep alert is the best way to prevent an accident.

³⁰ I have simplified the English gloss here. Huang (1994) uses more grammatical terms for exposition purposes.

They found that the use of a repeated name in the matrix subject position of the second sentence incurred a slowdown in reading (this is called the Repeated Name Penalty) while responses to empty pronouns or overt pronouns did not differ significantly.

Using the same method, the researchers compared the use of empty and overt pronouns in the ‘continue’ and ‘shift’ conditions in a Chinese discourse. In (17), the first sentence is followed either by a sentence which suggests its subject is coreferent with the subject in the first sentence (continue), or by a sentence which suggests its subject is coreferent with the object in the first sentence (shift). The results showed that overt and empty pronouns did not differ in the continue condition but the overt form facilitated the reading of the second sentence in the shift condition. Thus, the findings provided evidence that empty pronouns in subject position are preferred to link to the subject in a preceding sentence.

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

Continue Condition

He/Ø thought vegetables are of more utility than flowers.

Shift Condition

She/Ø thought, however, that both vegetables and flowers should be planted.

The usage and planning of a garden are worth studying.

Taking a cognitive approach, Tomlin and Pu (1991) and Pu (1995) provide experimental evidence to reject a ‘recency model’ and support an ‘episode model,’ to explain the distribution of pronominals in human languages. They claim that recency, that

is, the distance between a given reference and its nearest antecedent, is not the fundamental factor affecting the distribution of nominal and pronominal noun phrases. Instead, a tendency to favor recency is only a result of the limited capacity of working memory and should be included within a more general cognitive account. The episode model they propose maintains that discourse is hierarchically organized and constrained by attention and memory. Nominals are often used for referents that are not active in the working memory whereas pronominals³¹ are often used when their referents are in focus. Tomlin and Pu (1991) manipulated the presentation mode of pictures, varying whether two pictures were presented as a pair or each picture was presented on its own. They analyzed sentences produced by the Chinese speakers based on the pictures to see if the picture presentation mode affected the use of nominals and pronominals. The results supported the episode model, since pictures presented together tended to give the Chinese participants a sense that the two pictures depicted one episode, which consequently encouraged the use of pronominals more often for coreference. Pu (1995) presented three different episodes in pictures consecutively. There were two experimental conditions, even or odd. In the even condition, the pictures were presented in pairs, and the three original episode boundaries were preserved. (Each of the three episodes consisted of eight pictures.) In the odd conditions, two of the three episode boundaries were disrupted, with the last picture of two episodes presented with the first picture of the next episode. In both on-line and recall tasks,³² both Chinese and English participants showed

³¹ In the studies, the researchers did not tally zero pronouns in the narratives. Hence, pronominals refer to overt pronouns only.

³² The on-line task required the participants to make up stories based on the pictures. The recall task required the participants to recall the entire story they had just described, without the pictures in sight.

sensitivity, in their own native language, to the episode boundaries and produced more full NPs at the beginning of a new episode.

Pu (1997) studied anaphora distribution in written Chinese narratives. She identifies six factors that trigger the use of a pronominal instead of a zero anaphora. They are: 1) local topic change, 2) weakened topicality, 3) weak semantic link, 4) story-line interruption, 5) intervening materials, 6) referential emphasis. She maintains that the underlying force driving the use of one type of anaphora over another is the cognitive limitation of humans in focusing on and retaining a referent. In the writing domain, although a writer can take the liberty of overlooking some cognitive constraints, she has to facilitate comprehension by attending to the audience's constraints. Hence, texts are not exempt from the cognitive 'rules.'

This section has summarized the findings of studies that examine antecedent assignment for zero pronouns in Chinese beyond a single-sentence level. In general, these studies agree that the choice between pronominals or overt NPs at sentence-initial positions reflects information flow; the use of zero pronouns suggests a continuation of the story-line, whereas the use of overt pronouns or lexical NPs, especially the latter, implies a shift of focus or subject. The present study also investigates empty subject interpretation in main clauses. However, all experimental sentences or fragments are presented in isolation. The lack of discourse support implies that a preceding antecedent is not available for the empty subject within a main clause. This experimental design allows us to investigate how the requirement for empty category interpretation and the possibility of a later antecedent for the empty category influences the structural choice

when the parser faces a structural ambiguity. Chapter 4 will elucidate the experimental goals and design.

In conclusion, this chapter has reviewed studies that examine the reference of an empty subject within object complement, relative, subject complement, and main clauses in Chinese. For an object complement clause, the matrix verb can control the co-referential plausibility of the matrix and embedded null subjects. The empty subject within a relative clause must be linked to the head noun that follows. A subject gap within a subject complement clause can be either controlled by a nominal in the predicate or interpreted generically. An empty subject within a main clause is referentially dependent on a topic in the discourse. Note that these four types of constructions can share very similar surface word order, which is why they can create local ambiguity in on-line sentence processing. Chapter 3 will review previous studies on empty category processing and Chapter 4 will report the experiments of this study in detail.

CHAPTER 3

Processing empty categories: Previous research

This chapter reviews and evaluates existing research on the processing of empty categories, especially those that occur in constructions that are relevant to the present study. It starts with an overview (section 3.1) summarizing the established parsing strategies employed in on-line filler-gap association, and the arguments surrounding many unresolved issues. The remaining sections of this chapter focus on gap processing in the constructions central to the present study. Many studies (section 3.2) have investigated the processing of subject gaps within control constructions, though most of them are not on Chinese. They have addressed an array of research questions concerning the filler-gap relation in this type of construction. There is also research (section 3.3) on the processing of Chinese relative clauses. No study seems to have investigated the processing of subject gaps within a clausal subject. The present work therefore could be the first one to investigate this type of gap from the processing perspective. This chapter serves as the backdrop for the next chapter, which discusses the experimental design, method and results of the present study.

3.1 An overview of filler-gap association

Earlier research on filler-gap dependencies was mostly on English, and much of the investigation effort concentrated on how the identification of a *wh*-filler in a sentence affects the processing of ensuing potential gap positions. Substantial experimental evidence, as discussed in section 3.1.1, has indicated that the parser follows the guidance

of some parsing strategy in establishing a filler-gap dependency on-line in a sentence. There has also been research (section 3.1.2) that compared the processing of other types of empty category, such as *pro*, PRO, and NP-trace. The data were interpreted as supporting the psychological reality of these empty categories but painted a less clear picture of their linguistic status. Section 3.1.3 further explores this issue: whether a gap is a structural or a semantic element.

3.1.1 Processing *wh*-gaps

The *wh*-gap is the most well-studied empty category. In English, a *wh*-word usually occurs at the beginning of a clause; later in the clause or sentence there is a gap position, from where the *wh*-word is displaced.³³ (Since a gap is a position where a phrase is displaced, the gap and the displaced element must be of the same syntactic category. Section 1.1 has a detailed discussion of the nature of a gap.) In many cases the filler (i.e., the *wh*-word) and its associated gap are not contiguous in the word string. The fact that there is nevertheless consistent correct interpretation of the filler-gap relation by native speakers suggests that the parsing mechanism has an efficient strategy that it uses in relating the filler and the gap in on-line sentence processing. Fodor (1978) contrasted a “gap-as-last-resort” strategy and a “gap-as-first-resort” strategy. The last-resort hypothesis depicted a passive parser which does not postulate a gap until a noun phrase is absent at a position in which it is normally obligatory. This strategy can be considered efficient for sentence processing because the parser does not need to posit a gap at each point in the sentence where a noun phrase *might* be missing. However, experimental

³³ The discussion here is limited to gaps of the category noun phrase. Gaps can be of other categories such as verb phrase, prepositional phrase, and adverbial phrase.

evidence suggested that the parser is in fact more pro-active, in line with the “gap-as-first-resort” strategy (Crain & Fodor, 1985; Frazier, 1987a; Frazier & Clifton, 1989; Frazier & Flores D’Arcais, 1989; Stowe, 1986); the parser appears to give top priority to resolving a filler-gap relation. Frazier (1987a) dubbed this first-resort strategy the Active Filler Strategy.

- (1) Active Filler Strategy: 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.

This requires that the parser, once it identifies a filler, will actively seek a gap to associate with the filler. It is an active strategy in the sense that the parser will posit a gap wherever possible (i.e., wherever a noun phrase could appear next in the sentence), rather than waiting to see if subsequent words actually allow for a gap in that place. For instance, in sentence (2a) (an example from Stowe, 1986), the first potential gap position for the filler *who* is the object position after *bring*. Employment of the Active Filler Strategy means the parser will immediately posit a gap there, which happens to be correct in (2a).

However, this active gap search leads to an error on-line in (2b), where the first potential gap position (after *bring*) is thwarted by the subsequent appearance of *us*, which is the overt object of *bring*. This garden-path in processing is called the *filled gap effect*. The parser has to reanalyze by removing the empty category it has posited in that position and then revive its search effort for a gap. The filled-gap garden-path typically shows up in processing difficulty at the overt noun phrase in the potential (but incorrect) gap position.

- (2) a. My brother wanted to know who Ruth will bring _____ home to Mom at Christmas.
- b. My brother wanted to know who Ruth will bring **us** home to _____ at Christmas.

Earlier studies on filler-gap dependencies often employed self-paced reading in testing the Active Filler Strategy. Though a standard methodology, this may encourage phrasal closure after each presented segment, thereby creating what looks like a filled-gap effect. A more recent study by Sussman and Sedivy (2003) avoids this potential problem by employing headmounted eyetracking, with auditory sentence input spoken at a normal pace. In their experiment, after listening to a passage, the participants were required to answer a comprehension question, which was either a yes-no question (e.g. *Did Jody squash the spider with her shoe?*) or a *wh*-question (e.g. *What did Jody squash the spider with?*). Depictions of objects mentioned in the passage were displayed on a computer screen, and the eye-movements of the participants were recorded while they were listening to the question. The results showed a different eye-movement pattern in the processing of a *wh*-question than in the processing of a yes-no question (which contains no *wh*-filler-gap dependency). The direct object referent (e.g., the spider) was significantly more likely to be fixated at the verb and the following direct object regions in a *wh*-question than at the same regions in a matched yes-no question. This lends support to the claim that ‘the identification of a WH-filler results in an active search for the referent corresponding to the filler’ (p. 158).

de Vincenzi (1991a, 1991b, 1996, 1998) examined chain formation in Italian and formulated the Minimal Chain Principle, which was intended to be a universal processing principle. The definition of the principle is given in (3).

- (3) Minimal Chain Principle: Avoid postulating unnecessary chain members at surface-structure, but do not delay required chain members.

This principle has two parts, and the second part is basically a restatement of the Active Filler Strategy. The Active Filler Strategy stipulates to establish a filler-gap dependency as soon as possible, which in turns means not to delay required chain members. The first part, though, is a new addition, and is based on the assumption that chains are costly to process. Thus if not required, the parser should not postulate any chain. For example, in Italian both *chi* ‘who’ and *quale*-N ‘which-N’ can be *wh*-operators binding an empty noun phrase position. But they differ in that the latter can also function as an antecedent for a resumptive pronoun, in which case there is no *wh*-chain. Hence, during sentence comprehension, Italian speakers may analyze *chi* as a chain member as soon as it is encountered because a chain is unavoidable for a nonreferential *wh*-phrase. In contrast, they may delay chain formation for *quale*-N until all arguments of the verb are received so that it is clear whether the *quale* phrase is linked to a gap or to a resumptive pronoun. de Vincenzi (1991b) reports an experiment on sentences like those in (4). On the third segment (in bold below), the *chi*-object sentences exhibited a greater processing cost than the *chi*-subject sentences. This can be explained on the assumption that for the former, the parser later had to reanalyze an initial misanalysis in which *chi* was co-indexed with

the subject position.³⁴ In contrast, the *quale*-subject and *quale*-object sentences were processed similarly on the third segment. This would follow from the first part of the Minimal Chain Principle, under which the parser would prefer not to begin a chain for *quale*-N until or unless it proved necessary, when all arguments were processed later.

(4) a. *Chi/Quale*-subject³⁵

Chi/Quale ingegnere | ha licenziato | **il metalmeccanico** | senza dare |
 Who/Which engineer fired the steelworker without giving
 il preavviso?
 notice

b. *Chi/Quale*-object

Chi/Quale ingegnere | ha licenziato | **il proprietario** | senza dare |
 Who/Which engineer fired the owner without giving
 il preavviso?
 notice

Aoshima, Phillips, and Weinberg (2004) employed Japanese to investigate the reason behind the parser's use of the Active Filler Strategy and the Minimal Chain Principle. The motivation for them might be memory or other cognitive limitations, or it might be purely linguistic, with its source being either syntactic or semantic. Japanese is a head-final language and has a basic SOV word order. Hence, if a sentence has an embedded object complement clause, the arguments of the matrix clause typically precede those of the embedded clause in linear word order, while the embedded verb

³⁴ Even though SVO is the basic word order in Italian, OVS is a possible alternative. The subject and object relation in the sentences in (4) is thus syntactically ambiguous, but disambiguated by pragmatics (e.g., an owner can plausibly fire a worker but not vice versa).

³⁵ The slash sign in the examples indicates either *chi* or *quale*-object was used in the sentence.

precedes the matrix verb. After a filler is identified, if the parser's priority is to create a gap as soon as possible, it should do so in the matrix clause because in real time processing, the matrix arguments are encountered before the embedded arguments. But if the parser is eager to discharge the thematic role onto the *wh*-phrase, it should posit a gap in the embedded clause because Japanese is a head-final language so the embedded verb appears before the matrix verb and the *wh*-phrase can be interpreted sooner by relating it to the first verb encountered. The difference between the two strategies is schematically illustrated in Figure 3.1, taken from Aoshima et al. (2004); this is part of their Figure 1 (p.26), with a paraphrase of the associated caption.

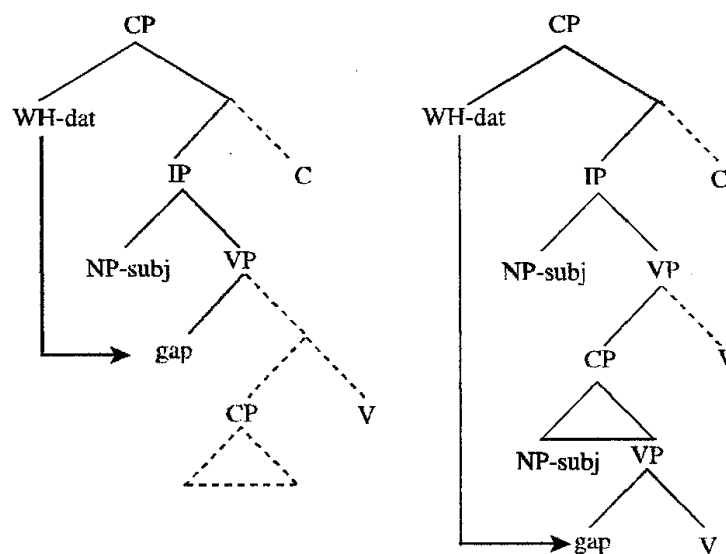


*Figure 3.1: The configuration on the left shows the Active Filler Strategy, by which a parser would postulate a gap as early as possible, i.e., in the matrix clause. The configuration on the right shows a competing strategy, by which a parser would associate the gap with the first verb available to assign a thematic role to the *wh*-phrase, so the gap is in the embedded clause. (Dashed lines indicate structure that is not yet confirmed when the filler-gap dependency is completed.)*

Three experiments were conducted to test the gap-creation process in *wh*-scrambling constructions in Japanese. A dative (*ni*-marked) *wh*-NP was the filler in all target sentences (see Figure 3.1). Results of the first self-paced reading experiment indicated that embedded verbs with a question particle were read significantly faster than those without, suggesting that readers expected the *wh*-word encountered previously to be an argument in the embedded clause. In the second self-paced reading experiment, a significant reading slowdown was found at the phrase in the embedded clause that carried the same functional particle (e.g., the dative particle) as the preceding *wh*-word. This indicates that the phrase in the embedded clause clashed with the gap posited for the *wh*-word. This in turn implies that a gap was already posited before the embedded verb was processed. A sentence completion study further confirmed the preference for the gap being created in the embedded rather than in the main clause. Together these results lend support to the hypothesis that an active parser, in forming a filler-gap dependency, is driven by the need to satisfy thematic role assignment requirements. The predominance of thematic concerns in on-line parsing has often been argued in the literature; see references in Aoshima et al.'s paper.

To summarize, the studies discussed in this section have pointed to three important characteristics of filler-gap dependencies relevant to their processing:

- Chains (filler-gap dependencies) are costly to process, so the parser attempts to avoid them if possible;
- Once a chain member is unambiguously recognized, so that opening a chain is unavoidable, the parser attempts to close out the chain as soon as possible by

identifying the other chain member even before unambiguous evidence is available in the word string;

- After recognition of a filler, a gap may be anticipated in whatever position is first identified that provides the filler with a thematic role.

3.1.2 Processing other types of empty categories

A number of studies have investigated the processing of other types of empty categories, including PRO, *pro*, and NP-trace in raising, passive and unaccusative constructions. These filler-gap dependencies differ from a *wh*-dependency in that the filler is not processed as a filler when it is encountered. Instead, only when the gap is recognized does the parser start to look for its antecedent. Thus, this kind of filler-gap dependency is gap-driven, as discussed in Chapter 1, in contrast to the filler-driven *wh*-filler-gap dependencies. The present section will focus on this question: Are all empty categories processed similarly? In the next section I will tackle issues concerning the psychological reality and status of empty categories.

In early studies Bever and McElree (1988) and McElree and Bever (1989) employed a visual word probe task to investigate the processing of different types of empty category, including the PRO gap, as in (5a), the NP-raising gap, as in (5b), the NP-*tough* gap, as in (5c), and the passive gap, as in (5d). Note that in all these constructions, the matrix subject is the filler for the gap. The probe word used in the task was an adjective that modified the head noun of the subject noun phrase, for example, *stern* or *shrewd* for the examples in (5).

- (5) a. The stern judge / who met with the defense / adamantly refused [PRO] to / argue about the appeal.
- b. The stern judge / who met with the defense / is sure [t] to / argue about the appeal.
- c. The stern judge / was difficult for the defense / to argue with [t] about / the pending appeal.
- d. The shrewd lawyer / who argued for the defense / was suspected [t] / by the judge.

The probe word was presented either at the earliest point at which the gap could be identified (i.e., at the word following the gap position for (5a-c) ³⁶ and at the matrix verb for (5d)), or at the end of the sentence. The test sentences were divided into chunks as illustrated in (5) and the participants controlled the speed of presentation. When a probe word appeared, participants were required to indicate whether the sentence contained that word or not. The reaction times to the probe were interpreted as reflecting the level of activation of the antecedent.³⁷ The baseline was the reaction time to the same probe word in sentences that did not contain a gap in the segment of interest (e.g., *The stern judge who met with the defense flatly rejected the arguments for an appeal.*).

The results were mixed. No significant differences were found in the reaction times to the probe word at the point where the empty categories actually occurred.

³⁶ In general, since empty categories are not physically realized in word strings, the cost of processing an empty category may only be observed at the word (or end of sentence) that immediately follows it.

³⁷ It was hypothesized that processing of the gap would reactivate its antecedent. This increase in the activation level of the antecedent would be displayed in a faster reaction to the probe word, since it was a word that had appeared in the antecedent.

However, there were significant differences in reaction times when the probe point was at the end of the sentence. The NP-raising and NP-*tough* gaps were found to trigger significantly faster reaction times than the PRO gap, implying that these empty categories are not all processed similarly; the unique linguistic properties of different empty categories may affect their association with the antecedent in on-line sentence processing. Reactivation, though only at sentence-final positions, of the antecedent was also found in the passive sentence, relative to the baseline active (e.g., *The shrewd lawyer who argued for the defense had spoken to the judge.*) or adjectival (e.g., *The ragged drifter traveling the land was resentful constantly.*) sentences.

The findings of Bever and McElree's experiments were interpreted as showing that the antecedent of a gap is reactivated during sentence processing even though the effect is delayed. It is unknown whether the delay is an experimental artifact, in the sense that the probe task is not sensitive enough to pick up the effect immediately, or whether it genuinely reflects delayed processing of gaps, or perhaps delayed association of a filler with a gap (see discussion in Fodor, 1995). This timing issue has persisted in sentence processing research on empty categories; many studies discussed in this chapter found delayed effects, and the proper interpretation of such delays is of considerable importance.

Two other studies comparing the processing of NP-trace in the raising construction and PRO in the control construction also showed processing differences for these two types of empty category. (Additional studies on PRO will be discussed in section 3.2 below.) Featherston, Gross, Münte and Clahsen (2000) employed the

methodology of ERPs (event-related potentials) to compare the processing of control and raising constructions in German. The test sentences are shown in (6).

- (6) a. Der Sheriff_i hoffte als die Witwe plötzlich in das Zimmer kam PRO_i
 The sheriff hoped as the widow suddenly into the room came
 den Täter endlich verurteilen zu können.
 the offender at last sentence to can
 ‘The sheriff hoped, as the widow suddenly came into the room, to be able to sentence the offender at last.’
- b. Der Sheriff_i schien als die Witwe plötzlich in das Zimmer kam e_i
 The sheriff seemed as the widow suddenly into the room came
 den Täter endlich verurteilen zu können.
 the offender at last sentence to can
 ‘The sheriff seemed, as the widow suddenly came into the room, to be able to sentence the offender at last.’
- c. Der Sheriff_i verurteilte als die Witwe plötzlich in das Zimmer kam
 The sheriff sentenced as the widow suddenly into the room came
 den Täter endlich im Scheinwerferlicht.
 the offender at last in the spotlight
 ‘The sheriff, as the widow suddenly came into the room, sentenced the offender at last in the spotlight.’

The sentence in (6a) contains a control construction and that in (6b) contains a raising construction. (The sentence in (6c) does not contain a filler-gap relation and served as the baseline in the experiment.) On the surface, the sentences differ only in the matrix verb, which is the key word that informs the parser as to what construction it is processing. The

critical segment is the embedded object *den Täter*, which immediately follows the empty categories and thus is the point at which any difference in processing PRO versus NP-trace could first emerge.

Featherston et al. found significant differences in the ERPs between these constructions. The raising construction (6b) elicited a significantly stronger P600 effect, a positive wave peaking at approximately 600ms after the onset of the stimulus (i.e., the word immediately following the gap position), at the critical object position of the infinitival complement than the control construction (6a) did. The effect was distributed over the midline, parasagittal and temporal regions. Also, starting from about 300ms after the onset of the critical NP segment, both raising and control constructions elicited more positive-going ERPs than the baseline sentence (6c). The difference in the magnitude of the P600 effect between the two gap constructions was argued to result from a difference in the syntactic complexity of the two constructions. The raising construction involves a movement chain with the embedded subject moving to the matrix subject position, while the control construction only involves an antecedent-gap co-indexation. It can be speculated that the processing cost is higher for a construction with a chain than for one without.

Walenski (2002) followed up on the Featherston et al. study of German with an ERP and cross-modal priming study of the processing of raising and control constructions in English. He was interested in the possibility that the German findings were due not to gap characteristics, but to the degree of predictability of an infinitival complement with a null subject. He noted that while both the control and baseline predicates allow direct objects, which could be introduced with the determiner *den*, the raising verb *scheinen*

would occur with *den* if the following infinitive itself allows a direct object. This frequency difference in the occurrence of *den* after certain verbs could affect complementation expectation. As a result, the P600 data found in Featherston et al. might be caused by differences in the predictability of a complement rather than filler-gap processing. Walenski calls this the *complement expectancy* account.

The experimental sentences in Walenski's study are shown in (7), the (a) version containing a control construction, and the (b) version contain a raising construction.³⁸

- (7) a. The manager_i tried PRO_i to confront the mob of employees.
 b. The manager_i seemed e_i to confront the mob of employees.

The results were somewhat different from those of Featherston et al. At the matrix verb, an N400 was elicited (a negative wave peaking at approximately 400ms post-onset), which was significantly larger for the raising construction than for the control construction. By contrast, at the infinitival marker (which is the first overt word following the gap) the control construction yielded a larger (though not reliably so) P600 than the raising construction did. There were no significant differences at the subordinate predicate. Walenski suggests that the N400 could be a lexical effect even though the direction of the effect was contrary to previous studies: the raising verbs were more

³⁸ Walenski dropped the sentential modifier used in the materials of Featherston et al. so that the sentences would be shorter and sounded more natural. In addition, Walenski noted that both *den* in German and *to* in English are ambiguous. The former can be in a masculine accusative singular or in a dative plural noun phrase, neither of which necessarily signals a gap. The English *to* can be in an infinitive (a gap follows), or in a prepositional phrase (a gap may not follow). 'The presence of this ambiguity in the English materials could potentially impact predications for the size but not the direction of an effect of linguistic gaps (reducing the predicted size of the effect), but should not affect either the size or the direction of a predicted effect of expectancy' (p. 68).

frequent than the control verbs in the Walenski study,³⁹ but the former produced a greater amplitude of N400. Walenski did not have an explanation for this finding. The larger P600 for the English control constructions was in the opposite direction from the finding for German, and is in need of explanation. Walenski observes that the results in both languages are compatible with the complement expectancy account, because the word order in the subordinate clause differs between English and German: the English complement clause begins with the infinitival marker *to*, while German complement clauses are verb-final and in the Featherston et al. experiment they began with a direct object marked by an accusative determiner (e.g., *den*) and the infinitival marker *zu* appeared later with the clause-final verb. For the English verbs in Walenski's materials, the infinitival *to* is more expected for the raising verbs than for the control verbs. By contrast, in German, the occurrence of an accusative determiner is less expected for the raising verbs than for the control verbs. This is because the control predicates "allow direct objects (which could be introduced with *den*), while *scheinen* would only occur with *den* if the following infinitive itself allowed a direct object" (p. 55).

Following up on the ERP experiment, Walenski conducted two cross-modal priming experiments using the same sentences but they were lengthened to avoid intra-sentential priming effects. A test sentence is shown in (8).

³⁹ Raising adjectives (e.g., *be likely*) were used in almost half of the raising constructions in Walenski's study, and no corpus data was reported regarding the frequency and complement expectancy of these raising adjectives, but only for verbs.

- (8) The manager_i with the handlebar mustache (resolved / was bound) with an air of fatality, *e_i* to heroically and bravely confront the mob of the employees.

The word *resolve* in the sentence is a control verb, while *be bound* is a raising predicate. Each trial contained either a control verb or a raising predicate.

In the first of these two experiments, the participants listened to the sentences spoken at a normal rate. At the word *to* or at the subordinate verb (e.g., *confront*),⁴⁰ a word that was a semantic associate of the matrix subject appeared on the computer screen; in a baseline condition, a non-associated word of matched frequency and length was presented instead. For instance, for the sentences in (8) the associated target word was *store*, while the baseline target word was *nurse*. The task was naming; that is, participants were required to say the visually presented word out loud as promptly as possible. Reactivation of the antecedent during processing of the gap was expected to be revealed in faster responses to the target word associated with the antecedent. In fact some priming of the target word, though not statistically significant ($p=.07$), was found in the raising construction at *to* but not in the control construction. No significant difference was found at the subordinate verb.

Further analysis of the reaction times to the baseline target words (words that were unrelated to the matrix subject) was conducted to investigate the processing load of control and raising constructions. No processing load difference was found at the first test point. However, a significant decrease in reaction time between the two test points was

⁴⁰ At this point, the subordinate verb reveals the thematic information of the gap. The thematic status of the control subject must be adjusted so that it can perform the activities specified by the matrix and subordinate predicate. This adjustment may increase the processing load of control.

found in raising but not in control. This seems to suggest that processing of raising constructions became easier at the subordinate predicate but processing of control constructions remained difficult through the two test points.

The second priming experiment was identical to the first except that the probe appeared 300ms after the test points used in the first priming study. The reason for this adjustment was priming could be delayed for control sentences and hence, it could be detected at later test points. This time, more priming was found in control than raising at the first test point (300ms after *to*), even though the difference was not statistically significant ($p=.07$). At the second test point (300ms after the onset of the subordinate verb), no priming was found in either version. Once again, further analysis of the unrelated target primes indicated a significant decrease in reaction time between the two test points for only the raising constructions. This echoes the finding of the first cross-modal priming experiment, that control remained more difficult than raising at the latter part of the sentence.

Many of the foregoing results are not robust statistically, but Walenski attempts to draw valuable insights from them in terms of his complement expectancy approach. He proposes that “the thematic status of the matrix subject is checked at the onset of the infinitive for both control and raising, but differences in the expectancy of the complement, cause this to be done at different times for each type of complement” (p. 112). That is, while the experimental results seem to suggest a delay in establishing the control relation, in comparison to the movement chain in raising, Walenski attributes this not to any inherent aspect of empty category processing but to simple frequency effects in the relation between a matrix verb and the complement it selects. The control verbs in

these materials were more frequent than the raising verbs, but the nature of the following complement (infinitival clause with null subject) was more predictable following the raising verbs than following the control verbs. It remains to be seen whether a similar account can be given for the experimental materials in other studies, such as Bever and McElree's.

Even though the two methodologies (ERP and cross-modal priming) differ in some outcomes, the results of the processing studies discussed in this subsection have generally been perceived as supporting the psychological reality of gaps in on-line sentence processing inasmuch as the antecedent of an empty category is reactivated at some point when or after the empty category is encountered and processed.

3.1.3 The psychological reality of a gap

One critical question concerning the study of empty category processing is: Are empty categories psychologically real? This can be broken down into two questions, one about competence and one about performance. (i) Do the structures of sentences dictated by the competence grammar for a language include syntactically active elements that lack phonological form (such as traces, null pro-forms, and so forth)? (ii) If so, can the sentence processing routines detect their presence in a sentence? Many researchers have reasoned that if the second question is answered affirmatively, then it can be inferred that the answer to the linguistic question (i) is also affirmative. However, many of the psycholinguistic experiments address only whether and how the parser identifies a gap in a weaker sense: a locus in a sentence where an element is understood but does not appear overtly. Sensitivity to gap positions in this weak sense cannot be counted as proof that the

parser is detecting genuine phonologically empty categories as defined in (i) above unless evidence is also provided that those gap positions detected by the parser house silent syntactic constituents. (Pickering & Barry, 1991; Sag & Fodor, 1995) This is an issue that has been difficult to settle.

The discussion that follows begins with studies whose findings indicate the parser's sensitivity to gaps, as revealed for instance in reactivation of the antecedent. The further question of whether there is a silent syntactic constituent at the gap position has generally not been addressed.

As discussed in Section 3.1.2, Bever and McElree (1988) and McElree and Bever (1989) investigated antecedent reactivation by different types of gap in a sentence. They found reactivation in a probe task when the probe word was presented at the end of the sentence but not when it appeared at the place where the empty category actually occurred. This provides evidence to support that antecedents can be reactivated at some point after a gap, notwithstanding the fact that no reactivation is found right at the gap position.

Other studies focused on the verbal passive construction, analyzed as due to NP-movement and hence containing NP-trace. MacDonald (1989) and MacDonald and Clark (1988) tested for antecedent reactivation triggered by the NP-trace. They compared the processing of the verbal passive against adjectival and adjectival passive sentences which are not thought to contain an NP-trace. Examples of the materials tested by MacDonald (1989) are shown in (9).

- (9) The Irish terrorists wanted to disrupt the ceremonies.
 The new mayor at the centre podium was furious/surprised/shot.

The first sentence provides context. In the second sentence the word *furious* is an adjective. No standard linguistic theory predicts an empty category to follow an adjective of this type, so a parser that is sensitive to gaps would not react to this as a gap position. The word *surprised* can be either an adjective or a passive verb, but in this context it would be more natural to parse it as an adjective. A standard linguistic analysis derives such adjectives by means of a passive transformation in the lexicon, which creates the passive adjective before it is inserted into a sentence derivation. Assuming that lexical rules do not create traces, the parser should perceive no gap following *surprised*. *Shot* is a real passive verb, so that sentence would be derived, according to GB theory, by application of a transformation rule in the syntactic derivation, moving the underlying object into subject position and leaving a trace behind. Thus, GB theory postulates an empty category after *shot* in (9), which refers to the mayor. MacDonald reasoned that if the NP-trace is psychologically real, its processing (at the position of the passive verb) by the parser can be expected to reactivate its antecedent, *the mayor*, but not other phrases in the sentence. No reactivation of *mayor* or other NPs should be triggered by either the pure adjective or the passive adjective.

A visual probe task was employed similar to that used by Bever and McElree. A probe word appeared following the second sentence and the participants were required to decide whether it had occurred somewhere in the passage. Two probes were used: an antecedent probe and an agent probe. For the sentences in (9), the antecedent probe was *mayor*, and the agent probe was *terrorists*, since the context implies that it was the terrorists who were doing the shooting. The results revealed significantly faster reaction

times to the antecedent probe in the verbal passive condition, relative to the adjective condition. The verbal passive condition was also faster, though not statistically reliably so, than the adjectival passive condition. This indicates that the parser might process sentences with and without gaps differently, and suggests that the NP-trace gap is detected by the parser, triggering reactivation of its antecedent. It is also important that no reliable difference was observed in the response times to the agent probe even in the passive version, which MacDonald took as confirmation that it is only genuine empty categories that trigger antecedent reactivation; the understood agent of a passive sentence is merely an implicit argument (i.e., present at the semantic level but not as an element in the syntax) so there would be no empty category to trigger reactivation.

This is an extremely interesting form of argument for the claim that the passive gap corresponds not merely to an understood argument of the verb, but actually contains a syntactic empty category. However, the implied agent in the verbal passive sentences was not as definitive as MacDonald implied. (See Fodor, 1989.) For example, in (9), even though the terrorists mentioned in the first sentence seemed to be the most possible assassins, there could be many different people at the ceremonies who were responsible for the shooting. Thus, it comes as no surprise that *terrorists* was not as strongly activated as the antecedent of the gap, about which no question arises as to whether or not it is the internal argument of the passive verb.⁴¹ The results to date leave it open, therefore, of whether or not so-called ‘activation’ effects occur for any understood (implicit) argument. To conclude, though there has been some evidence that antecedent reactivation

⁴¹ Other examples from MacDonald’s experiment are even clearer in this regard. Fodor (lecture handout 2005) cites *The carpenter started work in the kitchen yesterday. The tile floor next to the stove was removed.* It is far from clear that the carpenter is the agent of the tile removal.

is found at the purported gap position, there is no concrete evidence that there is a silent syntactic element at that position.

It has been argued that for testing reactivation, an on-line task such as cross-modal priming is more suitable than a delayed task such as a post-sentence probe (see Swinney, Onifer, Prather, & Hirshkowitz, 1979; Fodor, 1995). For *wh*-gaps, Nicol and Swinney (1989) discussed a number of studies employing cross-modal priming and ERPs to look for antecedent reactivation in relative clause constructions (e.g., *The policeman saw the boy_i that_i the crowd at the party accused t_i of the crime.*). The experimental data of four studies supported antecedent reactivation at the *wh*-gap position.

Cross-modal priming data concerning antecedent reactivation by other types of gaps have not been as straightforward, however. A cross-modal priming study by Osterhout (reported by Nicol and Swinney, 1989) found antecedent reactivation when testing 1000ms after the NP-gap position in passive sentences (e.g., *The dentist_i from the new medical center in town was invited t_i by the actress to go to the party.*) but not when testing at the gap position or at the 500ms point. Added evidence of a delay of activation is presented by Osterhout and Swinney (1993), another cross-modal priming study that investigated the processing of active and passive sentences. They found a similar 1000ms delay in antecedent reactivation in passive sentences. On the other hand, a delayed effect was not supported by the findings of Clahsen and Featherston (1999), who employed the same methodology. In their second experiment,⁴² they tested German particle-verb constructions, which, according to some syntactic theories, involve movement of the direct object leaving a NP-trace located before the clause-final particle. A test sentence is shown in (10).

⁴² Their first experiment is less relevant here.

- (10) Nach zwei Tagen Streit sprach der Richter das Geschäft;
 after two days dispute awarded the judge the business
 dem ziemlich überraschten Andreas e_i zu.
 the rather surprised Andreas to
 ‘After two days of dispute the judge awarded the business to the rather
 surprised Andreas.’

The data showed a significantly faster reaction time to target probes (i.e., the displaced noun such as *Geschäft* in (10)) than unrelated probes at the purported gap position. Such a difference was not found at the baseline test point, which was 400ms earlier than the gap position. The result was interpreted as evidence that supports antecedent reactivation at the assumed gap position, and thus supports a movement analysis of the scrambling construction.

The findings of the studies discussed in this section and in Section 3.1.2 have made it clear that there is some distinctive kind of psychological processing related to filler-gap dependencies; antecedent reactivation is found for different types of gap. However, evidence that supports an empty category as a syntactic constituent in the strong sense of Government-Binding theory is far from concrete. It is not even clear what kind of data would settle the matter. Possibly in future the ERP methodology that has been increasingly employed in the study of filler-gap relations will bring some insight into the issue. Neurolinguistic methodology is particularly well-suited to distinguishing the several sub-components in the processing of a filler-gap association. Recent ERP studies of filler-gap constructions include Felser, Clahsen, and Münte, 2003; Fiebach,

Schlesewsky, and Friederici, 2001; Phillips, Kazanina, and Abada, 2005; Ueno and Kluender, 2003.

To conclude, it remains an open question to date whether some syntactically active but phonologically null elements exist in a sentence, although much has been learned about processing filler-gap dependencies from previous studies. This dissertation primarily does not focus on the psychological reality of traces and other empty categories but rather on how gap constructions are interpreted. Therefore, I leave unresolved here the issue of the linguistic status of the sentence locations that are frequently referred to in the literature as ‘gaps.’

3.2 Processing gaps within control constructions

One construction that is particularly relevant to the present study is the control construction. Control implies co-reference, with the gap ‘borrowing’ its referent from another element in the same sentence. The relation between the controller (the element that lends out the referent) and the controllee (the element that borrows the referent) simulates a binding relation, in which both elements have the same referent. For reasons of brevity my exposition throughout the thesis will not explicitly distinguish conference from binding. On a standard GB analysis, a control relation does not involve movement (but see Hornstein (1999) for a movement analysis within the Minimalist program). Control is constrained by grammatical requirements; a c-command relation is required in some cases between the controller (e.g., a main clause argument) and the controllee (i.e., the gap, always in a subordinate clause). The controllee is PRO in English, where control

occurs only into non-finite clauses, though Section 2.2.1 has revealed the complications involved in categorizing the gap in a control construction in Chinese.

Control is not only found in clausal objects, as in (11a). It also commonly occurs in adjunct clauses, as in (11b), and in clausal subjects, as in (11c).

- (11) a. John_i promised Sue [PRO_i to keep the secret].
- b. PRO_i Entering the room, Mary_i found Peter was already there.
- c. [PRO_i To climb the Everest] is Nicole_i's ambition.

In (11a), the implicit subject within the complement clause is obligatorily *John*. If the matrix verb were *asked* instead of *promised*, the implicit subject would be *Sue*. When the matrix subject is the antecedent of the gap within the complement clause, it is called subject control. When the matrix object is the antecedent, it is called object control. Which matrix item is the controller usually hinges on the matrix verb: as noted, *promise* imposes subject control while *ask* imposes object control.

In (11b), the antecedent of PRO is the matrix subject that follows the initial adjunct clause. In (11c), the subject within the clausal subject is empty and its antecedent is a possessor that appears later in the main clause predicate. Control in (11a,b) is often called obligatory control, as the controller can c-command the controllee. Control in (11c) is called non-obligatory control and there need be no c-command relation between the controller and the controllee. This is especially clear when the antecedent *Nicole* in (11c) is in the modifier position of a noun phrase, which relegates it unable to c-command the gap in the clausal subject. Non-obligatory control may allow an 'arbitrary'

interpretation, with no controller explicitly present in the sentence (e.g., [*PRO Eating spicy food*] *is fun.*). (See Section 2.4 for the meaning of an arbitrary interpretation.) Note that the filler-gap dependencies in all of the control constructions in (11) are gap-driven: it is the gap that first signals the presence of a filler-gap relation in the sentence.⁴³

Most previous sentence processing studies of the control construction investigated control into a complement clause in object position. The present study investigates control in both subject and object clauses. However, since it appears that no previous study has investigated the processing of controlled empty categories within a clausal subject, the following review of the literature mainly focuses on the processing of control into clausal objects.

A few processing studies on PRO have already been discussed in section 3.1.2. The focus there was on studies that compared antecedent reactivation of PRO with other types of gap. Antecedent reactivation was found for gaps of all types but there was conflicting evidence about the strength and time course of the reactivation. The present section is directed toward processing studies that exclusively investigated PRO and take a deeper look at how the control relation is constructed on-line by the parser. Section 3.2.1 examines what strategies the parser uses in finding an antecedent for PRO on-line. Section 3.2.2 discusses studies that investigated the use of lexical and plausibility information in PRO resolution. Section 3.2.3 considers PRO in discourse, and the use of discourse information in its interpretation.

⁴³ Strictly speaking, not all control constructions contain a gap-driven filler-gap dependency. Type (11a) is not gap-driven if the matrix verb can select *only* a controlled complement clause; in that case, the matrix subject is recognizable as a filler when the matrix verb is processed. Relatively few control verbs, however, have no other selection possibilities (e.g., even *try* can take a direct object NP in an example like *She tried the octopus soup*).

Most of the studies discussed below investigated control in English; a recent few were on Spanish. Almost none of them examined Chinese, except for a recent one (Zhai & Sakamoto, 2007) that investigated PRO interpretation by Chinese speaking children. Even though most studies considered control processing in languages other than Chinese, their findings are still valuable to the present study of Chinese, because control constructions in English and Chinese are similar in structure, and the factors that affect gap interpretation on-line in both languages also appear to be analogous. The conclusion of each subsection below will highlight the findings most relevant to the present study.

3.2.1 The Most Recent Filler Strategy

Given that filler-gap processing in control constructions is gap-driven, the choice that the parser faces is which noun phrase in the sentence is the antecedent of the gap it has detected. There are various potential strategies for locating the antecedent, which can be divided into strategies that treat the input sentence as a linear string of words, which would tend to favor a linearly recent antecedent, and strategies that consult the competence grammar to identify legitimate structural positions for the antecedent. Of course the rules of the grammar must ultimately dominate the decision, but in cases of temporary ambiguity the parser may first opt for some simpler choice strategy and then later reanalyze if necessary. To investigate this issue, an experiment needs to present participants with temporarily ambiguous sentences with competition between two (or more) noun phrases that the parser might select on-line as antecedent for the gap. If one is favored while the other results in a garden path, that can reveal the parser's preferred strategy.

Frazier, Clifton and Randall (1983) conducted an experiment with this design. Their experimental sentences, illustrated in (12), contained a relative clause, such as *the teacher wanted to talk to* in (12a). The gap in a relative clause is a *wh*-trace, whose location typically exhibits some on-line ambiguity (see section 3.1.1 above). In (12a), for example, the *wh*-trace is sentence-final, following the preposition, while in (12b) it is between *want* and *to*, yet these sentences are indistinguishable on-line until the very end.

- (12) a. This is the girl the teacher wanted _____ to talk to _____.
- b. This is the girl the teacher wanted _____ to talk.
- c. This is the girl the teacher decided _____ to talk to _____.
- d. This is the girl the teacher forced _____ to talk.

In particular, at the gap position between *want* and *to*, it is impossible to tell on-line whether the gap is the *wh*-trace or not. If it is not, then it must be a controlled PRO. Thus, the potential antecedents for the sentence-medial gap in (12a/b) on-line would be *the girl*, which would be antecedent of *wh*-trace,⁴⁴ or *the teacher*, which would be the controller of PRO. Examples (12c,d) are unambiguous counterparts to (12a,b); the matrix verb *decided* permits only PRO in the sentence-medial gap, while the matrix verb *forced* requires a *wh*-trace there. This is because *decide* has a subject but no object when it is followed by a complement clause, so there is no object position after *decide* for a *wh*-trace to occupy;

⁴⁴ Strictly speaking, the antecedent of the *wh*-trace is the relativizer, for example, *who*, which is not phonologically realized in (12), and the relativizer is co-indexed with the relativized nominal, *the girl* in (12). But since the relativizer and the relativized nominal share the same reference, the relativized nominal is like the antecedent of the trace.

on the other hand, *force* obligatorily has a direct object preceding its complement clause, and since there is no overt object in (12d) it must be the *wh*-trace. (Following Frazier et al.'s exposition, the gap positions in (12) are marked by underscores, leaving the properties of the empty category undesignated.) It will become important to the discussion below that in (12d) the *wh*-trace must control PRO in the subordinate clause, so that there are two adjacent empty categories in (12d).⁴⁵ In the meantime, however, discussion here will be restricted to *overt* noun phrases as potential antecedents, following Frazier et al.

Note that in all versions of (12), *the girl* precedes *the teacher* in the word string. Frazier et al. hypothesized that the parser abides by a Most Recent Filler Strategy, which favors the linearly closest antecedent for the gap. If this is correct, then the parser should favor *the teacher* to fill the ambiguous medial gap in both (12a,b), and the (12a) construction should be easier to process than the (12b) construction because the latter, but not the former, would eventually need a structural reanalysis. Alternatively the parser might give priority to *the girl*, since that already have been recognized as a filler on-line; the grammar demands that the head of a relative clause construction be associated with a *wh*-trace within the relative clause. In that case the (12b) construction should be easier to process than the (12a) construction. Versions (12c,d) with unambiguous verbs can yield information about the timing of the parser's decisions. If the parser can quickly make use of the unambiguous lexical information in (12c,d), no ambiguity of gap interpretation should arise in the processing. If it cannot, then (12c,d) are as ambiguous as (12a,b) in terms of gap interpretation and should show a similar distribution of parsing difficulty.

⁴⁵ The same must be true of (12b), even though the argument structure of *want* is not lexically unambiguous, as the argument structure of *force* is. See discussion below.

Frazier et al. used the “got it” judgment task. Sentences were presented one word at a time on a screen, experimenter-paced at 300 ms per word. Participants indicated at the end of the sentence whether they had grasped its meaning and were ready to answer a comprehension question. The results showed that verb type did not significantly affect the “got-it” rate or reaction times, even for the unambiguous (c,d) versions, but the distance of the filler did show a reliable effect. Sentences which ended in such a way that a recent filler (*the teacher*) was correct for the sentence-medial gap position, such as (12a,c), were understood faster than those for which a distant filler (*the girl*) proved to be correct, such as (12b,d). The findings thus yielded two important conclusions: that verb control information is not used rapidly enough to resolve ambiguity at the gap position, and that the parser follows the Most Recent Filler Strategy on-line when a gap position has been identified.

However, subsequent discussions of this experiment observed that, according to standard GB theory, the more difficult (b,d) sentence versions actually contain two consecutive gaps, as shown in (12).

(12) e. This is the girl_i the teacher wanted/forced e_i PRO_i to talk.

As noted by Crain and Fodor (1985), the first of the two consecutive gaps is the *wh*-trace direct object of the matrix verb, whose antecedent must be the distant filler, *the girl*. The second gap is PRO, and since (12) is an object-control construction, the antecedent of PRO must be the direct object of the matrix clause, which in (12) happens to be the *wh*-

trace. Since the filler of the *wh*-trace is *the girl*, the net result is that the PRO must be interpreted as referring to the girl, though *the girl* is further away than *the teacher*.

What is important about this linguistic analysis is that the differential costs of processing the (b,d) versions, as revealed by Frazier et al.'s experimental data, could very well be due to the extra effort needed to construct two empty categories in quick succession in those versions, and associate one as the filler for the other. If so, the experiment would not offer support for the hypothesized Most Recent Filler strategy. Noting the presence of double gaps in some test items in their first experiment, Frazier et al. conducted a second experiment identical to the first except that it compared ambiguous verbs that are commonly analyzed as being followed by one gap (e.g. *want* and *expect*) with those commonly analyzed as being followed by two gaps (e.g. *ask* and *choose*). It could be expected that participants would assign only PRO at the ambiguous gap position, whereas sentences with the latter verb type would be perceived as containing an object *wh*-trace as well as PRO. The results showed Recent filler sentences were comprehended significantly faster than Distant Filler sentences and this result held for each individual verb. On the other hand, the double-gap verbs *ask* and *choose* showed a marginally larger difference in reaction time between Recent and Distant Filler sentences than the single-gap verbs *want* and *expect*. This suggests that sentences with double gaps might have a higher processing cost than sentences with one gap, but the increased cost is far lower than that incurred by a distant filler. Frazier et al. then concluded that 'there is no evidence to support the hypothesis that some, or all, of the effect of Recent versus Distant Filler sentences is due to the requirement of filling two gaps rather than one in some Distant Filler sentences' (p. 210).

Clifton and Frazier (1986) heeded the criticisms of Crain and Fodor (1985) by eliminating verbs used in their experiments that could allow a reduced relative clause reading. (For example, in (12d) above, ...*the teacher forced*... could be read as ...*the teacher who was forced*..., so that the sentence no longer has any bearing on testing the Most Recent Filler strategy.) In their first experiment, Clifton and Frazier presented the sentences word-by-word at two rates: 350 ms and 550ms per word. Participants made an “understood it” response at the end of the sentence. Half of the test sentences were relative clause constructions similar to those of (12), and the other half were *wh*-questions (from Crain & Fodor, 1985), as shown in (13).

(13) a. Who_i could the little child_j have begged / started *e_j* to sing those stupid French songs for *e_i* last Christmas?

b. Who_i could the little child_j have begged / forced *e_j e_i* to sing those stupid French songs for Cheryl last Christmas?

The sentences in (13) contain either an ambiguous or unambiguous verb. The ambiguity refers to the obligatory or optional presence/absence of an object in the matrix clause. The verb *beg* is an ambiguous verb; its object complement is optional. The verbs *start* and *force* are unambiguous verbs; for the former, an object must be absent, while for the latter, it must be present. Thus on encountering a gap of *beg* the parser has a choice about how to fill it, but a gap that follows *start* and *force* must be filled by the matrix subject and the *wh*-word respectively. This experiment replicated the findings of Frazier, Clifton and Randall (1983). There was a marginal effect of verb type: the ambiguous verbs triggered slower reactions times than the unambiguous verbs. On the other hand, the

difference in the reaction times between recent and distant filler sentences was significant, with the recent filler sentences being understood significantly faster than the distant filler sentences. Finally, the presentation speed had no significant effect, which suggested that even a quite slow reading mode (550 ms per word) still could not encourage readers to consult verb control information at the earliest phase of real-time processing. These results therefore appear to support the claim that, in looking for a filler for an identified gap, the parser uses strategies defined over word strings, rather than based on competence grammar. However, in making their case for that conclusion, Clifton and Frazier do present the parser as drawing on quite sophisticated aspects of the competence grammar including subcategorization information, the case filter, and trace-binding principles (p. 213). This throws some doubt on the likelihood that the parser specifically ignores control information.

Osterhout and Nicol (1988) (discussed in Nicol & Swinney (1989))⁴⁶ conducted a cross-modal priming experiment to investigate the time course of using verb control information on-line. The experimental sentences are like those in (14). The matrix clause in (14a) is in the active voice, and that in (14b) is in the passive voice. This was meant to create variation in the linear position of the correct antecedent. Five probe points were employed, which were intended to detect when the antecedent is reactivated after PRO is identified. The reactivation of the correct antecedent regardless of its distance from PRO suggests verb control information is already used at that point of processing to resolve the reference of PRO.

⁴⁶ Section 3.1.3 reviewed a few studies reported in Nicol and Swinney, but in the context of comparing the time course of *wh*-gap and NP-gap reactivation. The study by Osterhout and Nicol discussed here considered the processing of PRO.

(14) a. The actress invited the dentist_i from the new medical center PRO_i to ¹ go to the pa²rty at the ³ mayor's ⁴ house ⁵.

b. The actress_i was invited *e_i* by the dentist from the new medical center PRO_i to ¹ go to the pa²rty at the ³ mayor's ⁴ house ⁵.

The results showed no reactivation of either *actress* or *dentist* at the first two probes. But at the third probe (1000 milliseconds after PRO), *dentist* was reactivated for both (14a) and (14b), even though it was not the proper antecedent for PRO in the latter. *Dentist* remained activated throughout the last two probes in (14a), but in (14b) *actress* became activated at the fourth probe and remained so at the fifth, concomitant with the declining activation level of *dentist*. These findings indicated that PRO triggered reactivation of all the potential antecedents in a right-to-left fashion, i.e., antecedent-search was recency-driven. In (14a), *dentist*, the closest potential antecedent for the gap, was reactivated before *actress*, which was further back in the sentence. This reactivation pattern was also found in (14b) in the first two probes though *dentist* was not the true controller of PRO in (14b). These findings seem to imply that there is delay in the reactivation of potential antecedents, regardless of whether the reactivated element is the correct or incorrect antecedent. Also, the initial interpretation of PRO is guided by a string-based strategy. A grammar-guided strategy is employed later, as shown in the reactivation of the correct antecedent for PRO at the last two probes in (14b).

It should be noted that there is a passive trace in (14b) but it is not in the critical area of the sentence (unlike the *wh*-trace in the experiments by Clifton & Frazier, 1986, and Frazier, Clifton, & Randall, 1983; see above). Osterhout and Nicol's study also yielded clearer outcomes in another respect. In the studies by Frazier and colleagues,

there were two potential fillers in a sentence which had different syntactic properties: the *wh*-filler is a thematically unassigned argument residing in a non-argument position while the PRO-filler is a thematically assigned argument residing in an argument position.

Thus, the competition between these two types of fillers may not be related to distance from the gap: maybe the recent filler is preferred because thematically assigned arguments are preferred over thematically unassigned arguments. In Osterhout and Nicol's study, by contrast, the two potential fillers for the PRO gap are both thematically assigned arguments. This permits a more controlled investigation into the recency factor. Thus, Osterhout and Nicol's study has provided evidence to clarify that it is not the thematic or syntactic status of a potential antecedent that affects the on-line selection of antecedents for a gap. Instead, it does appear to be the linear distance factor that matters.

The verb-final language provides a different way to study on-line PRO interpretation and the recency factor. In a verb-final language, the controller can remain ambiguous for some time after a PRO gap in an object complement clause is encountered. Japanese is one such language whose verb-final property allows local ambiguity to prevail until the matrix verb appears at the end of the sentence, by which time the parser has encountered the gap and all the candidate fillers. For example, the basic word order of a subject control construction in Japanese can be: NP-NOM NP-DAT [PRO Verb] Verb, where the matrix verb at the end of the sentence imparts the information about which argument in the matrix clause is the controller for the PRO gap in the subordinate clause. Thus, in these languages, the Most Recent Filler Strategy can be reformulated as the preference for subject or object control. In the case of Japanese, the object most often follows the subject in surface word order, so a preference for object

control over subject control would constitute evidence to support the Most Recent Filler Strategy. On the other hand, the object can be scrambled to the beginning of the sentence, in which case, it precedes the subject. The Most Recent Filler Strategy would then prescribe a preference for subject control. Thus, the flexibility in the order of the recent and distant filler in Japanese offers a useful testing ground for the Most Recent Filler Strategy.

In investigating whether there is a preference for subject or object control in Japanese, Sakamoto (2001) obtained conflicting results. He reported the results of four experiments with materials like (15); the first two experiments involved a recognition task and the second two involved a retrieval task. The sentences in (15) differ only in the matrix verb, which occurs at sentence-final position. The matrix verb dictates the antecedent assignment for the subject gap in the subordinate clause: the subject control verb *moosideta* designates Kooiti (a male name) as the antecedent, and the object control verb *saisokusita* designates Tamae (a female name) as the antecedent. But this information that is crucial to how the gap is filled is not available until the gap and all of its potential antecedents have been parsed, giving an opportunity for a performance strategy to be employed in the meantime.

(15) a. Subject-Control Sentence

Kooiti-ga kaisya-de Tamae-ni [Tokyo iki-o] wazato moosideta.
 -NOM company-at -Dat going-Acc purposely offered
 ‘Kooiti, at the company, purposely offered Tamae that **he** would go to
 Tokyo.’

b. Object-Control Sentence

Kooiti-ga kaisya-de Tamae-ni [Tokyo iki-o] wazato saisokusita.
 -NOM company-at -Dat going-Acc purposely urged
 ‘Kooiti, at the company, purposely urged Tamae that **she** would go to
 Tokyo.’

In both tasks, the participants listened to the sentences spoken with normal intonation and pauses. The recognition task solicited from the participants a yes/no answer to questions concerning the agent of the embedded clause (e.g., *Kooiti* Yes/No). The retrieval task required the participants say the agent of the embedded event (e.g., *Who is supposed to go to Tokyo?*) orally at the end of each experimental item. The data from the recognition experiments supported a preference for subject control but those from the retrieval experiments supported a preference for object control. Sakamoto attributed these conflicting results mainly to the nature of the task, arguing that the parser used different types of information to resolve a filler-gap dependency in the two tasks. It can be noted also that the final verb in these materials is not lexically matched across the versions, which may add a confounding factor since it immediately precedes the participants’ response. One could try to avoid this problem by using the same verb in both versions and scrambling the order of the two potential fillers (as Sakamoto did in two of the experiments). However, in that case, there is another complication because there is an asymmetry between the two fillers, given a standard analysis of scrambling as movement of the object. Thus difficult design problems arise in this area, making it difficult to test the Most Recent Filler Hypothesis where everything except sheer distance between antecedent and gap has been controlled out.

Witzel and Witzel (2007) employed region-by-region self-paced reading to further investigate controller preference in Japanese. Moreover, they compared the interpretation of PRO with the interpretation of an overt pronominal disambiguated by the gender of the antecedents (*karejisin* ‘himself’ and *kanojojisin* ‘herself’) in the same context, thus providing a baseline. Examples of their materials are shown in (16).

(16) a. Subject Control sentence

Daisuke-ga (male) Kyoko-ni (female) kuruma-o koonyuusuru koto-o
 Daisuke-nom Kyoko-dat car-acc purchase do fact-acc
 kyutoositsu-de jimansita yoo desu.

office kitchen in showed off seems

‘It seems like Daisuke showed off to Kyoko in the office kitchen that he is purchasing a car.’

b. Object Control sentence

Daisuke-ga (male) Kyoko-ni (female) kuruma-o koonyuusuru koto-o
 Daisuke-nom Kyoko-dat car-acc purchase do fact-acc
 kyutoositsu-de saisokusita yoo desu.

office kitchen in urged seems

‘It seems like Daisuke urged Kyoko in the office kitchen (for her) to purchase a car.’

They found an Object Control bias: subject control sentences were harder to process at the critical control verb region (i.e., *jimansita* ‘showed off’ and *saisokusita* ‘urged’) than baseline sentences in which PRO was replaced by an overt pronominal, but no such effect was found for the object control sentences. Thus, the more recent filler, which in the test sentences is the dative object (e.g., *Kyoko*), seems to have processing

advantage over the more distant filler (e.g., *Daisuke*). This in turn supports a linear-based gap-filling strategy in on-line sentence processing.⁴⁷

Let us turn now to the small amount of data available on the processing of the control construction in Chinese. In a recent self-paced reading study, Zhai and Sakamoto (2007) investigated how Chinese-speaking children in first to fifth grade understood subject and object control sentences such as those shown in (17).

(17) a. Subject Control sentence

Dongdong₁ dui Dandan₂ fashi [(PRO_{1/2}) jintian
Dongdong (male) to Dandan (female) swear today
renzhen zuo zuoye].
seriously do homework
'Dongdong swore to Dandan that today he will do homework seriously.'

b. Object Control sentence

Dongdong₁ dui Dandan₂ zhufu shuo [(PRO_{1/2}) jintian
Dongdong (male) to Dandan (female) order today
renzhen zuo zuoye].
seriously do homework
'Dongdong ordered Dandan that today she will do homework seriously.'

Since the basic word order of Chinese is SVO, the matrix verb precedes the empty category in the subordinate clause, which means the information crucial to antecedent assignment is available when the gap is identified. As a result, the linear-based strategy would predict a temporary preference for object control, while the grammar-based

⁴⁷ The researchers suggested that there could be language-specific reasons for this object control preference in Japanese, for example: the relative frequency of subject/object control sentences, or their semantic and/or syntactic structure, in addition to or instead of an effect of the linear position of their constituents as advocated by the Most Recent Filler Strategy.

strategy would predict the rapid use of verb control information in establishing the filler-gap dependency.

The answers to post-sentence questions showed that, regardless of the matrix verb type, the first and second graders were significantly more likely to adopt the recent filler (i.e., the object) than the fourth and fifth graders were. (The fifth graders identified the correct filler 75% of the time in both the subject control and object control sentences.) This finding implies that the Most Recent Filler Strategy may be active in early stages of language development. Since its role declines with age, it may be merely a stop-gap until the child has developed a secure grasp of the grammar of the language in applying it on-line. If this is the correct interpretation of the age-related data, it does provide some psycholinguistic support for the Most Recent Filler Strategy, but not support for its use in normal adult processing as Frazier et al. (1983) hypothesized.

To conclude, this section has surveyed the available experimental data on on-line antecedent choice for a subject gap in a non-finite object complement clause. When a gap is identified in a complement clause, the verb control information that helps select its antecedent may or may not be available. The SVO word order of English and Chinese entails that this information is available, but the SOV word order of Japanese entails the unavailability of this information. A general strategy, such as the Most Recent Filler Strategy, may be required if the crucial verb information is absent and if the parser is under pressure to try to establish a filler-gap dependency promptly. On the other hand, if the crucial verb information is available, it could be used quickly on-line for antecedent assignment (unless hampered by performance limitations of some kind).

Most studies discussed in this subsection have yielded evidence that appears to support the Most Recent Filler Strategy. Use of the Most Recent Filler strategy is in competition with the immediate use of verb control information, at least in VO languages like English where verb information is available when a controlled gap is identified; therefore, use of the Most Recent Filler strategy implies that verb control information cannot be accessed promptly enough to be used in antecedent assignment on-line. Thus, experimental evidence for the Most Recent Filler strategy and experimental evidence for the delayed use of verb control information in resolving a gap tend to go hand in hand, and support each other. However, a few problems with the design or outcomes of the earlier studies have been noted.

First, creating an ambiguity which combines a trace and a PRO may add complication to the investigation of the control construction and the role of recency in interpreting PRO. Second, there could be different language-specific parsing strategies for a controlled gap. The Most Recent Filler Strategy may work in different fashions or to different degrees in different languages. The matrix verb, which determines which noun phrase is the controller, follows the gap in Japanese, unlike the matrix verb in English. This late appearance of control information in Japanese could force the parser to rely on some very general parsing heuristic until more specific grammatical information is encountered. Given that a grammar-independent strategy is needed, the Most Recent Filler Strategy is a very natural one to adopt. It could be more controversial, though, whether such a strategy is adopted in real-time parsing of English sentences. Third, in Clifton and Frazier's (1986) clarification of their model, it is stated that for an object control sentence with the matrix object extracted by *wh*-movement, the parser correctly

assigns the *wh*-filler to the matrix object gap (on the basis of the case filter and trace binding principles) and then uses “the most recent NP in the sentence that has not already been taken as an antecedent” (p. 213) to fill the PRO gap in the clausal object; the only remaining filler is the subject of the matrix clause.⁴⁸ This means that the Most Recent Filler Strategy does not need to be invoked at all, to explain the hypothesized incorrect filler assignment for the PRO. Fourth, even if the Most Recent Filler Strategy *were* invoked at this point in the explanation, it would be necessary to assume that the Most Recent Filler strategy operates only over overt NPs. This is because the correct filler for PRO in (12e) is indeed the empty category that is closest to it, i.e., the phonologically null *wh*-trace, which is the noun phrase that most closely precedes the PRO. Hence the Most Recent Filler Strategy predicts that the processing of such examples should be easy if the strategy is sensitive to all potential fillers, both overt and null. Thus, if the Most Recent Filler Strategy is to explain the parser’s antecedent preferences, it would have to apply only to overt but not covert fillers. This would make it a very superficial strategy, out of touch with the competence grammar. Even more important is that this heuristic could not in principle deliver the correct analysis for *any* sentence type in which one filler-gap dependency is chained with another even one which appears to be easy to comprehend (e.g., *Which girl e has been forced e e to smile?*). Finally, it is still unknown whether the Most Recent Filler Strategy serves the parser as a useful heuristic or is merely a side effect of limited capacity of the working memory. The fact that, as shown in Zhai and Sakamoto (2007), younger children are more likely to rely on it in selecting a filler suggests it may be a strategy used only by people whose processing capacity is

⁴⁸ Note the surprising prediction that a sentence such as *This is the girl the teacher forced to talk* is preferentially interpreted on-line as meaning that the teacher forced the girl to permit the teacher to talk.

limited due, for example, to less sophisticated language skills or reduced working memory. Thus, it may be not so much a general parsing principle, but instead a practical compensation for a cognitive deficit in real time sentence processing. The second experiment that I report in the next chapter provides evidence for prompt on-line use of control information in the processing of Chinese.

3.2.2 Use of lexical and pragmatic information in interpreting control constructions

Tanenhaus, Boland, Garnsey, and Carlson (1989), and Boland, Tanenhaus, and Garnsey (1990) argue against the validity of the Most Recent Filler Strategy, and propose alternative strategies that the parser could use in interpreting the gaps in control constructions. This research team conducted a series of experiments using whole-sentence and self-paced word-by-word reading to study the use of lexical knowledge in processing a controlled gap. The data indicates the immediate use of not only verb control information, but also verb transitivity and plausibility information. Because the control construction is the focus of the present study, only their experiments relevant to PRO interpretation will be discussed here.

In one experiment, Tanenhaus et al. (1989) employed sentences with verbs that clearly exert either subject or object control, such as those in (18), to examine the time course of using verb control information. *Wh*-questions, containing a *wh*-filler and its trace, as in (18a), were compared with matched declarative sentences with no *wh*-filler-gap dependency, as in (18b).

(18) a. Which frog / snake did the girl force to hop past the rock?

b. The girl forced the frog / snake to hop past the rock.

Since only frogs but not snakes can hop, both (18a,b) have one plausible reading (with *frog*) and one implausible reading (with *snake*). In (18a), if the parser mechanically applied the Most Recent Filler strategy online, it would first choose *the girl* as the filler for the subject gap in the object complement clause. In that case, the use of *frog* or *snake* in the matrix clause should make little difference in the reading times. However, if the filler-gap relations are being correctly computed by the parser on-line, the *frog* version of (18a) should be easier to process at the gap position than the *snake* version; it is predicted that, just as (18b), the use of *snake* in (18a) would make the sentence immediately recognizable as semantically anomalous when the parser encounters the verb *hop*. Thus, a comparison of the reading times at critical loci in the sentences in (18) can be informative of the role of plausibility as well as competence grammar facts in gap resolution.

The experimental protocol employed the “stop making sense” task, a variant of the self-paced word-by-word reading paradigm, which required the participants to signal if they encountered a word where the sentence started not to make sense. The results showed that the difference in reading times and in sensibleness judgments between the plausible and implausible readings were similar between the *wh*-question in the (a) version and the baseline declarative (b) version. In both the (a) and (b) versions the semantic anomaly of *snake* was detected starting from the verb *hop*,⁴⁹ which was also

⁴⁹ In fact, the anomaly of the *wh*-sentences was detected one word sooner than the anomaly of the non-*wh*-sentences. The stop-making sense judgments for the former type of sentences began to rise significantly at the subordinate verb, while those for the latter type of sentence started at the word right after the subordinate verb.

where the reading times started to increase significantly for the implausible readings. This implies that *frog/snake* was assigned as the interpretation of the PRO subject of the complement clause, both in the (b) version where only simple control is involved, and also in the (a) version where assignment of *frog/snake* to PRO presupposes that it has already been assigned to the *wh*-trace object of *force*. It was therefore concluded that verb control information is used rapidly to interpret a gap in real-time processing.

The experimental design of Boland et al. (1990) was similar to that of Tanenhaus et al. except that in their second experiment, Boland et al. manipulated verb type (subject control vs. object control) in much the same fashion as Frazier et al. (1983) had done, as well as manipulating filler plausibility (the plausibility/implausibility of the *wh*-phrase as subject of the subordinate verb) as in the Tanenhaus et al. experiment just described. The experimental sentences are illustrated in (19), with (19a,c) being the object control sentences, and (19b,d) being the subject control sentences, as indicated by the subscripted indices. The implausible sentence is (19a) in which *horse* is the filler for the PRO subject of *surrender*, because a horse does not have volition to surrender, unlike the outlaw in version (19c). Versions (19b,d) have the subject-control verb *refuse*, so they have *the cowboy* as a plausible antecedent for the PRO in the subordinate clause.

- (19) a. Which horse_i did the cowboy signal _____i _____i to surrender to the authorities?
- b. Which horse_i did the cowboy_j refuse _____j to surrender _____i to the authorities?

- c. Which outlaw_i did the cowboy signal _____i _____i to surrender to the authorities?
- d. Which outlaw_i did the cowboy_j refuse _____j to surrender _____i to the authorities?

Boland et al. found an effect of filler plausibility and an effect of verb type at the subordinate verb (*surrender* in (19)) and the word immediately following it. The implausible sentence with object control (19a) triggered more ‘stop-making-sense’ judgments starting from *surrender*, than the other three sentences, and incurred longer reading times at the second *to*. This indicates that verb control information is used rapidly to resolve the reference of the gaps, resulting in early detection of implausibility in (19a). In addition, slower reading times were found at the final two words in *both* object control sentences (19a,c), relative to the subject control sentences (19b,d). This suggests that ‘object control sentences may be more difficult than subject control sentences, although the difficulty arises late, after the subject gap has been correctly associated with the filler’ (p.427). Overall, these findings support the rapid use of both plausibility and verb control information in pairing up fillers with control gaps (as well as accurate use of grammatical principles in assigning fillers to *wh*-gaps). The use of plausibility information was the source of rapid recognition of the implausibility of (19a). The rapid use of verb control information differentiated the subject-control and object-control verbs, blocking the implausible reading of *which horse* as the subject of *surrender* in (19b), resulting in similar stop-making-sense judgments and reading times for (19b) as for the fully plausible (19c,d).

If the control relation had been resolved long before the final two words, why did that location show a significant difference in the reading times between the subject-control and object-control verb conditions? One tentative explanation offered by Boland et al. is the difficulty of constructing the event structure for the object control sentence. In a subject control sentence, the ‘doer’ is the same for the matrix clause and the infinitival complement. This, however, is not the case for an object control sentence, where the object, being the theme or patient in the matrix sentence, becomes the agent of the embedded clause. Hence the semantic complexity of the object control construction may lead to a reading slowdown of the sentence, in comparison to its subject control counterpart. However, Boland et al. (1990) pointed out that the longer reading times found at the end of the object control sentences over the subject control sentences were not a good basis for precise estimates of the difference in reading patterns between subject and object control constructions, because the last few words of these two types of sentences were not exactly matched for all the test items (even though those words in the example sentence (19) are the same for the four versions). Note that whole-sentence reading times, or post-sentence judgment data, would not have discriminated in this way between local gap-filling difficulty and global difficulty of semantic interpretation.

Spanish has also been studied in recent years as the target language for some studies on antecedent assignment to PRO in control constructions. These studies have often utilized research methods other than self-paced reading in their investigation and have thus contributed novel data to the understanding of these issues.

Demestre, Meltzer, García-Albea, and Vigil (1999) recorded ERPs in a study of the effect of gender agreement violations in controlled infinitival complements, as

illustrated in (20). Detection of the violations at some point of processing would indicate that the parser has established the correct coreference relation between the null subject and its antecedent at that point.

- (20) a. Pedro_i quiere PRO_i ser **rico**(masc) en un futuro próximo.
 ‘Peter wants PRO to be rich in the near future.’
- b. *María_i quiere PRO_i ser **rico**(masc) en un futuro próximo.
- c. Pedro_i ha aconsejado a María_i PRO_i ser **educada**(fem) con los trabajadores.
 ‘Peter has advised Mary PRO to be more polite with the employees.’
- d. *María_i ha aconsejado a Pedro_i PRO_i ser **educada**(fem) con los trabajadores.

Adjectives in Spanish agree in gender with the nominals they modify. The adjective *rico* in (20a) modifies the subject of the subordinate clause, which is PRO. Since *quiere* ‘want’ is a subject control verb, the PRO is coreferential with *Pedro*, a masculine name. Hence masculine *rico* is correct in (20a), but it is incorrect in (20b) where the controller of PRO is feminine *Maria*. Similar considerations apply in (20c,d) except that the matrix verb *aconsejar* is an object control verb that requires the matrix object to be the controller of the PRO. The adjective *educada* must agree with PRO, which must agree with the object of the matrix clause. So *educada*, which is feminine, is correct in (20c) where it agrees with the matrix object *María*, but is incorrect in (20d) where it does not agree with the matrix object *Pedro*. If control information is consulted rapidly, the parser should be

able to detect the mismatches in (20b) and (20d), and the consequent disruption of processing may be revealed in voltage changes measurable at scalp locations in an ERP study.

Participants listened to sentences like those in (20) spoken at a normal speaking rate and made a post-sentence acceptability judgment. The results showed a biphasic ERP pattern at the disagreeing adjectives, with an early negativity, distributed over frontal and central sites, starting at 150ms and peaking at 200ms, followed by a positivity, widely distributed over central and posterior regions of both hemispheres and extending from 250 ms to 500ms. A significant main effect of grammaticality was found in the statistical analysis of data in the two time windows, which the researchers construed as showing that the interpretation of PRO is both rapid and involves syntactic processing.

Betancort, Meseguer, and Carreiras (2004) made use of plausibility in an eye-tracking study to investigate gender mismatch effects for Spanish adjectives in the processing of the control construction. They manipulated these two factors in the test sentences, as shown in (21).

(21) a. Object-Plausibility-Matched

La abogada(fem.) oyó al juez(masc.) [PRO] sentenciando

The lawyer heard the judge sentencing

muy seguro(masc.) al acusado de homicidio.

very confident to the accused of homicide.

‘The (female) lawyer heard the (male) judge sentencing the defendant of homicide very confidently(masc agreement).’

b. Subject-Plausibility-Matched

El juez(masc.) oyó a la abogada(fem.) [PRO] sentenciando

The judge heard to the lawyer sentencing

muy seguro(masc.) al acusado de homicidio.

very confident to the accused of homicide.

‘The (male) judge heard the (female) lawyer sentencing the (male) defendant of homicide very confidently(masc agreement).’

c. Object-Plausibility-Mismatched

La abogada(fem.) oyó al juez(masc.) [PRO] sentenciando

The lawyer heard to the judge sentencing

muy segura(fem.) al acusado de homicidio.

very confident to the accused of homicide.

‘The (female) lawyer heard the (male) judge sentencing the defendant of homicide very confidently(fem agreement).’

d. Subject-Plausibility-Mismatched

El juez(masc.) oyó a la abogada(fem.) [PRO] sentenciando

The judge heard to the lawyer sentencing

muy segura(fem.) al acusado de homicidio.

very confident to the accused of homicide.

‘The (male) judge heard the (female) lawyer sentencing the defendant of homicide very confidently(fem agreement).’

Oyó is a perception verb that does not dictate either subject or object control. But the judge is the more plausible person to sentence an accused person. Thus, plausibility dictates that the sentences in (21a,c) are object control sentences, and those in (21b,d) are subject control sentences. However, in (21c,d) the gender features of the adjectives in the complement clause do not match with those of the more plausible subject.

Results of the eye-tracking experiment showed a significant plausibility effect in first-pass reading times in the PRO-verb region (e.g., *sentenciando*), which is the first point at which the plausibility of a potential controller could be assessed on-line. Sentences with a plausible antecedent in the distant position (i.e. the matrix subject position) were read slower than sentences with a plausible antecedent in the recent position (i.e. the matrix object position). The object control advantage was also found in the AdjP (an adverb in the English translation) region (e.g., *muy segura*) of the matched sentences in total time and in the PP region (e.g., *al acusado de homicidio*) of the matched sentences in regression-path time. Despite this, recency did not seem to dictate antecedent assignment for PRO. Instead, plausibility appeared to ultimately control PRO interpretation. This was evidenced in a gender mismatch effect found in the total reading times in the PRO-verb region. Readers took more time to read the gender mismatched sentences than the gender matched sentences, indicating that the *correct* antecedent for PRO had been assigned when the agreeing adjective was encountered. The mismatch effect was also found in the PP region of the object plausibility sentences in regression-path time and total time, and in the AdjP region of the object plausibility sentences in total time. The implications of these results will be discussed later, together with results of the follow-up experiment. But clearly, these findings seem to imply that recency is initially adopted in filler search for the controlled gap, but plausibility, as revealed in the gender mismatch effects, dictates the ultimate filler assignment.

However, a preference for object control does not unequivocally support a recency preference; it might be a grammatical role preference. To untangle this, it would be helpful if an additional experiment on Spanish could be run with materials like (21)

with a gerundive verb, but with a manipulation of word order such that in one case the main clause subject precedes the main clause object, as in (21), and in a contrasting case the main clause object precedes the main clause subject, as in materials like (22) used in the second experiment. The latter word order would render the object phrase the distant filler. This design would permit a comparison of recency versus grammatical role. If recency rules, subject bias should be found in this study; if object bias persists, it indicates that distance per se does not drive PRO assignment on-line.

A follow-up eye-tracking study was conducted employing materials with infinitival verbs in place of gerunds. Because of this change in verbal morphology, these sentences are not ambiguous with respect to the controller of PRO, once the subordinate verb has been processed. (The disambiguation by the subordinate verb does not rely on pragmatics, unlike the examples in (21).) Spanish grammar dictates that in an infinitival complement, only the direct object of the matrix verb (e.g., *al juez* in (22)) can be the subject of PRO. As a result, all fillers of PRO in the test sentences in this experiment were distant fillers. This removed the distance contrast between potential fillers, so that the investigation could focus on effects of plausibility and gender. In this study the positions of the two matrix NPs switched, so that all the sentences had an object-verb-subject word order. An example is shown in (22): *al juez* is the object in this example, despite its initial position, while *la abogada* is unambiguously the subject despite being post-verbal.

- (22) Al juez lo oyó la abogada [PRO] sentenciar
 To the judge (acc. masc.) him heard the lawyer (nom. fem.) to sentence
 muy seguro (masc.) al acusado de homicidio.
 very confident to the accused of homicide.
 ‘The (female) lawyer heard the (male) judge sentencing the defendant of
 homicide very confidently (masc agreement).’

Four versions of sentence were obtained by crossing the plausibility factor (e.g., judge versus lawyer as the more plausible person to do the sentencing) with the gender agreement factor (match and mismatch of the AdjP with the grammar-assigned filler). Note that the role of plausibility in this experiment was different from that in Betancort et al.’s first experiment. Plausibility in the first experiment provided a bias that could guide the parser in selecting a filler for the gap, which the grammar did not disambiguate; but in this experiment, the grammar dictated the filler and the plausibility manipulation merely made some sentence versions semantically more acceptable than others.

A gender mismatch effect was found in regression-path times and total reading times in the AdjP region (e.g., *muy seguro*), in total reading times in the PRO-verb (e.g., *sentenciar*) region, and in the regression-path times in the final PP region (e.g., *al acusado de homicidio*). Once again, the mismatched sentences were harder to process than the matched sentences, suggesting that PRO had been rapidly assigned the correct (object) controller on-line, and a mismatch in gender agreement features of PRO, which inherits the gender features from the controller, and the AdjP disturbed processing, as revealed in the various measures. Interestingly, the plausibility effect was apparently less robust than that in the first experiment; it was found only in some indirect measures. It was observed mainly in the probability of a first-pass fixation in the PRO-verb region,

with the plausible sentences being skipped in that region more often than the implausible sentences. A marginal plausibility effect was found in the PRO-verb region in total reading time. These results suggest a rapid selection of antecedent for PRO, which is guided by the grammar. In addition, once the grammar has chosen a controller, anomaly does not trigger reanalysis. Overall, the results of the two experiments appear to support a constraint satisfaction model, which predicts that grammar, plausibility, and recency all contribute as constraints on guiding antecedent assignment. But they do not all contribute equally. The data of the first experiment show both recency and plausibility affect PRO assignment on-line. The second experiment pitted the grammar against plausibility, and the former apparently dominates the latter. Hence, it appears that even though the parser consults an assortment of information in antecedent assignment, grammar is the dominating factor. If grammar does not favor one analysis over another, the parser will use other types of information on-line; in this case, recency and plausibility. Nevertheless, results of Experiment 1 show that by the time the adjective in the complement clause is encountered, plausibility, rather than recency, has dictated PRO assignment.

On the whole, the findings of these two experiments support the earlier finding of Demestre et al. (1999) that the parser is sensitive to gender agreement between PRO and its predicate in a control construction. This in turn suggests that the parser does not delay the antecedent assignment for PRO;⁵⁰ otherwise, the gender mismatch effect would not be so rapidly detectable.

⁵⁰ Despite the fact that the AdjP region in these experiments immediately followed the PRO-verb region, one might still argue that the gender mismatch effects were not detected immediately because there was at least a subordinate verb (e.g., *sentenciar*) that mediated between the gap and the agreeing adjective. Of

The range of contexts in which the parser encounters PRO was expanded in another eye-tracking study, by Betancort, Carreiras, and Acuña-Fariña (2006), who tested examples with PRO in complement and adjunct clauses. Their first experiment retested subject and object control in complement clauses. The findings essentially replicated those of the previous studies described above, with respect to immediate use of verb control information and the recency effect. In their second experiment, the sentences contained non-finite adverbial clauses headed by one of two prepositions: *para* ‘in order to’ (introducing a purpose clause that biases in favor of subject control), or *por* ‘because of’ (introducing a reason clause that biases in favor of object control). An example of the test sentences is shown in (23).

(23) a. Subject control bias (preposition “para”) match condition

Yolanda_i se casó con Jorge_j para [PRO1]_i tener dinero
 Yolanda_i(fem) married George_j(mas) in order to have money
 y [PRO2]_i ser heredera de una fortuna.
 and be the heir (fem) to a fortune
 ‘Yolanda married George in order to have money and inherit a fortune.’

b. Subject control bias (preposition “para”) mismatch condition

Yolanda_i se casó con Jorge_j para [PRO1]_i tener dinero
 Yolanda_i(fem) married George_j(mas) in order to have money
 y [PRO2]_i ser heredero de una fortuna.
 and be the heir (mas) to a fortune
 ‘Yolanda married George in order to (for him) have money and inherit a fortune.’

course, the mismatch effects were detected much earlier in these experiments than the antecedent reactivation of gaps in Bever and McElree’s studies (see section 3.1.2).

c. Object control bias (preposition “por”) match condition

Yolanda_i se casó con Jorge_j por [PRO1]_j tener dinero
 Yolanda_i(fem) married George_j(mas) because have money
 y [PRO2]_j ser heredero de una fortuna.
 and for being the heir (mas) to a fortune
 ‘Yolanda married George because he has/had money and he is/was the
 heir to a fortune.’

d. Object control bias (preposition “por”) mismatch condition

Yolanda_i se casó con Jorge_j por [PRO1]_j tener dinero
 Yolanda_i(fem) married George_j(mas) because have money
 y [PRO2]_j ser heredera de una fortuna.
 and for being the heir (fem) to a fortune
 ‘Yolanda married George because she has/had money and she is/was the
 heir to a fortune.’

Faster reading times were observed for the object-control *por*-clauses than for the subject-control *para*-clauses in the PRO1-infinitive region in regression-path time and in some regions in various late measures (e.g., total reading time and second pass time). A gender agreement effect was observed in the PP region (e.g., *de una fortuna*) in regression-path time and also in various late measures. These results suggest that recency initially favored object control, and that preposition control information in the grammar was only consulted later, in a reanalysis stage. Once again, the agreement effect suggests that the correct controller for the gap had been assigned by the time this region was being processed. These findings were taken to imply that recency information is used in the first pass; otherwise, an earlier use of lexical information should be able to suppress the object control advantage, especially in late measures. In the discussion, the researchers

maintain that in comparison to prepositions, control information carried by verbs may act as stronger lexical signposts (little ambiguity with respect to which nominal should be the controller) to guide the parser's interpretation of PRO. For prepositions, the lexical bias toward one or other controller is weaker, so linear distance between a potential antecedent and the gap guides early PRO interpretation in the adverbial clauses.

To sum up this subsection (3.2.2): Boland and colleagues, and Betancort and colleagues, have presented evidence, from English and Spanish respectively, that the interpretation of PRO is rapid and the parser makes prompt use of verb control information in addition to a preference for a plausible and/or recent controller. The finding of these studies and the others discussed in this section that control of PRO is computed rapidly in the course of on-line syntactic processing does not agree with earlier findings in probe recognition and cross-modal priming studies (see sections 3.1.2 and 3.1.3), whose data indicated a delayed PRO assignment. Another important outcome of the later studies is their evidence of the rapid use of recency and plausibility information, but *only* if the grammar doesn't determine the controller on-line. Together, these findings strongly suggest that the parser intends to use all available linguistic information, though it may be held back by the limits on the time and memory resources available on-line to access all that information. The performance limits may encourage the parser to quickly choose the most recent or the most plausible filler for a gap if and when more decisive grammatical information is not yet available.

3.2.3 Use of discourse information in interpreting control constructions

Studies that investigate gap interpretation in a control construction consider how the parser reaches beyond the bounds of the sentence to access information in the preceding discourse. The studies discussed in this section examined at what point in processing discourse information is used in guiding antecedent assignment for PRO.

Marslen-Wilson and Tyler (1987) employed a naming task to investigate contextual effects in English on the assignment of an antecedent to what they call a ‘zero anaphor,’ which is what I would classify as PRO. The PRO appeared in sentence-initial position, where it was contrasted with an overt pronoun and a proper name, as shown in (25) below. The target sentence was preceded by a context as in (24), which provides a set of potential referents for pro-forms in the target sentence that followed.

(24) As Philip was walking back from the shop he saw an old woman trip and fall flat on her face in the street. She seemed unable to get up again.

- (25) a. Philip ran towards...
 b. He ran towards...
 c. Running towards...

Versions (25a,b) are unambiguous with respect to who was running. The question of interest is how the empty category in (25c) is interpreted. Since the old woman is unable to get up, it would be impossible for her to run. Thus, the logical subject for the fragment in (25c) is *Philip*, the only other protagonist mentioned in the context; and the most probable person Philip is running towards is the old woman. Therefore, *her* would be an acceptable continuation for any of the fragments in (25); *him* would be an unacceptable continuation in all cases because it would violate Binding Principle B which would

prohibit it from being bound by the subject, i.e., from being coindexed with *Philip/he/PRO* (which is the only male referent in the context). It was predicted, therefore, that *him* would be perceived as a poor continuation not only of (25a,b) but also of (25c) *if* the parser can make use of the contextual information in (24) which excludes the old woman as the referent of PRO; otherwise there would be no preference between *him* and *her* in the case of (25c).

After the participants heard the background passage (24) and one of the fragments in (25), a word would appear on a computer screen which was a target for naming. In the case of (25) the probe word was either *her* or *him*, of which *her* was the appropriate probe but *him* was not. The results showed significant differences in the response times to the two types of probe. Participants took longer to respond to the inappropriate probes (e.g., *him*, in the case of (25)) compared to the appropriate probes, in all three conditions. Marslen-Wilson and Tyler concluded that the parser can make use of contextual information in a preceding sentence, to guide selection of a suitable antecedent for a zero anaphor.

Swinney (1991) argued that the findings of Marslen-Wilson and Tyler's experiment might not provide definitive evidence for the rapid use of contextual information in gap-filling. This is because the test point was not right at the gap position but at some later position. In (25c), for example, there are two words between the occurrence of PRO and the presentation of the probe. This leaves open the possibility that an antecedent was not assigned to the gap until two words later, when the probe was actually seen. Fodor, Garrett, and Swinney (1990; reported in Swinney, 1991) conducted a cross-modal priming experiment using materials (contexts and target sentences) with a

structure identical to those of Marslen-Wilson and Tyler's. The only difference was that an adverb was inserted between the verb (e.g., *ran/running*) and the preposition, as shown in (26) (perhaps to separate the probe points more clearly). Fodor et al. also used three probe points, as indicated by the superscripts in (26).

(26) ¹ Running rapidly ² toward her ³, he tried to help her get up.

Participants listened to the context and the target sentence. At one of the probe points either the correct antecedent of PRO (e.g., *Philip* in the case of (25)) or an unrelated matched control word would appear on the computer screen. Participants were required to name the probe as quickly as possible. If contextual information is used rapidly in resolving the referent of PRO, the target probe should be named quicker than the control probe at the first test point. If use of contextual information is delayed, the speed difference in naming the two probes might emerge only at one of the last two probe points. The experiment included matched baseline sentences with an overt pronoun in place of the empty category.

The data showed a priming effect at the first and second test points for the baseline sentences with an overt pronoun, but no priming at those two points for the sentences with a gap; only at the third test point did the priming effect emerge. It was therefore concluded that PRO interpretation may be delayed, at least when it is grammatically ambiguous, and that prior contextual information cannot always be recruited to guide the assignment of an appropriate antecedent.

A related study on Spanish reported in García-Albea and Meltzer (1996) and Meltzer (1995) echoed the finding of Fodor et al. that PRO interpretation is delayed even though a preceding context strongly hints at its antecedent. PRO was compared in this study not only with an overt pronoun, but also with *pro*, which provides another useful baseline. In the experiment, as in those on English, a background context preceded each target sentence, establishing potential referents for pro-forms in the target sentences. For the example in (28) below, the context was (27).

- (27) La arrogante millonaria y el huérfano abandonado llegaron al mismo tiempo a la puerta del restaurante.
 ‘The arrogant millionaire(fem) and the abandoned orphan(masc) arrived at the same time at the door of the restaurant.’

It was followed by one of the three sentences in (28), containing PRO as in (28a), or *pro* as in (28b), or an overt pronoun (*él*) as in (28c). The context, together with the first verb of the sentence, biased in favor of the orphan but not the millionaire as the antecedent for the anaphors.

- (28) a. PRO Mendigando lastimeramente una comida caliente, se desmayó.
 ‘(PRO) Begging sorrowfully a hot meal, (pro) fainted.’
 b. Mientras pro mendigaba lastimeramente una comida caliente, se desmayó.
 ‘While (pro) was begging sorrowfully a hot meal, (pro) fainted.’
 c. Mientras él mendigaba lastimeramente una comida caliente, se desmayó .
 ‘While he was begging sorrowfully a hot meal, (pro) fainted.’

The task was cross-modal naming. While participants were listening to the sentences, visual probes appeared coinciding with the first syllable of the word following the subordinate verb in all of the conditions (i.e., *lastimeramente* in (28a,b,c)), and the participants were required to say the probe word as soon as possible. There were four types of probe word: plausible experimental (e.g., *huérfano*, ‘orphan’) and implausible experimental (e.g., *millonaria* ‘millionaire’), drawn from the preceding context that the participants had heard. There were also control probes matched in gender and length with the experimental probes, but not semantically related to the context or target sentences in any way. It was predicted that if the contextual information was used quickly to resolve the meaning of the various pro-forms, the plausible experimental probe would be primed when it appeared, but no priming would be found for the implausible experimental probe. As a result, the difference in the naming time between the plausible experimental probe and its control probe should be significantly larger than that between the implausible experiment probe and its control probe.

The results showed a processing advantage for plausible probes relative to implausible probes in the *pro* and overt pronoun sentences, but not in the PRO sentences. This was taken to show that PRO, unlike *pro* and the overt pronoun, had still not been interpreted at the test point which immediately followed the verb that revealed the presence of PRO. While there were some technical issues,⁵¹ it is of interest to note that,

⁵¹ As acknowledged by the researchers, the finding was problematic because the effect of PRO came largely from the unusually slow reaction times to the plausible control probe, relative to the plausible control probes of *pro* and the overt pronoun; this was attributed to an inhibitory effect such that the plausible antecedent was not primed but its control was inhibited. However, most cross-modal priming studies have found facilitation rather than inhibitory effects, and a subsequent study on English reflexives reported in García-Albea and Meltzer (1996) did not find such an inhibitory effect.

according to grammatical constraints, the true filler for the PRO in (28c) (unlike *pro* in (28b) and the overt pronoun in (28c)) is the *pro* in the main clause that follows. Thus the grammar does not permit a PRO in that position to be interpreted on the basis of discourse or plausibility, but requires that interpretation be withheld until the matrix clause is processed.

A follow-up study used the same materials but with a delayed visual probe that appeared 300ms later than the test position in the first experiment. In this case the results showed no significant difference in the processing of the three types of pronominal. García-Albea and Meltzer suggest that “the 300 ms delay was sufficient for the pragmatic influences to begin to emerge in the PRO constructions, coinciding with the decline of those same influences over the *pro* and overt pronoun constructions” (p. 232, García-Albea and Meltzer).⁵² This is consistent with other findings observed above: where strict grammatical constraints exist but cannot be applied by the parser on-line, for lack of available information at the relevant point, strategic preferences begin to make themselves felt.

To summarize this section: Marslen-Wilson and Tyler (1987) found an immediate use of discourse information in PRO interpretation in English, but Fodor, Garrett, and Swinney (1990) and García-Albea and Meltzer (1996) found a delayed PRO interpretation in English and Spanish respectively, even when the discourse clearly indicates the correct antecedent. This is a very important topic, but in view of the relatively small number of studies that have tackled this issue, it remains inconclusive as to the time course of use of discourse information in on-line PRO interpretation.

⁵² An alternative explanation is possible. If PRO was still not interpreted at the later test point while the priming effect found for other two constructions at the first test point died out, it came as no surprise the antecedents were not primed at the later test point for all the pronominals.

To conclude Section 3.2 as a whole: Sentence processing studies on PRO interpretation have presented evidence to support the rapid use of lexical/grammatical information, when it is available, for antecedent assignment, but they also indicate a significant role for non-grammatical factors such as recency and plausibility information, at least where harder information is lacking. The evidence for rapid use of discourse information in interpreting PRO is weaker.

The experiments to be presented in the chapters that follow investigate PRO (or *pro*) interpretation in Chinese, in subject position and primarily in subject and object complement clauses. Thus, the present study focuses on gaps in complement clauses (rather than adjunct clauses), and on gap interpretation within a single sentence rather than between sentences in a discourse. To date there have been very few studies of PRO interpretation in Chinese, so for insight it has been necessary to turn to studies of PRO in other languages. The previous studies on PRO in English and Spanish summarized in this section are particularly of relevance to a study of PRO in Chinese, since these languages are similar in that they all have basic SVO word order. This permits, for example, investigation of the use of verb control information on PRO interpretation in Chinese, comparable to such investigations in English and other SVO languages. But Chinese is different from English and Spanish in that the linguistic character of its empty categories is often ambiguous on-line. It is less easy for the parser to determine, on a local basis, whether a gap that it has encountered is a PRO, *pro* or trace. This is because Chinese has considerable temporary structural ambiguity (e.g., due, in part, to weakness of finiteness marking), which often interacts with ambiguity as to the nature of the gap. Knowing the structure may allow the parser to pin down the gap type, or vice versa; but very often the

parser must juggle alternative analyses in both domains at the same time. When a structural ambiguity arises, the parser may need to consider how the choice of a structural analysis would affect the identity of a gap and its potential antecedent. This is an issue that will be addressed in my experiments; it does not seem to have been studied before.

3.3 Processing Chinese relative clauses

In dealing with the extensive on-line ambiguity of gap type in Chinese, the parser must consider the possibility that a gap is a trace of movement. Chinese does not have *wh*-movement in questions, but it does arguably have *wh*-movement in relative clauses. (NP-trace in Chinese will not be considered in this dissertation because the ambiguous structures of interest to this study do not contain an NP-trace.) There have been relatively few psycholinguistic studies of *wh*-trace in Chinese, but in this section I will pull together some relevant work on the processing of relative clauses in Chinese.

The Chinese relative clause is pre-nominal, and its trace thus precedes the head noun, which is the filler. So far, processing research has concentrated on comparing the processing difficulty of subject-extracted and object-extracted relative clauses. (See Section 3.3.1 below.) A few studies focused on some other aspects of relative clause processing. (Sections 3.3.2 and 3.3.3.)

3.3.1 Subject-extracted vs. object-extracted relative clauses

Many previous studies (e.g., Gibson, Desmet, Grodner, Watson, & Ko, 2005; Traxler, Morris, & Seely, 2002) have established that in a head-initial language like English, a

subject-extracted relative clause is easier to process than an object-extracted relative clause. Examples of the two types of relative clause are shown in (29).

(29) a. Subject-extracted relative clause

The reporter_i [who_i e_i attacked the senator]...

b. Object-extracted relative clause

The reporter_i [who_i the senator attacked e_i]...

Competing accounts have been proposed to explain the processing advantage of the subject-extracted relative clause. (See the reviews of these accounts in Hsiao and Gibson, 2003; Kwon, Polinsky, and Kluender, 2006; Lin and Bever, 2006.) These accounts can be roughly divided into two groups, with one attributing the subject advantage to a structural difference and the other to a difference in linear distance between the gap and the filler, in the two types of relative clause. The subject position is universally more prominent, and more accessible than the object position (Keenan & Comrie, 1977). In addition, the gap in a subject-extracted relative clause is structurally closer to the filler than that in an object-extracted relative clause, in terms of syntactic configuration (i.e., the number of nodes between them in the tree). The gap is also linearly closer to the filler than that in an object-extracted relative clause, in terms of the number of intervening words in the surface word string, which could translate into a saving in memory costs of carrying a filler until its gap is found. In a head-initial language with a post-nominal relative clause, all of these factors lead to the same prediction of subject advantage, and therefore, there is no way to validate one over the others.

The pre-nominal relative clause, often found in head-final languages, such as Korean and Japanese, provides an opportunity to differentiate these accounts. The pre-nominal relative clause precedes the head noun, which means the gap also precedes the filler. Chinese is not a typical head-final language, as its basic word order is essentially SVO. However, its noun phrase is strictly head-final, which means the relative clause precedes the head noun that it modifies. Because of this characteristic, the two types of relative clause contrast with respect to the structural and linear differences between them. A pre-nominal Chinese relative clause is illustrated in (30) and graphically in Figure 3.2.

(30) a. Subject-extracted relative clause

[e_i Gongji yiyuan] de jizhe_i...
 attack senator reporter
 ‘The reporter who attacked the senator...’

b. Object-extracted relative clause

[Yiyuan gongji e_i] de jizhe_i...
 senator attack reporter
 ‘The reporter who the senator attacked...’

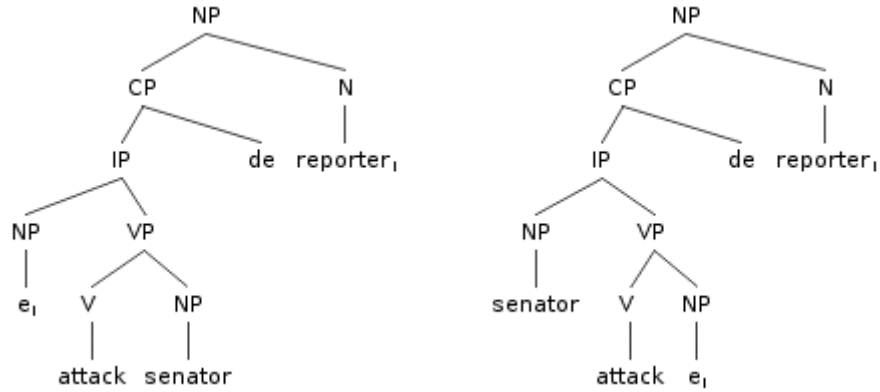


Figure 3.2: Left: The structure of a Chinese Subject-extracted relative clause (with English gloss); Right: The structure of a Chinese Object-extracted relative clause (with English gloss).

The examples in (30) show that the object-extracted relative clause has fewer intervening elements linearly between the gap and the filler. But the configurations in Figure 3.2 show that in the subject-extracted relative clause the subject gap is less embedded than the object gap and thus structurally closer to the filler. In addition, researchers have proposed that the prominence and accessibility of the subject position also converge to favor subject-extracted over object-extracted relative clauses. Given this contrast, pre-nominal relative clauses provide a means to test the different proposals to explain the subject advantage commonly found in head-initial languages. If a subject gap is easier even in a pre-nominal clause, it may be inferred that the relevant factor could be structural; if the object gap is easier in a pre-nominal clause, it can be inferred that linear distance is what matters.

The prospect is of a clear and unarguable resolution of this theoretical debate. Unfortunately, the experimental data on processing pre-nominal relative clauses has been equivocal, leading to contradictory conclusions in different studies. For processing of a

single sentence (no context), studies that found a subject gap advantage in Chinese are Lin and Bever (2006, 2009), and in Korean and Japanese are Kwon, Polinsky, and Kluender (2006), and Miyamoto and Nakamura (2003) and Ueno and Garnsey (2008) respectively. On the other hand, studies that found an object gap advantage are Hsiao and Gibson (2003), Lin and Garnsey (2009), and Packard, Ye, and Zhou (2009). For processing relative clauses in context, studies on both Chinese (Wu & Gibson, 2008) and Japanese (Ishizuka, Nakatani, & Gibson, 2006) found an object advantage.⁵³ Thus, the pre-nominal relative clause has not straightforwardly solved the puzzle concerning the reason for the subject advantage in post-nominal relative clauses. Rather, it has raised a new puzzle of why the findings for pre-nominal relative clauses are not more similar across experiments.

A possible reason for the inconsistent findings is the structural ambiguity surrounding the beginning of a relative clause. Pre-nominal relative clauses, unlike post-nominal relative clauses, are typically not preceded by a relativizer, like *who* (or *that*) in English, which can foretell the presence of a relative clause. Instead, a pre-nominal relative clause is likely to begin as any other clause. For example, in Chinese, a relative clause that modifies the subject of a sentence, like those in (30a,b) above, is temporarily ambiguous between a main clause, a clausal subject, a relative clause and an adjunct clause analysis. (See examples in (1) in Section 1.1.) On the other hand, a relative clause that modifies the object of a sentence, like those in (31a, b), is ambiguous between a

⁵³ In this kind of study, a context with two referents was provided before the sentence that contained the relative clause, which then occurred naturally to select one of the two referents.

clausal object, a clausal subject inside a clausal object, and a relative clause analysis. (See examples in (2) in section 1.3.)⁵⁴

(31) a. Object-modifying subject-extracted relative clause

Renren dou piping [e_i gongji yiyuan] de jizhe_i.
 everyone all criticize attack senator DE reporter
 ‘Everyone criticized the reporter who attacked the senator.’

b. Object-modifying object-extracted relative clause

Renren dou piping [yiyuan gongji e_i] de jizhe_i.
 everyone all criticize senator attack DE reporter
 ‘Everyone criticized the reporter who the senator attacked.’

This substantial structural ambiguity is associated with gap-type ambiguity, as noted in section 1.3, because the linguistic properties of the gap, including its range of possible fillers, hinge on the structural analysis. It is far from clear, therefore, that a relative clause construction is recognized as such by the parser until the head noun is eventually encountered, in which case the on-line data may not reflect the processing of a relative clause gap at all. In short: the processing of the filler-gap relation in a relative clause may involve factors that go beyond merely the structural or linear distance between the filler and the gap, including factors affecting the recognizability of a clause as a relative clause prior to its completion. The interplay of the structural and gap ambiguities, as well as the

⁵⁴ Some studies (e.g., Hsu, Hurewitz, & Phillips, 2006; Yoshida, Aoshima, & Phillips, 2004) have shown that the use of cues like a pre-relative clause classifier and context facilitate the relative clause reading of an ambiguous segment, but most of the studies investigating subject versus object advantage in processing relative clauses in Chinese did not use either of the cues. Lin and Bever (2007) explicitly instructed the participants of an experiment about the presence of relative clauses in the test materials, but this may involve metalinguistic knowledge that the participants might not be able to avail themselves of. On the other hand, it is unknown as yet, especially in Chinese, how *much* such cues actually increase the preference for the relative clause analysis as opposed to other analyses.

filler-gap distance, may vary between sentences in one experiment and those in another, and this may be the source of the contradictory results.

Another problem concerns where the experimental effects were found in processing pre-nominal relative clauses. In the studies that employed self-paced word-by-word reading and ERPs, which provide more localized data of the effect than whole-sentence reading (with potential look-ahead), the processing advantage was found within the relative clause (e.g., Hsiao & Gibson, 2003), or later at the head noun (e.g., Kwon, Polinsky, & Kluender, 2006; Lin & Bever, 2006; Miyamoto & Nakamura, 2003; Packard, Ye, & Zhou, 2009), or at both (e.g., Lin & Garnsey, 2009). There is seemingly no sound theory at present that can unequivocally relate the processing advantage to the location of the effect. The processing difficulty found within the relative clause may be related to structural disambiguation and then reanalysis, and the memory of maintaining a gap. The processing difficulty found at the head noun may be related to structural disambiguation and delayed building of the filler-gap association. Many proposals on this issue are not precise on their predictions for the location of the processing cost. More importantly, a meaningful comparison of the processing cost of a subject-extracted and an object-extracted relative clause requires an early disambiguation of the relative clause structure; many studies did not have this factor under control.

To summarize, there is overwhelming evidence to support that post-nominal subject-extracted relative clauses are easier to process than post-nominal object-extracted relative clauses. In terms of both structural and linear distance, the head noun and the gap are closer in the former, which may account for its lower processing cost. Pre-nominal relative clauses, by contrast, differentiate the two concepts of distance, with the gap

structurally closer to the head noun, but linearly more distant from it, in subject-extracted than object-extracted relative clauses. But the experimental data for pre-nominal relative clauses are conflicting. One of the reasons may be related to the structural ambiguity surrounding the beginning of a relative clause. Experiment 1 in the present study examined the structural preference for an ambiguous fragment that begins with a null subject and a verb, and that could be disambiguated as a relative clause. The results of this experiment show that the relative clause analysis is strongly dispreferred compared with other analyses for such a fragment in Chinese.

3.3.2 The Active Gap hypothesis

The Active Filler Strategy requires the parser to assign an identified filler as soon as possible to a gap. As discussed in section 3.1.1, many studies have provided experimental data to support the use of this strategy on-line. Given this, a parallel question naturally arises: will the parser actively look for the filler for an identified gap? This strategy, corresponding to the Active Filler Strategy, may be called an Active Gap Strategy.

Hsu and Bruening (2003) investigated the Active Gap Hypothesis, in a context where a recognizable gap linearly precedes the filler, and thus the creation of a filler-gap association could be driven by a search for the filler for an identified gap. The construction in their investigation contained a Chinese relative clause, where the gap was in the subject position within the relative clause and the filler, as usual, was the head noun that follows the relative clause. Their experimental sentences were created in two versions, shown in (32). Note that CL denotes classifier, an element that unambiguously

occurs in a noun phrase in Chinese, and must be followed by a noun, with a possible intervening modifier such as an adjective or relative clause.

- (32) a. Na-wei [e_i zuotian bianzhi-le yi-jian maoyi songgei ta-erzi] de
 That-CL yesterday knit-PAST one-CL sweater give-to her-son DE
 lao-taitai; shenbing-le.
 old-lady get-sick-PAST
 ‘That old lady who knitted a sweater to give to her son yesterday got sick.’
- b. Na-wei lao-taitai zuotian bianzhi-le yi-jian maoyi songgei ta-erzi.
 That-CL old-lady yesterday knit-PAST one-CL sweater give-to her-son
 ‘That old lady knitted a sweater to give to her son yesterday.’

The sentence in (32a) contains a relative clause modifying the head noun *lao-taitai* ‘old lady.’ The demonstrative and the classifier at the beginning of the sentence are a characteristic introduction of a noun phrase, and therefore signal that the words that follow are part of a noun phrase. In the baseline sentence (32b), without a relative clause, that noun phrase can be *na-wei lao-taitai* ‘that old lady’ and the rest of the clause can be analyzed as a main clause. However, in (32a), the word *zuotian* ‘yesterday’ follows the classifier *wei* that is reserved for people. The two words are incongruous and thus suggest that *zuotian* is likely to be the beginning of a relative clause embedded inside a larger noun phrase. In that case, the subject of the relative clause is missing; therefore, a trace must be created in the subject position. After that, the parser would anticipate a suitable filler to appear in the head noun position, to complete the dependency. Note that the two sentence versions are lexically identical from the beginning of the relative clause in (32a) to the end of that relative clause.

The results from Hsu and Bruening's experiment showed increased reading times in (32a) for each word of the adjunct phrase *songgei ta-erzi* 'give-to her-son,' and for the adjunct phrase as a whole, compared with the same segments of the baseline sentence (32b). The findings were ascribed to a 'missing-filler effect:' once a gap was identified in sentences like (32a), the parser would actively look for its filler to complete the dependency and would suffer less processing cost if the filler were found sooner rather than later. The relative clause in (32a) *could* have terminated at *maoyi* 'sweater' so the parser, actively seeking a filler, would expect to find the head noun (the filler) right after that point in the sentence, so that it could close off the filler-gap dependency. Instead, the adjunct phrase in the relative clause delayed the completion of the dependency, which would increase the processing load, causing a reading slowdown.

This is one possible explanation of the Hsu and Bruening finding. However, the results could be open to alternative interpretations, which need to be considered before a clear conclusion can be drawn. One likely explanation is that the effect could be related to an increased memory or processing load because of the prolonged relative clause. With or without a gap, a pre-nominal relative clause requires the parser to simultaneously maintain two clauses, that is, the main clause and the relative clause. Processing load during a pre-nominal relative clause may be more critical than for a post-nominal relative, so there may be a greater penalty for long relative clauses, which prolong the costly processing. To exclude this alternative explanation for the finding of Hsu and Bruening, a different construction is needed for the testing. The present study employs the clausal subject construction to revisit the Active Gap hypothesis. Details are presented in the next chapter.

3.3.3 An ambiguity between relative and complement clause analyses

As noted in section 1.3, a sentence-initial clause in Chinese has several possible analyses, and this structural ambiguity can impact on the interpretation of a potentially ambiguous empty category. Some evidence concerning the parser's preferred interpretation of an ambiguous initial clause is provided by a sentence completion experiment by Hsieh, Boland, Zhang, and Yan (in press). This was one part of a larger study that investigated serial versus parallel parsing. Their sentence completion study employed the ambiguous sentence-initial fragment *e Verb NP₁ de NP₂* in Chinese. (Strictly, NP₂ should be a noun instead of a noun phrase, but that is not important here.) The fragment can be read as what the authors call a "complement clause," which appears to subsume three alternative structures: a main clause, a clausal subject, and an adverbial clause. All three contain the structure [IP *e* [VP Verb [NP NP₁ de N]]], in which NP₁ is the modifier of the following noun: see their Figure 1.⁵⁵ Alternatively, the fragment can be read as a noun phrase that contains a relative clause with the structure [NP [CP [IP *e* [VP Verb [NP NP₁]]] de] N]. The participants in this study (native speakers of Chinese) were required to create a continuation of the ambiguous sequence *e Verb NP de*.⁵⁶ A great majority (95%) of the fragments were continued as relative clause constructions rather than as complement

⁵⁵ Since these three possible analyses were not distinguished in the paper, it is unknown which or all of them are less preferred than the relative clause analysis. For example, it is not known to what extent the fragment might have been understood as a main clause with implicit understanding of an antecedent for the empty subject in preceding context (see Experiment 1 of the present study in Chapter 4).

⁵⁶ In either case, the fragment *e Verb NP de* requires a noun to follow. The question is whether the noun that is added serves as the subject or the object of the verb. In the former case, the whole fragment becomes a noun phrase containing a relative clause. In the latter case, the fragment could be a main clause, a clausal subject, or an adjunct clause, in all of which the post-verbal noun phrase is the modifier of the object head noun that follows.

clauses, which was taken as evidence that a relative clause analysis is generally preferred by the parser over a complement clause analysis.⁵⁷

This is inconsistent with results of Experiments 1 and 2 of the present study; see discussion in sections 4.1 and 4.2. It is important, therefore, to understand why the relative clause analysis might be preferred in this case. In addition to the account by the authors, a very likely explanation is that there is a tendency to interpret any fragment as a complete constituent if possible. In this experiment, the fragment constituted a complete clause if the relative clause analysis was adopted, but would be an incomplete constituent if a main clause, or a clausal subject, or an adjunct clause analysis were adopted. In the case of the relative clause analysis, the whole fragment is a relative clause, creating a complete phrase structure [_{CP} *e Verb NP de*]. On other analyses, NP₁ in the fragment would have to be taken as a modifier for a head noun that follows *de*, which is not included in the fragment. The structure of the fragment would be *e Verb* [_{NP} *NP de...*]. In this case, the segment *NP de* is a partial nominal phrase, to be completed by an object head noun. In a sentence completion task, participants are likely to read the fragment as a group of closely related words, with the expectation that the fragment has a complete phrasal structure. This expectation could well be strengthened by the participants' projecting a prosodic break at the end of the fragment, at the division between what they read and what they create as its completion. Thus, when a fragment like *e Verb NP de* is presented for completion, it can be expected that an analysis giving it a complete clausal status will be preferred over an analysis that treats it as an incomplete phrase. In view of

⁵⁷ The authors offer several reasons, not all of which are entirely clear, for why the relative clause would be the preferred analysis, including: structural simplicity (Minimal Attachment); "complete propositional meaning;" higher corpus frequency of *de* as a relative clause marker than as a possessive marker in the sequence *Verb NP de NP*.

this, it is not necessary to conclude from the findings of Hsieh et al. (op. cit.) that the relative clause analysis has a fundamental processing advantage over other analyses in on-line parsing of a sentence that begins *e Verb NP₁ de NP₂*. Other tasks than sentence completion, which are less sensitive to an appearance of phrasal integrity on-line, could well yield a different conclusion. This will be important in section 4.1, where new data are reported from two sentence completion tasks which indicate, to the contrary, that a relative clause analysis is a very low-ranked option, as might be expected on the basis of Minimal Attachment, unless it is encouraged by the ease of empty category interpretation.

3.4 Conclusion

Pulling together the threads of this long chapter: the chapter has reviewed a number of previous studies that have investigated the processing of gaps in control constructions in English, Spanish, Japanese, and Chinese, and relative clause constructions in Chinese. These studies have produced much interesting data, though some of it is not definitive, in part because of the difficulty of avoiding confounding factors in the constructions tested.

These studies provide an informative background for the present study, which also investigates control and relative clause constructions in Chinese but from a somewhat different perspective. Its focus is the parser's strategies to complete a gap-driven filler-gap dependency. The experimental findings point to the psychological reality of an Active Gap Strategy. The next chapter reports the four experiments of the present study. The first experiment examines structural preferences for a fragment containing a null subject and a verb. Its primary purpose is to clarify the interplay of

structural and empty category ambiguities; in particular, whether a good interpretation for the empty category outweighs Minimal Attachment. The second experiment continues this investigation. A manipulation of the matrix verb varies the availability of an antecedent for an empty category in sentences ambiguous between a control construction and a relative clause construction. The manipulation of the antecedent indirectly biases the preference for one structural analysis over another. The purpose, once again, is to examine whether the options for empty category interpretation can affect the parser's structural choices. The third experiment investigates the Active Gap Hypothesis, employing a construction other than that studied by Hsu and Bruening (2003). The outcomes of these first three experiments suggest that the parser actively seeks out a filler for an identified gap. The fourth experiment investigates whether the parser's need to interpret a gap rapidly is so strong that it prefers a generic interpretation which needs no association with an overt filler at all. This can be examined in just one construction—a clausal subject containing a null subject. No studies, as far as I know, have examined this before.

CHAPTER 4

Processing Chinese empty categories: Methods and Results

This study employed two research methods and four experiments to investigate the three research questions outlined in Chapter 1 and repeated here:

- I. When a gap is identified before its filler is, does the parser adopt the first candidate filler, or does it wait to see whether a better filler may subsequently appear?
- II. How does empty category interpretation interact with structural ambiguity resolution?
- III. Is local interpretation of a gap (as generic in reference) preferred over association with a filler elsewhere in the sentence?

The two research methods were a pencil-and-paper sentence completion questionnaire and a non-cumulative self-paced word-by-word reading task. The general procedure for each of these methods is described below, as well as some general remarks about the language background of the participants, before the detailed reports for Experiments 1-4, which begin in section 4.1.

In the sentence completion task, participants read the beginning of a sentence and were asked to add words to finish it. In the critical cases, the fragments presented were structurally ambiguous; what structure a participant assigned to them was revealed by how they were continued. All fragments were presented in simplified Chinese characters (MS Song font, 12 points), and were followed by a blank line.

The first page of the questionnaire contained instructions on completing the task. Participants were asked to read the instructions carefully before turning to the next page to begin the task. The instructions included a brief background of the study, the appropriate ways to go about the task, and two completion examples. Participants were specifically reminded to do the task following the order of fragments in the questionnaire, and not to insert words before the fragments or cross out any word provided. The instructions also clearly indicated that the number of words participants added did not matter but that the sentence completions had to result in complete and grammatical sentences, even if they were uninteresting or factually untrue.

In the non-cumulative self-paced word-by-word reading task, participants read sentences and answered comprehension questions. For each item, the sentence was presented on a computer screen one word at a time—the pacing of the presentation controlled by the participant—and was followed by its corresponding comprehension question. The computer registered the time spent reading each word, following the assumption that fluctuations in reading times reflect fluctuations in processing cost. The comprehension questions were meant to motivate participants to attend to the task; they were used to exclude inattentive participants, but do not constitute the data of interest to this study. The presentation of the materials and recording of participant responses was controlled by DMDX software developed at the University of Arizona by K. I. Forster and J.C.Forster.

Each word, in simplified Chinese characters, was presented at the center of the computer screen (MS Song font, 14 points). Before the first word of a sentence was displayed, a cross (‘ + ’) appeared at the center of the screen. For each trial, when the

participant pressed the spacebar once, the cross was replaced by the first word of the sentence. After reading the first word, pressing the right-shift key on a keyboard replaced the first word with the next word, and likewise for each successive word. The end of the sentence was signaled by the period (‘。’), which was displayed separately from other words. (The reason for this display method will be explained in section 4.2.) At this point, pressing the right-shift key would bring up a comprehension question, together with two possible answers beneath it, one on the left hand side and the other on the right hand side. Participants pressed the left or right-shift key to choose their answer. After they selected the answer, a feedback message (in Chinese) flashed on the screen for 15 ms, indicating whether the answer chosen was correct. The message for an incorrect choice was in red. Then the cross would appear on the screen again, indicating the next sentence was ready for display.

All the materials except the cross had pre-set time-outs. In the absence of a response from the participant, a word disappeared from the screen after 5000 ms, and each question after 10000 ms. A message would flash on the screen when the time limit expired.

Participants received a sheet with instructions before they started the task. The sheet explained the procedures they needed to follow to perform the task, and it specifically reminded them that both accuracy and speed were important. It explained that the function of the cross was to offer them a break if needed, and that there was no time limit on the break. When the participants started the task, they were asked to do five practice sentences so that they could get accustomed to the procedures and key positions. After these five practice sentences, a message on the computer screen instructed

participants to ask questions if they still were not sure of the nature of the task, or to begin, if they were confident about the procedure. The first three trials were covert practice items; the complete target and filler trials, interspersed and pseudorandomized, followed.

All participants were required to sign a consent form and fill out a language background questionnaire before they began the experiment. Only participants who were native speakers of Mandarin Chinese,⁵⁸ and had lived in mainland China for at least ten years, were selected. At the time of testing, most of them were students at Queens College in Flushing, New York, either studying for a Bachelor's degree, or taking English language classes. Some already had a Bachelor's degree from mainland China. One participant had a Master's degree and was an English teacher in China on an exchange program. Most participants took part in more than one experiment in this study, but none participated, within a month, in both Experiments 1a and 1b, whose materials shared some similarities. Some participants earned a Psychology course credit, while others received US\$10 for their participation in each experiment. The testing took place in a language lab, or a classroom, or my office on the Queens College campus.

This chapter reports data from four experiments; one employed sentence completion (Experiment 1), and the other three self-paced reading (Experiments 2-4). Experiment 2 was preceded by a norming task to guide materials construction, which will be explained in detail in section 4.2.

⁵⁸ Some participants speak other Chinese dialects as well as Mandarin, and sometimes they could not recall when they started speaking Mandarin. (Some people started using Mandarin when they started formal education, that is, around age 6. But some might start earlier than that because their parents, relatives or neighbors spoke Mandarin occasionally.) For these cases, the qualification criteria became: 1) both of the participant's parents also speak Mandarin; and 2) Mandarin is one of their most often spoken languages.

4.1 Experiment 1

This experiment included two sentence completion studies, of which the second was a follow-up of the first. Sections 4.1.1 and 4.1.2 discuss them in turn.

4.1.1 Experiment 1a

4.1.1.1 Aims

This experiment addressed Research Question II: Does empty category interpretation interact with structural ambiguity resolution? In particular, will the processor trade off Minimal Attachment to gain a determinate interpretation of an empty category?

4.1.1.2 Method

Materials. Four types of sentence-initial fragments, as illustrated in (1), were presented to the participants for completion.

- (1) a. **SV:** Overt referential subject + transitive verb

e.g. Mali zhengli...

Mary tidy

- b. **V:** Null subject + transitive verb

e.g. Zhengli...

tidy

- c. **QV:** Quantified overt subject + transitive verb

e.g. Daduoshu ren zhengli...

most people tidy

d. **AdvV**: Null subject + frequency adverbial + transitive verb

e.g. Changchang zhengli...
often tidy

(Frequency adverbials used in this experiment: *changchang* ‘often,’
youshihou ‘sometimes,’ and *congbu* ‘never.’)

The fragments in (1a) and (1b) are identical except that the former contains an overt subject whereas the latter has an empty subject. Both of them are ambiguous in the same way: either one could be continued as a main clause, as shown in the sentences in (2), or as a clausal subject, as shown in the sentences in (3), or as a relative clause, as shown in the sentences in (4).⁵⁹ (The potential completions are underlined in these examples.) The completions reveal what structure was assigned to the fragment, from which it can be inferred the preferences of Chinese readers in resolving the ambiguity.

(2) a. Mali zhengli fangjian.

Mary tidy room
‘Mary tidied the room.’

b. *e* Zhengli fangjian.

tidy room
‘(Someone) tidied the room.’

⁵⁹ The adjunct clause is a possible continuation. (See section 1.3.) But this completion was rarely found in this study, probably because it is structurally more complex than the clausal subject and relative clause but offers no additional processing advantage for the empty category. Thus, this completion option is not considered to be a real competitor to the others and is not included in the discussion.

- (3) a. [Mali zhengli shufang] ling ta mama hen kaixin.
 Mary tidy reading-room CAU her mother very happy
 ‘That Mary tidied the reading room pleased her mother.’
- b. [*e* Zhengli shufang] xuyao hen-duo shijian.
 tidy reading-room need much time
 ‘To tidy the reading room needs much time.’
- (4) a. [Mali zhengli *e_i*] de shuzhuo_i zui ganjing.
 Mary tidy DE desk most clean
 ‘The desk that Mary tidied was the cleanest.’
- b. [*e_i* Zhengli shuzhuo] de ren_i shi Mali.
 tidy desk DE person is Mary
 ‘The person who tidied the desk is Mary.’

The main objective of this task was to investigate differences in the completion patterns for fragments with an overt subject (1a) and fragments with a null subject (1b). Of particular interest is whether the presence of an empty category in an ambiguous fragment affects the application of the principle of Minimal Attachment. (The Minimal Attachment principle encodes the general preference of the parser to assign the simplest analysis to an ambiguous fragment.) Structurally, the main clause analysis is simpler than the clausal subject and relative clause analyses, so it is likely to be preferred on that basis. However, this structural preference could be outweighed by the ease of interpreting the empty subject. The clausal subject and the relative clause can provide a referent to the empty subject while the main clause cannot, so the former might be preferred. The empty category within a clausal subject may be assigned a generic referent, as in (3b), or it can

acquire its referent from a nominal in the main clause predicate that follows, as in the Chinese equivalent of *Tidying the reading room is Mary's job*; see (5b) below. The empty category within a relative clause is bound by the head noun (e.g., *shuzhuo* 'desk' in (4a), and *ren* 'person' in (4b)) that follows the relative clause, and cannot be interpreted in any other way.

The comparison of responses to fragments like (1a) and (1b) is a simple test of how the presence of an empty category affects processing decisions. However, it is open to the alternative interpretation that the relevant factor might be how informative the fragment is; perhaps participants would be inclined to complete the shorter fragment (1b) with a more complex structure simply to compensate for its being less informative than (1a). This can be checked by comparing (1c) and (1d). This pair also differs with respect to the presence or absence of an overt subject, but are roughly equal in informativeness: where (1c) contains a quantified overt subject (*daduoshu ren* 'most people'), (1d) contains an adverb (*changchang* 'often') that carries similar quantificational information. A difference in the completion patterns for (1a,b) can safely be attributed to the empty category, rather than to information load, if a comparable difference is found for (1c,d).

Note that all the fragments in the questionnaire only provided the constituents up to the transitive verb; hence they did not constitute a complete clause or phrase on any of the potential completions. As a result, no one completion was favored on this structural basis. Thus, the fragments in this experiment, unlike those of the completion study in Hsieh, Boland, Zhang, and Yan (in press) were not biased in favor of one type of completion over others; as discussed in section 3.3.3.

The experiment had a 2 x 2 design such that the fragments

- contain an overt (1a, c) or a null (1b, d) subject (Subject Type, within items);
- have no quantifier (1a, b) or have a quantifier (1c, d) (Quantifier, between items).

The questionnaire had two counterbalanced versions, each consisting of 48 target items (12 each in the SV, V, QV, and AdvV categories) and 24 filler items of varied structure, begun and ended with 2 covert practice items. (All target items are given in Appendix C.) Items were pseudo-randomized so that no more than three target items, and no more than two target items of the same type were presented consecutively.

Participants. Twenty-six native speakers of Mandarin Chinese (age range 18-23; mean age 20; 20 female) from mainland China (see criteria above) participated in this experiment. No time limit was imposed on the task; participants usually took 20 to 30 minutes to finish it.

Data Treatment. The completions were hand-coded into four categories according to the syntactic status of the presented fragment in the completed sentence: main clauses, clausal subjects, relative clauses, and others. The last category included cases in which the completion was structurally ambiguous, or grammatically or semantically anomalous. There were no missing completions.

4.1.1.3 Results

The overall results are shown graphically in Figure 4.1. For the numeric continuation rates of each fragment category, see Table B1 in Appendix B.

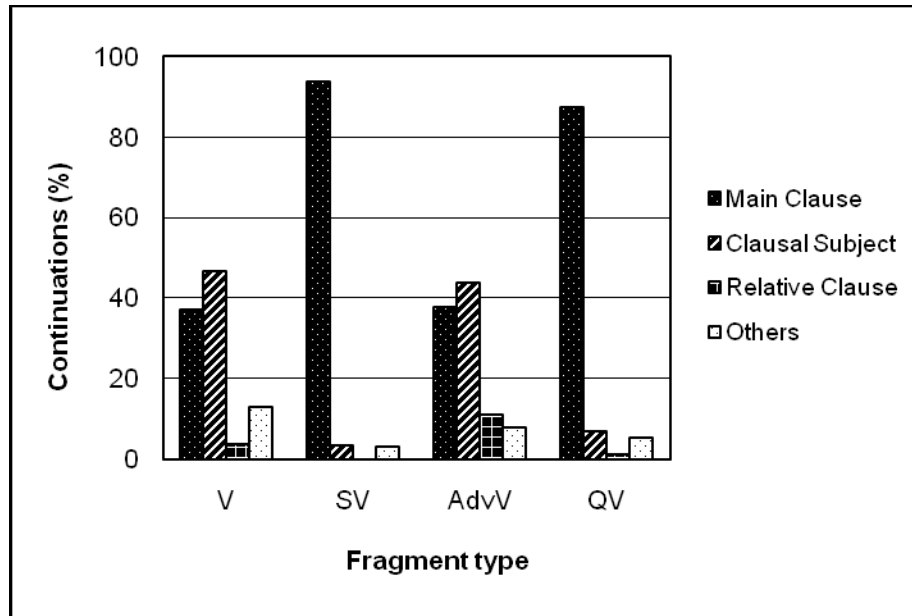


Figure 4.1: Percentages of completion types by fragment type, in Experiment 1a.

For the main clause completions across fragment types, analyses of variance showed a main effect of Subject Type ($F_1(1, 24)=160.86, p<.001$; $F_2(1, 44)=251.10, p<.001$) but not of Quantifier ($F_1(1, 24)=3.14, p>.05$; $F_2(1, 44)=0.59, p>.4$). No interaction of these two factors was found ($F_1(1, 24)=3.43, p>.05$; $F_2(1, 44)=1.24, p>.2$). For the clausal subject completions, analyses of variance also showed a main effect of Subject Type ($F_1(1, 24)=107.76, p<.001$; $F_2(1, 44)=174.31, p<.001$) but not of Quantifier ($F_1(1, 24)=.12, p>.7$; $F_2(1, 44)=.02, p>.8$), with no interaction ($F_1(1, 24)=2.88, p>.1$; $F_2(1, 44)=1.04, p>.3$). Thus, the findings indicate that the presence of an empty category, rather than the amount of information in the fragment, was the source of the differential completion patterns: the presence of an empty subject in a fragment caused a significant increase in clausal subject completions, relative to a fragment with an overt subject.

Since the V fragment category is the main focus of the investigation, an additional t-test was performed to compare the main clause and clausal subject completions. For the V fragments, there were more continuations as a clausal subject than as a main clause. Out of the total of main clause plus clausal subject continuations, only 44% were main clauses, which is reliably less than chance ($t_1(25)=-2.17$, $p<.02$; $t_2(23)=-2.98$, $p<.005$). Although this is not a strong asymmetry, it shows that the clausal subject is preferred over the main clause for the fragment with a null subject.

Further analyses of the data revealed two interesting additional findings, concerning empty category interpretation and the scope of frequency adverbials. The first of these is that for clausal subject continuations, participants showed a strong preference for a generic (or so-called ‘arbitrary;’ see section 2.4) interpretation of an empty category, an example of which is shown in (5a) (=3a), over a co-referring noun phrase in the matrix predicate, as illustrated in (5b). Figure 4.2 shows the breakdown of the clausal subject continuations into three categories, based on how the empty category was interpreted.

- (5) a. [e **Zhengli** shufang] xuyao hen-duo shijian.
 tidy reading-room need much time
 ‘To tidy the reading room needs much time.’
- b. [e_i **Zhengli** shufang] shi Mali_i de gongzuo.
 tidy reading-room is Mary DE job
 ‘Tidying the reading room is Mary’s job.’

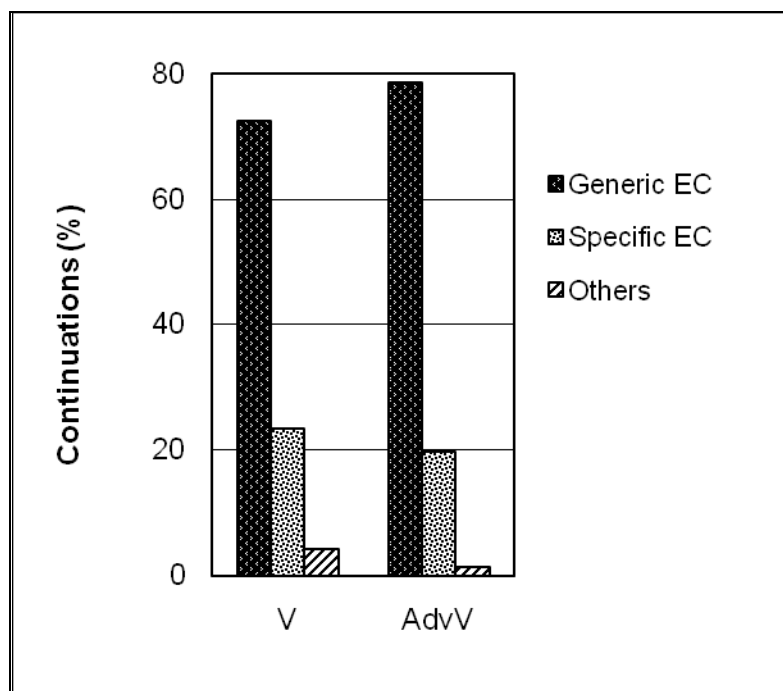


Figure 4.2: Percentages of completion types by fragment type, in clausal subject continuations of null subject fragments in Experiment 1a.

Another finding concerns the frequency adverbials in the AdvV fragments.

Further analyses of the AdvV continuations revealed that the three adverbials used in the task elicited rather different continuations. Figure 4.3 shows that fragments with *congbu* ‘never’ were more likely to be continued as a main clause, while fragments with *youshihou* ‘sometimes’ tended to be continued as a clausal subject; *changchang* ‘often’ fell roughly in the middle of these two extremes.

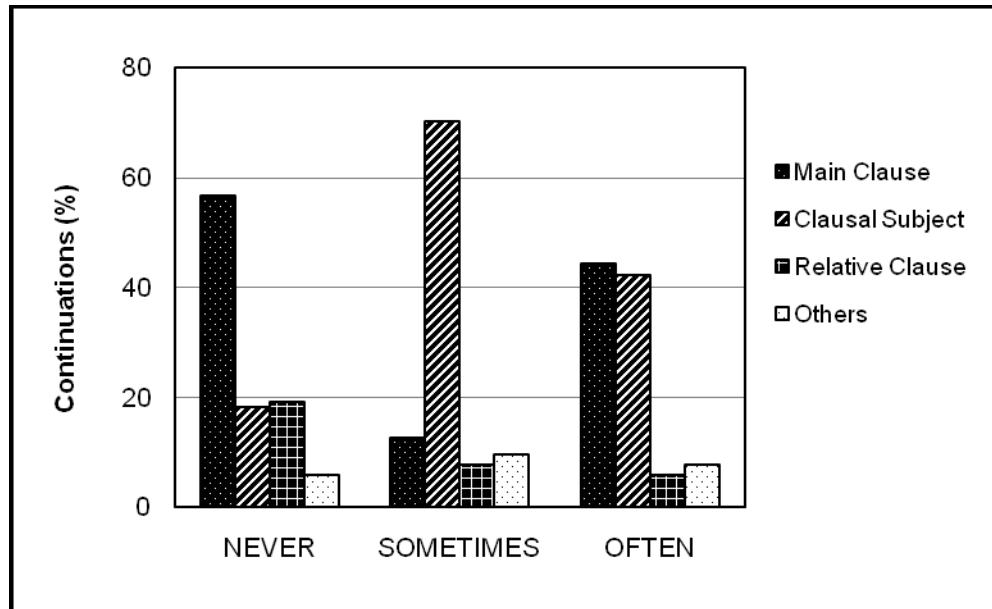


Figure 4.3: Percentages of completion types by fragment type, for the AdvV fragments in Experiment 1a.

These two ancillary findings will be discussed in sections 4.1.1.4.2 and 4.1.1.4.3 respectively, following discussion of the main result of the study.

4.1.1.4 Discussion

4.1.1.4.1 Overall Results

Results of Experiment 1a, as shown in Figure 4.1, clearly showed that the presence or absence of an empty category in a fragment considerably affected how it was continued. A fragment that contained an overt subject, like those in the SV category, was almost always continued as a main clause, the simplest structure for the fragment. But when a fragment included an empty category as the subject, like those in the V category, the main clause continuation was somewhat less preferred than the clausal subject

continuation. The relative clause was least preferred for both SV and V categories. There could be two reasons for the strong preference for the clausal subject over the relative clause. First, the relative clause is structurally more complex than the clausal subject. This difference is illustrated in Figure 4.4, where there are additional nodes NP and CP in the relative clause, relative to the clausal subject.

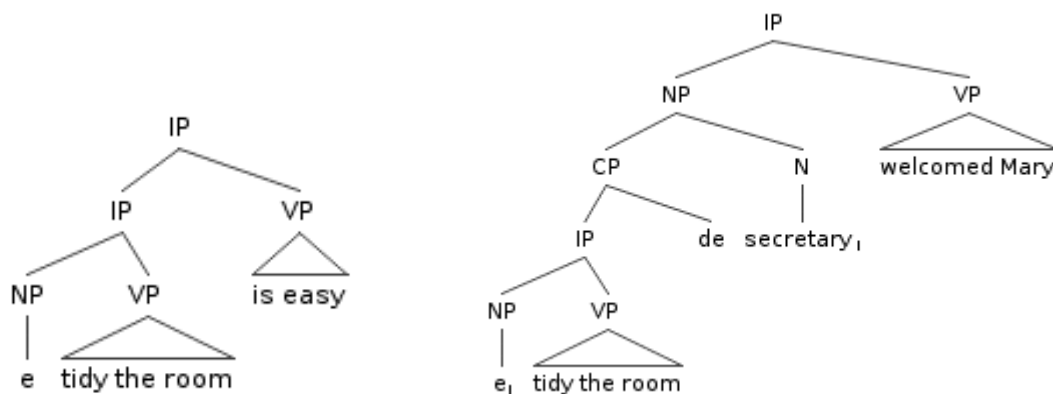


Figure 4.4: Left: The structure of a Chinese clausal subject construction (with English gloss); Right: The structure of a Chinese relative clause construction (with English gloss).

A second reason for preferring a clausal subject over a relative clause is related to the empty category and its association with the antecedent. The link of the empty category in a relative clause with the head noun involves a syntactic chain. (See the discussion in section 2.3.1.) By contrast, the link between a subject gap within a clausal subject and a referent in the main clause predicate, if there is one, is achieved through non-obligatorily control that involves no syntactic movement and hence no chain in a strict formal sense; the relation is apparently mediated by semantics. (See section 2.4.) According to the Minimal Chain Principle, as discussed in section 3.1.1, on-line construction of a chain should be avoided if possible. Thus, for both structural and empty

category reasons, a clausal subject analysis would be expected to be preferred by the parser over a relative clause analysis, which is borne out by the results of this experiment.

However, these two reasons hold only if a clausal subject is just like a nominal subject that occupies an argument position of a sentence. Koster (1978) has argued that ‘subject sentences’ do not actually exist; instead, the clausal subject is in a non-argument topic position (it is a ‘satellite sentence’), binding the null subject of the main sentence. This structural analysis is illustrated in Figure 4.5.⁶⁰

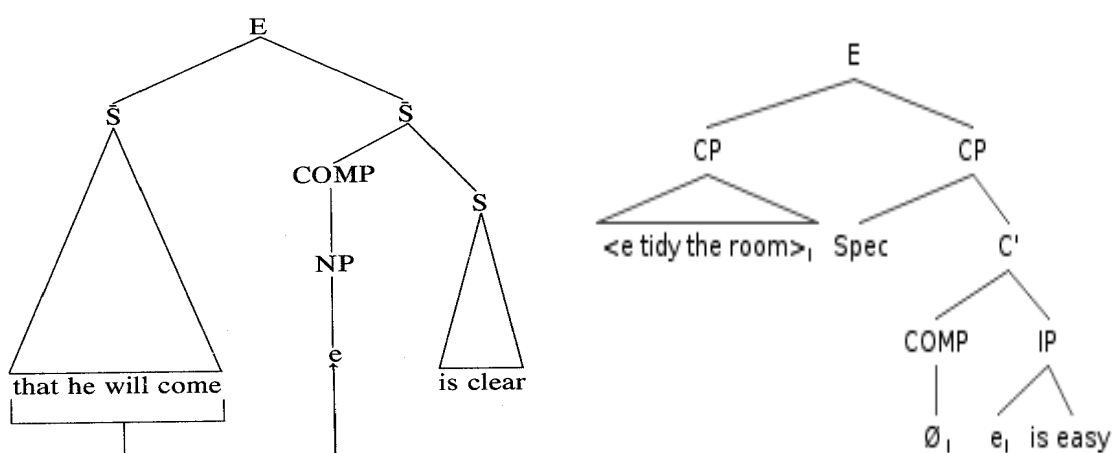


Figure 4.5: Left: Koster's structural representation of a topic sentence; Right: an attempt to extrapolate from Koster (1978) the structure of a Chinese clausal subject construction (with English gloss, and updated category labels).

If this analysis is adopted, a clausal subject construction has less advantage over a relative clause construction for the parser. In terms of structural nodes, the satellite analysis inserts one extra node (the *E* node in Figure 4.5.) over the clausal subject. Even so, there are still fewer nodes over the clausal subject than over the relative clause (see Figure 4.4 above). However, with the clausal subject in satellite position, the construction

⁶⁰ ‘*E* (= expression) is a symbol that dominates the satellite NP together with the root sentence’ (p. 57-58).

contains two filler-gap dependencies while the relative clause analysis contains only one. The satellite must be analyzed as the filler for a subject gap in the root clause that follows; note that this constitutes a syntactic chain. The subject gap inside the clausal subject, as usual, may find a filler somewhere elsewhere in the sentence or discourse.⁶¹ Thus, if Koster's analysis is adopted for the clausal subject construction in Chinese, it pits one extra filler-gap relation (in the clausal subject analysis) against an extra structural node (in the relative clause analysis). This complicates the above discussion about why the clausal subject was much more preferred than the relative clause in this experiment. On the other hand, no studies seem to have proposed Koster's analysis for Chinese subject sentences. One of Koster's arguments that a topic on top of a subject sentence is unacceptable does not seem to apply to Chinese.⁶² Thus, it remains an open question that Chinese clausal subjects are actually topics. There will be more discussion of Koster's analysis in Section 4.1.2.4.

Overall, the results of this experiment provide evidence to support both the principle of Minimal Attachment and the influence of empty category interpretation on structural ambiguity resolution. When the subject was overt in the fragments, the parser observed Minimal Attachment, as shown in the strong preference for the main clause over the two-clause constructions. However, when the subject was null, the parser was willing to violate Minimal Attachment in order to gain an interpretation for an empty category, which resulted in significantly more clausal subject continuations. This can be attributed to the fact that when the main clause is presented in isolation (in the 'null

⁶¹ But see section 2.4 on the possibility of a local interpretation of the empty subject in a clausal subject.

⁶² For example, the following sentence is acceptable in Chinese: *wo de xin gongzuo, wo meitian dou zheme kaixin jiu zhengming wo xihuan*. 'My new job_i, that I am so happy every day proves that I like e_i.'

context'), an empty subject within the main clause has no accessible co-referring noun phrase, and therefore no optimal interpretation. The clausal subject construction, however, can easily offer a referent for the empty category: the empty category can quite naturally assume generic reference, or it can co-refer with a noun phrase in the subsequent main clause predicate.

The lack-of-interpretation problem for an empty category within a main clause can be subsumed under the Principle of Parsimony discussed in Crain and Steedman (1985) and related works.⁶³ The gist of this principle is: In case of ambiguity, prefer an interpretation with as few presuppositions as possible. When an empty category does not have a co-referring referent, either within the sentence or in the discourse situation, the sentence presupposes the existence of an individual not previously introduced into the discourse, so a referent for it has to be mentally conjured up in order to interpret the sentence. In this case, the participant must imagine not only shared knowledge of an individual but also the existence of a prior discourse in which that individual was mentioned and is now referred back to. Under the Principle of Parsimony, this is dispreferred. (Recall that Experiment 1a provided no prior context for the target fragment. In a conversational situation the first and second person "I" and "you," referring to speaker and hearer, are available as potential referents, but these are unlikely in the impersonal situation of an experiment.) In contrast, for the fragments with an overt subject, e.g., *Mary*, a normal discourse situation is created with an individual supposedly known to both the speaker and the hearer. Of course, for a participant in the experiment a

⁶³ The Principle of Parsimony is defined as: "If there is a reading that carries fewer unsatisfied but consistent presuppositions or entailments than any other, then, other criteria of plausibility being equal, that reading will be adopted as most plausible by the hearer, and the presuppositions in question will be incorporated in his or her model" (Crain & Steedman, 1985, p. 333).

name like *Mary* has no real referent (as is often the case for experimental materials), but it partially simulates normal conversation with shared background knowledge.

4.1.1.4.2 Generic vs. Specific interpretation

Unlike some other kinds of empty category that have been studied from a psycholinguistic perspective (such as the gap in a relative clause or in a *wh*-question or in a subject-control or raising construction), the empty subject of a clausal subject may have a generic interpretation. (See section 2.4 for the discussion of the difference between arbitrary and generic reference.) Among the clausal subject continuations, Figure 4.2 shows that a generic interpretation was strongly preferred over a specific co-referential interpretation for the empty category. There are two possible explanations for this. It might have been due either to the demands of the completion task or to the Principle of Parsimony. Participants in the experiment might have been trying to minimize effort and time in creating their completions of the fragment. A generic interpretation for the empty category can be achieved through the absence of an explicit co-referent in the main clause predicate, or through co-reference between the empty category and an overt generic noun phrase in the main clause predicate. In the former case, not mentioning a referent at all is less effortful than specifying one. In the latter case, a generic reference is typically expressed by *ren* in Chinese, which is a single character word, whereas Chinese names are typically composed of two or more characters. Hence, a generic reference could be preferred on this basis. Alternatively, participants in the experiment might have been trying to minimize effort in conjuring up a discourse situation containing suitable referents. A generic interpretation has fewer presuppositions than a specific interpretation

(because the existence of a general class of individuals, such as people, or tigers, or blackboards, can be taken for granted more readily than the existence of a particular individual with specific distinguishing properties), so it requires less work to compose an imaginary context that satisfies its presuppositions. Thus, a generic interpretation may be favored on this basis by the Principle of Parsimony.

However, drawing this conclusion may be legitimate only for a completion task, not for a standard comprehension task where the perceiver could in principle simply wait to see whether or not the producer (the speaker or writer) mentions a specific referent later in the sentence. If no referent is provided later, the empty category could *then* be assigned the generic interpretation. It would be of interest to know whether this is the strategy that the human parser pursues. This raises the related question of *when* an interpretation is assigned to the empty category within a clausal subject in normal sentence comprehension. One option is that the parser adopts a passive strategy: it makes no decision at all, places no bets, until it finds out whether or not a plausible filler appears in the main clause predicate, and if so it associates the filler with the empty category at that time. An alternative option is that the parser adopts a more active strategy: it assigns an immediate interpretation to the empty category as soon as it encounters it. Since no coreferent has yet been encountered, the simplest interpretation is generic. The parser would revise this generic interpretation later if a more specific filler appears in the main clause predicate subsequently. Experiment 4, reported in section 4.4 below, was designed to evaluate these two strategies.

4.1.1.4.3 Frequency Adverbials

The adverbial constructions were included in Experiment 1a simply as a means of controlling out information load as a relevant factor in the outcomes. Figure 4.3 indicates that, unexpectedly, the three adverbials, *congbu* ‘never,’ *youshihou* ‘sometimes,’ and *changchang* ‘often’ behaved differently from each other in the sentence completion task: fragments with *congbu* were mostly continued as main clauses, but fragments with *youshihou* were typically continued as clausal subjects. For the time being, no satisfactory account can be offered in explanation of these unexpected findings. It can be noted, however, that morphologically, *youshihou* is different from the other two adverbials: While *congbu* and *changchang* are adverbs, *youshihou* can be a clause. *You* is a verb meaning ‘have,’ and *shihou* is a noun meaning ‘time.’ Together they mean ‘there is time,’ and semantically the expression is analogous to ‘sometimes’ in English. In addition, for some probably morphological reason, *youshihou* can be placed before or after the subject, which means it can be either a sentence modifier or a verb phrase modifier. In contrast, *congbu* and *changchang* usually occur after the subject; as a result, they are likely to be local modifiers, taking the scope of the clause where they are located. These differences are illustrated in the sentences in (6).

- (6) a. Youshihou [*e* *congbu*/*changchang* *zhengli fangjian*] *shi yige huai xiguan*.
 sometimes never/often tidy room is a bad habit
 ‘Never/often tidying the room is sometimes a bad habit.’
- b. **Congbu* [*e* *youshihou*/*changchang* *zhengli fangjian*] *shi yige huai xiguan*.
 never sometimes/often tidy room is a bad habit
 ‘Sometimes/often tidying the room is never a bad habit.’

- c. *Changchang [*e* *congbu*/*youshihou* *zhengli fangjian*] *shi yige huai*
 often never/sometimes tidy room is a bad
*xiguan.*⁶⁴
 habit
 ‘Never/sometimes tidying the room is often a bad habit.’

The consecutive occurrence of two adverbials in the sentences in (6) forces the first adverbial to be a modifier of the whole sentence and the second adverbial to be a modifier of the clausal subject. When *youshihou* precedes the other two adverbials, which inevitably forces it to be a sentence modifier, the whole sentence is good, as in (6a). On the other hand, when *youshihou* is preceded by the other two adverbials, which then forces them to be sentence modifiers, the whole sentence is hard to interpret, as in (6b,c). The fact that in the completion experiment, continuation patterns varied with the type of frequency adverbial in the fragment may be related to the modifying scope of the adverbials, even though it remains unknown why this linguistic property would be a contributing factor.

4.1.2 Experiment 1b

4.1.2.1 Aims

This follow-up study investigated whether the presence of a plausible antecedent in a preceding clause solves the lack-of-referent problem for the empty category within the V fragments in Experiment 1a and consequently, leads to more main clause continuations.

⁶⁴ This sentence is good if both *changchang* and *congbu* are read as local modifiers, and the sentence means ‘To often not tidy the room is a bad habit.’ But this just shows that *changchang* is highly preferred to take a local scope.

This is what my explanation of the Experiment 1a results predicts. The results could further verify the trade-off between empty category interpretation and structural ambiguity resolution that appears to have been driving the outcomes of Experiment 1a. Additionally, this experiment attempted to answer research question I: if a plausible filler is available when a gap is encountered, will the parser adopt it immediately?

4.1.2.2 Method

Materials. Two types of fragments, each consisting of one complete subordinate clause followed by one incomplete clause, were presented to participants for completion. The difference between them concerned whether or not the initial clause offered a plausible antecedent for an empty subject in the second clause. Examples of the fragments are shown in (7).

(7) a. Plausible antecedent

Xiaohua likai yiqian, *e* shuofu...

Xiaohua leave before convince

‘Before Xiaohua left, (someone) convinced...’

b. No plausible antecedent

Huocheli zhan yiqian, *e* shuofu ...

train leave station before convince

‘Before the train left the station, (someone) convinced...’

The second clause was identical in the two fragment types: it contained a null subject and a verb. The verbs used in this experiment were the same as those used in the V fragments in Experiment 1a. (See Appendix C for a list of the experimental items.) The first clause

of the ‘plausible antecedent’ fragments provided a plausible antecedent for the null subject in the second clause. In the case of (7a), it is a person called Xiaohua, who is a plausible subject for the verb *shuofu* ‘convince.’ In contrast, the first clause of the ‘no plausible antecedent’ fragments does not provide a plausible antecedent for the empty category. In the case of (7b), *huoche* ‘train’ is not a good subject for the verb *shuofu* (nor is *zhan* ‘station’). Thus, the difference between the two types of fragment in this study simulated the difference between the SV and V fragments in Experiment 1a: the plausible antecedent fragments in Experiment 1b, like the SV fragments in Experiment 1a, had a readily interpretable main clause subject, while the ‘no plausible antecedent’ fragments in Experiment 1b, like the V fragments in Experiment 1a, had no accessible referent to provide a good interpretation for the empty category. Therefore, the results of this study could be compared with those of Experiment 1a, to verify whether it is indeed the absence of a referent for the empty category that drives the parser to choose a more complex phrase structure analysis for an ambiguous fragment.

The questionnaire had two counterbalanced versions, each consisting of 24 target fragments as in (7), interleaved with 24 filler fragments of different structure but with similar length. These were sandwiched between four covert practice items, for a total of 52 fragments. The experimental items were pseudo-randomized so that no more than three target fragments were presented consecutively.

Participants. Twenty-six native speakers of Mandarin Chinese (age range 18-32; mean age 21; 18 female), from the same pool of Queens College students as in Experiment 1a, participated in the task. They usually took 20 to 30 minutes to finish the task.

Data Treatment. The completions were hand-coded, on the basis of the form of their second clause, into the same four categories as in Experiment 1a: main clauses, clausal subjects, relative clauses, and others. There were no missing completions.

4.1.2.3 Results

The results are shown graphically in Figure 4.6. For the numeric continuation rates of each fragment category, see Table B2 in Appendix B.

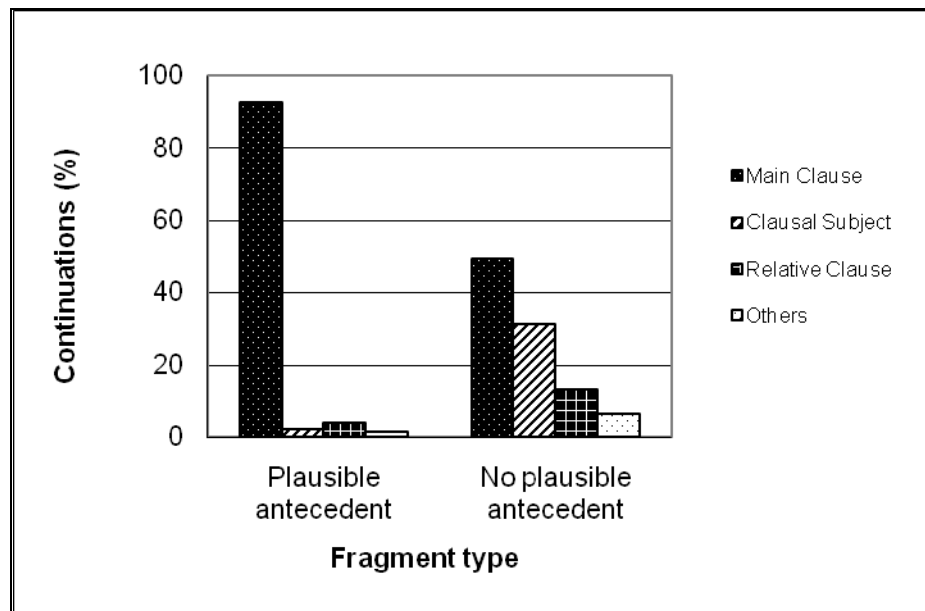


Figure 4.6: Completion results of Experiment 1b: form of the second clause.

Analyses of variance showed that the two types of fragment elicited reliably different main clause continuations—more with ‘plausible antecedent’ ($F_1(1, 24)=96.94$, $p<.001$; $F_2(1, 22)=59.75$, $p<.001$) and clausal subject continuations—more with ‘no plausible antecedent’ ($F_1(1, 24)=47.96$, $p<.001$; $F_2(1, 22)=51.53$, $p<.001$). As anticipated,

the ‘plausible antecedent’ items in this experiment behaved almost identically to the SV items in Experiment 1a. But when comparing Figures 4.1 and 4.6, it becomes clear that the completion patterns of the ‘no plausible antecedent’ fragments in this experiment were slightly different from those of the V fragments in Experiment 1a : there were more main clause and fewer clausal subject continuations in Experiment 1b in which the fragments were preceded by a context, than for the V fragments in Experiment 1a in which the fragments were presented without a context, even though both types of fragment lacked a plausible antecedent for the empty category. Moreover, out of the total of main clause plus clausal subject continuations for the ‘no plausible antecedent’ fragments, 62% were main clauses, which is reliably different from chance ($t_1(25)=1.95$, $p<.05$; $t_2(23)=1.96$, $p<.05$); this stands in contrast with Experiment 1a, where the clausal subject was significantly preferred over the main clause for the V fragments. Despite this, the two experiments showed a basic similarity, in that the number of main clause continuations was approximately halved when the main clause subject would have been an empty category with no (suitable) antecedent.

4.1.2.4 Discussion

The results of Experiment 1b support the proposed explanation of findings of Experiment 1a that the parser considers the ease of interpreting an empty category when it chooses an analysis for a structurally ambiguous fragment. In Experiment 1a, participants were more likely to choose the clausal subject than the main clause analysis for the fragments with an empty subject. In Experiment 1b, the absence of a plausible antecedent in the first clause triggered significantly more clausal subject continuations for the fragment in the

second clause, while the main clause was overwhelmingly preferred for the fragments with a plausible antecedent.

The clausal subject was preferred over the main clause for the V fragments in Experiment 1a, but the contrary was found for the ‘no plausible antecedent’ fragments in Experiment 1b. There could be several explanations for this difference. First, this could suggest that *any* context helps in empty category interpretation. In other words, any discourse context at all makes it a little easier for a reader to conjure up a likely referent for the empty category. The underlined parts of the sentences in (8) are completions by two participants; they can help illustrate this point.

- (8) a. Huoche li zhan yiqian, *e* shuofu xuduo qinren likai zhantai shi
 train leave station before convince many relative leave platform is
hen nan de yixiang renwu.
 very difficult DE one task
 ‘Before the train leaves the station, to convince the many relatives to leave the platform is a difficult task.’
- b. Huoche li zhan yiqian, *e* shuofu songxing de ren zoukai.
 train leave station before convince see-off DE people leave
 ‘Before the train left the station, (someone) convinced the people who saw (someone) off to leave.’

The first clause of the sentences in (8) does not provide a good antecedent for the empty subject within the second clause. The completion in both cases has to be a main clause in order to create a grammatical sentence. The difference is that the main clause in (8a) begins with a clausal subject within which the empty category can assume a generic

interpretation. The main clause completion in (8b) has the empty category as its subject, and this cannot have a generic interpretation in Chinese,⁶⁵ so no linguistic referent can easily be assigned to the empty category. However, given that the first clause of the sentence in (8b) creates the discourse context of a train platform, a referent for the empty category in the second clause could well be conjured up based on this non-verbal context as, for example, the train conductor. Because of that, empty category interpretation is less troublesome for the parser, and a violation of Minimal Attachment becomes less necessary to solve the lack-of-referent problem for the empty category, compared to the case of Experiment 1a where the absence of the first clause gave the perceiver no assistance in conjuring up a cast of characters in the imagined context.

The other explanations for the weaker preference for the clausal subject in the ‘no plausible antecedent’ condition in Experiment 1b, compared with Experiment 1a where there was no preceding context at all, have to do with the presence of an adjunct clause in the fragment for completion in Experiment 1b. According to Koster’s (1978) analysis, discussed in Section 4.1.1.4.1, a subject clause is a ‘satellite’ to the root clause, and he seems to imply that a satellite is equivalent to a topic (see, e.g., p.59). Since a sentence-initial adjunct clause can also be a topic, a subject-clause continuation of an Experiment 1a fragment would create a double-topic sentence, which may be generally dispreferred.

Another possibly relevant factor is that if the Experiment 1b fragments are accorded a clausal subject completion, the complete sentence must contain at least 3 clauses; in Experiment 1a, by comparison, the corresponding completion could consist of just 2 clauses. If, as seems quite plausible, the processing cost of an additional clause

⁶⁵ The empty subject of a main clause, unlike that of a clausal subject, cannot naturally assume a generic interpretation.

increases with the number of clauses already in the sentence, this would create a greater discouragement for the clausal subject analysis in Experiment 1b than in Experiment 1a.

Additionally, a clausal subject analysis may create an internal conflict which makes it a less preferred analysis. A clausal subject construction is often associated with a generic interpretation of the sentence; see the discussion in Section 4.1.1.4.2. The sentence-initial temporal adverbial would optimally therefore be absorbed by the clausal subject, leaving the matrix clause free to have a generic interpretation, e.g., with no specific temporal reference. However, in the experimental materials of Experiment 1b, there was a comma after the sentence-initial adverbial which in Chinese would be a very strong cue to attach the adverbial to the whole of the following clause. These two points are thus in tension and might therefore reduce the number of clausal subject continuations.

Finally, a clausal subject analysis may violate a Locality constraint. After the adverbial clause is parsed, the next word (the verb, e.g., *shuofu* ‘convince’ in (8)) has to be attached into the tree structure. The transition from the adverbial clause to the start of a clausal subject creates a discontinuity in the tree structure, that is, two words adjacent in the word string are distant in the structure; see Inoue and Fodor (1995: p.51ff.). (This is not the case for the Experiment 1a sentences with no initial adverbial.) It is not important for present purposes which of these various proposed explanations is correct, or whether some combination of them is.

The experimental results also indicate that when a gap has been identified, the parser will preferentially adopt a plausible referent if one is available to fill the gap. This is the most obvious explanation for the predominance of main clause continuations for

the ‘plausible antecedent’ fragments: once the gap was filled by the antecedent, it would not be necessary to create a two-clause construction to solve the problem of empty category interpretation. At least to this extent, then, it has been discovered that the parser is *active* in resolving the reference of an empty category, readily adopting an interpretation that is offered.

In a nutshell, the findings of Experiments 1a and 1b indicate that the structurally simple main clause analysis is preferred to the extent that a plausible discourse referent is available, but that the more complex clausal subject analysis, which can be interpreted without reliance on discourse context, may often be adopted otherwise. This implies that the parser adopts a plausible preceding antecedent, if one is available, for an identified gap.

4.2 Experiment 2

4.2.1 Aims

This experiment was designed to answer research questions I and II. The findings of Experiments 1a and 1b have shown that when facing a structural ambiguity, the parser is sensitive to how different structural analyses affect empty category interpretation and would sacrifice Minimal Attachment to secure a referent for the empty category. Moreover, it readily adopts a plausible referent to fill an identified gap. While these findings lend evidence to support an active parser in completing a filler-gap dependency, it might be argued that the off-line task employed by the two experiments sheds little light on the gap-filling strategy in real-time processing. Experiment 2, therefore,

employed self-paced word-by-word reading to collect on-line data. In addition to looking into the interaction of structural and empty category ambiguity resolution, this experiment also studied the effect of verb choice on empty category interpretation.

4.2.2 Method

Materials. The sentence completion study compared the proportions of main clause, clausal subject, and relative clause analyses assigned to an ambiguous fragment. But because mono-clausal and bi-clausal sentences are structurally very different, they are not good experimental materials for a self-paced reading task, which requires lexically matched test sentences for a useful comparison of reading times across experimental conditions. Therefore, this experiment used test sentences that were all bi-clausal; they began with a main clause and then contained either a clausal object, or else a relative clause modifying an object noun phrase. Thus in this experiment I switched from studying clausal subjects to studying clausal objects. The internal structure of a clausal subject and a clausal object is identical, though they differ in their position in the larger sentence. In addition to providing a better surface match between complement and relative clauses, the use of the clausal object also opens the door to an investigation on how verbs can affect empty category interpretation.

The test sentences of this experiment are illustrated in (9). In each case there is a main clause followed by a subordinate clause, the beginning of which is ambiguous between a clausal object and a relative clause. (In what follows I will abbreviate clausal object as CO, and relative clause as RC.) The difference between coreferential and non-coreferential verbs (abbreviated Coref and Non-coref) is explained below.

(9) a. **Coref+CO:** Coreferential verb + Clausal objectYao_i jujue [*e_i* tuichu zhegebisai de zongjuesai].

Yao refuse withdraw-from this-tournament DE final

'Yao refused to withdraw from this tournament's final.'

b. **Non-coref+CO:** Non-coreferential verb + Clausal objectYao_i fengci [*e_i* tuichu zhegebisai de zongjuesai].

Yao ridicule withdraw-from this-tournament DE final

'Yao ridiculed (someone) for withdrawing from this tournament's final.'

c. **Coref+RC:** Coreferential verb + Relative clauseYao jujue [*e_i* tuichu zhegebisai] de yundongyuan_i.

Yao refuse withdraw-from this-tournament DE athlete

'Yao rejected the athletes who withdrew from this tournament.'⁶⁶d. **Non-coref+RC:** Non-coreferential verb + Relative clauseYao fengci [*e_i* tuichu zhegebisai] de yundongyuan_i.

Yao ridicule withdraw-from this-tournament DE athlete

'Yao ridiculed the athletes who withdrew from this tournament.'

Sentences were presented visually word by word, following the self-paced reading procedure described at the beginning of this chapter. The presentation regions were as shown in (10). Each region contained only one word, except that the matrix subject within one target sentence was a complex noun phrase with three words, each of which was presented separately.

⁶⁶ *Jujue* can be translated into two English words; if it is followed by a complement clause, it means *refuse*, as in (9a), and if it is followed by a noun phrase, it means *reject*, as in (9c).

- (10) 1 2 3 4 5 6 7
 Matrix subject / matrix verb / subordinate verb / NP / DE / Noun / PERIOD

Two factors are varied in these sentences: the type of subordinate clause (clausal object vs. relative clause), and the type of matrix verb (coreferential vs. non-coreferential). The clause-type is established only by the last word of each sentence: *zongjuesai* ‘final’ (in the sense of final round of a competition) in (9a,b) forces the clausal object reading because it makes sense only as the object of the subordinate verb *tuichu* ‘withdraw-from,’ not as its subject; in contrast, *yundongyuan* ‘athlete’ in (9c,d) forces the relative clause analysis because it makes sense only as the subject of *tuichu*, not as its object. The subordinate clause factor is crossed with the matrix-verb factor. The matrix verb precedes the subordinate clause in all of these sentence types, so it can influence the subsequent processing of the empty category in the subordinate clause.

The two classes of matrix verbs contrasted in this experiment differ with respect to whether they encourage or discourage coreference between the subject of the matrix clause and the empty subject of a clausal object.⁶⁷ The verb *jujue* ‘refuse/reject’ in (9a,c) is strongly compatible with a clausal object whose empty category is coreferential with the matrix subject (i.e., the person who does the refusing is the person who does the

⁶⁷ The coreference relation between an overt element and a gap within a clausal object in the experimental sentences resembles the control relation in English and other languages. What I am calling ‘coreferential verbs’ are similar to subject-control verbs in English where the subject within the matrix clause is the controller. The ‘non-coreferential verbs,’ in contrast, discourage subject control; instead, the empty subject within the clausal object has to be bound by a discourse referent. However, I refrain from using the “control” terminology commonly used in the analysis of English, for two reasons. First, there has been debate about whether the type of filler-gap relation found in Chinese between an overt element in the matrix clause and a gap in a complement clause is the same as the control relation found in English. (See section 2.2.) Second, the gaps within the experimental sentences are not exclusively controlled, but only preferentially controlled by the subject; the gap can corefer with a discourse referent. In English, in this structural configuration (matrix clause followed by clausal object with null subject), the subject of a subject-control verb obligatorily controls the empty category.

withdrawing). This can be expected to influence the analysis of the ambiguous subordinate clause. The verb *jujue* is compatible with the relative clause analysis of that clause as well as with the clausal object analysis of it. However, given that a complement clause analysis is favored over a relative clause analysis for its structural simplicity, as indicated by Experiment 1, it can be anticipated that the parser would adopt the clausal object analysis on-line in (9a,c) and finding no conflict would continue with it through the sentence. Therefore it can be predicted that for the *jujue* sentences, the final word of (9a), which forces the clausal object analysis, will be easier to process than the final word of (9c), which forces the relative clause analysis. (See discussion below on how these final words can be legitimately compared.)

By contrast, the verb *fengci* ‘ridicule’ in (9b,d) does not naturally tolerate coreference of the empty category with the matrix subject (it is unlikely that the person who does the withdrawing is the same as the person who does the ridiculing), so a different interpretation has to be assigned when the processor detects the empty category in the clause following *fengci*. One possibility is a clausal object analysis whose empty category refers to a salient individual in the preceding discourse. That would require introduction of an imagined individual into the context since no preceding linguistic context was presented in this experiment. According to Crain and Steedman (1985), an enrichment of the context incurs a cost in sentence processing, as noted above (section 4.1.1.4.1).⁶⁸ The alternative is a relative clause analysis, in which the empty category is

⁶⁸ Y. Huang (1994) maintains that an “arbitrary interpretation” for the empty subject within a clausal object is possible though it is the least accessible interpretation. (See section 2.2.2.) However, I and other native speakers I have consulted do not accept an arbitrary interpretation in the sense that is roughly equivalent to generic (see section 2.4). Huang does not explain the meaning of “arbitrary” as he uses it. I suspect that what he has in mind is what I have been calling a mental creation of a discourse referent even in the absence of an overt discourse. In that sense, his judgment that this interpretation of the empty subject is possible but least preferred is compatible with native speaker intuitions.

coreferential with the head noun that occurs later in the sentence; this can avoid the need to ‘create’ an individual in the context, but it violates Minimal Attachment if a relative clause structure, rather than a clausal object structure, is chosen on-line.⁶⁹ Thus, which of these two analyses (clausal object versus relative clause) is adopted on-line by the parser for the *fengci* sentences will reveal whether the parser is prepared to override Minimal Attachment and adopt the relative clause analysis in order to reap the benefit of a guaranteed filler later in the sentence (the head noun that the relative clause modifies). If the clausal object analysis is adopted, the final word of (9b) is predicted to be easier to process than the final word of (9d); if the relative clause analysis is adopted, the reverse would be true.

Processing difficulty can be assessed in terms of longer reading times, but it is improper to compare these measures for different lexical items, such as *zongjuesai* and *yundongyuan*; however, the four-way comparison among (9a,b,c,d) controls for this lexical difference. It can be inferred that the relative clause analysis is adopted on-line (at least sometimes) for the *Non-coref* sentences if the results show that the (b) version is harder at its final word than the (a) version, but the (d) version is easier at its final word than the (c) version. In other words: A significant interaction between the factors Matrix-Verb Type and Clause Type will indicate that structural simplicity does not outweigh optimal empty category interpretation; a significant effect of Clause Type without any interaction with Matrix-Verb type will show that it does.

⁶⁹ As shown in Figure 4.4 above, a relative clause construction has two more structural node than a clausal subject construction; therefore the former is structurally more complex. Since the structure of a clausal object is identical to that of a clausal subject, the clausal object analysis is also preferred over the relative clause analysis by Minimal Attachment.

Spillover is a common phenomenon in self-paced reading, or even in reading in general (Mitchell, 2004). It refers to a phenomenon such that processing difficulty at one point in a sentence may result in longer reading times not at that segment itself but at a following segment. Thus, in employing this research method, it is important that the segments following the critical region be identical, so that they could not be the source of any reading time differences observed there, and any effect found at those following segments can safely be attributed to the critical region that precedes them. In this experiment, this condition is met: content is constant in the region immediately following each of the target regions (i.e., the subordinate verb in target region 3, and the sentence-final noun in target region 6). Hence, any effect found at the regions following these target regions (i.e., at regions 4 and 7 respectively) is likely to have originated in the processing costs of the different versions of the target regions. Also relevant, though not yet evident, is that spillover may be greater for plausibility disambiguation than for syntactic disambiguation, because syntactic information could be used prior to semantic/plausibility information on-line (van Gompel & Pickering, 2006). Therefore, a delayed effect may result if a structure is disambiguated by plausibility.

Note that one of the regions of interest is the last word of the sentences (i.e., region 6), which may be subject to a sentence-final ‘wrap-up’ effect. As shown in many previous self-paced reading studies (see Mitchell, 2004), readers may take time to consolidate the structure and meaning of the whole sentence if they know they are reading the last word of a sentence. As a result, the reading time of this word may not only reflect the processing load due to the local structure, but also the processing effort accrued by the whole sentence. A way to mitigate this wrap-up effect is to add a phrase

after this region so that it will no longer be in the sentence-final position. This, however, is not an easy undertaking for Chinese. Chinese permits few structural categories to occur after the verb except for the object. Thus, the usual tactic used for English, of adding an adverbial after the object, is not feasible in Chinese.⁷⁰ The approach adopted here to ameliorate this problem is to display the final period (the symbol ‘。’ in Chinese orthography) separately from the last word. In this way, participants do not know they are reading the final word when they are at region 6.⁷¹ Region 7 contains only the period in all of the target sentences; therefore its reading times are easy to compare.

Apart from exploring the possibility of an interaction between Matrix Verb Type and Clause Type, this experiment also investigated the time course of the parser's use of verb-type information to guide adoption of a suitable filler for a gap. The second verb in the test sentences (region 3) establishes clear that the sentences contain a subordinate clause with a subject gap. Since the *jujue*-type of verb tends to suggest coreference of the empty category with the matrix subject, while the *fengci*-type of verb renders this unlikely, a clausal object analysis for the *jujue* sentences easily solves the interpretation problem of the empty category. However, the same is not true for the *fengci* sentences; a clausal object analysis requires the creation of an individual for empty category interpretation, while a relative clause analysis requires trading a simpler structure for a more complex one. The adoption of either non-optimal analysis will probably cause

⁷⁰ In Chinese, two types of adverbial are allowed after the object. One is cardinal frequency adverbials like *sanci* ‘three times,’ and the other is cardinal duration adverbials like *santian* ‘(for) three days.’ But these adverbials are often not compatible with the meaning of the whole sentence, and their repeated use would make the target sentences too conspicuous.

⁷¹ Theoretically, given that very few constituents can occur after an object in Chinese, the reader may be able to guess region 6 in an experimental sentence is the last word of the sentence. However, that seems to be unlikely, for two reasons. First, it requires substantial metalinguistic knowledge of Chinese, which naïve participants are unlikely to possess. Second, anticipating the end of a sentence at every word requires additional processing resources but it brings very little benefit in facilitating comprehension.

processing difficulty, resulting in a longer reading time. A question of interest is when this effect emerges in the reading times. That will depend on how fast the verb-type information is made use of on-line. (See section 3.2.2 for review of the debate over the time course of use of lexico-semantic information on-line.) If matrix verb information is used rapidly, a reading slowdown might appear at the subordinate verb, or the word after it if there is spillover, in (9b,d), as compared to (9a,c). If use of verb information is subject to delay, there might be no significant difference between the reading times until later, perhaps not until the final word.

Note that a rapid co-indexation of the matrix subject and the gap hinges not only on the rapid use of verb information, but also on whether the parser is inclined to immediately adopt a plausible filler that presents itself despite the possibility that the structure could turn out not to be an object complement construction and a different filler could be encountered later. If the parser does not favor immediate filler adoption, it could hold back and wait to see how the structure develops and whether there is a better filler that appears later. In that case, Minimal Attachment would create a general preference for the clausal object analysis for *all* the sentences in (9) regardless of what kind of verb is in the matrix clause, so the *jujue* sentences would have no processing advantage over the *fengci* sentences at the beginning of the subordinate clause.

There are three additional concerns regarding the test sentences in (9). First, it might be argued that the sentence in (9a) contains only one gap but that in (9b) it contains two gaps. Note that the English verb *refuse* is subcategorized for a complement clause, and the English verb *ridicule* is subcategorized for an object noun phrase and a complement clause. One might therefore wonder whether the structures in (9a,b) are

accurate syntactic representations of the sentences. This is a concern especially because a two-gap structure may be read slower than a one-gap structure. A reading slowdown found for (9b), relative to (9a), may therefore not be due to the lack-of-referent problem for the gap, as discussed above. However, no studies, as far as I know, have shown that a double-gap sentence is harder to comprehend than a single-gap sentence. (For the syntactic arguments of this number of gaps problem, see Appendix A.)

Frazier, Clifton, and Randall (1983), and Clifton and Frazier (1986) (see Section 3.2.1) first drew attention to the issue of possible processing difference between sentences with one and two gaps, but their interpretation of the experimental data was very controversial and was largely refuted in a series of studies by Crain & Fodor (1985), Tanenhaus et al. (1989) and Boland et al. (1990). These latter works all indicated that both the *wh*-gap and the control gap in the constructions tested were filled correctly (i.e., by reference to the grammar, not by a recency strategy) as they were encountered, as long as the matrix verb was unambiguous. There was some indication that the two-gap construction required more processing effort at the location of the gaps than the one-gap construction, but the evidence was slight: in the Crain & Fodor data the difference was non-significant, and in the Boland et al. data it showed up only later in the sentence, not at the gap position. In addition, the portion of sentence that showed the effect in their study was not matched for the four conditions of most of the experimental sentences, thereby significantly weakening the claim that the effect is due to an additional gap in the sentence. Thus the source of such effects remains unsettled and deserves further research. However, there is some reason to believe that matrix verb ambiguity may have been the significant factor. A relevant finding from the Crain & Fodor study is that a two-gap

construction with an ambiguous matrix verb was significantly harder at the gap position than a two-gap construction with an unambiguous matrix verb. Clifton and Frazier (1986) found a marginal effect of the same kind. In the present study, as discussed in Appendix A, both types of matrix verb are ambiguous between a one-gap and a two-gap analysis, so it is unlikely that the number of gaps could be the cause of easier processing of the *jujue*-type over the *fengci*-type at the beginning of the subordinate clause in Chinese. As proposed later in sections 4.2.3 and 4.2.4, that difference might be attributed most plausibly to a gap-filling problem in the *fengci*-type version, which clearly does exist regardless of how many gaps there are.

A second concern is that the strength of the complementation preference of a main verb may influence the likelihood that a particular structural analysis is assigned to the subordinate clause. For example, if a certain verb is subcategorized for both a noun phrase object and a clausal object, but with a strong bias toward the latter, then the clausal object analysis may be overwhelmingly preferred on-line regardless of the interpretive needs of the empty category. On the other hand, a strong preference for a nominal object might drive the processor to adopt the relative clause analysis, regardless of its slightly more complex structure.

A third concern is that there could be disagreement about how strongly a given matrix verb suggests a coreferential or a non-coreferential reading between the empty category and the matrix subject. This depends on the semantics of the matrix verb, perhaps also in interaction with the meaning of the matrix subject and the subordinate verb. These two verb properties (degree of preference for a complement of one syntactic category or another; and strength of bias toward coreference or non-coreference between

the subjects of the two clauses) could have a substantial impact on the results of the experiment, and need to be controlled for. A verb norming study and a subsequent materials refining procedure were therefore undertaken to assess the properties of candidate matrix verbs and select those most suitable for the experiment. Their details are reported in sections 4.2.2.1 and 4.2.2.2.

The experiment had a 2 x 2 Latin Square design, fully crossing Verb Type (co-referential vs. non-co-referential) with Clause Type (clausal object vs. relative clause). The 32 x 4 target items were counterbalanced across 4 lists and interspersed among 64 fillers. The fillers included 16 items serving as target materials for Experiment 3; the remaining 48 filler items of various constructions were included in the experiment to distract attention away from the targets. Each list began with 3 covert practice items immediately followed by the 96 (32 targets, 64 fillers) items presented in a pseudo-random order. (See Appendix D for a complete list of items.)

Procedure. Sentences were presented visually, segmented into regions as shown in (10) above. A comprehension question following each sentence with two answers provided. The comprehension questions did not directly ask about the local ambiguities of interest to this study, in order to avoid drawing too much attention to the target items. Thus, the accuracy rates for the questions shed no light on the processing of the target regions and was intended only to exclude inattentive participants. In addition, since the comprehension questions were different for different types of sentences, their reading times were non-comparable.

Participants. Participants who had an error rate higher than 15% (14 wrong answers to a total of 96 comprehension questions) were excluded from the reading time

data analysis. As a result, 2 participants were rejected and replaced. In the end, 14 participants for each list, totaling 56 participants, successfully completed the task (age range 18-33; mean age 22; 38 female). For the 56 participants contributing to the reading time data, the average error rate on the comprehension questions was 4.7 %. (The error rate of the targets was 5.4%, and that of the fillers was 4%.)

Data Treatment. For each region of the target sentences, reading times more than 3 standard deviations away from the mean reading time of an individual participant were discarded. This procedure eliminated 283 data points. Together with 4 display errors, there were, in total, 287 data points discarded, which accounted for 2.3% of the total data points.

Analyses of variance were performed on the reading times for each region in the target sentences to identify the effect of Verb Type (coreferential vs. non-coreferential), Clause Type (clausal object vs. relative clause), and possible interactions.

4.2.2.1 Norming Study

The norming study aimed to match the complementation preferences of the two types of matrix verbs to be used in Experiment 2. (See discussion of Walenski (2002) in section 3.1.2 for the importance of controlling complement expectations.) A sentence completion task was employed, and participants were instructed to complete the fragments in their preferred way. The task interspersed 30 target fragments⁷² and 30 filler fragments, which were all sandwiched by six covert practice items. All of the target fragments included an

⁷² A greater number of items would have been ideal but was not a practical option. This is because only a small proportion of Chinese verbs can take as their complement either a clausal object with a null subject, or a [+human] object noun phrase (which will be linked to an empty category in a relative clause modifying it). Thus, out of 1,223 Chinese verbs listed in Meng, Zheng, Meng, and Cai (1999), only 30 were suitable for this norming study.

overt animate subject, and a transitive verb that (according to my native speaker intuitions) can be complemented by a clause or a noun phrase. An example of the target items is shown in (11).

- (11) Wo xihuan...
I like

Materials were counterbalanced across 2 lists. Fragments were pseudo-randomized, and any runs of more than 3 targets were eliminated.

Twenty-six native speakers of Mandarin Chinese (age range 18-24; mean age 20; 19 female) from the Queens College subject pool participated in the task. No time limit was imposed on the task. Participants usually took 20 to 30 minutes to finish the task. The completions were hand-coded into three categories: noun phrases, clausal objects, and others. There were no missing completions.

Out of the 30 target verbs, 16 were selected and used in the target sentences for Experiment 2. A major selection criterion was whether a verb could be paired up with another verb that has a similar preferred category of complement but an opposite (non)coreferentiality bias. (I will discuss coreferentiality bias in section 4.2.2.2.) Table 4.1 shows the verbs selected and their complementation patterns.

Table 4.1: The verb pairs selected for Experiment 2. The NP preference score (in percent) next to each verb is the probability that the verb takes a noun phrase as its complement. The verbs in the left column are considered ‘coreferential’ verbs and those on the right are ‘non-coreferential’ verbs.

Co-referential	NP	Non-co-referential	NP
Verbs	preference	Verbs	preference
	score (%)		score (%)
jide (‘remember’)	19	guli (‘encourage’)	15
danxin (‘worry’)	24	bangzhu (‘help’) ^a	20
wangji (‘forget’)	35	zhizhi (‘stop-from’)	31
xihuan (‘like’)	44	fandui (‘oppose’)	46
taoyan (‘detest’)	50	zhichi (‘support’)	54
jujue (‘refuse’)	56	fengci (‘ridicule’)	64
fankang (‘resist’)	72	huanying (‘welcome’)	77
denghou (‘wait’)	87	kongzhi (‘control’)	79
Mean	48	Mean	48

Note. The figures listed in Table 4.1 are derived from the total number of cases in which a noun phrase was used in completion, divided by the total number of cases in which either a noun phrase or a clausal object was used. As noted in the preceding paragraph, there was a category of ‘others’ in categorizing the completions. But since this category only accounts for 0.1% of the total completions for the verbs selected, it was not counted in deriving the probability ratios.

^a *Bangzhi* ‘help’ is a verb that can easily cause confusion about the reference of the null subject within a clausal object. For example, in *Jim helped to renovate the house*, Jim certainly helped someone else’s renovation efforts, but he also participated in the renovation. Who to count as the doer of renovation is thus unclear. The experimental sentences with *bangzhi* ‘help’ for Experiment 2 were therefore carefully constructed so that the agent of the action in the subordinate clause must be someone else but not the matrix subject. As a result, *bangzhu* was a non-coreferential verb. For example, if Jim helped (someone) to join a big company, then Jim himself was not joining, but only someone else.

Note that the verbs in both columns of table 4.1 show a wide range of NP preference, characteristic of the language at large. (It might have been ideal if the preference for clausal or nominal complement for each verb was around 50% but this was not a realistic

possibility in view of the limited range of candidate verbs. Note, however, that the means across the verbs of each type are close to 50%.)

Results of a t-test showed that the NP preference score of the two groups of verbs are minimally different ($p=.95$). Test sentences for Experiment 2 were constructed using these eight pairs of verbs. The total number of target sentences in Experiment 2 was 32. Each pair of verbs would appear in four different sentence contexts, but for each sentence context participants would see only one verb of the pair; hence a participant would see each verb twice. Given that these are all common verbs in Chinese, and that there were 48 fillers and 16 test sentences from Experiment 3 in the task, this repetition did not seem conspicuous.

4.2.1.1 Refining the materials

To ensure that the sentences formed by each pair of verbs had opposite biases with regard to coreference between the matrix subject and the empty category in the subordinate clause, the materials were refined in consultation with 2 expert judges. Only the target sentences with a clausal object (that is, the *Coref+CO* and *Non-coref+CO* sentences; see (9) above) were included in the questionnaire for this study. The reason for excluding sentences with a relative clause was that the empty category within the relative clause must refer to the object noun that follows, and hence, it would be pointless to check the interpretation of the empty category. Only when the subordinate clause is a clausal object will it make sense to examine how likely the matrix subject and the empty subject co-refer. In the self-paced reading task of the main experiment, the participants certainly would not know whether the sentence ended in a clausal object or a relative clause at the

point when they saw the second verb. Thus, results of this procedure in fact had implications for the verb preference for empty category interpretation in all the target sentence types.

A questionnaire containing only the clausal object target sentences for Experiment 2 was given to 2 native Mandarin speakers, who at the time of this experiment were doctoral students in the Linguistics Program at the CUNY Graduate Center. A question in the questionnaire is illustrated in (12). (The questions were all presented in simplified Chinese characters in the questionnaire, but for readers' convenience, the example and the question in (12) are given in English translation.)

(12)	Yao Chun Ming refused to <u>withdraw</u> from the final of this tournament.	Yao	[]	[]	[]	[]	[]	someone else

Is this sentence about 'Yao Chun Ming,'
or someone else, who withdraws from the
final of this tournament?

The first page of the questionnaire was the instruction page. The judges were told to consider who is more likely to be the subject of the underlined verb in each sentence in the questionnaire. If they thought it very likely to be the matrix subject, they should check the box on the far left. If they thought it very likely to be someone other than the matrix subject, they should check the box on the far right. If their intuitions did not incline toward either extreme, they should check one of the three boxes in the middle. It was explained in the instructions that the center box was reserved for cases in which both the matrix subject and someone else were equally likely to be the subject of the

underlined verb. The two judges completed the questionnaire at their own pace and time. They knew each other but did not communicate with each other regarding the questionnaire. They were not compensated for the task.

The two judges did not easily agree on some of the sentences in the initial version of the questionnaire. The items the judges did agree on were put aside, and those on which they did not were modified and the questionnaire task was repeated. After several alterations of the sentences, thirty-two test sentences with the necessary properties for Experiment 2 were successfully constructed, each in four versions as illustrated in (9) above.

4.2.3 Results

For ease of reference in interpreting the results of this experiment, the definition of presentation regions in (10) above is repeated here.

(10)	1	2	3	4	5	6	7
	Matrix subject / matrix verb / subordinate verb / NP / DE / Noun / PERIOD						

Results of the analyses of variance are summarized in Table 4.2. For the mean reading times of each region, see Table B3 in Appendix B.

Table 4.2. Analysis of variance results by region in Experiment 2

Region	Main Effect			Main Effect			Clause Type $\times$ Verb			
	Clause Type			Verb Type			Type Interaction			
	<i>df</i>	<i>F</i>	Sig.*	<i>df</i>	<i>F</i>	Sig.*	<i>df</i>	<i>F</i>	Sig.*	
1	<i>F</i> ₁	1,52	.07	<i>F</i> ₁	1,52	.63		<i>F</i> ₁	1,52	.85
	<i>F</i> ₂	1,28	.24	<i>F</i> ₂	1,28	.29		<i>F</i> ₂	1,28	.83
2	<i>F</i> ₁	1,52	.06	<i>F</i> ₁	1,52	18.40	●●●	<i>F</i> ₁	1,52	.00
	<i>F</i> ₂	1,28	.23	<i>F</i> ₂	1,28	14.16	●●●	<i>F</i> ₂	1,28	.00
				<i>minF'</i>	1,66	8.00	●●			
3	<i>F</i> ₁	1,52	.96	<i>F</i> ₁	1,52	1.46		<i>F</i> ₁	1,52	3.07 ○
	<i>F</i> ₂	1,28	.54	<i>F</i> ₂	1,28	1.07		<i>F</i> ₂	1,28	3.16 ○
								<i>minF'</i>	1,73	1.56
4	<i>F</i> ₁	1,52	1.08	<i>F</i> ₁	1,52	9.66	●●	<i>F</i> ₁	1,52	1.58
	<i>F</i> ₂	1,28	.95	<i>F</i> ₂	1,28	5.11	●●	<i>F</i> ₂	1,28	2.30
				<i>minF'</i>	1,57	3.34	○			
5	<i>F</i> ₁	1,52	.00	<i>F</i> ₁	1,52	2.05		<i>F</i> ₁	1,52	.59
	<i>F</i> ₂	1,28	.00	<i>F</i> ₂	1,28	1.10		<i>F</i> ₂	1,28	.49
6	<i>F</i> ₁	1,52	.00	<i>F</i> ₁	1,52	.00		<i>F</i> ₁	1,52	.69
	<i>F</i> ₂	1,28	.01	<i>F</i> ₂	1,28	.21		<i>F</i> ₂	1,28	.46
7	<i>F</i> ₁	1,52	.12	<i>F</i> ₁	1,52	.01		<i>F</i> ₁	1,52	10.48 ●●
	<i>F</i> ₂	1,28	.25	<i>F</i> ₂	1,28	.08		<i>F</i> ₂	1,28	5.5 ●
								<i>minF'</i>	1,58	3.61 ○

* Sig. = Significance level:

- $p < .10$
- $p < .05$
- $p < .01$
- $p < .001$

The reading time results will be discussed region by region.

Region 1, e.g., *Yao* (1-6 characters, mean: 2.5): This region contained the matrix subject of the sentence, identical in all versions. There were no significant differences in the reading times between conditions.

Region 2, e.g., *jujuelfengci* ‘refuse/ridicule’ (2-3 characters, mean: 2.13): This region contained the matrix verb. A main effect of Verb Type was found: the non-co-referential verbs took longer to read than the co-referential verbs. But no interaction of Verb Type and Clause Type was found, as expected. Since the verb types were not matched for length, frequency or other possibly relevant factors, the reading time difference between them cannot be interpreted in relation to the purposes of this experiment.

Region 3, e.g., *tuichu* ‘withdraw’ (1-3 characters, mean: 1.88): This region contained the second verb of the sentence, and therefore, signaled the presence of a subordinate clause lacking an overt subject. This was where the structural ambiguity and empty category ambiguity began. The subordinate clause can be either a clausal object or a relative clause, and the empty category may or may not refer to the matrix subject, depending on the structural analysis assigned to the subordinate clause and the plausibility of the matrix subject as the filler for the gap. For a coreferential verb, a clausal object with coreference would be an easy analysis. For a non-coreferential verb, a longer reading time might be incurred if the parser were building the structurally more complex relative clause, or a clausal object with a non-optimal antecedent for the empty category. However, the results showed no significant differences in the reading times in this region.

Region 4, e.g., *zhegebisai* ‘this-tournament’ (2-6 characters, mean: 4.19): This region contained a noun that could be the object of the subordinate verb. The reading times for this noun in the sentences with a non-co-referential verb were significantly longer (on average, 40 ms) than those for sentences with a co-referential verb. Figure 4.7 below shows the reading times at this region graphically. The lexical material is identical for all variants of the sentence, so it is reasonable to consider this effect to be ‘spillover’ from region 3. As noted above, at region 3 the parser would be faced with an easy analysis in sentences with a coreferential verb, but in sentences with a non-coreferential verb the parser would have to select one of two non-optimal solutions, which would be expected to elevate the reading times. The results are fully compatible with this prediction, if the difference observed in region 4 is regarded as being a delayed effect (spillover) of the processing costs at region 3.

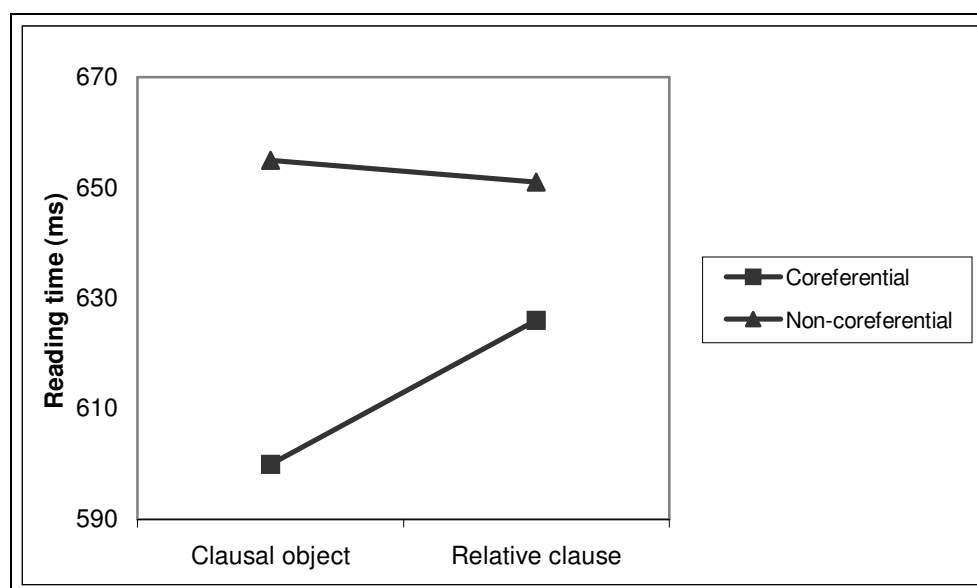


Figure 4.7: Mean reading times to Region 4 in Experiment 2.

Region 5, *de* (1 character): This region contained the character *de* in all sentences, and no significant differences in the reading times were found. *De* is a very common character in Chinese, and has different functions depending on its position in a sentence, and what phrase it is attached to. One of those functions is to mark the preceding phrase or phrases as modifiers for the nominal that follows. In this experiment, *de* could indicate that region 4 alone was a modifier of the following noun, or that regions 3 and 4 together were a relative clause modifying that noun. In either case, no substantial structural reanalysis was required at this region. If a clausal object analysis had been assumed for the subordinate clause, the appearance of *de* only required a downgrade of the region 4 noun from the object of the subordinate verb to a prenominal modifier of the object (for example: *zhegebisai* ‘this-tournament’ would become a modifier of *zongjuesai* ‘final’). If a relative clause analysis had been assumed, the appearance of *de* further supported this analysis since most relative clauses end with *de*.

Region 6, e.g., *zongjuesailyundongyuan* ‘final/athlete’ (2-4 characters, mean: 3.06): This region contained a single noun. These nouns were unmatched between the sentences with a clausal object and those with a relative clause. It was this word that disambiguated the subordinate clause to either the clausal object or the relative clause analysis. As discussed earlier, it was predicted that reading of this noun would be more difficult for sentences with a coreferential verb if disambiguated to the relative clause analysis, and for sentences with a non-coreferential verb if disambiguated to the clausal object analysis. Note that these two comparisons are legitimate since they involve lexically matched items.

However, statistical analysis showed no significant difference in the reading times of all sentences. It could be concluded that either the experimental hypothesis was false, or else this was another case of spillover of processing difficulty to a subsequent region.

Region 7, PERIOD (1 symbol): This region contained the same symbol “。” (the period in Chinese orthography) in all sentences. Analyses of variance showed a significant interaction of Verb Type and Clause Type (see Table 4.2 above and Figure 4.8 below): the *Coref+CO* and *Non-coref+RC* sentences were read significantly faster than the *Non-coref+CO* and *Coref+RC* sentences (for clausal object only: $\Delta 32$; $F_1(1, 52)=8.24$, $p<.01$; $F_2(1, 28)=2.83$, $p=0.1$; for relative clause only: $\Delta 34$; $F_1(1, 52)=5.58$, $p<.05$; $F_2(1, 28)=4.88$, $p<.05$).

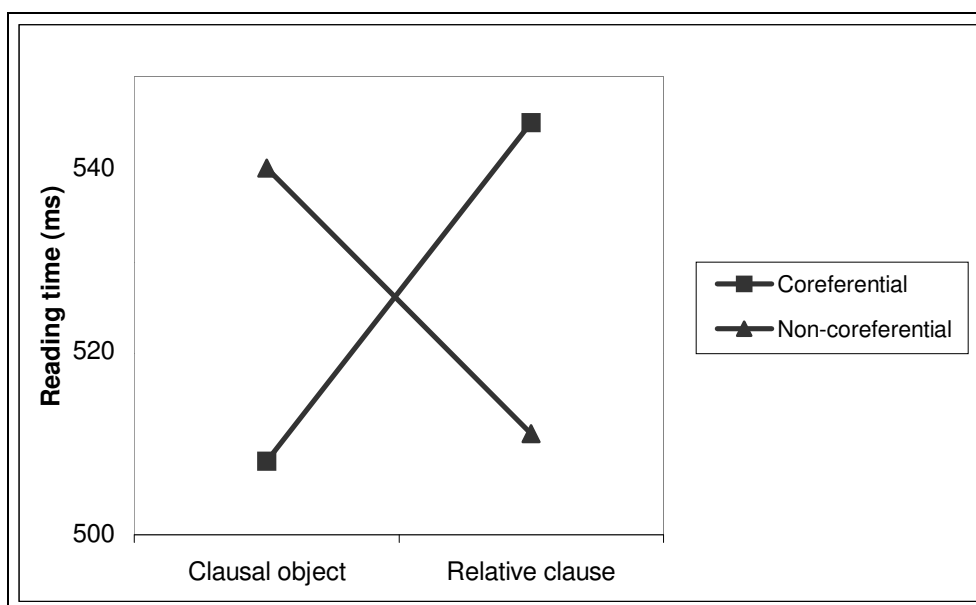


Figure 4.8: Mean reading times to Region 7 in Experiment 2.

There could be two explanations for the interaction, given that this sentence-final region is lexically matched across experimental conditions. One is that it was due to end-

of-sentence wrap-up processing. The other possibility is that it was due to spillover from the previous region, which would be compatible with the predictions outlined above for region 6 but which were not realized there. A careful study of the reading times in other regions discounts the first explanation, if we take it to imply that aspects of the sentence other than immediately local processing enter into wrap-up costs. The two *Coref* sentence types were identical except for region 6; hence any difference in the reading times of these two types of sentence must come from the processing of region 6. The same was also true for the two *Non-coref* sentence types. Moreover, between the relative clause sentences, the *Non-coref+RC* sentences were overall harder than the *Coref+RC* sentences prior to region 7 (specifically, at regions 2 and 4), but at region 7 the *Non-coref+RC* were easier. Together, these considerations suggest that region 7 findings are not due to wrap-up processing that consolidates the whole sentence, but are due specifically to spillover from region 6, exhibiting exactly the interaction that was predicted on the basis of the parser's encounter with the disambiguating noun there.

If the interaction at region 7 can safely be attributed to spillover from region 6, it implies that there was indeed a tradeoff between structural ambiguity resolution and empty category interpretation, which is the issue of central interest in this dissertation. An account of on-line processing which unites all the findings noted above goes as follows. First, abiding by Minimal Attachment and encouraged by the presence of an antecedent for the empty category, the parser adopts a clausal object analysis for both the *Coref* sentences, which later (at the disambiguating noun in region 6) turns out to be the correct analysis for the *Coref+CO* sentences but results in a garden path for the *Coref+RC* sentences. The clausal object analysis not being suitable for the *Non-coref* sentences, it

can be surmised that a relative clause analysis initially has been adopted on-line for both of the *Non-coref* sentences, to solve the problem of empty category interpretation. This analysis later turns out to be correct for the *Non-coref+RC* sentences, but creates a garden path for the *Non-coref+CO* sentences. In short: The *Coref+CO* and *Non-coref+RC* sentences were the only ones that avoided a need for structural reanalysis at region 6; and they were precisely the ones that were read more rapidly at region 7. It can be deduced from this that it is not necessarily the case that a relative clause must be less preferred than a complement clause in sentence processing; the presence of an empty category in need of interpretation can override the otherwise very general preference for structural simplicity.

The present findings may also have a contribution to the understanding of how to interpret self-paced reading data. The lexical effect triggered in region 2 was realized there, locally. By contrast, structural effects consistently showed up in the regions following the ones that, by the best available reasoning, must have been those that triggered them. The combined structural and empty category ambiguity was first identified at region 3, but the effect actually showed up in region 4. The same is true for the interaction between verb type and disambiguation: Region 6 disambiguated the subordinate clause and the reference of the empty category, but the effect was observed in region 7. (Note that the structural disambiguation at regions 3 and 6 was a plausibility disambiguation.) Such a delay in timing has been reported before for the self-paced reading task (see, for example, Mitchell, 2004), but its occurrence is not always consistent. The present data suggest that a relevant factor determining its incidence is whether the source of processing difficulty is lexical or structural.

As discussed above (section 4.2.2), the absence of lexical difference in regions 4 and 7 could allow us to safely attribute the effects to the differences in the previous regions.

4.2.4 Discussion

This experiment attempted to answer research questions I (i.e., whether the parser adopts the first candidate filler) and II (i.e., whether empty category interpretation interacts with structural ambiguity resolution). Taking question II first: The results provided evidence to support the claim that the parser is sensitive to the interpretative needs of empty categories, and may be willing to sacrifice economy of phrase structure in order to obtain a suitable filler for an empty category that has been identified on-line. This finding is revealed in the interaction found at region 7, as has been discussed in the previous section. In regard to question I: A plausible filler is indeed rapidly adopted for gap interpretation. This process is sensitive to verb information which is used on-line in sentence processing: the parser evidently knows within a word or two whether a nominal is a plausible filler for a gap or not. Question I can be pursued still further by asking: *How rapidly is a plausible filler adopted online?*

At region 4, sentences with a coreferential matrix verb were read faster than sentences with a non-coreferential matrix verb. The influence of the matrix verb (in region 2) on reading times at the noun in region 4 that follows the subordinate verb, reveals that the parser is sensitive to different matrix verb types, including sensitivity to their meanings in so far as the meaning dictates the likelihood that the matrix subject is coreferential with the subject of the clausal object. This information had to be used

rapidly (with just one intervening word, mean reading time 494 ms) in order to cause the effect at region 4. It seems clear, also, that during this short time, the parser must not only have registered the contrast in verb class, but must also have computed its consequences for the interpretation of the subject of the subordinate clause, and also the structural status of the subordinate clause.

The verb effect in region 4, and the interaction effect found later, showed that these two conditions were met for the coreferential sentences: a rapid use of verb information and a rapid adoption of plausible fillers. Otherwise, if the verb information was not used rapidly, there should be no verb effect at region 4. Additionally, if the matrix subject was not rapidly adopted to fill the gap, the gap within both the coreferential and non-coreferential sentences would remain uninterpreted at the beginning of the subordinate clause, and consequently, there should be no main verb effect within the subordinate clause.

Finally, a question may arise as to why, for the *Non-coref* verb sentences in this experiment, the relative clause analysis was preferred over the possibility of a clausal object analysis with a discourse referent for the empty category. In the sentence completion study of Experiment 1, the relative clause analysis was hardly exhibited at all, and the main clause was the strongest competitor to the clausal subject despite its need of a discourse referent for the empty category. This makes it seem that the parser's decision criteria must be ranked differently for the two experiments. Fortunately it is not necessary to draw this conclusion. There are two factors that could contribute to the different outcomes. First, the difference in structural complexity between a clausal object and a

relative clause is smaller than that between a main clause and a clausal subject.⁷³ This could provide more incentive to produce main clauses in the sentence completion study, while the relative clause could still overwhelm the clausal object as the most preferred analysis for the non-coreferential sentences in the self-paced reading study. Second, the difference may lie in the effort needed to conjure up a referent for empty category interpretation. In the sentence completion study the null subject was in a main clause, whereas in Experiment 2 it was in a complement clause. In the latter case, a discourse referent is less common in Chinese and needs to be very salient in order to overcome interference from the matrix subject, which intervenes. In the absence of a discourse, as in the materials for this experiment, creating a salient referent for the subject of a clausal object could be a formidable task.

To summarize, this experiment provided additional evidence to support the vulnerability of the principle of Minimal Attachment in the context of sentence constructions containing empty categories which impose their own needs on sentence comprehension. The human parser may choose on-line a structurally more complex phrase structure analysis for an ambiguity in return for an early or optimal assignment of a referent to an empty category. In order to be able to juggle the trade-off in such a case, the parser evidently needs fast access to the relevant verb information which encodes possible coreference relations, and also needs a flexible policy of rapid adoption of a plausible filler when available even when there is a chance that this will result in reanalysis subsequently if the remainder of the sentence signals a different structure.

⁷³ This is based on the simple arithmetic of counting the number of clause in a sentence. A clausal subject, clausal object, and relative clause construction all contain two clauses, but a main clause construction only contains one clause. Thus, the difference in structural complexity could be more prominent between a main clause and a clausal subject, than between a clausal object and a relative clause.

The finding of a speedy on-line adoption of a plausible filler for an empty category in this context supports the hypothesis that the human parsing mechanism is an ‘active gap’ parser, which does not wait to view all possible fillers before adopting one of them. This active gap parser hypothesis is further tested in Experiment 3, in a different and more stringent context. In Experiment 2 the competition was between a potential filler which is already available when the gap is encountered, and the possibility of a filler following the gap which would not be available until later. In Experiment 3, both potential fillers follow the gap.

4.3 Experiment 3

4.3.1 Aims

This experiment was designed to answer research question II: whether the parser actively searches for the filler for an identified gap. Experiments 1 and 2 had investigated this question, but in the relevant cases, a plausible filler was available when a gap was encountered. In this experiment, a plausible filler was not provided at the time a gap was identified. As a result, the parser needed to look for the filler in the incoming material, and the decision it had to make was whether to adopt the first candidate that became available.

4.3.2 Method

Materials. This experiment exploited animacy features of a nominal to create plausible and implausible decoy fillers for a gap. It investigated whether the parser would rapidly

adopt the first plausible candidate filler for a gap it had identified at the beginning of a sentence. The immediate association of filler and gap would imply that the parser actively seeks a filler to complete a gap-filler dependency as soon as possible.

This self-paced reading experiment employed materials with a clausal subject containing a null subject. In the main clause predicate that follows the clausal subject, there is a noun phrase with the structure N_1 *de* N_2 , where N_1 is the modifier of the head noun N_2 , and *de* is the marker that mediates between a nominal modifier and the head noun. (Bear in mind that Chinese noun phrases are strictly head-final. See the discussion in section 1.1.) In on-line processing, N_1 is encountered before N_2 . Because elements of a sentence unfold serially in real-time (both under ordinary listening conditions and in the conditions imposed by the self-paced reading paradigm used in the experiments), and the parser cannot look ahead, it does not know whether N_1 is a modifier or is itself the head noun. As a result, this presents an ambiguity as to whether N_1 is the filler for the gap; N_1 is likely to be the filler if it is the head noun, but unlikely to be so if it is a modifier. (See footnote 74 below.) An example of the experimental sentences is shown in (13). Note that in both sentence versions, N_1 is not in fact the filler; it is a ‘decoy’ which the parser might temporarily take to be the filler. (See Appendix E for a complete list of experimental items.)

(13) a. **Plausible decoy filler**

[e_i Nonghuai-le jige wanju] bingweishi **xiaohaizi** de baomu_i gengxiaoxin.
 broken a-few toy not-CAU child DE nanny more-careful
 ‘Having broken a few toys did not make the child’s nanny more careful.’

b. **Implausible decoy filler**

[e_i Nonghuai-le jige wanju] bingweishi **youeryuan** de baomu_i gengxiaoxin.
 broken a-few toy not-CAU kindergarten DE nanny more-careful
 ‘Having broken a few toys did not make the kindergarten’s nanny more careful.’

The presentation regions were as shown in (14):

(14)	1	2	3	4	5	6
	All words				All words and period	
	preceding N ₁ / N ₁ / de / N ₂ / N ₂ +1 / following N ₂ +1					

The material shown in brackets in (13) is a clausal subject with a null subject.

(The presence of a clausal subject in the sentence becomes obvious when the first element *bingweishi* ‘not-CAU’ in the main clause predicate is encountered.) On recognizing the empty category at the beginning of the sentence, the parser may take its referent to be *xiaohaizi* ‘child’ in (13a), which is the first candidate filler it encounters. By contrast, *youeryuan* ‘kindergarten’ in (13b) is not a plausible subject for the verb *nonghuaile* ‘broke,’ thus not a good antecedent for the empty category; so if the parser uses plausibility information rapidly, it would wait for a better referent. When the parser encounters *baomu* ‘nanny’ in (13a), it must recognize that *xiaohaizi* ‘child’ is only a modifier of the real filler, which follows; it was a decoy, which created a garden path analysis.⁷⁴ Dissolving the link between the empty category and *xiaohaizi*, and

⁷⁴ In some circumstances, it is possible for the modifier, rather than the head noun, to be the filler. In this respect, Chinese and English are similar. For example, in English sentences like *e_i Breaking a few toys was Jim_i’s idea*, Jim is the filler. The Chinese equivalent also makes *Jim* the filler (*Jim de zhuyi* ‘Jim’s idea’). But if what follows the possessive marker is a plausible filler, it takes precedence and the modifier cannot be the filler. For example, in *e_{*ij} Breaking a few toys was Jim_i’s sister_j’s idea*, the filler cannot be *Jim* but

establishing a new link with *baomu*, would incur a higher processing load than in (13b) where no link was previously established. Thus, a comparison of the processing time of *baomu* in the two types of sentences will indicate whether the parser is actively checking incoming words for a filler for the gap previously identified.

The task contained 16 target sentences, each in two conditions. The target sentences of this experiment were combined with those of Experiment 2 to form one single reading task. Recall that the materials for this experiment served as fillers for Experiment 2. The 16 (x 2) target sentences were interspersed among 32 targets for Experiment 2, and 48 unrelated fillers, for a total of 99 sentences. (There were additional 3 covert practice items.) The 2 x 2 design of Experiment 2 required four lists for counterbalancing. For Experiment 3—which involved a simpler one-way contrast—the 16 targets were counterbalanced between the first two experimental lists and again between the last two experimental lists.

Procedure. As in Experiment 2, each sentence of this experiment was followed by a comprehension question with two answers. The question did not directly ask about the empty category and its antecedent in the sentences. The accuracy rates for these questions were used only to exclude inattentive participants. (The accuracy rates of the comprehension questions for both Experiment 2 and this experiment were used to exclude participants. As noted in section 4.2.2, two participants from List A were excluded from data analysis.)

Data Treatment. As in Experiment 2, response times more than three standard deviation units away from the mean reading time of an individual participant for each

only *Jim's sister*. In all the target items in this experiment, N₂ was a plausible filler that would take precedence over N₁.

region were discarded. Only the reading times of the target regions (i.e., region 2 to region 5) will be reported. Within the four target regions, there were 70 data points beyond the three standard deviation cutoff values and two display errors, which were all discarded. This accounted for 2% of all the data points.

The simple experimental design warranted the use of one-tailed t-tests instead of ANOVA for the analysis. (By participants, the data were corrected by item set, and vice versa for item-based data.)

4.3.3 Results

The results of this experiment are shown in Table 4.3 and graphically in Figure 4.9.

Table 4.3: Mean reading times (ms) to the target regions and t-test results by region in Experiment 3

Region	Plausible Decoy	Implausible Decoy	Main effect: Filler Type		
				<i>df</i>	<i>t</i> Sig.*
2	557	566	t_1	55	-.68
			t_2	31	-.47
3	433	465	t_1	55	-3.25 ●●●
			t_2	31	-1.92 ●
4	477	457	t_1	55	1.50 ○
			t_2	31	1.11
5	512	495	t_1	55	1.38 ○
			t_2	31	1.11

* Sig. = Significance level:

- $p < .10$
- $p < .05$
- $p < .01$
- $p < .001$

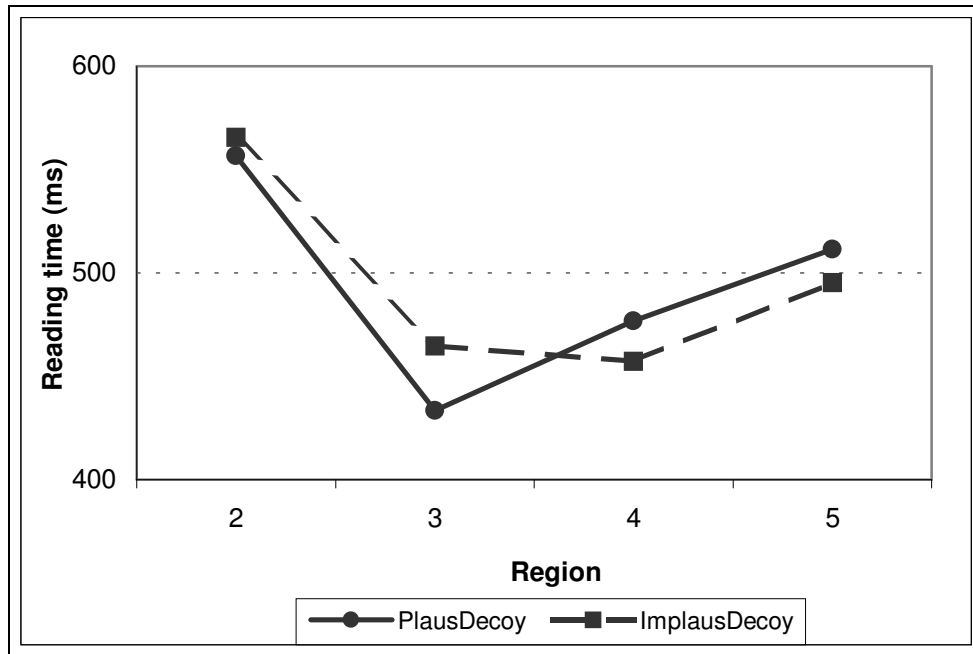


Figure 4.9: Mean reading times to the target regions in Experiment 3.

The reading time results will be discussed region by region. Once again, there appears to be ‘spillover’ of processing effort, with the expected effects for a region showing up in the following region. Like Experiment 2, plausibility disambiguation was in play in this experiment; plausibility dictated whether the noun phrase in region 2 is a candidate filler for the identified gap.

Region 2, e.g., *xiaohaizi/youeryuan* ‘child/kindergarten’ (2-4 characters, mean: 3): This region was the first structural position that could provide a filler for the gap, and plausibility dictated whether a nominal that occurred in this region was a good filler. An impatient parser that could rapidly use plausibility information to identify potential fillers might immediately adopt the plausible nominal as the filler. While an implausible filler in this region would be less attractive, showing slower reading. However, the t-test showed no significant difference in the reading times of the plausible

and implausible nominals in this region, despite the lexical difference. It can be concluded that either the parser was not regarding this nominal as a potential filler, so was not evaluating its plausibility in that role, or else the predicted plausibility effect was registered only in the following region. The latter assumption is supported by the data that follow.⁷⁵

Region 3, *de* (1 character): This region contained only the character *de*, which indicated that the nominal N_1 in region 2 was a modifier, and would probably be followed by the head noun.⁷⁶ An effect of plausibility was found in this region, with the plausible decoy filler sentences read significantly faster than the implausible decoy filler sentences. Because a structural reanalysis to downgrade the nominal to a modifier was needed for both versions, it could not be the reason for the plausibility effect. Instead, the cause is likely to have been spillover from region 2. There are two reasons for drawing this conclusion. Note that the direction of the difference observed is exactly as was predicted on the basis of region 2. Also, *de* is a single-character word with a very high frequency in Chinese texts. Its familiarity therefore reduces the possibility that the reader would give vastly different responses when encountering it in different sentences that have similar structure. Hence, the effect found in region 3 suggests that preceding words must have been the contributing factor. Thus understood, the plausibility effect observed in region 3 indicates that the parser was expecting a filler for the gap, and found that the plausible nominal in region 2 satisfied that expectation whereas the implausible nominal did not.

⁷⁵ There is a third possibility, which is that no filler evaluation is occurring, but the plausible N_1 nouns happened to be more frequent and hence more easily processable than the implausible N_1 nouns. See discussion below.

⁷⁶ Because Chinese noun phrases are head-final, the parser is rarely certain whether a nominal is a head noun until it encounters a word, for example, a verb, that signals that the noun phrase has ended.

Region 4, e.g., *baomu* ‘nanny’ (2-3 characters, mean: 2.06): This region contained N_2 , the head noun, which was the real filler for the empty category. There was a reading time difference between the sentences with plausible versus implausible N_1 which was marginally significant by participants, non-insignificant by items, with N_2 being read more slowly in the plausible decoy filler sentences than in the implausible decoy filler sentences. This difference is in the reverse direction compared with the preceding region. Importantly, this is consistent with the expected processing difficulty associated with the plausible decoy filler sentences. If the parser had previously associated the plausible N_1 in region 2 with the empty category, it now had to dissolve that link, and co-index the empty category with the N_2 in region 4. By contrast, assuming that no link was previously established between N_1 and the gap in the implausible decoy filler sentences, there would be no need for any structural and interpretational reanalysis at region 4. It is curious that the marginal plausibility effect at region 4 was not delayed by spillover to the next region. A possible explanation for this is that *de* in region 3 alerted the parser to the imminence of a different head noun following *de*, which would tip off the parser that N_1 was not the correct filler. (*De* is a reliable cue for a following noun but until the parser sees that noun it cannot be certain whether it will prove to be a possible filler for the gap, for reasons explained in footnote 74 due to examples such as *e_i Breaking a few toys was Jim_i’s idea.*) Thus the first part of the reanalysis — dissolving the link with N_1 — could have begun in region 3 (showing up in region 4 by spillover) but only weakly because of the uncertainty.

Region 5, e.g., *geng xiaoxin* ‘more-careful’ (1-4 characters, mean: 2.31): This region unequivocally marks the end of the noun phrase, thus confirming N_2 as the head

noun of the noun phrase, and also (most probably) as the filler of the empty category. Once again, no reliable plausibility effect was found in this region, but the reading time trend found in the previous region was sustained, indicating that the effect was to some extent divided across the two regions. More processing difficulty was found for the plausible decoy filler sentences than for the implausible decoy filler sentences, consistent with the prediction that gap reanalysis was needed only in the plausible decoy filler sentences. In light of the above discussion of the predictive role of *de*, it can be suggested that some of the work of breaking the link with the wrong filler had already been done at region 3 (manifested at region 4) so that the workload at region 4 (manifested at region 5) was not as heavy as might have been expected, thus accounting for the relatively weak effect on reading time. An alternative possibility is that having been forced to give up N_1 as the filler, the parser is disinclined to substitute any other filler without better evidence, on the principle ‘once bitten, twice shy.’ Thus even a usually active filler-seeking parser might show reduced activity at region 4.

To summarize, the plausible decoy filler sentences were easier to process than the implausible decoy fillers sentences in region 3, as predicted, while in regions 4 and 5 the implausible decoy fillers sentences were easier, though the effects were marginally significant by participants, unreliable by items. In addition, both these integration effects seem to have been subject to spillover with the cost of integrating an item into the currently parsed structure consistently showing up in the following region (as in Experiment 2). The effect of the implausibility of N_2 as the filler in region 2 showed up in region 3, and the cost of filler-gap revision for the plausible decoy filler sentences was

manifested in regions 4 and 5 with *de* in region 3 probably already providing an early warning for such a revision.

4.3.4 Discussion

The findings of this experiment provide a positive answer to research question I, supporting the conclusion of Experiment 2: the parser is actively seeking a filler after identifying a gap, and it adopts the first grammatically legitimate plausible candidate as the filler, despite the risk of having to undertake reanalysis later if it proves to be wrong. This tendency is what has been called the Active Gap Strategy.

The Active Gap Strategy discussed here shares the same general philosophy as the more familiar Active Filler Strategy and they may prove to be instances of the same general underlying tendency in parsing; but it is also possible that they may differ in interesting details. Many previous studies of the Active Filler Strategy employed a *wh*-filler, whose association with the gap is mediated by a structural chain resulting from syntactic movement, as emphasized in de Vincenzi's statement of the Minimal Chain Principle (see section 3.1.1). In that case, it can be argued that the use of the Active Filler Strategy in on-line sentence processing is to complete a structural requirement on well-formedness as rapidly as possible: a *wh*-filler needs a gap to complete the *wh*-chain. An alternative, for which Aoshima, Phillips, and Weinberg (2004) have argued, is that the parser's primary aim is to discharge a thematic role onto the *wh*-filler by identifying its underlying (theta-relevant) position, which is reminiscent of the emphasis by Pritchett (1988) on resolving theta relations as rapidly as possible (see section 3.1.1 for details). Gap-first dependencies can also involve a syntactic chain. In their investigation of the

active gap hypothesis, Hsu and Bruening (2003) (discussed in 3.3.2) employed Chinese relative clause constructions that contained a *wh*-chain between the gap and the head noun filler. By contrast, in the present experiment, the gap is a null subject within a clausal subject, and its association with the filler involves no chain relation; instead, the filler and gap are related through semantic inference. (See section 2.4 for discussion of this relation.) Yet it is found that the Active Gap Strategy is also active in this kind of filler-gap relation. This could be important. It may imply that the parser's active search for the filler for an identified gap is to fulfill an interpretational requirement, not a structural one: a null subject gap needs an interpretation, even if its relation with a filler is not part of its licensing requirement. (On the distinction between licensing and interpretation (for *pro*), see Jaeggli and Safir (1989).) In a gap-driven filler-gap dependency, such an interpretational requirement may be especially clear. A gap may have a theta role but it has no referential meaning (and hence does not contribute to a mental picture of 'who did what to whom') until it is linked to a filler. On the other hand, in a filler-driven dependency, to which the Active Filler Strategy applies, the pressure to link filler and gap may not apply so forcefully, because a filler is a content expression which already has meaning and reference, even if it does not yet have a thematic role in relation to the rest of the sentence. Thus, even though active-filler processing and active-gap processing appear to have much in common, so that they can be subsumed under a single principle (such as the Minimal Chain Principle, possibly extended to dependency relations beyond strictly syntactic chains), the driving force underlying the pressure to look for an associated gap or filler respectively could be different. More research will be needed to explore this interesting issue.

4.4 Experiment 4

4.4.1 Aims

This experiment had two objectives. First, it aimed to further verify the results of Experiments 1 and 2. The findings of those two experiments suggested that when a gap is identified, the parser will quickly adopt the first plausible antecedent that is available to interpret the gap. This indicates an active parser that is trying to fill a gap as soon as possible in real-time sentence processing. The present experiment employed a different approach to reexamine this finding, using a construction with a clausal subject comparable to the English *Tidying the reading room leaves Mary exhausted*. The second and more important aim of this experiment was to investigate two options in filling the subject gap within a clausal subject. In constructions other than the clausal subject, a gap is usually filled (in Chinese, among other languages) either by a discourse referent or by an overt nominal in the same sentence. However, for the clausal subject in Chinese, as in English and other languages, there is a third option: a generic referent, which may be overt or covert.⁷⁷ (To the best of my knowledge, this generic interpretation is not available in Chinese for gaps other than the null subject of a subject clause.) An overt generic filler is like any other overt filler; it is typically part of the main clause predicate that follows the clausal subject in this construction. For example, the fragment *Tidying the reading room...* might be completed with a reference to Mary, as above, or as *Tidying*

⁷⁷ It can be said that a generic noun phrase refers to everyone at large; this is convenient in the present discussion but it is a considerable oversimplification. There have been many treatises, both linguistic and philosophical, concerning the semantic analysis of generics, which is clearly a subtle matter and also subject to much disagreement. For some discussion see section 2.4.

the reading room leaves one exhausted. In the latter example the gap is associated with a generic filler (in English *one* or *people* or *anyone*, etc.; in Chinese primarily *ren* ‘people’⁷⁸) in the matrix predicate. In the case of a covert generic interpretation, there is no overt filler in the sentence at all, as in *Tidying the reading room is exhausting*. In this case the gap may be assigned a generic interpretation locally, as referring generically to people in general, without any connection to a filler in the discourse or the matrix clause.⁷⁹

Because a subject gap within a clausal subject can be interpreted generically, whether or not an overt filler is present in the sentence, there are two possible on-line strategies for filling a gap in this structural position. First, if no plausible filler is available, the parser could opt for local assignment of a generic referent to the gap without seeking out an associated filler; I will call this the ‘Local (generic) Interpretation Strategy.’ The advantage of this local strategy is speed, as the parser can immediately interpret the gap, rather than waiting for a filler in subsequent incoming material. The disadvantage of this strategy is an increased chance of a later gap-revision, if an overt filler appears subsequently and is not compatible with the generic referent initially assigned to the gap. An alternative tactic would be a waiting strategy in which the parser assigns no immediate interpretation to the subject gap but seeks an overt filler in the incoming material; it could still adopt the generic interpretation later, if it had not found a

⁷⁸ *Ren* is the most inclusive generic expression for humans and the most natural; there does not seem to exist another noun phrase in Chinese that could equally well express a generic statement with an overt generic referent.

⁷⁹ It may seem natural to assume that local assignment of generic interpretation, without any association with a filler elsewhere in the sentence, would be the easiest option for the parser on-line. However, the generic interpretation may involve some syntactic/semantic complexity. Chierchia (1995) assumes a Generic operator (Gn-operator) that binds a variable in the empty category position. So computing this additional structure might make the generic interpretation more complex than associating the gap with a referential filler. I will not pursue this possibility but it is not inconsistent with the data obtained; see below.

plausible overt filler later in the sentence. This could be called the ‘Forward-looking Strategy.’ As defined here, it is compatible with either passive waiting for a gap or active search for a gap. On the basis of the results of Experiment 3, I will henceforth assume active search, and will refer to the strategy as the ‘Forward Search Strategy.’ This strategy would delay gap interpretation on-line because the gap remains uninterpreted while the parser looks for the filler. However, this strategy would minimize gap revision because the gap is interpreted only when a plausible referent is found in the sentence or else the absence of such a referent is established. Thus, there is a trade-off here between the two strategies; the parser may opt for immediate (generic) gap interpretation or for a delayed interpretation which minimizes gap revision. Establishing which of these it is designed to do was a major goal of Experiment 4.

In sum, this experiment was designed to investigate what strategy is used to fill the subject gap within a clausal subject in Chinese, in particular whether the parser prefers a local generic interpretation, or coreference with a subsequent filler in the matrix clause.

4.4.2 Method

Materials. The target sentences for Experiment 4 all contained three clauses, as illustrated in (15). All items were constructed in four versions, which differed with respect to the properties of the initial clause-1, and also differed with respect to whether a filler in the final clause was specific or generic. (See Appendix F for all the experimental items.)

(15) a. **-Referential subject, Specific Filler**

Hen nanyizhixin $[[e_i \text{ kan } \text{kehuan dianying}] \text{ keyi rang } \text{Lili}_i \text{ geng}$
 hard-to-believe watch science movie can CAU Lili more
liaojie kexue].
 understand science.
 ‘It is hard to believe that watching science movies can make Lili
 understand science better.’

b. **+Referential subject, Specific Filler**

Liao xiwang $[[e_i \text{ kan } \text{kehuan dianying}] \text{ keyi rang } \text{Lili}_i \text{ geng}$
 Liao hope watch science movie can CAU Lili more
liaojie kexue].
 understand science.
 ‘Liao hopes watching science movies can make Lili understand science
 better.’

c. **-Referential subject, Generic Filler**

Hen nanyizhixin $[[e_i \text{ kan } \text{kehuan dianying}] \text{ keyi rang } \text{ren}_i \text{ geng}$
 hard-to-believe watch science movie can CAU people more
liaojie kexue].
 understand science.
 ‘It is hard to believe that watching science movies can make people
 understand science better.’

d. **+Referential subject, Generic Filler**

Liao xiwang $[[e_i \text{ kan } \text{kehuan dianying}] \text{ keyi rang } \text{ren}_i \text{ geng}$
 Liao hope watch science movie can CAU people more
liaojie kexue].
 understand science.
 ‘Liao hopes watching science movies can make people understand science
 better.’

The presentation regions were as shown in (16); the target regions for data analysis are regions 3 to 7. Note that the noun *N* in region 5 is either the specific filler (e.g., *Lili*) or the generic filler (*ren*).

(16)	1	2	3	4	5	6	7	8
	Clause-1 / Clause-2 /		clause-3[N-2	/ N-1	/ N	/ N+1	/ N+2	All words
	and period							
	following N+2]							

In seven of the 32 target sentences, an additional region was inserted between region 3 and region 4 so that these sentences would sound more natural. An example is shown in (17), in which region 3 is *keneng* ‘possibly,’ followed by an extra word *hui* ‘will.’ (*Gei* ‘to’ is in region 4, and the generic filler *ren* is in region 5.)

- (17) Hen qiguai paoqi suoyou keneng hui gei ren dailai xin
 very strange give-up everything possibly will to people bring new
 shengming.
 life
 ‘It is strange that giving up everything will possibly bring new life to
 people.’

This additional region was short, containing one to two characters, and consisted mostly of modal verbs like *hui* ‘will,’ or *keyi* ‘can,’ or an adverb like *ye* ‘also.’ Its reading times are not reported here.

Clause-2 and clause-3 are elucidated in (18) first. Then see below for the properties of clause-1, in which clause-2 and clause-3 are embedded. Examples (18a,b) have the specific filler *Lili*, while (18c,d) have the generic filler *ren*.

(18) a/b. **Specific filler in clause-3**

[*e_i* kan kehuan dianying] **keyi rang *Lili_i* geng liaojie** kexue].
 watch science movie can CAU *Lili* more understand science
 ‘Watching science movies can make *Lili* understand science better.’

c/d. **Generic filler in clause-3**

[*e_i* kan kehuan dianying] **keyi rang *ren_i* geng liaojie** kexue].
 watch science movie can CAU people more understand science
 ‘Watching science movies can make people understand science better.’

The examples in (18) represent only clause-2 and clause-3 of the target construction, which are embedded (ambiguously) into clause-1, as described below. Of interest is how these clauses are interpreted on-line. But it will clarify the situation to consider first what the correct (final) interpretation of these clauses must be. In the final analysis, clause-2 must be a clausal subject with a subject gap, embedded in clause-3. A subject gap within a clausal subject is commonly (though, as observed, not invariably) interpreted as coreferential with a noun phrase in the matrix predicate, which here is provided by clause-3. On this analysis the filler in (18a/b) would be *Lili* and in (18c/d) it would be *ren*. Let us consider how these sentence continuations relate to the possible on-line interpretative decisions of the parser.

If the parser assigns a generic interpretation locally to the gap, the generic *ren* (meaning ‘people in general’) in the final clause of (18c/d) is compatible with that initial

interpretation, so the processing of *ren* but not *Lili* should be facilitated.⁸⁰ On the other hand, if the parser applies a Forward Search Strategy, delaying gap interpretation to see whether or not a referent will be supplied by a later part of the sentence, it is not expected that there will be a preference for either kind of filler (either generic *ren* or specific *Lili*), except as derives from their respective lexical frequencies or inherent reading times.

In the (a/b) versions of all the target items in this experiment, the specific filler in the final clause is always a proper name like *Lili*, or is a surname plus a title such as *Chen laoshi* ‘Teacher Chen.’ while in the (c/d) versions the filler is always the single-character word *ren*. It is clearly inappropriate to directly compare the reading times for the specific nominals versus *ren*; the former are longer and less frequent and differ across items, while *ren* is not only very frequent but also was repeatedly used throughout the experiment. (Each participant received eight sentences with *ren* out of a total of 83 sentences in the whole experiment, whereas no specific name was repeated.) Thus, each filler item needs to be compared with the same word in a baseline condition. This baseline is provided by the three-clause structure discussed above, which has an initial matrix clause (clause-1) dominating everything else in the sentence.

The content of the upper matrix clause (clause-1) is what distinguishes the (a) version of the target sentences from the (b) version, and the (c) version from the (d) version. For target item (18), the versions of clause-1 are as follows:

⁸⁰ If *ren* in the final clause were perceived as redundant, in that it unnecessarily repeats the generic content already assigned to the empty category, it might cause processing difficulty. It is important in this context to note that the overt generic filler is not redundant in the sentences used in this experiment. This is because for matrix predicates of this type (typically causative), if the null subject is interpreted as generic, then *ren* is obligatory in the later clause. (This depends to some extent on the position of *ren* in the matrix predicate. But it was true of all target sentences in Experiment 4.)

In (18a) and (18c): *Hen nan-yi-zhi-xin*⁸¹ (No overt filler in clause-1)
 ‘(It is) hard-to-believe’

In (18b) and (18d): *Liao xiwang* (Overt filler in clause-1)
 ‘Liao hopes’

With this initial clause added, all target sentence versions have three clauses, and the empty category of interest is now in an embedded clause, beneath this initial clause-1. The content of the initial clause can affect the processing of what follows. In all cases the gap in clause-2 will be recognized on-line, but how that gap is filled is affected by the content of clause-1. In (18b,d) the name *Liao* in clause-1 is strongly likely to be taken on-line as the filler for the subject gap in clause-2, because the parser is likely to be interpreting clause-2 as the clausal object of clause-1 under temporary analysis A; see Figure 4.10 below. It is important to note that at this point (i.e., the beginning of the second clause) the parser has no way to know that clause-2 is really a clausal subject inside a third clause (which, combined with clause-2, is the true clausal object of clause-1). Thus at this point, structural analysis A is not only possible but is presumably very strongly preferred by Minimal Attachment, though the correct analysis by the end of the sentence must be as in B.

⁸¹ Chinese does not have overt expletive subjects like *it* in English. Thus, the subject in this clause is phonologically null.

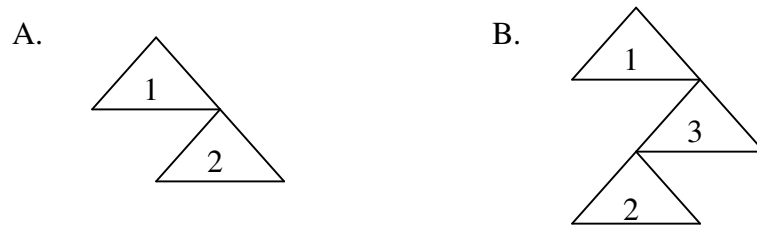


Figure 4.10: Diagram A illustrates the initial analysis of the first two clauses of the target sentences in Experiment 4; Diagram B illustrates the correct analysis of the target sentences.

The preference for analysis A in Figure 4.10 is further boosted by the presence of a plausible antecedent for the empty category. (Results of Experiments 1 and 2 have provided evidence to support rapid antecedent assignment for an identified empty category. Moreover, the lexical semantics of all of the matrix verbs used in this experiment permit coreference between the matrix subject and the embedded null subject.) Thus, it is predicted that for the (18b,d) versions, clause-2 is initially taken as a simple complement clause to clause-1, and the gap is temporarily filled by the matrix subject (e.g, *Liao*). But when the first elements of clause-3 are received, a structural reanalysis from configuration A to configuration B in Figure 4.10 becomes unavoidable. Note that this structural reanalysis does not necessarily render the initial gap assignment wrong. It is because *Liao* could still be the filler of the clause-2 gap in (18b,d): the sentence could end with an overt anaphor (*ziji*) in filler position, as in *Liao xiwang kan kehuan dianying keyi rang ziji geng liaojie kexue* “Liao hopes that watching science movies can make him(self) understand science better,” where *Liao* is both the person watching science movies and the person who would understand science better. But the true filler for the null subject of clause-2 might eventually prove to be not *Liao* but some

other NP in clause-3, at which point revision of the filler would be unavoidable.⁸² In the experimental materials, clause-3 always contained an overt filler (*ren* or a name) which was always incompatible with the on-line hypothesis that the subject of clause-1 was the filler. As a result, a gap revision was required for both (18b,d), which also served as the baseline for the target sentences (18a,c); the reading time of the fillers in these two sentence versions could reveal the gap-filling strategy used on-line.

For the (a/c) version of clause-1, which does not contain an overt filler, the parser tends to favor the structure B on-line, with clause-2 analyzed as the clausal subject of a potential upcoming clause-3. Even though it is more complex, this analysis could be favored because the (a/c) initial clause provides no potential referent for the gap in clause-2; the adoption of the clausal subject analysis for clause-2 on-line allows for an antecedent to appear in the following predicate (just as in Experiment 1a). Indeed, the bias towards the clausal subject analysis may be even stronger in this experiment than it was in Experiment 1a, because the latter required participants to *produce* a continuation for the sentence, and continuation tasks probably tend to favor short, less complex sentence structures.

Given analysis B in Figure 4.10 for (18a,c), the gap in clause-2 may be locally interpreted as generic or the parser may wait to see if a specific filler will occur later. Hence, the prediction remains the same as above: *ren* in the final clause of (18c) will be facilitated if a generic referent is assigned to the gap when it is encountered, but there

⁸² This is so for the materials used in Experiment 4, though it is not so for Chinese generally. More generally, in this syntactic construction the filler could be either the matrix subject, as in *Liao_i hopes that e_i showing science movies in class may make Lili understand science better*, or the noun phrase in clause-3 (i.e., *Lili*), as in *Liao hopes that e_i watching science movies may make Lili_i understand science better*. It appears that semantics dictates what the filler is taken to be. In this experiment, the target sentences were designed to consistently favor the later filler (*Lili* rather than *Liao*). See more discussion of this in section 4.4.3.

will be no processing advantage for *ren* in (18c) compared with (18d) if the parser adopts the Forward Search Strategy.

Table 4.4 below summarizes the predictions for reading times in relation to these various potential gap-filling strategies. Note that this table, and the data reported below, use the label +Ref for examples like (18b,d) which have a referential NP in clause-1, and the label -Ref for examples like (18a,c) which have only an (empty) expletive NP in clause-1. Examples like (18a,b) which have a specific filler in clause-3 are labeled SpecF, while examples like (18c,d) which have a generic filler in clause-3 are labeled GenF. As in previous experiments, reading time effects predicted at one sentence position (as noted in the Table) are in fact expected to show up in the data at a subsequent position.

Table 4.4: Reading time predictions for gap-filling strategies employed in Experiment 4

Gap-filling strategies	Predictions
Assignment of the clause-1 subject in +Ref sentences; revision required at the filler in clause-3	Increased reading time triggered by the filler in the final clause for +Ref relative to -Ref
Possible assignment of generic referent on-line in -Ref sentences; revision required at the specific filler in clause-3 of -Ref, SpecF	Shorter reading time for <i>ren</i> in -Ref, GenF than for +Ref, GenF, but no difference in reading time for the specific filler in clause-3 for -Ref, SpecF and +Ref, SpecF
Possible forward search for a later filler in -Ref sentences; no revision required	No difference in reading time at the specific filler in -Ref, SpecF versus +Ref, SpecF, and no difference for <i>ren</i> in -Ref, GenF versus +Ref, GenF

This experiment employed self-paced reading. The materials consisted of 32 target sentences, and 48 filler sentences of various constructions that were comparable to

the targets in length and complexity. The task had four counterbalanced lists in a 2 x 2 Latin Square Design, crossing Matrix Subject Type (+referential vs. -referential) with Filler Type (generic vs. specific).

Procedure. The experimental procedures were identical to those of Experiments 2 and 3, and the same DMDX program and computers were used for the testing.

Participants. Participants who answered 12 or more out of 80 comprehension questions incorrectly (15 % of the total responses) were excluded. As a result of this performance criterion, 3 participants were rejected and replaced. One participant was also rejected for not following experimental procedures, and her data was also excluded for further analysis. In the end, 48 participants (age range 18-36; mean age 21; 34 female) successfully finished the experiment. The average error rate for the comprehension questions was 4.1% for these 48 participants.

Data Treatment. The data clean-up procedures were identical to those of Experiments 2 and 3. Reading times more than three standard deviation units away from the mean reading time of an individual participant for each region were discarded. This procedure identified 180 data points to be discarded in the five target regions. One display error was also discarded. Together, these procedures affected 2.3% of the target data points.

The standard deviation cut-off was applied for each region separately, because of lexical content considerations. (Some regions were substantially longer than others.) Region 5 includes a contrast between a single word, identical for all items (the generic filler *ren*), and a word that varies from item-to-item (specific fillers, like *Lili* in (18a,b)). For this region, the standard deviation cut-off was applied separately for reading times for

the generic filler *ren* and reading times for the specific fillers. This avoids unfairly discarding reading times at the lower end of the distribution for the generic filler *ren*.

Analyses of variance were then performed on the reading times for the target regions taking as factors the referential property of the matrix subject (+referential / -referential subject) and that of the filler (specific / generic filler).

4.4.3 Results

The results of this experiment are shown in Table 4.5, and graphically in Figure 4.11. Data are presented only for regions in the third clause, for which specific predictions have been made, summarized in Table 4.4 above. (For the mean reading times of the target regions, see Table B4 in Appendix B.)

Table 4.5: Analysis of variance results by region in Experiment 4

Region	Main Effect			Main Effect			Filler Type $\times$ Subject					
	Subject Type			Filler Type			Type Interaction					
	<i>df</i>	<i>F</i>	Sig.*	<i>df</i>	<i>F</i>	Sig.*	<i>df</i>	<i>F</i>	Sig.*			
3	<i>F</i> ₁	1,44	.05	<i>F</i> ₁	1,44	.01	<i>F</i> ₁	1,44	.01			
	<i>F</i> ₂	1,28	.11	<i>F</i> ₂	1,28	.03	<i>F</i> ₂	1,28	.02			
	<i>minF'</i>	1,70	.03	<i>minF'</i>	1,67	.01	<i>minF'</i>	1,71	.01			
4	<i>F</i> ₁	1,44	.13	<i>F</i> ₁	1,44	.34	<i>F</i> ₁	1,44	.01			
	<i>F</i> ₂	1,28	.05	<i>F</i> ₂	1,28	.30	<i>F</i> ₂	1,28	.01			
	<i>minF'</i>	1,49	.04	<i>minF'</i>	1,66	.16	<i>minF'</i>	1,68	.01			
5	<i>F</i> ₁	1,44	.48	<i>F</i> ₁	1,44	55.24	●●●	<i>F</i> ₁	1,44	1.64		
	<i>F</i> ₂	1,28	.10	<i>F</i> ₂	1,28	27.61	●●●	<i>F</i> ₂	1,28	1.48		
	<i>minF'</i>	1,77	.08	<i>minF'</i>	1,96	18.41	●●●	<i>minF'</i>	1,99	.78		
6	<i>F</i> ₁	1,44	.01	<i>F</i> ₁	1,44	77.57	●●●	<i>F</i> ₁	1,44	.45		
	<i>F</i> ₂	1,28	.12	<i>F</i> ₂	1,28	41.42	●●●	<i>F</i> ₂	1,28	1.90		
	<i>minF'</i>	1,51	.01	<i>minF'</i>	1,56	27.00	●●●	<i>minF'</i>	1,62	.36		
7	<i>F</i> ₁	1,44	4.28	●	<i>F</i> ₁	1,44	4.2	●	<i>F</i> ₁	1,44	2.01	
	<i>F</i> ₂	1,28	3.02	◦	<i>F</i> ₂	1,28	1.59		<i>F</i> ₂	1,28	4.62	●
	<i>minF'</i>	1,62	1.77		<i>minF'</i>	1,58	1.15		<i>minF'</i>	1,70	1.40	

* Sig. = Significance level:

- $p < .10$
- $p < .05$
- $p < .01$
- $p < .001$

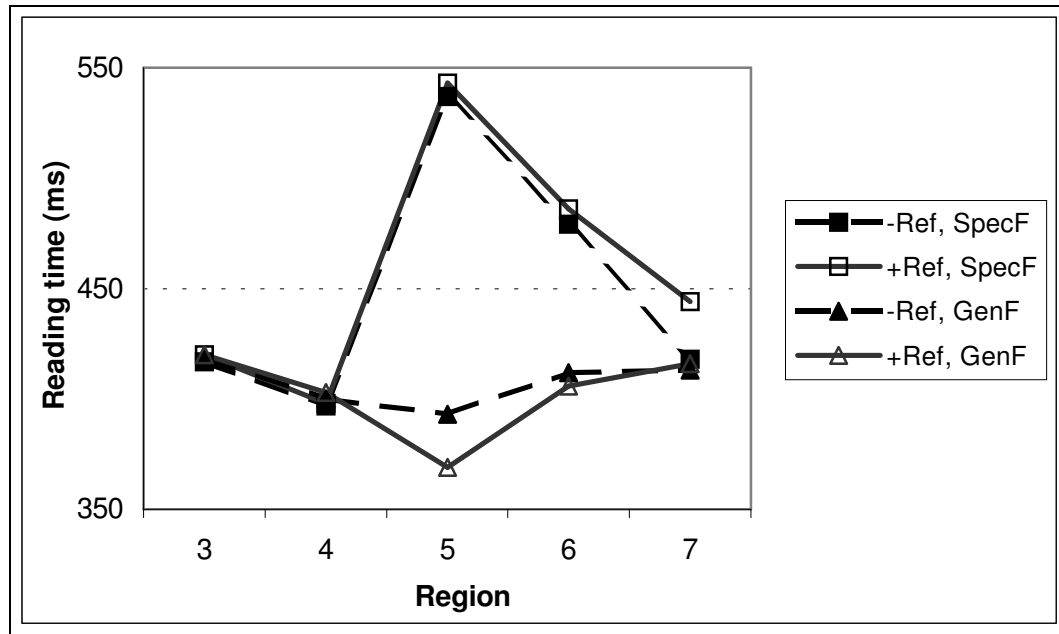


Figure 4.11: Mean reaction times (in milliseconds) to the target regions in Experiment 4.

The reading time results will be discussed region by region.

Region 3, e.g., *keyi* ‘can’ (1-3 characters, mean: 1.75): This region marked the beginning of the third clause. If prior to this point the parser had assumed structure A in Figure 4.10, with a clausal object analysis for the second clause, the appearance of clause-3 would call for structural reanalysis, with clause-2 being downgraded to be a clausal subject within the larger construction (clause-2 inside clause-3) that is the true clausal object of the sentence. It was predicted that this reanalysis would occur more commonly in the sentence versions that had a specific filler in clause-1, since the availability of a filler for the gap could encourage the garden path analysis A. However, analyses of variance showed no significant differences in the reading times of the four types of sentences.

Spillover to the next region must be considered as a possible explanation for lack of differences in region 3. Alternatively, the absence of effects could be due to the fact that a reanalysis of clause-2 from a clausal object to a clausal subject only involved a slight adjustment, whose processing cost was too slight to reveal itself in the reading time difference. Inoue and Fodor (1995) note that for Japanese, the parser shows no intuitively detectable difficulty when finding out that a clause just processed is in fact embedded in another clause; for example, downgrading a main clause to a relative clause incurs little processing cost. This downgrading is similar to the downgrading of a clausal object to a clausal subject in Chinese.

Region 4, e.g., *ling* (a causative marker) (1-2 characters, mean: 1.31): This region immediately preceded the clause-3 filler. In most sentences, it consisted of a causative marker, but in some it was a verb. Both causative markers and verbs were of a kind that is usually followed by a noun. Thus, the item in this region could foretell the imminent appearance of a nominal, and therefore, a potential filler for the gap in clause-2. Once again, no significant differences were found in the reading times of the four sentence versions.

As noted above, this region might have received some spillover from region 3, due to the structural reanalysis predicted there for sentences with a referential subject in clause-1, but the lack of significant differences in the reading times in region 4 discounts that possibility.

Region 5, e.g., *ren/Lili* (1 or 1-4 characters, mean: 1.72): This region contained the ultimate filler for the gap. For the generic filler, a single character *ren* ‘people’ was used for all the test sentences. The specific filler, on the other hand, contained two to four

characters. Because of the difference in length and frequency of these two types of filler, the enormous effect of the Filler Type factor in this region came as no surprise. Of more interest is the interaction between the Filler Type and Subject Type. Despite the fact that the interaction failed to reach significance for Region 5, comparisons were performed separately for specific and generic fillers. (This comparison is particularly warranted, given their substantial differences.) A reliable effect of Subject Type was found for the generic filler: generic fillers were read 15 ms faster, on average, if the matrix subject was referential ($F_1(1,44)=8.04$, $p<.01$; $F_2(1,7)=11.04$, $p<.02$). As predicted, no such difference was observed for specific fillers, whose reading times did not differ by Subject Type ($F_1(1,44)=.10$, $p>.5$; $F_2(1,28)=.22$, $p>.5$).

For the generic filler, reading times were higher in the version with no appropriate filler in clause-1, than in the version with an appropriate overt filler in clause-1. This difference is in the opposite direction from what was predicted on the assumption that a local generic interpretation of the gap would be favored when no specific filler was available. The persistent use of the word *ren* as the generic filler makes this result especially pronounced, because low reading times would be expected for such a repeated and high frequency, simple (one-character) word, making differences between conditions harder to discern. The fact that the generic filler in clause-3 was significantly more difficult following an expletive subject than following a specific human subject in clause-1 suggests that when the parser is still in need of an interpretation of the gap in clause-2 (because the expletive matrix subject in clause-1 provided no antecedent for it), the generic referent is *not* what it anticipates. Interestingly, this differential response to *ren* shows up in region 5 itself, where *ren* appears, and does not spill over to the next region.

This seems to contrast with the data of Experiments 2 and 3, where spillover was common. There is, though, one difference between those experiments and the present one, which might account for this. In Experiments 2 and 3, plausibility information was needed to resolve an ambiguity or identify a possible filler. In Experiment 4, both the generic and the specific filler are plausible. Thus, it could be argued that it was the need to consult plausibility information that delayed the emergence of the processing difficulty in Experiments 2 and 3. When plausibility was not a factor, as in this region of the Experiment 4 sentences, the processing cost was immediate. This suggests, however, that the earlier proposal (section 4.2.4) that spillover occurs not for lexical processing but for integrative processing may need to be revised; it may be that spillover occurs only for integrative processes that involve plausibility assessments.

For the sentences with a specific subject in clause-1, the appearance of the ultimately correct filler in region 5 called for a revision at this point, assuming the gap had been temporarily filled previously by the clause-1 subject. This would be reflected in the data as a longer reading time in the +*Ref* items triggered by the filler in clause-3. No such difference was found in region 5 but there is reason to believe that due to spillover, it emerged in the reading times of a following region.

Region 6, e.g., *geng* ‘more’ (1-4 characters, mean: 1.88): This region immediately followed the clause-3 filler, and contained an assortment of categories: verbs, nouns, adverbs, and so on. The Filler Type effect persisted in this region, very likely caused by spillover from the previous region.

Region 7, e.g., *liaojie* ‘understand’ (1-2 characters, mean: 1.96 or 1 symbol): In five of 32 sentences, this region contained the period ‘。’, and in others, it contained a

word. In constructing the test sentences, it was not expected that the Subject or Filler effect would still persist in this region; this is why it was allowed to vary, with a mix of words and the period symbol. Including all items in the statistical analysis, main effects of Subject Type and Filler Type were found by participants and a significant interaction was found by items. (In paired comparisons, for sentences with a referential subject: $\Delta 28$; $F_1(1,44)=4.77$, $p<.05$; $F_2(1,28)=3.13$, $p<.1$; for sentences without a referential subject: $\Delta 5$; $F_1(1,44)=.29$, $p>.5$; $F_2(1,28)=.15$, $p>.5$.) Hence, reading times were similar for the sentences without a referential subject, but reading times for the sentences with a referential subject and a specific filler were notably higher than the sentences with a referential subject and a generic filler. For the sentences with a referential subject, once the better filler in clause-3 appeared, the gap initially filled by the clause-1 subject had to be revised, which could significantly increase the reading time. However, a similar effect was not found for the +*Ref*, *GenF* sentences, which were also expected to undergo the filler-gap reanalysis when the clause-3 filler *ren* was encountered. The unexpected difference between *SpecF* and *GenF* in this regard stands in need of explanation.

It might be argued that the source of this unexpected outcome is that the reading times of a word and the period symbol are sufficiently incomparable as to unsettle the results if combined in the mean reading times for region 7. Thus, in order to see if the interaction was still present when excluding the five sentences with only a period in region 7, a separate ANOVA was performed for region 7 for sentences in which it included a word. The results were similar: there was a significant main effect of Subject Type: -*Ref*: 405ms; +*Ref*: 430ms ($F_1(1,47)=11.43$, $p<.01$; $F_2(1,26)=6.83$, $p<.05$), a significant main effect of Filler Type: *GenF*: 403ms; *SpecF*: 431ms ($F_1(1,47)=7.46$,

$p < .01$; $F_2(1,26) = 5.81$, $p < .05$), and still a significant interaction by items ($F_1(1,47) = 2.6$, $p > .1$; $F_2(1,26) = 6.34$, $p < .05$).

The region 7 reading times raise two issues. First, if the interaction effect is indeed due to revision of the filler, why was it not found for the +*Ref*, *GenF* sentences? Second, if the effect is indeed due to revision of the filler, why did it appear so late: two regions following the parser's encounter with the ultimately correct filler? It can be speculated that the first point is related to the semantic inclusiveness of the generic referent. In the +*Ref*, *GenF* sentences, the gap was presumably initially filled by the matrix subject, a specific referent, and was later reinterpreted as filled by a generic referent. According to Sigurðsson and Egerland (2009), a generic reference has a non-restricted reading, referring to people in general, whereas a specific reference has a reading "referring to a wholly or a partly specific set of individuals" (p. 161); see discussion in section 2.4 above. Thus, a revision of a reference from specific to generic is like an extension of the meaning from a restricted set of individuals to a more inclusive set of individuals. This undertaking seems to be much easier than a revision of a reference from specific to specific, with which the formerly assumed set of individuals is totally eliminated as a member of the new set. Consider, for instance, an English sentence such as *Liao thinks that exercising every day is good for one's health*, in which the initial impression might be that it is about Liao exercising (as in *Liao thinks that exercising every day will make him slender*), but when the generic *one's* is encountered in clause-3, it is not difficult to subsume Liao as just one of many individuals under the umbrella of the generic reference. In contrast, in the +*Ref*, *SpecF* sentences, gap revision involved a change from a specific referent to another specific referent (e.g., from *Liao* to *Lili*). The

two specific referents were mutually exclusive, and would compete with each other; so a full-scale replacement of one with the other would have to take place. On this basis it is unsurprising that the reanalysis effect is greater for the *+Ref, SpecF* than for the *+Ref, GenF* sentences.

The second issue concerns the extended delay of the revision effect. One possible reason is that when the correct filler was encountered, the parser was not certain that it was correct. In that case, the least-effort principle Revision as Last Resort (RALR, Fodor & Frazier, 1980; see also the Minimal Revisions principle of Frazier, 1990, and elsewhere) would be relevant; the parser should be reluctant to undertake revision of the gap assignment until it is clear that it is necessary. In fact, as noted in footnote 82 the semantics of all three clauses is relevant to making a definitive judgment as to which is the correct filler. In particular, the decision may depend crucially on the material following the later filler (*Lili*).⁸³ For example, if the sentence is *Liao hopes that watching science movies will make Lili understand science better*, then *Lili* is indeed the right choice as filler. But if the sentence ends as in *Liao hopes that watching science movies will make Lili admire him*, it is Liao who would be watching science movies, i.e. *Liao* is the correct filler for the subject gap in clause-2. In fact, all the target sentences in the experiment were such that the later filler was the obviously intended one, but of course participants did not know this and so for them the ambiguity would remain alive for some time after the encounter with that later filler. Thus it would be wise to delay any decision to revise, in order to discover what follows *Lili* before undertaking a reanalysis – which might subsequently prove to have been unnecessary or wrong. This could explain why

⁸³ In only five out of 32 experimental sentences, region 6 definitively indicated that the nominal in region 5 was the better filler. In the majority of cases, the parser would need to consult the remainder of the matrix clause (beyond region 6) in order to be certain that the later filler (e.g., *Lili* or *ren*) is the correct one.

the gap revision effect was manifested not even in region 6, the region immediately following the better filler, but as late as region 7 when more (sometimes all) of the content of clause-3 has been encountered. (Note that this contrasts with Experiment 3, where we saw that the parser more quickly adopted an antecedent for an identified gap. However, in that case RALR did not apply; the gap was not previously filled, so no reanalysis was involved when the first candidate filler was encountered.)

4.4.4 Discussion

There are two important findings of this experiment. First, results corroborate those of Experiments 1b and 2, providing more evidence to support the immediate adoption of an available plausible filler for an identified gap. Once the gap has thus been filled, the parser does not anticipate or seek out another filler, though it is still open to the possibility of gap revision if necessary. In the *+Ref* experimental sentences the initial subject noun phrase provided a referent for the gap when it was encountered in clause-2. When a nominal in clause-3 emerged as a better filler, the parser revised the interpretation of the gap. But it was reluctant to do so. The gap-revision effect showed up in region 7, two regions following the correct filler, indicating that the decision to revise was delayed while the parser found out more about the meaning of the sentence in order to make the global assessment of which filler was right.

The second finding is: In seeking a filler for the subject gap within a clausal subject with no prior antecedent, the parser does not anticipate a generic filler. A significant dispreference for generic interpretation was found in region 5, with increased reading times for the overt generic filler (but not for the specific filler) in clause-3 for the

expletive subject sentences compared with the referential subject sentences. This result is unexpected. According to the predictions in Table 4.4 above, processing of *ren* should have been either easier or equally easy for the *-Ref* sentences compared with the *+Ref* sentences: the former if the parser adopts the Local (generic) Interpretation Strategy; the latter if it adopts the Forward Search Strategy. In fact, all the considerations raised in this dissertation so far, supported by the findings of Experiments 1, 2 and 3, encourage the expectation that the parser's preference would be for local assignment of a generic interpretation. This would involve the least amount of work and is seemingly the easiest solution for arriving at a rapid on-line interpretation, as discussed in section 4.4.1. But if indeed a generic meaning were adopted on-line, why is the subsequent appearance of the overt generic *ren* troublesome to the parser? Alternatively, if *ren* is troublesome because a generic meaning was *not* adopted on-line, why would that be so? The explanation for the discrepancy in this regard cannot be stated with any certainty at this time, but some possibilities can at least be confidently ruled out.

The explanation cannot be that *ren* is infrequent in Chinese or is inherently difficult to process; because that would not account for the different outcomes for the *-Ref* and *+Ref* cases. It cannot be that the *-Ref* sentences in the experiment were inherently biased against generic statements. The majority of the predicates in clause-1 of the *-Ref* sentences were equally compatible with a statement about a particular individual or about people in general; for example, *shiwang* 'disappointing,' *chuqi* 'surprising,' and *yihan* 'regrettable' (consider English: *It is regrettable that Sam/people can't be bothered to vote*). There were two or three adjectives that might perhaps have shown a bias towards a generic statement (e.g., *xianyou* 'rare') but none (to my best judgment) that would have

excluded a generic statement. Therefore the *GenF* sentences are just as acceptable as the corresponding *SpecF* sentences in the experiment. It is also not the case that a generically interpreted gap associated with an overt generic filler is not fully acceptable in Chinese. When contemplated off-line without processing pressure, all the *GenF* sentences in the experimental materials are perfectly acceptable to my native speaker judgment.

Though only speculation is possible at this point, it does begin to seem that there is nothing wrong with *ren* itself, but rather that the generic interpretation is not adopted in the first place, i.e., at the gap position.

One possible explanation, though no more than a speculation at present, is that although generics in general are quite common in Chinese, a generically interpreted gap is infrequent. Recall that it is possible only for a subject gap in a clausal subject; even there it is in competition with a specific filler in a matrix clause, and to determine whether a specific or a generic interpretation is more plausible could involve complex computation evaluating the syntax, semantics and pragmatics of the clause containing the gap. So perhaps the parser on encountering a subject gap in a clausal subject treats it as a gap that needs a filler (assigning it an index, which it expects to match to the index on a subsequent noun phrase), with the back-up plan that if no suitable filler is encountered, a last-minute and very low-cost option is to go back and delete the index and assign the generic interpretation locally.⁸⁴ Because the parser determines to give up the local generic interpretation in favor of a filler search, it therefore may not anticipate an overt generic filler. This lack of anticipation or even dispreference for an overt generic filler in the search might explain the higher reading times for the *-Ref* sentences with a generic filler.

⁸⁴ If the generic interpretation always involves coindexing with a generic filler, either overt or null (see discussion in footnote 79 above), then the low-cost last resort would be to insert and coindex a null generic filler.

To summarize this chapter: Four experiments were conducted to answer various questions related to empty category interpretation in Chinese. The findings, however, go beyond the three research questions laid out at the beginning of this chapter. The implications of the findings will be discussed in detail in the next chapter, and a comprehensive gap-filling strategy for the Chinese language will be proposed.

CHAPTER 5

GENERAL DISCUSSION

Chinese is an interesting language to study from a psycholinguistic perspective because it has a great deal of ambiguity. Even more interestingly, it illustrates a point which has not been previously noted, to the best of my knowledge, which is that ambiguities of phrase structure can create ambiguities of empty category identity and interpretation. It might have been expected, on functional grounds, that a language with one kind of ambiguity would avoid as far as possible ambiguities of other kinds; but clearly this is not necessarily so. The Chinese language is not ‘designed’ to make processing easy or straightforward. Chinese language users nevertheless manage to cope with the on-line uncertainties and seem to understand each other very well. How they do this has been the focus of this dissertation.

This study started out with the aim of answering three specific research questions regarding empty category processing in Chinese. Four experiments were conducted. The findings not only provided answers to these questions, but also generated far-reaching implications concerning the parser’s strategies for coping with empty categories in Chinese. This chapter will discuss, first, how the design of the experiments equipped them to provide evidence to answer the research questions of interest (section 5.1). Then, it will evaluate how the experimental findings shed light on the parser’s general strategy for processing gap-driven filler-gap dependencies in Chinese (section 5.2). Finally, it will lay out several directions for future research (section 5.3).

5.1 Three research questions

5.1.1 Question one: When a gap is identified before its filler is, does the parser adopt the first candidate filler, or does it wait to see whether a better filler may subsequently appear?

This question inquires how active the parser is in completing a gap-driven filler-gap dependency. The Active Filler Strategy, as discussed in section 3.1.1, depicts an active parser in the sense that, after encountering a filler, it will associate it with the first potential gap position that becomes available. Here, the question is whether the parser will be equally active when a gap is identified before its filler is. As has been noted in section 1.1, rapid completion of the dependency could be as urgent in the case of a gap-first dependency. Note that when a filler is identified before the gap is, the filler has a reference but an unknown thematic role. By contrast, when a gap is identified before the filler is, the gap has a thematic role but an unknown reference. It is not clear which situation is more troubling to the parser. Nevertheless, in both cases, there is some linguistic feature about the first identified element in a filler-gap relation that the parser needs to find out. This is likely to be the reason that motivates the parser to complete a filler-gap dependency.

In order to quickly obtain an interpretation for a gap it has encountered, an active parser is presumed to adopt the first candidate filler it can locate, even though it thereby runs the risk of having to undertake gap revision if it finds a better filler later in the sentence. An Active Gap Strategy can then be formulated as: Interpret an identified gap as soon as possible; that is, rank the option of a filler analysis above the option of a non-

filler analysis on-line. In simple terms: If a constituent *could* be the filler for an as yet unassigned gap, assume that it *is* the filler.

An Active Gap Strategy can be tested on-line under two different circumstances, which differ with respect to the relative configuration of the filler and gap in the sentence. In one case: when a gap is encountered, a candidate filler is already available. This candidate filler can be a referent in the parsed segment of the sentence or in the discourse preceding the sentence. A parser that employed an Active Gap Strategy would be likely to adopt this candidate filler to interpret the gap immediately. In the second case: when a gap is encountered, no candidate filler is yet available. Then, the parser has to look for the filler in the incoming material. In the search process, an active parser is likely to adopt the first candidate filler. In both situations, there is often a risk that a better filler will appear after the gap is filled, which forces a gap revision. An Active Gap parser favors a quicker rather than a safer gap interpretation. It is very much in keeping with other experimental findings in psycholinguistics which portray the human parsing routines as non-deterministic, serial, incremental and risk-taking, with biases which guide it as it makes guesses on-line rather than waiting for more complete information before committing itself.

The findings of Experiments 1b, 2 and 4 support the use of an Active Gap Strategy in the first situation, whereas the findings of Experiment 3 support the use of an Active Gap Strategy in the second situation. In Experiment 1b, an initial adjunct clause did or did not contain a plausible antecedent for a subject gap in the second clause. When it was present, the plausible filler was often used to interpret the gap. As a result, fragments that contained a subject gap and a verb were mostly continued as main clauses.

In contrast, the absence of a plausible antecedent in the first clause resulted in substantial clausal subject continuations for the second clause of the fragment. Note that this decision was made at the verb of the second clause, which was the first word indicating that the subject gap was present. Thus, this result indicates that when a candidate filler is already present when a gap is encountered, it is favored immediately by the parser.

In Experiment 2, the lexical semantics of the matrix verb determined whether the matrix subject was a plausible filler for an empty subject in the ambiguous subordinate clause that followed. When a plausible filler was available for its subject gap, the subordinate clause was preferentially disambiguated as a clausal object, the simplest structure. But when the matrix clause was such that it did not offer a plausible filler, the subordinate clause was preferentially disambiguated as a relative clause, with the head noun following it as the filler for the gap. Exactly when this structural decision was taken by the parser is not known. The statistical interaction of Matrix Verb Type and Clause Type was found at the period, three words later than the subordinate verb that indicated the presence of a gap to be filled, and it clearly indicated that the parser had adopted the relative clause analysis in the absence of a suitable filler in the matrix clause. There is a possibility that the structural decision towards the relative clause analysis occurred earlier in the subordinate clause. There was a main effect of Matrix Verb Type apparently triggered by the subordinate verb (since it was at the word immediately following that verb). However, this might not reflect the adoption of the relative clause analysis but merely the parser's recognition of the presence of a gap without (yet) a suitable filler.

In Experiment 4, the subject gap was in a clausal subject, and its filler appeared in the matrix clause, later than the gap. This whole construction was embedded as an object

complement clause within a preceding higher clause, which in some cases provided a plausible ‘decoy’ filler. The decoy was the first candidate filler accessible to the parser, but it later proved to be incorrect. As the true (complex) phrase structure configuration became clear after further input, the parser would recognize that the true filler followed the gap. A reanalysis cost was found for sentences with an early decoy filler, preceding the gap, indicating that it had been adopted on-line for gap interpretation. All in all, the evidence in these experiments converges to support the picture of an active parser that quickly adopts a candidate filler, if available, for an identified gap.

Experiment 3 was designed to test the second situation of on-line gap-filling, when a gap is encountered but no candidate filler is yet available. In this situation, the question is whether the parser will actively search for a filler for the gap. Decoy fillers were used in the testing. The experimental sentences contained a clausal subject with a subject gap. In the experiment, nothing preceded the gap; hence, the parser had to find the filler in the sentence material that appeared subsequently. The first structural position that could possibly offer a filler contained a noun phrase that was a plausible filler in one case but an implausible filler in another condition. Both turned out later to be decoy fillers, as they were modifiers of a following nominal, which was the real filler. Since Chinese noun phrases are strictly head-final, it is often unknown whether a nominal received is the head noun or a prenominal modifier. An Active Gap parser would grasp the first potential filler and link it with the gap, and pay the cost later in reanalysis if it turned out instead to be just a modifier of the real filler. The results showed that at the word immediately following the decoy noun phrase, the parser had detected whether that noun phrase was plausible or implausible *as* a filler for the gap. Then, at the position of the real

filler and subsequently, the sentences with a plausible decoy filler were read slower than the sentences with an implausible decoy filler, presumably due to the need for reanalysis in the former case. These findings indicate, once more, that the parser actively searches for a filler for an identified gap, and rapidly adopts the first candidate available, regardless of the risk of having to undertake reanalysis later.

In sum, for both types of on-line gap-filling situations, an Active Gap Strategy is employed in assigning an antecedent to an identified gap. When a gap is encountered, if a plausible antecedent is available, it will be immediately adopted as the filler. If no such antecedent is available, the parser will look for the filler in the incoming material, and adopt the first plausible candidate.

5.1.2 Question two: How does empty category interpretation interact with structural ambiguity resolution?

An especially interesting finding from Experiments 1 and 2 was that the parser is willing to trade off Minimal Attachment to facilitate empty category interpretation. The results of Experiment 1 showed that a sentence fragment was most likely to be continued as a main clause, the structurally simplest construction, if the subject was overt or a plausible referent was available for the subject gap. But if a plausible referent was not available when the subject gap was encountered, the chance for the fragment to be continued as a clausal subject increased significantly. A sentence with a clausal subject is a bi-clausal construction, hence structurally more complex than a main clause. But the antecedent for the gap can appear in the main clause predicate, a segment that could readily be added to the fragment in this completion task, whereas adding an antecedent for the gap in a

mono-clausal main clause is nearly impossible. Hence, the clausal subject continuation, though structurally more complex, could solve the lack-of-referent problem in the main clause continuation. This indicates that although Minimal Attachment is known to be a powerful influence on syntactic parsing, it is not always the dominant one; the parser will sacrifice Minimal Attachment in order to secure a determinate filler for the gap.

These findings are further supported by the self-paced reading results of Experiment 2. In this study, the matrix verb determined the possibility of coreference between the matrix subject and the subject gap in the subordinate clause. If the matrix subject was a plausible controller, the clausal object analysis was preferred for the subordinate clause. However, if the matrix subject was not a plausible controller, the structurally more complex relative clause analysis was instead favored for the subordinate clause with a guarantee of a subsequent filler for the relative clause gap. This finding suggests that when a gap is identified on-line, the parser gives a high priority to finding an interpretation for it, even at the cost of more complex phrase structure assignment if necessary.

Thus, the results of the sentence completion and the on-line reading studies converge to show an interaction of empty category interpretation and structural ambiguity resolution. Syntactic economy, as often couched in the principle of Minimal Attachment, is only one factor the parser takes into account in resolving structural ambiguity. The findings of these studies provide empirical evidence of the importance of empty category interpretation in shaping the parser's on-line decisions about structure.

5.1.3 Question three: Is *local* interpretation of a gap (as generic in reference) preferred over association with a filler elsewhere in the sentence?

The issue of generic interpretation is not usually raised in experimental work on empty category processing. Experiment 4 was specifically designed to answer this question. The experimental sentences were a three-clause construction: a main clause that was complemented by a clausal object with a clausal subject. The results of the on-line reading study showed that when there was not a plausible antecedent preceding the gap, the reading time increased significantly when the filler that followed the gap was a generic filler, compared to the same generic filler in a sentence where the gap was initially filled by a preceding filler and therefore, there should be no anticipation for a subsequent filler. On the other hand, the reading times of the specific filler did not differ in the sentences with or without a plausible filler preceding the gap. These findings suggest that when the parser is looking for the filler for an identified gap within a clausal subject, the generic filler is not anticipated. This in turn implies that when a gap is identified, the parser prefers to look for a filler, rather than making an immediate local assignment of the generic referent. This finding is unexpected because the Forward Search Strategy seems to require more work than the Local Interpretation Strategy. Nevertheless, based on the finding of Experiment 4, I have speculated that the parser does not anticipate a generic referent in the search process, and the generic interpretation is used only as the last resort when no overt filler is found in the sentence. It remains to be studied whether this is a language specific or a universal parsing strategy.

5.2 A parsing strategy for gap-driven filler-gap dependencies

Results of the experiments in this study provide empirical evidence to answer the three questions raised here concerning empty category processing in Chinese in general. The issues are sufficiently related to each other that it is possible to integrate them into a comprehensive parsing strategy for gap-driven filler-gap dependencies in Chinese. This strategy is called an Active Gap Strategy in this dissertation. It encompasses the following ordered steps to complete a gap-driven filler-gap association.

1. When a gap is identified, look for the filler among the parsed material in the current sentence or prior discourse;
2. If there is structural ambiguity, consider adopting an analysis that is likely to contain a filler for the gap, even if this would entail a sacrifice of structural economy;
3. If no filler has yet been found, search for the filler in the incoming material, and adopt the first grammatically legitimate and plausible candidate;
4. As the last resort, adopt the generic interpretation where that is acceptable, i.e., for a null subject within a clausal subject.

I would like to propose the Active Gap Strategy as a universal parsing strategy, alongside Minimal Attachment and others. Of course, a great deal of cross-linguistic research will be needed to support this conjecture.

5.3 Directions for future research

The present study has presented some data to answer the three questions discussed in this chapter, and has formulated an Active Gap Strategy for completing gap-driven filler-gap

dependencies in Chinese. However, some interesting questions concerning empty category interpretation in on-line sentence processing remain to be addressed, and therefore it is worth considering some follow-up and related studies in Chinese and other languages. This section presents a few directions for future research on this topic.

First, the data of Experiments 1 and 2 in the present study have shown that Minimal Attachment is a violable constraint; the parser may choose to override it and adopt a more complex analysis for an ambiguous structure in order to optimize empty category interpretation. Hence a related question naturally arises: Is the parser willing to sacrifice Late Closure in order to optimize empty category interpretation? Late Closure, which is also called Right Association, was briefly discussed in Section 1.2. In a nutshell, Late Closure requires that the parser attach a new word to the phrase that is currently being processed. In Chinese, the conflict of Late Closure and empty category interpretation can be seen in the completion of a relative clause as shown in Figure 5.1.

FRAGMENT: Zhege *e* wuru laoban de pengyou...

This insult boss DE friend

‘The friend who insulted the boss...’

‘The...who insulted the boss’s friend...’

POSSIBLE STRUCTURES:

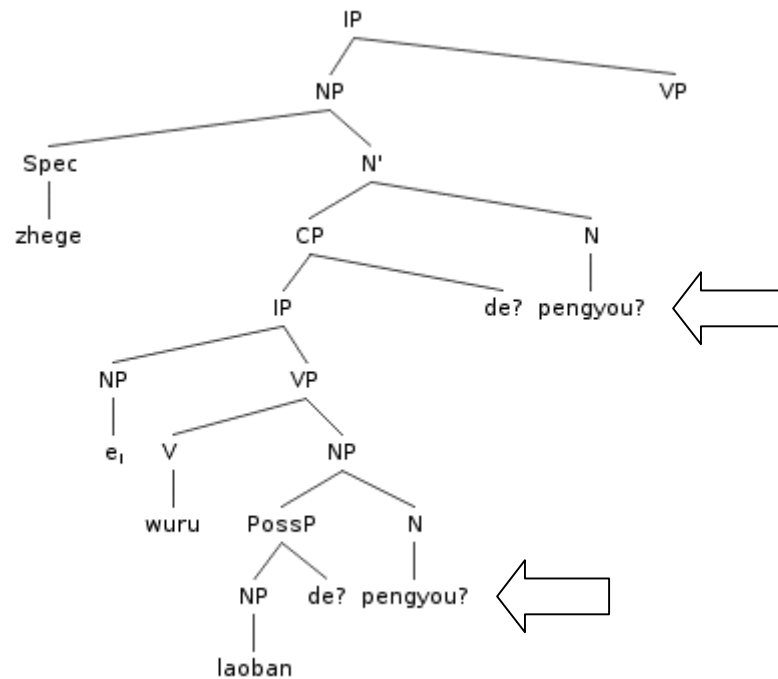


Figure 5.1: An Early/Late Closure ambiguity in Chinese relative clauses.

The demonstrative/classifier *zhege* at the beginning of the clause signals that what follows is part of a noun phrase. The following verb *wuru* hints that this noun phrase includes a relative clause with an empty subject. A parser that employs an Active Gap Strategy would want to have this gap filled as soon as possible. When *de* appears, there are two choices presented to the parser: either attach it low as part of the object noun phrase within the relative clause (*laoban de pengyou* ‘the boss’s friend’), or attach it high as the relative clause marker (*wuru laoban de pengyou* ‘the friend who insulted the boss’). The former analysis complies with Late Closure because *de* would be tucked into the noun phrase the parser is currently building; however, the gap would be left unfilled. On the latter analysis the positioning of *de* permits the next word to be the filler for the gap; however, Late Closure is violated because *de* would be attached high in the syntactic

tree. Experiments with carefully designed materials can pit one strategy against the other, and the data will reveal whether the parser would give up Late Closure to facilitate gap interpretation.

Another promising research direction is to reexamine the surprising results obtained in Experiment 4. The results of that experiment suggest that the generic overt filler is less expected than the specific overt filler, in the search for a reference for the subject gap within a clausal subject. The overt fillers used in the experiment were *ren* ‘people’ and proper names. It is possible that these fillers are not representative of generic and specific references a reader frequently encounters in daily reading materials. The two types of fillers are also not well-matched in terms of number of characters and familiarity. (*Ren* is a one-character and very common word whereas Chinese proper names tend to be novel to the reader and contain at least two characters.) Thus, a follow-up study could use a similar sentence pattern but the overt fillers are, for instance, the Chinese equivalent of *those students* and *students*. These two types of fillers are better matched in terms of semantic content and the number of characters they contain. In both cases, the overt filler when encountered would be associated with the gap in the clausal subject replacing any other filler that had already been assigned. But this would be a less extreme revision for *students* if a generic interpretation had been assigned on-line.

A third future research direction concerns methodology. Experiment 3 of the present study investigates whether the first candidate filler is adopted for an identified empty category. The results show a longer reading time for the implausible decoy filler (e.g., *youeryuan* ‘kindergarten’), compared with the plausible decoy filler (e.g., *xiaohaizi* ‘child’), at the position where a candidate filler could appear. But a faster reading time is

observed for the implausible condition relative to the plausible condition when the real filler (e.g., *baomu* ‘nanny’) subsequently appears, presumably because in the former case no dependency has previously been established between the implausible decoy filler and the gap, but in the latter case the previously established filler-gap link has to be revised.

While the findings of the reading time study are consistent with the prediction that the parser anticipates the filler once a gap is identified, a follow-up study employing the visual world eye-tracking paradigm may provide a more direct means to demonstrate the anticipation in advance of the filler. Visual world eye-tracking is used to track eye-movements in response to auditory stimuli. Actual objects or pictures of objects related to the auditory materials are either displayed in front of a participant or presented on a computer screen. While listening to the stimuli, participants’ eye-movements are recorded. The fixation patterns to the objects in the scene are taken as reflecting the underlying linguistic processing.

The visual world study would not need to include materials with the implausible decoy filler (*youeryuan* ‘kindergarten’) in Experiment 3; the filler can also be simplified from a complex noun phrase to a simple one (*child’s nanny* to just *nanny*).⁸⁵ Pictures depicting various easily identifiable animate referents (e.g., toddler, nanny, carpenter, and waiter) may serve as the control and target. A test sentence could be (in English gloss): *Tidying the toys tired out the nanny*. When the verb *tidy* is presented, there may be more fixations on the nanny, the carpenter and the waiter than on the toddler, because the former three characters are more likely to tidy something. But when *toys* is heard, fixation patterns for the more plausible filler like ‘nanny’ may be compared with those

⁸⁵ With a simple noun phrase as the filler, this proposed experiment can be run on English. It would be even more interesting to run the experiment with similar materials in the two languages, to allow a cross-linguistic comparison of filler-gap processing.

for implausible fillers like ‘toddler,’ ‘carpenter,’ and ‘waiter,’ even though toys are more closely related to toddlers. More fixations on the plausible filler can be rechecked at the matrix verb *tire out*, which indicates that the first clause is a clausal subject and that the filler for its PRO may appear in the matrix predicate. If participants are anticipating the filler at this point, it would be predicted that more fixations will land on the plausible filler, the nanny character, than on the other three implausible fillers.

Note that it is predicted that participants’ fixations on the nanny picture do not change through the segment of the sentence from *toys* to *tired out*. It might be argued that this persistency is due not to anticipating the filler but to perseveration, i.e., the participants just continuing to look wherever they were looking before. One way to circumvent this is to insert intervening material into the sentence which mentions another character, such as the toddler: *Tidying the toys and the books that the toddler was looking at tired out the nanny*. At the mention of ‘toddler,’ the participants would probably shift their gaze temporarily from the nanny to the toddler. It could then be observed whether fixations then shift back from the toddler to the nanny when *tired out* is received. If so, that would constitute strong evidence that the participants are anticipating the filler that will occur later in the matrix predicate.

As a last future research direction, I would like to revisit an interesting issue raised by Xie (1997) while changing the methodology from cross-modal priming to ERPs. The issue concerns the difference in the processing of filler-driven A and A-bar dependencies. In Chinese, a topic construction involves an A-bar dependency, with a phrase at the beginning of a clause linked to a gap position within the clause. On the other hand, a passive construction involves an A-dependency (similar to passive in English),

but with the agent phrase *before* the passive verb and unambiguously marked as the passive agent by a preceding passive morpheme *bei*. The sentences in (1) and (2) illustrate a topic and a passive construction in Chinese respectively.

(1) Xiaozhang_i, Xiaoli qipian le e_i sanc_i.

Xiaozhang Xiaoli cheat PAST three-time

‘Xiaozhang, Xiaoli cheated three times.’

(2) Xiaozhang_i bei Xiaoli qipian le e_i sanc_i.

Xiaozhang BEI Xiaoli cheat PAST three-time

‘Xiaozhang was cheated by Xiaoli three times.’

One question is: when a topic is identified, for example, *Xiaozhang* in (1), is a search for a gap immediately initiated? This type of filler-gap dependency involves the filler in a non-argument position and the gap in an argument position. A second question is whether this dependency will exhibit the characteristic ERP patterns found for *wh*-movement in English, and also scrambling in Japanese. Then a third question of interest is whether the pattern for passive resembles that for topicalization. In a passive construction, the filler, for example, *Xiaozhang* in (2), cannot be recognized as a filler until the distinctive passive morpheme *bei* is encountered. This type of filler-gap dependency involves both the filler and the gap in an argument position. It is possible that the parser will initiate a search for a gap as soon as it encounters *bei*. Alternatively, a filler in A position might not trigger any gap search. Indeed, some syntactic theories argue against the presence of a

filler-gap relation in a passive construction, and some experimental research on other languages has claimed that passives do not show strong indicators of filler-gap processing. Note that in (1) and (2), the portion of the sentence starting from *Xiaoli* is surface-identical, which therefore offers an unusual opportunity to compare the processing difference, if any, of A and A-bar dependencies in lexically matched circumstances. Also, it is possible to track the comparison of passive processing and topicalization processing over time in Chinese, even though passive is not a long-distance dependency. This is because noun phrases of various lengths can be substituted for *Xiaoli* in both (1) and (2), increasing the distance between filler and gap in both constructions.

There are two merits for using the ERP methodology. First, it is superior to reading methods because a topic in Chinese is not easily identified as such unless it is distinctively marked by prosody, for example, a prosodic break inserted between the topic and the rest of the sentence. Auditory materials can be used in an ERP study but not in a reading study. Second, it is superior to response time measures because it provides multidimensional data (amplitude, latency, topography, etc.). Previous ERP studies have taken advantage of this to map out brain responses to filler-driven filler-gap dependencies; see section 3.1.3.

Appendix A: One gap or two gaps

Controversy hovers over the number of gaps in sentences with a subject gap in an object complement clause, such as the target sentences in Experiment 2. This problem might affect the interpretation of the experimental results because the longer reading times found for the two-gap sentence might be related to gap number but not gap interpretation. An example of the test sentences in that study is repeated here in (1), where the structures of their matrix clauses are shown as parallel in their lack of an object noun phrase.

- (1) a. Yao **jujue** [*e* tuichu zhegebisai de zongjuesai].
 Yao refuse withdraw this-tournament DE final
 ‘Yao refused to withdraw from the final of this tournament.’
- b. Yao **fengci** [*e* tuichu zhegebisai de zongjuesai].
 Yao ridicule withdraw this-tournament DE final
 ‘Yao ridiculed (someone) for withdrawing from the final of this tournament.’

In (1a,b), only a subject gap is represented in both the *jujue* and the *fengci*-type sentences. In the case of English, according to Government and Binding theory, the verb *refuse* is subcategorized for a complement clause, containing a subject gap, like *jujue* in (1a), but the verb *ridicule* is subcategorized for an object noun phrase followed by a complement clause. Thus GB theory ascribes different structures to the English equivalents of the Chinese sentences, as shown in (2).

- (2) a. Jim_i refused [*e*_i to withdraw from the final of the tournament].

- b. Jim ridiculed Tom_i [for e_i withdrawing from the final of the tournament].

In (2a), the null subject is controlled by the matrix subject. In (2b), the null subject is controlled by the matrix object. Note that the matrix object in English (2b) must be overt. The former type of control is called *subject control* and the latter type *object control*. In English a construction with a matrix clause followed by a clausal object that contains a null subject must be a control construction of one kind or another, because English, unlike Chinese, does not permit the null subject in the subordinate clause of either (2a) or (2b) to be discourse-bound.

Since Chinese permits discourse-bound null subjects and objects, it is possible in principle for *both* (1a,b) to have either one empty category, as shown above, or else two empty categories, one being the matrix object and bound by the discourse, and the other being the null subject within the complement clause and controlled by the null object.⁸⁶ Thus the question is: Is (3) or (4) the accurate syntactic representation of (1a) and (1b)?⁸⁷

- (3) Yao_i refuse/ridicule [$e_{i/j}$ withdraw this-tournament DE final].

- (4) Yao_i refuse/ridicule $e_{i/j}$ [$e_{i/j}$ withdraw this-tournament DE final].

In (3), there is only one empty category, which resides in the subject position of the complement clause. Either the subject gap refers to Yao (i.e., is controlled by the matrix

⁸⁶ In Chinese, for both the *jujue* and *fengci*-type sentences, a person different from the matrix subject can be the doer of the action mentioned in the complement clause. See the example in (5) below.

⁸⁷ I will not address here an interesting new analysis with one empty category which is in the main clause and controlled by an overt item in the subordinate clause; see Polinsky and Potsdam (2002).

subject *Yao*) or else it refers to someone other than Yao, due to the possibility of a discourse-bound empty category. These sentences would then mean that Yao refuses (in the sense of *rejects*) or ridicules a proposition, viz that someone withdrew from the final of the tournament. (The person who withdrew from the final of the tournament could be Yao if the empty category is controlled by the matrix subject, rather than discourse-bound.) In contrast, if there are two gaps in these sentences, as in (4), the meaning would be that Yao refuses (to let) someone to do something (i.e., prevents him from doing it) or ridicules someone for doing something. (Once again, the person being refused or ridiculed could be Yao if the matrix object is like a reflexive (e.g., *himself*), which could be overt or covert.) In both cases, the matrix object controls the embedded null subject. Note that for both verbs, this construction is acceptable in Chinese with an overt noun phrase between the two clauses, as shown in (5).

- (5) Yao jujue/fengci Tom_i jinnian you tuichu zhegebisai.
 Yao refuse/ridicule Tom this-year again withdraw this-tournament

This indicates that the Chinese *jujue* is different from the English *refuse*, because in the latter, the subordinate subject must be covert, and must refer to the matrix subject.

There is independent evidence to suggest that both (3) and (4) are possible structural representations for the *jujue*-type or the *fengci*-type of verb. For (3), an adverbial test provides the structural evidence and a proposition test provides the semantic evidence. Time adverbials in Chinese are reliable markers for a left edge clause boundary because they (or most of them) must occur before the verb of a clause. Thus, if a time adverbial occurs after a verb but before a noun phrase, it shows that the verb and

the noun phrase belong to different clauses. The sentence in (6) simulates those in (1); it contains an additional time adverbial, and the empty category becomes an overt noun phrase.

- (6) Yao jujue/fengci [jinnian Tom you tuichu zhegebisai].
 Yao refuse/ridicule this-year Tom again withdraw this-tournament DE
 ‘Yao refused (to let) Tom withdraw from the tournament again this year.’
 ‘Yao ridiculed Tom for withdrawing from the tournament again this year.’

The important observation is that *jinnian* ‘this-year’ is one of the time adverbials that must precede the verb in order for it to modify the clause that contains the verb. In the sentence in (6), it cannot be a matrix clause adverbial, because if it is part of the matrix clause, it must occur before the matrix verb *jujue/fengci*. Its position therefore indicates that it belongs to the complement clause, which in turns implies that anything following it is also in the complement clause. Hence, *Tom* in (6), and likewise for its covert counterpart if the position is empty, must be inside the complement clause and thus, cannot be the matrix object. If there were a null matrix object, it would follow that *Tom*, being in the complement clause, could not bind or control it, because of Binding Principle C (see section 2.1 for discussion of this principle). In addition, for verbs like *jujue/fengci* it is not possible for the matrix object and the embedded subject in these sentences to have distinct referents. In other words, a sentence like *Yao jujue/fengci Mary Tom tuichu zhegebisai*. (‘Yao refused Mary for Tom to withdraw from this tournament.’ or ‘Yao ridiculed Mary for Tom to withdraw from this tournamen.t’) is not acceptable in Chinese.

This provides structural evidence to support the claim that verbs like *jujue/fengci* might be subcategorized for only a complement clause.

There is also semantic evidence to support the structural representation in (3). If in Chinese someone can reject (*jujue*) or ridicule (*fengci*) just a proposition, instead of a nominal referent, this means that a matrix object noun phrase is not obligatory. An exploration of the Internet using a search engine has yielded examples of sentences with *jujue* or *fengci* followed by a proposition.

- (7) a. Qiuyuan de zhuangtai, guanzhong de xinqing, dianshi zhuanbo de
 athlete DE preparedness audience DE mood TV broadcast DE
 jihua, yiqie de yiqie dou chengwei-le wangqiu yundong **jujue**
 plan everything DE everything all became tennis sport refuse
 xia yu de liyou.
 fall rain DE reason
 ‘The preparedness of the athletes, the expectation of the audience, and the
 broadcast plan of TV stations, all this has become the reason for why
 (organizers of) tennis tournaments refuse to let it rain.’
- b. Hai yiwei ni **fengci** zher shi seqing shangdian ne.
 originally think you ridicule here is sex shop PART
 ‘I originally thought you ridiculed that here was a sex shop.’

In (7a), the relevant portion of the sentence is *wangqiu yundong jujue xia yu*. The clause *jujue xia yu* (refuse-fall-rain) does not have a referential subject. Thus, that segment of the sentence cannot mean that the organizers reject, in the sense of *forbid*, someone to rain. Instead, it must mean that the organizers reject (the possibility) that it rains.

Likewise, the sentence in (7b) shows that the Chinese verb *fengci* can take only a

proposition as its complement: that someone ridicules (the assumption) that here is a sex shop. These examples indicate that *jujue* and *fengci* are both able to take only a proposition as complement.

So far, I have provided evidence to attest the structural representation in (3) for the *jujue* and *fengci*-type sentences. However, I have not provided evidence to eliminate (4) as a possible structural representation. In fact, there is no evidence to suggest that (4) could not be an alternative representation for the *jujue* and *fengci*-type sentences. For one thing, *jinnian* ‘this-year’ can follow *Tom*, as in (8a,b). In this case, it is unknown whether *Tom* should be a matrix object, as in (8a), or an embedded subject, as in (8b).

- (8) a. Yao *jujue/fengci* Tom_i [*e_i* *jinnian* you tuichu zhegebisai].
 Yao refuse/ridicule Tom this-year again withdraw this-tournament
- b. Yao *jujue/fengci* [Tom_i *jinnian* you tuichu zhegebisai].
 Yao refuse/ridicule Tom this-year again withdraw this-tournament
 ‘Yao refused (to let) Tom withdraw from the tournament again this year.’
 ‘Yao ridiculed Tom for withdrawing from the tournament again this year.’

If the structural representation in (4) is an alternative to that in (3), why is it impossible for the two gaps to have distinct referents? For example, as mentioned above, sentences like *Yao jujue/fengci Mary Tom tuichu zhegebisai* (‘*Yao refused Mary for Tom to withdraw from this tournament.*’ and ‘*Yao ridiculed Mary for Tom to withdraw from this tournament.*’) are not acceptable. This in turn implies that the gap within the complement clause cannot be discourse-bound. This contrasts with the single gap representation in (3), where the gap can be discourse-bound. Thus, it appears that the type

of complement clause in (3) could be different from that in (4), which leads to the “protection” of the embedded subject gap from discourse referents in the latter but not in the former. One explanation for this is perhaps the complement clause in (3) is finite, with the subject gap being *pro*. In that case, it can be bound by the matrix subject, or by a discourse referent. By contrast, the complement clause in (4) is non-finite, with the subject gap being PRO. In that case, it must be controlled by either the matrix subject or object, and cannot co-refer with a constituent outside the sentence. This analysis would give independent evidence to support the finite and non-finite distinction of a complement clause in Chinese. But for sure more evidence is needed to support this account. I leave this to future research.

To sum up, there could be two structural representations for the sentences in (1), differing with respect to the empty categories they contain. One has just an embedded null subject, as shown in (3). The other has a matrix null object and an embedded null subject, as in (4). But the more important thing is both the *jujue* and the *fengci*-type sentences are open to these two options of representation. This is clearly different from English. In English the verb *refuse* must control the null subject in the complement clause, and no matrix object is allowed in the sentence. This is not the case with the Chinese verbs used in Experiment 2. All the *refuse*-type verbs used in the experiment can be complemented by a clause with an overt subject that has a referent different from the matrix subject.

Appendix B: Tables

Experiment 1a

Table B1: Percentages of completion types by fragment type, in Experiment 1a

	SV	V	QV	AdvV
Main clause	94	37	87	38
Clausal subject	3	46	7	44
Relative clause	0	4	1	11
Others	3	13	5	8

Experiment 1b

Table B2: Completion results of Experiment 1b: form of the second clause

	Plausible antecedent	No plausible antecedent
Main Clause	93	49
Clausal Subject	2	31
Relative Clause	4	13
Others	1	6

Experiment 2

Table B3: Mean reading times (ms) for all regions of the target sentences in Experiment 2

Region	Clausal Object		Relative Clause	
	Coreferential	Non-coreferential	Coreferential	Non-coreferential
1	791	762	763	766
2	458	490	459	493
3	484	512	491	487
4	600	655	626	651
5	435	430	440	425
6	521	534	533	521
7	508	540	545	511

Experiment 4

Table B4: Mean reading times (ms) of the target regions in Experiment 4

Region	Specific Filler		Generic Filler	
	-Referential	+Referential	-Referential	+Referential
	Subject	Subject	Subject	Subject
3	417	420	419	420
4	397	398	400	403
5	537	543	393	378
6	479	486	412	406
7	418	444	413	416

Appendix C: Experimental materials for Experiment 1

Experiment 1a

This experiment had two sets of sentence fragments, with two conditions in each set. The two conditions (SV and V) of the first set differ in the presence or absence of an overt subject. (The overt subject is in brackets below.) The two conditions (QV and AdvV) of the second set differ in the presence of a quantified subject or a frequency adverbial respectively. The overt subject and the quantified subject are inside square brackets below, separately by a slash (/). Empty categories are shown as EC. All materials were presented in simplified Chinese characters, as shown here.

SV and V fragments

1. (家辉) 安慰...
(JiaHui) anhui
JiaHui console
'JiaHui consoled...'
'EC consoled...'
2. (他们) 占领
(Tamen) zhanling
they occupy
'They occupied...'
'EC occupied...'
3. (何 经理) 表扬
(He jingli) biaoyang
He Manager praise
'Manager He praised...'
'EC praised...'
4. (小盈) 赢得
(XiaoYing) yingde
XiaoYing win
'XiaoYing won...'
'EC won...'
5. (黄 婆婆) 怀念
(Huang popo) huainian
Huang Lady remember
'Lady Huang remembered...'
'EC remembered...'

6. (司徒 小姐) 修改
(Situ xiaojie) xiugai
Situ Miss amend
'Miss Situ amended...'
'EC amended...'
7. (我 哥哥) 加入
(Wo gege) jiaru
my brother join
'My brother joined...'
'EC joined...'
8. (小黄) 消灭
(XiaoHuang) xiaomie
XiaoHuang destroy
'XiaoHuang destroyed...'
'EC destroyed...'
9. (姐姐) 解决
(Jiejie) jiejie
sister solve
'The sister solved...'
'EC solved...'
10. (徐 教授) 推翻
(Xu Jiaoshou) tuifan
Xu professor reject
'Professor Xu rejected...'
'EC rejected...'
11. (万秦) 卖弄
(WanQin) mainong
WanQin flaunt
'WanQin flaunted...'
'EC flaunted...'
12. (我们的 工会) 通过
(women-de gonghui) tongguo
our union pass
'Our union passed...'
'EC passed...'

13. (史 老师) 轻视
(Shi laoshi) qingshi
Shi teacher deride
'Teacher Shi derided...'
'EC derided...'

14. (学校) 挑选
(Xuexiao) tiaoxuan
school choose
'The school chose...'
'EC chose...'

15. (政府) 推广
(Zhengfu) tuiguang
government popularize
'The government popularized...'
'EC popularized...'

16. (妈妈) 说服
(Mama) shuofu
mother convince
'The mother convinced...'
'EC convinced...'

17. (妹妹) 完成
(Meimei) wancheng
sister finish
'The sister finished...'
'EC finished...'

18. (秦同学) 使用
(Qin tongxue) shiyong
Qin classmate use
'Classmate Qin used...'
'EC used...'

19. (我) 掩饰
(Wo) yanshi
I conceal
'I concealed...'
'EC concealed...'

20. (她们) 专重
(Tamen) zhuanzhong
they respect
'They respected...'
'EC respected...'
21. (这 群 流氓) 侵占
(Zhe qun liumang) qinzhan
this group rascal occupy
'This group of rascals occupied...'
'EC occupied...'
22. (李梅) 维护
(LiMei) weihu
LiMei defend
'LiMei defended...'
'EC defended...'
23. (江 太太) 抛弃
(Jiang taitai) paoqi
Jiang Mrs abandon
'Mrs Jiang abandoned...'
'EC abandoned...'
24. (我的 同事) 整理
(wo-de tongshi) zhengli
my colleague tidy
'My colleague tidied...'
'EC tidied...'

QV and AdvV fragments

1. [没有人 / 从不] 整理⁸⁸
[Meiyouren / congbu] zhengli
no-one never tidy
'No one tidied...'
'EC never tidied...'
2. [没有人 / 从不] 挪用
[Meiyouren / congbu] nuoyong
no-one never embezzle
'No one embezzled...'
'EC never embezzled...'

⁸⁸ Due to an experimental oversight, the verb *zhengli* (tidy) was used in both the V and QV categories.

3. [没有人 / 从不] 熟悉
 [Meiyouren / congbu] shuxi
 no-one never know
 'No one knew...'
 'EC never knew...'
4. [没有人 / 从不] 收取
 [Meiyouren / congbu] shouqu
 no-one never collect
 'No one collected...'
 'EC never collected...'
5. [没有人 / 从不] 搜集
 [Meiyouren / congbu] souji
 no-one never gather
 'No one gathered...'
 'EC never gathered...'
6. [没有人 / 从不] 领取
 [Meiyouren / congbu] lingqu
 no-one never receive
 'No one received...'
 'EC never received...'
7. [没有人 / 从不] 巴结
 [Meiyouren / congbu] bajie
 no-one never flatter
 'No one flattered...'
 'EC never flattered...'
8. [没有人 / 从不] 解散
 [Meiyouren / congbu] jiesan
 no-one never dissolve
 'No one dissolved...'
 'EC never dissolved...'
9. [有些人 / 有时候] 霸占
 [Youxieren / youshihou] bazhan
 Some people sometimes occupy
 'Some people occupied...'
 'EC sometimes occupied...'

10. [有些人 / 有时候] 建立
 [Youxieren / youshihou] jianli
 Some people sometimes establish
 ‘Some people established...’
 ‘EC sometimes established...’
11. [有些人 / 有时候] 继承
 [Youxieren / youshihou] jicheng
 Some people sometimes inherit
 ‘Some people inherited...’
 ‘EC sometimes inherited...’
12. [有些人 / 有时候] 恢复
 [Youxieren / youshihou] huifu
 Some people sometimes restore
 ‘Some people restored...’
 ‘EC sometimes restored...’
13. [有些人 / 有时候] 捏造
 [Youxieren / youshihou] niezao
 Some people sometimes fabricate
 ‘Some people fabricated...’
 ‘EC sometimes fabricated...’
14. [有些人 / 有时候] 勾结
 [Youxieren / youshihou] goujie
 Some people sometimes collude
 ‘Some people colluded...’
 ‘EC sometimes colluded...’
15. [有些人 / 有时候] 欺压
 [Youxieren / youshihou] qiya
 Some people sometimes oppress
 ‘Some people oppressed...’
 ‘EC sometimes oppressed...’
16. [有些人 / 有时候] 改良
 [Youxieren / youshihou] gailiang
 Some people sometimes improve
 ‘Some people improved...’
 ‘EC sometimes improved...’

17. [大多数人 / 常常] 散布
 [Daduoshuren / changchang] sanbu
 Most-people often spread
 'Most people spread...'
 'EC often spread...'
18. [大多数人 / 常常] 发挥
 [Daduoshuren / changchang] fahui
 Most-people often bring-into-full-play
 'Most people brought into full play...'
 'EC often brought into full play...'
19. [大多数人 / 常常] 挽救
 [Daduoshuren / changchang] wanjiu
 Most-people often save
 'Most people saved...'
 'EC often saved...'
20. [大多数人 / 常常] 采用
 [Daduoshuren / changchang] caiyong
 Most-people often use
 'Most people used...'
 'EC often used...'
21. [大多数人 / 常常] 陷害
 [Daduoshuren / changchang] xianhai
 Most-people often slander
 'Most people slandered...'
 'EC often slandered...'
22. [大多数人 / 常常] 保存
 [Daduoshuren / changchang] baocun
 Most-people often preserve
 'Most people preserved...'
 'EC often preserved...'
23. [大多数人 / 常常] 巩固
 [Daduoshuren / changchang] gonggu
 Most-people often strengthen
 'Most people strengthened...'
 'EC often strengthened...'

24. [大多数人 / 常常] 爱惜
 [Daduoshuren / changchang] aixi
 Most-people often cherish
 ‘Most people cherished...’
 ‘EC often cherished...’

Experiment 1b

Each of the items in this list represents a full set of stimuli from Experiment 1b. The two conditions (‘plausible antecedent’ and ‘no plausible antecedent’) differ with respect to the first clause. The alternative first clauses are inside square brackets, separated by a slash (/). (All materials were presented in simplified Chinese characters, as shown here.)

1. [家辉 看见 国强 失恋 以后 / 房子 烧掉了 以后], 安慰...
 [JiaHui kanjian GuoQiang shilian yihou / fangzi shaodiao-le yihou], anhui
 JiaHui saw GuoQiang jilted after house burned-down after console
 ‘After JiaHui saw GuoQiang jilted, EC consoled...’
 ‘After the house burned down, EC consoled...’
2. [大军 攻破了 城门 以后 / 战争 结束了 以后], 占领
 [Dajun gongpo-le chengmen yihou / zhanzheng jieshu-le yishou], zhanling
 troop breached walls-of-city after war ended after occupy
 ‘After the troop breached the walls of the city, EC occupied...’
 ‘After the war ended, EC occupied...’
3. [当 何 经理 发现 今年 公司 赚了 很多 钱 的时候 /
 [Dang He jingli faxian jinnian gongsi zhuan-le henduo qian de-shi-hou/
 just-at He Manager discover this-year company made a-lot money time
 当 这个 镇 治安 不靖 的时候], 表扬
 dang zhege zhen zhian bujing de-shi-hou], biaoyang
 just-at this town public-security not-good time praise
 ‘When Manager He discovered the company had made a lot of money, EC
 praised...’
 ‘When the public security of this town was not good, EC praised...’
4. [小盈 决定 参加 比赛 以后 / 比赛 结束 以后], 赢得
 [XiaoYing jue ding canjia bisai yihou / bisai jieshu yihou], yingde
 XiaoYing decide join tournament after tournament finish after win
 ‘After XiaoYing decided to join the tournament, EC won...’
 ‘After the tournament finished, EC won...’

5. [当 黄 婆婆 在抽屉里 发现 一些 旧 信件 的时候 /
 [Dang Huang popo zai-chouti-li faxian yixie jiu xinjian de-shi-hou /
 just-at Huang Lady in-drawer discover some old mail time
 当 花 开 的时候], 怀念
 dang hua kai de-shi-hou], huainian
 just-at flower bloom time remember
 ‘When Lady Huang discovered some old mail in the drawer, EC remembered...’
 ‘When the flowers bloomed, EC remembered...’
6. [司徒 小姐 提交 文件 以前 / 杂志 出版 以前], 修改
 [Situ xiaojie tijiao wenjian yiqian / zazhi chuban yiqian], xiugai
 Situ Miss submit document before magazine publish before amend
 ‘Before Miss Situ submitted the document, EC amended...’
 ‘Before the magazine was published, EC amended...’
7. [我 哥哥 毕业 以后 / 报纸 报导了 这宗 新闻 以后], 加入
 [Wo gege biye yihou / baozhi baodaole zhezong xinwen yihou], jiaru
 my brother graduate after newspaper reported this news after join
 ‘After my brother graduated, EC joined...’
 ‘After the newspapers reported this news, EC joined...’
8. [我们 搬进 这个 房子 以前 / 冬天 到来 以前], 消灭
 [Women banjin zhege fangzi yiqian / dongtian daolai yiqian], xiaomie
 we move-in this house before winter come before destroy
 ‘Before we moved into this house, EC destroyed...’
 ‘Before the winter came, EC destroyed...’
9. [李美芳 当了 我们的 队长 以后 / 困难 不断 出现
 [LiMeiFang dang-le womende duizhang yihou / kunnan buduan chuxian
 LiMeiFang became our team-captain after problem continually appear
 以后], 解决
 yihou], jie jue
 after solve
 ‘After LiMeiFang became our team captain, EC solved...’
 ‘After problems kept coming up, EC solved...’
10. [徐 教授 找到 新的 证据 以后 / 实验 失败 以后], 推翻
 [Xu jiaoshou zhaodao-le xinde zhengju yihou / shiyan shibai yihou], tuifan
 Xu professor found new evidence after experiment fail after reject
 ‘After Professor Xu found new evidence, EC rejected...’
 ‘After the experiment failed, EC rejected...’

11. [万秦 赢了 冠军 的时候 / 电影 开始 的时候], 卖弄
 [WanQin ying-le guanjun de-shi-hou/dianying kaishi de-shi-hou], mainong
 WanQin won championship time movie begin time flaunt
 ‘When WanQin won the championship, EC flaunted...’
 ‘When the movie began, EC flaunted...’
12. [我们 开会 以后 / 很多 国家 公园的 树 死了 以后], 通过
 [Women kaihui yihou / henduo guojia gongyuan-de shu si-le yihou], tongguo
 we meet after many national park’s tree died after pass
 ‘After we had the meeting, EC passed...’
 ‘After many trees in the national park died, EC passed...’
13. [他 失败 以前 / 台风 侵袭 以前], 轻视
 [Ta shibai yiqian / taifeng qinxi yiqian], qingshi
 he fail before hurricane attack before deride
 ‘Before he failed, EC derided...’
 ‘Before the hurricane attacked, EC derided...’
14. [他们 考试 的时候 / 当 地球的 温度 不断 上升
 [Tamen kaoshi de-shi-hou / dang diqiu-de wendu buduan shangsheng
 they take-exam time just-at earth’s temperature continually rise
 的时候], 挑选
 de-shi-hou], tiaoxuan
 time choose
 ‘When they took exams, EC chose...’
 ‘When the temperature of the earth kept rising, EC chose...’
15. [政府 开始 注重 环保 以后 / 艾滋病 变得 流行
 [Zhengfu kaishi zhuzhong huanbao yihou / aizibing biande liuxing
 government begin pay-attention environment after AIDS became prevalent
 以后], 推广
 yihou], tuiguang
 after popularize
 ‘After the government began to pay attention to the environment, EC popularized...’
 ‘After AIDS became prevalent, EC popularized...’
16. [小华 离开 以前 / 火车 离 站 以前], 说服
 [XiaoHua likai yiqian / huoche li zhan yiqian], shuofu
 XiaoHua leave before train leave station before convince
 ‘Before XiaoHua left, EC convinced...’
 ‘Before the train left the station, EC convinced...’

17. [妹妹 起床 以后 / 复印机 坏了 以后], 完成
 [Meimei qichuang yihou / fuyinji huai-le yihou], wancheng
 sister get-up after / copier broke after finish
 ‘After the sister got up, EC finished...’
 ‘After the copier broke, EC finished...’
18. [秦 同学 放弃了 黄 老师的方法 以后 / 雪 融化了 以后],
 [Qin tongxue fangqi-le Huang laoshi-de fangfa yihou / xue ronghua-le yihou],
 Qin classmate gave-up Huang teacher’s method after snow melt after
 使用
 shiyong
 use
 ‘After Classmate Qin gave up Teacher Huang’s method, EC used...’
 ‘After the snow melt, EC used...’
19. [美娟 犯错 以后 / 工厂 塌下 以后], 掩饰
 [MeiJuan fancuo yihou / gongchang taxia yihou], yanshi
 MeiJuan make-mistake after factory collapse after conceal
 ‘After MeiJuan made mistakes, EC concealed...’
 ‘After the factory collapsed, EC concealed...’
20. [当 马 教授 开会 的时候 / 这个 皇朝 灭亡了 以后],
 [Dang Ma jiaoshou kaihui de-shi-hou / zhege huangchao miemang-le yihou],
 just-at Ma professor meet time this kingdom collapsed after
 专重
 zhuanzhong
 respect
 ‘When Professor Ma was at the meeting, EC respected...’
 ‘After this kingdom collapsed, EC respected...’
21. [这 群 流氓 打走了 这条 村的 居民 以后 / 水灾 发生了
 [Zhe qun liumang dazou-le zhetiao cun-de jumin yihou / shuizai fasheng-le
 this group rascal chased-away this village’s resident after flooding occurred
 以后], 侵占
 yihou], qinzhan
 after occupy
 ‘After this group of rascals chased away the residents of this village, EC occupied...’
 ‘After flooding occurred, EC occupied...’

22. [当 总经理 辞职 的时候 / 当 证据 不 成立 的时候],
 [Dang zoujingli cizhi de-shi-hou / dang zhengju bu chengli de-shi-hou],
 just-at general-manager resign time just-at evidence not hold time
 维护
 weihu
 defend
 ‘When the general manager resigned, EC defended...’
 ‘When the evidence did not hold, EC defended...’
23. [江 太太 变了心 以后 / 新的 衣服 款式 出现了 以后], 抛弃
 [Jiang taitai bian-le-xin yihou / xinde yifu kuanshi chuxian-le yihou], paoqi
 Jiang Mrs changed-heart after new clothing style appeared after abandon
 ‘After Mrs Jiang changed her heart, EC abandoned...’
 ‘After new style of clothing appeared, EC abandoned...’
24. [我 准备 搬家 以前 / 新的 工作 出现 以前], 整理
 [Wo zhunbei banjia yiqian / xinde gongzuo chuxian yiqian], zhengli
 I prepare move before new task appear before tidy
 ‘Before I prepared to move, EC tidied...’
 ‘Before a new task came, EC tidied...’

Appendix D: Experimental materials for Experiment 2

Each of the items in this list represents a full set of stimuli from Experiment 2. The four conditions differ either in the matrix verb (coreference or non-coreference) or in the last word of the sentence (object or subject of the subordinate clause). The two choices at the verb position and at the last word are inside square brackets below, separated by a slash (/). Empty categories are shown as EC. All materials were presented in simplified Chinese characters, as shown here.

1. 村长 [记得 / 鼓励] 缴纳 地租 的 [利息 / 村民]。
 Cunzhang [jide / guli] jiaona dizu de lixi / cunmin
 Village-chief remember encourage pay land-rent DE interest villager
 ‘The village-chief remembered / encouraged EC to pay the interest of the land rent.’
 ‘The village-chief remembered / encouraged the villager who EC paid the land rent.’
2. 何国中 [记得 / 鼓励] 听 这个演讲 的 [录音带/ 公务员]。
 HeGuoZhong [jide / guli] ting zhege-yanjiang de [luyindai/ gongwuyuan].
 HeGuoZhong remember encourage listen this-talk DE tape public-employee
 ‘HeGuoZhong remembered / encouraged EC to listen to the tape of this talk.’
 ‘HeGuoZhong remembered / encouraged the public employees who EC listened to this talk.’
3. 我 [记得 / 鼓励] 完成 这个考试 的 [所有题目 / 所有学生]。
 Wo [jide / guli] wancheng zhege-kaoshi de [suoyou-timu / suoyou-xuesheng].
 I remember encourage finish this-exam DE all-question all-student
 ‘I remembered / encouraged EC to finish all of the questions of this exam.’
 ‘I remembered / encouraged all of the students who EC finished this exam.’
4. 黄董辉 [记得 / 鼓励] 提出 这个工作计划 的 [目标 / 同事]。
 HuangDongHui [jide / guli] tichu zhege-gongzuo-jihua de [mubiao/ tongshi].
 HuangDongHui remember encourage suggest this-work-plan DE aim / colleague].
 ‘HuangDongHui remembered / encouraged EC to suggest the aim of this work plan.’
 ‘HuangDongHui remembered / encouraged the colleague who EC suggested this work plan.’

5. 李先生 [担心 / 帮助] 加入 这个公司 的 [人事部 / 旧同事]。
 Li xiansheng [danxin / bangzhu] jiaru zhege-gongsi de [renshibu / jiutongshi].
 Li Mr worry help join this-company DE personnel-dept. former-colleague
 'Mr Li was worried / helped EC to join the personnel department of this company.'
 'Mr Li was worried about / helped the former colleague who EC joined this company.'
6. 老先生 [担心 / 帮助] 搬离 这个旧区 的 [津贴房屋 / 多年邻居]。
 Lao xiansheng [danxin / bangzhu] banli zhege-jiuqu de [jintie-fangwu / duonian-linju].
 old Mr worry help move-away this-old-neighborhood DE subsidized-apt. many-year-neighbor
 'The old man was worried / helped EC to move away from the subsidized apartment of this old neighborhood.'
 'The old man was worried about / helped the old neighbor who EC moved away from this old neighborhood.'
7. 高静 [担心 / 帮助] 入读 这个名校 的 [工程学院 / 两个女儿]。
 GaoJing [danxin / bangzhu] rudu zhege-ming-xiao de [gongcheng-xueyuan / liangge-nǚr].
 GaoJing worry help enter this-famous-college DE engineering-school two-daughters
 'GaoJing was worried / helped EC to enter the engineering school of this famous college.'
 'GaoJing was worried about / helped the two daughters who EC entered this famous college.'
8. 黎凯华 [担心 / 帮助] 选修 哲学科 的 [高级课程 / 新生]。
 LiKaiHua [danxin / bangzhu] xuanxiu zhexueke de [gaoji-kecheng / xinsheng].
 LiKaiHua worry help choose philosophy DE advanced-course new-student
 'LiKaiHua was worried / helped EC to choose the advanced courses in philosophy.'
 'LiKaiHua was worried about / helped the new students who EC chose the philosophy courses.'
9. 我 [忘记了 / 制止了] 下载 这个软件 的 [一个档案 / 一些网友]。
 Wo [wangjile / zhizhile] xiazai zhege-ruanjian de [yige-dang'an / yixie-wangyou].
 I forgot stopped download this-program DE one-file some-internet-friends
 'I [forgot EC to download / stopped EC from downloading] one file of this program.'
 'I forgot /stopped some of the internet friends who EC were downloading this program.'

10. 我 [忘记了 / 制止了] 看 这个电视剧 的 [其中一集 / 两个弟弟]。
 Wo [wangjiele / zhizhile] kan zhege-dianshiju de [qizhong-yiji / liangge-didi].
 I forgot stopped watch this-TV-drama DE one-episode two-brothers
 'I [forgot EC to watch / stopped EC from watching] one episode of this TV drama.'
 'I forgot / stopped the two brothers who EC were watching this TV drama.'
11. 郑 经理 [忘记了 / 制止了] 检查 公司帐目 的 [收入项 /
 Zheng jingli [wangjiele / zhizhile] jianche gongsi-zhangmu de [shouruxiang /
 Zheng manager forgot stopped check company-ledger DE credit-column
 会计师]。
 kuaijishi
 accountant
 'Manager Zheng [forgot EC to check / stopped EC from checking] the credit-column
 in the company ledger.'
 'Manager Zheng forgot / stopped the accountant who EC was checking the company
 ledger.'
12. 她 [忘记了 / 制止了] 吃 这个健康餐 的 [甜品 / 会员]。
 Ta [wangjile / zhizhile] chi zhege-jiankangcan de [tianpin / huiyuan].
 She forgot stopped eat this-healthy-meal de dissert member
 'She [forgot EC to eat / stopped EC from eating] the dissert of this healthy meal.'
 'She forgot / stopped the member who EC was eating this healthy meal.'
13. 沈家峰 [喜欢 / 反对] 讥笑 自由主义 的 [浅薄 / 同学]。
 ShenJiaFeng [xihuan / fandui] jixiao ziyoushuyi de [qianbo / tongxue].
 ShenJiaFeng like oppose ridicule liberalism DE shallowness classmate
 'ShenJiaFeng [liked EC to ridicule / opposed EC ridiculing] the shallowness of
 liberalism.'
 'ShenJiaFeng liked / opposed the classmate who EC ridiculed liberalism.'
14. 她 [喜欢 / 反对] 嫉妒 别人 的 [成就 / 女生]。
 Ta [xihuan / fandui] jidu bieren de [chengjiu / nǚsheng].
 she like oppose envy other-people DE success women
 'She [liked EC to envy / opposed EC envying] the success of other people.'
 'She liked / opposed the women who EC envied other people.'
15. 这个作家 [喜欢 / 反对] 批评 这些流行小说 的 [故事线 /
 Zhege-zuojia [xihuan / fandui] piping zhexie-liuxingxiaoshuo de [gushixian /
 This-author like oppose criticize these-pop-fictions DE plot
 教育家]。
 jiaoyujia].
 educator
 'This author [liked EC to criticize / opposed EC criticizing] the plot of these pop
 fictions.'
 'This author liked / opposed the educator who EC criticized these pop fictions.'

16. 国强 [喜欢 / 反对] 鄙视 女性 的 [能力 / 男生]。
 GuoQiang [xihuan / fandui] bishi nǚxing de [nengli / nansheng].
 GuoQiang like oppose despise women DE ability men
 ‘GuoQiang [liked EC to despise / opposed EC despising] the ability of women.’
 ‘GuoQiang liked / opposed the men who EC despised women.’
17. 他们 [讨厌 / 支持] 参加 这个训练营 的 [所有项目 /
 Tamen [taoyan / zhichi] canjia zhege-xunlianying de [suoyou-xiangmu /
 they detest support join this-training-camp DE all-program
 所有小孩]。
 suoyou-xiaohai].
 all-children
 ‘They [detested EC joining / supported EC to join] all of the programs of this training
 camp.’
 ‘They detested / supported all the children who EC joined the training camp.’
18. 陈 同学 [讨厌 / 支持] 参与 这个研究 的 [实验 / 教授]。
 Chen tongxue [taoyan / zhichi] canyu zhege-yanjiu de [shiyen / jiaoshou].
 Chen classmate detest support participate this-study DE experiment professor
 ‘Classmate Chen [detested EC participating / supported EC to participate] in the
 experiment of this study.’
 ‘Classmate Chen detested / supported the professor who EC participated in this
 study.’
19. 爷爷 [讨厌 / 支持] 写 这个故事 的 [结局 / 作家]。
 Yeye [taoyan / zhichi] xie zhege-gushi de [jieju / zuojia].
 Grandfather detest support write this-story DE ending author
 ‘The grandfather [detested EC writing / supported EC to write] the ending of this
 story.’
 ‘The grandfather detested / supported the author who wrote this story.’
20. 她们 [讨厌 / 支持] 参观 这个博物馆 的 [科学中心 /
 Tamen [taoyan / zhichi] canguan zhege-bowuguan de [kexue-zhongxin /
 they detest support visit this-museum DE science-center
 中小学生]。
 zhong-xiao-xue-sheng].
 secondary-primary-student
 ‘They [detested EC visiting / supported EC to visit] the science center of this
 museum.’
 ‘They detested / supported the secondary and primary school students who EC visited
 this museum.’

21. 何 经理 [拒绝 / 讽刺] 执行 新制度 的 [时间表 / 新老板]。
 He jingli [jujue / fengci] zhixing xin-zhitu de [shijianbiao / xin-laoban].
 He manager refuse ridicule implement new-policy DE schedule new-boss
 ‘Manager He [refused EC to implement / ridiculed EC for implementing] the schedule of the new policy.’
 ‘Manager He rejected / ridiculed the new boss who EC implemented the new policy.’
22. 姚春明 [拒绝 / 讽刺] 退出 这个比赛 的 [总决赛 / YaoChunMing [jujue / fengci] tuichu zhege-bisai de [zongjuesai / YaoChunMing refuse ridicule withdraw this-tournament DE final
 运动员]。
 yundongyuan].
 athletics
 ‘YaoChunMing [refused EC to withdraw / ridiculed EC for withdrawing] from the final of this tournament.’
 ‘YaoChunMing rejected / ridiculed the athletics who EC withdrew from the tournament.’
23. 研究员 [拒绝 / 讽刺] 繁殖 这种细菌 的 [两个细胞 / Yanjiuyuan [jujue / fengci] fanzhi zhezhong-xijun de [liangge-xibao / researcher refuse ridicule grow this-kind-bacteria DE two-cell
 生物学家]。
 shengwuxuejia].
 Biologist
 ‘The researcher [refused EC to grow / ridiculed EC for growing] the two cells of this kind of bacteria.’
 ‘The researcher rejected / ridiculed the biologist who EC grew this kind of bacteria.’
24. 这个环保小组 [拒绝 / 讽刺] 支持 这份建议书 的
 Zhege-huanbao-xiaozu [jujue / fengci] zhichi zhefen-jianyishu de
 This-environmental-group refuse / ridicule support this-proposal DE
 [环保政策 / 压力团体]。
 [huanbao-zhengce / yali-tuanti].
 environmental-policy pressure-group
 ‘This environmental group [refused EC to support / ridiculed EC for supporting] the environmental policy in this proposal.’
 ‘This environmental group [rejected / ridiculed] the pressure group who EC supported this proposal.’

25. 共和党的 这个党员 [反抗 / 欢迎] 支持 这份建议书 的
 Gonghedang-de zhege-dangyuan [fankang / huanying] zhichi zhefen-jianyishu de
 Republican-party's this-member resist welcome support this-proposal DE
 [财政项目 / 党副主席]。
 [caizheng-xiangmu / dang-fu-zhuxi].
 financial-terms party-vice-chairman
 'The member of the Republican Party resisted / welcomed EC to support the financial
 terms of this proposal.'
 'The member of the Republican Party resisted / welcomed the party vice-chairman
 who EC supported this proposal.'
26. 黄 经理 [反抗 / 欢迎] 参与 新计划 的 [工作小组 /
 Huang jingli [fankang / huanying] canyu xin-jihua de [gongzuo-xiaozu /
 Huang manager resist welcome participate new-project DE task-group /
 何 总经理]。
 He zongjingli].
 He general-manager
 'Manager Huang resisted / welcomed EC to participate in the task group of the new
 project.'
 'Manager Huang resisted / welcomed General Manager He who EC participated in
 the new project.'
27. 许 同学 [反抗 / 欢迎] 使用 这本教科书 的 [光碟 / 老师]。
 Xu tongxue [fankang / huanying] shiyong zheben-jiaokeshu de [guangdie / laoshi]
 Xu classmate resist welcome use this-textbook DE CD teacher
 'Classmate Xu resisted / welcomed to use the CD of this textbook.'
 'Classmate Xu resisted / welcomed the teacher who EC used this textbook.'
28. 史东利 [反抗 / 欢迎] 接受 这份合约 的 [两个条件 /
 ShiDongLi [fankang / huanying] jieshou zhefen-heyue de [liangge-tiaojian /
 ShiDongLi resist welcome accept this-contract DE two-terms
 工人工会]。
 gongren-gonghui].
 labor-union
 'ShiDongLi resisted / welcomed EC to accept the two terms of this contract.'
 'ShiDongLi resisted / welcomed the labor-union which EC accepted this contract.'
29. 他们 [等候 / 控制] 领取 这种水果 的 [种子 / 农民]。
 Tamen [denghou / kongzhi] lingqu zhezhong-shuiguo de [zhongzi / nongmin].
 they await control receive this-kind-fruit DE seed farmer
 'They awaited / controlled EC to receive the seed of this kind of fruit.'
 'They awaited / controlled the farmers who EC received this kind of fruit.'

30. 爸爸 [等候 / 控制] 购买 这种新款音响 的 [扩音器 /
 Baba [denghou / kongzhi] koumai zhezhong-xinhuan-yinxiang de [kuangyinqi/
 father await control buy this-new-style-Hi-Fi DE amplifier
 大哥哥]。
 dagege].
 brother
 ‘The father awaited / controlled EC to buy the amplifier of this new styled Hi-Fi.’
 ‘The father await / controlled the brother who EC was buying this new styled Hi-Fi.’
31. 他们 [等候 / 控制] 参观 这个博物馆 的 [新展品 /
 Tamen [denghou / kongzhi] canguan zhege-bowuguan de [xin-zhanpin /
 they await control visit this-museum DE new-exhibit /
 小学生]。
 xiaoxuesheng].
 primary-school-student
 ‘They awaited / controlled EC to visit the new exhibit of this museum.’
 ‘They awaited / controlled the primary school students who EC visited this museum.’
32. 我们 [等候 / 控制] 进入 迪士尼乐园 的 [主题酒店 / 各国游客]。
 Women [denghou / kongzhi] jinru Dishini-leyuan de [zhuti-jiudian / geguo-youke].
 we await control enter Disneyland De theme-hotel international-
 tourist
 ‘We awaited / controlled EC to enter the theme hotel of Disneyland.’
 ‘We awaited / controlled the international tourists who EC were entering Disneyland.’

Appendix E: Experimental materials for Experiment 3

Each of the items in this list represents a full set of stimuli from Experiment 3. The two conditions differ in the decoy filler (plausible decoy and implausible decoy) in the main clause. The two decoy fillers are inside square brackets below, separated by a slash (/). Empty categories are shown as EC. All materials were presented in simplified Chinese characters, as shown here. (NOM: nominalizer; CAU: causative marker)

- 课后 进修 是 [这个学生 / 这个学校] 的老师 应该 做 的。
Kehou jinxu shi [zhege-xuesheng / zhege-xuexiao] de laoshi yinggai zuo de.
class-after study is this-student this-school DE teacher should do NOM
'EC To study after class was what [the student's / the school's] teacher should do.'
- 打错了 一份文件 使 [我妹妹 / 我公司] 的 秘书 很担心。
Dacuo-le yifen-wenjian shi [womeimei / wogongsi] de mishu hendanxin.
typed-wrong one document CAU my sister my company DE secretary worried
'EC Having made a typo in a document worried [my sister's / my company's] secretary.'
- 常常 出国 访问 令 [这个皇帝 / 这个国家] 的 大公主
Changchang chuguo fangwen ling [zhege-huangdi / zhege-guojia] de da-gongzhu
often go-overseas visit CAU this-emperor this-nation DE first-princess
很疲倦。
henpijuan.
tired
'EC To often pay official visits overseas tired out [the emperor's / the nation's] first princess.'
- 加入 公司 的 新部门 给 [副经理 / 财政部] 的
Jiaru gongsi de xin-bumen gei [fu-jingli / caizhengbu] de
join company DE new-department give assistant-manager finance-department DE
翻译 更多 工作。
fanyi gengduo gongzuo.
translator more work
'EC Having joined the new department of the company increased the workload of [the assistant manager's / the finance department's] translator.'
- 收到 裁员 的 消息 教 [他们 / 美国] 的 同事 无法
Shoudao caiyuan de xiaoxi jiao [tamen / Meiguo] de tongshi wufa
received layoff DE notice CAU they / America DE colleagues unable
集中精神 工作。
jizhongjingshen gongzuo.
focus-on work
'Having received the layoff notice made [their / America's] colleagues unable to focus on their work.'

6. 看护 这些 孩子 把 [那个朋友 / 那个灾区] 的 医生 累坏。
 Kanhu zhexie haizi ba [nage-pengyou / nage-zaiqu] de yisheng leihuai.
 look-after these children BA that-friend / that-disaster-area DE doctor exhausted
 ‘Looking after the children exhausted [that friend’s / that disaster area’s] doctor.’
7. 习惯 新 的 教学法 要求 [留学生 / 文学院] 的
 Xiguan xin de xiaoxuefa yaoqiu [liuxuesheng / wenxueyuan] de
 get-used-to new DE teaching-method demand foreign-student / Arts-Faculty DE
 教授 很大 的 耐心。
 jiaoshou henda de naixin.
 professor much DE patience
 To get used to the new teaching method demanded a lot of patience from [the foreign student’s / the Arts Faculty’s] professor.’
8. 经常 忘记了 入帐 是 [这个朋友 / 这个公司] 的 老板
 Jingchang wangji-le ruzhang shi [zhege-pengyou / zhege-gongsi] de laoban
 often forgot enter-transaction is this-friend / this-company DE boss
 应该 改掉 的 坏习惯。
 yinggai gaidiao de huai-xiguan.
 should change DE bad-habit
 ‘To often forget to enter the transactions into the ledger was the bad habit [this friend’s / this company’s] boss should change.’
9. 喜欢 邻居 的 小狗 并未使 [这个大狗 / 这个房子] 的 主人
 Xihuan linju de xiaogou bing-weishi [zhege-dagou / zhege-fangzi] de zhuren
 adore neighbor DE puppy not-CAU this-big-dog / this-house DE owner
 喜欢 她 的 邻居。
 xihuan ta de linju.
 liked her neighbor
 ‘Adoring the neighbor’s puppy did not make [the big dog’s / this house’s] owner like her neighbor.’
10. 买了 旁边 的 单位 令 [这个业主 / 这个公寓] 的 租客 终于
 Mai-le pangbian de danwei ling [zhege-yezhu / zhege-gongyu] de zuke zhongyu
 bought neighboring DE unit CAU this-landlord / this-apartment DE tenant finally
 拥有 自己 的 地方。
 yongyou ziji de difang.
 own self DE place
 ‘Having bought the neighboring unit allowed [the landlord’s / the apartment’s] tenant to finally own a place of his own.’

11. 工作 至 深夜 往往 令 [富豪 / 房车] 的 司机 失去 与
 Gongzuo zhi shenye wangwang ling [fuhao / fangche] de siji shiqu yu
 work till late-night often CAU tycoon / limousine DE chauffeur lose with
 家人 欢聚 的 时间。
 jiaren huanju de shijian.
 family happy-gather DE time
 ‘To often work until late night made [the tycoon’s / the limousine’s] chauffeur
 sacrifice valuable time he could spend with his family.’
12. 收到 政府 的 收地 通知 令 [这些村民 /
 Shoudao zhengfu de shoudi tongzhi ling [zhexie-cunmin /
 received government DE land-use-change notice CAU these-villagers /
 这个渔村] 的 领导 很愤怒。
 zhege-yucun] de lingdao hen-fennu.
 this-fishing-village DE leader angry
 ‘Having received the government’s notice for a change in land use angered [the
 villagers’ / the fishing village’s] leader.’
13. 执行 这个 危险 的 工作 要求 [政府官员 /
 Zhixing zhege weixian de gongzuo yaoqiu [zhengfu-guanyuan /
 implement this dangerous DE job require government-official /
 公家银行] 的 护卫 接受 更多 的 训练。
 gongjia-yinhang] de huwei jieshou gengduo de xunlian.
 public-bank DE security-guard receive more DE training
 ‘To implement this dangerous job required [the government officials’ / the public
 banks’] security guards to receive more training.’
14. 学习 用 这个 电脑 程式 弄得 [我爸爸 / 我们系] 的
 Xuexi yong zhege diannao chengshi nongde [wo-baba / women-xi] de
 learn use this computer program CAU my-father / our-department DE
 学生 头昏脑胀。
 xuesheng touhunnaozhang.
 student flummoxed
 ‘Learning this new computer program flummoxed [my father’s / our department’s]
 students.’
15. 拥有 出众 的 口才 增加 [这个原告人 / 这个律师行]
 Yongyou chuzhong de koucai zengjia [zhege-yuangaoren / zhege-lushihang]
 own outstanding DE eloquence increased this-plaintiff / this-law-firm
 的 律师 对 赢得 这个 案件 的 信心。
 de lushi dui yingde zhege anjian de xinxin.
 DE attorney to win this case DE confidence
 ‘Owning outstanding eloquence increased the confidence of [the plaintiff’s / the law
 firm’s] attorney to win this case.’

16. 弄坏了 几个 玩具 并未使 [小孩子 / 幼儿园] 的 保姆
 Nonghuai-le jige wanju bing-weishi [xiaohaizi / youeryuan] de baomu
 broke a-few toy not-CAU child / kindergarten DE nanny
 更小心。
 geng-xiaoxin.
 more-careful
 ‘Having broken a few toys did not make [the child’s / the kindergarten’s] nanny more careful.’

Appendix F: Experimental materials for Experiment 4

Each of the items in this list represents a full set of stimuli from Experiment 3. The four conditions differ either in the first clause (without an overt filler or with an overt filler) or in the third clause (with a specific filler or with a generic filler). The two choices in the first and third clauses are inside square brackets below, separated by a slash (/). (All materials were presented in simplified Chinese characters, as shown here.) (CAU: causative marker; PASS: passive marker)

1. [很自然 / 何队长 害怕] 每天 做 强烈运动 往往 令
[Henziran / He-duizhang haipa] meitian zuo qianglie-yundong wangwang ling
natural He-team-captain fear every-day do intense-exercise often CAU
[赵东 / 人] 感到 疲倦。
[ZhaoDong / ren] gandao pijuan.
ZhaoDong people feel tired
'[It is natural that / Team Captain He fears that] doing intense exercise every day often
tires [ZhaoDong / people] out.'
2. [很不幸 / 王医生 承认] 工作过劳 常常 影响
[Henbuxing / Wang-yisheng chengren] gongzuoguolao changchang yingxiang
unfortunately Wang-doctor admit overwork often affect
[马健明 / 人] 的 健康。
[MaJianMing / ren] de jiankang.
MaJianMing people DE health
'[It is unfortunately that / Dr. Wang admits that] overworking often affects
[MaJianMing's / people's] health.'
3. [很明显 / 国军 希望] 拥有 一段 幸福 的 婚姻 可以 教
[Henmingxian / GuoJun] xiwang] yongyou yiduan xingfu de hunyin keyi jiao
obvious GuoJun hope have one happy DE marriage can CAU
[钱锋夫妇 / 人] 更 了解 爱情。
[QianFeng-fufu / ren] geng liaojie aiqing.
Qianfeng-couple people more understand love
'[It is obvious that / GuoJun hopes that] living in a happy marriage can make
[QianFeng and his wife / people] understand love better.'
4. [很意外 / 爸爸 说] 找到 一份 薪金优厚 的 工作 常常 不能
[Henyiwai / baba shuo] zhaodao yifen xinjinyouhou de gongzuo changchang buneng
surprising father say found one well-paid DE job often cannot
给 [老方 / 人] 带来 快乐。
gei [LaoFang / ren] dailai kuaile.
to LaoFang people bring happiness
'It is a surprise that / The father says that] having found a well-paid job often cannot
bring [LaoFang / people] happiness.'

5. [很可惜 / 他们 担心] 使用 电脑 并 未让 [马力 / 人] 减少
 [Henkexi / tamen danxin] shiyong diannao bing weirang [MaLi / ren] jianshao
 piteous they worry use computer still not-CAU MaLi people reduce
 工作 时间。
 gongzuo shijian.
 work time
 ‘[It is a pity that / They worry that] using the computer still cannot reduce [MaLi’s /
 people’s] work hours.’
6. [很可能 / 李美军 否认] 模仿 偶像 往往 使 [黄同学 /
 [Henkeneng / LiMeiJun fouden] mofang ouxiang wangwang shi [Wang-tongxue /
 possible LiMeiJun deny imitate idol often CAU Wang-classmate
 人] 失去 自己。
 ren] shiqu ziji.
 people lose self
 ‘[It is possible that / LiMeiJun denies that] to imitate idols often make [Classmate
 Wang / people] lose himself/oneself.’
7. [很遗憾 / 谢老师 忘记了] 教导 这个小学生 有时
 [Henyihan / Xie-laoshi wangji-le] jiaodao zhege-xiaoxue-sheng youshi
 regretful Xie-teacher forgot teach this-primary-school-student sometimes
 令 [陈老师 / 人] 很头疼。
 ling [Chen-laoshi / ren] hentouteng.
 CAU Chen-teacher people headache
 ‘[It is regretful that / Teacher Xie forgot that] teaching this primary school student
 sometimes gives [Teacher Chen / people] a headache.’
8. [很奇怪 / 沈红 同意] 抛弃 所有 可能 会 给 [小华 / 人]
 [Henxiguai / ShenHong tongyi] paoqi suoyou keneng hui gei [XiaoHua / ren]
 strange ShenHong agree give-up everything probably will to XiaoHua people
 带来 新 生命。
 dailai xin shengming.
 bring new life
 ‘[It is strange that / ShenHong agrees that] giving up everything will probably bring
 [Xiaohua / people] new life.’
9. [很讽刺 / 她 记得] 吃 补药 有时 令 [葛大妈 / 人] 的 身体
 [Henfengci / ta jide] chi buyao youshi ling [Ge-Dama / ren] de shenti
 irony she remember eat tonic-herb sometimes CAU Ge-Aunt people DE body
 更 衰弱。
 geng shuairuo.
 more weak
 ‘[It is an irony that / She remembers that] taking tonic herbs sometimes can weaken
 [Aunt Ge’s / people’s] health.’

10. [很出乎意料 / 我坚持] 离开自己的故乡 可能 对 [华碧 / 人]
 [Henchuhuyiliao / wo jianchi] likai ziji de guxiang keneng dui [HuaBi / ren]
 unexpected I insist leave self DE home-town probably to HuaBi people
 有 好处。
 you haochu.
 have advantage
 ‘[It is unexpected that / I insist that] leaving her/one’s hometown may be good for
 [HuanBi / people].’
11. [很喜出望外 / 哥哥 暗示] 辞了工 可能 使 [宝峰 / 人]
 [Henxichuwangwai / gege anshi] ci-le-gong keneng shi [BaoFeng / ren]
 surprising brother imply quit-job probably CAU [BaoFeng / people]
 突然 发现 生活 的乐趣。
 turan faxian shenghuo de lequ.
 saddening discover life DE joy.
 ‘[It is a surprise that / The brother implies that] having quit the job may make
 [BaoFeng / people] suddenly find new joy in his/their life.’
12. [很难得 / 王冰韵 估计] 错过了 这些机会 不会 影响
 [Hennande / WangBingYun guji] cuoguo-le zhexie-jihui buhui yingxiang
 rare WangBingYun guess missed these-opportunity will-not affect
 [宁飞 / 人] 的前途。
 [NingFei / ren] de qiantu.
 NingFei people DE future
 ‘[It is rare that / WangBingYun guesses that] having missed these opportunities will
 not affect [NingFei’s / people’s] future.’
13. [很可怜 / 虞经理 表示] 不 加班 工作 很难 令 [老容 /
 [Henkelian / Yu-jingli biaoishi] bu jiaban gongzuo hennan ling [LaoRong /
 piteous Yu-Manager say not overtime work difficult CAU LaoRong
 人] 有 晋升 机会。
 ren] you jinsheng jihui.
 people have promotion opportunity
 ‘[It is a pity that / Manager Yu says that] not working overtime will make it difficult
 for [LaoRong / people] have promotion opportunities.’
14. [很惭愧 / 明霞 觉得] 可以 安享 晚年 可能 是 [老高 / 人]
 [Hencankui / MingXia juede] keyi anxiang wannian keneng shi [LaoGao / ren]
 regretful MingXia think can enjoy old-age probably is LaoGao people
 最 难得 的东西。
 zui nande de dongxi.
 most rare DE thing
 ‘[It is a regret that / MingXia thinks that] enjoying an old age may be the thing most
 difficult to come by for [LaoGao / people].’

15. [很特别 / 郭清清 庆幸] 不用 工作 也 可 使 [郑大夫 /
[Hentebie / GuoQingQing qingxing] buyong gongzuo ye ke shi [Zheng-Dafu /
strange GuoQingQing feel-lucky not-need work also can CAU Zheng-Doctor
人] 感到 生活 有 意义。
ren] gandao shenghuo you yiyi.
people feel life have meaning
'[It is strange that / GuoQingQing feels lucky that] not needing to work can also
make [Dr. Zheng / people] enjoy a meaningful life.'
16. [很理想 / 这个工人 不相信] 可以 自由 投票 是 [谢厂长 /
[Henlixiang / zhege-gongren bu-xiangxin] keyi ziyou toupiao shi [Xie-changzhang /
ideal this-worker not-believe can freely vote is Xie-factory-boss
人] 的 权利。
ren] de quanli.
people DE right
'[It is an ideal that / This worker does not believe that] to vote freely is [the factory
boss Xie's / people's] right.'
17. [很正常 / 文中 不相信] 可以 取得 别人 的 信任 是
[Henzhengchang / WenZhong bu-xiangxin] keyi qude bieren de xinren shi
reasonable WenZhong not-believe can obtain others DE trust is
[美美 / 人] 成功 的 第一步。
[MeiMei / ren] chenggong de diyi-bu.
MeiMei people success DE first-step
'[It is reasonable that / Wenzhong does not believe that] to obtain others' trust is the
first step to [MeiMei's / people's] success.'
18. [很难以置信 / 廖明辉 希望] 看 科幻 电影 可以 让
[Hen nan-yi-zhi-xin / LiaoMingHui xiwang kan kehuan dianying] keyi rang
hard-to-believe LiaoMingHui hope watch science movie can CAU
[小莲 / 人] 更 了解 科学。
[XiaoLian / ren] geng liaojie kexue.
XiaoLian people more understand science
'[It is hard to believe that / LiaoMingHui hopes that] watching science movies can
make [XiaoLian / people] understand science better.'
19. [很明白 / 唐明光 承认] 考试 作弊 是 [史同学 / 人]
[Henmingbai / TongMingGuang chengren] kaoshi zuobi shi [Shi-tongxue / ren]
clear TongMingGuang admit] exam cheat is Shi-classmate people
害人害己 的 行为。
hai-ren-hai-ji de xingwei.
destructive DE behavior
'[It is clear that / TongMingGuang admits that] cheating on the exam is [Classmate
Shi's / people's] destructive behavior.'

20. [很出奇 / 陈教授 说] 不吃 早饭 不会 降低 [商同学 /
[Henchuqi / Chen-jiaoshou shuo] bu-chi zaofan bu-hui jiangdi [Shang-tongxue /
unexpected Chen-professor say not-eat breakfast not-will reduce Shang-classmate
人] 的 学习 能力。
ren] de xuexi nengli.
people DE learning ability
'[It is unexpected that / Professor Chen says that] not eating breakfast will not reduce
[Classmate Shang's / people's] learning ability.'
21. [很鲜有 / 钱海祺 估计] 损失了 十年 的 积蓄 不会 打乱
[Henxianyou / QianHaiQi guji] sunshi-le shinian de jixu bu-hui daluan
rare QianHaiQi guess lost ten-years DE savings not-will disturb
[孙逊国 / 人] 的 退休 计划。
[SunXunGuo / ren] de tuixiu jihua.
SunXunGuo people DE retirement plan
'[It is rare that / QianHaiQi guesses that] having lost ten years of savings will not
disturb [SunXunGuo's / people's] retirement plan.'
22. [很肯定 / 简老师 否认] 多次 被 辞退 会 打垮 [潘彤 /
[Henkending / Jian-laoshi fouden] duoci bei citui hui dakua [PanTong/
sure Jian-teacher deny many-times PASS lay-off will dampen PanTong/
人] 的 斗志。
ren] de douzhi.
people] DE fighting-spirit
'[It is for sure that / Teacher Jian denies that] being laid off many times will dampen
[PanTong's / people's] fighting spirit.'
23. [很可怕 / 文小姐 害怕] 曾 被 骗财骗色 会 使 [雯雯 /
[Henkepai / Wen-xiaojie haipa] ceng bei pian-cai-pian-se hui shi [WenWen /
scary Wen-Miss fear once PASS cheat will CAU [WenWen /
人] 对 爱情 失去 信心。
ren] dui aiqing shiqu xinxin.
people] to romance lose confidence
'[It is scary that / Miss Wen fears that] being cheated once will make [WenWen /
people] lose confidence in romance.'
24. [很痛心疾首 / 他们 担心] 考不上 心仪 的 大学 会 使
[Hentongxinjishou / tamen danxin] kao-bu-shang xinyi de daxue hui shi
upsetting they worry unable-to-get-in favorite DE college will CAU
[龚森 / 人] 自暴自弃。
[GongSen / ren] zi-bao-zi-qi.
[GongSen / people] give-up-on-oneself
'[It is upsetting that / They worry that] unable to get in the favorite college will make
[GongSen / people] give up on himself/themselves.'

25. [很失望 / 兰贵 表示] 变卖了 自己的 房子 仍 可能 使
 [Henshiwang / LanGui biaooshi] bianmai-le ziji de fangzi reng keneng shi
 disappointing LanGui say sold self DE house still probably CAU
 [晴晴 / 人] 负债累累。
 [QingQing / ren] fu-zhai-leilei
 [QingQing / people] deep-in-debt
 ‘[It is disappointing that / LanGui says that] having sold the house may still make
 [QingQing / people] deep in debt.’
26. [很讨厌 / 她 暗示] 中了 彩票 可能 教 [关家仁 / 人]
 [Hentaoyan / ta anshi] zhong-le caipiao keneng jiao [GuanJiaRen / ren]
 disgusting she imply won lottery probably CAU [GuanJiaoRen / people]
 抛弃 妻儿。
 paoqi qier.
 abandon family
 ‘[It is disgusting that / she implies that] having won the lottery may make
 [GuanJiaRen / people] abandon the family.’
27. [很吓人 / 我 忘记了] 接受过 手术 可能 给 [老王 / 人] 带来
 [Henxiaren / wo wangji-le] jieshou-guo shoushu keneng gei [LaoWang / ren] dailai
 scary I forgot underwent surgery probably to LaoWang people bring
 很多 后遗症。
 henduo houyizheng.
 a-lot sequelae
 ‘[It is scary that / I forgot that] having undergone a surgery may bring a lot of
 sequelae to [LaoWang / people].’
28. [很确定 / 紫玲 同意] 去 外国 旅游 可以 增广 [紫辉 / 人] 的
 [Henqueding / ZiLing tongyi] qu waiguo lǚyou keyi zengguang [ZiHui / ren] de
 certain ZiLing agree go overseas travel can widen ZiHui people DE
 见闻。
 jianwen.
 horizon
 ‘[It is certain that / ZiLing agrees that] traveling overseas can widen [ZiHui’s /
 people’s] horizon.’
29. [很庆幸 / 他们 觉得] 读不上 大学 也 可以让 [万秦 /
 [Henqingxing / tamen juede] du-bu-shang daxue ye keyi rang [WanQin /
 lucky they think not-get college-education still can CAU WanQin
 人] 有 高薪厚职。
 ren] you gaoxinhouzhi.
 people have good-salary-good-job
 ‘[It is lucky that / They think that] not getting a college education can still bring
 [WanQin / people] a good job and salary.’

30. [很感慨 / 我们 坚持] 打败 宿敌 往往 使 [韩棋王 /
 [Hengankai / women jianchi] dabai sudi wangwang shi [Han-Qiwan /
 regretful we insist beat nemesis often CAU Han-chess-champion
 人] 自骄自傲。
 ren] zi-jiao-zi-ao.
 people arrogant
 ‘[It is a regret that / We insisted that] beating the nemesis often makes [the chess
 champion Han / people] arrogant.’
31. [很幸运 / 这个小说家 庆幸] 出了名 往往 也 未使
 [Henxingyun / zhege-xiaoshuojia qingxing] chu-le-ming wangwang ye wei-shi
 lucky this-novelist feel-lucky being-famous often still not-CAU
 [兰西 / 人] 忘却 童年 的 好友。
 [LanXi / ren] wangque tongnian de haoyou.
 LanXi people forget childhood DE good-friend
 ‘[It is lucky that / This novelist feels lucky that] being famous often still does not
 make [LanXi / people] forget the good friends from childhood.’
32. [很简单 / 友叔叔 记得] 多 睡眠 常常 使 [华明 /
 [Henjiandan / You-shushu jide] duo shuimian changchang shi [HuaMing /
 simple You-uncle remember] more sleep often CAU [HuaMing /
 人] 精神焕发。
 ren] jingshen-huanfa.
 people] energetic
 ‘[It is a simple truth that / Uncle You remembers that] sleeping more often energizes
 [HuaMing / people].’

REFERENCES

- Alonso-ovalle, L., Fernández-Solera, S., Frazier L., & Clifton, C. Jr. (2002). Null vs. overt pronouns and the topic-focus articulation in Spanish. *Journal of Italian Linguistics*, 14, 151-169.
- Aoshima, S., Phillips, C. & Weinberg, A. (2004). Processing filler-gap dependencies in a head-final language. *Journal of Memory and Language*, 51, 23-54.
- Aoun, J., & Li, Y.-H. A. (2003). *Essays on the Representational and Derivational Nature of Grammar*. Cambridge, MA: MIT Press.
- Ariel, M. (1994). Interpreting anaphoric expressions: A cognitive versus a pragmatic approach. *Journal of Linguistics*, 30, 3-42.
- Betancort, M., Carreiras, M., & Acuña-Fariña, C. (2006). Processing controlled PROs in Spanish. *Cognition*, 100, 217-282.
- Betancort, M., Meseguer, E., & Carreiras, M. (2004). The empty category PRO: Processing what cannot be seen. In M. Carreiras & C. Clifton (Eds.), *The Online Study of Sentence Comprehension: Eyetracking, ERPs and Beyond* (pp. 95-118). New York: Psychology Press.
- Bever, T. G., & McElree, B. (1988). Empty categories access their antecedents during comprehension. *Linguistic Inquiry*, 19, 35-43.
- Boland, J. E., Tanenhaus, M. K., & Garnsey, S. M. (1990). Evidence for the immediate use of verb control information in sentence processing. *Journal of Memory and Language*, 29, 413-432.
- Bresnan, J. (1982). *The Mental Representation of Grammatical Relations*. Cambridge, MA: MIT Press.
- Burzio, L. (1986). *Italian Syntax*. Dordrecht, Holland: Reidel.
- Carminati, M. N. (2002). *The Processing of Italian Subject Pronouns*. Unpublished doctoral dissertation, University of Massachusetts, Amherst.
- Carminati, M. N. (2005). Processing null and overt subject pronouns: Evidence from Italian. Poster presented at The 18th Annual CUNY Sentence Processing Conference, University of Arizona at Tucson, March, 2005.
- Chafe, W. (Ed.). (1980) *The Pear Stories: Cognitive, Cultural, and Linguistic Aspects of Narrative Production*. Norwood, New Jersey: Ablex.

- Chen, P. (1984). *A discourse analysis of third person zero anaphora in Chinese*. University of California, Los Angeles.
- Chierchia, G. (1995). The variability of impersonal subjects. In E. Bach, E. Jelinek, A. Kratzer, & B. H. Partee (Eds.), *Quantification in Natural Languages* (pp. 107-143). Dordrecht, Holland: Kluwer Academic Publishers.
- Chomsky, N. (1981). *Lectures on Government and Binding*. Dordrecht, Holland: Foris Publications.
- Chomsky, N. (1986). *Barriers*. Cambridge, MA: MIT Press.
- Chomsky, N. (1995). *The Minimalist Program*. Cambridge, MA: MIT Press.
- Chu, C. (1998). *A Discourse Grammar of Mandarin Chinese*. New York: Peter Lang.
- Cinque, G. (1988). On *si* construction and the theory of *arb*. *Linguistic Inquiry*, 19, 521-581.
- Clahsen, H., & Featherston, S. (1999). Antecedent priming at trace positions: Evidence from German scrambling. *Journal of Psycholinguistic Research*, 28, 415-437.
- Clifton, C., & Frazier, L. (1986). The use of syntactic information in filling gaps. *Journal of Psycholinguistic Research*, 15, 209-224.
- Crain, S., & Fodor, J. D. (1985). How can grammars help parsers? In D. Dowty, L. Karttunen, & A. Zwickey (Eds.), *Natural Language Parsing: Psycholinguistic, Computational, and Theoretical Perspectives* (pp. 94-127). Cambridge: Cambridge University Press.
- Crain, S., & Steedman, M. (1985). On not being led up the garden path: The use of context by the psychological parser. In D. Dowty, L. Karttunen, & A. Zwickey (Eds.), *Natural Language Parsing: Psycholinguistic, Computational, and Theoretical Perspectives* (pp. 320-358). Cambridge: Cambridge University Press.
- Culicover, P. W., & Jackendoff, R. (2001). Control is not movement. *Linguistic Inquiry*, 32, 493-512.
- Demestre, J., Meltzer, S., García-Albea, J. E., & Vigil, A. (1999). Identifying the null subject: Evidence from event-related brain potentials. *Journal of Psycholinguistic Research*, 28, 293-312.
- de Vincenzi, M. (1991a). *Syntactic Parsing Strategies in Italian: The Minimal Chain Principle*. Dordrecht, Holland: Kluwer Academic Publishers.

- de Vincenzi, M. (1991b). Filler-gap dependencies in a null subject language: Referential and Nonreferential WHs. *Journal of Psycholinguistic Research*, 20, 197-214.
- de Vincenzi, M. (1996). Syntactic Analysis in Sentence Comprehension: Effects of Dependency Types and Grammatical Constraints. *Journal of Psycholinguistic Research*, 25, 117-133.
- de Vincenzi, M. (1998). Reanalysis aspects of movements. In J. D. Fodor & F. Ferreira (Eds.), *Reanalysis in Sentence Processing* (pp. 47-71). Dordrecht, Holland: Kluwer Academic Publishers.
- Egerland, V. (2003). Impersonal Pronouns in Scandinavian and Romance. *Working Papers in Scandinavian Syntax (WPSS)*, 71, 75-102.
- Featherston, S., Gross, M., Münte, T. F., & Clahsen, H. (2000). Brain potentials in the processing of complex sentences: An ERP study of control and raising constructions. *Journal of Psycholinguistic Research*, 29, 141-154.
- Felser, C., Clahsen, H., & Münte, T. F. (2003). Storage and integration in the processing of filler-gap dependencies: An ERP study of topicalization and *wh*-movement in German. *Brain and Language*, 87, 345-354.
- Fernández Soriano, O. (1989). Strong pronouns in null-subject languages and the Avoid Pronoun Principle. *MIT working paper in Linguistics*, 54-67.
- Fiebach, C. J., Schlesewsky, M., & Friederici, A. D. (2001). Syntactic working memory and the establishment of filler-gap dependencies: Insights from ERPs and fMRI. *Journal of Psycholinguistic Research*, 30, 321-338.
- Fodor, J. D. (1978). Parsing strategies and constraints on transformations. *Linguistic Inquiry*, 9, 427-473.
- Fodor, J. D. (1989). Empty categories in sentence processing. In G. Altmann (Ed.), *Parsing and Interpretation*, Special Issue of *Language and Cognitive Processes* 4 (3/4), 155-209.
- Fodor, J. D. (1995). Comprehending sentence structure. In L. R. Gleitman & M. Liberman (Eds.), *Invitation to Cognitive Science* (Vol. 1) (2nd ed.) (pp. 209-246). Cambridge, MA: MIT Press.
- Fodor, J. D., & Frazier, L. (1980). Is the human sentence parsing mechanism an ATN? *Cognition*, 8, 417-459.

- Fodor, J. D., & Inoue, A. (2000). Garden path re-analysis: Attach (Anyway) and Revision as Last Resort. In M. de Vincenzi & V. Lombardo (Eds.), *Cross-linguistic Perspectives on Language Processing* (pp. 21-61). Dordrecht, Holland: Kluwer Academic Publishers.
- Frazier, L. (1987a). Syntactic processing: Evidence from Dutch. *Natural Language and Linguistic Theory*, 5, 519-559.
- Frazier, L. (1987b). Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and Performance XII: The Psychology of Reading* (pp. 559-586). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Frazier, L. (1990). Identifying structure under X^0 . In G. Booij & J. van Marle (Eds.), *Yearbook of morphology*, 3 (pp. 87-105). Amsterdam, Holland: Foris Publications.
- Frazier, L., & Clifton, C. (1989). Successive cyclicity in the grammar and the parser. *Language and Cognitive Processes*, 4, 93-126.
- Frazier, L., Clifton, C., & Randall, J. (1983). Filling gaps: Decision principles and structure in sentence comprehension. *Cognition*, 13, 187-222.
- Frazier, L., & Flores D'Arcais, G. B. (1989). Filler driven parsing: A study of gap filling in Dutch. *Journal of Memory and Language*, 28, 331-344.
- Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14, 178-210.
- Frazier, L., & Rayner, K. (1988). Parameterizing the language processing system: Left- vs. right branching within and across languages. In J. Hawkins (Ed.), *Explaining Language Universals* (pp. 247-249). Oxford: Basil Blackwell.
- García-Albea, J. E., & Meltzer, S. (1996). Processing empty categories in Spanish. In M. Carreiras, J. E. García-Albea, & N. Sebastián-Gallés (Eds.), *Language Processing in Spanish* (pp. 207-240). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Gibson, E., Desmet, T., Grodner, D., Watson, D., & Ko, K. (2005). Reading Relative Clauses in English. *Cognitive Linguistics*, 16, 313-353.
- Gibson, E., & Pearlmutter, N. J. (2000). Distinguishing serial and parallel parsing. *Journal of Psycholinguistic Research*, 29, 231-240.
- Haegeman, L. (1994). *Government and Binding Theory* (2nd ed.). Oxford: Blackwell.
- Hornstein, N. (1999). Movement and control. *Linguistic Inquiry*, 30, 69-96.

- Holmberg, A., Nayudu, A., & Sheehan, M. (2009). Three partial null-subject languages: a comparison of Brazilian Portuguese, Finnish, and Marathi. *Studia Linguistica*, 63, 59-97.
- Hsiao, F., & Gibson, E. (2003). Processing relative clauses in Chinese. *Cognition*, 90, 3-27.
- Hsieh, Y., Boland, J. E., Zhang, Y., & Yan, M. (in press). Limited syntactic parallelism in Chinese ambiguity resolution. *Language and Cognitive Processes*.
- Hsu, C.-C. N., & Bruening, B. (2003). Investigating gap-filler dependencies in Chinese: Is there an "active gap"? Poster presented at AmLap conference, Glasgow, Scotland, September, 2003.
- Hsu, C.-C. N., Hurewitz, F., & Phillips, C. (2006). Contextual and syntactic cues for head-final relative clauses in Chinese. Paper presented at the 19th annual CUNY conference on human sentence processing, CUNY Graduate Center, March, 2006.
- Hu, J., Pan, H., & Xu, L. (2001). Is there a finite vs. nonfinite distinction in Chinese? *Linguistics*, 39, 1117-1148.
- Huang, C.-T. J. (1982). *Logical Relations in Chinese and the Theory of Grammar*. Doctoral dissertation, MIT; published in 1998 by Garland Publishing, New York.
- Huang, C.-T. J. (1984a). On the distribution and reference of empty pronouns. *Linguistic Inquiry*, 15, 531-574.
- Huang, C.-T. J. (1984b). On the typology of zero anaphora. *Language Research*, 20, 85-106.
- Huang, C.-T. J. (1987). Remarks on empty categories in Chinese. *Linguistic Inquiry*, 18, 21-337.
- Huang, C.-T. J. (1989). Pro-drop in Chinese: A generalized control theory. In O. Jaeggli, & K. J. Safir (Eds.), *The Null Subject Parameter* (pp. 185-214). Dordrecht, Holland: Kluwer Academic Publishers.
- Huang, Y. (1992). Hanyu de kongfanchou (Empty categories in Chinese). *Zhongguo Yuwen*, 230, 283-293.
- Huang, Y. (1994). *The Syntax and Pragmatics of Anaphora*. Cambridge: Cambridge University Press.
- Huang, Y. (2000). *Anaphora : A Cross-linguistic Approach*. Oxford: Oxford University Press.

- Inoue, A., & Fodor, J. D. (1995). Information-paced parsing of Japanese. In R. Mazuka, & N. Nagai (Eds.), *Japanese Sentence Processing* (pp. 9-63). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Ishizuka, T., Nakatani, K., & Gibson, E. (2006). Processing Japanese relative clauses in context. Paper presented at the 19th annual CUNY conference on human sentence processing, CUNY Graduate Center, March, 2006.
- Jaeggli, O., & Safir, K. J. (1989). The null subject parameter and parametric theory. In O. Jaeggli, & K. J. Safir (Eds.), *The Null Subject Parameter* (pp. 1-44). Dordrecht, Holland: Kluwer Academic Publishers.
- Kayne, R. (1994). *The Antisymmetry of Syntax*. Cambridge, MA: MIT Press.
- Keenan, E. L., & Comrie, B. (1977). Noun phrase accessibility and universal grammar. *Linguistic Inquiry*, 8, 63-99.
- Koster, J. (1978). Why subject sentences don't exist. In S. J. Keyser (Ed.), *Recent Transformational Studies in European Languages* (pp. 53-64). Cambridge: The MIT Press.
- Kwon, N., Polinsky, M., & Kluender, R. (2006). Subject preference in Korean. In D. Baumer, D. Montero, & M. Scanlon (Eds.), *Proceedings of the 25th West Coast Conference on Formal Linguistics* (pp. 1-14). Somerville, MA: Cascadilla Proceedings Project.
- Landau, I. (2001). Control and extraposition: The case of Super-Equi. *Natural Language and Linguistic Theory*, 19, 109-152.
- Lewis, R. L. (2000). Falsifying serial and parallel parsing models: Empirical conundrums and an overlooked paradigm. *Journal of Psycholinguistic Research*, 29, 241-248.
- Li, C. N., & Thompson, S. A. (1979). Third-person pronouns and zero-anaphora in Chinese discourse. In T. Givon (Ed.), *Syntax and Semantics Vol 12: Discourse and Syntax* (pp. 311-335). New York: Academic Press.
- Li, W. (2004). Topic chains in Chinese discourse. *Discourse Processes*, 37, 25-45.
- Li, Y.-H. A. (1990). *Order and Constituency in Mandarin Chinese*. Dordrecht, Holland: Kluwer Academic Publishers.
- Lin, C.-J. C., & Bever, T. G. (2006). Subject preference in the processing of relative clauses in Chinese. In D. Baumer, D. Montero, & M. Scanlon (Eds.), *Proceedings of the 25th West Coast Conference on Formal Linguistics* (pp. 1-14). Somerville, MA: Cascadilla Proceedings Project.

- Lin, C.-J. C., & Bever, T. G. (2009). Garden path and the comprehension of head-final relative clause. To appear in H. Yamashita, J. Packard, & Y. Hirose (Eds.), *Processing and Producing Head-final Structures*. Springer-Verlag.
- Lin, Y. B., & Garnsey, S. M. (2009). Animacy and the resolution of temporary ambiguity in relative clause comprehension in Mandarin. To appear in H. Yamashita, J. Packard, & Y. Hirose (Eds.), *Processing and Producing Head-final Structures*. Springer-Verlag.
- MacDonald, M. C. (1989). Priming effects from gaps to antecedents. *Language and Cognitive Processes*, 4, 35-56.
- MacDonald, M. C., & Clark, R. (1988). Empty categories, implicit arguments, and processing. *Proceedings of NELS*, 18, 300-314.
- Mani, N. (2004). The Role of Prosody in Parsing Ambiguous Sentences. *Speech Prosody 2004: International Workshop in Phonetics*.
- Manzini, R. (1983). On control and control theory. *Linguistic Inquiry*, 14, 421-446.
- Marslen-Wilson, W., & Tyler, L. K. (1987). Against Modularity. In J. L. Garfield (Ed.), *Modularity in Knowledge Representation and Natural-Language Understanding* (pp. 37-62). Cambridge, MA: MIT Press.
- Mazuka, R. (1991). Processing of empty categories in Japanese. *Journal of Psycholinguistic Research*, 20, 215-232.
- McElree, B., & Bever, T. G. (1989). The psychological reality of linguistically defined gaps. *Journal of Psycholinguistic Research*, 18, 21-35.
- Mehler, J., & Carey, P. (1967). Role of surface and base structure in the perception of sentences. *Journal of Verbal Learning and Verbal Behavior*, 6, 335-338.
- Meltzer, S. (1995). *Modularity: Evidence from CoReference Processing in Spanish*. Doctoral dissertation, City University of New York.
- Meng, C., Zheng, H. D., Meng, Q. H., & Cai, W. L. (2003). *Hanyu Dongci Yongfa Cidan* (The Dictionary of the usage of Chinese verbs) (3rd ed.). Beijing: Shangwu Yinshuyuan (The Commercial Press).

- Mitchell, D. C. (2004). On-line methods in language processing: Introduction and historical review. In M. Carreiras, & C. Clifton, Jr. (Eds.), *The On-Line Study of Sentence Comprehension: Eye-tracking, ERPs and Beyond* (pp. 15-32). New York: Psychology Press.
- Miyamoto, E. T., & Nakamura, M. (2003). Subject/object asymmetries in the processing of relative clauses in Japanese. In G. Garding, & M. Tsujimura (Eds.), *Proceedings of the 25th West Coast Conference on Formal Linguistics* (pp. 342-355). Somerville, MA: Cascadilla Proceedings Project.
- Newmeyer, F. J. (2005). *Possible and Probable Languages: A Generative Perspective on Linguistic Typology*. Oxford: Oxford University Press.
- Nicol, J., & Swinney, D. A. (1989). The role of structure in coreference assignment during sentence comprehension. *Journal of Psycholinguistic Research*, 18, 5-19.
- Osterhout, L., & Swinney, D. A. (1993). On the temporal course of gap-filling during comprehension of verbal passives. *Journal of Psycholinguistic Research*, 22, 273-286.
- Packard, J. L., Ye, Z., & Zhou, X. (2009). Filler-gap processing in Mandarin relative clauses: Evidence from event-related potentials. To appear in H. Yamashita, J. Packard, & Y. Hirose (Eds.), *Processing and Producing Head-final Structures*. Springer-Verlag.
- Pan, H., & Liang, H. (2002). Youxuelun yu hanyu zhuyu de queren (Optimality theory and subject identification in Chinese). *Zhongguo Yuwen*, 1, 3-13.
- Phillips, C., Kazanina, N., & Abada, S. H. (2005). ERP effects of the processing of syntactic long-distance dependencies. *Cognitive Brain Research*, 22, 407-428.
- Pickering, M., & Barry, S. (1991). Sentence processing without empty categories. *Language and Cognitive Processes*, 6, 229-259.
- Polinsky, M., & Potsdam, E. (2002). Backward Control. *Linguistic Inquiry*, 33, 245-282.
- Pollard, C., & Sag, I. A. (1994). *Head-Driven Phrase Structure Grammar*. Chicago: University of Chicago Press and Stanford: CSLI Publications.
- Pritchett, B. L. (1988). Garden path phenomena and the grammatical basis of language processing. *Language*, 64, 539-576.
- Pritchett, B. L. (1992). *Grammatical Competence and Parsing Performance*. Chicago, IL: The University of Chicago Press.

- Pu, M. M. (1995). Anaphoric patterning in English and Mandarin narrative production. *Discourse Processes*, 19, 279-300.
- Pu, M. M. (1997). Zero anaphora and grammatical relations in Mandarin. In T. Givón (Ed.), *Grammatical relations: Typological Studies in Language* (pp. 281-321). Amsterdam: John Benjamins.
- Pu, M. M. (2007). The distribution of relative clauses in Chinese discourse. *Discourse Processes*, 43, 25-53.
- Rosenbaum, P. (1967). *The Grammar of English Predicate Complement Constructions*. Cambridge, MA: MIT Press.
- Sag, I. A., & Fodor, J. D. (1995). Extraction without traces. *Proceedings of the 13th West Coast conference on formal linguistics*, 365-384.
- Sag, I. A., & Pollard C. (1991). An integrated theory of complement control. *Language*, 67, 63-113.
- Sakamoto, T. (2001). Processing filler-gap constructions in Japanese: The case of empty subject sentences. In M. Nakayama (Ed.), *Sentence Processing in East Asian Languages* (pp. 189-221). Stanford: CSLI Publications.
- Sigurðsson, H. Á., & Egerland, V. (2009). Impersonal null-subjects in Icelandic and elsewhere. *Studia Linguistica*, 63, 158-185.
- Simpson, A. (2002). On the status of modifying de and the structure of the Chinese DP. In S.-W. Tang, & C.-S. L. Liu (Eds.), *On the Formal Way to Chinese Languages* (pp. 74-101). Stanford: CSLI Publications.
- Stowe, L. (1986). Parsing WH-constructions: Evidence for on-line gap location. *Language and Cognitive Processes*, 1, 227-245.
- Sussman, R. S., & Sedivy, J. C. (2003). The time-course of processing syntactic dependencies: Evidence from eye movements. *Language and Cognitive Processes*, 18, 143-163.
- Swinney, D. A. (1991). The resolution of indeterminacy during language comprehension: Perspectives on modularity in lexical, structural and pragmatic process. In G.B. Simpson (Ed.), *Understanding Word and Sentence* (pp. 367-385). North-Holland: Elsevier Science Publishers.
- Swinney, D. A., Onifer, W., Prather, P., & Hirshkowitz, M. (1979). Semantic facilitation across sensory modalities in the processing of individual words and sentences. *Memory and Cognition*, 7, 159-165.

- Tanenhaus, M. K., Boland, J., Garnsey, S. M., & Carlson, G. N. (1989). Lexical structure of parsing long-distance dependencies. *Journal of Psycholinguistic Research*, 18, 37-49.
- Tao, H. Y. (2002) Hanyu kouyu xushiti guanxi congju jiegou de yuyi he pianzhang shuxing (The semantics and discourse properties of the relative clause construction in Chinese oral narratives). *Contemporary Research in Modern Chinese*, 4, 47-57.
- Tomlin, R. S., & Pu, M. M. (1991). The management of reference in Mandarin discourse. *Cognitive Linguistics*, 2, 65-93
- Traxler, M. J., Morris, R. K., & Seely, R. E. (2002). Processing subject and object relative clauses: Evidence from eye movements. *Journal of Memory and Language*, 47, 69-90.
- Ueno, M., & Garnsey, S. M. (2008). An ERP study of the processing of subject and object relative clauses in Japanese. *Language and Cognitive Processes*, 23, 646-688.
- Ueno, M., & Kluender, R. (2003). Event-related brain indices of Japanese scrambling. *Brain and Language*, 86, 243-271.
- van Gompel, R. P. G., & Pickering, M. J. (2006). Syntactic parsing. In M. Traxler, & M. A. Gernsbacher (Eds.), *Handbook of Psycholinguistics* (pp.289-307). Oxford: Oxford University Press.
- Walenski, M. (2002). *Relating Parsers and Grammars: On the Structure and Real-time Comprehension of English Infinitival Complements*. Doctoral dissertation: University of California, San Diego.
- Williams, E. (1980). Predication. *Linguistic Inquiry*, 14, 287-304.
- Witzel, J. D., & Witzel, N. O. (2007). The processing Japanese control sentences. Poster presented at the International Conference on Processing Head-final Structures, Rochester Institute of Technology, September, 2007.
- Wu, H.-H. I., & Gibson, E. (2008). Processing Chinese relative clauses in context. Poster presented at the 21st annual CUNY conference on human sentence processing, University of North Carolina at Chapel Hill, March, 2008.

- Wu, F., Kaiser, E., & Andersen, E. (2009). Subject preference, head animacy, and lexical cues: A corpus study of relative clauses in Chinese. To appear in H. Yamashita, J. Packard, & Y. Hirose (Eds.), *Processing and Producing Head-final Structures*. Springer-Verlag.
- Xie, J. (1997). *Processing NP-trace and Reflexives in Chinese*. Unpublished doctoral dissertation, CUNY Graduate Center.
- Xu, L. (1985-86). Towards a lexical-thematic theory of control. *The Linguistic Review*, 5, 345-376.
- Xu, L. (1986). Free empty category. *Linguistic Inquiry*, 17, 75-93.
- Yang, C. L., Gordon, P. C., Hendrick, R., & Wu, J. T. (1999). Comprehension of referring expressions in Chinese. *Language and Cognitive Processes*, 14, 715-743.
- Yang, C. L., Gordon, P. C., Hendrick, R., Wu, J. T., & Chou, T. L. (2001). The processing of coreference for reduced expressions in discourse integration. *Journal of Psycholinguistic Research*, 30, 21-35.
- Yang, C. L., Gordon, P. C., Hendrick, R., & Hue, C. W. (2003). Constraining the comprehension of pronominal expressions in Chinese. *Cognition*, 86, 283-315.
- Yoshida, M., Aoshima, S., & Phillips, C. (2004). Relative clause prediction in Japanese. Paper presented at The 17th Annual CUNY Sentence Processing Conference, University of Maryland, March, 2004.
- Zhai, Y., & Sakamoto, T. (2007). The developmental change of strategies in processing Chinese control sentences. Poster presented at the International Conference on Processing Head-final Structures, Rochester Institute of Technology, September, 2007.