

GRAMMAR AND PARSING: A TYPOLOGICAL INVESTIGATION OF
RELATIVE-CLAUSE PROCESSING

by

Chien-Jer Charles Lin

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LIST OF ABBREVIATIONS

ACC	accusative
Ag	agent
ASP	aspect marker
CL	classifier
DE	<i>de</i> , relativizer in Mandarin
Erg	ergative
NOM	nominative
ORC	relative clause with object extraction
Perf	perfect
Pt	patient
PRC	possessor relative clause
RC	relative clause
rel	relativizer
RT	response/reading time
SRC	relative clause with subject extraction
t	trace

ABSTRACT

This dissertation investigates the role of grammar and parsing in processing relative clauses across languages. A parsing theory called the Incremental Minimalist Parser (IMP), which parses sentences incrementally from left to right, is sketched based on the Minimalist Program (Chomsky, 2001, 2005). We provide sentence processing evidence which supported a universal parsing theory that is structure-based. According to IMP (and other structure-based theories), a gap located at the subject position is more easily accessed than a gap located at the object position in both head-initial (e.g. English) and head-final (e.g. Mandarin) relative clauses. Experiment 1 (self-paced reading tasks) showed a processing advantage for Mandarin relative clauses that involved subject extractions over object extractions, consistent with the universal subject preference found in all other languages. Experiments 2 to 4 (naturalness ratings, paraphrasing tasks, and self-paced reading tasks) focused on possessor relative clauses. When the possessor gap was located at the subject position (i.e. in passives), a possessive relation was easier to construct than when the gap was located at an object position (i.e. in canonical constructions and sentences involving BA). The results of Experiments 1-4 suggested that processing accounts based on locality and canonicity, but not on syntactic structure, cannot account for the processing preferences of filler-gap relations in relative clauses. Experiment 5 (self-paced reading tasks) investigated whether the surface NVN sequence of relative clauses at sentence-initial positions induced garden path, and whether the animacy of the first noun in such sequences could rescue the garden path. Mandarin relative clauses involving topicalization of the embedded object were investigated. The results suggested that the surface NVN sequence did induce main-clause misanalysis (as Subject-Verb-Object). Even when the first noun was (semantically) an unlikely agent, the parser took it as a subject in the initial syntactic analysis. Semantics did not have an immediate effect on syntactic processing.

Keywords: sentence comprehension; processing; parsing; relative clause

CHAPTER 1

INTRODUCTION

The Martian scientist might reasonably conclude that there is a single human language, with differences only at the margins. For our lives, the slight differences are what matter, not the overwhelming similarities, which we unconsciously take for granted. No doubt frogs look at other frogs the same way. But if we want to understand what kind of creature we are, we have to adopt a very different point of view, basically that of the Martian studying humans.

Noam Chomsky (1996)

Human languages are so different yet so similar. Such seemingly contradictory views about language can be found at every level of linguistic inquiry. At the structural level lie debates on the existence of the Universal Grammar. At the processing level lies the controversy of whether users of different languages deal with language using the same or different basic mechanisms. Such contradicting perspectives are the motivations for this dissertation. The central question of this dissertation is whether different languages are processed in similar ways. In particular, we focus on the processing of relative clauses with a view to pursuing a universal parsing account. The goal of this dissertation is to sketch a general human language parser that constructs syntactic structures incrementally

and to show that such a parser is able to account for a range of structural preferences in sentence processing. In 1.1, we discuss the theoretical architecture of the current research, including the relation between grammar, the parser, and the processor. 1.2 defines the goals and provides an overview of the dissertation.

1.1 Grammar and the Parser in Processing

Three aspects need to be discussed separately when we talk about the universality and diversity of sentence processing: grammar, the parser, and the processor. Grammar refers to the syntactic knowledge that derives the formal structure of the sentence being processed. The parser constructs syntactic structures incrementally from left to right in a computationally idealized situation. The processor puts the parser in real time and space, parsing sentences within the constraints of human capacity (such as working memory, resulting in locality, recency, and frequency effects). Processing involves knowledge about grammatical structures, the parser, and the human cognitive capacity. As illustrated by (1), the processor level encloses the parser, which requires the grammar as its basis.

(1)



The diversity of processing strategies across languages could result from diversity of the

grammar or the diversity of the parser. Structural differences may result in different parsing strategies. Parsing mechanisms can also differ across languages. The cognitive constraints on language processing, such as working memory, are more likely to be universal since they are not language-dependent. In this dissertation, we focus mainly on the grammatical structure and the parser in processing, keeping the cognitive (i.e. processor-specific) factors constant during processing.

There exist contrasting proposals about the relation between the grammar and the parser. Phillips (1996) takes the stance that the grammar is identical to the parser in the “Parser Is Grammar (PIG)” model. In the PIG model, grammaticality is regarded as “parsability in the limit (Phillips, 1996: 255).” In his categorization, therefore, the grammar is the parser endowed with unbounded processing power, while the parser is the grammar that is constrained by available processing resources (equivalent to the term *processor* in my categorization). The grammar and the parser are indistinguishable in this model, since without constraints on processing resources, the parser is the grammar; under resource constraints, what people judge as grammatical may actually be what is parsable to them.

The analysis-by-analysis model, as reviewed by Phillips (1996: 258-261), on the

other hand, argues that parsing a sentence involves reversing the grammatical derivations. This is the position taken by this dissertation. The basis for taking such a position hinges on the finding that sentences that are equally grammatical, can be processed with different efficiencies. Such a difference does not arise from differences in the demand on processing resources, but from the differences in parsing demands.

Therefore, we take the position that the grammar and the parser should be distinguished. Grammar provides the static knowledge that enables the construction of syntactic structures in a two-dimensional space, while the parser uses this knowledge to construct structures incrementally. In sentence comprehension, the parser transforms a one-dimensional string of words into a two-dimensional structure, from which it composes the semantic interpretation. An important task specific to the parser is to construct associations between words in the sentence based on the available grammatical cues.

The goal of this dissertation is to show that a universal parsing mechanism produces universal processing preferences even though the grammars being processed are different. The specific aspect of grammar considered is head-initial and head-final relative clauses in a variety of languages. We show that parsing based on the Incremental Minimalist

Parser (introduced in Chapter 2) accounts for a universal subject preference both across languages with different relative-clause structures, and across different kinds of relative clauses within one language (e.g. Mandarin). The parser also predicts garden-path readings of the relative clauses that appear in superficial NVN orders.

1.2 Goals and Overview

We aim at answering the following questions in this dissertation:

- Do users of different languages adopt similar parsing strategies in sentence processing?
- Is there a common parser that can account for processing preferences and garden path effects within and across languages?
- How does semantic information affect the processing of sentences that involve syntactic garden paths?

The goal of this dissertation is, therefore, to propose a parser that is based on Universal Grammar, and to examine processing preferences predicted by certain properties of this parser. Specifically, we look at the formal structure of relative clauses across typologically different languages such as English and Chinese, review cross-linguistic processing preferences regarding subject and object extractions, and conduct experiments

in Mandarin Chinese. We will also investigate how relative clauses that induce garden paths are processed and whether semantic information facilitates reanalysis. The experimental results show that there is indeed a universal processing preference for relative clauses with gaps located at the subject position. Superficial NVN word orders induce the main-clause garden-path analysis of relative clauses. Semantic information (in terms of animacy) of the first noun in the NVN sequence does not facilitate a relative-clause parse; it is overridden by the strong top-down syntactic templatic effect.

The dissertation is organized as follows. Chapter 2 proposes a structure-based parsing theory called the Incremental Minimalist Parser, reviews the formal structures of relative clauses in English and Chinese, and describes how the proposed parser parses English and Chinese relative clauses. Chapter 3 investigates the processing differences between subject and object extracted relative clauses across typologically different languages. A universal subject preference is supported by an experiment on Mandarin relative clauses. Chapter 4 extends the finding of a universal subject preference to the processing of gaps at different positions within one language. We show that a gap located at the subject position of Mandarin possessor relative clauses is preferred over gaps located at object positions. Chapter 5 discusses issues of garden path effects related to

relative clauses in terms of structural preferences and semantic information. Garden-path effects on reduced relative clauses in English are first reviewed. Different garden-path effects associated with Mandarin relative clauses are discussed. We then investigate the processing of relative clauses that involve object topicalization in Mandarin. It is shown that semantic information regarding animacy does not initiate early syntactic reanalysis in these Mandarin relative clauses. Chapter 6 summarizes the findings and concludes this dissertation by returning to the general issues and questions raised in this chapter.

CHAPTER 2

INCREMENTAL MINIMALIST PARSING THEORY AND RELATIVE CLAUSES

This chapter sketches a left-to-right, incremental parsing theory—the Incremental Minimalist Parser (IMP)—based on the mechanisms of the Minimalist Program (Chomsky, 2001, 2005). We review the formal structures of relative clauses and apply IMP to the parsing of relative clauses. The basic mechanisms of IMP are first introduced in 2.1. Relative clauses are introduced in 2.2; issues regarding the representation and derivation of both head-initial and head-final relative clauses in different languages are introduced in 2.3. How IMP parses relative clauses during sentence comprehension will be discussed in 2.4.

2.1 Incremental Minimalist Parser (IMP)

A major discrepancy between generative syntactic theories and real-time sentence processing is that the formal derivation of a sentence is bottom-up, and proceeds from most to least embedded. Constituents are allowed to move only leftwards and upwards.

These derivational restrictions are contrary to people's experience of language in real time; sentences are inevitably produced and perceived linearly from left to right. A two-dimensional syntactic structure is realized in one dimension.

In order to understand better the on-line process of parsing and sentence comprehension while maintaining the general architecture of a formal grammar, we investigate the possibility of a parser that builds syntactic structures incrementally from left to right. We hypothesize that the process of sentence comprehension is a process of structure building and interpretation. The human language parser builds structures that it calculates to be most likely. When the hypothesis goes wrong, the parser has to reanalyze and construct a new parse.

This section describes the architecture and properties of this incremental syntactic parser, which adopts the basic mechanisms in the Minimalist Program (Chomsky 1993, 1995, 2000, 2005). In later chapters, we adopt this parser as the basis for building syntactic structures on-line; we also discuss how the experimental results can be understood in light of the incremental minimalist parser proposed. IMP assumes the incrementality hypothesis of Phillips (1996, 2003):

(1) Incrementality Hypothesis (Philips, 2003: 42): Sentence structures are built incrementally from left to right.

The following subsections define the basic operations in IMP.

2.1.1 The Y-Model of Derivation

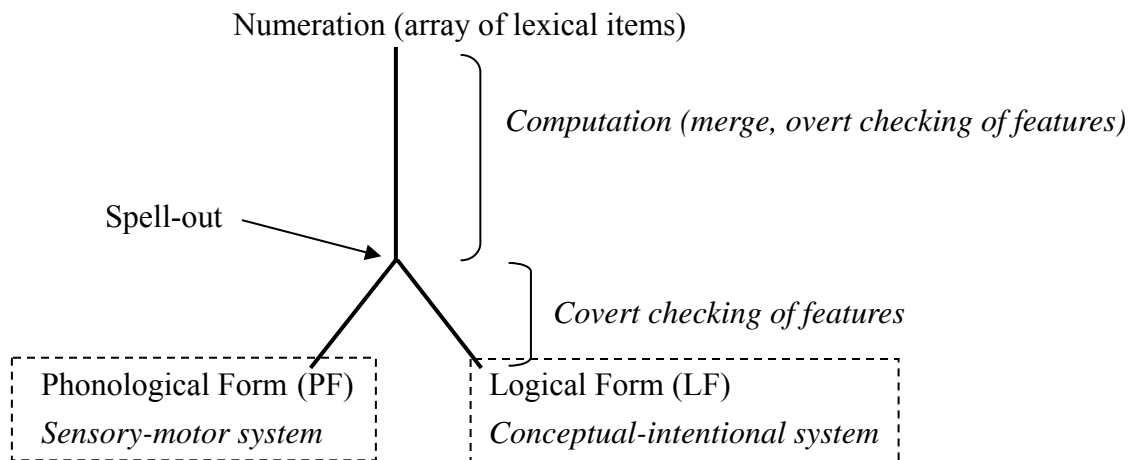
The goal of IMP is to efficiently compute the correct structures and interpretations of the sentences being processed based on a set of structural algorithms. As a model of the human sentence parser, it aims at deriving the correct logical and semantic relations within a sentence and at providing the structural basis for garden path and processing preferences.

The general mechanism of IMP adopts the Y-model of derivation assumed in generative grammar, whereby a sentence is derived by merging the numerated lexical items both internally and externally. The constituents are sent to the phonological component (Phonological Form or PF) for pronunciation at the point of Spell-Out.¹ The syntactic structures go on deriving with covert internal merges after Spell-Out and reach Logical Form (LF), at which point the structure is interpreted by the

¹ This Y-model of the Minimalist Program is reminiscent of the T-model of Government and Binding Theory. However, in the Minimalist Program, the different levels of representation during derivation are eliminated, keeping only the necessary interface levels.

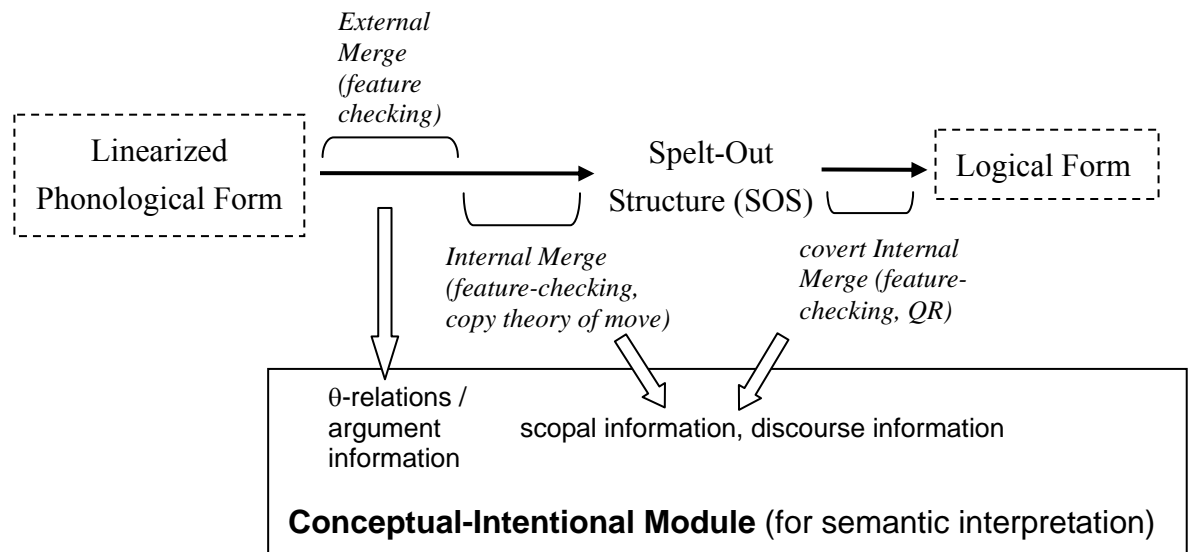
conceptual-intentional interface. This Y-model of derivation is illustrated by (2).

(2) Y-Model of Derivation in the Minimalist Program (cited from Townsend & Bever, 2001: 76)



In sentence comprehension, however, derivation does not start from the numeration of lexical items into a lexical array. Instead, words of a sentence appear in their Phonological Forms and in the spelt-out linear order. From these inputs, the parser reconstructs the structure at the point of spell-out and applies covert derivations to get at the Logical Form. Based on the Y-model of derivation, IMP proceeds in the following manner:

(3) Derivational Model of the Incremental Minimalist Parser



The goal of the parser is to arrive at the correct LF. Inputs are composed of linearized PFs.

The current model leaves open the possibility of direct mappings between the PF and the LF, though we do not elaborate on this possibility (cf. Jackendoff (1997) on stress-focus correspondences; see also Szendroi, 1997). An LF is computed based on the spelt-out structure (SOS) constructed. LF and the SOS match perfectly when no covert movement is involved; that is, when all features are already checked at the SOS, no further derivations will be needed at LF. Conversely, interpretation at LF may differ from that at the SOS when further covert movement is motivated by unchecked features at the SOS.

Let us now consider the nature of linguistic inputs in sentence comprehension. They

are linearized PFs with words (DPs in particular) appearing in the positions where Case and strong features are already checked.² Case on arguments is checked by functional heads such as I and *v*; therefore, as soon as (part of) a DP is encountered, an associated functional head is assumed to exist.

Let us also consider the end product of sentence comprehension, namely the LF. It should provide complete information about the thematic relations between the DPs and the verbs, the incorporation of adjuncts, and the correct semantic scopes. Case is a purely syntactic entity. Its existence provides the parser with information about where a DP may have been base-generated.³

The parser reconstructs the structure at Spell-Out using the linearized PF inputs. Based on the features of the lexical items, and reversing the Merge operation (to be defined in 2.1.1.2), the parser constructs the most likely SOS. Both Merge and Move are considered at each lexical input. As soon as an SOS is constructed, the thematic relations and relevant argument information can be computed and sent to LF. The parser also links

² According to Chomsky (1986), Case-checking can occur either when a DP appears at the overt case-checked positions at Spell-Out or when it is associated with another coindexed DP through a *chain* and moved to a case-checked position at LF. Therefore, at Spell-Out, Cases of DPs are either already checked, or they have to be associated with a coindexed expletive and be checked at LF. Strong and weak features are defined based on individual languages. Strong features are checked prior to Spell-Out, causing overt movements. Weak features induce covert movements at the LF due to the principle of *procrastinate* (Chomsky 1995).

³ Case also provides information about the finiteness of the clause. In the case of non-finite clauses, nominative case cannot be checked.

an operator with the variable that it binds, and interprets scopal relations. LF simultaneously receives information from two sources—the thematic relations from local External Merge and semantic scopes and discourse information from Internal Merge (i.e. movement) and operator-variable relationship.⁴

An important property of the proposed IMP is that an LF is computed at each incremental point in the parsing of the SOS. Semantics is computed incrementally as syntax is, as illustrated by (4).⁵ An alternative hypothesis could be that semantics is *not* computed until after the whole spelt-out structure is constructed, which is illustrated by (5). However, IMP adopts an incrementally constructed LF since miscomputed LFs do exist during the processing of a sentence. These miscomputed LFs get revised when more information is available. In Chapter 5, we provide evidence that LF is incrementally constructed, as misassignment of thematic roles and misanalyzed scopal relations do occur in the middle of a sentence.

It remains an open question whether the computed semantic information within each incremental step needs to arrive at LF through SOS. Since the goal of the parser is to

⁴ This idea that dual information feeds into LF matches with the dual semantics that is incorporated by the conceptual-intentional interface in Chomsky (2005: 7).

⁵ It remains open as to whether the parser may hold several SOSs into a buffer (in the spirit of the Phase Theory) and send the chunks of SOSs to LF for interpretation. The crucial point here is that LF interpretation takes place incrementally during the middle of a sentence; it does not wait till the end.

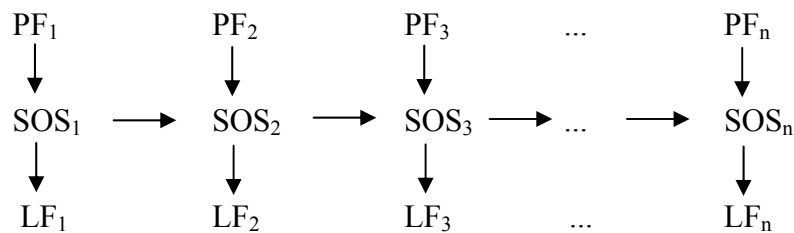
compose the LF, the SOS may not be necessary as an independent level during processing.

However, since the linearized PFs directly reflect the SOSs, but not necessarily the LF,

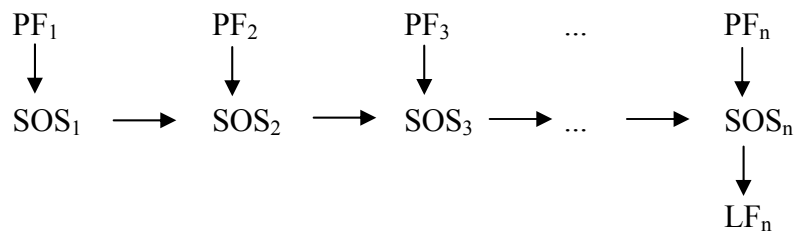
we consider it a reasonable working hypothesis to have the intermediate SOS level on the

way to computing the LF.

(4) Incremental Computation of Spelt-Out structure and LF in IMP



(5) Non-Incremental Computation of LF



In the following, we define and discuss these operations mentioned in greater detail.

2.1.2 External Merge, and the Basic Categories

In the Minimalist Program, syntactic objects are combined through an operation called

Merge (Chomsky, 1995: 226; 2005), which lies at the heart of the infinite generative

capacity of human language, since it enables combination and recursion in a theoretically

unlimited way. Merge is formally defined as the following:

(6) Merge (Uriagereka, 1998: 178)

Given a term $\tau_i = \alpha$ that is targeted for merger, and a term $\tau_j = \beta$ that is to merge with τ_i , τ_j merges with τ_i if and only if a new term $\{\underline{1}, \{\tau_i, \tau_j\}\}$ is obtained, such that $\{\underline{1}, \{\tau_i, \tau_j\}\}$ immediately dominates τ_i and τ_j and $\underline{1} = \alpha$.

Merge takes *two* syntactic objects X and Y and yields a set $\{X, Y\}$. One of the combined objects projects as the head of the new object. This new object is represented as $\{X, \{X, Y\}\}$ when X gets projected as the head. The merging of X and Y is possible when the head X has an unchecked c-selectional feature (also called the *edge feature* (EF) in Chomsky (2005)) that can be checked by Y. According to the *no-tempering condition* (a.k.a. Extend Target, Strict Cyclicity, etc.), Merge cannot break up or add new features to the combined objects. Therefore, Merge always occurs at the *edge* of a constituent.

Chomsky (2005) distinguishes between two kinds of Merges—External Merge (EM) and Internal Merge (IM). Both kinds of Merges are driven by feature-checking. EM refers to $\{X, Y\}$, where Y is not part of X. IM refers to $\{X, Y\}$, where Y is part of X, i.e. where Y has been copied from a more embedded part of the structure of X and then merged with the root node X. IM is traditionally called *Move*. Chomsky explicates that for semantic

interpretation, EM and IM have different effects. EM generates the “generalized argument structure (theta roles, the “cartographic” hierarchies, and similar properties),” while IM produces “discourse-related properties such as old information and specificity, along with scopal effects (7).”

IMP has two major components—a series of top-down functional templates, and the lexico-syntactic information of each incoming word (in the form of syntactic features). In processing sentences, the functional templates are top-down structures based on projections of functional heads. Each incoming word seeks to attach to the topmost available position in this structure. IMP assumes the top-node of the input sentence to be a CP. The input items occupy various structural positions within this CP, from left to right.⁶ The selectional relations between functional projections produce the schematic structure for each sentence. A C selects for an I (a.k.a. T), which selects for a *v*, and so on. These functional heads are elements that exist in the lexical array of every sentence, given

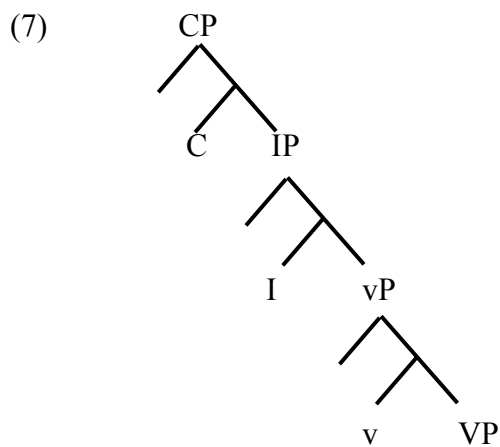
⁶ This is similar to the spirit of Kayne’s (1994) LCA as the universal structure-building mechanism for all sentences in all languages:

- a. X asymmetrically c-commands Y iff X c-commands Y and Y does not c-command X. (Kayne, 1994: 4)
- b. Linear Correspondence Axiom (Kayne, 1994: 6): $d(A)$ is a linear ordering of T [where d stands for the non-terminal-to-terminal dominance relation, A refers to the set of ordered pairs $\langle X_j, Y_j \rangle$ such that for each j , X_j asymmetrically c-commands Y_j , and T stands for the set of terminals.]

Words that appear first (on the left) are assumed to asymmetrically c-command those that appear second (on the right). Therefore, all structures are assumed to branch to the right.

It is similar to Phillips’ Branch/Merge-Right. Even though the parses that Phillips (1996) produces are invariably right branching trees similar to Kayne’s (1994), Phillips does not rely on the idea of antisymmetric c-command to derive word orders.

that the parser expects every utterance to express a proposition, i.e. to be part of a sentence. However, they are only valued as the sentence is incrementally built. Prior to the input of the first word, IMP is already prepared to fill the structure, schematically represented as (7).



Meanwhile, based on the syntactic features of individual words, IMP considers the possibility of merging the input word with previous local structure and attaching the word to the top-down templatic structure. An input is always considered in terms of its relation to the head in the structure. It can either be the head itself, or it can be something selected for by the head. This is depicted as the probe-goal relationship. If the input is part of an adjunct, it can be taken to adjoin to the phrase projected by the head, as in a modificational adjunct like an adverbial. Case features are checked at the linearized position by the head. Thematic relations are not assigned until the verb-associated

projections (i.e. v and V) are reached.⁷

The basic lexical categories within IMP include the following:

(8) D selects for an NP and composes a DP.

(9) P selects for a DP and composes a PP.

(10) N projects as an NP.

(11) There are three types of Vs projecting as VPs:⁸

- a. V_t (Verb-transitive) selects for a DP as the complement and values the theta feature of the DP as [patient].
- b. V_{ua} (Verb-unaccusative) selects for a DP as the complement.
- c. V_{ue} (Verb-unergative) does not select for a complement.

Functional heads include:

(12) C (operator position) selects for an IP as the complement, merges with a DP at the specifier position, and projects maximally as a CP. C can be valued as [+Q] or [-Q] depending on whether there is a *wh*-phrase or an auxiliary appearing at Spec-CP to check the feature [+Q] at C . A default feature [-Q] is selected when [+Q] is not

⁷ At this point, we only consider the relation between verbs and arguments. Adjuncts may be merged by adjunction, which should be regarded as a special case of Merge.

⁸ We follow Fong (2005) in adopting a three-way categorization of VPs.

checked.

(13) I selects for a vP as the complement, merges with a DP at the specifier position, and projects maximally as an IP. I assigns the Case feature [nom] and the theta feature [agent] to a DP at Spec-IP.

(14) Little v selects for a VP as the complement, merges with a DP at the specifier position, and projects maximally as a vP. Little v bears [acc] and values the Case feature on the object as [acc].

When a constituent functions as an adjunct, it adjoins to an XP, and projects as an XP.

Each incoming word is first recognized in terms of its part of speech. This incoming word projects maximally with the specifier and complement positions created in the projected structure. For example, a preposition would project as a PP with the preposition as the head and a DP as the complement. It first attempts to merge externally with the structure of the previous word. If it can be the complement of the previous head, it merges with the previous head as a complement. If the previous head is already argument-complete, it seeks the possibility of merging with the previous maximal projection (i.e. an XP). If no such option is available, it merges as an adjunct. External Merge operates primarily based on subcategorization and checking of syntactic features.

2.1.3 Probe, Goal, and Move

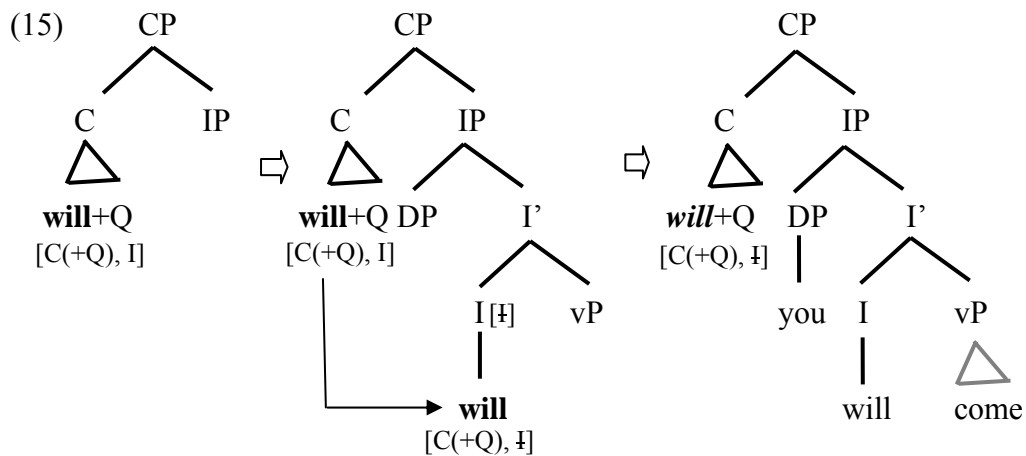
As discussed earlier, there are two kinds of Merge. In 2.1.1.2, we discussed External Merge. Internal Merge (IM), on the other hand, copies part of a syntactic object and re-merges it with the same syntactic object. IM is traditionally referred to as Move. As noted, it is an operation that involves both Merge and Copy (Bočkovič, 2001; Chomsky, 1993; Nunes, 2001, 2004). A syntactic object is driven to move to a position to check features, leaving a copy at the trace position. In IMP, the reconstruction of Move also involves making a copy of a lexical item at a higher edge position and merging that copy with a local head or phrase. Every lexical item carries with it a bundle of features to be checked and valued during derivation. The parser builds the top-down templatic structure. As each lexical item appears, it is placed into the structure starting from the topmost position. After merging externally with the previous items, the item also seeks the possibility of making copies at lower positions to check features with the functional heads. Let us consider the three kinds of movements typically discussed: head-movement, A-movement, and A-bar-movement.

Head Movement

Head movement in English includes V-to-I and I-to-C movements. A sentence

always starts as a CP. At the C-head position, the parser has to determine whether the syntactic object residing there could require a copy downstairs, that is, whether a head-movement chain exists between the head of the CP and the heads of the closest IP and VP. IMP adopts the feature-checking approach to movements. Lexical items carry features when they enter the derivation, and movements occur because these features need to be checked.

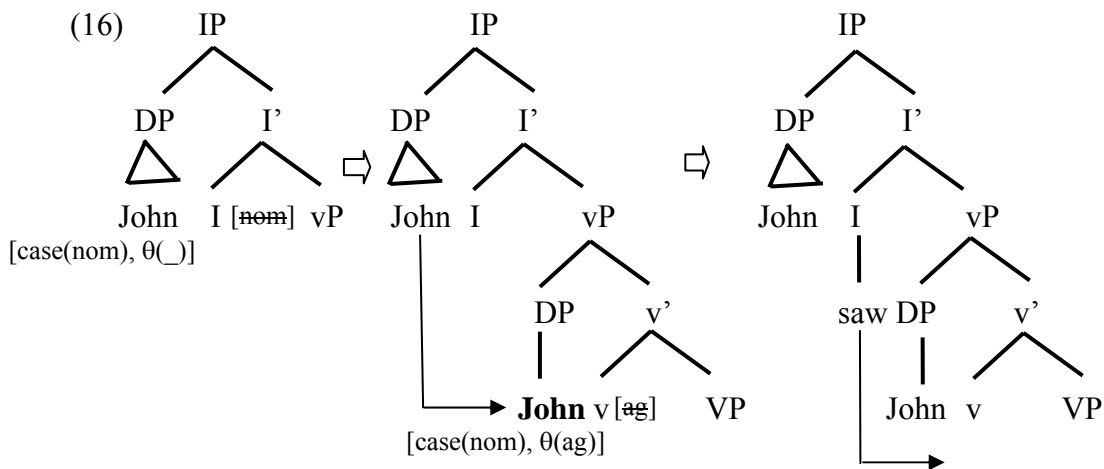
Take the sentence *Will you come?* as an example. The parser starts with a CP node. If it encounters a DP, it is taken to be in the Spec-CP position; a verb or auxiliary is taken to be in the C-head position. All C-heads assign either a [+Q] or [-Q] feature. When it is filled by an unembedded wh-phrase, C assigns [+Q]. When filled by *that* or unfilled (i.e. null) or when it is filled by an embedded wh-phrase, it assigns [-Q]. In (15), *will* appears as the first lexical item of the sentence and is taken as the head of a CP. C therefore takes the value of [+Q]. The feature [C] of *will* gets valued as [+Q] from the C head.



Since *will* has the feature $[I]$ still unchecked, the parser copies *will* to an I-head position to check this feature. When the DP *you* enters, it takes the specifier position of the IP.

A-Movement

A-movement refers to the operation by which a DP argument is moved from a theta-assigning position to an upper argument position to check a case or EPP feature. For example, a subject is moved from spec-vP to spec-IP. These DPs do not have unchecked $[wh]$ features, so they do not reside in the Spec-CP position. The second highest position for a DP is Spec-IP. The parser assumes that this incoming DP has the theta feature unvalued. It, therefore, makes a copy of the DP and merges it into spec-vP to value the feature as agent. An example is provided in (16).



A-Bar Movement

Now, let us turn to A-bar movements, which include *wh*-movement, topicalization, scrambling, and movement of quantificational operators. To demonstrate how IMP parses sentences involving A-bar movements, we focus only on *wh*-movements as an exemplification. Other types of A-bar movements proceed similarly. In a bottom-up derivation, *wh*-phrases as operators move to spec-CP to check their *wh*-feature in English. They leave a trace/copy in the base-generated position and Case position. In languages like Mandarin Chinese, however, *wh*-phrases remain in-situ. Even though in languages like Mandarin Chinese, the *wh*-operators remain in-situ at Spell-Out, these operators undergo covert movements at LF (Huang, 1982). This generates correct quantificational scopes and interpretations associated with *wh*-phrases. Consider examples (17)-(19), summarized by Huang (1994: 149). These three sentences in Mandarin all have the

wh-phrase in situ. However, the different interpretations available suggest that selectional restrictions of the verb blocked or required certain movements at LF. With *yiwei* ‘think’ and *jide* ‘remember,’ the *wh*-phrases scope over the whole sentence. With *xiangzhidao* ‘wonder,’ and *jidie* ‘remember,’ the *wh*-phrase scopes over the embedded clause. As a consequence, (17) and (18) each has only one interpretation available. (19), however, has two available interpretations because the verb *jide* can select CPs with both [+Q] and [-Q]. Even though the SOSs of the three sentences seem identical, the individual verbs select CPs with only certain kinds of unchecked features, thus producing different scopes of interpretations.

(17) Zhangsan yiwei Lisi maile **sheme**

Zhangsan think Lisi bought what

‘**What** does Zhangsan think Lisi bought?’

(18) Zhangsan xiang-zhidao Lisi maile **sheme**

Zhangsan wonder Lisi bought what

‘Zhangsan wonders **what** Lisi bought.’

(19) Zhangsan jide Lisi maile **sheme**

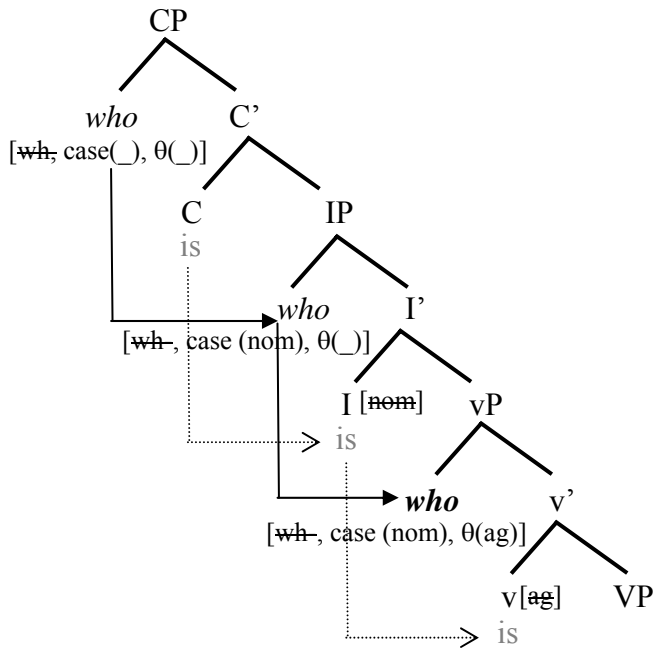
Zhangsan remember Lisi bought what

(a) ‘**What** does Zhangsan remember Lisi bought?’

(b) ‘Zhangsan remembers **what** Lisi bought.’

How does IMP deal with these sentences? In a language with overt *wh*-movement like English, *wh*-phrases, as DPs, are associated with the spec of a CP, assuming that that is where a [*wh*-feature] can be checked. However, a *wh*-phrase, like all DPs, contains a case feature that has to be valued. Take the sentence, *Who is Meg dating?*, as an example. The parser constructs a CP, locating *who* at spec of the CP, where *who* checks its *wh*-feature. The unchecked case and theta feature of *who* motivate it to search for positions downstairs to value the case feature. The shortest move at the point of *who* is for it to be copied to spec-IP and further to spec-vP. Thus the parser constructs a hypothetical structure like (20), valuing the case-feature of *who* as nominative in Spec-IP and valuing its theta-feature as agent in Spec-vP. Then *is* comes along, occupying the C-head and gets associated with I and *v* through head movement.

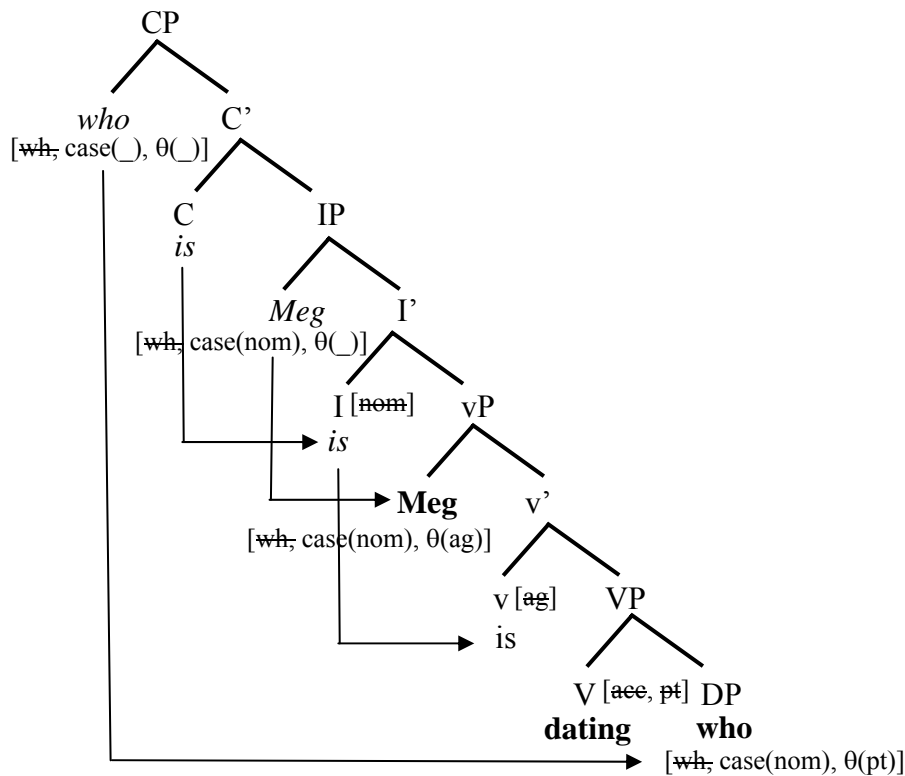
(20) **Who** is Meg dating?



The prediction of this structure building strategy is that before any other elements are encountered, the parser will interpret a DP *wh*-phrase (except adjunct *wh*-phrases like *why*, *how*, *when*, *where*, etc.) as a subject. The sentence in (20) can already lead to a garden path because not until the parser meets the word *Meg* does it realize that *who* is not a subject. The parser has to abandon the first parse and construct a correct one like (21).

The case and theta features of *who* get reassigned.

(21) Who is Meg dating?



Crucial information for the parser to compute the LF for this sentence includes the quantifier scope and thematic relations. In English, the quantifier scopes of *wh*-phrases are overtly indicated at SOS; therefore the job of the parser is to find the location of the variable that is bound. This is accomplished by finding a position where the theta-feature can be valued.

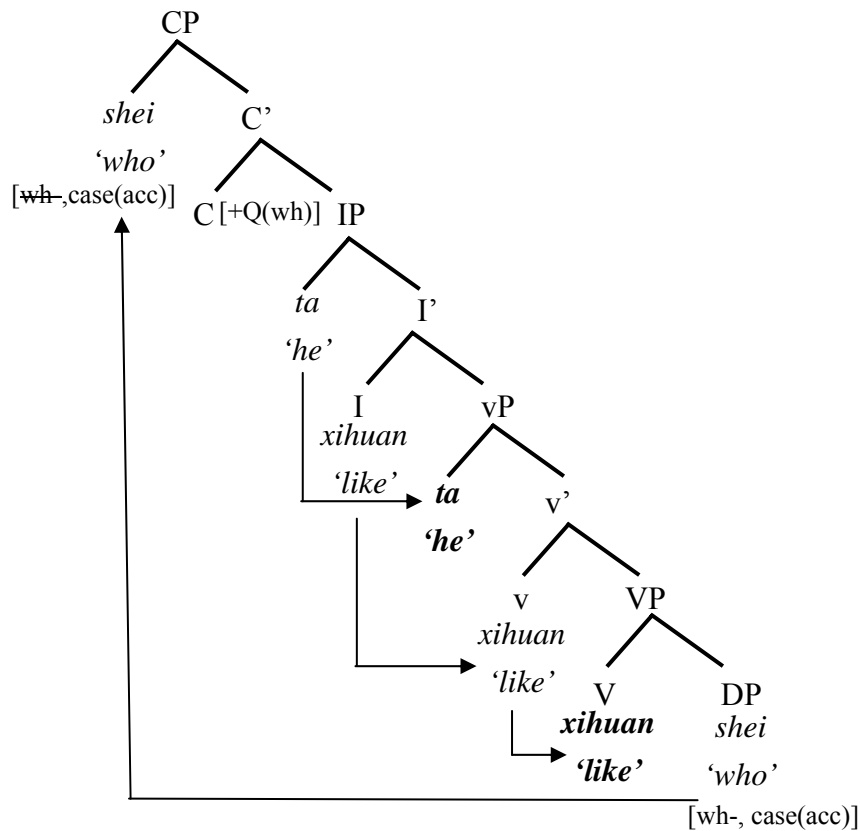
In Mandarin Chinese, where *wh*-phrases remain in situ, however, thematic relations can be directly read off from the base-generated argument position. The *wh*-phrase

searches the structure above for an operator position to check the *wh*-feature—a spec-CP position that binds the *wh*-phrase variable. In this case, encountering the *wh*-phrase in situ triggers the search for an operator upstairs. It is associated with the closest operator position, leading to the embedded question interpretation (b) of (19) to be more dominant than the question interpretation (a).

For a Chinese sentence like *ta xihuan shei* ‘who does she like,’ the parser analyzes it as a declarative CP ([-Q]) before reaching the *wh*-phrase. When the *wh*-phrase *shei* ‘who’ is reached, the parser has to reanalyze the upper C-head as [+Q], and associate this operator with the bound *wh*-variable. This is illustrated by (22).

Ta ‘he’ as a DP enters the position of spec-IP to check [nom], gets copied to spec-vP, and values its theta feature as agent. At this point, the parser also determines that the C-head carries the feature [-Q] since no *wh*-phrase resides in Spec-CP. *Xihuan* ‘like’ occupies the head-I position and is copied to head-v and head-V through head movement. *Shei* ‘who’ as a *wh*-phrase appears at the object position and gets its case-feature valued as accusative. With its *wh*-feature unchecked, the parser reanalyzes the C-head as [+Q] to check and bind the *wh*-feature.

(22) Ta xihuan shei? she likes who ‘Who does she like?’



2.1.4 Interim Summary

In section 2.1.1, I sketched an incremental parser based on operations within the Minimalist Program. This parser aims at constructing syntactic structures from left to right incrementally, and deriving semantic interpretations. The proposed Incremental Minimalist Parser uses Merge, Copy, Probe-Goal relations, and feature-checking as the basic mechanisms. All operations are driven by the need to check or value features.⁹ In

⁹ Since this is a brief sketch of the IMP, other details such as Binding Conditions, more complicated

the following sections, we review the formal structure of relative clauses and demonstrate how relative clauses in English and Chinese are parsed by IMP.

2.2 Types of Relative Clauses in English and Chinese

Relative clauses (RCs) are subordinate clauses embedded within nominal phrases.

Semantically, this embedded clause modifies the dominating nominal head. Syntactically, the nominal head is associated with an empty element within the subordinate clause.

Grosu (2002: 145) provides a definition for RCs based on their syntactic and semantic properties:

- (23) a. A relative clause is subordinated [to an NP/DP].
- b. A relative clause includes, at some level of semantic representation, a variable that ultimately gets bound in some way by an element of the matrix [NP or DP].

This definition describes both the syntactic and semantic properties of RCs. Structurally, an RC is a subordinate clause embedded within a DP. Semantically, the matrix nominal head is associated with an element in the subordinate clause for interpretation. In languages such as English and Chinese, a relative clause is overtly marked with a relativizer, traditionally called a relative pronoun (*who/which/that* in English, and *de* in

quantificational scopes, and the issues related to Phase cannot be addressed here. These are, nevertheless, issues that the IMP aims at addressing and accounting for.

Mandarin Chinese). We use the term “head noun” to refer to the nominal head, which is also referred to as an antecedent.

2.2.1 Head Positions in Relative-Clause Constructions

An important issue in the typology of RC constructions is where the head noun is located in relation to the RC. In languages with head-initial relative clauses, like English, German and Dutch, the head noun precedes the RC as exemplified by (24). In languages with head-final relative clauses, such as Chinese, Japanese, and Korean, the head noun follows the RCs as in (25). In the processing literature, the head noun is often referred to as the *filler*, and the empty nominal within the RC as the *gap*. The issue of head position is crucial for processing because it results in different linear relations between the filler and the gap in a sentence. In head-initial languages, the filler precedes the gap, while in head-final languages, the gap precedes the filler.

(24) English: [the man]_{head N} [that John saw _ yesterday]_{RC}

(25) Japanese: [John-ga _ mita]_{RC} [dansei]_{head N}

John-NOM saw man

‘the guy that John saw’

In some languages (e.g. Austronesian, Korean, etc.), there are also internally-headed RCs

(see Aldridge (2004) and Chapter 5 of Hiraiwa (2005)). However, in these languages, RCs are usually not exclusively head-internal; they co-exist with head-initial and/or head-final RCs. An example from Seediq, an Austronesian language, showing a structure with an internal head is provided in (26).

(26) Seediq: [s-n-malu [sapah]_{head N} na tama]_{RC}

-Perf-build house Erg father

‘the house Father built’

In this dissertation, we restrict our scope to head-initial and head-final RCs.

2.2.2 Restrictive versus Non-Restrictive Relative Clauses

Typical RCs contain a nominal gap at an argument position. This nominal gap is connected both syntactically and semantically with the head noun. Based on the semantic relation between the RC and the head noun, RCs are traditionally divided into *restrictive* and *non-restrictive* (or *appositive*). A restrictive RC, as the name suggests, restricts the reference of the whole DP to a subset of the referents of the head noun. It denotes the intersection of the set denoted by the head noun and the set denoted by the RC. For example, *the girls that John greeted* denotes the intersection of all girls and all the people the John greeted (just as *red flowers* denotes the intersection of all flowers and all red objects).

Non-restrictive RCs, also called appositives, are any RCs that do not function to restrict the semantic denotation of the head noun. The distinction between restrictive and non-restrictive RCs ((27) and (28) respectively) is primarily semantic. Non-restrictive RCs provide additional information about the head noun without restricting the denoted referents, while restrictive RCs denote a subset of the referents of the head noun.

(27) The classes that John took last semester were extremely easy.

(28) The plumber, who Meg took an immediate dislike to, stopped by yesterday.

In English, these two types of RCs can be distinguished by the kinds of relativizers used (*who/which/that* for restrictive RCs, and *who/which/*that* for non-restrictive RCs) and based on overt syntactic differences as summarized by Carlson (1977: 520):

(29) a. Appositive RCs occur with a “comma intonation pattern,” while restrictive RCs do

not. (e.g. *Gregg Smith, who I saw for the first time yesterday, is an interesting guy.*)

b. Appositive RCs may co-occur with a proper-name head noun, while restrictive RCs may not.

c. Appositive RCs may not co-occur with certain quantifiers. (e.g. **Any lion, which eats small animals, is cowardly.*)

d. Appositive RCs cannot stack, while restrictive RCs can. (e.g. **The lion, which was*

five weeks old, which was fed twice a day, ate only fillet of salmon.)

e. Appositive RCs are more like conjoined sentences, while restrictive RCs are more like adjectives.

f. Appositive RCs may relativize certain NPs that may not be relativized in a restrictive RC. (e.g. *The men, of whom all were astronauts, left.* **The men of whom all were astronauts left.*)

Most of these generalizations derive from the observation that restrictive RCs compose with the head noun by intersection, with the RC-head-noun constituent denoting the intersection of the set denoted by the RCs and the set denoted by the head noun, and therefore the head nouns themselves must refer to a set of referents that can be further delimited. This keeps proper nouns from being the head nouns in restrictive RCs because a proper noun denotes only one definite referent.

In Mandarin Chinese, the distinction between restrictive and non-restrictive RCs is not overt, and is controversial among Chinese linguists. Chao (1968) suggests that the position of the determiner distinguishes restrictive from non-restrictive RCs in Chinese. When the determiner *nage* ‘that’ precedes the whole DP as in (30), he claims that the RC has an appositive reading. When *nage* immediately precedes the head NP as in (31), the

RC has a restrictive reading. This generalization was, however, disagreed with by Tang (1979) and Chu (1983).

(30) Appositive RC in Mandarin Chinese:

nage Meg bu xihuan de ren you lai le

that Meg not like DE person again come ASP

‘This person, who Meg did not care much for, came again.’

(31) Restrictive RC in Mandarin Chinese:

Meg bu xihuan de nage ren you lai le

Meg not like DE that person again come ASP

‘The person that Meg did not care much for came again.’

Determiners are optional in Mandarin. An RC that is not overtly marked by a determiner, as in (32), is interpreted as restrictive. The unmarked semantic status of a Mandarin RC is restrictive.¹⁰ In the research presented in this dissertation, we focus exclusively on restrictive RCs in Mandarin.

¹⁰ The issue about restrictive versus non-restrictive relative clauses in Mandarin is complicated by the indefiniteness of the bare noun phrase in Mandarin. In the following example, the relative clause is actually non-restrictive since it provides additional information about the proper head noun, without limiting the referent further:

zhao canting women chang dei tebie kaolyu chi su de Meg

find restaurant we often must special consider eat vegetables DE Meg

‘We often have to consider for Meg, who is a vegetarian, when looking for a restaurant.’

(32) Restrictive RC in Mandarin Chinese:

Meg bu xihuan de ren you lai le

Meg not like DE person again come ASP

‘The person who Meg did not care much for came again.’

2.2.3 Possessor Relative Clauses

In Possessor RCs, one nominal element in the embedded clause is semantically the possessee of the head noun. In English, possessor RCs are marked by a genitive relativizer, *whose*, as in (33).

(33) The customer *whose* daughter won the lottery was extremely happy.

In Mandarin, even though there is no special grammatical marker for possessor RCs, a possessive relation may be constructed between the head noun and a nominal in the RC.

Whether a nominal can be the possessee depends on the plausibility of a possessive relation between this nominal and the head noun, and presumably whether there is any other gap in the RC. In (34), for example, *nyuer* ‘daughter’ can be perceived as the possessee of the head noun *guke* ‘customer.’

(34) nage nyuer zhong caijuan de guke feichang gaoxing

that daughter win lottery DE customer very happy

‘The customer whose daughter won the lottery was very happy.’

This relatively flexible possessive connection allows a sentence like (35) to have multiple possessees (*daughter* and *wife* in this case).

(35) nage nyuer dashang laopo de guke hen shengqi

that daughter hurt wife DE customer very angry

‘The customer whose daughter hurt his wife was very angry.’

Even though these possessor RCs are not grammatically marked and the relation between the nominals and the head noun seems to be primarily semantic, the syntactic gap does exist within the embedded RCs. This is evidenced by the optional appearance of resumptive pronouns in the usual possessor positions as in (36). (35) can, therefore, be represented as (37) with possessor gaps indicated.

(36) nage ta_i nyuer dashang ta_i laopo de guke_i hen shengqi

that he daughter hurt he wife DE customer very angry

‘The customer whose daughter hurt his wife was very angry.’

(37) nage _i nyuer dashang _i laopo de guke_i hen shengqi

- (40) Time Adjunct: ta xiu che de nage wanshang
 he fix car DE that evening
 ‘the evening when he fixed his car’
- (41) Manner Adjunct: ta xiu che de fangfa
 he fix car DE way
 ‘the way he fixed his car’
- (42) Instrument Adjunct: ta xiu che de qianzi
 he fix car DE pliers
 ‘the pliers with which he fixed his car’
- (43) Reason Adjunct: ta xiu che de yuanyin
 he fix car DE reason
 ‘the reason why he fixed his car’

2.3 Representing and Deriving Relative Clauses

RCs have been attested in different languages; whether there is a universal structure for all RCs across languages is, however, controversial. Within generative grammar, different hypotheses have been proposed for the formal structure of RCs across languages. The wh-movement analysis is pursued by Chomsky (1977). The promotion analysis is

advocated by Kayne (1994) (along with Schachter (1973) and Vergnaud (1974)). Both analyses target a universal solution to all RCs in all languages.¹² Aoun and Li (2003) review the pros and cons of both analyses and propose an integrated solution. They conclude that there is no single derivational process or structure that can uniformly account for all RCs within and across languages. Instead, the “general morphological and syntactic properties of the individual languages and constructions” determine the variations across languages (p.191). In the following, we briefly describe the wh-movement analysis and the promotion analysis and introduce the RC structures proposed by Aoun and Li (2003) for Chinese and English. The purpose of this section is to provide a structural basis for RC parsing by IMP. For detailed arguments about the various structures, the readers are advised to consult Chapters 4 and 5 of Aoun and Li (2003).

2.3.1 Chomsky’s (1977) Wh-Movement Analysis

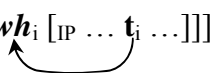
The wh-movement analysis of Chomsky (1977, 1995: 70) takes RCs to involve wh-movement like interrogatives. According to this analysis, a wh-phrase as an operator

¹² Fukui and Takano (2000) also propose a universal adjunction structure for RCs in different languages such as Japanese and English. They claim that a base-generated RC is left adjoined to an N; head-final RCs therefore represent the base-generated word order. RCs in head-initial languages, such as English, are derived by raising the N to a D. This proposal is reviewed and criticized by Aoun and Li (2003: 192-207) for being unable to account for a range of data in English, Lebanese Arabic, and Chinese.

is base-generated within IP, moved to Spec-CP, and matched with the head noun NP.

Crucially, the head NP is base-generated as the head of the matrix NP, not raised from the CP or IP. The CP is adjoined to the head NP. Therefore, the NP cannot be reconstructed within the IP. This derivation can be schematically represented as (44).

(44) [NP [_{Head} NP_i] [_{CP} *wh*_i [_{IP} ... *t*_i ...]]]



A crucial advantage of the wh-movement analysis for English and similar languages is that it captures the similarities between the wh-relative pronouns in RCs and wh-movement in regular interrogatives. However, the wh-movement analysis fails to account for certain important reconstruction effects, which the promotion analysis can.

2.3.2 Kayne's (1994) Promotion Analysis

Chomsky's (1977) *wh*-movement analysis adopts right adjunction of the CP to the NP, which is problematic for the theory of antisymmetry advanced by Kayne (1994).

According to the antisymmetry theory of syntax, the linear order of words is determined by asymmetrical *c*-command and a universal principle—the Linear Correspondence Axiom (LCA).

(45) X asymmetrically *c*-commands Y iff X *c*-commands Y and Y does not *c*-command X.

(Kayne, 1994: 4)

(46) Linear Correspondence Axiom (Kayne, 1994: 6)

$d(A)$ is a linear ordering of T [where d stands for the non-terminal-to-terminal dominance relation, A refers to the set of ordered pairs $\langle X_j, Y_j \rangle$ such that for each j , X_j asymmetrically c-commands Y_j , and T stands for the set of terminals.]

Kayne's theory hypothesizes that all languages follow a universal base structure that is right-branching. All the terminals dominated by X precede all the terminals dominated by Y if X asymmetrically c-commands Y . In this theory, all movements can only be left-adjoined. The promotion analysis of RCs, first proposed by Schachter (1973) and Vergnaud (1974), is therefore adopted by Kayne. A promotion-based analysis has the following schematic derivation:

(47) $[_{DP} D [_{CP} NP/DP_i [_C [_{IP} \dots t_i \dots]]]]$



The essence of this analysis is that the head NP is base-generated within the IP, and raised to Spec-CP. The relativizer (i.e. relative pronoun) heads the CP. Major evidence for this analysis includes relativization out of idioms, and reconstruction effects (Aoun & Li 2003: 97-99).

Idioms are usually treated as a lexical chunk that is numerated as one unit. The extraction of the object out of the VO idiom *make headway* in (48), therefore, suggests

that the head noun should be base-generated within the IP as an idiom chunk. In (49), the binding relation between the embedded subject and the head noun also suggests that the head noun should be base-generated below the embedded subject.

(48) The headway that Mel made was impressive.

(49) a. [The portrait of himself_i] that John_i painted t_i is extremely flattering.

b. John_i painted a flattering portrait of himself_i.

c. *Himself_i painted a flattering portrait of John_i.

2.3.3 Aoun and Li's (2003) Hybrid Solution

Aoun and Li (2003) review the merits and weaknesses of these above two analyses, and conclude that RCs within and across languages do not have uniform representations and derivations. Both analyses should be adopted (with revision) to account for different kinds of RCs in different languages.

Restrictive RCs in English can be divided into two different kinds—those with *wh*-phrases like *who* and *which*, and those with *that* as the relativizer. This distinction is based on Carlson's (1977) observation about "amount RCs" (such as (50)). Amount RCs do not allow the use of *wh*-relative pronouns and can co-occur only with certain determiners. These determiners (called Type-I determiners) share a common property:

they can all be followed by numeral expressions (as in *every ten minutes*). Type-I determiners include *the, these, every, any, all, what, -er, those*, and possessive determiners like *my*. Amount RCs do not occur with Type-II determiners, such as *many, several, some, a few, most, each*, which cannot be followed by numerals as in **several three books*.

(50) Amount Relative Clause:

- a. Marv put *everything that* he could in his pocket.
- b. *Marv put *everything which* he could in his pocket.

(51) Non-Amount Relative Clause:

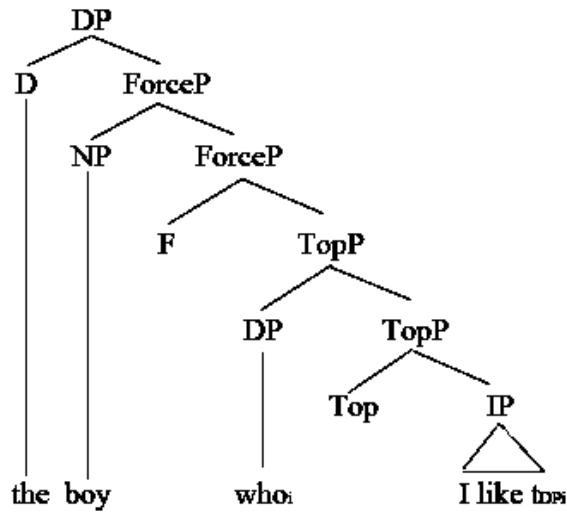
- a. Marv put *several things that* he likes in his pocket.
- b. Marv put *several things which* he likes in his pocket.

Aoun and Li extend Carlson's distinction by categorizing *wh*-pronouns with Type-II determiners, and the relativizer *that* with Type-I determiners. Hence, they adopt a *wh*-movement analysis for *wh*-RCs, and a promotion analysis for *that* RCs.¹³ These two RC structures in English are given in (52) and (53). The split-CP analysis of Rizzi (1997) is adopted. Both structures involve complementation, not adjunction.

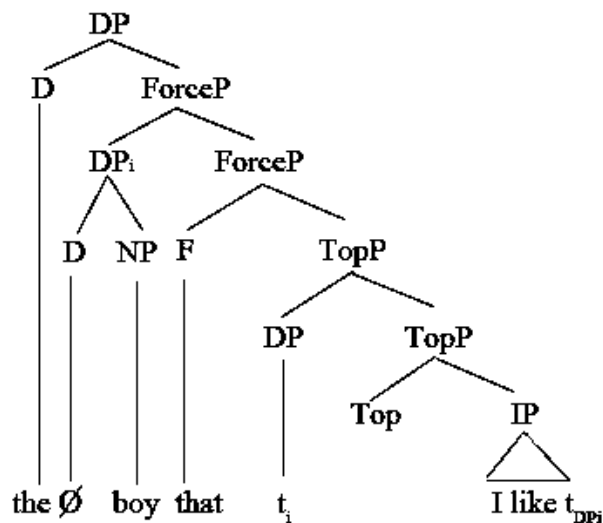
¹³ The prediction is that *wh*-relatives should not allow reconstruction of idiom chunks. The following grammaticality judgments are provided by Aoun and Li (2003: 110):

The headway that Mel made was impressive.
 ??The headway which Mel made was impressive.

(52) *wh*- Relative Clause (Aoun & Li, 2003: 122):



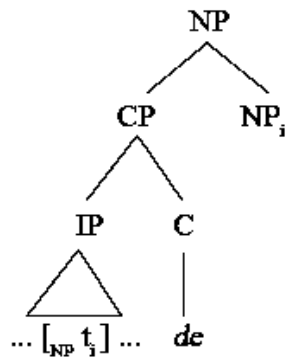
(53) Relative Clause with *that* (Aoun & Li, 2003: 122):



For Mandarin Chinese, Aoun and Li propose that RCs are CPs that are adjoined to the head nouns to make an NP. For standard RCs, the RC is adjoined to an NP that is moved out of the CP. Aoun and Li (2003: 159) propose the following adjunction structure

for Chinese RCs:

(54) Structure of a Chinese Relative Clause (Aoun & Li, 2003: 159):



An example is provided in (55).

(55) wo xiang zhao yi ge [t_i dongde zhaogu ziji_i] de laopo_i

I want find one CL know care self DE wife

‘I want to find a wife who can take care of herself.’

2.4 Parsing Relative Clauses in English and Chinese in IMP

In this section, we describe how IMP parses relative clauses in English and Chinese. I

adopt some of the insights of Aoun and Li’s (2003) analyses. For English RCs, we

distinguish between *wh*-phrases and *that*. *Wh*-phrases carry the [wh] feature to be checked

by a C-head. *That* is a complementizer and resides in the C-head position. RCs with

wh-phrases involve *wh*-movement and a matching relation between the head noun and the

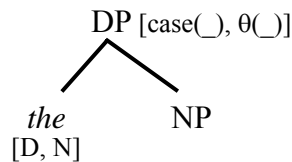
wh-phrase. RCs with *that* involve promotion of the head noun from the relative clause.

2.4.1 Parsing English Relative Clauses

Let us first consider the step-by-step parsing of the two types of English RCs described by Aoun and Li (2003). We take *the boy who I like* and *the boy that I like* as examples.

When the parser receives *the* as the first input, it constructs a DP placing *the* as the D head as in (56).

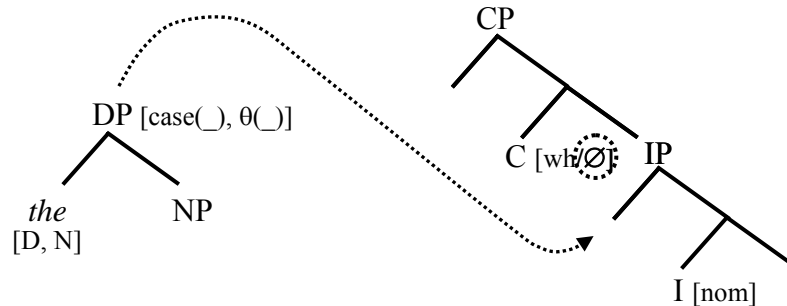
(56) *the boy*



Starting from the top, the functional heads of the top-down syntactic template probe at each incoming XP for feature checking. Since the C head can be either [+wh] or empty, and is taken as empty in this case, I probes at the DP to check the case feature, [nom].

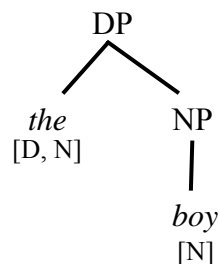
This DP is therefore attached to the spec position of the IP (as in 57), since it is the topmost available position for a non-wh DP.

(57) the boy



The second lexical item *boy* is then merged with *the* making the DP a complete syntactic object like (58). It remains an open question whether the DP gets attached to the functional template as soon as it is constructed or only when it is argument complete.

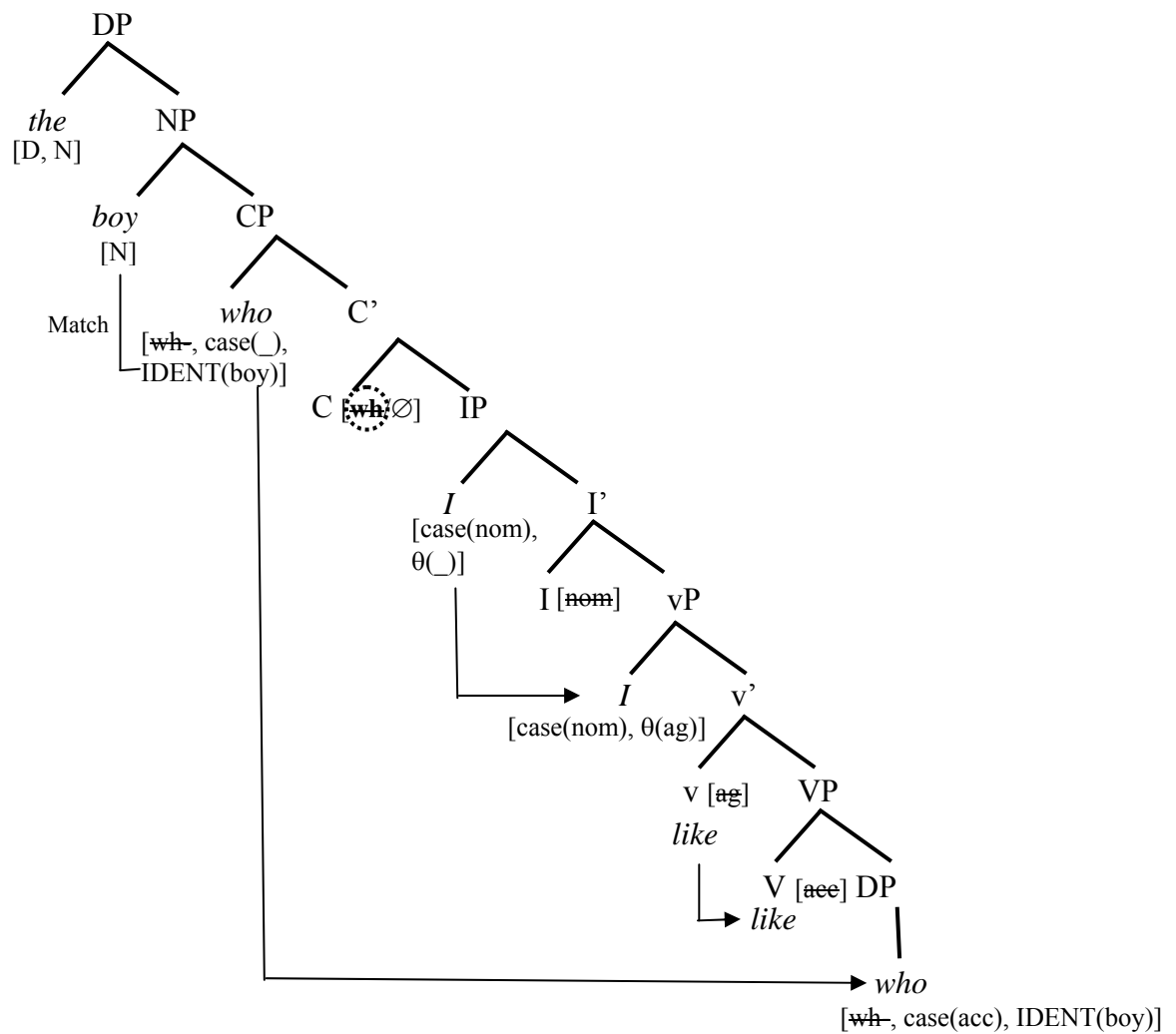
(58) the boy



When the parser receives *who* as the third incoming word, it recognizes *who* as a *wh*-operator, which should be located at Spec-CP to have the [wh] feature checked. The parser revises locally within the DP just constructed, reanalyzing the NP inside into an NP that contains a relative clause (i.e. an embedded CP). A series of top-down functional projections is again constructed within this embedded CP as shown in (59). *Who* is

because that is the topmost position where its case feature can be checked while revising the previous structure the least.¹⁴ *I* checks the nominative case of *I*, then the agent feature at Spec-vP. *Like* enters v, and gets copied to V. At this point, *who*, with an unvalued case feature is copied to the DP position internal to the VP to value the accusative case.

(60) the boy *who* I like

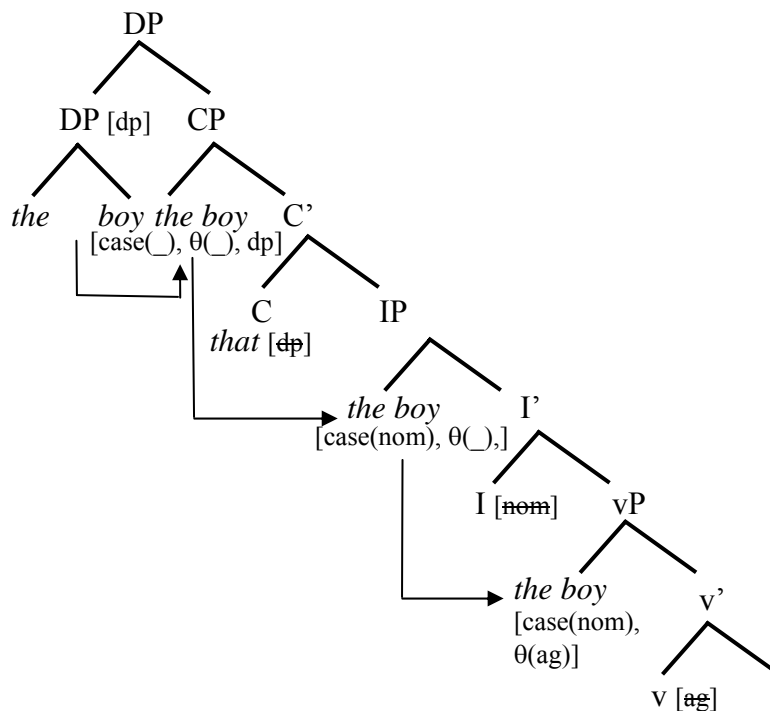


For RCs with *that*, the parser takes *that* as a C-head and creates a CP with the

¹⁴ This is the minimal revision principle: revise the structure minimally when reanalysis is required.

CP-IP-vP-VP projections. *That* is a complementizer that takes a DP in the specifier position. The parser therefore makes a copy of the DP (*the boy*) just constructed at the Spec-CP position to check the [dp] feature of *that*. In order to check the nominative case of *I* and [agent] of *v*, *the boy* also gets copied to spec-IP and spec-vP. Relative clauses with subject extractions, therefore, also receive advantage in parsing. This is illustrated by (61).

(61) *the boy that I like*

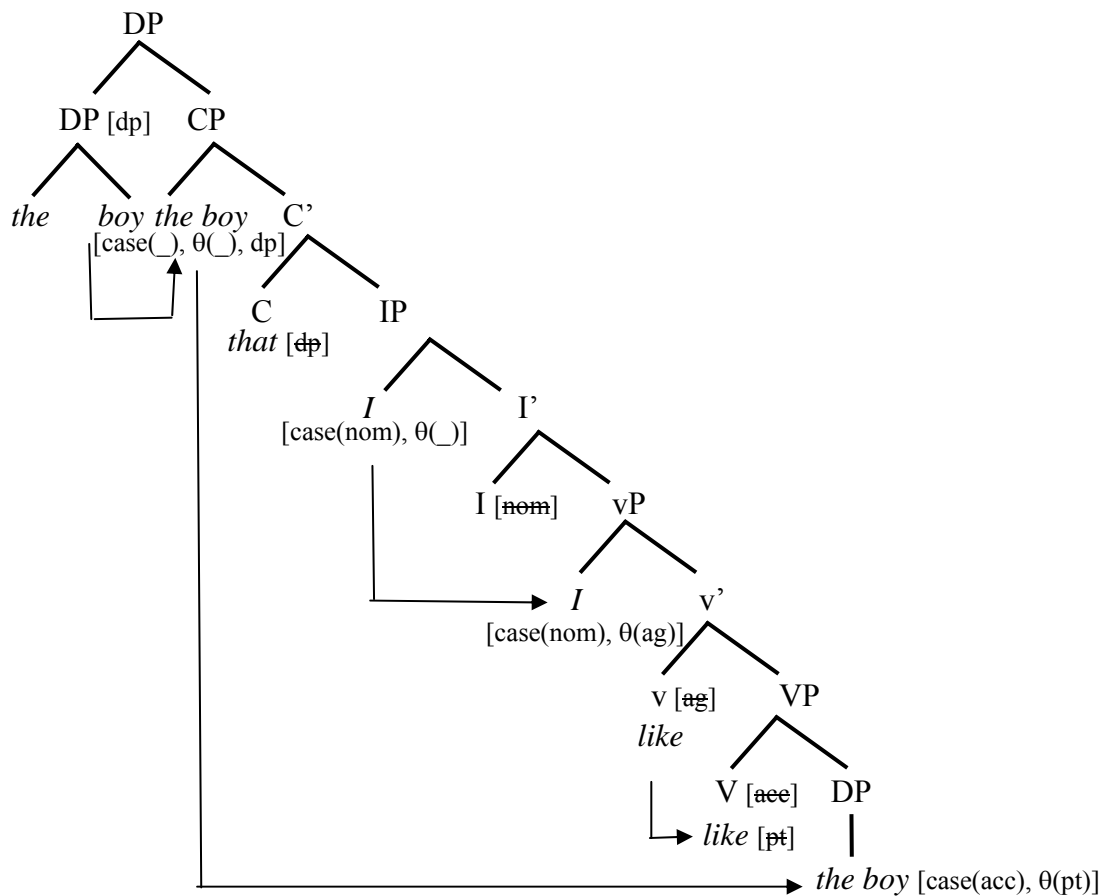


However, the fourth input *I* occupies Spec-IP and Spec-vP, forcing the parser to revise the first parse. The last input *like* takes the positions of *v* and *V*. *The boy* gets copied to the

VP-internal DP position to receive the accusative case. This is illustrated by (62).

In both parses, the simplest LF interpretation for *who* in (59) and *the boy* in (61) is an agent/nominative interpretation at the point of the relativizer. The experimental data that we review in Chapter 3 confirms this prediction.

(62) the boy *that* I like

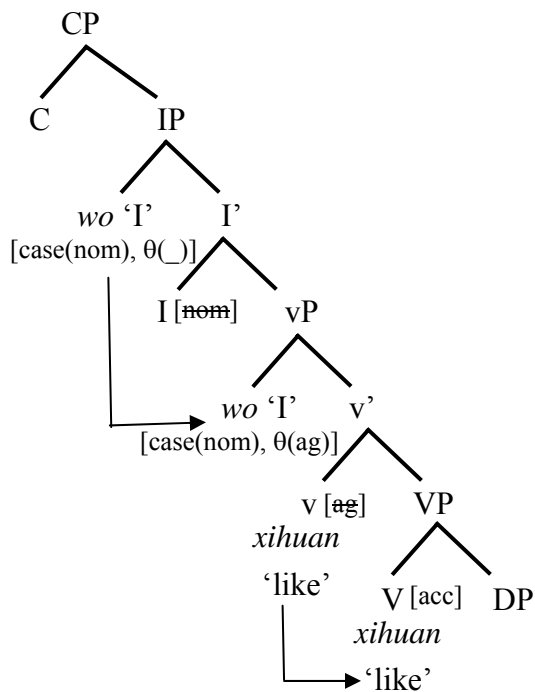


2.4.2 Parsing Chinese Relative Clauses

Turning to Chinese RCs, let us take the noun phrase *wo xihuan de nanhai* 'the boy who I

like’ as an example to demonstrate the IMP parsing. At *wo* ‘I’, the parser determines that it is a DP, attaching it to spec-IP. *Wo* ‘I’ is copied to spec-vP from spec-IP to value its theta feature as [agent]. When *xihuan* ‘like’ appears, it is taken to be located at v-head with a copy at the V head. At this point, the parser expects a DP to be merged with the V so that the accusative case of the verb can be checked. The structure thus far is illustrated by (63).

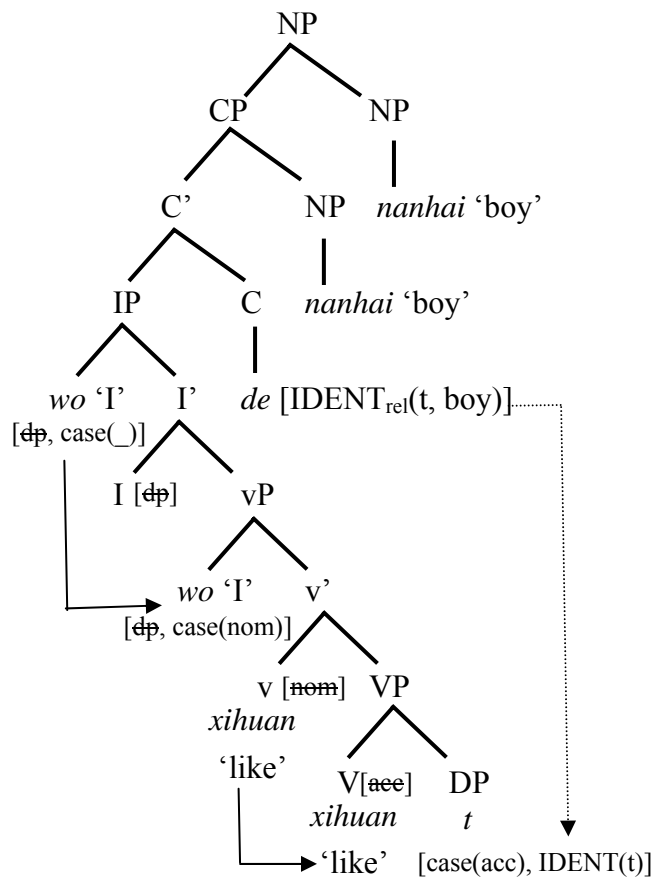
(63) *wo xihuan de nanhai* – I like DE boy – ‘the boy who I like’



However, the parser receives *de*, which is a C-head within a head-final CP. A trace is created at the embedded DP position (complement of V), so that the accusative case of V

can be checked. The relativizer *de* carries the feature [IDENT (X, Y)], a two-place function that relates a trace DP (X) to a head noun NP (Y). It probes at the DP trace in the IP, valuing one argument. Then the head noun *nanhai* ‘boy’ enters Spec-CP to value the [IDENT] feature of *de*. The CP adjoins with a copy of the head NP into another NP.

(64) *wo xihuan de nanhai* – I like DE boy – ‘the boy who I like’



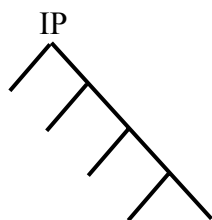
An advantage of this incremental analysis is that the derivation of structures is strictly from left to right in incremental steps. As demonstrated in the previous derivations,

all structures are right-branching. In the case of Chinese RCs just depicted, the derivation involves the construction of three levels of syntactic objects—the IP, the CP, and the NP.

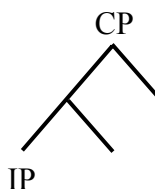
Within each stage, the parser constructs structures by strictly branching to the right. (65)

schematically illustrates this derivation.

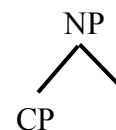
(65) I. IP



II. CP



III. NP



2.4.3 Comparison between IMP and Other Incremental Parsers

2.4.3.1 Phillips (1996)

Phillips (1996) proposes a grammatical theory that builds syntactic structures incrementally from left to right. Such a grammar is parsing-based. He argues that grammar is in fact identical to the parser. This parsing-based incremental grammar provides solution to some existent constituency discrepancies. Strings of words that are once constituents in the course of derivation can be taken as constituents until another element is added which destroys that constituency. Take the examples in (66) (Phillips, 2003: 47-49); the sentence *Wallace will give Gromit crackers before breakfast* produces

various constituents during the course of derivation. These constituents can be coordinated with constituents of similar structures.

- (66)a. Wallace and Wendolene will give Gromit crackers before breakfast.
- b. Wallace will and Wendolene probably won't give Gromit crackers before breakfast.
- c. Wallace will give and Wendolene will send Gromit crackers before breakfast.
- d. Wallace will give Gromit and Wendolene will give Peston crackers before breakfast.
- e. Wallace will give Gromit crackers and Wendolene will give Peston dog food before breakfast.
- f. Wallace will give Gromit crackers before and Peston dog food after breakfast.

Phillips shows that an incremental parser is able to account for these constituents that are otherwise hard to explain in the standard bottom-up syntactic theory.

IMP adopts the central claim of Phillips' theory that syntactic structures are built incrementally from left to right. As a real-time sentence processor, IMP focuses more on the actual syntactic mechanisms used on-line, and how certain preferences (see Chapters 3 & 4) and misanalyses (see Chapter 5) in processing can be borne out based on some

structure-building generalizations.

2.4.3.2 Fong (2005)

Fong (2005) develops an incremental left-to-right parser based on the probe-goal feature-checking approach of the Minimalist Program. In his parser, lexical items carry features that need to be valued or checked. Fong's parser adopts elementary tree composition in Tree Adjoining Grammar (Joshi & Schabes, 1997) for the structure of functional phrases. Syntactic trees are created based on selectional relations encoded in the lexicon. For example, a C selects for a T and a T selects for *v, etc. In addition, Fong's parser uses "a 'move box'" to temporarily store the moved element(s) and "a 'probe box'" to enforce the Agree relations.

IMP inherits many of its properties from Fong's (2005) parser, such as the selectional relations and features encoded within the lexicon, which drive structure building and movement, and the probe-goal basis for parsing. There are, however, at least two differences between Fong's parsing theory and IMP.

First, IMP does not use a Move Box to deal with movements. Movements are driven by unvalued or unchecked features. As soon as a lexical item is encountered, and as soon as adequate structures are constructed, this lexical item gets copied to lower positions to

check/value its features. This kind of movement operates in a look-ahead fashion, which is avoided by Fong. Therefore, in IMP, it is possible to have an item already copied multiple times to lower positions before an upcoming item comes up to fill the intermediate positions. In Fong's parser, however, an item is placed in the Move Box and then copied to a position when that position is reached.

Second, IMP does not adopt elementary trees in constructing structure. The parser starts every sentence with a CP as the top node, assuming that all parsable utterances are propositions. Each phrasal level contains selectional information about the internal positions (such as the specifier, the head, and the complement). This constructs a top-down syntactic template based on functional projections, to which individual lexical items can attach to check features.

In short, the goal of IMP is to be a parser that reflects the procedures by which real language users build syntactic structures on-line. IMP should be able to provide the structural basis for certain processing preferences, as well as the derivational basis for misanalysis and reanalysis that take place during human sentence processing. The experimental results discussed in the following chapters are intended to investigate whether this goal has been approximated.

CHAPTER 3

ASYMMETRICAL PROCESSING OF SUBJECT AND OBJECT RELATIVE CLAUSES

In this chapter, we focus on the issue of asymmetrical preferences in processing relative clauses involving subject and object extractions. Various theories of sentence comprehension and their predictions on RC processing are first discussed. The related typological and processing issues and experimental data from different languages are then reviewed. In section 3.4, new findings from an experiment on Mandarin RCs (Experiment 1) are presented. The results support a universal structural account of the asymmetrical preference in processing subject and object relative clauses.

3.1 Asymmetry in Processing Subject and Object Relative Clauses

In the sentence processing literature, it has been reported in various languages that the difficulty in processing relative clauses (RCs) that involve subject extractions is different from that of processing object extractions (see review in 3.3 for details). Relative clauses with subject extractions, as in (1), are also called subject relative clauses (SRCs). They are RCs where the gap in the relative-clause region is in subject position. Object-extracted

RCs (ORCs), on the other hand, are RCs, where the gap is located at the object position, as in (2).

(1) The guy who ___{SUBJ} invited me caught a trout. (SRC)

(2) The guy who I invited ___{OBJ} caught a trout. (ORC)

In the processing literature, the head noun is also regarded as the filler; the trace in the RC, the gap. The filler and the gap in a sentence form dependent relations. A complete comprehension of sentences with fillers and gaps should, thus, involve accurate syntactic and semantic representations of such associations. Different theories of sentence comprehension, as will be reviewed in 3.2, focus on different aspects of the linguistic structure and the human parser in constructing filler-gap dependencies on-line.

Research has consistently found an advantage for processing SRCs. Evidence has been drawn from English (self-paced moving-window reading tasks: King & Just, 1991, Gibson, Desmet, Grodner, Watson, & Ko, 2005; eye-movement monitoring tasks: Traxler, Morris, & Seely, 2002), German (self-paced reading tasks: Schriefers, Friederici, & Kühn 1995; ERP: Mecklinger, Schriefers, Steinhauer, & Friederici, 1995), Dutch (self-paced reading tasks: Frazier, 1987b, Van Gompel 1995), etc. However, an advantage for ORC was reported by Hsiao and Gibson (2003) for Mandarin Chinese. In the following

sections, we first review how different theories account for this asymmetrical preference in processing in 3.2. In 3.3, we review experimental data from languages with head-initial RCs and languages with head-final RCs. These results will be discussed in relation to their compatibility with the sentence comprehension theories. Section 3.4 presents an experiment on Chinese RCs, providing new data to evaluate the existent generalizations. A universal account for processing RCs in different languages is provided in 3.5.

3.2 How Theories of Sentence Comprehension Account for the Asymmetry

In this section, we review theories of sentence comprehension and discuss their predictions regarding processing RCs in English and Chinese.

3.2.1 Structure-Based Theories

In a structure-based theory, the parser assumes the existence of syntactic structure when processing filler-gap dependencies. Syntactic structure is constructed either prior to or at an early stage of processing. In processing filler-gap dependencies, the challenge for the parser is to recognize the positions of the fillers and the gaps in the syntactic structure and to make correct associations between them.

3.2.1.1 Frazier's (1987a) Garden-Path Theory

Based on the assumptions that processing resources are limited and that syntactic

categories are the only information used in parsing, Frazier's (1987a) Garden-Path Theory (GPT) allows the parser to only construct *one* structure for an ambiguous sentence being parsed. When this structure is proven wrong, the parser has to revise the parse. The time it takes to do this revision is known as the garden-path effect. Three parsing principles have been discussed in predicting what kind of parses are preferred—Minimal Attachment, Late Closure, and Minimal Chain Principle (Frazier & Clifton, 1996: 9):

- (3) Minimal Attachment: Do not postulate any potentially unnecessary nodes.
- (4) Late Closure: If grammatically permissible, attach new items into the clause or phrase currently being processed (i.e., the clause or phrase postulated most recently)
- (5) Minimal Chain Principle: Postulate required chain members at the earliest point grammatically possible, but postulate no potentially unnecessary chain members (De Vincenzi, 1991).

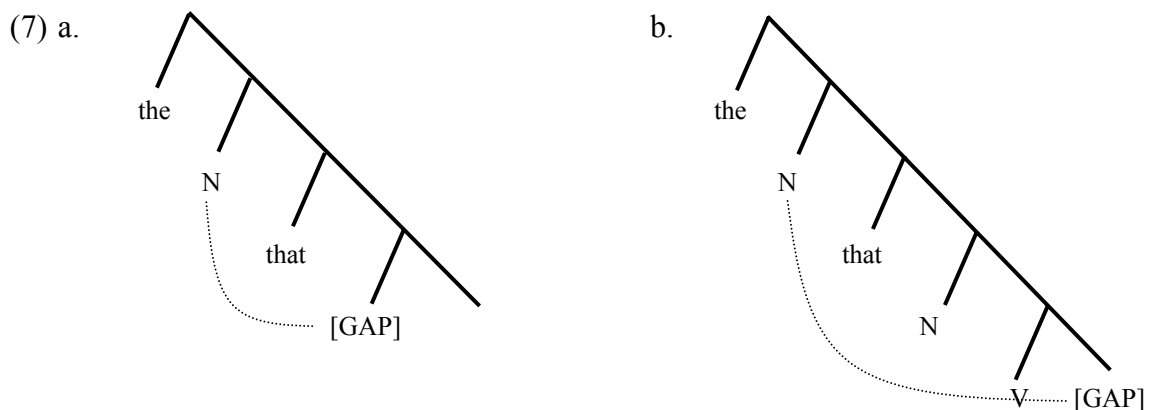
These three principles can be seen as surface phenomena that result from a more general principle: the parser builds syntactic structures *locally*. New structures are attached locally to the ones being operated upon, and reanalysis should involve as little revision as possible.

The Minimal Chain Principle is of particular relevance to the construction of

filler-gap dependencies because a generalization called Active Filler Strategy is proposed based on it (Frazier, 1978, 1987a; De Vincenzi, 1991):

(6) 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. (Frazier & d'Arcais, 1989)

According to the Active Filler Strategy, as soon as a filler (i.e. the head noun) is recognized, the parser creates a minimal chain between the filler and a potential position for the gap. In languages like English, the potential gap that minimizes the filler-gap distance (thus creating a minimal chain) in relative clauses is at the subject position. Therefore, the parser prefers subject RCs, as illustrated in (7a) to object RCs in (7b).



The Active Filler Strategy predicts an immediate increase of reading times at the post relativizer region of an ORC, where a gap is expected for a short filler-gap dependency.

The Active Filler Strategy, however, does not make specific predictions about head-final RCs, where the RCs precede the head nouns. In these languages, the gap precedes the filler in linear relation. To facilitate a comparable discussion, we postulate a corresponding hypothesis called the Active Gap Strategy, as defined in (8).

(8) Active Gap Strategy: Fill an identified gap as soon as possible; i.e., take the closest lexical noun phrase as a filler within the domain of an identified gap.

According to the Active Gap Strategy, when a gap is detected in the RC, the parser tries to fill it as soon as possible. The longer this gap lingers in the working memory, the harder the sentence gets. This predicts that when processing Chinese RCs (schematically represented in (9)), an ORC should be easier, since the linear distance between the gap and the filler is shorter in ORCs than in SRCs.

(9) a. SRC in Mandarin: $[\underbrace{[GAP] V N}] \text{ de } N_{\text{head}}$
 b. ORC in Mandarin: $[N V \underbrace{[GAP]}] \text{ de } N_{\text{head}}$

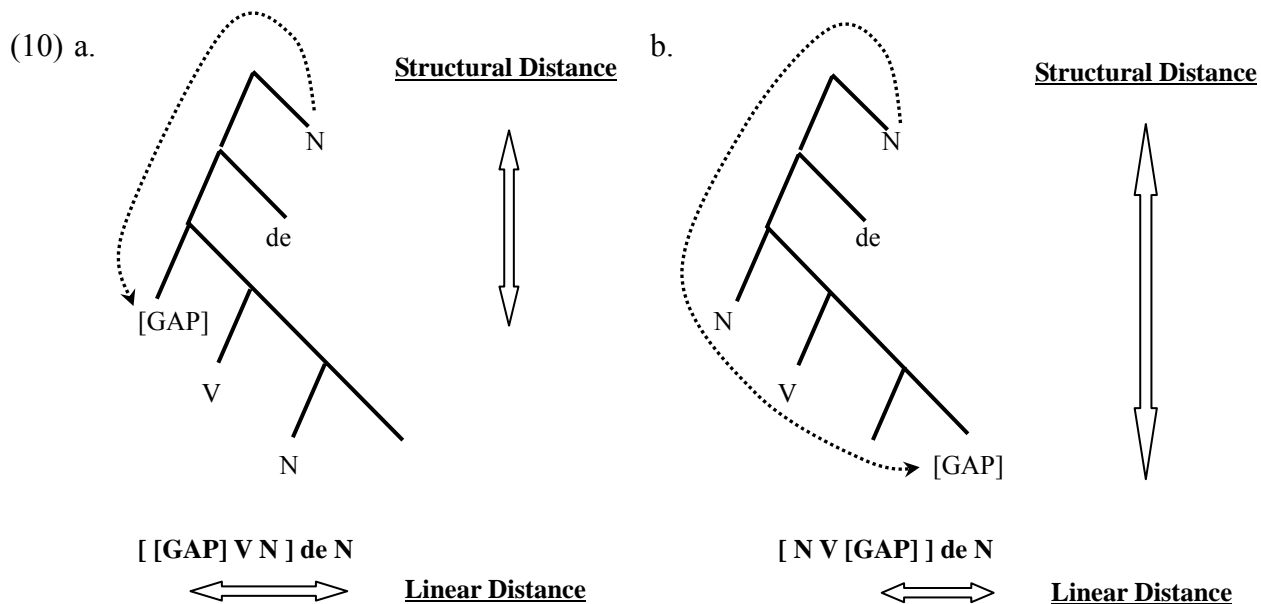
However, the gap-filler relation is actually not as straightforward as a filler-gap relation.

The Active Filler Strategy assumes that a filler can be identified easily; then the gap-filling process can be initiated. When the gap precedes the filler as depicted in the

Active Gap Strategy, however, a gap is usually not identified with equivalent ease.¹⁵ This is especially true when the gap is not overtly marked, or not filled by a resumptive pronoun. In languages with head-final RCs, the parser usually does not recognize the inputs as part of an RC until the relativizer or the head noun is reached. A gap may first be taken as an unpronounced argument (e.g. a pro), not necessarily as a variable bound by a relativized head noun. It is, therefore, not obvious whether the gap in head-final RCs is already detected and waits to be filled prior to the appearance of the head noun.

If an RC is not identified until the parser reaches the relativizer, then the Active Gap Strategy cannot be correct. Instead, we can hypothesize that an active filler will still search for a gap. If the filler searches structurally from top down, then the subject gap will be found first, thus generating a preference for SRCs. If the filler probes linearly backwards, then an object gap should be reached first; thus an ORC receives an advantage in processing. This is illustrated by (10).

¹⁵ Hawkins (2003: 145-146) makes a typological generalization that in languages that have the fillers prior to the gaps, processing is maximized, in comparison with languages where the gaps precede the fillers. He suggests that when fillers come first, they can be fully processed. When gaps appear first, however, their properties “can only be assigned retrospectively when the filler is encountered resulting in a processing delay (p.145).”



Furthermore, even if a gap is detected prior to the filler's appearance, the parser may not need to fill that gap with every upcoming noun it encounters. Instead, the parser only needs to wait for certain grammatical cues (e.g. a relativizer) that identify an upcoming NP as a filler. Then the parser can construct the dependency between the gap and the head NP. If the parser makes associations through a structural pathway, it should construct a dependency between a subject gap and the head noun with less difficulty than that between an object gap and the head noun. However, if the parser associates the filler and the gap across linear positions (disregarding structure), then an object gap should be easier in Mandarin Chinese.

In summary, head-final RCs allow us to address two issues about the Active Filler

Strategy that cannot be teased apart if we only look at languages with head-initial RCs:

- (11) a. Are filler-gap and gap-filler relationships similar in nature? (That is, does the relative order between the filler and the gap affect the strategies adopted by the parser?) Does the gap search for a filler in the same way as the filler searches for a gap?
- b. Does linear distance or structural distance matter for the construction of filler-gap relations?

By looking at how head-final RCs are processed (in 3.3.2 & 3.4), we will be able to address these issues and better understand the Active Filler Strategy.

3.2.1.2 Pritchett's (1992) Grammatical Theory of Processing

Pritchett (1992) proposes a theory of human language processing that is “grammar-driven (68).” This theory adopts the Government and Binding framework, and proposes the following principles for sentence processing (Pritchett, 1992: 68-69):

- (12) Theta Attachment: The theta criterion attempts to be satisfied at every point during processing given the maximal theta grid.
- (13) Theta Reanalysis Constraint (TRC) [Version 1]: Syntactic reanalysis which reinterprets a theta-marked constituent as outside of its current theta domain is costly.

(14) Theta Domain: α is in the γ theta domain of β iff α receives the γ theta role from β or α is dominated by a constituent that receives the γ theta role from β .

A generalization based on these principles is that the parser attempts to assign a theta role to a DP as soon it can. This is why in a sentence like *After Todd drank, the water proved to be poisoned* leads to a garden path; the preferred analysis is to analyze *the water* as the patient of *drank* rather than the theme of a separate theta domain.

In processing SRCs and ORCs, the parser uses the same strategy, trying to fill an argument position and assign theta roles as soon as possible. Pritchett's theory does not make specific predictions about RC processing. However, if we assume that the head noun in an RC should receive a theta role from the embedded verb as soon as possible, then an SRC in English receives an advantage because when an embedded verb is reached as in (15), the parser is already able to assign a theta role to the head noun. On the other hand, the head noun of an ORC has to wait until the first theta role of the verb is assigned to the embedded subject to receive its theta role.

(15) The guy who _{SUBJ} **invited** me caught a trout.




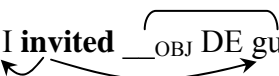
(16) The guy who I **invited** _{OBJ} caught a trout.



For Chinese RCs, however, the difference between processing an SRC and an ORC is

not obvious. For SRCs, the parser has to wait until after the theta role of the embedded object is assigned in order to associate the theta role of the later filler with the head noun. For ORCs, the parser first assigns a theta role to the embedded subject, and then assigns the theta role to the object gap and the head noun. SRC may be predicted to be relatively more difficult to comprehend because the distance between the head noun and gap position where a theta role is assigned is longer in SRCs than ORCs. However, this prediction is not made explicit in Pritchett's theory.

(17)  **invited** me DE guy caught a trout.

(18)  **invited** DE guy caught a trout.

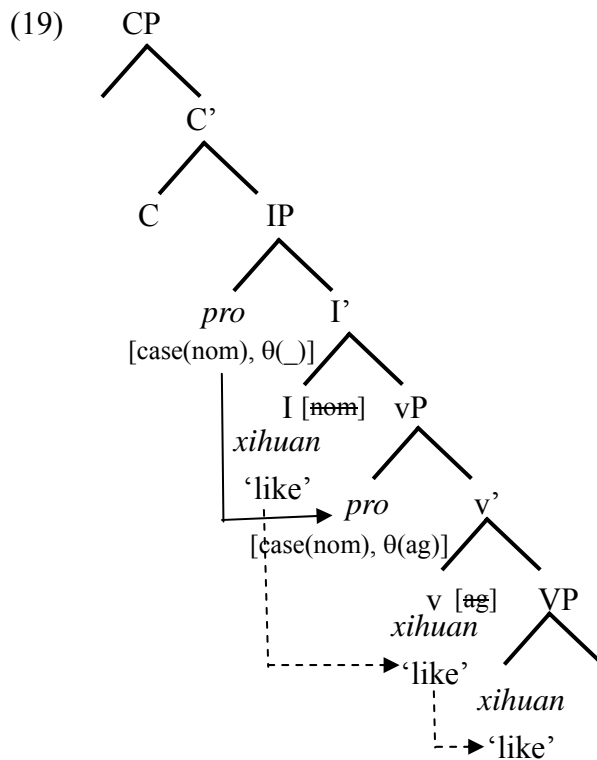
3.2.1.3 Incremental Minimalist Parser

The Incremental Minimalist Parser (IMP) proposed in Chapter 2 builds syntactic structure incrementally from left to right, with operators searching to bind their variables downstairs in a syntactic tree. As discussed in section 2.4, when parsing English RCs, IMP constructs a chain between the relativizer and the subject position within the RC as soon as the relativizer is reached (based on the Minimal Link Condition). A subject gap is, therefore, preferred to an object gap because the closest base-generated position for the *wh*-operator is a subject gap, not an object gap. For the same reason, in processing RCs

with *that*, the IMP also prefers a subject gap to an object gap. The only difference is that for RCs with *that*, the head noun is directly copied to the base-generated position.

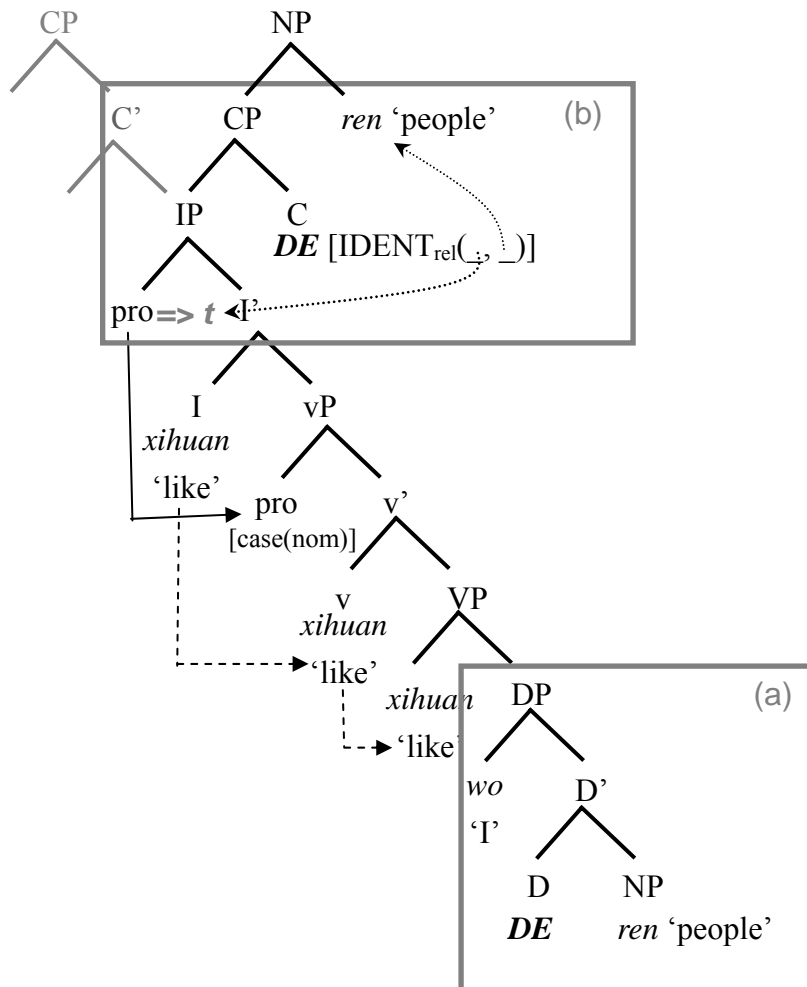
For the processing of head-final RCs in Mandarin, IMP also predicts that a subject gap should be preferred. When parsing an SRC (e.g. *xihuan wo de ren* – like me DE people – ‘the people who like me’) in Mandarin, the first input is a verb. The parser fills Spec-IP with a *pro* as in (19), maintaining a main-clause analysis since subjects in Mandarin can be dropped when the context is adequately rich.¹⁶

¹⁶ Harley (p.c.) pointed out that this may predict that the parser would be searching for an antecedent for the postulated *pro* during the rest of the parse until the DE is reached. If a plausible antecedent exists in the preceding discourse, this predicts the garden-path effect will be stronger since the parser will be more confident in the existence of the postulated *pro*. If no plausible antecedent exists, the parser will be more ready to revise when it reaches DE.



The main-clause analysis continues till the object *wo* 'me' appears. The sentence becomes ambiguous at the relativizer *de* because *de* can be attached low as a genitive marker heading a DP (20a), thus retaining a main-clause parse, or it can be a relativizer—a C head taking the IP as a complement as in (20b).

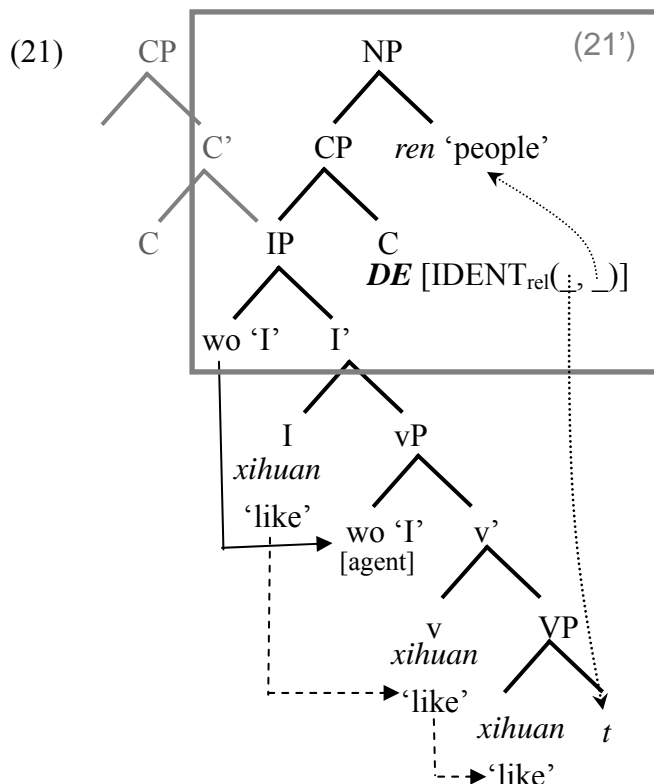
(20)



Taking DE as a C head involves destroying the mis-postulated CP and reanalyzing pro as a trace of the head noun. The relativizer *de* also carries with it a two-place feature ([IDENT(X, Y)]) that must be valued by matching with an embedded trace and the upcoming head noun. The head noun *ren* 'people' is adjoined to the CP, and identifies with the embedded trace by checking the [IDENT] feature of the relativizer. In the

genitive DP analysis (i.e. (20a)), the head noun would be misanalyzed as an NP that attaches low as the complement of the genitive *de*. This parse, even if pursued, will eventually be abandoned at the appearance of the matrix verb, which enforces an embedded-clause analysis rather than a main-clause analysis of the previous materials.

For ORCs, however, there is not as much ambiguity. The embedded clause may be taken as main clauses initially (for the regions *wo xihuan* – I like – ‘I like’). However, no long-term confusion between a *pro* and a trace exists at the object gap because the relativizer *de* appears after the embedded verb, making trace the only possibility. In ORCs, *de* can only be taken as a relativizer—a CP-head as in (21’).



A trace is postulated at the embedded object position. The [IDENT] feature of the relativizer *de* contains two arguments to be valued. The head noun values one of the argument; the parser has to search down the syntactic tree to the object position to check the trace argument of the [IDENT] feature. In comparison with SRCs, the dependency between the head noun and the trace is harder to establish in ORCs because the structural distance between the relativizer and the object gap is longer than that between the relativizer and the subject gap.

SRCs and ORCs in Mandarin thus face different kinds of processing challenges. SRCs are potentially ambiguous at the relativizer region. If a low-attachment strategy is (wrongly) adopted on *de*, then reanalysis has to take place when the matrix verb is reached. If *de* is attached high, then as in an ORC, it is analyzed as the head of a CP that should be adjoined to an NP. It should then be easier for the relativizer (and the head noun) to probe at the subject trace, which is higher in the structure than a trace located at the object position. In summary, the wrongly postulated *pro* may make SRCs more difficult than ORCs at the RC region. The ambiguity associated with SRCs may also make them harder to process at the post RC region. However, the filler-gap/probe-goal relationship should make ORCs harder to process than SRCs. This effect should be most obvious at

the relativizer and head-noun regions.

An additional note about the IMP account is that it provides a structural/grammatical basis for the somewhat ad hoc typological generalization of Keenan and Comrie (1977, 1979), usually referred to as the Keenan-Comrie Accessibility Hierarchy:

(22) Accessibility Hierarchy: Subject > Object > Indirect Object / Oblique Case >

Genitive (revised version, cited from Hawkins, 2004: 177)

Their original proposal was that across languages, NPs of different syntactic functions show a universal pattern regarding how easily it can be relativized/extracted. NPs at the subject positions are generally easier to extract in all languages. NPs that are lower in the hierarchy are harder to relativize. Like other structure-based theories such as O'Grady (1997) and Hawkins (2004), IMP provides such universal tendencies with structural substance. The accessibility hierarchy actually reflects the syntactic positions of the NPs. Those that are higher in the hierarchy are also higher in the syntactic structure and are therefore easier to get at than those at lower syntactic positions.¹⁷

¹⁷ Hawkins (1999, 2004) offers a structural account for the Keenan-Comrie Hierarchy by measuring the "Filler-Gap Domain" involved in processing. A Filler-Gap Domain is defined as "the smallest set of terminal and nonterminal nodes dominated by the mother of a filler and on a connected path that must be accessed for gap identification and processing (Hawkins, 1999: 248)." However, the structure that he assumes for the different syntactic positions is different from that of IMP, and the counting of nodes in the structure is also different from the feature theory, on which IMP is based.

3.2.1.4 Gibson's (1998) Syntactic Prediction Locality Theory

Gibson (1998) proposes the Syntactic Prediction Locality Theory (SPLT), which takes into consideration both sentence processing mechanisms and computational resources that are required for processing. SPLT assumes the existence of syntactic structures in sentence processing. However, it focuses more on the computational resources needed to construct and maintain these syntactic structures than the nature of the structure itself.

The two major components of computational resources are the structure integration cost and the structure storage cost, defined in (23).

- (23) a. An integration cost component dictates what quantity of computational resources needed to be spent on integrating new words into the structures built so far.
- b. A memory cost component dictates what quantity of computational resources [is] required to store a partial input sentence. (Gibson, 1998: 8)

Gibson's SPLT can be taken as a memory/resource-based theory. The human processor is assumed to possess limited computational resources at each temporal point of processing.

When a sentence is more complex in structure and/or when it involves dependencies that are less local (e.g. involving units that should be kept in the working memory longer before it can be integrated), this sentence requires more computational resources and is

thus more costly to process. Locality is a central theme in SPLT. The constructed syntactic units that are “held in memory over longer distances are more expensive, ..., and longer-distance head-dependent integrations are more expensive (Gibson, 1998: 8).” It should be noted that SPLT places special emphasis on the role of discourse referents in calculating integration costs. A new discourse referent (such as pronouns, tenses, etc.) is believed to increment the integration cost substantially.

SPLT takes the subject/object asymmetry in RC processing as one important piece of evidence for the distance-based integration cost. The theory predicts that ORCs in English should be more difficult at the point of the embedded verb because it has to integrate two new discourse referents (i.e. the embedded verb itself—as an event referent which assigns a theta role to the embedded subject, and the embedded empty category—the object). The embedded verb of an SRC only has to integrate one new discourse referent (i.e. the verb itself as an event referent), thus making SRCs less difficult.

Take the SRC in (24) and the ORC in (25) as examples to illustrate the predictions of SPLT for Chinese RCs.

(24) Yaoqin wo de pengyou zhuadao yi zhi zunyu

invite I DE friend catch one CL trout

‘The friend that invited me caught a trout.’

(25) Wo yaoqin de pengyou zhuadao yi zhi zunyu

I invite DE friend catch one CL trout

‘The friend that I invited caught a trout.’

For SRCs, the first word as a verb introduces an event referent, assigning the agent theta role to the gap prior to it. The second word *wo* introduces another new referent. Therefore, the embedded RC of an SRC contains two discourse referents and a gap that is unresolved.

As for ORCs, the verb is taken as the first new referent. Within the RC section, an ORC is easier because it encounters only one new referent. In addition, the gap is closer to the head noun for ORCs than SRCs in terms of linear distance. Based on the locality theory of integration cost, therefore, an ORC in Chinese should be easier than an SRC.

3.2.2 Word-Order and Template-Based Theories

A different line of theories takes a top-down approach to sentence processing. Bever (1970) argues that linguistic structure and behavior are “the joint product of both linguistic and psychological structures (282).” By proposing perceptual strategies

underlying language behavior, such as (26) and (27), Bever makes predictions on interpretations that are preferred and dispreferred in sentence comprehension.

(26) The first N ... V ... (N) ... clause is the main clause, unless the verb is marked as subordinate. (Strategy B, cited from Bever, 1970: 294)

(27) Any *Noun-Verb-Noun* (NVN) sequence within a potential internal unit in the surface structure corresponds to “*actor-action-object*.” (Strategy D, cited from Bever, 1970: 298, italics original)

These two strategies are top-down mechanisms that underlie the syntactic and semantic expectations during sentence processing. The human processor adopts a simple template-based strategy to assign syntactic and semantic roles. Any sentence-initial NVN sequence is perceived as the matrix element of a clause. The most dominant semantic template is mapped onto this NVN sequence. Thus the first noun is taken as an actor, the second noun as the object (i.e. patient). These strategies do not guarantee correct parsing, and may lead to garden-path effects in sentences such as *the horse raced past the barn fell* (Bever, 1970: 316).

In recent years, a model called the Late Assignment of Syntax Theory (LAST) has been advanced by Townsend and Bever (2001). LAST is a two-stage model for sentence

comprehension. The first stage is called “pseudosyntax,” during which the parser uses the canonical word order in a language as a template to map the default grammatical and thematic relations onto the input sentences. In English, as discussed earlier, this template is NVN or Agent-Action-Patient. The second stage is “real syntax” where more complicated reanalysis and phrase structures are constructed. Based on LAST and the canonical-template hypothesis of Bever (1970), SRCs in English should be easier than ORCs since English SRCs follow the canonical order, SVO. The order in ORCs, which is OSV, does not conform to the template, and is more costly to understand.¹⁸

(28) **The guy** who __SUBJ **invited me** caught a trout.

S (S) V O

(29) **The guy** who **I invited** __OBJ caught a trout.

O S V (O)

In Mandarin Chinese, the dominant word order is SVO as in English. However, RCs are prenominal in Mandarin, thus making an ORC easier since its word order matches the canonical order.

¹⁸ Essentially, a word-order based theory has the same predictions as a theory that is based on the direction of thematic assignment (e.g. “trace-deletion theory” for Aphasic RC processing, Grodzinsky, 1986, 1995). A theory based on the assignment of theta role hypothesizes that the verb assigns the agent role to the left and the patient role to the right when the canonical word order in the language is SVO. When the direction has to be altered (e.g. ORCs in English and SRCs in Chinese) for the head noun to receive the correct theta role, this sentence is predicted to be more difficult to comprehend.

(30) **Yaoqin wo** de **pengyou** zhuadao yi zhi zunyu

invite I DE friend catch one CL trout

V O S

‘The friend that invited me caught a trout.’

(31) **Wo yaoqin** de **pengyou** zhuadao yi zhi zunyu

I invite DE friend catch one CL trout

S V O

‘The friend that I invited caught a trout.’

3.2.3 Parallel Function and Perspective-Shifting Theories

Sheldon (1974) proposes the strategy of “parallel function,” focusing on the grammatical function of the embedded gap and that of the head noun within the matrix clause. An SRC that modifies the subject in the matrix clause is easier to process than an SRC that modifies the object position because in the former case, the head noun plays the same functions in the matrix clause and the embedded clause, while in the latter case, the grammatical function has to be shifted, which makes the sentence more difficult to process. Likewise, an ORC modifying the object in the matrix clause is easier than an ORC that modifies the subject. The prediction of Sheldon’s theory is that subject-modifying SRCs and object-modifying ORCs should both be easier than

subject-modifying ORCs and object-modifying SRCs.

MacWhinney and Pleh (1988) extended Sheldon's theory by considering the "viewpoint" of an "active agent" as an important factor in predicting processing difficulties. The processor is assumed to take the viewpoint of the subject in the sentence. When the referent of the subject shifts in a sentence, the processor's viewpoint has to be shifted. The prediction is that "structures that maintain the perspective or subject should be easier to process than those that shift it (106)." Accordingly, subject-modifying SRCs in English should be the easiest to process because it involves no perspective shifting (32). Object-modifying ORCs and object-modifying SRCs are both more difficult because they involve one shift of perspective. Subject-modifying ORCs are predicted to be the hardest because the perspective has to be shifted twice. This is illustrated by (32)-(35).

- (32) The guy who __SUBJ invited me caught a trout. (subject-modifying SRC)
Subject₁ -----
- (33) The guy who I invited __OBJ caught a trout. (subject-modifying ORC)
Subject₁ ---- *Subject₂* ----- *Subject₁* -----
- (34) John knows the guy who __SUBJ invited me. (object-modifying SRC)
Subject₁ ----- *Subject₂* -----
- (35) John knows the guy who I invited __OBJ. (object-modifying ORC)
Subject₁ ----- *Subject₂* -----

The prediction of a perspective-shifting theory on the difficulty in processing Chinese

RCs is that subject-modifying SRCs should be the easiest since they do not involve any shift of perspective. Object-modifying ORCs, object-modifying SRCs, and subject-modifying ORCs all involve the shifting of perspective once, and should be equally difficult. Examples are provided in (36)-(39).

(36) *gouyin yuanzhang de shaonyu zhuangdao le yiyuan* (subject-modifying SRC)

seduce dean DE young lady bump into ASP congressman

Subject₁ -----

‘The young lady that seduced the dean bumped into the congressman.’

(37) *yuanzhang gouyin de shaonyu zhuangdao le yiyuan* (subject-modifying ORC)

dean seduce DE young lady bump into ASP congressman

Subject₁ ----- *Subject₂* -----

‘The young lady that the dean seduced bumped into the congressman.’

(38) *yiyuan zhuangdao le gouyin yuanzhang de shaonyu* (object-modifying SRC)

congressman bump into ASP seduce dean DE young lady

Subject₁ ----- *Subject₂* -----

‘The congressman bumped into the young lady that seduced the dean.’

(39) *yiyuan zhuangdao le yuanzhang gouyin de shaonyu* (object-modifying ORC)

congressman bump into ASP dean seduce DE young lady

Subject₁ ----- *Subject₂* -----

‘The congressman bumped into the young lady that the dean seduced.’

3.2.4 Summary: Predictions of Different Theories

The predictions of the theories reviewed above regarding processing RCs in English and Chinese are summarized in Table 3.1.

Table 3.1. Predictions of RC Processing in English and Chinese
(< is read as “less difficult than”)

Theory	English	Chinese
Active Filler/Gap Strategy (Frazier & Flores d'Arcais, 1989)	SRC < ORC	ORC < SRC (distance-based) SRC < ORC (structure-based)
Grammatical Theory of Processing (Pritchett, 1992)	SRC < ORC	--
Incremental Minimalist Parser	SRC < ORC	SRC < ORC
Syntactic Prediction Locality Theory (Gibson, 1998)	SRC < ORC	ORC < SRC
Canonical Word Order (Bever, 1970)	SRC < ORC	ORC < SRC
Parallel Function (Sheldon, 1974)	{subject-modifying SRC, object-modifying ORC} < {subject-modifying ORC, object-modifying SRC}	{subject-modifying SRC, object-modifying ORC} < {subject-modifying ORC, object-modifying SRC}
Perspective Shift (MacWhinney & Pleh, 1988)	subject-modifying SRC < {object-modifying SRC, object-modifying ORC} < subject-modifying ORC	subject-modifying SRC < {object-modifying SRC, object-modifying ORC, subject-modifying ORC}

3.3 A Typological Review of the Asymmetry

This section reviews the experimental findings on RC processing across various languages in terms of subject versus object extractions. This review focuses on experiments (such as self-paced reading tasks, phoneme-monitoring, eye-tracking, and ERP) that record reading activities in different regions of a sentence. Tasks that present sentences as a whole (e.g. the Hungarian study by MacWhinney & Pleh, 1988)¹⁹ and those that used the picture-matching paradigm are not included because the strategies involved in those tasks are assumed to be different, thus making the results incomparable.²⁰ By examining the empirical data available and the relevant RC structures in different languages, we are able to examine the explanatory power and validity of the predictions of the theories discussed in 3.2.

¹⁹ MacWhinney and Pleh (1988) studied the processing of Hungarian RCs. Their study is not reviewed in this section because the methodology they adopted was not by-region self-paced readings, but reading of sentences as a whole. All studies reviewed in this section used methods that involve incremental presentation of the stimulus sentences. Studies that present whole sentences are excluded because they may involve more global types of processing strategies, thus making direct comparison across studies difficult. (see also note 20)

²⁰ As a methodological note, experiments presenting sentences word by word may involve very different processing strategies from experiments that present sentences as a whole. The former technique generates data that are sensitive to the on-line, incremental process of sentence comprehension, while the latter may induce strategies that rely on global mapping of thematic relations. Take picture-matching tasks as an example of the latter kind. A strategy that participants may adopt is to match the sequences of nouns and verbs to primary thematic template(s). Such tasks are different from the incremental comprehension processes in reading tasks that present sentences word by word.

3.3.1 Processing Head-Initial Relative Clauses

Languages with head-initial RCs have the head nouns preceding the RCs. In this section, we review studies in Brazilian Portuguese, Dutch, English, French, and German.

3.3.1.1 Brazilian Portuguese

Gouvea (2003) conducted a Rapid Serial Visual Presentation (RSVP) experiment on Brazilian Portuguese RCs by presenting words of a sentence consecutively in the center of the monitor to the participants and then asking them to determine whether the sentence they saw was grammatical or not. They contrasted SRCs and ORCs modifying subjects (i.e. center-embedding) or objects (i.e. right-branching). The results showed the following patterns of difficulty in grammaticality judgments: object-modifying SRC < object-modifying ORC < subject-modifying SRC < subject-modifying ORC. Both the main effect of modification types and the main effect of extraction types were significant. The participants made more errors in grammaticality judgments with ORCs than with SRCs, suggesting a preference for SRCs. They also made more errors with subject-modifying RCs (which involved center-embedding) than object-modifying RCs (which involved right-branching). Her results supported all but the last two theories (i.e. parallel function and perspective shift) discussed in the last section.

3.3.1.2 Dutch

The word order of RCs in Dutch is SOV. In the examples below (cited from Mak, Vonk, & Schriefers, 2002: 50), RCs are indicated by the relativizer *die* following the head nouns.

Because both the subject NP and the object NP in Dutch RCs precede the verb, the head noun can be ambiguously associated with a subject or an object gap in the RC.

Disambiguation does not occur until the auxiliary or the verb is reached. If the head noun and the embedded NP cannot be distinguished by number, the RC can be completely ambiguous in terms of subject or object extraction.²¹

(40) a. Morgen zal de professor, die __ de studenten ontmoet heeft, de diploma's uitreiken.

Tomorrow will the professor, that the students met has, the diplomas present

Tomorrow the professor, who has met the students, will present the diplomas.

b. Morgen zal de professor, die de studenten __ ontmoet hebben, de diploma's uitreiken.

Tomorrow will the professor, that the students met have, the diplomas present

Tomorrow the professor, whom the students have met, will present the diplomas.

²¹ Nominative case and accusative case are not overtly coded on Dutch nouns. Dutch also lacks gender agreement between nouns and verbs.

Frazier (1987b) reported that the SRCs were read faster than ORCs. The same results were replicated by self-paced reading tasks and eye-tracking data of Mak et al. (2002), who showed that even when the animacy of the object was factored in (i.e. when the objects are animate), SRCs were still read faster. When the objects were inanimate, however, they did not find the asymmetrical preference. The results of Mak et al. (2002) suggest that SRCs in Dutch are generally preferred, but the animacy of the head nouns and the gaps may also affect processing.

These Dutch results showing that SRCs were easier than ORCs are consistent with all of the theories reviewed previously. The Active Filler Strategy predicts that a subject gap should be preferred because the filler can fill a subject gap right after the relativizer appears. IMP predicts a universal subject preference, which is also confirmed by the Dutch data. Since the SRCs have closer filler-gap relations than ORCs, a locality-based theory like SPLT correctly predicts a subject preference. The results also supports a theory based on canonical word order (SOV in Dutch RCs), which predicts that the ORCs, where the word order is OSV, should be dispreferred. A theory of perspective-shifting also receives support since the ORCs in Dutch involve perspective shifting while the SRCs do not.

3.3.1.3 English

The structures of English RCs have been discussed in Chapter 2. In this section, we review the results of previous studies on the processing of SRCs versus ORCs in English. A preference for SRCs over ORCs has been consistently found. Ford (1983) designed a “Continuous Lexical Decision Task,” in which the participants made lexical decisions (i.e. whether a stimulus is a word or not) on each word of a sentence. She demonstrated that this task was sensitive to both the internal syntactic structure of a sentence and the whole sentence as a processing unit. Ford’s results showed that the difficulty with ORCs started at the gap location and continued till two words after the gap.

King and Just (1991) conducted a self-paced reading study of English RCs by comparing the performance of participants with high and low working memory spans. They asked the participants to read sentences at their own pace, to memorize the last words of the sentences they read, and to answer comprehension questions regarding the target sentences. Their results confirmed that ORCs were harder to understand, as participants with low memory span spent longer time reading ORCs, while producing higher rates of comprehension errors. Participants with high memory span also made more errors with ORCs than SRCs when the demand for working memory increased. The

difference between reading SRCs and ORCs was also observed in follow-up ERP studies (King & Kutas, 1995), and eye-movement-monitoring experiments (Traxler, Morris, & Seely, 2002).

Gibson, Desmet, Grodner, Watson, and Ko (2005) compared the comprehension of SRCs and ORCs by including factors such as whether the RC modifies the subject or the object in a sentence, and whether the sentence is embedded within the sentential complement of a noun. Their results, based on reading times of the whole sentences, confirmed that ORCs were read more slowly than SRCs. In addition, they showed that RTs were longer when the RC modifies an object. These results contradicted the predictions of Sheldon's theory of parallel function and MacWhinney and Pleh's theory of perspective-shifting. Gibson et al. attributed the longer RTs for object-modifying RCs to a conflict of information status in the sentence. Restrictive RCs are meant to convey background information, and should preferably occur early in the sentence. Thus, RCs modifying the subject were read faster than those modifying the objects.²²

In addition to the studies reviewed, which invariably suggest a subject preference,

²² It should be noted that in English, subject-modifying RCs are center-embedded, while object-modifying RCs are right-branching; the matrix clause is interrupted in sentences with subject-modifying RCs, but not in sentences with object-modifying RCs. The finding that sentences with subject-modifying RCs are less difficult is peculiar because the discontinuity caused by subject-modifying RCs should have made the subject-modifying RCs more difficult to process.

Frazier, Clifton, and Randall (1983) tested the Most Recent Filler Strategy²³ by comparing the comprehension times between the following two sentences (200 [The gaps in the examples are my addition.]):

(41) a. Recent Filler:

The mayor is the crook_i who the police_j wanted to ___j leave town with ___i.

b. Distant Filler:

The mayor is the crook_i who the police_j wanted ___i to ___i leave town.

Using a task that recorded the time participants spent determining if they understood a sentence after it was presented to them word by word, Frazier et al. found sentences in the recent-filler condition were understood faster than those in the distant-filler condition.

This study did not directly compare between an SRC and an ORC per se, since all the sentences were ORCs. Even though closer filler-gap relations seemed to have been processed faster, the conclusion that a recent filler was preferred was confounded by two factors. First, the gap of the recent filler condition is located at the end of a sentence.

When the reading time was recorded at the end of the sentence, not by regions throughout

²³ Most Recent Filler Strategy, similar to the Active Filler Strategy, is a locality-based hypothesis. Frazier et al. (1983: 196) define it as the following: “During language comprehension a detected gap is initially and quickly taken to be co-indexed with the most recent potential filler.”

the sentence, a gap that is located at an obvious position (such as an edge) can be easier to locate. Second, the distant-filler condition involves reassignment of theta-role (or assignment of opposite case features) for the object gap. It is first assigned the accusative case (and the theta-role of the patient), then assigned the nominative case (and the role of agent) within the complement ECM clause. These contradicting features may induce increased comprehension times, which were not related to filler-gap distances.

3.3.1.4 French

RCs in French are postnominal and indicated by case-marked relativizers such as *qui* (for SRCs) and *que* (for ORCs). The relatively flexible word order in French results in cases where SRCs and ORCs can only be distinguished by the relativizer, as exemplified by (42).

(42) RCs in French (a & b are cited from Frauenfelder, Segui, & Mehler, 1980: 330)

a. SRC:

Le savant qui connaît le docteur travaille dans une université moderne.

‘The scientist who knows the doctor works in a modern university.’

b. ORC (transposed):

Le savant que connaît le docteur travaille dans une université moderne.

‘The scientist who the doctor knows works in a modern university.’

c. ORC (typical):

Le savant que le docteur connaît travaille dans une université moderne.

‘The scientist who the doctor knows works in a modern university.’

(42b) is usually used to avoid the occurrence of two consecutive verbs as a stylistic variation of a normal ORC like (42c).

Frauenfelder, Segui, and Mehler (1980) conducted a phoneme-monitoring task, in which the participants were asked to respond when they hear a target phoneme (e.g. /t/ or /d/) in a sentence. They contrasted between (42a) and (42b), and found that when the target phoneme appears right after the RC boundary at the beginning of the main verb, participants took significantly longer time to respond to ORCs than to SRCs. No difference was found when the target phoneme was located within the RC on the embedded noun. Similar results were obtained from more recent click-monitoring experiments (Cohen & Mehler, 1996). Even though their results showed a processing preference for SRCs, they did not conclude that SRCs were intrinsically easier than ORCs.

In their study, the word order of ORCs was OVS, not the dominant word order in French (i.e. SVO). This peculiar word order may be the factor that caused longer reading times for ORCs.

Holmes and O'Regan (1981) conducted an experiment monitoring the eye movements of participants reading the three RC types in (42). Note that the SRCs and transposed ORCs have identical superficial word orders (i.e. N V N Rel V N ...) but different underlying thematic relations, while transposed and typical ORCs have identical underlying representations but different surface orders. They analyzed both the initial fixations and regressions, and found that initial fixations were sensitive to the surface orders, while regression patterns were determined by the underlying deep structures. Based on initial fixation data, SRCs and transposed ORCs show a similar pattern, which is distinct from typical ORCs. The regression data showed that participants spent less time on SRCs than on both types of ORCs. The error rates of comprehension questions after reading each sentence also confirmed that SRCs were better understood than ORCs. Typical ORCs were better understood than transposed ORCs. In sum, Holmes and O'Regan supported a two-stage model (like that of Townsend & Bever, 2001), in which the NVN pattern is initially mapped onto the input sentence, followed by a deeper

syntactic analysis. The overall preference for SRCs confirmed the predictions of theories that are based on syntactic structures, filler-gap distances, locality, and/or canonical word orders.²⁴

3.3.1.5 German

German RCs, like those in Dutch, can be ambiguous between subject and object extractions. Though the dominant word order in German is SVO, the word order of the embedded clause is SOV. Thus, the gap always occurs before the verb in RCs, and can be taken as a subject gap or an object gap. One way this can be disambiguated is through subject-verb agreement. If the verb in the RC agrees with the head noun, then the head noun should be associated with the subject gap in the RC. If the embedded verb agrees with the embedded NP, not the head noun, then the head noun should be associated with an object gap in the RC. However, if the head noun and the embedded NP have the same number and gender properties, then the RC cannot be disambiguated.²⁵ Examples of SRCs and ORCs in German, cited from Schriefers, Friederici, and Kuhn (1995: 502), are

²⁴ Schelstraete and Degand (1998) studied French RC experiments using self-paced readings. They also found higher comprehension rates and shorter reading times for SRCs. However, the reading times of the typical and transposed ORCs showed the opposite pattern from Holmes and O'Regan's. As Schelstraete and Degand provided only participant analyses, not item analyses of the data, it is difficult to evaluate their results in relation to Holmes and O'Regan's.

²⁵ The relativizer in German is case and gender marked, but the relativizer *die* is ambiguous between marking feminine nominative and marking feminine accusative (singular as well as plural).

provided below:

(43) RCs in German (cited from Schriefers, Friederici, & Kuhn, 1995: 502)

a. SRC: Das ist die Managerin, die Arbeiterinnen gesehen hat.

this is the manager who the workers seen has

‘This is the manager who has seen the workers.’

b. ORC: Das sind die Arbeiterinnen, die Managerin gesehen hat.

these are the workers who the manager seen has

‘These are the workers who the manager has seen.’

Schriefers et al. (1995) conducted self-paced reading tasks regarding RC types (SRC vs. ORC) and semantic biases (i.e. whether the semantics of the nouns and verbs biases towards a subject reading or an object reading). They found that the parser tends to take the head noun to be the subject rather than the object of the RC. This preference exists even when there is a semantic bias for an ORC interpretation. Similar distinctions between SRCs and ORCs were found in ERP studies by Mecklinger, Schriefers, Steinhauer, and Friederici’s (1995).

3.3.2 Processing Head-Final Relative Clauses

In languages where RCs are head-final, the RCs precede the head nouns. In these

languages, the gaps precede the fillers. We review studies on the gap-filler relations in Chinese, Japanese, and Korean. Languages with head-final RCs provide us with an opportunity to tease apart issues that cannot be separated in languages with postnominal RCs.

3.3.2.1 Mandarin Chinese

We have discussed the structures of Chinese RCs and related processing issues in Chapter 2 and section 3.2. In this section, we focus on reviewing the experiment conducted by Hsiao and Gibson (2003).

Hsiao and Gibson (2003) conducted a self-paced reading experiment looking at the processing differences between Chinese SRCs and ORCs modifying the subjects of matrix clauses. They looked at both singly-embedded RCs and doubly-embedded RCs. Examples of the sentences used in their experiments are provided in (44). (44a) and (44b) are singly-embedded RCs that involve the extraction of the subject and the object respectively. To make the tasks harder, so that the effect is bigger, they included doubly-embedded RCs like (44c) and (44d), which are SRCs that are embedded within SRCs, and ORCs that are embedded within ORCs respectively.

(44) Chinese RCs (Hsiao & Gibson, 2003: 6—with minor correction on pinyin)

a. Singly-embedded SRC:

__ yaoqing fuhao de guanyuan xinhuaibugui danshi shanyu yincang

invite tycoon DE official have bad intentions but good at hiding

‘The official who invited the tycoon has bad intentions but is good at hiding them.’

b. Singly-embedded ORC:

fuhao yaoqing __ de guanyuan xinhuaibugui danshi shanyu yincang

tycoon invite DE official have bad intentions but good at hiding

‘The official whom the tycoon invited has bad intentions but is good at hiding them.’

c. Doubly-embedded SRC:

[__ yaoqing [__ goujie faguan de] fuhao de] guanyuan xinhuaibugui

invite conspire judge DE tycoon DE official have bad intentions

‘The official who invited the tycoon who conspired with the judge has bad intentions.’

d. Doubly -embedded ORC:

[[fuhao yaoqing __ de] faguan goujie __ de] guanyuan xinhuaibugui

tycoon invite DE judge conspire DE official have bad intentions

‘The official whom the judge whom the tycoon invited conspired with has bad intentions.’

The results of the self-paced reading tasks on these sentences suggested that for singly embedded RCs, SRCs were read more slowly than ORCs only at the combined regions of the first two words (VN in SRCs & NV in ORCs). The comprehension rates and RTs at all other regions were not significantly different. Speculating that word-order differences between singly-embedded SRCs and ORCs may be too small to cause significant differences, they also compared the RTs of doubly embedded RCs.

Sentences with doubly-embedded SRCs were read more slowly than those with doubly-embedded ORCs regarding overall reading times of the RCs, and RTs of three individual regions within the RC. They concluded that SRCs in Mandarin Chinese were harder to comprehend than ORCs. Hsiao and Gibson's results were crucial because this was the first finding in the literature that showed a processing advantage for ORCs instead of SRCs. Such a finding supports a locality-based theory (Gibson, 1998) and a theory based on canonical word orders (Bever, 1970), but contradicts a structure-based theory that views subject positions as more easily accessed than object positions.

There were, however, several important issues, which have undermined Hsiao and Gibson's results. First of all, the comprehension rate in their study was very low (71.6% for the target sentences, 88.7% for the filler sentences) compared with most other studies

of self-paced reading tasks (e.g. 80.5% for the English RCs in Gibson et al, 2005; 95% for all items in Dutch from Mak et al., 2002). This may have to do with the relatively old age of their participants (45 in average, according to Hsiao, 2003) and the unusual experimental setting (7 of the 40 participants were attending a wedding in California). In their analysis of the RT data, they included all items. The high error rate suggests that at least 30% of their results were not based on accurate comprehension of the sentences.

Crucially, in the singly-embedded RC data, they only found significant advantage for ORCs at the combined region of the first two words of the clause. This difference can simply be accounted for by the fact that Mandarin SRCs contain a missing subject argument, which may be taken as a *pro* in the initial analysis. Missing arguments induce longer reading times, thus making SRCs harder to process in the beginning. This is illustrated by (45). Therefore, Hsiao and Gibson's results of singly-embedded RCs did not hinge on the differences of filler-gap relations within Mandarin RCs, but on the differences between clauses with and without a *pro*.

(45) a. *pro* yaoqing fuhao de guanyuan ... (SRC)

invite tycoon DE official

'The official who invited the tycoon ...'

b. fuhao yaoqing [gap] de guanyuan ... (ORC)

tycoon invite DE official

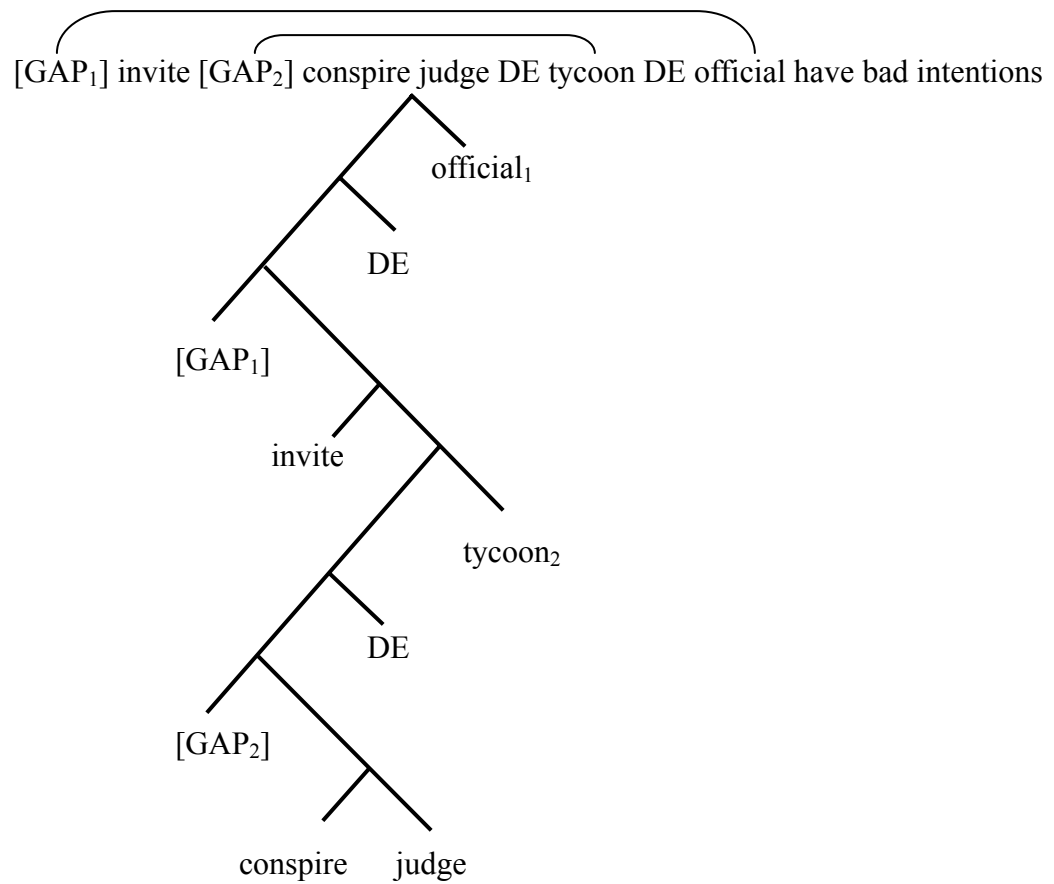
‘The official who the tycoon invited ...’

Their doubly-embedded RCs were even more problematic. The results did show robust reading difficulties for SRCs embedded in SRCs. However, a crucial confound was not considered in their study, namely the kinds of dependencies involved in different conditions. Double embedding of SRCs actually involved nested embeddings, while that of ORCs involved serial dependencies, as illustrated by the syntactic diagrams of in (46). Therefore, the preference they reported did not reflect the intrinsic differences of filler-gap relations in SRCs and ORCs. Instead, it simply showed that nested dependencies, where the dependency cannot be resolved locally, were harder than serial dependencies.

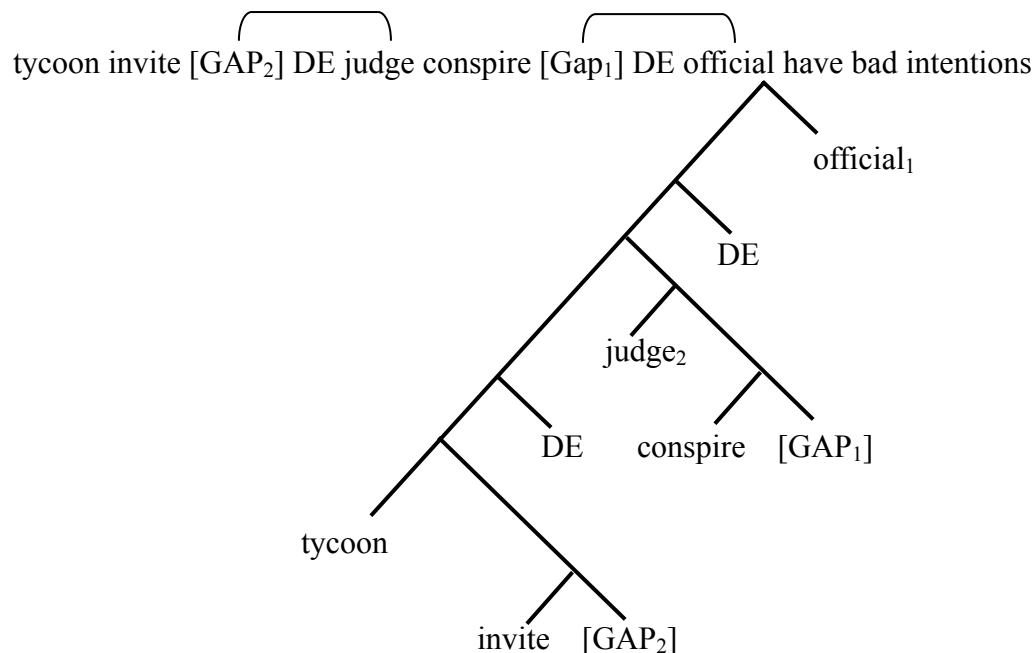
Hsiao and Gibson’s motivation to study doubly-embedded RCs was to maximize the difficulty of the task in order to gain a more robust effect of SRC/ORC difference. To avoid the confound of nested versus serial dependencies, they should have compared SRCs and ORCs embedded within the same types of RCs. A valid comparison should, therefore, be made between SRCs and ORCs embedded in SRCs (nested dependencies in

both conditions, with maximal difficulty), and/or between SRCs and ORCs embedded in ORCs (both serial dependencies, with less difficulty).

(46) a. SRCs embedded in SRCs



b. ORCs embedded in ORCs



Another confound of Hsiao and Gibson (2003) concerns their materials. The verbs used in their experiment were not strictly controlled for syntactic ambiguity. Among the forty verbs used in the twenty sets of sentences, 7 can take sentential complements, and 13 can take verbal complements. Three verbs appeared more than once in different sentences (*xihuan* ‘like,’ *renshi* ‘know,’ & *bulihui* ‘ignore’). One sentence was ungrammatical because the verb *bianhu* ‘defend’ was misused.²⁶ Among the 20 sentences, 7 involved complex verb constructions such as negation (n = 4) and serial verb

²⁶ *Bianhu* in Chinese is pseudo-transitive. Its object has to appear in preverbal oblique case, not the postverbal object case position, as was used by Hsiao and Gibson (2003: 19).

lyushi wei shizhang bianhu	*lyushi bianhu shizhang
lawyer for mayor defend	lawyer defend mayor
‘The lawyer defended *(for) the mayor.’	

construction (n = 3). An experiment tacking the accessibility of subject and object positions in RCs should use verbs that are minimally ambiguous, that is, verbs that only subcategorize for nominal objects.

For the reasons reviewed above, we conclude that the results of Hsiao and Gibson should be re-examined. A self-paced reading task using singly-embedded RCs with verbs that predominantly take nominal objects was conducted as Experiment 1. The results will be reported in section 3.4.

3.3.2.2 Japanese

The word order of Japanese is SOV in both the matrix and embedded clauses. The case of nominal arguments is overtly marked. RCs are not indicated by an overt relativizer. The head nouns directly follow the RCs. Examples of Japanese RCs are provided in (47).

(47) a. Japanese SRC (cited from Miyamoto & Nakamura, 2003: 343)

[_{RC} __ tosiyorino obaasan-o basutei-made miokutta] onnanoko

elderly woman-Acc bus stop-to accompanied girl

‘the girl that accompanied the elderly woman to the bus stop’

b. Japanese ORC (cited from Miyamoto & Nakamura, 2003: 343)

[_{RC} tosiyorino obaasan-ga __ basutei-made miokutta] onnanoko

elderly woman-Nom bus stop-to accompanied girl

‘the girl that the elderly woman accompanied to the bus stop’

Because the word order of Japanese is SOV, and because head nouns follow RCs in Japanese, the linear distance between an object gap and the head noun is closer than that between a subject gap and the head noun. However, the structural distance between a subject gap and the head noun is still closer than that between the object gap and the head noun. Like Mandarin RCs, Japanese RCs help tease apart a linearity-based theory and a structure-based theory. Miyamoto and Nakamura (2003) conducted self-paced reading tasks comparing the comprehension of SRCs and ORCs in Japanese. Their results showed that RTs were not different at the RC section. At the head-noun region, ORCs took longer to read than SRCs. No significant difference was found on all other regions. The same results were obtained when case-marking on the head noun (e.g. topic, nominative, & accusative) was controlled for. A similar preference for subject gaps was found when the RCs have both subject and object gaps (see Nakamura, 2003). Miyamoto and Nakamura concluded that the results were better accounted for by a structure-based theory (e.g.

Hawkins, 1999; O’Grady, 1997) than by a theory that is based on linear distance between the filler and the gap (Warren & Gibson, 2002). The Japanese results also cannot be accounted for by a theory that is based on canonical word orders.

3.3.2.3 Korean

The structural properties of RCs in Korean are similar to those in Japanese. They are prenominal; the basic word order is SOV; nominal arguments are morphologically case-marked. However, the verbs in Korean RCs are marked by an inflectional suffix morpheme. Examples of Korean RCs are provided in (48). Kwon, Polinsky, and Kluender (2004) conducted self-paced reading tasks and also found SRCs to be read faster than ORCs.

(48) a. Korean SRC (Kwon, p.c.)

[_{RC} __ naitun pwin-ul bes cenkecang-kkaci tonghayngga]-n sonye

elderly lady-acc bus stop-to accompany-rel girl

‘the girl that accompanied the elderly woman to the bus stop’

b. Korean ORC (Kwon, p.c.)

[_{RC} naitu-n pwuin-i __ bes cenkecang-kkaci tonghaynggha]-n sonye

elderly lady-nom bus stop-to accompany-rel girl

‘the girl that the elderly woman accompanied to the bus stop’

3.4 Experiment 1: RC Processing in Mandarin

In this section, we report an experiment revisiting RC processing in Mandarin Chinese.

As reviewed in 3.3.2.1, Hsiao and Gibson’s (2003) experiment was confounded by the

syntactic ambiguity of the verbs, and the complexity involved in the double-level

embeddings. In the experiment reported below, we used verbs that primarily take nominal

objects, and restricted the materials to single-level embeddings. Two variables were

studied in a 2 x 2 design, including RC types (SRC versus ORC) and the types of

modification (RCs modifying the matrix subject versus RCs modifying the matrix object).

3.4.1 Participants

Fifty-three undergraduate students (11 males, 42 females) from National Cheng-Chi

University were paid 150 NTD (approximately \$5.00) to participate in the experiment.

All participants were native speakers of Mandarin Chinese, who were exposed to

Mandarin since birth. The participants had normal vision, and were naïve to the purpose

of the experiment. The age range of the participants was between 19 and 23, with an average age of 21. All but 2 participants were right-handed.

3.4.2 Materials

The materials included twenty-four sets of sentences, each with four conditions (subject-modifying SRC, subject-modifying ORC, object-modifying SRC, & object-modifying ORC). An example of each condition is given in (49), with labels of each region indicated.

(49) a. Subject-modifying SRC

gouyin yuanzhang de shaonyu zhuangdao le yiyuan
 V1 N1 DE N2 V2 N3

seduce dean DE young lady bump into ASP congressman

‘The young lady that seduced the dean bumped into the congressman.’

b. Subject-modifying ORC

yuanzhang gouyin de shaonyu zhuangdao le yiyuan
 N1 V1 DE N2 V2 N3

dean seduce DE young lady bump into ASP congressman

‘The young lady that the dean seduced bumped into the congressman.’

c. Object-modifying SRC

yi yuan zhuang dao le gou yin yuan zhang de shaonyu

N1 V1 V2 N2 DE N3

congressman bump into ASP seduce dean DE young lady

‘The congressman bumped into the young lady that seduced the dean.’

d. Object-modifying ORC

yi yuan zhuang dao le yuan zhang gou yin de shaonyu

N1 V1 N2 V2 DE N3

congressman bump into ASP dean seduce DE young lady

‘The congressman bumped into the young lady that the dean seduced.’

The four conditions of each sentence were distributed into four lists in a Latin-Square design. Each participant only reads one condition of each sentence. A complete list of the target stimuli is provided in Appendix A. In addition to the 24 target sentences, 76 filler sentences of various structures were included.

3.4.3 Plausibility Ratings

In order to ensure that the difference between the four conditions is not confounded by differences in semantic plausibility, a questionnaire of plausibility ratings was conducted.

The four conditions of the target sentences in (49) involved two pairs of reversible argument-verb relations in (50) and (51). Each sentence of each pair was placed into a

different list of two lists, so that each participant only rated the plausibility of one of the reversible argument-verb relations.

(50) a. A young lady bumped into a congressman. (Subject-modification)

b. A congressman bumped into a young lady. (Object -modification)

(51) a. A young lady seduced the dean. (SRC)

b. The dean seduced a young lady. (ORC)

Forty-seven undergraduate students (13 males, 34 females) from National Cheng-Chi University volunteered to participate in this norming study. All participants were native speakers of Mandarin Chinese, exposed to Mandarin since birth. The average age of all participants was 19.4 (age ranging between 19 and 21). No participants in the questionnaire study participated in any of the on-line experiments, and all of them were naive to the purpose of the study.

Materials were distributed into two questionnaires. Each questionnaire contained 48 target sentences based on the 24 sets of target sentences in Experiment 1. A hundred and forty-four filler sentences of various plausibility statuses were included, making a total of 192 sentences in each questionnaire. All materials were randomly ordered.

Participants were randomly given one of the two questionnaires. They were

instructed to rate the plausibility for each sentence to be observed in the real world on a scale of 1 (very unlikely) to 6 (very likely). The instruction also stated that each sentence should be rated independently with no relation to any other sentences in the questionnaire. Three examples were provided before the ratings began. The whole questionnaire took 15 minutes to complete.

Twenty-four participants (6 males, 18 females) filled out Questionnaire A; twenty-three participants (7 males, 16 females) filled out Questionnaire B. The average rating for all sentences was 4.25 (SD = 1.68). Two ANOVAs with repeated measures were conducted on the plausibility of sentences across RC types (SRC vs. ORC) and on sentences across modification types (subject vs. object modification). By-item analysis showed no significant difference in plausibility either across RC types ($F(1, 23) = 1.41, p = 0.25$), or across modification types ($F(1, 23) = 1.97, p = 0.17$).²⁷ The results suggested that semantic plausibility was not a factor that differentiated the target sentences across different conditions of RC types and modification types.

²⁷ Since all items in one condition were rated by the same group of participants, no by-participant analysis was conducted. Participant differences should not have affected the results since by-item analysis already showed insignificant differences across conditions, which meant the differences across participants was not significant either.

3.4.4 Procedure

A self-paced reading experiment, with a moving-window presentation, was conducted, using Linger 2.94 developed by Doug Rohde at MIT. Each participant was tested individually, and seated in front of a laptop computer in a quiet lab on the campus of National Cheng-Chi University. Each trial started with a line of dashes indicating the length of the sentence. Participants hit the space bar for words in a sentence to appear. As a new phrase appeared, the previous item turned back into dashes. Each dash indicated a character in Mandarin. No spaces were inserted between words or phrases since the standard writing of Chinese does not contain spaces. All the target sentences were short enough to appear in one single line on the screen. All materials were presented randomly, with consecutive occurrences of the target items avoided. After the last word of each sentence, the whole sentence disappeared. A comprehension question asking about the content of that sentence appeared. The comprehension question was either a true/false question or a multiple-choice question. For true/false questions, the participants were instructed to hit the key “F” for true and the key “J” for false. For multiple-choice questions, the participants had to select between two options indicated by F and J. The keys “F” and “J” were chosen because they each had a small tactile bump on the

keyboard, so that the participants could easily hit the correct responding buttons while focusing their attention on the screen at all times. What F and J stood for was indicated at the bottom of the screen along with each comprehension question. No feedback was given if the participant response was correct. If incorrect, the Chinese sentence *ni dacuo le o* ‘you answered it wrong!’ would flash on the screen before a line of dashes covering the next sentence appeared. Participants were instructed to read the sentences at a natural rate, and to understand the sentences in order to answer the comprehension questions correctly. They were also told to read without unnecessary delay as long as they could accurately comprehend the sentences. Fourteen practice trials were presented before the main section started. The reading time for each region, the time taken to answer the comprehension questions, and the responses to the comprehension questions were recorded. Participants were given a chance to take a break after the first 50 sentences. The whole experiment took 20 to 25 minutes to complete. For a graphic illustration of the experimental procedure, refer to Appendix B.

3.4.5 Results

The data of four participants (2 males, 2 females) were excluded because their error rate on the overall comprehension questions was equal to or more than 25%. The data of one

other female participant were excluded because she grew up in a more complicated linguistic environment (not in Taiwan) before the age of seven. The following results are based on data from the remaining 48 participants (9 males, 39 females). Performance on the comprehension questions and reading time data are presented in separate sections.

3.4.5.1 Comprehension Performance

The overall comprehension accuracy including both the target and filler sentences was 84.63%. The accuracy rates for the target sentences broken down to the four conditions are given in Table 3.2. Numerically, SRCs were comprehended more accurately than ORCs. However, this difference was not statistically significant.

Table 3.2. Experiment 1: Accuracy on Comprehension Questions by Conditions

	SRC	ORC
Subject-modification	97.22%	95.14%
Object-modification	96.53%	95.83%

3.4.5.2 Reading Time Data

The average reading time per region, as given in Table 3.3, was compared across conditions.

Table 3.3. Experiment 1: Average Reading Time (ms) per Region and SD (in parenthesis) by Conditions

	SRC	ORC
Subject-modification	744.27 (259.25)	796.30 (277.83)
Object-modification	729.10 (246.88)	840.70 (356.72)

The main effect of RC type was significant ($F(1, 47) = 12.87, p = 0.001$; $F(1, 23) = 8.16, p = 0.009$). ORCs took longer time to comprehend than SRCs. Neither modification type nor interaction was significant ($F_s < 1.56, p_s > 0.22$).

Average reading time per region from the relative clause to the head noun (including N/V V/N DE N) in each condition was compared and summarized in Table 3.4.

Significant main effects of RC types ($F(1, 47) = 10.42, p < 0.002$; $F(1, 23) = 10.90, p < 0.003$) and modification types ($F(1, 47) = 44.43, p < 0.001$; $F(1, 23) = 99.98, p < 0.001$) were found. Interaction was significant by participant analysis but not by item analysis ($F(1, 47) = 4.79, p < 0.034$; $F(1, 23) = 2.83, p = 0.106$).

Table 3.4. Experiment 1: Average Reading time (ms) per Region from RC to the Head Noun (SD in Parenthesis) by Conditions

	SRC	ORC
Subject-modification	600.87 (207.95)	642.90 (247.62)
Object-modification	803.48 (297.55)	963.90 (479.08)

The main effects suggested that in the RC sections (from the RC to the head noun), SRCs

were read significantly faster than ORCs. RCs modifying subjects of the matrix clauses were also read faster than those modifying the objects. The SRC-ORC difference was larger when the RCs modified objects.

Figure 3.1 shows the reading time from the beginning of the RC region to the head noun (aligned by position) in the four conditions. Only the main effect of modification type was significant at the initial position ($F(1, 47) = 18.90, p < 0.001$; $F(1, 23) = 18.50, p < 0.001$), and the second position ($F(1, 47) = 19.15, p < 0.001$; $F(1, 23) = 28.39, p < 0.001$).

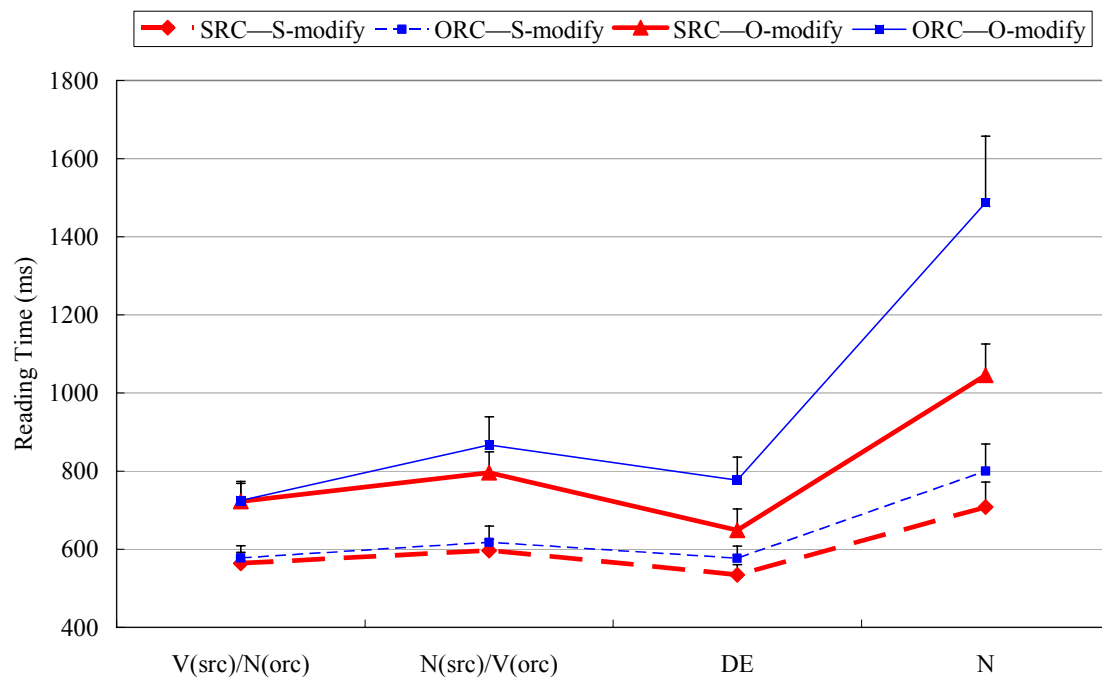


Figure 3.1. Experiment 1: Reading time by regions across 4 conditions aligned from the start of the RC to the head noun.

Since the first two positions were not identical words or words of the same syntactic

categories, we added up the reading times of the two regions as the combined pre-relativizer region for comparison (as was done by Hsiao & Gibson, 2003). The results, as given in Table 3.5, only showed a significant main effect of the modification type ($F(1, 47) = 32.06, p < 0.001$; $F(1, 23) = 38.80, p < 0.001$), but not that of RC type or interaction ($F_s < 1.03, p_s > 0.316$). These comparisons at the RC-relativizer-head-noun regions suggested that the main effect of modification type was robust across all regions. RCs modifying object positions were harder than RCs modifying subject positions.

Table 3.5. Experiment 1: Combined Reading Time (ms) of the Pre-Relativizer Region (SD in Parenthesis) by Conditions

	SRC	ORC
Subject-modification	1160.94 (351.29)	1195.43 (432.17)
Object-modification	1518.81 (605.54)	1591.78 (697.06)

The reading times on the relativizer (*de*) and the head nouns were also compared across conditions. For the relativizer *de*, there were significant main effects on both RC types ($F(1, 47) = 6.96, p < 0.011$; $F(1, 23) = 3.41, p = 0.078$) and modification types ($F(1, 47) = 12.70, p < 0.001$; $F(1, 23) = 29.21, p < 0.001$), but no significant interaction ($F_s < 2.36, p_s > 0.131$). Table 3.6 provides the average RTs of *de* across conditions. The relativizers for SRCs were read faster than those for ORCs (though only approaching significance for item analysis), and the relativizers for subject-modifying RCs were read

faster than those for object-modifying RCs.

Table 3.6. Experiment 1: Average Reading Time (ms) on the Relativizer *de* (SD in Parenthesis) by Conditions

	SRC	ORC
Subject-modification	534.78 (180.55)	576.51 (216.75)
Object-modification	649.19 (372.45)	776.97 (410.20)

For the head nouns, significant main effects of RC types ($F(1, 47) = 9.92, p < 0.003$; $F(1, 23) = 13.63, p < 0.001$) and modification types ($F(1, 47) = 25.76, p < 0.001$; $F(1, 23) = 74.66, p < 0.001$), and significant interaction ($F(1, 47) = 5.02, p < 0.030$; $F(1, 23) = 3.16, p = 0.088$) were found. Table 3.7 provides the average RTs of head nouns across conditions.

Table 3.7. Experiment 1: Average Reading Time (ms) on the Head Nouns (SD in Parenthesis) by Conditions

	SRC	ORC
Subject-modification	707.74 (447.69)	799.66 (483.45)
Object-modification	1045.91 (553.74)	1486.84 (1184.97)

The head nouns for SRCs were read faster than those for ORCs; the head nouns for subject-modifying RCs were read faster than those for object-modifying RCs. The difference between SRCs and ORCs was larger when the RCs modified objects. The difference between RCs modifying subjects and those modifying objects was larger when this RC involved object extraction. These results showed that the effect of RC type

became significant only at the relativizer and head-noun regions; ORCs took longer than SRCs. The difference was larger for object-modifying RCs than subject-modifying RCs at the head-noun region.

Reading times by region for the whole sentences are shown in Figures 3.2 and 3.3.

Figure 3.2 shows the average RTs by region for subject-modifying SRCs and ORCs. The time taken to read ORCs was generally longer than the time taken for SRCs. The differences were not significant when we compare the RTs for subject-modifying RCs alone ($F_{1s} < 3.64$, $ps > 0.063$; $F_{2s} < 1.64$, $ps > 0.214$), though numerically, the line for ORC was above that for SRC.

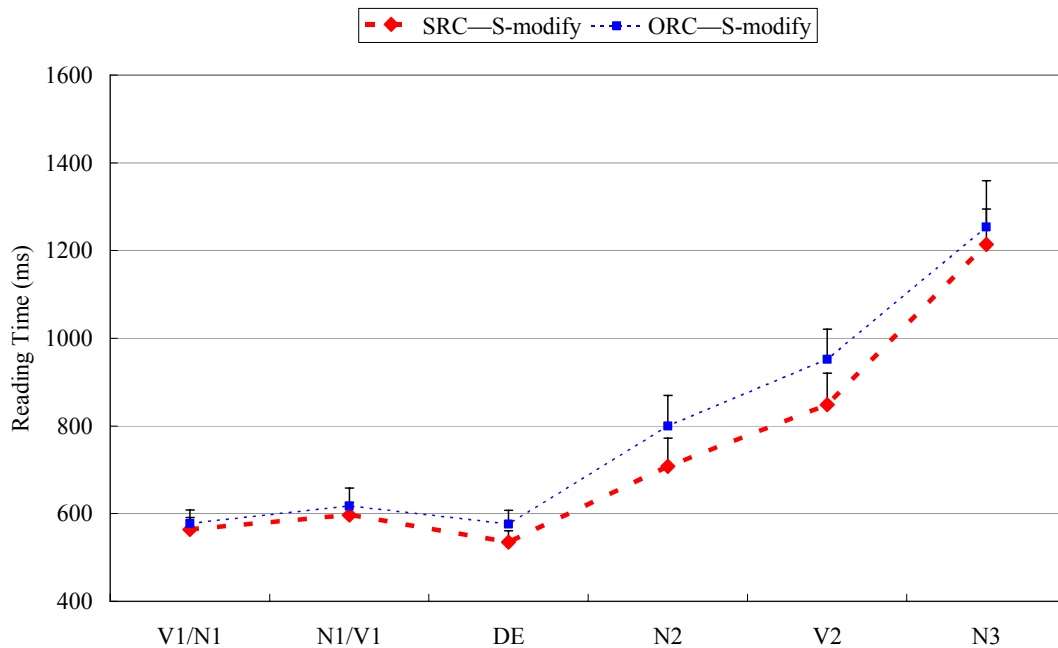


Figure 3.2. Experiment 1: Reading time by regions for SRCs and ORCs modifying the subject position.

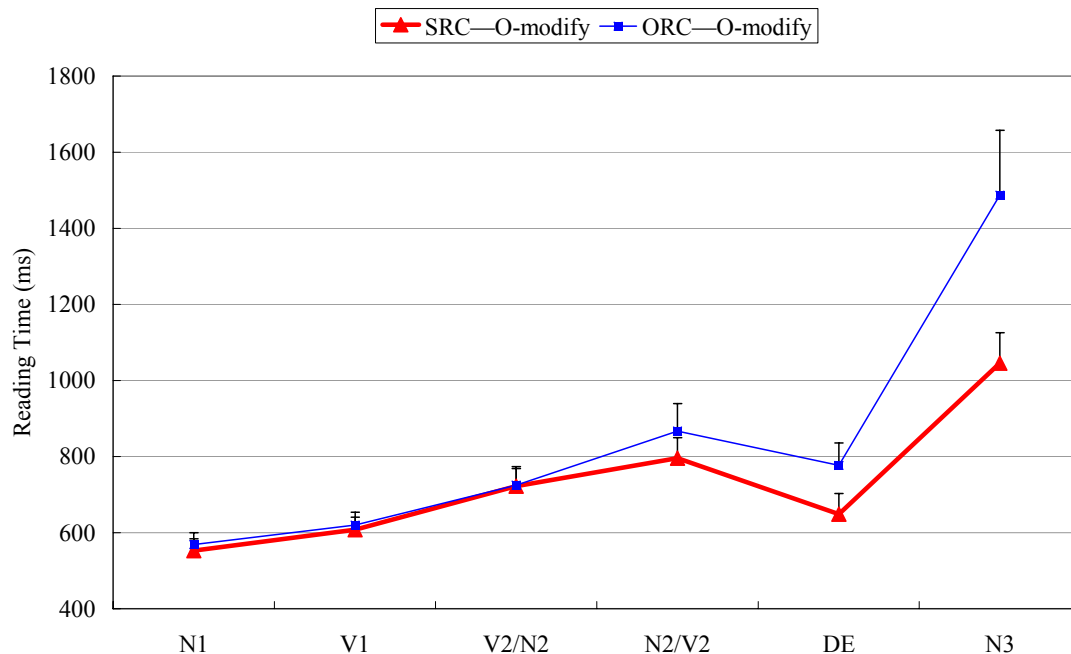


Figure 3.3. Experiment 1: Reading time by regions for SRCs and ORCs modifying the object position.

Figure 3.3 shows the average RTs by region for object-modifying SRCs and ORCs. ORCs did not get significantly harder to read than SRCs until the relativizer ($F(1, 47) = 5.59, p < 0.022$; $F(1, 23) = 2.57, p = 0.123$) and the head-noun ($F(1, 47) = 8.06, p < 0.007$; $F(1, 23) = 8.20, p < 0.009$) regions. All other regions did not differ significantly ($F(1s < 1.16, ps > 0.287$; $F(2s < 1.25, ps > 0.275)$).

3.4.6 Discussion

The results suggested that in Mandarin Chinese, SRCs were easier to comprehend than ORCs. This effect was observed on the average reading times for the whole sentences, and on the reading times of the relativizer and the head noun. A robust effect of

modification type was also found on each region from the RC to the head noun and on the overall average reading times. RCs modifying the object positions were harder than those modifying the subject positions. The difference between SRCs and ORCs were larger for object-modifying RCs than for subject-modifying RCs.

These results differed from those of Hsiao and Gibson's (2003), who obtained shorter reading times for ORCs on the pre-relativizer regions combined, but not on any other regions. As pointed out in 3.3.2.1, the pre-relativizer regions in SRCs involve an unpronounced *pro*, which may have caused extra processing load. However, in our study, we did not replicate that effect. Instead, we obtained shorter reading times on the relativizer and the head noun for SRCs. Note that Hsiao and Gibson only looked at RCs modifying the subject positions. In our study, the difference between SRCs and ORCs was less obvious for subject-modifying RCs than for object-modifying RCs. The reason why Hsiao and Gibson did not get an effect of RC types with the subject modifying RCs could be that the difference only becomes obvious on object-modifying RCs.

One concern that kept Hsiao and Gibson from looking at object-modifying RCs was the potential local ambiguity (and thus a garden-path effect) for ORCs that modify objects. To illustrate this point, (49c&d) are repeated below. The concern was that as participants

read object-modifying ORCs, they may mistake the subject of the RC as the object of the matrix clause in an NVN sequence. Reanalysis may be required to comprehend ORCs, which could have made object-modifying ORCs more costly to process.

(49) c. Object-modifying SRC

yi yuan zhuang dao le gou yin yuan zhang de sha on yu
 N1 V1 V2 N2 DE N3

congressman bump into ASP seduce dean DE young lady

‘The congressman bumped into the young lady that seduced the dean.’

d. Object-modifying ORC

yi yuan zhuang dao le yuan zhang gou yin de sha on yu
 N1 V1 N2 V2 DE N3

congressman bump into ASP dean seduce DE young lady

‘The congressman bumped into the young lady that the dean seduced.’

Our results comparing the reading times of the initial RC regions (Figure 3.1) showed that this garden path effect, even if existent, was minimal for the following four reasons. First, there was no RT difference between reading the initial verb (V2) of an object-modifying SRC and reading the initial noun (N2) of an object-modifying ORC. The garden-path effect should at least produce longer reading times for SRCs at the point of the embedded verb since the word sequence was NVV instead of NVN for the object-modifying SRC.

Second and more crucially, at the second region (N2 vs. V2) of the object-modifying RCs, there was still no significant difference between SRCs and ORCs. If there was reanalysis effect for object-modifying ORCs, it should have taken place when the parser realized that the NVN sequence was not a simple agent-verb-patient sequence. Third, the significant difference between SRCs and ORCs was observed on the head noun (N3), which suggested that the effect has more likely resulted from a gap-filling process rather than reanalysis. Furthermore, Figure 3.1 observes similar RT patterns for SRCs and ORCs across modification types, which suggested that the fact that sentences with object-modifying RCs were generally more difficult has made the difference between SRCs and ORCs more obvious.

Another issue concerns why sentences with object-modifying RCs are more difficult. First, it is a general tendency that reading times tend to increase towards the end of a sentence. Relative clauses are more complicated by nature since they involve gaps and variable-binding relations. When they appear early in the sentence, they can be read more rapidly because the parser only needs to deal with the RC itself. However, when they appear at the object modifying position, the parser is already burdened by processing the matrix clause. Second and more crucially, the filler-gap dependency for

subject-modifying RCs can already be solved locally before the matrix clause is reached.

However, for object-modifying RCs, the subject and verb of the matrix clause are first

processed and stored in the working memory. The parser still waits for an upcoming

nominal argument, to which the verb can assign the patient theta role. This is, however,

interrupted by the object-modifying RC. The filler-gap dependencies for

object-modifying RCs are thus nested within the thematic relation between the verb and

the matrix object. Compared with the serial dependencies in subject-modifying RCs,

sentences with object-modifying RCs are more difficult to process than subject-modifying

RCs. This is illustrated by (52) below. The solid lines indicate the filler-gap dependency,

and the dotted lines indicate the thematic relations between the verb and its nominal

arguments in the matrix clause.

(52) a. Subject-modifying SRC: $\text{--- V1 N1 DE } \underline{\text{N2}} \text{ V2 N3}$

matrix word order: S V O

b. Subject-modifying ORC: $\text{N1 V1 --- DE } \underline{\text{N2}} \text{ V2 N3}$

matrix word order: S V O

c. Object-modifying SRC: $\text{N1 V1 --- V2 N2 DE } \underline{\text{N3}}$

matrix word order: S V O

d. Object-modifying ORC: N1 V1 N2 V2 DE N3
 matrix word order: S V O

The significant interaction between RC types and modification types suggest that the difficulty of sentences with object-modifying RCs has augmented the difference between SRCs and ORCs. Studying both factors in a 2 x 2 design thus provides us with a more salient effect on RC types, which would not have been obvious if we had focused only on sentences with subject-modifying RCs.

Since Experiment 1 was intended to verify Hsiao and Gibson's (2003) results, it is useful to summarize below (in Table 3.8) the differences in experimental design and results between Hsiao and Gibson (2003) and Experiment 1 in the current work. Hsiao and Gibson looked at RC types and levels of embedding. As discussed earlier, the double embedding that Hsiao and Gibson investigated was confounded by nested dependencies making SRCs more difficult than ORCs. All RCs in their study modified the subject positions. In Experiment 1, we looked at RCs modifying both subjects and objects and showed that the difference between SRCs and ORCs was larger when the RCs modified objects.

Table 3.8. Comparison between Hsiao and Gibson (2003) and Experiment 1

	Hsiao and Gibson (2003)	Experiment 1 of Lin (2006)
Variables	RC types {SRC vs. ORC} Levels of embedding {single vs. double}	RC types {SRC vs. ORC} Modification types {subject-modifying vs. object-modifying}
Participant age	45	21
Experimental setting	During a wedding (for 7 participants)	In the middle of the semester, at a lab (in a university)
Presentation	Words were separated by spaces.	Words were not separated by spaces.
Materials	Many of the verbs took nominal objects, sentential complements, and/or verbal complements. Some verbs appeared in serial verb constructions.	All the verbs predominantly took nominal objects. All verbs appeared by themselves.
Comprehension Accuracy	Low (71.6% for the target sentences, 88.7% for the filler sentences)	High (84.63% for both the target and filler sentences)
Reading Times	SRCs were harder than ORCs at the combined pre-relativizer regions.	SRCs were <i>easier</i> than ORCs at the relativizer and head-noun regions.

The relatively older age of the participants, the experimental setting, the ambiguous verbs used in the materials, and the lower accuracy in responding to comprehension questions have undermined the validity of Hsiao and Gibson's results. One additional experimental difference between the two studies concerns the presentation of experimental items. In Experiment 1, we did not use spaces to separate the words in a sentence because typical Chinese sentences do not have any spaces. Word boundaries are not marked by spaces in

Chinese. Separating words with spaces, as Hsiao and Gibson did, likely made the reading process rather unnatural.

In summary, even though RCs in Mandarin precede the head nouns, the construction of filler-gap relations does not start until the head noun is reached. This suggests that there exists no active gap prior to the relativizer. The head noun initiates a gap-searching process in the same way as a language with head-initial RCs. We conclude that with better control on various factors, Experiment 1 obtained processing preferences for SRCs over ORCs on the relativizer and the head noun (where filler-gap relations are constructed). In Mandarin Chinese, it is, therefore, reasonable to conclude that SRCs are easier to comprehend than ORCs. These results support a structure-based theory, but contradict a locality-based theory, a theory of canonical word order, and a theory based on parallel function or perspective shifting.

3.5 A Typology of Relative-Clause Processing

We are now in a position to put all the experimental data across various languages together to evaluate the processing theories discussed in 3.2. Table 3.9 summarizes the RC properties in the languages reviewed and the processing preferences reported by various studies.

Table 3.9. Typology of Preferences for RC Processing

Language	RC Word Order	RC position	Preference	Task	References
Brazilian Portuguese	SVO	Postnominal	SRC	RSVP	Gouvea (2003)
Dutch	SOV	Postnominal	SRC	Self-paced reading	Frazier (1987b)
			SRC	Self-paced reading Eye-movement monitoring	Mak, Vonk, & Schriefers (2002)
English	SVO	Postnominal	SRC	Continuous Lexical Decision Task	Ford (1983)
			SRC	Self-paced reading	King and Just (1991), Gibson, Desmet, Grodner, Watson, & Ko (2005)
			SRC	Eye-movement monitoring	Traxler, Morris, & Seely (2002)
				ERP	King & Kutas, 1995
French	SVO (flexible)	Postnominal	SRC	phoneme-monitoring task	Frauenfelder, Segui, & Mehler (1980)
			SRC	click-monitoring	Cohen & Mehler (1996)
			SRC	Eye-movement monitoring	Holmes and O'Regan (1981)
German	SOV	Postnominal	SRC	Self-paced reading	Schriefers, Friederici, and Kuhn (1995)
			SRC	ERP	Mecklinger, Schriefers, Steinhauer, & Friederici's (1995)
Mandarin	SVO	Prenominal	ORC	Self-paced reading	Hsiao & Gibson (2003)
			SRC	Self-paced reading	Experiment 1 (Lin, 2006)
Japanese	SOV	Prenominal	SRC	Self-paced reading	Miyamoto & Nakamura (2003)
Korean	SOV	Prenominal	SRC	Self-paced reading	Kwon, Polinsky, & Kluender (2005)

Except Hsiao and Gibson's finding of an ORC preference for Mandarin, all other studies confirmed the asymmetrical preference for SRCs. Experiment 1 as presented in 3.4 resolved the discrepancy that Hsiao and Gibson's study created for a universal account across languages. These crosslinguistic results supported a structure-based processing theory, such as the Incremental Minimalist Parser, but contradicted the predictions of a template (word order)-based theory, a locality theory based on linear distance or numbers of interfering discourse referents (Gibson, 1998), and a theory based on parallel functions and perspective shifts. In the next chapter, we provide further evidence that supports this subject preference by looking at the processing of possessor relative clauses in Mandarin.

Appendix A.

Target Experimental Items of Experiment 1.

exp1 1

熟識富人的國代遇見了牧師。
富人熟識的國代遇見了牧師。
牧師遇見了熟識富人的國代。
牧師遇見了富人熟識的國代。

exp1 2

配合家屬的刑警恨透了嫌犯。
家屬配合的刑警恨透了嫌犯。
嫌犯恨透了配合家屬的刑警。
嫌犯恨透了家屬配合的刑警。

exp1 3

告發校長的學生很信任父母。
校長告發的學生很信任父母。
父母很信任告發校長的學生。
父母很信任校長告發的學生。

exp1 4

奉承小開的男子看不起專家。
小開奉承的男子看不起專家。
專家看不起奉承小開的男子。
專家看不起小開奉承的男子。

exp1 5

勾引院長的少女撞到了議員。
院長勾引的少女撞到了議員。
議員撞到了勾引院長的少女。
議員撞到了院長勾引的少女。

exp1 6

欣賞董事的秘書暗戀著主任。
董事欣賞的秘書暗戀著主任。
主任暗戀著欣賞董事的秘書。
主任暗戀著董事欣賞的秘書。

exp1 7

責怪縣長的居民問候著立委。
縣長責怪的居民問候著立委。
立委問候著責怪縣長的居民。
立委問候著縣長責怪的居民。

exp1 8

帶來里長的攤販怒罵著農民。
里長帶來的攤販怒罵著農民。
農民怒罵著帶來里長的攤販。
農民怒罵著里長帶來的攤販。

exp1 9

打昏包商的歹徒見到了記者。
包商打昏的歹徒見到了記者。
記者見到了打昏包商的歹徒。
記者見到了包商打昏的歹徒。

exp1 10

敬佩教練的選手招呼著會長。
教練敬佩的選手招呼著會長。
會長招呼著敬佩教練的選手。
會長招呼著教練敬佩的選手。

exp1 11

雇用員工的律師糾正了經理。
員工雇用的律師糾正了經理。
經理糾正了雇用員工的律師。
經理糾正了員工雇用的律師。

exp1 12

陪伴課長的職員打傷了暴民。
課長陪伴的職員打傷了暴民。
暴民打傷了陪伴課長的職員。
暴民打傷了課長陪伴的職員。

exp1 13

責怪家長的老師誤導了學生。
家長責怪的老師誤導了學生。
學生誤導了責怪家長的老師。
學生誤導了家長責怪的老師。

exp1 14

檢舉廠商的市民逼瘋了官員。
廠商檢舉的市民逼瘋了官員。
官員逼瘋了檢舉廠商的市民。
官員逼瘋了廠商檢舉的市民。

exp1 15

包庇|商人的|政客|低估了|部長。
 商人|包庇的|政客|低估了|部長。
 部長|低估了|包庇|商人的|政客。
 部長|低估了|商人|包庇的|政客。

exp1 16

巴結|隊長|的|老翁|趕走了|書記。
 隊長|巴結|的|老翁|趕走了|書記。
 書記|趕走了|巴結|隊長|的|老翁。
 書記|趕走了|隊長|巴結|的|老翁。

exp1 17

殺死|台商|的|少年|不認識|醫師。
 台商|殺死|的|少年|不認識|醫師。
 醫師|不認識|殺死|台商|的|少年。
 醫師|不認識|台商|殺死|的|少年。

exp1 18

照顧|祖母|的|男子|吵醒了|隊長。
 祖母|照顧|的|男子|吵醒了|隊長。
 隊長|吵醒了|照顧|祖母|的|男子。
 隊長|吵醒了|祖母|照顧|的|男子。

exp1 19

救活|遊客|的|農民|很尊敬|老闆。
 遊客|救活|的|農民|很尊敬|老闆。
 老闆|很尊敬|救活|遊客|的|農民。
 老闆|很尊敬|遊客|救活|的|農民。

exp1 20

聯絡|媒體|的|畫家|很愛慕|歌手。
 媒體|聯絡|的|畫家|很愛慕|歌手。
 歌手|很愛慕|聯絡|媒體|的|畫家。
 歌手|很愛慕|媒體|聯絡|的|畫家。

exp1 21

陷害|雇主|的|勞工|拜訪了|貴賓。
 雇主|陷害|的|勞工|拜訪了|貴賓。
 貴賓|拜訪了|陷害|雇主|的|勞工。
 貴賓|拜訪了|雇主|陷害|的|勞工。

exp1 22

玩弄|女子|的|商人|看到了|警探。
 女子|玩弄|的|商人|看到了|警探。
 警探|看到了|玩弄|女子|的|商人。
 警探|看到了|女子|玩弄|的|商人。

exp1 23

邀集|工人|的|民眾|沒遇見|市長。
 工人|邀集|的|民眾|沒遇見|市長。
 市長|沒遇見|邀集|工人|的|民眾。
 市長|沒遇見|工人|邀集|的|民眾。

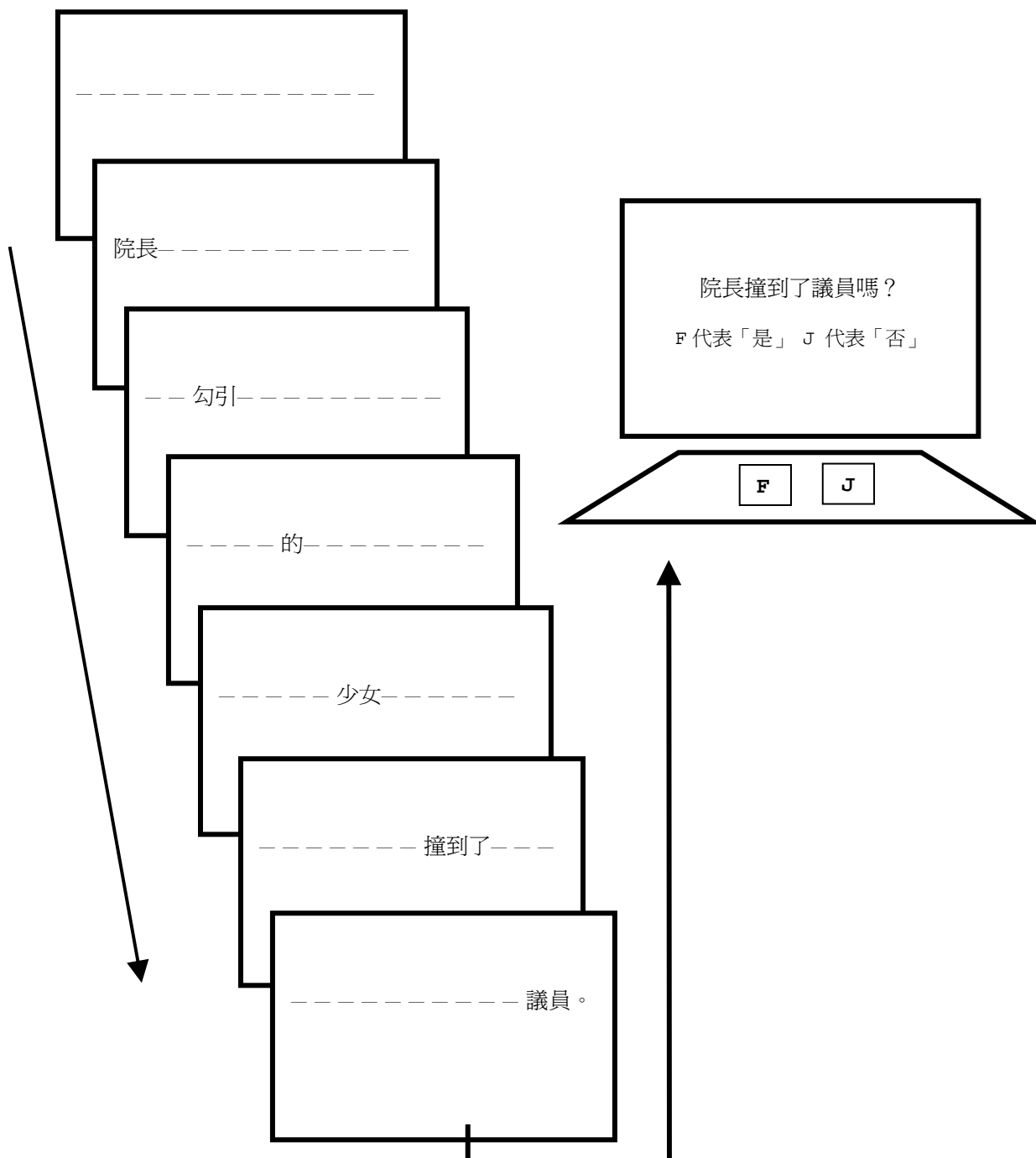
exp1 24

迴避|客戶|的|小姐|找到了|法師。
 客戶|迴避|的|小姐|找到了|法師。
 法師|找到了|迴避|客戶|的|小姐。
 法師|找到了|客戶|迴避|的|小姐。

Appendix B.

Sample Computer Screen for the Self-Paced Reading Tasks in Chinese

For the sentence 院長勾引的少女撞到了議員。 , the participants saw the following presentations on the computer screen:



CHAPTER 4

PROCESSING POSSESSOR RELATIVE CLAUSES IN MANDARIN CHINESE

This chapter explores the construction of filler-gap dependencies in Chinese possessor relative clauses (PRCs), which are different from typical relative clauses (RCs) because Chinese PRCs appear gapless on the surface, with the head noun and a nominal element in the RC holding a possessive relationship. The PRC data show that in Mandarin Chinese, a language with head-final RCs, there is a processing preference for head nouns associated with possessees at the subject position than head nouns associated with possessees at an object position, despite the fact that the subject position is linearly farther away from the head noun. Three experiments investigating possessees located at different structural positions confirmed this subject preference, including naturalness and grammaticality ratings (Experiment 2), paraphrasing of sentences with PRCs (Experiment 3), and self-paced reading tasks (Experiment 4). The results supported a structure-based theory. Issues regarding locality and canonicity will also be discussed.

4.1 Introduction

As human language is replete with dependent relations within and across sentences, one crucial task of the parser concerns the efficient recovery of such relations and their correct interpretation. Various factors are important, including the required processing load (often discussed in terms of working memory), the complexity of the processed materials,

human syntactic knowledge, etc.²⁸ Most previous research focused on the first two factors. When a sentence consumes more processing resources, it is assumed to be more difficult and thus takes longer to understand. Similarly, when a sentence is more complicated or less usual, it requires longer processing time. However, the third factor, i.e. the structural properties of different syntactic positions in strategic on-line processing, has not been studied as much. In Chapter 3, we looked at how RCs that involve different kinds of extractions are processed. Studies of focus positions and their salience for processing are also examples of this vein of inquiry (see for example Birch, Albrecht, & Myers, 2005, and Frazier, Clifton, Rayner, Deevy, Koh, & Bader, 2005). In this chapter, I present additional data that support structural knowledge as a prominent factor in sentence processing.

Structural or syntactic knowledge refers to knowledge about specific positions in the syntactic structure. This knowledge allows the human parser to recover structure and access positions in an efficient fashion. For example, in a probe-goal model such as Chomsky (2001), the parser has specific and direct access to certain syntactic positions (e.g. probing from I-head to spec-IP). A top-down parsing model like the Incremental Minimalist Parser (IMP), discussed in Chapter 2, also hinges upon syntactic knowledge.

The experimental data with possessor relative clauses (PRCs) suggests that surface subject positions are the easiest position for the parser to access. In what follows, section 4.2 discusses classic effects such as locality and canonicity. Section 4.3 introduces Chinese PRCs and issues regarding filler-gap dependencies. Sections 4.4 to 4.6 present

²⁸ This is not meant to underestimate the importance of semantic and pragmatic knowledge in processing dependencies. However, in this chapter, we mainly focus on the syntactic aspect of dependent relations.

three experiments on the comprehension of Mandarin PRCs. Section 4.7 discusses the implications of the experimental results and the process of gap-searching in the framework of IMP. Crosslinguistic evidence from Japanese and Turkish will also be discussed.

4.2 Locality and Canonicity

In this section, we discuss two important factors in sentence processing—locality and canonicity, both of which are relevant in understanding the experiments on PRC processing, which are reported in sections 4.4-4.6.

4.2.1 Locality

Locality-based theories of sentence comprehension posit that when two dependent elements are farther away from each other, the dependency is more time consuming to construct. Frazier and d'Arcais (1989) call this the Active Filler Strategy, which we discussed in Chapter 3.

This strategy accounts for Stowe's (1986) observation that (1b) is more likely to lead to garden path than (1a). In on-line word-by-word reading, as soon as a filler is detected, the filler is expected to fill a gap at each potential point (indicated by the underlined spaces).

(1) a. My brother wanted to know *if* Ruth will bring us home to Mom at Christmas.

b. My brother wanted to know *who* Ruth will bring us home to at Christmas.

Gibson's (1998) Syntactic Prediction Locality Theory (SPLT) (a.k.a. Dependency Locality Theory) extends this strategy by focusing on the cognitive resources required during on-line sentence processing. Both the Active Filler Strategy and SPLT predict that

sentences with locally dependent elements are easier to understand than those with distant relations. As will be shown in this chapter, however, a locality-based theory is not adequate to account for the processing preferences observed on Chinese PRCs.

4.2.2 Canonicity

The effect of canonicity predicts that sentences that undergo more complex syntactic derivations are more difficult to comprehend than sentences that resemble base-generated word orders. The assumption is that in order to understand a sentence, the parser has to recover the base-generated structure; a sentence that has all elements in situ is easier than a sentence with elements displaced. This complexity is also due to more complicated thematic assignment involved in sentences with movement. If we assume that thematic roles are assigned at the base-generated positions, then sentences with displacement are more difficult because the moved elements have to be associated with the traces to receive their theta roles.

In English, this theory has received support from evidence that passives are more difficult to comprehend than actives. Ferreira (2003: 164), for example, asked participants to identify thematic roles in aurally presented sentences, and found that people adopted “simple processing heuristics” that relied on canonical word order. Passives, with the thematic roles appearing at non-typical positions, induce more errors in identifying thematic roles than their active counterparts.

In languages with scrambling, it has also been found that sentences with scrambling tend to be harder than sentences with words in situ. This has been confirmed in Japanese, as scrambled sentences took longer both to read (Mazuka, Itoh, & Kondo, 2002) and to be

judged as correct sentences (Tamaoka, Sakai, & Kawahara, 2003, 2005).

Both locality and canonicity are well-attested. However, we will demonstrate that in Chinese sentences with PRCs, those with distant filler-gap dependencies and more complex syntactic structures (e.g. passives) are actually easier to process than more local (in linear terms) and canonical ones. These results support a gap-searching mechanism that recognizes structural positions and performs a top-down search, resulting in the subject position being reached earlier.

4.3 Chinese Possessor Relative Clauses

Possessor relative clauses (PRCs) are relative clauses in which the head noun serves as the possessor of an NP within the relative clause. In languages like English, PRCs are overtly marked by the possessor relativizer *whose* as in (2).

(2) Possessor Relative Clause in English:

The lady *whose* daughter spilled some water has a loud voice.

In Chinese, there is no special relativizer that distinguishes PRCs from regular RCs.

Nevertheless, the possessive relationship between the head noun and the appropriate nominal element is established when the relativizer *de* and the head noun are reached. In (3), for instance, the head noun *nyushi* ‘lady’ serves as the possessor of *nyuer* ‘daughter’, the subject of the embedded RC.

(3) Possessor Relative Clause in Chinese:

_ **nyuer** dafan shui de nawei **nyushi** sangmen hen da
 daughter spill water DE that lady voice very loud
 ‘The lady whose daughter spilled the water has a loud voice.’

Chinese PRCs are different from the RCs typically considered in the literature because all argument slots seem filled on the surface. A possessor-possessee relationship, nevertheless, exists between the head noun and a nominal argument.²⁹ Because of this property, PRCs may be taken as thematically-complete sentences prior to the relativizer. Only when the relativizer and the head noun are reached is the process of gap-construction initiated.³⁰

Before getting into the different kinds of PRCs that we use in the experiments, it is useful to introduce the word-order properties associated with the semantic role of patient in Mandarin. The canonical position of the patient role in Mandarin is the object in an SVO sequence as in (4). It can also appear at the preverbal position following the morpheme *ba* (5), or at the subject position in a passive construction with *bei* (6).

(4) Zhangsan jieju le Lisi de wenti

Zhangsan solve ASP Lisi GEN problem

‘Zhangsan solved Lisi’s problem.’

²⁹ Both alienable and inalienable possessives can appear in these possessor relative clauses. The strength of the relation between the possessor and the possessee varies with the kind of semantic relation that holds between them. Inalienable relations, such as kinship relations, part-whole relations, and body-part relations, associate the possessor and possessee more closely. In this chapter, however, we mainly focus on the variant syntactic positions of the possessee. The semantic relations between the possessors and the possessee are of less relevance since they are kept constant across conditions. See Lin (2006) for evidence that inalienable nouns are processed with more efficiency than alienable nouns when integrating with the head nouns (i.e. the possessors).

³⁰ Note that the possessor gap within the PRCs can also be filled by an overt resumptive pronoun as in the following example:

ta de nyuer dafan shui de nawei nyushi sangmen hen da
she DE daughter spill water DE that lady voice very loud

‘The lady whose daughter spilled the water has a loud voice.’

In these cases, the PRCs are even more likely to be taken as argument-complete sentences. The filler-gap relation is not constructed until the head noun is reached.

(5) Zhangsan ba Lisi de wenti jieju le

Zhangsan BA Lisi GEN problem solve ASP

‘Zhangsan solved Lisi’s problem.’

(6) Lisi de wenti bei Zhangsan jieju le

Lisi GEN problem BEI Zhangsan solve ASP

‘Lisi’s problem was solved by Zhangsan.’

These variant positions of the patient role allow us to manipulate the position of a patient-associated gap in a PRC. In (7)-(9), the possessor gap is associated with the patient *maowu*. By locating the patient of the embedded PRC at different syntactic positions using the canonical structure, the *ba* construction, and the passive construction, we can manipulate the structural and linear distance between the filler and the gap. Sentence (7) contains a PRC with the canonical order of agent-verb-patient. Sentence (8) contains the *ba* variant with the patient preposed to the pre-verbal position. Sentence (9) contains the passive *bei* construction, where the patient is at the initial subject position.

(7) Chinese possessor relative clause with canonical order (*agent-V-patient*):

taifeng chuikua _ **maowu** de **nongren** gandao shifen juewang

typhoon blow.down hut de farmer feel very despair

‘The farmer whose hut the typhoon blew down was in despair.’

(8) Chinese possessor relative clause with *ba* (*agent-BA-patient-V*):

taifeng ba _ **maowu** chuikua de **nongren** gandao shifen juewang

typhoon BA hut blow.down de farmer feel very despair

‘The farmer whose hut the typhoon blew down was in despair.’

(9) Chinese possessor relative clause in the passive construction (*patient-BEI-agent-V*):

_ **maowu** bei taifeng chuikua de **nongren** gandao shifen juewang

hut BEI typhoon blow.down de farmer feel very despair

‘The farmer whose hut was blown down by the typhoon was in despair.’

As far as linear locality is concerned, the distance between the filler and the gap is longest in passives, shorter in *ba* sentences, and shortest in canonical sentences. A theory based on (linear) locality, in which the parser searches the NPs that are most recent first, resembling a stack, push-down automaton, would predict (9) > (8) > (7) in terms of difficulty.

The canonicity factor also predicts (8) and (9) to be more difficult than (7) because passives and BA sentences involve more complex syntactic derivations and trace relations than their canonical variants.³¹ However, a structure-based theory predicts that the gap located at the subject position as in the passive construction should receive an advantage. Three experiments were conducted to test the validity of these predictions.

4.4 Experiment 2: Naturalness and Grammaticality Ratings

Experiment 2 was composed of questionnaires that collected naturalness and grammaticality ratings of four sets of experimental sentences, including sentences with PRCs and three sets of baseline sentences. The purpose of this experiment was to get at whether sentences with the possessor gaps located at different syntactic positions were perceived differently by language users. We compared possessives located at the canonical

³¹ The semantics associated with BA and the passive construction, though important in its own right, is not a factor here, since the semantic differences depicted in the literature have more to do with the information/discourse status across sentences rather than the semantics within the sentences themselves. In the experiments reported below, the sentences all appeared independently without context. The discourse effect or information difference, if any, is expected to be minimal.

object position, the preverbal position following BA, and the subject position in a passive construction. In order to show that the pattern of difficulty observed resulted from the different possessee positions, we also collected ratings for baseline sentences, which do not involve filler-gap relations.

4.4.1 Participants

Fifty-seven undergraduate students (9 males, 42 females, 6 unidentified) from National Cheng-Chi University participated in this experiment. The participants were all native speakers of Mandarin Chinese between the age of 19 and 22. The average age of the participants was 20. These participants did not participate in any other experiments reported in this dissertation.

4.4.2 Materials

The materials included three sets of baseline sentences in addition to the target PRCs. The purpose of the baseline sentences was to establish the general pattern of structural preferences without the influence of filler-gap dependencies, so that the particularity of filler-gap relations in PRCs can be revealed in comparison. These baseline sentences included (i) simple sentences, (ii) sentences with normal relative clauses, and (iii) sentences with adjunct relative clauses. For each set of sentences, the canonical, *ba* and *bei* (passive) variants were all rated. (10)-(12) are examples of the first set of baseline sentences in the three constructions.

(10) Baseline simple sentences (canonical version):

kexuejia jiejie le xuduo miti

scientist solve ASP many puzzle

‘Scientists have solved many puzzles.’

(11) Baseline simple sentences (BA version):

kexuejia ba xuduo miti jiejie le

scientist BA many puzzle solve ASP

‘Scientists have solved many puzzles.’

(12) Baseline simple sentences (passive BEI version):

xuduo miti bei kexuejia jiejie le

many puzzle BEI scientist solve ASP

‘Many puzzles have been solved by scientists.’

(13)-(15) are examples of sentences that contain nouns modified by simple relative clauses. These second set of baseline sentences were included mainly to increase the difficulty level of the baseline sentences. Since the relative clauses in these sentences modified either the subject or the object argument of the matrix clause, the relation between the filler and the gap remains constant across conditions. The different constructions moved the NP to different positions without affecting the RC-internal construction. We used this set of baseline sentences simply to compare canonical, BA, and BEI sentences that are more complicated than simple sentences.

(13) Baseline sentences with relative clauses (canonical version):

bianju xinshang de yanyuan dianran le lazhu
 playwright like DE actor light ASP candle
 ‘The actor that the playwright admires lit the candle.’

(14) Baseline sentences with relative clauses (BA version):

bianju xinshang de yanyuan ba lazhu dianran le
 playwright like DE actor BA candle light ASP
 ‘The actor that the playwright admires lit the candle.’

(15) Baseline sentences with relative clauses (passive BEI version):

lazhu bei bianju xinshang de yanyuan dianran le
 candle BEI playwright like DE actor light ASP
 ‘The candle was lit by the actor that the playwright admires.’

The third set of baseline sentences (16)-(18) are sentences with adjunct RCs. For these sentences, we varied the structure of the pre-relativizer RC section, which are argument-complete clauses. This set of baseline sentences is of special interest for our comparison because their surface structures are exactly the same as the sentences with PRCs. The only difference between adjunct RCs and PRCs is that PRCs involve filler-gap relations between the head noun and an argument in the RC, while the head nouns in adjunct RCs are not associated with any particular gaps in the RC.

(16) Baseline sentences with adjunct relative clauses (canonical version):

liwei shanchu yusuan de liyou hen nan rang ren jieshou
 legislator cut budget DE reason very hard make person accept
 ‘The reason why legislators cut the budgets was difficult to accept.’

(17) Baseline sentences with adjunct relative clauses (BA version):

liwei ba yusuan shanchu de liyou hen nan rang ren jieshou
 legislator BA budget cut DE reason very hard make person accept
 ‘The reason why legislators cut the budgets was difficult to accept.’

(18) Baseline sentences with adjunct relative clauses (passive BEI version):

yusuan bei liwei shanchu de liyou hen nan rang ren jieshou
 budget BEI legislator cut DE reason very hard make person accept
 ‘The reason why the budgets were cut by the legislators was difficult to accept.’

The target sentences of this experiment were sentences with PRCs. Examples of PRCs in (7)-(9) are repeated below for comparison. If we can observe different patterns especially between the adjunct RCs and the PRCs, then it is reasonable to conclude that this difference resulted from the additional filler-gap associations between the head noun and the possessed argument in the PRCs, which do not exist in adjunct RCs.

(7) Chinese possessor relative clause with canonical order (*agent-V-patient*):

taifeng chuikua _ maowu de nongren gandao shifen juewang
 typhoon blow down hut de farmer feel very despair
 ‘The farmer whose hut the typhoon blew down was in despair.’

(8) Chinese possessor relative clause with *ba* (*agent-BA-patient-V*):

taifeng ba _ maowu chuikua de nongren gandao shifen juewang
 typhoon BA hut blow down de farmer feel very despair
 ‘The farmer whose hut the typhoon blew down was in despair.’

(9) Chinese possessor relative clause in the passive construction (*patient-BEI-agent-V*):

_ maowu bei taifeng chuikua de nongren gandao shifen juewang
 hut BEI typhoon blow down de farmer feel very despair
 ‘The farmer whose hut was blown down by the typhoon was in despair.’

Each set of the experimental materials contained 24 different sentences, which appeared in one of the three structural variants (i.e. canonical, BA, & BEI constructions) in each questionnaire. Three different questionnaires were created, each of which contained 24 simple sentences (Baseline I), 24 sentences with RCs (Baseline II), 24 sentences with adjunct RCs (Baseline III), 24 sentences with PRCs (experimental group), and 77 filler sentences of various sentence types and grammaticality status. For each set of the baseline and experimental sentences, 8 sentences were in the canonical variant, 8 in the *ba* construction, and 8 in the passive construction. Each sentence was presented only in one variant (canonical, *ba*, or passive) in each questionnaire. Each questionnaire was composed of a total of 173 sentences. All the experimental materials are provided in Appendix C.

4.4.3 Procedure

Each participant was randomly given one questionnaire, which started with questions about their linguistic background, followed by a set of instructions and examples.

Participants were instructed to rate the naturalness of each sentence on a scale of 1 (very natural) to 6 (very unnatural). Immediately following each naturalness rating, they were asked to rate the grammaticality of each sentence. Three choices were given: grammatical, ungrammatical, and unsure (selected when the participants were unsure of the grammatical status of the sentence). Each questionnaire was completed in an average of 25 minutes.

4.4.4 Results

The questionnaires of two participants (both female) were excluded due to apparent carelessness in their responses. The analyses were based on data from 55 questionnaires (9 males, 40 females, 6 unidentified). The average of all naturalness ratings (including filler sentences) was 3.12 (SD = 1.98). The means and SDs (given in parentheses) of each condition are given in Table 4.1.

Table 4.1. Experiment 2: Average Naturalness Rating of each Experimental Condition

	Baseline I: Simple Sentences	Baseline II: Sentences with RCs	Baseline III: Sentences with Adjunct RCs	Target Condition: Sentences with PRCs
Canonical	1.41 (0.39)	1.64 (0.55)	1.75 (0.56)	4.48 (0.81)
BA	1.52 (0.55)	1.84 (0.66)	2.51 (0.85)	4.92 (0.80)
BEI	1.79 (0.76)	2.27 (0.79)	3.03 (0.84)	2.87 (1.09)

ANOVAs with repeated measures showed significant differences in main effects across sentence types ($F(3, 162) = 502.30, p < 0.001$) and construction variants ($F(2, 108) = 23.53, p < 0.001$) by subject analysis. The different construction variants within each sentence type were also significantly different from each other by item analysis (simple sentences: $F(2, 46) = 5.17, p < 0.05$; sentences with RCs: $F(2, 46) = 11.91, p < 0.001$;

sentences with adjunct RCs: $F(2, 46) = 21.34, p < 0.001$; sentences with PRCs: $F(2, 46) = 102.47, p < 0.001$).

Further paired-samples t-tests showed that the construction variants within each sentence type were significantly different from each other by subject analysis ($p < 0.05$). By item analysis, passives were rated less natural than both canonical and *ba* variants for simple sentences ($t(23) = 2.90, p < 0.01$; $t(23) = 2.27, p < 0.05$), sentences with RCs ($t(23) = 6.10, p < 0.001$; $t(23) = 2.96, p < 0.01$), and sentences with adjunct RCs ($t(23) = 6.51, p < 0.001$; $t(23) = 2.14, p < 0.05$), but *more* natural than both the canonical and BA variants for PRCs ($t(23) = 9.56, p < 0.001$; $t(23) = 12.37, p < 0.001$). A bar chart with the means of each group is given in Figure 4.1.

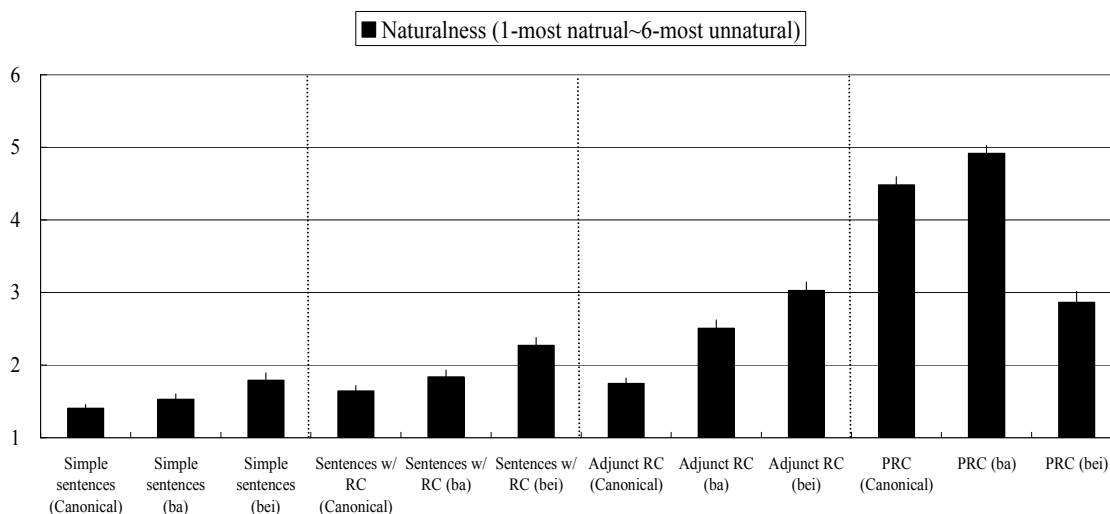


Figure 4.1. Bar chart for the naturalness scores in Experiment 2.

Similar patterns were found with the grammaticality judgments. Table 4.2 gives the percentage of responses in each category.

Table 4.2. Experiment 2: Percentage of Grammaticality Judgments in each Condition

	Baseline I: Simple Sentences			Baseline II: Sentences w/ RC			Baseline III: Adjunct RCs			Target Condition: Possessor RCs		
	gram.	ungram.	unsure	gram.	ungram.	unsure	gram.	ungram.	unsure	gram.	ungram.	unsure
Canonical	96.10	3.21	0.68	92.89	5.75	1.36	88.56	7.95	3.48	18.06	77.62	4.32
BA	92.01	6.85	1.14	85.68	13.18	1.14	71.07	24.84	4.09	10.39	83.86	5.75
BEI	86.69	10.81	2.50	77.14	18.96	3.90	58.57	37.27	4.16	65.02	31.96	3.02

(gram. = grammatical, ungram. = ungrammatical)

We only focus on the percentages of grammatical judgments for simplicity of presentation; the ungrammatical percentages follow exactly same patterns, only in the opposite direction. ANOVAs with repeated measures showed significant differences in main effects across sentence types ($F(3, 162) = 509.22, p < 0.001$) and construction variants ($F(2, 108) = 19.96, p < 0.001$) by subject analysis. The different construction variants within each sentence type were significantly different from each other by item analysis (simple sentences: $F(2, 46) = 5.92, p < 0.01$; sentences with RCs: $F(2, 46) = 10.50, p < 0.001$; sentences with adjunct RCs: $F(2, 46) = 14.30, p < 0.001$; sentences with PRCs: $F(2, 46) = 111.68, p < 0.001$). Further paired-samples t-tests showed that the construction variants within each sentence type were significantly different from each other by subject analysis ($p < 0.05$). By item analysis, passives were rated less grammatical than the canonical variants for simple sentences ($t(23) = 3.07, p < 0.01$), less grammatical than both canonical and *ba* variants for sentences with RCs ($t(23) = 5.68, p < 0.001$; $t(23) = 2.27, p < 0.05$), and less grammatical than canonical variants for sentences with adjunct RCs ($t(23) = 4.92, p < 0.001$). Passives were, however, rated *more* grammatical than both the canonical and BA variants for PRCs ($t(23) = 11.31, p < 0.001$; $t(23) = 11.43, p < 0.001$). Figure 4.2 illustrates the patterns of these grammaticality ratings.

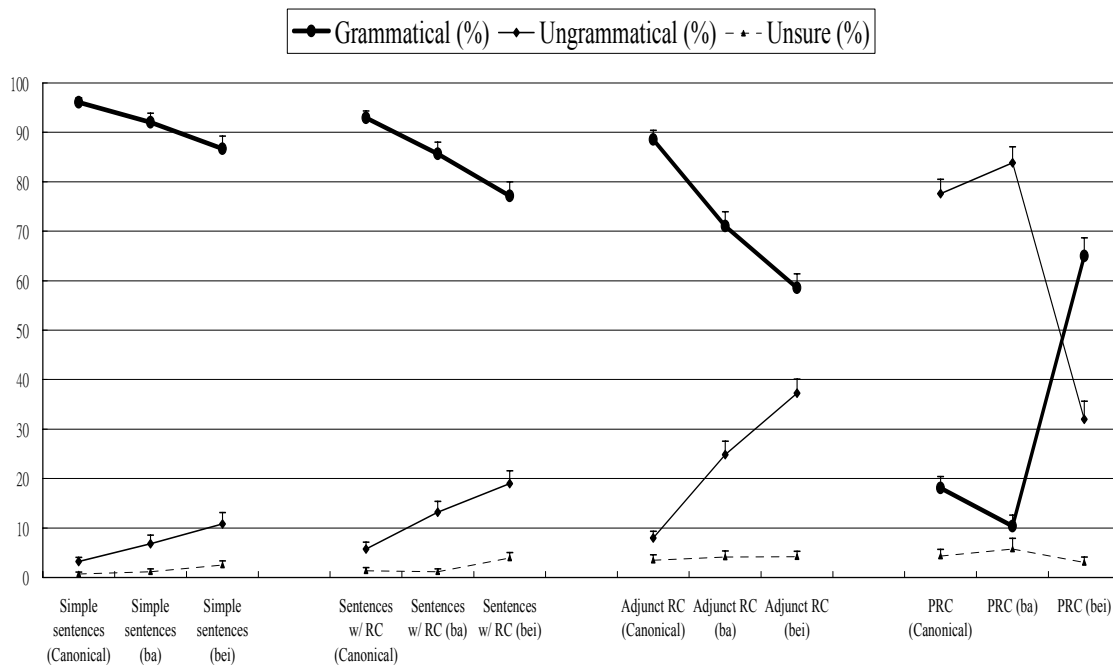


Figure 4.2. Percentages of grammaticality ratings in Experiment 2.

4.4.5 Discussion

The results for all the baseline sentences showed a very similar trend. The canonical variants were rated more natural than the *ba* variants. Passives were rated most unnatural and most ungrammatical. This confirms the canonicity effect. However, such a pattern was only partially observed on PRCs. PRCs with *ba* were rated more difficult and less grammatical than their canonical counterparts. Passive PRCs were, however, rated more natural and more grammatical than both the canonical and the BA variants. These results suggested that when no filler-gap relations are involved, the naturalness of the sentences can be predicted by how canonical the sentences are. However, when a filler-gap relation needs to be constructed, a gap that is located at the subject position, as in the sentences with passive PRCs, received advantage. The gap-searching effect overrode the effect of

canonicity, resulting in passive PRCs being considered more natural than the canonical and *ba* PRCs.

4.5 Experiment 3: Paraphrasing Tasks

Since these PRCs were quite uncommon and predominantly rated as rather unnatural, we collected paraphrases of the sentences with PRCs in Experiment 3 to get at how they were actually understood, and whether the possessive relations between the head nouns and the possessed arguments were really perceived.

4.5.1 Participants

Eighty-three undergraduate students (14 males, 62 females, 7 unidentified) from National Cheng-Chi University, National Taipei Teachers' College, and National Hsin-Chu Teacher's College participated in this experiment. The participants were all native speakers of Mandarin Chinese between the age of 19 and 22. None of them participated in any other experiments reported in this dissertation.

4.5.2 Materials

Twelve sets of sentences with PRCs were selected from those used in Experiment 1. These sentences were quasi-randomly placed into 4 questionnaires. Each questionnaire contained 9 sentences that were randomly ordered. Each participant only paraphrased at most one structure variant of each sentence.

4.5.3 Procedure

Participants were instructed to carefully read each sentence and then use their own words to paraphrase the sentences. They were instructed to put a cross on the sentences that they did not understand. The whole questionnaire took about 10 minutes to finish.

4.5.4 Results and Discussion

Among all the 741 collected paraphrases, participants were able to paraphrase 638 correctly. The overall accuracy of correct paraphrases was 86.1%. This shows that most of the sentences with PRCs were understood and interpreted correctly. Among these correct paraphrases, 331 responses (51.88%) overtly specified the possessive relation between the head noun and the possessed NP. Among the sentences that were not understood correctly, only 18% were passive PRCs; 38% were canonical PRCs; 44% were PRCs with BAs. This further confirms the findings in Experiment 2 that passive PRCs were easier to comprehend. The raw frequencies and percentages of accurate and inaccurate paraphrases are given in Table 4.3.

Table 4.3. Frequencies and Percentages of Correct and Incorrect Paraphrases among PRCs

Possessor RCs	Correct Paraphrasing		Incorrect Paraphrasing	
	N	%	N	%
Canonical	207	83.81	40	16.19
BA	202	81.78	45	18.22
BEI	228	92.31	19	7.69

In addition to the accuracy of interpretations, the percentage of correct paraphrases that overtly mentioned possessive relations was also calculated. Passive PRCs were most likely (59%) to induce overt mentioning of possessive relations in paraphrasing.³² These results are reported in Table 4.4.

³² Note, however, that the overt mentioning of possessive relations was an underestimate of the possessive relations that were actually perceived, since not all perceived possessive relations got reported. These data were, nevertheless, indicative that the possessive relations in passive PRCs were more obvious than those in canonical and BA PRCs.

Table 4.4. Frequencies and Percentages of Possessive Relations Identified
in the Correct Paraphrases across Structure Types

Possessor RCs	Possessive Relations Identified	
	N	%
Canonical	101	48.79
BA	94	46.53
BEI	135	59.21

The results of this experiment confirmed the advantage for passive PRCs found in Experiment 2. Participants were able to correctly understand sentences with PRCs. Passive PRCs were most likely to be correctly interpreted. They also established a stronger possessive relation between the filler and the gap, resulting in a higher percentage of possessive relations being reported in the paraphrases of passive PRCs.

4.6 Experiment 4: Self-Paced Reading Tasks

Experiment 4 collected self-paced reading data so that we can understand the real-time process in understanding sentences of different constructions, and constructing filler-gap dependencies in different structures.

4.6.1 Participants

Twenty-six undergraduate students (8 m, 18 f) from National Cheng-Chi University were paid 150 NTD (approximately \$5.00) to participate in Experiment 4. The participants were all native speakers of Mandarin Chinese between the age of 19 and 22. They had normal vision, and were naïve to the purpose of the experiment. All of these participants also participated in Experiment 1 (reported in Chapter 3), only that Experiment 4 was conducted following Experiment 1 with a 5-minute break between the two experiments. None of the participants participated in the questionnaires (Experiment 2) or the

paraphrases (Experiment 3).

4.6.2 Materials

Experimental materials included the three sets of baseline sentences (i.e. simple sentences, sentences with RCs, & sentences with adjunct RCs) and the experimental sentences (i.e. sentences with PRCs) used in Experiment 2. These sentences were arranged into three lists by a Latin-square design. Each list contained 24 sentences from each set. These 24 sentences appeared in three structural variants in the three lists. Each list contained only one sentence in one structural variant. One hundred and four sentences of various types were added to each list as filler sentences. All sentences (200 in total) were randomly presented to the participants.

4.6.3 Procedure

The procedure of this experiment was the same as that of Experiment 1 (reported in Chapter 3). The whole experiment took about 30 minutes to complete.

4.6.4 Results

The data of one participant were excluded due to technical problems during the experiment. The average comprehension accuracy for all other participants for all trials was 94.46%. All the participants were able to answer at least 90% of the comprehension questions correctly. Reading time data were analyzed by collapsing words and phrases into regions. For simplification, only the RTs of the adjunct RCs and the PRCs were compared since these two sentence types matched best in their surface word orders, differing only in the existence of a filler-gap dependency. The average reading times per Chinese character for the whole sentences were calculated for comparison. In a 2 x 3

ANOVA analysis of repeated measures, we found main effects in both sentence types (adjunct RCs versus PRCs) ($F(1, 24) = 7.80, p < 0.10$) and construction variants (canonical, *ba*, and passives) ($F(2, 48) = 5.64, p < 0.01$; $F(2, 46) = 3.56, p < 0.05$ for adjunct RCs, $F(2, 46) = 11.24, p < 0.001$ for PRCs). The interaction was also significant ($F(2, 48) = 34.40, p < 0.001$).

Paired-samples *t*-tests showed that among the adjunct RCs, the passives took longer to comprehend than both the canonical variants ($t(24) = 3.59, p < 0.01$; $t(23) = 2.54, p < 0.05$) and the *ba* variants ($t(24) = 2.24, p < 0.05$; $t(23) = 1.54, p = 0.14$). RTs for the canonical adjunct RCs were shorter than those of the *ba* variants but the difference did not reach significance ($t(24) = 2.04, p = 0.05$; $t(23) = 1.14, p = 0.27$). Among the PRCs, passives were read faster than both the canonical ($t(24) = 5.56, p < 0.001$; $t(23) = 4.31, p < 0.001$) and *ba* variants ($t(24) = 5.48, p < 0.001$; $t(23) = 5.13, p < 0.001$). RTs for the canonical and *ba* PRCs were not significantly different ($t(24) = 0.08, p = 0.94$; $t(23) = 0.34, p = 0.74$). Comparing between adjunct RCs and PRCs within the same construction types, we found PRCs to be longer than adjunct RCs for both the canonical ($t(24) = 4.80, p < 0.001$) and the *ba* variants ($t(24) = 3.76, p < 0.01$), but *shorter* for the passives ($t(24) = 3.13, p < 0.01$). The mean RTs per character are given in Table 4.5.

Table 4.5. Mean RTs (ms) per Chinese Character of Adjunct RCs and

PRCs across Construction Variants (SDs in Parentheses)

	Sentences with Adjunct RCs	Sentences with PRCs
Canonical	332.80 (80.47)	412.74 (137.18)
BA	347.95 (80.11)	414.00 (141.21)
BEI	368.08 (89.88)	329.54 (89.07)

For by-region RT analyses, we labeled the different regions within the sentences with adjunct RCs and within the sentences with PRCs as the following.

(19) Sentences with adjunct relative clauses:

<i>Canonical</i>	liwei legislator N1	Shanchu cut V1	yusuan budget N2		de DE DE	liyou reason N3	...	V2
<i>BA</i>	liwei legislator N1	ba BA BA	yusuan budget N2	shanchu cut V1	de DE DE	liyou reason N3	...	V2
<i>BEI</i>	yusuan budget N1	bei BEI BEI	liwei legislator N2	shanchu cut V1	de DE DE	liyou reason N3	...	V2

(20) Sentences with possessor relative clauses:

<i>Canonical</i>	taifeng typhoon N1	chuikua blow down V1	maowu hut N2		de DE DE	nongren farmer N3	...	V2
<i>BA</i>	taifeng typhoon N1	ba BA BA	maowu hut N2	chuikua blow down V1	de DE DE	nongren farmer N3	...	V2
<i>BEI</i>	maowu hut N1	bei BEI BEI	taifeng typhoon N2	chuikua blow down V1	de DE DE	nongren farmer N3	...	V2

By-region reading time analyses are provided in Figures 4.3 and 4.4. We compared the RTs of the regions across conditions, especially focusing on the regions starting from the relativizer *de* where the relative clauses were recognized and the process of filler-gap identification was initiated. Both the RTs across sentence types and between construction variants were compared.

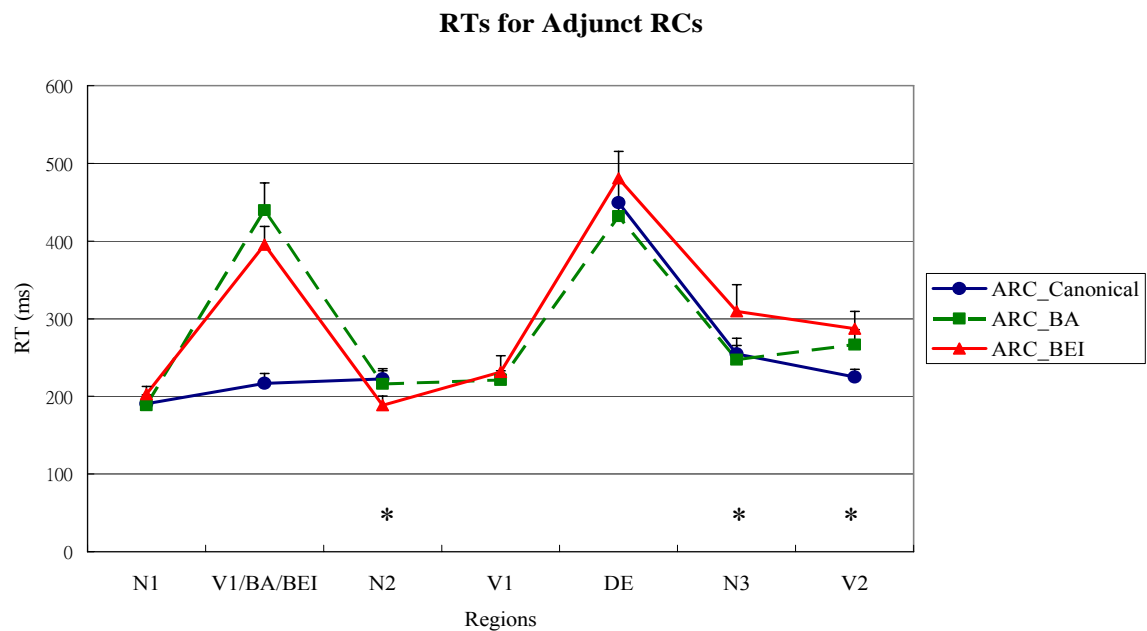


Figure 4.3. RTs (in ms) per Chinese character of adjunct RCs in three construction variants.

Focusing on adjunct RCs, the main effect of construction types was found on N2 ($F(2, 48) = 18.27, p < 0.001$; $F(2, 46) = 5.16, p < 0.01$), N3 ($F(2, 48) = 5.85, p < 0.005$; $F(2, 46) = 3.80, p < 0.03$) and V2 ($F(2, 48) = 7.02, p < 0.002$; $F(2, 46) = 5.60, p < 0.007$), but not on DE ($F(2, 48) = 0.31, p = 0.738$; $F(2, 46) = 1.54, p = 0.226$) or any other regions ($F_1s < 3.38, ps > 0.079$; $F_2s < 1.81, ps > 0.192$). At N2 of adjunct RCs, the passive variant was read more quickly than the canonical ($t(24) = 4.44, p < 0.001$; $t(23) = 3.29, p < 0.003$;) and the *ba* variants ($t(24) = 2.19, p < 0.039$; $t(23) = 2.26, p < 0.033$). RTs of passive adjunct RCs were longer than the canonical variants at N3 ($t(24) = 2.17, p < 0.04$; $t(23) = 2.09, p < 0.048$) and V2 ($t(24) = 3.45, p < 0.002$; $t(23) = 3.19, p < 0.004$), and longer than the *ba* variants at N3 ($t(24) = 2.18, p < 0.04$; $t(23) = 2.05, p = 0.052$). At V2, the *ba* variant was read longer than the canonical variant ($t(24) = 2.40, p$

< 0.025 ; $t_2(23) = 2.86$, $p < 0.009$).

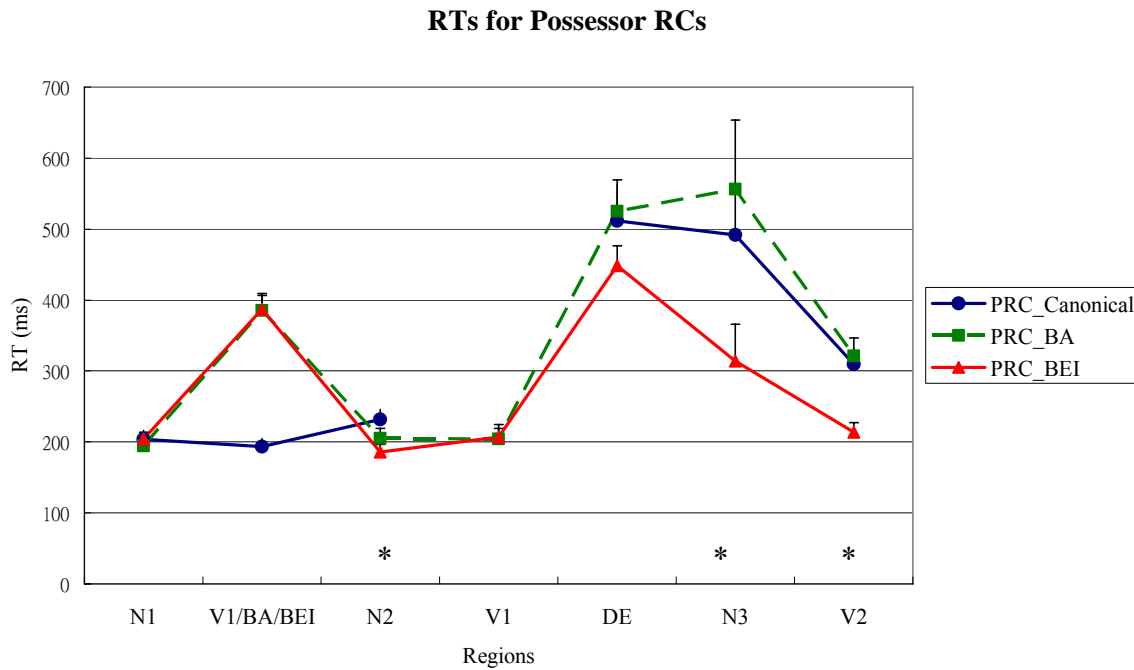


Figure 4.4. RTs (in ms) per Chinese character of PRCs in three construction variants.

For sentences with PRCs, the main effect of construction variants was found with N2 ($F_1(2, 48) = 18.27$, $p < 0.001$; $F_2(2, 46) = 6.82$, $p < 0.003$), N3 ($F_1(2, 48) = 5.85$, $p < 0.005$; $F_2(2, 46) = 10.56$, $p < 0.001$) and V2 ($F_1(2, 48) = 7.02$, $p < 0.002$; $F_2(2, 46) = 14.24$, $p < 0.001$), but not on DE ($F_1(2, 48) = 0.31$, $p = 0.738$; $F_2(2, 46) = 2.44$, $p = 0.148$) or any other regions ($F_1s < 3.38$, $ps > 0.079$; $F_2s < 1.08$, $ps > 0.348$). At N2 of PRCs, the passive variant was read more quickly than the canonical ($t_1(24) = 5.39$, $p < 0.001$; $t_2(23) = 3.18$, $p < 0.004$;) and the *ba* variants ($t_1(24) = 3.60$, $p < 0.001$; $t_2(23) = 1.54$, $p = 0.137$), and the *ba* variant was read more quickly than the canonical variant ($t_1(24) = 3.16$, $p < 0.004$; $t_2(23) = 2.70$, $p < 0.013$). RTs of passive adjunct RCs were *quicker* than the canonical variants at N3 ($t_1(24) = 4.31$, $p < 0.001$; $t_2(23) = 3.65$, $p < 0.001$) and V2

($t_1(24) = 4.58, p < 0.000$; $t_2(23) = 4.30, p < 0.001$), and also *quicker* than the *ba* variants at N3 ($t_1(24) = 4.14, p < 0.001$; $t_2(23) = 4.31, p = 0.001$) and V2 ($t_1(24) = 5.63, p < 0.001$; $t_2(23) = 6.06, p < 0.001$).

The main effect of RC type was found on V1 ($F(1, 24) = 11.33, p < 0.003$), and N3 ($F(1, 24) = 11.07, p < 0.003$), but not on any other regions ($F_s < 3.60, p_s > 0.070$). At V1, adjunct RCs took longer than PRCs. At N3, PRCs took longer than adjunct RCs. The interaction between the two main effects was significant at DE ($F(1, 24) = 4.59, p < 0.015$), N3 ($F(1, 24) = 14.36, p < 0.001$), and V2 ($F(1, 24) = 17.54, p < 0.001$), but not at other regions ($F_s < 2.51, p_s > 0.127$). At the regions including the relativizer *de*, the head noun, and the matrix verb, RTs for adjunct RCs were shorter than for PRCs in the canonical and BA constructions, but were *longer* than the PRC counterparts in passives. Figures 4.5, 4.6, and 4.7 demonstrate the by-region RTs across adjunct RCs and PRCs within each construction type.

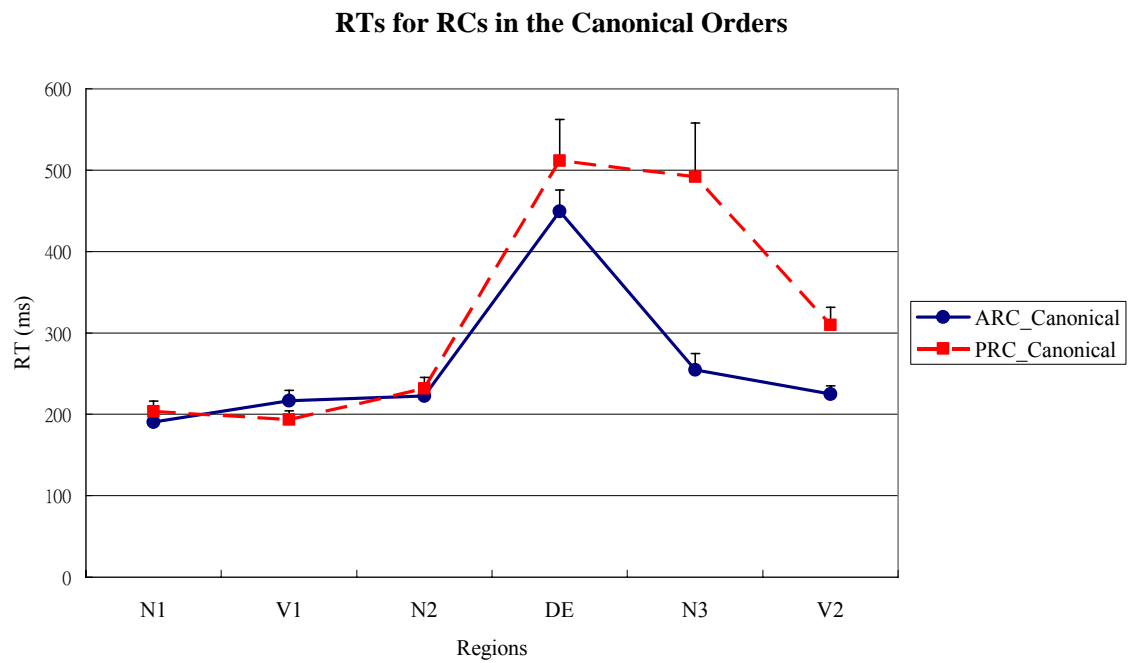


Figure 4.5. RTs (inms) per Chinese character of adjunct RCs and PRCs with canonical orders.

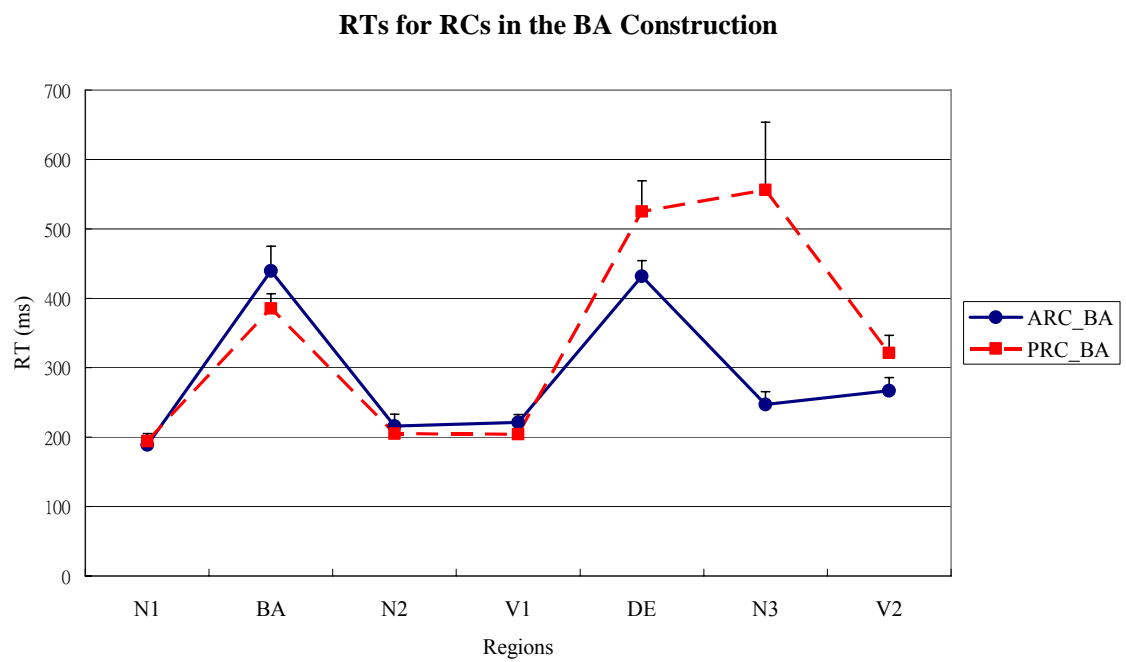


Figure 4.6. RTs (inms) per Chinese character of adjunct RCs and PRCs in the BA construction.

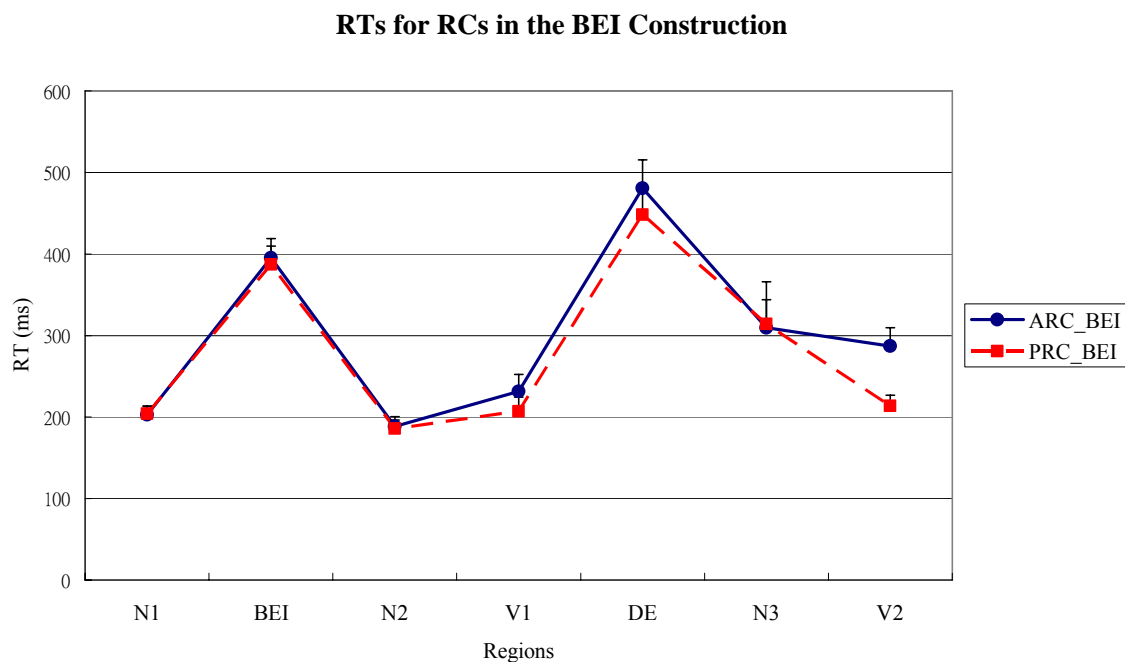


Figure 4.7. RTs (in ms) per Chinese character of adjunct RCs and PRCs in the passive construction.

4.6.5 Discussion

The on-line reading times showed that the main effect of RC type was significant on V1 and N3. The embedded verb of an adjunct RC took longer to read than that of a PRC.³³ RTs for the head nouns were longer for PRCs than for adjunct RCs, suggesting extra time was needed to construct filler-gap relations for PRCs, in which the parser started to look for filler-gap relations at the relativizer DE, producing longer reading times for PRCs than for adjunct RCs.³⁴ Such longer reading latencies consummated at the head noun (N3) and continued at the matrix verb (V2) for both canonical and *ba* PRCs, but not for the passive PRCs.

³³ The source of this RT difference was not obvious.

³⁴ The term adjunct RC is chosen because the head noun functions as an adjunct adverbial, rather than an argument in the RC.

The main effect of construction types was found on N2, N3, and V2. The noun following *bei* in passives was read faster than the nouns that followed *ba* in the BA construction and those that followed the embedded verb in the condition with canonical word orders. Significant interactions were found on DE and V2. This may have to do with an agent role being preferred and read faster than a noun with a patient role. On the head noun and the matrix verb, passives took longer to read for adjunct RCs but shorter for PRCs. This suggested that in adjunct RCs, where there is no filler-gap relation to be constructed, passives were read more slowly than both the canonical and *ba* variants, obeying the canonicity effect. However, in sentences with passive PRCs where the gaps were located at the subject position, the construction of a filler-gap relation between the head noun and the gap was easier, resulting in shorter reading times for passives PRCs (at the matrix verb (V2)). These results contradicted the predictions of linear locality. Passive PRCs received an advantage, even though their gaps were located the farthest from the fillers. The effect of canonicity observed on adjunct RCs was not found on PRCs. In summary, passive PRCs provided an advantage for gap-searching, which overrode the effects of both linear locality and canonicity. Such an effect on gap searching was not observed in adjunct RCs, which suggested that it was indeed a process related to the construction of filler-gap relations.

4.7 General Discussion

The three experiments reported in this chapter consistently suggested that passive PRCs received an advantage for filler-gap processing, which was not observed either in the canonical or in the *ba* conditions. In Experiment 2, passive PRCs were rated more natural

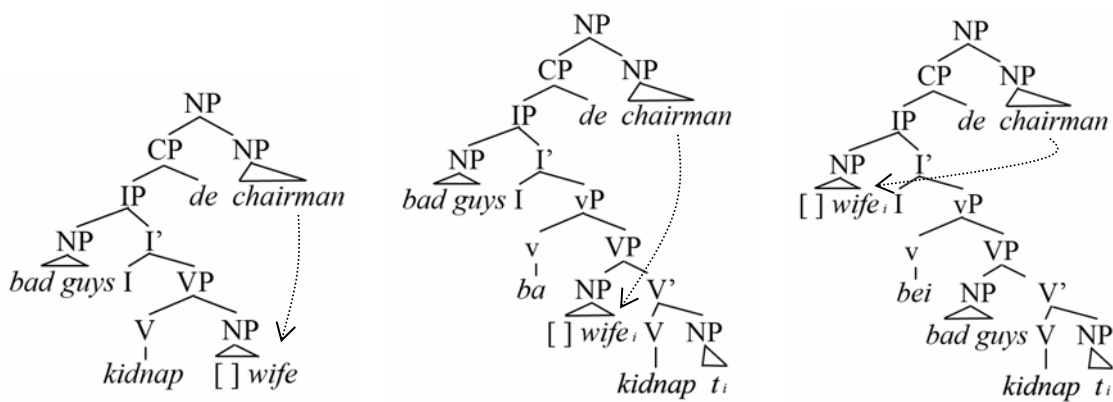
and more grammatical than both canonical and *ba* PRCs, countering the trends in all baseline conditions. Experiment 3 showed that even though sentences with PRCs were unusual, they were highly comprehensible. Passive PRCs were most frequently understood correctly, and most likely to incur the mention of possessive relations in the interpretations. In Experiment 4, we saw that the canonical and *ba* PRCs both required longer reading latencies in the construction of filler-gap dependencies at the relativizer, the head noun and the matrix verb regions. However, passive PRCs were read as fast as (at the relativizer and the head noun) or faster (at the matrix verb) than their adjunct RC counterparts.³⁵

These results suggested that in parsing Chinese PRCs, the construction of filler-gap relations does not start until the head noun is reached. Though Chinese PRCs are prenominal, the parser is not certain of any gaps since without missing arguments, PRCs look just like thematically-complete sentences. The regions prior to the relativizer *de* are therefore processed as regular clauses. When the parser reaches the relativizer, it

³⁵ We chose to focus on possessor relative clauses mainly because they allow comparisons with adjunct RCs in terms of canonical, BA, and BEI structures (with exact matching surface orders). One may as well compare between regular passive SRCs (a) and regular ORCs (b) so that the gaps are located at varying positions while the thematic roles of the gaps remain constant. However, this design only allows for the comparison between the canonical and passive structures, not the BA structure since a patient gap cannot be preceded by BA as in (c).

- (a) Passive SRC
 ___ bei kache zhuangdao de ren
 BEI truck hit DE person
 ‘the person that was hit by a truck’
- (b) Regular ORC
 kache zhuangdao ___ de ren
 truck hit DE person
 ‘the person that a truck hit’
- (c) *BA ORC
 *kache ba ___ zhuangdao de ren
 truck BA hit DE person
 ‘the person that a truck got hit’

incorporates the prior region as part of a relative clause. The head noun, as a filler, initiates the process of gap-searching. The parser probes at the subject position of the previous CP first, and then searches for other NPs down the tree structure. The tree diagrams in Figure 4.8 illustrate how gaps at different structural positions are accessed differently across the experimental conditions.



(a) PRC with canonical orders. (b) PRC with *ba* construction (c) Passive PRCs (with *bei*)

Figure 4.8. Syntactic diagrams for PRCs with different constructions.³⁶

Such a goal-searching strategy requires knowledge of syntactic structure. The parser does not start by probing at the NP that appeared most recently. (That is, the NPs were not stacked into a push-down machine for gap-filling.) Instead, it probes at the topmost NP, thus producing an advantage for passive PRCs. In canonical PRCs, the parser has to search down to the object position to reach the gap. The same is true with the *ba* PRCs. This top-down searching mechanism overrides the effect of NP recency (i.e. linear locality), and passive complexity (i.e. canonicity). PRCs with *ba* are harder than canonical PRCs for two reasons. The parser has to search through one additional XP node

³⁶ I follow Tsai (2003) for the syntactic structures of *ba* and *bei* sentences.

in *ba* PRCs than in canonical PRCs to reach the target NP. The non-canonicity of *ba* constructions in terms of theta location and additional NP movements also make them more difficult.

The above evidence suggests that even though RCs in Chinese are prenominal, when the gaps are not overt as in PRCs, the parser may search for gaps in a similar way as English, where the fillers precede and search for the gaps. This produces a subject preference for Chinese PRCs, which is consistent with the same preference in regular Chinese RCs (reported in Chapter 3) and English RCs. The results thus suggest that the top-down, structure-based parsing mechanism is universal, working for both prenominal and postnominal relative clauses.

This proposal also receives independent support from other languages with prenominal relative clauses like Japanese and Turkish. In Japanese, Fong and Hirose (2005) reported that when the object of an object PRC was scrambled to the surface subject position, it was rated no harder than a non-scrambled canonical PRC. This was different from their baseline sentences, where object scrambling was rated more difficult. Similar preferences were obtained in Turkish, where an ambiguous bare noun phrase appearing in a PRC is predominantly taken as a subject than an object (see also discussion in Fong & Hirose, 2005). Such crosslinguistic evidence suggests that similar gap-searching mechanisms operate in languages with prenominal and postnominal RCs. The parser searches the structure hierarchically in a top-down manner. Gaps at subject positions universally receive advantage when the filler is recognized prior to the gap.

Appendix C.

Experimental Materials for Experiments 2-4:**Possessor Relative Clauses (Experimental Condition)**

- 1
歹徒殺害了|女兒的|媽媽|哭得|很傷心。
歹徒把女兒殺害了的|媽媽|哭得|很傷心。
女兒被歹徒殺害了的|媽媽|哭得|很傷心。
- 2
流氓打傷妹妹的|國中生|準備|明天|要報復。
流氓把妹妹打傷的|國中生|準備|明天|要報復。
妹妹被流氓打傷的|國中生|準備|明天|要報復。
- 3
警察抓走|學生的|教授|馬上|通知|校方|處理。
警察把學生抓走的|教授|馬上|通知|校方|處理。
學生被警察抓走的|教授|馬上|通知|校方|處理。
- 4
朋友弄哭|孫子|的|婦人|趕緊|拿出一根|棒棒糖。
朋友把孫子弄哭的|婦人|趕緊|拿出一根|棒棒糖。
孫子被朋友弄哭的|婦人|趕緊|拿出一根|棒棒糖。
- 5
壞人綁架了|老婆|的|總裁|正在|調度|贖金。
壞人把老婆綁架了的|總裁|正在|調度|贖金。
老婆被壞人綁架了的|總裁|正在|調度|贖金。
- 6
父母錯怪了|女朋友|的|男子|急著|澄清|事實。
父母把女朋友錯怪了的|男子|急著|澄清|事實。
女朋友被父母錯怪了的|男子|急著|澄清|事實。
- 7
鄰居侵佔了|土地|的|地主|正開始|蒐集|證據。
鄰居把土地侵佔了的|地主|正開始|蒐集|證據。
土地被鄰居侵佔了的|地主|正開始|蒐集|證據。
- 8
班上同學扯破|制服|的|小朋友|哭了|出來。
班上同學把制服扯破的|小朋友|哭了|出來。
制服被班上同學扯破的|小朋友|哭了|出來。
- 9
受訪者敲壞了|攝影機|的|記者|只好|決定|停止|錄影。
受訪者把攝影機敲壞了的|記者|只好|決定|停止|錄影。
攝影機被受訪者敲壞了的|記者|只好|決定|停止|錄影。
- 10
敵軍炸毀|基地|的|官兵們|紛紛|躲進了|防空洞。
敵軍把基地炸毀的|官兵們|紛紛|躲進了|防空洞。
基地被敵軍炸毀的|官兵們|紛紛|躲進了|防空洞。
- 11
金光黨騙光|家產|的|富翁|晚景|十分|淒涼。
金光黨把家產騙光的|富翁|晚景|十分|淒涼。
家產被金光黨騙光的|富翁|晚景|十分|淒涼。
- 12
父親打斷腿的|不良少年|終於|覺悟了。
父親把腿打斷的|不良少年|終於|覺悟了。
腿被父親打斷的|不良少年|終於|覺悟了。
- 13
地下錢莊逼死了|兒子|的|老母親|從此|一病|不起。
地下錢莊把兒子逼死了的|老母親|從此|一病|不起。
兒子被地下錢莊逼死了的|老母親|從此|一病|不起。
- 14
卡車撞死|老公|的|女士|打算|提出|告訴。
卡車把老公撞死的|女士|打算|提出|告訴。
老公被卡車撞死的|女士|打算|提出|告訴。
- 15
濃煙嗆傷|孩子|的|媽媽|趕緊|逃出|火災|現場。
濃煙把孩子嗆傷的|媽媽|趕緊|逃出|火災|現場。
孩子被濃煙嗆傷的|媽媽|趕緊|逃出|火災|現場。
- 16
海浪捲走|顧客|的|飯店|老闆|急忙|報警|求救。
海浪把顧客捲走的|飯店|老闆|急忙|報警|求救。
顧客被海浪捲走的|飯店|老闆|急忙|報警|求救。

17
洪水淹死|牲畜的|養豬戶|祈禱|天氣|趕快轉晴。
洪水把|牲畜淹死的|養豬戶|祈禱|天氣|趕快轉晴。
牲畜被|洪水淹死的|養豬戶|祈禱|天氣|趕快轉晴。

18
電線絆倒|祖父的|男孩|馬上|打電話|告訴|母親。
電線把|祖父絆倒的|男孩|馬上|打電話|告訴|母親。
祖父被|電線絆倒的|男孩|馬上|打電話|告訴|母親。

19
太陽曬紅了|鼻子的|園丁|打算|進屋裡|休息。
太陽把|鼻子曬紅了的|園丁|打算|進屋裡|休息。
鼻子被|太陽曬紅了的|園丁|打算|進屋裡|休息。

20
法院查封了|房子的|老闆|終於|承認|生意失敗。
法院把|房子查封了的|老闆|終於|承認|生意失敗。
房子被|法院查封了的|老闆|終於|承認|生意失敗。

21
滾水燙傷|皮膚的|影星|必須|進行|人工植皮|手術。
滾水把|皮膚燙傷的|影星|必須|進行|人工植皮|手術。
皮膚被|滾水燙傷的|影星|必須|進行|人工植皮|手術。

22
颱風吹垮|茅屋的|農人|感到|十分|絕望。
颱風把|茅屋吹垮的|農人|感到|十分|絕望。
茅屋被|颱風吹垮的|農人|感到|十分|絕望。

23
大火燒光|作物的|佃農|難過得|吃不下飯。
大火把|作物燒光的|佃農|難過得|吃不下飯。
作物被|大火燒光的|佃農|難過得|吃不下飯。

24
暴風雨吹走|船隻的|漁民|擔心|生活|將成|問題。
暴風雨把|船隻吹走的|漁民|擔心|生活|將成|問題。
船隻被|暴風雨吹走的|漁民|擔心|生活|將成|問題。

Adjunct Relative Clauses (Baseline Condition III)

1
罪犯綁架|小開的|第一現場|在|飯店|停車場。
罪犯把|小開綁架的|第一現場|在|飯店|停車場。
小開被|罪犯綁架的|第一現場|在|飯店|停車場。

2
清潔工洗掉|污垢的|方法是|從書上|學來的。
清潔工把|污垢洗掉的|方法是|從書上|學來的。
污垢被|清潔工洗掉的|方法是|從書上|學來的。

3
李老闆買下|三間|店面的|地段|房價|不斷|飆漲。
李老闆把|三間店面買下的|地段|房價|不斷|飆漲。
三間店面被|李老闆買下的|地段|房價|不斷|飆漲。

4
老王弄丟|鑰匙的|時間|大約是|下午|五點鐘。
老王把|鑰匙弄丟的|時間|大約是|下午|五點鐘。
鑰匙被|老王弄丟的|時間|大約是|下午|五點鐘。

5
洪老師難倒|學生的|題目|連|大學教授|都不會做。
洪老師把|學生難倒的|題目|連|大學教授|都不會做。
學生被|洪老師難倒的|題目|連|大學教授|都不會做。

6
阿福毒死|老鼠的|砒霜|是|美國製的。
阿福把|老鼠毒死的|砒霜|是|美國製的。
老鼠被|阿福毒死的|砒霜|是|美國製的。

7
小張打敗|老王的|運動項目|都和|球類|有關。
小張把|老王打敗的|運動項目|都和|球類|有關。
老張被|老王打敗的|運動項目|都和|球類|有關。

8
黃小姐擊昏|小偷的|棒子|是|鋁製的。
黃小姐把|小偷擊昏的|棒子|是|鋁製的。
小偷被|黃小姐擊昏的|棒子|是|鋁製的。

9
小陳敗光|家產的|速度|令人|驚訝。
小陳把|家產敗光的|速度|令人|驚訝。
家產被|小陳敗光的|速度|令人|驚訝。

10

學校|寄丟|成績單|的原因|還在|調查|當中。
 學校|把|成績單|寄丟|的原因|還在|調查|當中。
 成績單|被|學校|寄丟|的原因|還在|調查|當中。

11

張三|記錯|電話|的|可能性|很高。
 張三|把|電話|記錯|的|可能性|很高。
 電話|被|張三|記錯|的|可能性|很高。

12

列強|瓜分|中國|的|手段|令人|慘不忍睹。
 列強|把|中國|瓜分|的|手段|令人|慘不忍睹。
 中國|被|列強|瓜分|的|手段|令人|慘不忍睹。

13

立委|刪除|預算|的|理由|很難|讓人|接受。
 立委|把|預算|刪除|的|理由|很難|讓人|接受。
 預算|被|立委|刪除|的|理由|很難|讓人|接受。

14

警衛|逮到|嫌犯|的|地點|在|大樓|地下室。
 警衛|把|嫌犯|逮到|的|地點|在|大樓|地下室。
 嫌犯|被|警衛|逮到|的|地點|在|大樓|地下室。

15

老闆娘|找到|首飾|的|過程|十分|曲折。
 老闆娘|把|首飾|找到|的|過程|十分|曲折。
 首飾|被|老闆娘|找到|的|過程|十分|曲折。

16

經理|罵哭|服務生|的|言詞|十分|苛刻。
 經理|把|服務生|罵哭|的|言詞|十分|苛刻。
 服務生|被|經理|罵哭|的|言詞|十分|苛刻。

17

海關|扣留|貨物|的|機會|並不大。
 海關|把|貨物|扣留|的|機會|並不大。
 貨物|被|海關|扣留|的|機會|並不大。

18

槍手|暗殺|總統|的|地方|竟然|在|熱鬧|的大街上。
 槍手|把|總統|暗殺|的|地方|竟然|在|熱鬧|的大街上。
 總統|被|槍手|暗殺|的|地方|竟然|在|熱鬧|的大街上。

19

主播|誤導|觀眾|的|新聞報導|已經|引起|新聞局|的|關切。
 主播|把|觀眾|誤導|的|新聞報導|已經|引起|新聞局|的|關切。
 觀眾|被|主播|誤導|的|新聞報導|已經|引起|新聞局|的|關切。

20

清潔婦|曬乾|衣服|的|方式|十分|傳統。
 清潔婦|把|衣服|曬乾|的|方式|十分|傳統。
 衣服|被|清潔婦|曬乾|的|方式|十分|傳統。

21

高僧|擺平|強盜|的|武器|只是|一把|短刀。
 高僧|把|強盜|擺平|的|武器|只是|一把|短刀。
 強盜|被|高僧|擺平|的|武器|只是|一把|短刀。

22

王老闆|賣掉|車子|的|價格|並不|划算。
 王老闆|把|車子|賣掉|的|價格|並不|划算。
 車子|被|王老闆|賣掉|的|價格|並不|划算。

23

情婦|出賣|導演|的|信件|刊登|在|報紙|上。
 情婦|把|導演|出賣|的|信件|刊登|在|報紙|上。
 導演|被|情婦|出賣|的|信件|刊登|在|報紙|上。

24

董事長|開除|祕書|的|名義|並不|正當。
 董事長|把|祕書|開除|的|名義|並不|正當。
 祕書|被|董事長|開除|的|名義|並不|正當。

Sentences with Relative Clauses (Baseline Condition II)

- 1
收養孤兒的有錢人賣掉了工廠。
收養孤兒的有錢人把工廠賣掉了。
工廠被收養孤兒的有錢人賣掉了。
- 2
修理馬路的工人清除了路障。
修理馬路的工人把路障清除了。
路障被修理馬路的工人清除了。
- 3
打掃廚房的工讀生扔掉了一大包垃圾。
打掃廚房的工讀生把一大包垃圾扔掉了。
一大包垃圾被打掃廚房的工讀生扔掉了。
- 4
教物理的老師搞錯了學生的名字。
教物理的老師把學生的名字搞錯了。
學生的名字被教物理的老師搞錯了。
- 5
管理許多基金的經理人忽略了一個重要的訊息。
管理許多基金的經理人把一個重要的訊息忽略了。
一個重要的訊息被管理許多基金的經理人忽略了。
組長告誡了散佈謠言的同事。
組長把散佈謠言的同事告誡了。
散佈謠言的同事被組長告誡了。
- 6
處理帳務的會計師糾正了許多錯誤。
處理帳務的會計師把許多錯誤糾正了。
許多錯誤被處理帳務的會計師糾正了。
- 7
教練喜愛的投手敲碎了玻璃杯。
教練喜愛的投手把玻璃杯敲碎了。
玻璃杯被教練喜愛的投手敲碎了。
- 8
編劇欣賞的演員點燃了蠟燭。
編劇欣賞的演員把蠟燭點燃了。
蠟燭被編劇欣賞的演員點燃了。
- 9
明星們害怕的小報公佈了名人整型前的照片。
明星們害怕的小報把名人整型前的照片公佈了。
名人整型前的照片被明星們害怕的小報公佈了。
- 10
里長請來的壯丁剷平了整塊草坪。
里長請來的壯丁把整塊草坪剷平了。
整塊草坪被里長請來的壯丁剷平了。
- 11
雜誌社選用的攝影師花光了所有預算。
雜誌社選用的攝影師把所有預算花光了。
所有預算被雜誌社選用的攝影師花光了。
- 12
節目聘請的專家誇大了塔羅牌的魔力。
節目聘請的專家把塔羅牌的魔力誇大了。
塔羅牌的魔力被節目聘請的專家誇大了。
- 13
交通警察攔下了違反規則的車輛。
交通警察把違反規則的車輛攔下了。
違反規則的車輛被交通警察攔下了。
- 14
軍官嚇走了闖入商店的流氓。
軍官把闖入商店的流氓嚇走了。
闖入商店的流氓被軍官嚇走了。
- 15
男主角演活了作盡壞事的反派角色。
男主角把作盡壞事的反派角色演活了。
作盡壞事的反派角色被男主角演活了。
- 16
總經理取消了慶祝退休的派對。
總經理把慶祝退休的派對取消了。
慶祝退休的派對被總經理取消了。
- 17
大力士撞開了囚禁野狗的牢籠。
大力士把囚禁野狗的牢籠撞開了。
囚禁野狗的牢籠被大力士撞開了。

19

小朋友|清乾淨了|路人|丟棄的|垃圾。
 小朋友|把|路人|丟棄的|垃圾|清乾淨了。
 路人|丟棄的|垃圾|被|小朋友|清乾淨了。

20

遊客|摘下了|果農|種的|草莓。
 遊客|把|果農|種的|草莓|摘下了。
 果農|種的|草莓|被|遊客|摘下了。

21

男童|玩壞了|姑姑|借來的|錄音機。
 男童|把|姑姑|借來的|錄音機|玩壞了。
 姑姑|借來的|錄音機|被|男童|玩壞了。

22

賭徒|趕走了|老和尚|救濟的|流浪漢。
 賭徒|把|老和尚|救濟的|流浪漢|趕走了。
 老和尚|救濟的|流浪漢|被|賭徒|趕走了。

23

店員|倒掉了|顧客|吃剩的|食物。
 店員|把|顧客|吃剩的|食物|倒掉了。
 顧客|吃剩的|食物|被|店員|倒掉了。

24

那寡婦|獨自|養大了|被害人|留下的|三個|孩子。
 那寡婦|把|被害人|留下的|三個|孩子|獨自|養大了。
 被害人|留下的|三個|孩子|被|那寡婦|獨自|養大了。

Simple Sentences (Baseline Condition I)

1

汪先生|吃光了|冰箱裡|的|藍莓。
 汪先生|把|冰箱裡|的|藍莓|吃光了。
 冰箱裡|的|藍莓|被|汪先生|吃光了。

2

師傅|烤焦了|一個|蛋糕。
 師傅|把|一個|蛋糕|烤焦了。
 一個|蛋糕|被|師傅|烤焦了。

3

老張|弄皺了|新的|地毯。
 老張|把|新的|地毯|弄皺了。
 新的|地毯|被|老張|弄皺了。

4

小華|搞砸了|這項|研究計畫。
 小華|把|這項|研究計畫|搞砸了。
 這項|研究計畫|被|小華|搞砸了。

5

陳老師|哭濕了|一整條|手帕。
 陳老師|把|一整條|手帕|哭濕了。
 一整條|手帕|被|陳老師|哭濕了。

6

小美|搞丟了|辦公室|的|鑰匙。
 小美|把|辦公室|的|鑰匙|搞丟了。
 辦公室|的|鑰匙|被|小美|搞丟了。

7

老王|穿反了|那件|花襯衫。
 老王|把|那件|花襯衫|穿反了。
 那件|花襯衫|被|老王|穿反了。

8

仲介|賣掉了|那棟|房子。
 仲介|把|那棟|房子|賣掉了。
 那棟|房子|被|仲介|賣掉了。

9

車行|修好了|你的|古董車。
 車行|把|你的|古董車|修好了。
 你的|古董車|被|車行|修好了。

10

一陣強風吹熄了桌上的蠟燭。
 一陣強風把桌上的蠟燭吹熄了。
 桌上的蠟燭被一陣強風吹熄了。

11

大雨困住了十多位旅客。
 大雨把十多位旅客困住了。
 十多位旅客被大雨困住了。

12

小黑狗咬傷了那個陌生人。
 小黑狗把那個陌生人咬傷了。
 那個陌生人被小黑狗咬傷了。

13

潘小姐淡忘了舊情人。
 潘小姐把舊情人淡忘了。
 舊情人被潘小姐淡忘了。

14

會員們學會了基本的防身術。
 會員們把基本的防身術學會了。
 基本的防身術被會員們學會了。

15

科學家解決了許多謎題。
 科學家把許多謎題解決了。
 許多謎題被科學家解決了。

16

冒險家克服了各式各樣的挑戰。
 冒險家把各式各樣的挑戰克服了。
 各式各樣的挑戰被冒險家克服了。

17

那位初學者完成了這項不可能的任務。
 那位初學者把這項不可能的任務完成了。
 這項不可能的任務被那位初學者完成了。

18

醫師拔掉了植物人的管子。
 醫師把植物人的管子拔掉了。
 植物人的管子被醫師拔掉了。

19

糊塗的學子玩掉了大學四年。
 糊塗的學子把大學四年玩掉了。
 大學四年被糊塗的學子玩掉了。

20

士兵拔除了營區的雜草。
 士兵把營區的雜草拔除了。
 營區的雜草被士兵拔除了。

21

負責任的班長收齊了寒假作業。
 負責任的班長把寒假作業收齊了。
 寒假作業被負責任的班長收齊了。

22

部長看輕了事情的嚴重性。
 部長把事情的嚴重性看輕了。
 事情的嚴重性被部長看輕了。

23

來賓洩漏了主持人的秘密。
 來賓把主持人的秘密洩漏了。
 主持人的秘密被來賓洩漏了。

24

委員會調低了今年的入學標準。
 委員會把今年的入學標準調低了。
 今年的入學標準被委員會調低了。

CHAPTER 5

WALKING DOWN THE GARDEN PATH OF RELATIVE CLAUSES

In this chapter, we discuss the issue of garden-path effects in relative clauses. A classic garden-path effect in reduced relative clauses such as *the horse raced past the barn fell* is first introduced, with different accounts for the effect reviewed. Then we report an experiment on Chinese relative clauses with object topicalization, in which a misleading thematic assignment takes place, leading to an unrecoverable garden-path effect. The cause of the garden path and the effect of semantic information will be discussed.

5.1 Processing Reduced Relative Clauses in English

Different types of garden-path effect can occur during the processing of relative clauses (RCs). For instance, in processing typical RCs, subject-extractions receive advantage over object-extractions, suggesting that the parser tends to assume the head noun is a filler for a subject gap rather than an object gap (see Chapter 3). A classic garden-path effect is exemplified by a sentence with reduced RCs like (1).

(1) The horse raced past the barn fell.

The garden-path effect of (1) results from the structural ambiguity between a main-clause analysis and a relative-clause analysis prior to the occurrence of the actual matrix verb.

Since the verb *raced* can be both the past tense and the past participle of *race*, both analyses are plausible. The parser analyzes the first six words as a main clause, with the verb *raced* taken as a main verb rather than as a past participle. The appearance of the real

main verb of the sentence, *fell*, calls for a reanalysis, which is, however, extremely difficult.

Two important lessons can be learned from the kind of garden-path effect considered above: (A) a main-clause analysis is preferred in such cases, and (B) it is extremely difficult, if not impossible, to recover from the misanalysis. Various theories have been proposed to account for the main-clause bias, including structural simplicity, the canonicity of word order, lexical subcategorizational properties, etc. An account based on structural simplicity argues that since main clauses are structurally simpler than embedded clauses, a parser that prefers a simple structure should prefer the main-clause analysis. Additional structural complexity should be postulated only when necessary (Frazier & Clifton, 1996). The word-order account argues that since the main-clause analysis matches the NVN template, a parser that is equipped with a top-down template-matching strategy can be misled by the seeming NVN surface order of these reduced RCs (Bever, 1970). The subcategorizational properties of the verb can also be a source of the ambiguity. *Raced* can be transitive (taking two arguments) or intransitive (taking only one argument). Since it is more frequently used as an intransitive verb, the parser is more inclined to taking it as an intransitive (MacDonald, 1994; Pritchett, 1992; Stevenson & Merlo, 1997). Other factors that have been proposed include the animacy of the initial noun phrase (MacDonald, 1994; Trueswell, Tanenhaus, & Garnsey, 1994, cf. Ferreira & Clifton, 1986), pragmatic information such as presuppositional status (Crain & Steedman, 1985), and the encyclopedic knowledge about agenthood (MacRae, Spivey-Knowlton, & Tanenhaus, 1998; Trueswell et al., 1994). These accounts, though

focusing on different factors, nevertheless, share a commonality—the parser relies on information from individual lexical items to construct the most likely or most simple structure.

The second issue—the extreme difficulty in reanalyzing the misparsed sentence—has to do with the difficulty in reversing thematic roles that have already been assigned. In *The horse raced past the barn fell*, the first noun is mistaken as the agent or theme with *raced* as the matrix verb. Such thematic information is sent to LF for incremental interpretation (see Chapter 2). When this analysis is proven wrong at the appearance of the final word *fell*, the parser needs to reanalyze the previous clause as an embedded RC. In so doing, it also has to reverse previous thematic assignments (i.e. reversing the information at LF). *The horse* should be re-assigned the theta role of *patient*. The fact that the parser cannot recover from the garden-path effect suggests that once the parser is semantically committed to an interpretation, a reinterpretation based on the reanalyzed structure is hard to achieve.³⁷

A radically different view, called Meaning through Syntax (MTS), has recently been advanced by McKoon and Ratcliff (2003). MTS argues that the reason why *The horse raced past the barn fell* is difficult is because it is *ungrammatical*. MTS takes the stance that constructions, like words, bear meanings (adopting the proposals of Construction Grammar of Goldberg (1995)). Object reduced RCs (such as (1)) denote “an event caused by some force or entity external to [the head noun] itself (McKoon & Ratcliff, 2003:

³⁷ A proposal of a similar flavor is made by Ferreira (2003), who argues that language users tend to stick to an interpretation that is “good enough.” Her evidence mainly comes from participants misinterpreting unambiguous passive sentences when asked to identify the do-*er* or the do-*ee* of an aurally-presented sentence. She also calls this “shallow processing (164).”

492).” The meanings of the reduced-RC construction and that of the manner-of-motion verb, such as *race*, are not compatible because the meaning of *race* involves internal rather than external cause. It should be noted that “ungrammaticality” according to MTS refers to semantic incompatibility between constructional meaning and lexical meaning, not having to do with the syntactic incongruity.

McKoon and Ratcliff’s evidence relies primarily on the rare co-occurrences of reduced RCs and transitive verbs-of-motion constructions in the corpora, the plausibility ratings of sentences with reduced RCs and verbs that involve external versus internal causes, and the lexical decision times of externally-caused versus internally-caused verbs. They, however, do not offer evidence based on on-line reading processes. MTS does not make specific predictions about the temporal aspect of semantic and syntactic composition.³⁸

The goal of this chapter is to examine how the assignment of theta roles and semantic information regarding animacy interact in the comprehension of a structurally misleading garden-path sentence. In Section 5.2, we first provide examples of garden-path RCs in Mandarin. We will then present an experiment focusing on Mandarin RCs with topicalized objects in 5.3.

5.2 The Garden Path of Relative Clauses in Mandarin

In this section, we discuss Chinese RCs that involve garden path. Two types of garden path sentences with RCs are considered—a garden path resulting from the left-edge element of the RC being mistaken as part of an on-going constituent, and garden path

³⁸ For a further review and critique of the MTS account, refer to McRae, Harem, and Tanenhaus, 2005.

effect that arises from movements within the RCs.

5.2.1 Misanalysis of RC Left Edges

In Mandarin, a major source of garden path effects in sentences with RCs arises from the fact that Mandarin RCs are prenominal, and that there is no overt marker that indicates the beginning of an RC. The lack of such RC-initial markers results in relatively late recognition of an RC structure (usually not until the relativizer or the head noun is reached) compared with a language where RCs are preceded by the relativizer. In Mandarin, the pre-relativizer region of an RC can be analyzed as a main clause with missing/unpronounced arguments.

Since the left boundaries of Mandarin RCs are not overtly marked, their appearance in ongoing sentences can often induce garden path, with the leftmost element of the RC mistaken as an argument of the previous constituent. For instance, in a simple object-modifying, object-extracted RC like (2), the subject of the RC ('president') may be taken as the object of the matrix verb *tuichong* 'respect.'³⁹

(2) Laowang hen tuichong [zongtong renyong de jiaoyu buzhang]

Laowang very respect president appoint DE education minister

'Laowang respected the minister of education who the president appointed.'

Laowang very respect president # 'Laowang respected the president very much.'⁴⁰

Such garden-path effects can be accounted for by the principle of Minimal Attachment:

(3) Minimal Attachment: "Attach incoming material into the phrase marker being constructed using the fewest nodes consistent with the well-formedness rules of the

³⁹ Some of the examples of garden path sentences in Mandarin are inspired by Lee (1995).

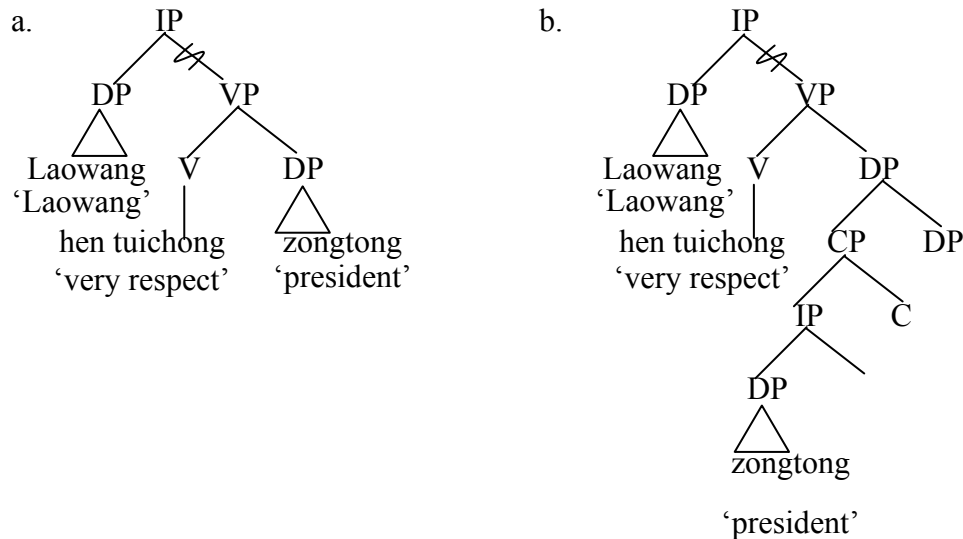
⁴⁰ Transliterations indicated by # are the garden-path misinterpretations.

language.” (Frazier & Rayner, 1982: 180)

The parser prefers to attach an upcoming node as part of the previous structure rather than postulating an entirely new CP with additional nodes that are temporarily unnecessary.

This is illustrated by the tree diagrams in (4).

(4) Laowang hen tuichong [zongtong ...



Pritchett’s principle of theta attachment, which we discussed in Chapter 3, can also account for this preference. At each step, the parser seeks to assign theta roles to satisfy the theta criterion. As soon as a potential recipient of theta role appears, the verb assigns theta role to this element.

Another instance of a similar flavor is given in (5), where the noun ‘president’ is preferably misanalyzed as part of a nominal compound subcategorized for by the preposition *chule* ‘besides.’

(5) chule meiguo [zongtong qu nian baifang de guojia] hai you jianada.

besides America president last year visit DE country still include Canada

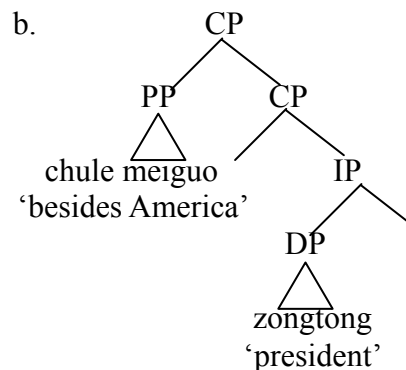
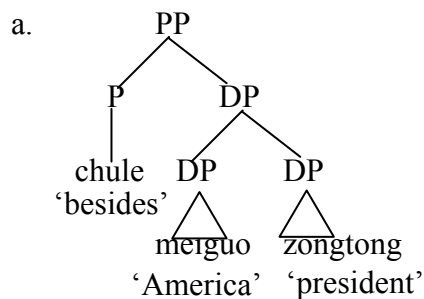
‘Besides America, the countries that the President visited last year also included Canada.’

besides America president ... # ‘Besides the American president, ...’

The principle of Late Closure (6) (Frazier, 1979) also correctly predicts the preferred parse. When an element can be integrated with previous material, such an analysis is preferred to analyzing it as part of a separate maximal projection. This is illustrated by (7).

(6) Late Closure: “When possible, attach incoming material into the clause or phrase currently being parsed.”

(7) chule meiguo [zongtong ...



This kind of garden path can also occur across clausal boundaries. The first NP of an RC that starts a different clause can be mistaken as the object argument of the verb in the previous clause, as exemplified by (8).

(8) jiran zhangsan ai chi qiaokeli zuo de dangao shi ge hao xuanze

since Zhangsan love eat chocolate make DE cake be CL good choice

‘Since Zhangsan loves eating, a cake that is made from chocolate is a good choice.’

#1 since Zhangsan love eat chocolate #1 ‘Since Zhangsan loves eating chocolate, ...’

#2 since Zhangsan love eat chocolate make DE cake #2 ‘Since Zhangsan loves eating cakes that are made from chocolate, ...’

All the examples above involve object extractions; the RCs start with an NP, which gets mistaken as an argument of the previous material. A garden-path RC can also involve subject extraction, where the pre-relativizer region can be taken as a VP or small clause dominated by some earlier VP. In (9), for instance, the verb *xihuan* ‘like’ can take both a nominal and a verbal argument.

(9) laowang bu xihuan shuodahua de ren

Laowang not like brag de person

‘Laowang does not like people who brag.’

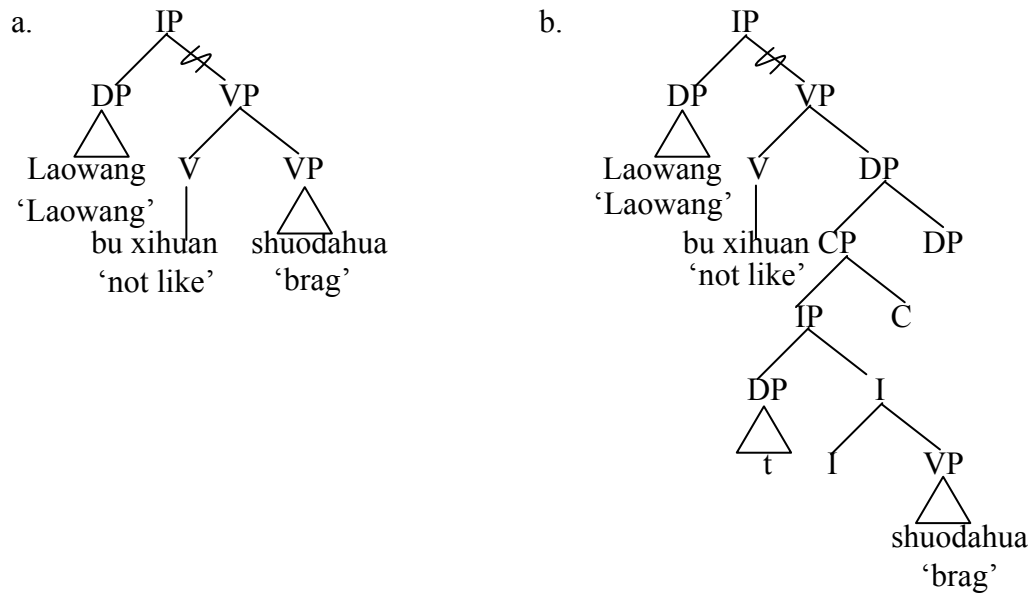
Laowang not like brag ... # ‘Laowang does not like to brag ...’

The parser tends to mistake the verb embedded in the RC as the verbal argument of ‘like’ rather than a verb of a separate RC. The results, as illustrated by (10), can also be accounted for by the principle of Minimal Attachment.

The same is true for sentences with an SRC embedded in another SRC like (11), where the verb of an embedded SRC is preferably analyzed as a verbal complement of the upper RC. In fact, (11) is ambiguous in that the second DE can be a relativizer or a genitive marker. If it is analyzed as a relativizer, the structure has to involve double RC

embeddings; if it is taken as a genitive marker, then it only involves one level of embedding.

(10) Laowang bu xihuan [shuodahua ...



(11) bu xihuan shuodahua de xuesheng de jiaoshou shifen yange

not like brag DE student DE professor very strict

‘The professor who does not like students who brag is very strict.’

#1 not like brag DE student ... #1 ‘The student who does not like to brag ...’

#2 not like brag DE student GEN professor ... #2 ‘The professor of the student who does not like to brag ...’

5.2.2 Movement-Induced Garden Path

A different type of garden-path RC involves topicalization of the embedded object within an SRC, thus causing confusion in the assignment of theta roles. (13), for example, is a topicalized variant of (12).

(12) [fangqi guo haoji wei nanyou] de nyuyanyuan conglai bu jue de houhui

forsake ASP many CL boyfriend DE actress always not feel regretful

‘The actress who has forsaken many boyfriends never felt regretful.’

(13) [nanyou_i fangqi guo haoji wei t_i] de nyuyanyuan conglai bu jue de houhui

boyfriend forsake ASP many CL DE actress always not feel regretful

‘The actress who has forsaken many boyfriends never felt regretful.’

boyfriend forsake ASP many CL DE⁴¹ actress ...

‘The boyfriend forsook many actresses ...’

In (13), the first NP encountered is a topicalized object. However, since it appears prior to the verb *fangqi* ‘forsake,’ the parser is inclined to taking it as a subject/agent. The NP *nyuyanyuan* ‘actress,’ which is supposed to be the head noun of an RC, is taken as the object/patient because it appears after the verb *fangqi*. Such misanalysis is consistent with a top-down strategy based on an NVN template, where the first N is taken as an agent, the second as a patient.

The tree diagrams in (14) illustrate the difference in structural complexity between the garden-path analysis (14a) and the correct parse (14b).

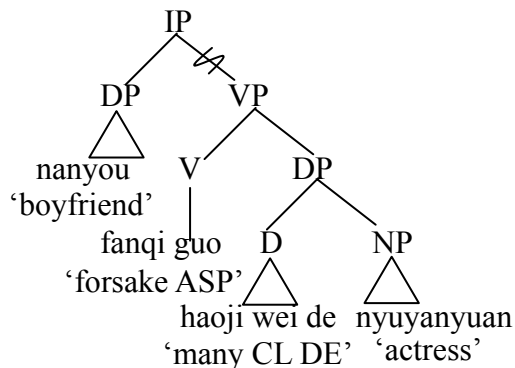
⁴¹ Note, however, that “many-CL-DE” is actually not a grammatical sequence in Mandarin, as classifiers in Mandarin do not co-occur with DE. A grammatical counterpart of this sequence is “many-Measure Word-DE” where measure words can optionally co-occur with DE followed by an NP. This ungrammaticality may serve as a cue that implies an embedded-clause rather than a main-clause analysis.

(a) henduo ben (*de) shu
many CL DE book
‘many books’

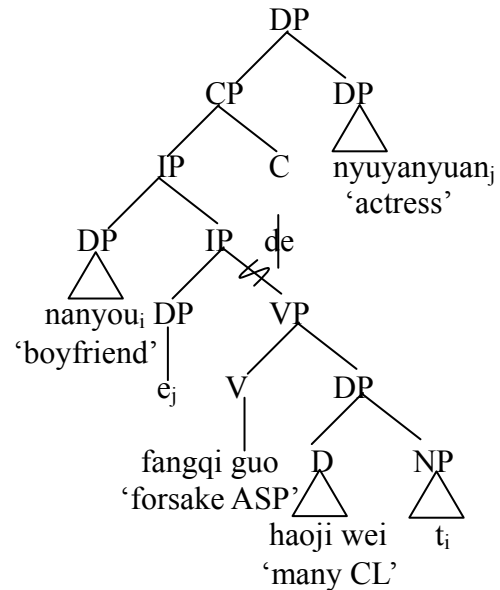
(b) henduo bei (de) shui
many glass DE water
‘many glasses of water’

(14) [nanyou_i fangqi guo haoji wei t_i] de nyuyanyuan ...

a.



b.



The garden path of a topicalized SRC in Mandarin is similar to the kind produced by a reduced RC in English. The first NP is mistaken as the subject of the sentence. The embedded verb, mistaken as the matrix verb, assigns the agent role to the NP prior to it, and the patient role to the NP following it. The appearance of the real matrix verb after the second NP suggests that the previous NVN sequence should be parsed as a subordinate clause rather than a main clause. However, such reanalysis involves reassignment of opposite theta roles to the NPs. (13) is, therefore, expected to be difficult or impossible to understand, compared to (12). This garden-path effect supports theories based on structural simplicity, the canonical NVN template, and thematic assignment.

In 5.3, I present an experiment that examines the on-line processing of sentences such as these, further considering the animacy of the topicalized object. In English, it remains controversial whether the animacy of the initial NP affects processing difficulty. Sentence (15) has the same syntactic structure as *The horse raced past the barn fell* but

starts with an inanimate NP; it is expected to be easier to process since the semantic information may guide parsing at an early stage. This was, however, not found by Ferreira and Clifton (1986), who argue that syntax precedes semantics.

(15) The evidence examined by the lawyer turned out to be unreliable.

Both MacDonald (1994) and Trueswell et al. (1994), however, show evidence that suggests an early animacy effect. In Experiment 5, we compare between sentences like (16a) and (16b) to examine whether and how the animacy of the initial NP affects processing.

- (16) a. [nanyou_i fangqi guo haoji wei t_i] de nyuyanyuan conglai bu jue de houhui
 boyfriend forsake ASP many CL DE actress always not feel regretful
 ‘The actress who has forsaken many boyfriends never felt regretful.’
- b. [jihui_i fangqi guo haoji ci t_i] de nyuyanyuan conglai bu jue de houhui
 opportunity forsake ASP many CL DE actress always not feel regretful
 ‘The actress who has forsaken many opportunities never felt regretful.’

If the animacy of the initial NP facilitates processing, then we should expect to see less garden-path effect on (16b) than (16a). If not, then they should be equally difficult.

5.3 Experiment 5

Two variables are examined in Experiment 5, including (a) whether an RC involves topicalization of the object, and (b) whether the topicalized object is animate or not.

5.3.1 Participants

The participants were the same as those who participated in Experiment 1.

5.3.2 Materials

The materials were twenty-four sets of sentences with SRCs, each with four conditions (non-topicalized RC with an animate object, topicalized RC with an animate object, non-topicalized RC with an inanimate object, & topicalized RC with an inanimate object).

An example of each condition is given in (17), with labels of each region indicated.

(17) a. non-topicalized RC with an animate object

fāngqǐ guo hǎoji wéi nányou de nǚyányuán cōnglái bù juéde hòuhuì
 V1 CL N1 DE N2 V2
 forsake ASP many CL boyfriend DE actress always not feel regretful

‘The actress who has forsaken many boyfriends never felt regretful.’

b. topicalized RC with an animate object

nányou_i fāngqǐ guo hǎoji wéi t_i de nǚyányuán cōnglái bù juéde hòuhuì
 N1 V1 CL DE N2 V2
 boyfriend forsake ASP many CL DE actress always not feel regretful

‘The actress who has forsaken many boyfriends never felt regretful.’

c. non-topicalized RC with an inanimate object

fāngqǐ guo hǎoji cǐ jīhuì de nǚyányuán cōnglái bù juéde hòuhuì
 V1 CL N1 DE N2 V2
 forsake ASP many CL opportunity DE actress always not feel regretful

‘The actress who has forsaken many opportunities never felt regretful.’

d. topicalized RC with an inanimate object

jīhuì_i fāngqǐ guo hǎoji cǐ t_i de nǚyányuán cōnglái bù juéde hòuhuì
 N1 V1 CL DE N2 V2
 opportunity forsake ASP many CL DE actress always not feel regretful

‘The actress who has forsaken many opportunities never felt regretful.’

The four conditions of each sentence were distributed into four lists in a Latin-Square design. Each participant only read one condition of each sentence. A complete list of the target stimuli is provided in Appendix D. In addition to the 24 target sentences, 76 filler sentences of various structures (among which 24 were the materials of Experiment 1) were included.

5.3.3 Procedure

The procedure was the same as that reported in Experiment 1.

5.3.4 Results

The data of four participants (2 males, 2 females) were excluded because their error rate on the overall comprehension questions was equal to or more than 25%. The data of one other female participant were excluded because she grew up in a more complicated linguistic environment (not in Taiwan) before the age of seven. The following results are based on data from the rest 48 participants (9 males, 39 females).

5.3.4.1 Comprehension Performance

The overall comprehension accuracy of the target sentences was 82.47%. The accuracy rates for the target sentences broken down by the four conditions are given in Table 5.1, and diagrammed by the bar chart in Figure 5.1.

Table 5.1. Experiment 5: Accuracy on Comprehension Questions by Conditions

	Non-topicalized	Topicalized
Animate object	95.14%	58.33%
Inanimate object	96.53%	79.86%

Both effects of topicalization and animacy were significant. Sentences with RCs that involved the topicalization of the object argument were understood more poorly than

those that involved no topicalization ($F(1, 47) = 81.22, p < 0.001$; $F(1, 23) = 41.79, p < 0.001$). The RCs that had inanimate objects were understood better than those with animate objects ($F(1, 47) = 18.94, p < 0.001$; $F(1, 23) = 12.79, p < 0.002$). The interaction was also significant ($F(1, 47) = 13.39, p < 0.001$; $F(1, 23) = 8.06, p < 0.009$). The effect of animacy was larger in the topicalized conditions, and the effect of topicalization was larger when the object was animate.

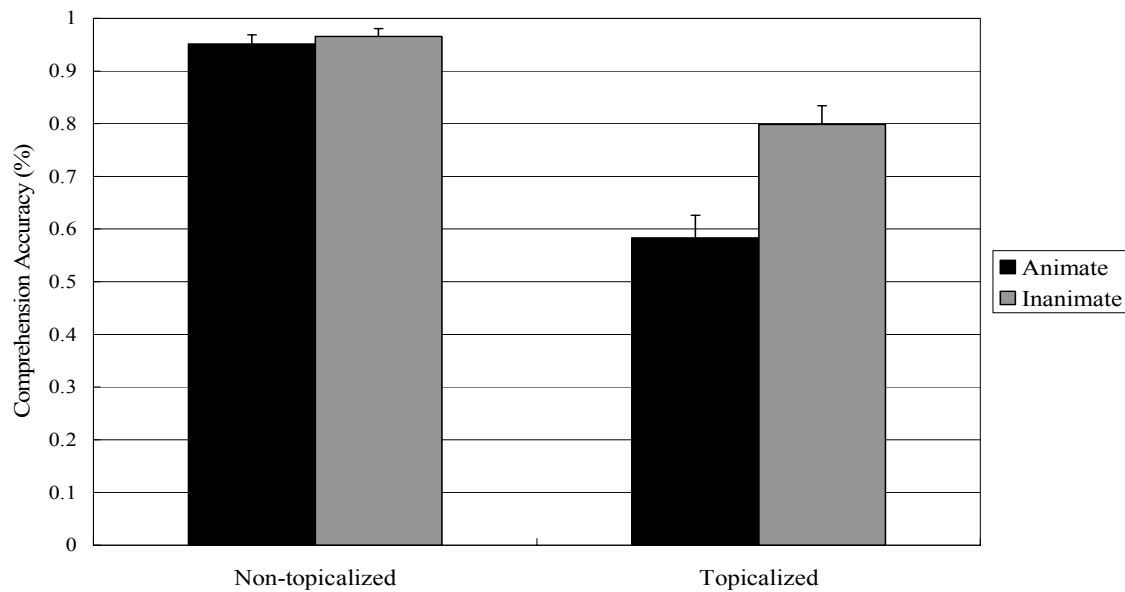


Figure 5.1. Comprehension accuracy across the 4 conditions of Experiment 5.

5.3.4.2 Reading Time Data

We compared the RTs of the pre-relativizer region as a whole, and each individual region starting from the relativizer *de* (including DE, N2, and V2). The pre-relativizer region was compared as a whole because the topicalized and non-topicalized conditions each had words in different word orders prior to the relativizer. Taken as a whole, however, these pre-relativizer regions contained exact same words, differing only in whether the object NP was topicalized. The RT of each region is reported in Table 5.2 and Figure 5.2.

Table 5.2. Reading Times (ms) by Conditions of Experiment 5

	V1/N1	CL/V1	N1/CL	DE	N2	V2
animate-non-topicalized	627.78	662.54	770.78	672.34	913.85	630.91
inanimate-non-topicalized	609.89	736.61	708.72	599.06	758.98	590.98
animate-topicalized	592.38	687.86	765.15	732.22	1042.86	909.15
inanimate-topicalized	622.38	709.04	750.04	750.43	1318.03	823.08

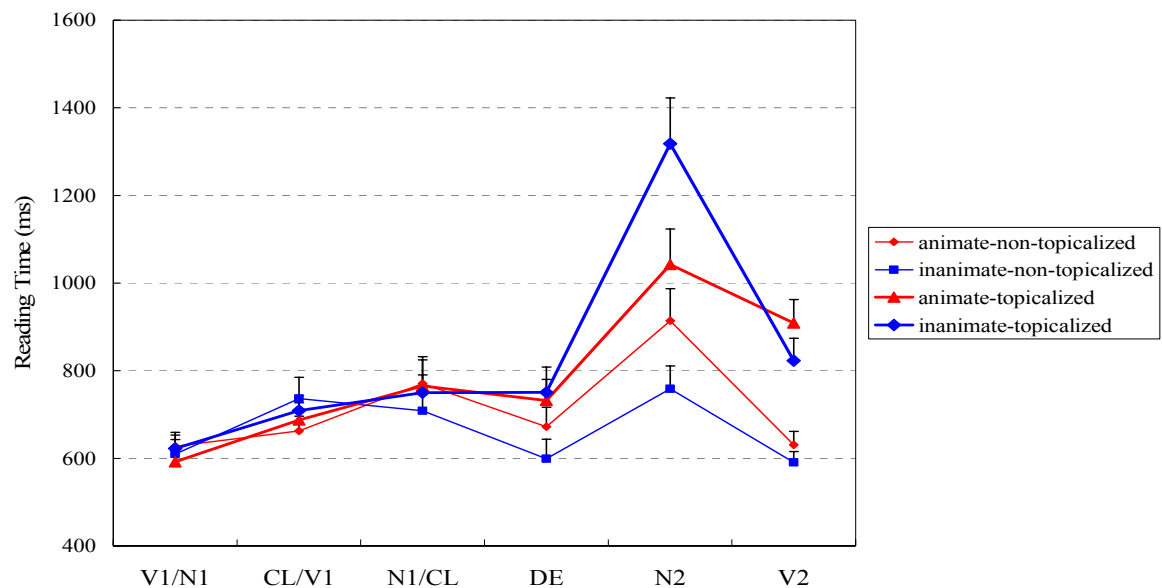


Figure 5.2. Reading time by regions across the 4 conditions of Experiment 5.

The main effect of topicalization was significant at DE ($F(1, 47) = 9.86, p < 0.003$; $F_2(1, 23) = 5.13, p < 0.033$), N2 ($F(1, 47) = 26.25, p < 0.001$; $F_2(1, 23) = 18.63, p < 0.001$), and V2 ($F(1, 47) = 48.29, p < 0.001$; $F_2(1, 23) = 37.24, p < 0.001$), but not at the combined region prior to the relativizer ($F_s < 0.01, p_s > 0.922$). The main effect of animacy was not significant at all regions ($F_s < 1.96, p_s > 0.175$), except the by-participant analysis at V2 ($F(1, 47) = 7.51, p < 0.009$). Interaction of the main effects was significant at N2 ($F(1, 47) = 15.91, p < 0.001$; $F_2(1, 23) = 12.52, p < 0.002$). Comparing within the two canonical conditions, the effect of animacy was significant at

N2 ($t(47) = 2.55, p < 0.014$; $t(23) = 2.16, p < 0.041$). The N2s of RCs with animate objects were read more slowly than those with inanimate objects. Comparing within the two topicalized conditions, the effect of animacy was also significant at N2 ($t(47) = 3.11, p < 0.003$; $t(23) = 2.50, p < 0.020$). This effect was, however, opposite to the one in the canonical conditions. The N2s of the RCs with animate objects were read more *quickly*.

5.3.5 Discussion

Regarding comprehension accuracy, the ORCs that did not involve topicalization were understood better, suggesting that topicalization of the RC-internal object to the beginning of the RC has led to a garden-path effect. Among the RCs involving topicalization of the object argument, those with animate objects were understood more poorly than those with inanimate objects. Such an effect of animacy suggests that a sentence-initial NP that is animate is more likely to be mistaken as a subject/agent than an inanimate NP. However, it should be noted that the effect of animacy was observed only on comprehension accuracy, not on any of the reading-time data. Such results imply overall “good enough” and “shallow” processing in sentences with garden-path structures (Ferreira, 2003). In comprehending these sentences, the first N in an NVN sequence tended to be taken as the do-er, and the second N as the do-ee. When the initial noun phrase was inanimate, it was less likely to be taken as the do-er, thus producing a better comprehension rate. When the initial noun phrase was animate, the comprehension rate was only slightly better than chance, suggesting that the participants were confused about the correct thematic assignment because of the superficial NVN sequence and the unhelpful semantic information about the initial NP. Overall, this suggests that the

garden-path effect resulting from a main-clause analysis of an NVN sequence was so strong that a reanalysis that involved the reassignment of the theta roles and construction of complicated embedded structure was never achieved. The participants answered the comprehension questions based primarily on the semantic information that is available.

No significant main effect of animacy was observed based on the reading-time data across the four conditions, suggesting that animacy of the topicalized object has not played an important role in keeping the parser from adopting the garden-path analysis. In the sentences with topicalized RCs, inanimate objects that appeared at the beginning did not lead the parser into adopting an embedded RC analysis. The effect of topicalization was observed on the relativizer, the head noun, and the matrix verb. The parser noticed the structural unusualness of the topicalized sentences upon reaching the relativizer, with longer reading times observed till the matrix verb.⁴² In summary, the results suggested that the parser was led down the garden path by the NVN sequence in sentences with topicalized object NPs, and that the animacy information of the initial NP did not help disambiguation during on-line comprehension.

5.4 General Discussion

Three main issues were explored in Experiment 5: (a) the cause of garden-path effect in RCs with topicalized objects, (b) recoverability from the garden path, and (c) the role of semantic information (e.g. animacy) in resolving the garden path.

⁴² The emergence of the effect of topicalization on the relativizer was because in Chinese *de* does not occur with the preceding classifier as a constituent. (See also note 41.)

san jian fangzi	*san jian de fangzi
three CL house	three CL DE house
'three houses'	

The occurrence of *de*, therefore, informed the parser that a main-clause analysis was incorrect.

Mandarin SRCs with the object topicalized to the clause-initial position exhibit a superficial NVN order. The parser predominantly analyzes such an NVN sequence as a main clause, taking the first N as an agent, and the second N as a patient. A main-clause analysis is preferred also because it involves minimal attachment (Frazier, 1979).

The assignment of theta roles (according to the principle of theta attachment of Pritchett, 1992) also predicts that the NPs preceding and following the verb receive theta roles immediately, thus preferring a main-clause analysis. Furthermore, like the English sentence *The horse raced past the barn fell*, once the theta role is assigned, reassignment that reverses the mis-assigned theta roles is extremely costly. In the case of Experiment 5, the reanalysis was never accomplished. The comprehension of these garden-path sentences only achieved heuristics-based shallow processing based on the position of the noun phrases in relation to the verb.

Another finding was that animacy of the topicalized object did not facilitate a correct parse. When the initial NP was inanimate, and thus unlikely to be the subject or agent of the following verb (due to semantic incompatibility), the parser did not reanalyze the structure immediately. Instead, it maintains the main-clause analysis until further upcoming materials (e.g. the relativizer and the head noun) more seriously rejected the first analysis. This supports Ferreira and Clifton's (1986) finding that animacy does not have an immediate effect in sentence comprehension. The parser builds a simple structure first, tolerating the semantic incongruity until the structural incompatibility reaches a threshold. Experiment 5 showed that such a threshold occurred at the head noun (N2). Prior to the head noun, the parser was able to tolerate the clause-initial inanimate NP

being an unlikely agent of the verb. At the head noun, however, the parser can no longer ignore the fact that the unlikely agent cannot perform an action on the NP that follows the verb; thus, a significant effect of animacy at the head noun was observed in the topicalized condition.

Appendix D.

Experimental Materials for Experiment 5:

- 1
運送了|很多位|球員的|教練|一直|抱怨|經費|不夠多。
球員|運送了|很多位的|教練|一直|抱怨|經費|不夠多。
運送了|很多件|球衣的|教練|一直|抱怨|經費|不夠多。
球衣|運送了|很多件的|教練|一直|抱怨|經費|不夠多。
- 2
接管了|數十個|官兵的|中校|感受到|很大的|壓力。
官兵|接管了|數十個的|中校|感受到|很大的|壓力。
接管了|數十個|計畫的|中校|感受到|很大的|壓力。
計畫|接管了|數十個的|中校|感受到|很大的|壓力。
- 3
已經|檢查過|許多個|旅客的|空姐|仍顯得|神采奕奕。
旅客|已經|檢查過|許多個的|空姐|仍顯得|神采奕奕。
已經|檢查過|許多個|座位的|空姐|仍顯得|神采奕奕。
座位|已經|檢查過|許多個的|空姐|仍顯得|神采奕奕。
- 4
專訪過|頗多|學者的|主播|已經|決定|明年|退休。
學者|專訪過|頗多的|主播|已經|決定|明年|退休。
專訪過|頗多|名校的|主播|已經|決定|明年|退休。
名校|專訪過|頗多的|主播|已經|決定|明年|退休。
- 5
視察了|十來個|士兵的|將軍|感嘆|軍中|風氣|大不如前。
士兵|視察了|十來個的|將軍|感嘆|軍中|風氣|大不如前。
視察了|十來個|崗哨的|將軍|感嘆|軍中|風氣|大不如前。
崗哨|視察了|十來個的|將軍|感嘆|軍中|風氣|大不如前。
- 6
管理過|好幾個|工友的|公務員|常常|提出|不恰當的|要求。
工友|管理過|好幾個的|公務員|常常|提出|不恰當的|要求。
管理過|好幾個|畫廊的|公務員|常常|提出|不恰當的|要求。
畫廊|管理過|好幾個的|公務員|常常|提出|不恰當的|要求。
- 7
洗劫過|三個|管理員的|囚犯|認為|自己的|行為|並沒有|錯。
管理員|洗劫過|三個的|囚犯|認為|自己的|行為|並沒有|錯。
洗劫過|三個|加工廠的|囚犯|認為|自己的|行為|並沒有|錯。
加工廠|洗劫過|三個的|囚犯|認為|自己的|行為|並沒有|錯。
- 8
載運了|不少|搬運工的|教官|在|高速公路|上|超速|被抓。
搬運工|載運了|不少的|教官|在|高速公路|上|超速|被抓。
載運了|不少|紹興酒的|教官|在|高速公路|上|超速|被抓。
紹興酒|載運了|不少的|教官|在|高速公路|上|超速|被抓。
- 9
修理過|不少個|雇員的|券商|沒想到|會有|淒涼的|晚年。
雇員|修理過|不少個的|券商|沒想到|會有|淒涼的|晚年。
修理過|不少個|鐘錶的|券商|沒想到|會有|淒涼的|晚年。
鐘錶|修理過|不少個的|券商|沒想到|會有|淒涼的|晚年。
- 10
熟悉|好幾個|僧侶的|雇主|決定|搬到|花蓮|去|住。
僧侶|熟悉|好幾個的|雇主|決定|搬到|花蓮|去|住。
熟悉|好幾個|港口的|雇主|決定|搬到|花蓮|去|住。
港口|熟悉|好幾個的|雇主|決定|搬到|花蓮|去|住。
- 11
喜歡|好幾種|女孩的|設計師|終於|打算|出國|留學。
女孩|喜歡|好幾種的|設計師|終於|打算|出國|留學。
喜歡|好幾種|樂器的|設計師|終於|打算|出國|留學。
樂器|喜歡|好幾種的|設計師|終於|打算|出國|留學。
- 12
查看|很多個|人犯的|警察|想|先|確保|自己的|安全。
人犯|查看|很多個的|警察|想|先|確保|自己的|安全。
查看|很多家|夜店的|警察|想|先|確保|自己的|安全。
夜店|查看|很多家的|警察|想|先|確保|自己的|安全。
- 13
巡視過|十多個|幕僚的|委員長|希望|大家|做好|準備。
幕僚|巡視過|十多個的|委員長|希望|大家|做好|準備。
巡視過|十多個|部門的|委員長|希望|大家|做好|準備。
部門|巡視過|十多個的|委員長|希望|大家|做好|準備。
- 14
贊助過|好幾個|名模的|美商|十分|受到|禮遇。
名模|贊助過|好幾個的|美商|十分|受到|禮遇。
贊助過|好幾家|餐廳的|美商|十分|受到|禮遇。
餐廳|贊助過|好幾家的|美商|十分|受到|禮遇。
- 15
讚美過|許多位|新外長的|元首|打算|尋求|連任。
新外長|讚美過|許多位的|元首|打算|尋求|連任。
讚美過|許多項|新設施的|元首|打算|尋求|連任。
新設施|讚美過|許多項的|元首|打算|尋求|連任。
- 16
清洗|不少|病人的|看護|常常|睡眠|不足。
病人|清洗|不少的|看護|常常|睡眠|不足。
清洗|不少|穢物的|看護|常常|睡眠|不足。
穢物|清洗|不少的|看護|常常|睡眠|不足。
- 17
扣押|十數位|當事人的|檢察長|期勉|屬下|早日|偵破|案件。
當事人|扣押|十數位的|檢察長|期勉|屬下|早日|偵破|案件。
扣押|十數噸|海洛英的|檢察長|期勉|屬下|早日|偵破|案件。
海洛英|扣押|十數噸的|檢察長|期勉|屬下|早日|偵破|案件。
- 18
搜查|十來個|米商的|農會|想|建立|可靠|的形象。
米商|搜查|十來個的|農會|想|建立|可靠|的形象。
搜查|十來個|米倉的|農會|想|建立|可靠|的形象。
米倉|搜查|十來個的|農會|想|建立|可靠|的形象。

19

供出|一大票|同夥|的|罪犯|希望|法官|從輕|量刑。
 同夥|供出|一大票|的|罪犯|希望|法官|從輕|量刑。
 供出|一大堆|名單|的|罪犯|希望|法官|從輕|量刑。
 名單|供出|一大堆|的|罪犯|希望|法官|從輕|量刑。

20

逮獲|五個|偷渡客|的|憲兵|等著|上級|嘉獎。
 偷渡客|逮獲|五個|的|憲兵|等著|上級|嘉獎。
 逮獲|五箱|走私菸|的|憲兵|等著|上級|嘉獎。
 走私菸|逮獲|五箱|的|憲兵|等著|上級|嘉獎。

21

放棄過|許多位|男友|的|女主角|從來|不覺得|後悔。
 男友|放棄過|許多位|的|女主角|從來|不覺得|後悔。
 放棄過|許多個|機會|的|女主角|從來|不覺得|後悔。
 機會|放棄過|許多個|的|女主角|從來|不覺得|後悔。

22

藏匿了|十來個|通緝犯|的|店家|聽到|警笛|總是|心驚膽跳。
 通緝犯|藏匿了|十來個|的|店家|聽到|警笛|總是|心驚膽跳。
 藏匿了|十來桶|私釀酒|的|店家|聽到|警笛|總是|心驚膽跳。
 私釀酒|藏匿了|十來桶|的|店家|聽到|警笛|總是|心驚膽跳。

23

走訪了|很多位|退休教師|的|校友|正在|募款|蓋新大樓。
 退休教師|走訪了|很多位|的|校友|正在|募款|蓋新大樓。
 走訪了|很多座|紀念銅像|的|校友|正在|募款|蓋新大樓。
 紀念銅像|走訪了|很多座|的|校友|正在|募款|蓋新大樓。

24

已經|容忍|許多位|蠻橫|的|長官|的|團員|是個|正直|的|老實人。
 蠻橫|的|長官|已經|容忍|許多位|的|團員|是個|正直|的|老實人。
 已經|容忍|許多個|不實|的|指控|的|團員|是個|正直|的|老實人。
 不實|的|指控|已經|容忍|許多個|的|團員|是個|正直|的|老實人。

CHAPTER 6

GRAMMAR AND PARSING: CONCLUDING REMARKS

In this chapter, we summarize the major findings, and consider the extent to which the universal incremental minimalist parser, IMP, proposed in Chapter 2 is able to account for structural preferences and semantic interpretation. In 6.1, we summarize the main findings of each chapter. 6.2 discusses the findings in relation to the incremental minimalist parser.

6.1 Summary of Findings

The central theme of this dissertation is whether there is a universal account for the processing of relative clauses across languages. In Chapter 2, the incremental minimalist parser (IMP) was proposed. IMP uses three kinds of information in constructing syntactic structures on-line: a top-down functional template to which incoming words are attached, syntactic/ subcategorizational information (by means of syntactic features) carried by each incoming lexical item, and mechanisms such as internal and external merges. We discussed how sentences with relative clauses are constructed on-line by IMP.

In Chapter 3, we discussed the issue of an asymmetric preference in processing relative clauses with subject and object extractions. Previous studies of self-paced readings across languages suggested an overall processing preference for subject extractions. The only published study that found a preference for object extractions was Hsiao and Gibson's (2003) study of Mandarin relative clauses. As reviewed in Chapter 3,

Hsiao and Gibson's (2003) study was confounded by nested versus serial embeddings. In Experiment 1, we re-examined this issue by considering two factors—the extraction types and whether the relative clauses modify the subject or the object in the matrix clause.

With Hsiao and Gibson's confound avoided, we found a processing advantage for relative clauses that involved subject extractions in Mandarin, a language with head-final relative clauses. The results supported a structure-based processing theory, such as IMP, according to which a gap at the subject position is more easily accessed than a gap at the object position. This parsing preference for gaps at the subject position is universal.

In Chapter 4, we further examined the effect of a gap's position on sentence processing. Possessor relative clauses in Mandarin Chinese, in which the head noun serves as the possessor of a nominal element in the relative clause, were the focus of Experiments 2 to 4. In this series of experiments, we varied the positions of the possessor gaps by disposing the patient argument (to which the possessor gaps were attached) from the object position, the oblique position (with the BA construction), to the subject position (in the passive construction). By varying the positions of the gap, we were able to determine whether structural distance or linear distance better predicted processing difficulties. Experiment 2 was composed of naturalness ratings. Experiment 3 was composed of paraphrasing tasks. Experiment 4 was composed of self-paced reading tasks. The experimental results across the three experiments consistently confirmed that when the possessor gaps were located at the subject position (that is, in the passive condition), the parser found it easier to construct the possessive relation between the head noun and the embedded nominal argument. This finding, together with the finding of Chapter 3,

supported a structure-based parsing theory, in which the parser searches for gaps from the top node of the structure. The results also suggested that processing theories based on locality and canonicity, but not on syntactic structure, cannot account for the processing preferences of filler-gap relations in relative clauses. An implication of the Chapters 3 and 4 is that in Mandarin Chinese, a language with prenominal relative clauses, the construction of filler-gap relations is not initiated until the head noun (i.e. the filler) is reached. This is due to the lack of an overt marker for a relativized gap at the embedded clause; as a result, a relative-clause construction is not ensured until the relativizer and the head noun are reached. The way a relativized gap is accessed is similar across languages. The fillers are first recognized; the parser then starts to search for a gap. This gap-searching process proceeds through the hierarchical structure from top down, producing a parsing advantage for gaps located at the subject position.

In Chapter 5, we looked at sentences with relative clauses that lead to garden path. We discussed reduced relative clauses in English and presented an experiment (Experiment 5) on processing relative clauses with the embedded object topicalized in Mandarin Chinese. In Experiment 5, two factors were considered—(a) whether the relative clauses involved topicalization of the object or not, and (b) the animacy of the embedded object. The goal was to investigate whether the surface NVN sequence in the topicalized conditions induces garden path, and whether the animacy of the first noun in such sequences rescues the garden path. The results suggested that the surface NVN order would induce a (main-clause) garden-path reading. Even when the first noun was an unlikely agent (i.e. when it is inanimate), the parser was still inclined to take it as the subject in the initial

analysis. The top-down syntactic analysis preceded semantic interpretation, leading to a reanalysis that took place very late. However, this reanalysis involved both revising the main-clause parse into a relative-clause parse and reassigning the theta roles. The incremental semantic commitment (in terms of theta assignment) in the early parse makes reanalysis unattainable. Therefore, sentences with topicalizations (leading to the superficial NVN orders) were not understood correctly even when the initial inanimate nouns suggested that the main-clause parse was not likely. The results had two implications:

- (A) The top-down NVN template is syntactic. The semantic anomaly of the first N (being inanimate) does not keep the parser from adopting the subject-verb-object parse.
- (B) Thematic relations are interpreted incrementally with the construction of syntactic structure. Once thematic roles are assigned, it is extremely costly (if not impossible) to remedy and to reverse the assignment of thematic roles.

6.2 Processing and Parsing Grammar

In the framework that we discussed in Chapter 1, we distinguished between grammar, the parser, and the processor:

(1)



IMP is a parsing model which constructs syntactic structures on-line based on grammatical knowledge. Various processing preferences and garden-path phenomena result from preferences at the parser level. An overall preference for processing relative

clauses with subject extractions suggest that subject positions are more easily accessed by the parser because they are located higher in the structure. This effect rejected a locality-based account, which is an account based on constraints of working memory. The parser has an effect that is independent from the processor. The garden-path phenomenon in Chapter 5 can best be accounted for by the top-down syntactic template made of a series of functional projections. An NVN sequence is preferably analyzed as subject-verb-object. Such a sequence is then sent to LF for the thematic interpretation (agent-action-patient).

The universality of subject preferences in processing relative clauses supports universal parsing mechanisms. Grammars may be different across languages, but the universal parser constructs sentences using similar strategies, thus producing similar parsing preferences across languages. Such parsing strategies also lead to similar garden paths across languages.

Syntax may be constructed (parsed) independently without semantic information. The parser attempts to analyze sentences based on syntactic categories and subcategorization. Semantics (e.g. thematic information) is then interpreted based on this syntactic analysis. A wrong parse may be strengthened once (incorrect) thematic roles are assigned. Reanalysis may thus become unattainable. Such is the case observed in reduced relative clauses in English and relative clauses with object topicalization in Chinese.

REFERENCES

- Aldridge, E. (2004). Internally Headed Relative Clauses in Austronesian Languages. *Language and Linguistics*, 5, 99-129.
- Aoun, J., & Li, Y.-h. A. (2003). *Essays on the Representational and Derivational Nature of Grammar*. Cambridge, MA: MIT Press.
- Bever, T. G. (1970). Cognitive Basis for Linguistic Structures. In J. R. Hayes (Ed.), *Cognition and the Development of Language* (pp. 279-362). New York: Wiley.
- Birch, S. L., Albrecht, J. E., & Myers, J. L. (2005). Syntactic Focusing Structures Influence Discourse Processing. *Discourse Processes*, 30, 285-304.
- Bošković, Ž. (2001). *On the Nature of the Syntax-Phonology Interface: Cliticization and Related Phenomena*. Amsterdam: Elsevier Science.
- Carlson, G. N. (1977). Amount Relatives. *Language*, 53, 520-542.
- Chao, Y.-R. (1968). *A Grammar of Spoken Chinese*. Berkeley, CA: University of California Press.
- Chomsky, N. (1977). On Wh-Movement. In P. Culicover, T. Wasow & A. Akmajian (Eds.), *Formal Syntax* (pp. 71-132). New York: Academic Press.
- Chomsky, N. (1986). *Knowledge of Language: Its Nature, Origin and Use*. New York, NY: Praeger.
- Chomsky, N. (1993). A Minimalist Program for Linguistic Theory. In K. Hale & S. J. Keyser (Eds.), *The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger* (pp. 1-52). Cambridge, MA: MIT Press.
- Chomsky, N. (1995). *The Minimalist Program*. Cambridge, MA: MIT Press.
- Chomsky, N. (1996). *Language and Mind: Current Thoughts on Ancient Problems (part I)*. Unpublished manuscript.
- Chomsky, N. (2000). Minimalist Inquiries: The Framework. In R. Martin, D. Michaels & J. Uriagereka (Eds.), *Step by Step: Essays on Minimalist Syntax in Honor of Howard Lasnik* (pp. 89-156). Cambridge, MA: MIT Press.
- Chomsky, N. (2001). Derivation by Phase. In M. Kenstowicz (Ed.), *Ken Hale: A life in language* (pp. 1-52). Cambridge, MA: The MIT Press.
- Chomsky, N. (2005). *On Phases*. Unpublished manuscript, Cambridge, MA.
- Chu, C. C.-H. (1983). *A Reference Grammar of Mandarin Chinese for English Speakers*. New York: Peter Lang Publishing.
- Cohen, L., & Mehler, J. (1996). Click Monitoring Revisited: An On-line Study of Sentence Comprehension *Memory and Cognition*, 24, 94-102.
- Crain, S., & Steedman, M. (1985). On Not Being Led up the Garden Path: The Use of

- Context by the Psychological Parser. In D. R. Dowty, L. Karttunen & A. M. Zwicky (Eds.), *Natural Language Parsing: Psychological, Computational, and Theoretical Perspectives* (pp. 320-358). New York: Cambridge University Press.
- De Vincenzi, M. (1991). *Syntactic Parsing Strategies in Italian: The Minimal Chain Principle*. Dordrecht: Kluwer.
- Ferreira, F. (2003). The Misinterpretation of Noncanonical Sentences. *Cognitive Psychology*, 47, 164-203.
- Ferreira, F., & Clifton Jr., C. (1986). The Independence of Syntactic Processing. *Journal of Memory and Language*, 25, 348-368.
- Fong, S. (2005). Computation with Probes and Goals: A Parsing Perspective. In A. M. D. Sciullo (Ed.), *UG and External Systems: Language, Brain and Computation* (pp. 311-333). Amsterdam: John Benjamins.
- Fong, S., & Hirose, Y. (2005). *Minimalist Parsing and Japanese: On Theory and Experiential Factors*. Paper presented at the Tokyo Conference on Psycholinguistics (TCP 2005), Tokyo.
- Ford, M. (1983). A Method for Obtaining Measures of Local Parsing Complexity throughout Sentences. *Journal of Verbal Learning and Verbal Behavior*, 22, 203-218.
- Frauenfelder, U., Segui, J., & Mehler, J. (1980). Monitoring around the Relative Clause. *Journal of Verbal Learning and Verbal Behavior*, 19, 328-337.
- Frazier, L. (1978). *On Comprehending Sentences: Syntactic Parsing Strategies*. University of Connecticut.
- Frazier, L. (1979). *On Comprehending Sentences: Syntactic Parsing Strategies*. Bloomington, IN: Indiana University Linguistics Club.
- Frazier, L. (1987a). Sentence Processing: A Tutorial Review. In M. Coltheart (Ed.), *Attention and performance XII: The Psychology of Reading* (pp. 559-586). Hillsdale, NJ: Erlbaum.
- Frazier, L. (1987b). Syntactic Processing: Evidence from Dutch. *Natural Language and Linguistic Theory*, 5, 519-559.
- Frazier, L., & Clifton Jr., C. (1996). *Construal*. Cambridge, MA: MIT Press.
- Frazier, L., Clifton Jr., C., & Randall, J. (1983). Filling Gaps: Decision Principles and Structure in Sentence Comprehension. *Cognition*, 13, 187-222.
- Frazier, L., Clifton Jr., C., Rayner, K., Deevy, P., Koh, S., & Bader, M. (2005). Interface Problems: Structural Constraints on Interpretation? *Journal of Psycholinguistic Research*, 34, 201-231.
- Frazier, L., & d'Arcais, F. G. (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.
- Fukui, N., & Takano, Y. (2000). Nominal Structure: An Extension of the Symmetry Principle. In P. Svenonius (Ed.), *The Derivation of VO and OV* (pp. 219-254). Amsterdam: John Benjamins.
- Gibson, E. (1998). Linguistic Complexity: Locality of Syntactic Dependencies. *Cognition*, *68*, 1-76.
- Gibson, E., Desmet, T., Grodner, D., Watson, D., & Ko, K. (2005). Reading Relative Clauses in English. *Cognitive Linguistics*, *16*, 313-353.
- Goldberg, A. E. (1995). *Constructions: A Construction Grammar Approach to Argument Structure*. Chicago, IL: Chicago University Press.
- Gouvea, A. C. (2003). *Processing Syntactic Complexity: Cross-Linguistic Differences and ERP Evidence*. University of Maryland, College Park, College Park.
- Grodzinsky, Y. (1986). Language Deficits and the Theory of Syntax *Brain and Language*, *135-159*.
- Grodzinsky, Y. (1995). Trace Deletion, Theta-Roles, and Cognitive Strategies. *Brain and Language*, *51*, 469-497.
- Grosu, A. (2002). Strange Relatives at the Interface of Two Millennia. *Glott International*, *6*, 145-167.
- Hawkins, J. A. (1999). Processing Complexity and Filler-Gap Dependencies Across Grammars. *Language*, *75*, 244-285.
- Hawkins, J. A. (2003). Efficiency and Complexity in Grammars: Three General Principles. In J. Moore & M. Polinsky (Eds.), *The Nature of Explanation in Linguistic Theory* (pp. 121-152). Stanford, CA: CSLI Publications.
- Hawkins, J. A. (2004). *Efficiency and Complexity in Grammars*. Oxford: Oxford University Press.
- Hiraiwa, K. (2005). *Dimensions of Symmetry in Syntax: Agreement and Clausal Architecture*. MIT, Cambridge, MA.
- Holmes, V. M., & O'Regan, J. K. (1981). Eye Fixation Patterns during the Reading of Relative-Clause Sentences. *Journal of Verbal Learning and Verbal Behavior*, *20*, 417-430.
- Hsiao, F. (2003). *The Syntax and Processing of Relative Clauses in Mandarin Chinese*. MIT, Cambridge, MA.
- Hsiao, F., & Gibson, E. (2003). Processing Relative Clauses in Chinese. *Cognition*, *90*, 3-27.
- Huang, C.-T. J. (1982). *Logical Relations in Chinese and the Theory of Grammar*. MIT,

Cambridge, MA.

- Huang, C.-T. J. (1994). Logical Form. In G. Webelhuth (Ed.), *Government and Binding Theory and the Minimalist Program* (pp. 127-173). Oxford: Blackwell.
- Jackendoff, R. (1997). *The Architecture of the Language Faculty*. Cambridge, MA: MIT Press.
- Joshi, A. K., & Schabes, Y. (1997). Tree Adjoining Grammars. In G. Rozenberg & A. Salomaa (Eds.), *Handbook of Formal Languages* (pp. 69-124). Berlin: Springer.
- 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.
- Keenan, E. L., & Comrie, B. (1979). Data on the Noun Phrase Accessibility Hierarchy. *Language*, 55, 333-351.
- King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language*, 30, 580-602.
- King, J. W., & Kutas, M. (1995). Who did what and when? Using word- and clause-level ERPs to monitor working memory usage in reading. *Journal of Cognitive Neuroscience*, 7, 376-395.
- Kwon, N., Polinsky, M., & Kluender, R. (2004). *Processing of Relative Clause Sentences in Korean*. Paper presented at the Poster presented at Architectures and Mechanisms for Language Processing (AMLaP) 2004
- Lee, T. H.-T. (1995). *Garden Path Sentences in Chinese*. Unpublished manuscript, Hong Kong.
- Lin, C.-J. C. (2006). *Processing Thematic Relations between Nouns*. Paper presented at the The 7th Chinese Lexical Semantics Workshop, Hsin-Chu.
- MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, 101, 483-506.
- MacWhinney, B., & Pleh, C. (1988). The Processing of Restrictive Relative Clauses in Hungarian. *Cognition*, 29, 95-141.
- Mak, W. M., Vonk, W., & Schriefers, H. (2002). The Influence of Animacy on Relative Clause Processing. *Journal of Memory and Language*, 47, 50-68.
- Mazuka, R., Itoh, K., & Kondo, T. (2002). Costs of Scrambling in Japanese Sentence Processing In M. Nakayama (Ed.), *Sentence Processing in East Asian Languages* (pp. 131-166). Stanford, CA: CSLI Publications.
- McKoon, G., & Ratcliff, R. (2003). Meaning through Syntax: Language Comprehension and the Reduced Relative Clause Construction *Psychological Review*, 110, 490-525.

- McRae, K., Hare, M., & Tanenhaus, M. K. (2005). Meaning through Syntax is Insufficient to Explain Comprehension of Sentences with Reduced Relative Clauses: Comment on McKoon and Ratcliff (2003). *Psychological Review*, *112*, 1022-1031.
- McRae, K., Spivey-Knowlton, M. J., & Tanenhaus, M. K. (1998). Modeling the Influence of Thematic Fit (and Other Constraints) in On-line Sentence Comprehension. *Journal of Memory and Language*, *38*, 283-312.
- Mecklinger, A., Schriefers, H., Steinhauer, K., & Friederici, A. D. (1995). Processing Relative Clauses Varying on Syntactic and Semantic Dimensions: An Analysis with Event-Related Potentials. *Memory and Cognition*, *23*, 477-494.
- Miyamoto, E. T., & Nakamura, M. (2003). Subject/Object Asymmetries in the Processing of Relative Clauses in Japanese. In G. Garding & M. Tsujimura (Eds.), *WCCFL 22 Proceedings* (pp. 342-355). Somerville, MA: Cascadilla Press.
- Nakamura, M. (2003). *Processing of Multiple Filler-Gap Dependencies in Japanese*. University of Hawaii.
- Ning, C. (1993). *The Overt Syntax of Relativization and Topicalization in Chinese*. University of California, Irvine, Irvine, CA.
- Nunes, J. (2001). Sideward Movement. *Linguistic Inquiry*, *31*, 303-344.
- Nunes, J. (2004). *Linearization of Chains and Sideward Movement*. Cambridge, MA: MIT Press.
- O'Grady, W. (1997). *Syntactic Development*. Chicago: The University of Chicago Press.
- Phillips, C. (1996). *Order and Structure*. MIT, Cambridge, MA.
- Phillips, C. (2003). Linear Order and Constituency. *Linguistic Inquiry* *34*, 37-90.
- Pritchett, B. L. (1992). *Grammatical Competence and Parsing Performance*. Chicago: University of Chicago Press.
- Schachter, P. (1973). Focus and Relativization. *Language*, *49*, 19-46.
- Schelstraete, M. A., & Degand, L. (1998). Assignment of grammatical functions in French relative clauses. *Language Sciences*, *20*, 163-188.
- Schriefers, H., Friederici, A. D., & Kuhn, K. (1995). The Processing of Locally Ambiguous Relative Clauses in German. *Journal of Memory and Language*, *34*, 499-520.
- Sheldon, A. (1974). The Role of Parallel Function in the Acquisition of Relative Clauses in English. *Journal of Verbal Learning and Verbal Behavior*, *13*, 272-281.
- Stevenson, S., & Merlo, P. (1997). Lexical Structure and Parsing Complexity. *Language and Cognitive Processes*, *12*, 349-399.
- Stowe, L. A. (1986). Parsing WH-Constructions: Evidence for On-Line Gap Location.

- Language and Cognitive Processes*, 1, 227-245.
- Szendroi, K. (2003). Focus and the Syntax-Phonology Interface. *Glott International*, 7(9/10), 261-268.
- Tamaoka, K., Sakai, H., & Kawahara., J. (2003). The Effects of Phrase-Length Order and Scrambling in the Processing of Visually Presented Japanese Sentences. *Journal of Psycholinguistic Research*, 32, 431-454.
- Tamaoka, K., Sakai, H., & Kawahara., J. (2005). Priority Information Used for the Processing of Japanese Sentences: Thematic Roles, Case Particles or Grammatical Functions? *Journal of Psycholinguistic Research*(34), 281-332.
- Tang, T.-C. (1979). *Studies in Chinese Syntax*. Taipei: Student Book.
- Townsend, D. J., & Bever, T. G. (2001). *Sentence Comprehension: The Integration of Habits and Rules*. Cambridge, MA: MIT Press.
- 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.
- Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic Influences on Parsing: Use of Thematic Role information in Syntactic Ambiguity Resolution. *Journal of Memory and Language*, 33, 285-318.
- Tsai, W.-T. D. (2003). Three Types of Existential Quantification in Chinese. In Y.-h. A. Li & A. Simpson (Eds.), *Functional Structure(s), Form and Interpretation: Perspectives from Asian Languages*. London: Routledge.
- Uriagereka, J. (1998). *Rhyme and Reason: An Introduction to Minimalist Syntax*. Cambridge, MA: MIT Press.
- Van Gompel, R. P. G. (1995). *The Processing of Subject and Object Relative Clauses in Dutch*. University of Nijmegen.
- Vergnaud, J.-R. (1974). *French Relative Clauses*. MIT, Cambridge, MA.
- Warren, T., & Gibson, E. (2002). The Influence of Referential Processing on sSentence Complexity. *Cognition*, 85, 79-112.