

**THE SYNTAX AND PROCESSING OF RELATIVE  
CLAUSES IN MANDARIN CHINESE**

by

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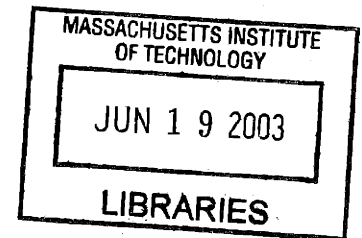
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**ARCHIVES**

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ABSTRACT

This thesis investigates relative clauses (henceforth RCs) in Mandarin Chinese as spoken in Taiwan from both syntactic and processing perspectives. I also explore the interaction between these two areas, for example, how evidence from one area lends support to or undermines theories in the other area.

There are several goals I hope to achieve:

First of all, there is a significant gap in the sentence processing literature on Mandarin Chinese and in particular on RCs in Mandarin Chinese. I aim to bridge this gap by conducting experiments that will provide basic understanding of how Chinese RCs are processed. In doing so, I also provide a more complete picture of processing RCs across languages. In this thesis, I report three online reading experiments on Chinese RCs. I show that even though Chinese is also an SVO language like English and French, the results with regard to processing subject-extracted versus object-extracted RCs in Mandarin Chinese are very different from results for the same construction in other SVO languages. Thus, even though subject-extracted RCs are less complex in other SVO languages, they are more complex in Mandarin Chinese. These findings

help tease apart various processing theories, in particular, I show that even though resource-based theories, canonical/non-canonical word order (frequency) theories, theory based on accessibility of syntactic positions and perspective shift theory all account for the facts reported in other SVO languages, results from Chinese are only compatible with resource-based theories and canonical/non-canonical (frequency) theories.

Secondly, it has been noted that in many cases, resource-based theories and canonical/non-canonical word order (frequency) theories are both compatible with data from sentence processing studies. Resource-based theories attribute processing difficulty associated with subject-extracted RCs to higher storage cost in processing subject-extracted RCs whereas frequency-based canonical word order theory such as the one proposed in Mitchell et al. 1995 attributes this to the less frequent occurrences of subject-extracted RCs in corpora. As a result, it is very difficult to tease these two theories apart. However, I conducted a Chinese corpus study in this thesis and I show that there is no correlation between structural frequencies in corpora and behavioral measures such as reading times, as predicted by frequency theories. As a matter of fact, subject-extracted RCs occur more frequently in the Chinese corpus. This undermines the validity of frequency theories in explaining the processing data reported in this thesis.

Thirdly, Aoun and Li to appear argue that there is syntactic and semantic evidence in favor of positing two distinct syntactic derivations for RCs with or without resumptive pronouns. RCs containing gaps involve head-raising of the head NP (i.e. no operator movement) as reconstruction of the head NP back to the RC is available. On the other hand, RCs containing resumptive pronouns involve an empty operator in [Spec, CP] and no head-raising of the head NP (since reconstruction is unavailable). As different syntactic structures predict different processing patterns, I explore the interaction between syntax and processing by investigating how syntactic structures differing only

in the presence of resumptive pronouns are processed. I show that to a large extent the findings support Aoun and Li's theory. This discovery is significant because we are able to draw empirical evidence from sentence processing in support of a syntactic theory.

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Keywords: Mandarin Chinese, relative clauses, sentence processing, resource-based theories, corpus analysis, resumptive pronouns, reconstruction, empty operator

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*And Canim, thank you.*

## **Chapter 1 Introduction**

This thesis investigates relative clauses (henceforth RCs) in Mandarin Chinese as spoken in Taiwan from both syntactic and processing perspectives. We also explore the interaction between syntax and processing, for example, how evidence from one area lends support to or undermines theories in the other area.

### **1.1 Goals of this Thesis**

The following subsections outline the goals of this thesis: (1) to bridge the gap in the sentence processing literature on Chinese RCs so as to provide a more complete picture of processing RCs across languages, (2) to tease apart resource-based theories and canonical/non-canonical (frequency) theories by conducting a corpus analysis and (3) to draw empirical evidence from sentence processing in support of syntactic theories/syntactic derivations of Chinese RCs.

#### **1.1.1 Goal: Bridging the Gap in the Sentence Processing Literature on RCs**

There is a significant gap in the sentence processing literature on Mandarin Chinese and in particular on RCs in Mandarin Chinese (for studies on word identification in Chinese during online reading, see e.g. Guo 1997 and Tsai 2001). One of my goals in this thesis is to bridge this gap by conducting experiments that will provide basic understanding of how Chinese RCs are processed. In doing so, we also provide a more complete picture of processing RCs across languages.

In this thesis, I report three online reading experiments on Chinese RCs. I show that even though Chinese is an SVO language like English and French, the results with regard to processing subject-extracted versus object-extracted RCs in Mandarin Chinese are very different from results for the same constructions in

other SVO languages. Thus, while subject-extracted RCs are less complex in other SVO languages, they are more complex in Mandarin Chinese. These findings help tease apart various processing theories, in particular; I show that even though resource-based theories, canonical/non-canonical (frequency) theories, a theory based on accessibility of syntactic positions and perspective shift theory all account for the facts reported in other SVO languages, results from Chinese are only compatible with resource-based theories and canonical/non-canonical (frequency) theories.

### **1.1.2 Goal: Teasing Apart Resource-based Theories and Canonical/Non-Canonical (Frequency) Theories – Corpus Analysis**

It has been noted that in many cases, resource-based theories and canonical/non-canonical (frequency) theories are both compatible with data from sentence processing studies. To be more specific, resource-based theories account for the fact that subject-extracted RCs in Chinese incur more processing difficulty by attributing it to more resource usage in processing subject-extracted RCs. Canonical/non-canonical (frequency) theories can also account for this fact because the canonical word order SV is present in object-extracted RCs whereas the non-canonical word order VO is present in subject-extracted RCs. In most cases, the canonical word order is also the more frequent word order found in corpus analysis. The greater processing difficulty associated with subject-extracted RCs is due to the less frequent word order. Thus, even though the explanations from both groups of theories differ greatly, they both account for the data successfully. As a result, it is very difficult to tease these two theories apart. However, a Chinese corpus study shows that singly subject-extracted RCs, which have the non-canonical word order VO, occur more frequently in the corpus. This finding undermines the ability of the frequency-based theory to explain the processing difficulty associated with processing subject-extracted RCs.



### **1.1.3 Goal: Drawing Evidence from Sentence Processing in Support of Syntactic Theories**

Results from sentence processing can also provide evidence relevant to the syntactic representation of Chinese RCs. In particular, the fact that subject-extracted RCs incur more processing difficulty than object-extracted RCs in Chinese makes an analysis unlikely in which there is an empty operator on the left of the RC, mediating between the head noun for the RC to the right and the empty position inside the RC. Such an analysis would make the structure of RCs more similar across languages, but it is not compatible with the current processing data. If there were such a position, and integrations to it incurred a processing cost (as they do in English), then there would be no processing advantage for object-extractions over subject-extractions in Chinese. The fact that there is such an advantage makes it likely that there is no empty operator initiating Chinese RCs.

This kind of discovery is meaningful because we are able to draw empirical evidence from sentence processing to eliminate certain syntactic representations of Chinese RCs.

In addition, Aoun and Li to appear argue that there is syntactic and semantic evidence in favor of positing two distinct syntactic derivations for RCs, one for RCs with resumptive pronouns and one for RCs without resumptive pronouns. Namely, they argue that even though there is no empty operator in RCs that contain resumptive pronouns, there is evidence in RCs with resumptive pronouns that an empty operator should be posited in the syntactic representations (see Chapter 2 for more details on their analysis). As different syntactic structures predict different processing patterns, we explore the interaction between syntax and processing by investigating how syntactic structures differing only in the

presence of resumptive pronouns are processed. I show that to a large extent the findings support Aoun and Li's theory.

This kind of discovery is meaningful because we are able to draw empirical evidence from sentence processing to test the predictions of a syntactic theory.

## **1.2 Outline of this Thesis**

The remainder of this thesis is divided into the following sections:

Chapter 2 lays out the current state of knowledge in syntax and sentence processing with regard to Chinese RCs. I outline the various types of RCs and the syntactic representations for them. In the discussion on syntactic theories of Chinese RCs, I focus on the analysis proposed in Aoun and Li to appear.

With respect to sentence processing, I give an overview of the existing experimental studies on processing RCs in other SVO languages. This chapter will help the readers get a sense of the unique place Chinese RCs hold in the study of RCs across languages.

Chapter 3 reports a self-paced reading study to test subject-extracted versus object-extracted RCs in Chinese in unambiguous structures. We look at both singly and doubly embedded RCs in the subject position. The results show that subject-extracted RCs are more difficult to process than object-extracted RCs when RCs occur in the subject position. This finding contrasts with results for the same construction in other SVO languages and helps tease apart various processing theories that are compatible with data from other SVO languages but incompatible with data from Chinese. I also discuss briefly a similar processing study on Japanese, which is head-final but also uses pre-nominal RCs.

Chapter 4 reports another self-paced reading study to test subject-extracted versus object-extracted RCs in Chinese in both unambiguous and ambiguous structures. I look at RCs in both the subject and the object positions. Ambiguity arises in the case of object-extracted RCs in the object position. We show that in spite of the temporary ambiguity in processing object-extracted RCs, subject-extracted RCs in the object position still occur more processing difficulty than object-extracted RCs in the object position.

Chapter 5 examines a Chinese corpus: the Chinese Treebank 3.0 published by Linguistic Data Consortium (LDC). This corpus consists of 325 data files written in simplified Chinese. They contain about 100k words and were taken from Xinhua newswire and were written between 1994 and 1998.

The results from the online reading experiments support resource theories. They could also support frequency theories as long as subject-extracted RCs occur less frequently and hence more difficulties would be expected to be associated with processing subject-extracted RCs. In this chapter, we are interested in finding out whether subject-extracted RCs do indeed occur less frequently than object-extracted RCs. Surprisingly, the results show that subject-extraction occurs 15% more frequently than object-extraction, undermining the validity of canonical/non-canonical (frequency) theories in accounting for the data.

Chapter 6 reports an online reading experiment designed to test the predictions made by Aoun and Li to appear. According to their analysis, RCs without resumptive pronouns do not have an empty operator whereas RCs containing resumptive pronouns have an empty operator in their syntactic representations. Thus, RCs containing resumptive pronouns are predicted to be harder to process due to the additional resources needed to link the empty operator with the resumptive pronoun and also to somehow link this relationship with the head

noun (more discussions on this issue to follow). RCs containing the gaps, on the other hand, should be easier to process, as the only intervening material between the trace and its head noun is the function word *de* (refer to Chapter 6 for more details). In addition, there is no empty operator in this structure that needs to be related to the gap and the head noun.

Both online and offline data support their analysis, i.e. RCs containing resumptive pronouns are harder to process and participants performed worse in answering questions about this type of RCs. This is a welcome result, as we are able to draw empirical evidence from sentence processing to validate predictions of syntactic theories.

Chapter 7 contains further discussions and concluding remarks.

## Chapter 2 Current State of Knowledge

In this chapter, I summarize the current state of knowledge in syntax and sentence processing with regard to Chinese RCs. The discussion here will help readers understand the special syntactic properties Chinese RCs have as compared to those in other SVO languages and consequently the significant place Chinese RCs hold in a cross-linguistic study of processing RCs. This kind of discussion is also essential in understanding another goal of this thesis, i.e. to draw empirical evidence from sentence processing to test predictions of syntactic theories. This kind of investigation is important because a syntactic theory should make correct predictions outside the domain of syntax evidence. And this is another area I am interested in exploring in this thesis.

### 2.1 Syntax of RCs

Linguists have taken interests in RCs since the 60's. There are various types of RCs (see Iatridou 1999 for a typology of RCs):

- full versus reduced RCs (i.e. whether the RCs are CPs or some smaller syntactic projections such as PPs, APs, Partiple Phrases, etc. – see Pesetsky 1995, Iatridou, Anagnostopoulou and Izvorski 1998, 2000 for treatment of different types of reduced RCs),
- restrictive versus non-restrictive/appositive RCs (i.e. whether the reference of the head noun is dependent on the RC – see Keenan 1985 for typology of restrictive relative clauses and also Grosu & Landman 1998),
- headed versus headless RCs (i.e. whether the RC contains an overt head noun),

- non-finite versus finite RCs (i.e. whether the highest main verb in the RC is finite or non-finite),
- pre-nominal versus post-nominal RCs (i.e. whether RCs occur before or after the head noun),

In this thesis, we focus our discussion on finite restrictive RCs only. The experimental items in the online reading experiments thus only contain RCs of this kind.

Theories regarding how finite restrictive relative constructions (i.e. head NP plus the RC) are derived also vary (refer to Ross 1967, Klima 1969, Jackendoff 1977, Emonds 1979, Safir 1986 and Kayne 1994 for treatment of non-restrictive RCs). There are three existing types of analysis (the English examples are taken from Iatridou 1999):

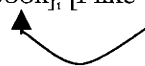
- Head-External Analysis (Chomsky 1977): wh-movement of the relative pronoun; head noun base-generated outside of RC

e.g. [the [book] [<sub>RC</sub>which<sub>i</sub> [I like t<sub>j</sub>]]]



- Matching Analysis (Lees 1960, 1961, Chomsky 1965, Kuroda 1968, Sauerland 1998): deletion of a nominal expression in the RC under identity with the externally based-generated head noun

e.g. [the [book] [<sub>RC</sub>which ~~book~~<sub>i</sub> [I like t<sub>j</sub>]]]



- Extraction/Raising/Promotion Analysis (Brame 1968, Schachter 1973, Vergnaud 1974, Kayne 1994, Hackl and Nissenbaum 1998, Bhatt 1999): raising of the head noun out of the RC

e.g. [the [book]<sub>k</sub> [<sub>RC</sub>[which t<sub>k</sub>] [I like t<sub>j</sub>]]]



Note that the Extraction/Raising/Promotion Analysis is the only analysis that posits internally base-generated head nouns. The other two analyses assume that the head noun is base-generated outside of the RC and that operator movement inside the RC is necessary. Arguments in favor of the Extraction/Raising/Promotion Analysis come from reconstruction facts, i.e. the head noun has to be interpreted inside the RC, which is impossible for the other two analyses to accommodate. In the following, we list some examples of reconstruction effects.

(1) Brame 1968: idiom chunks

- a. We made headway.
- b. \*The headway was satisfactory.
- c. The headway [<sub>RC</sub>that we made] was satisfactory. (*headway* must have originated in the RC for the idiom chunk *make headway* to have the right interpretation)

## (2) Shachter 1973: Binding Theory

- a. The portrait of himself [<sub>RC</sub>that John painted] is very flattering.  
(*himself* must have originated in the RC in order to be bound by *John*)
- b. The interest in each other [<sub>RC</sub>that John and Mary showed] was fleeting. (*each other* must have originated in the RC in order to be bound by *John and Mary*)

## (3) Sauerland 1998: scope reconstruction

No linguist would read the many books Gina will need for vet school.  
(*many* must have originated in the RC as *need* has wider scope than *many*)

For more detailed comparisons of these three types of analyses and for arguments in favor or against these analyses, refer to Iatridou 1999 and Aoun and Li to appear.

Let's now turn our discussion to RCs in Mandarin Chinese.

**2.1.1 General Descriptions of Chinese RCs**

Chinese is an SVO language like English and French but uses pre-nominal RCs only.<sup>1</sup> The RCs are marked by the functional word *de*, which appears at the end of the RC verb, as in (4) below.

---

<sup>1</sup> But see Li & Thompson 1981, He 1996 and Hsiao 2001 for discussions on the 'descriptive clause constructions' in Chinese, which exhibit some properties of post-nominal RCs.



- (4) tamen zhong de shuiguo  
 they grow fruit  
 'the fruit that they grow.'

Typically, there are no wh-pronouns (e.g. *the fruit which they grow*) or personal pronouns in Chinese RCs (e.g. *the fruit that they grow it*, but see the next section for discussions on possible personal pronoun retention in Chinese RCs). There are no overt complementizers in Chinese RCs, either. Note that verbs are generally not overtly marked for tense in Chinese.

Interestingly, the function word *de* is also used as an adjective marker (as in (5)), a nominalizer (as in (6)) and as a possessive marker (as in (7)). Note that examples such as (5) have also been treated as reduced relatives (e.g. Aoun and Li to appear) instead of simple adjectival phrases.

- (5) lanse-de  
 blue color  
 'blue'
- (6) mai dongxi de  
 sell things  
 'one who sells things'
- (7) tamen-de  
 they  
 'their'

The syntactic status of *de* has not received a unified treatment. He 1996 treats *de* as a complementizer, Li & Thompson 1981 analyze it as a nominalizer, Kayne

1994 treats it as an inflection marker, and Simpson and Wu 2002 analyze it as a determiner. Refer to these papers for justifications of their analyses.

Another interesting issue is whether Chinese pre-nominal RCs are reduced or full clauses. As case on noun phrases is not overtly marked in Chinese, it is not clear whether Chinese pre-nominal RCs have the status of reduced or full clauses (see Krause 2001 for tests regarding case marking to determine whether RCs are reduced or full). However, Li 2000a argues that Chinese relativization, like English full relatives but unlike reduced relatives in other languages such as Turkish, obeys the complex NP island constraint. In this thesis, we will therefore follow Ning 1993 and Li 2000a in assuming that Chinese pre-nominal RCs are full clauses that are derived in the same fashion as English full post-nominal RCs, i.e. that Chinese pre-nominal RCs are CPs.

### 2.1.2 Pronoun Retention in Chinese RCs

According to Keenan 1985:149, Mandarin Chinese is the only pre-nominal RC language which presents the relativized NP (what Keenan terms  $NP_{rel}$ ) as a personal pronoun. “The pattern of pronoun retention in Mandarin is ...not normal for  $NP_{rel}$  the subject of the RC, optional if  $NP_{rel}$  is the direct object of the RC, and generally obligatory otherwise.” Examples (8)-(10) below illustrate this point. “Gapping is the overwhelmingly dominant mode of RC formation in pre-nominals (Keenan 1985: 154).”

(8)  $NP_{rel}$  is the subject of pre-nominal RC – no pronoun retention:

na-ge	(*ta)	xihuan ting	yinyue de	nan-hai
that-CL	he	like	listen.to music	boy
‘the boy who likes to listen to music’				

(9) NP<sub>rel</sub> is the direct object in pre-nominal RC – pronoun retention optional<sup>2</sup>:

na-ge wo zuo-tian ren-shi (ta) de nan-hai  
 that-CL I yesterday meet him boy  
 ‘the boy who I met yesterday’

(10) NP<sub>rel</sub> is the indirect object in pre-nominal RC – pronoun retention obligatory:

na-ge wo zuo-tian ba shu gei \*(ta) de nan-hai  
 that-CL I yesterday Obj. marker book to him boy  
 ‘the boy to whom I gave the book yesterday’

### 2.1.3 Aoun and Li to appear

We have seen that there are convincing arguments from reconstruction effects in favor of the Extraction/Raising/Promotion Analysis in English. However, does the same kind of argument apply to Chinese as well?

A related and even more fundamental question is also whether Chinese RCs have the same syntactic representations as the ones posited for English RCs? In other words, does a universal syntactic representation for head-initial RCs or even for RCs across languages exist, as Kayne 1994 claims? In this section, we take a closer look at Aoun and Li to appear, as these are some of the core issues discussed at great length in their work.

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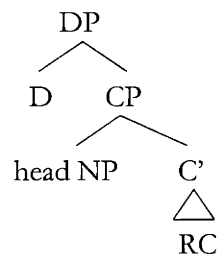
<sup>2</sup> The absence of the object pronoun is preferred in my dialect.

### 2.1.3.1 Syntactic Representations of Relative Constructions

#### 2.1.3.1.1 English: Complementation Structure

Aoun and Li to appear posit the following syntactic representation for relative constructions in English (see also Li 2000b, which makes essentially the same claim):

(11) English: complementation structure



They provide four kinds of arguments in favor of the complementation structure in English (examples below are taken from their work).

- Because the relative CP is complement of D, the presence of a relative CP requires the presence of D.

(12) The Obligatoriness of a DP Structure:

- \*He is an actor that wants to do everything and producer that wants to please everyone.
- He is an actor that wants to do everything and **a** producer that wants to please everyone.

- c. He is an actor and producer that wants to please everyone. (the relative clause must modify both conjuncts)
- d. He is an actor and a producer that does not know how to produce.

The contrast between (12a) and (12b) shows the obligatoriness of a determiner when an RC occurs. (12a) is bad because the second RC lacks a determiner. In (12c), since the second conjunct does not have its own determiner, the RC has to modify both conjuncts. In (12d), on the other hand, the RC can modify one single conjunct. The examples in (12) argue for the necessity of a DP projection when an RC occurs. See also Smith 1964 and Larson 1991, which posit a closer structural relationship between the determiner and the RC (Smith 1964 argues that a RC is part of its determiner and Larson 1991 places the determiner and the RC under the same node).

- A selection relation between D and CP exists (there is a very close dependency relationship between the RC and the determiner, Bianchi 1999, Alexiadou et al. 2000, Schmitt 2000)

(13) Selection Relation between D and CP

- a. the Paris \*(that I knew) (Vergnaud 1974:265)
  - b. the three books of John's \*(that I read)
  - c. the four of the boys \*(that came to dinner)
- D does not form a constituent with the head NP, which is in Spec of CP, i.e. D is outside of the RC

## (14) External Determiner

- a. \*There were the men in the garden.
  - b. The men<sub>i</sub> that there were t<sub>i</sub> in the garden were all diplomats.
  - c. \*They made the fun of me. (Fabb 1990:71)
  - d. the fun that they made of me
  - e. \*We made the headway on that problem. (Browning 1987: 130)
  - f. the headway that we made on that problem
- The head NP can be interpreted inside the RC

(15) Reconstruction Effects: their examples are similar to the ones listed in (1)-(3). Thus, no additional examples will be given here.

**2.1.3.1.2 Chinese: Adjunction Structure**

For Chinese, however, Aoun and Li to appear argue that such evidence does not exist in support of a complementation structure.

- Insignificance of D: the acceptability of a demonstrative is the same with or without a relative clause

## (16) Insignificance of D

- a. Ta kai de na-ge dao hen chenggong  
 He open De that-CL knife very successful  
 ‘That operation he performed was very successful.’

b. Deng ta kai-wan na-ge dao yihou zai zou  
 Wait he open-particle that-CL knife afterwards then leave  
 ‘Don’t leave before he finished the operation.’

- Chinese relativization structure does not necessarily project a DP

(17) DP Not Required (in the following example, only NP-conjunctive *jian* can occur with two instances of [head NP + RC]; note that neither of the two DP-conjunctives *he/gen* can occur with two instances of [head NP + RC])

Aoun and Li to appear discuss several conjunctives in Mandarin Chinese:

- *jian* connects NPs or VPs.

ta shi yi-ge [mishu] jian/\*he/\*gen [daziyuan]  
 he is one-CL secretary and typist  
 ‘He is a secretary and typist.’

Zhangsan [nian-shu] jian [zuo-shi], hen mang  
 Zhangsan study and work, very busy  
 ‘Zhangsan studies and works; (he is) very busy.’

- *he/gen* connects two DPs

wo xiang zhao [yi-ge mishu] he/gen/\*jian [yi-ge daziyuan]  
 I want find one-CL secretary and one-CL typist  
 ‘I want to find a secretary and a typist.’

- *erqie* connects other non-nominal categories

[wo xihuan ta] erqie [Zhangsan ye xihuan ta]  
 I like him and Zhangsan also like him  
 ‘I like him and Zhangsan also likes him.’

- these conjunctives are not interchangeable

However, only the NP-connector *jian* is compatible with two instances of [head NP + RC].

wo xiang zhao yi-ge [fuze yinwen de mishu] jian/\*he/\*gen/\*erqie  
[jiao xiaohai de jiajiao]

I want find one-CL charge English De secretary conjunctor  
teach children De tutor

'I want to find a secretary that takes care of English (matters) and  
tutor that teaches kids.'

This suggests that the head NP and the RC together form an NP instead of a DP.

- Reconstruction only possible with NPs (reflexives, names and bound pronouns) and not with DPs

(18) Reconstruction with reflexives (NPs) possible

a. wo jiao Zhansan quan meigeren kai ziji de chezi lai  
I ask Zhansan persuade everyone drive self De car come  
'I asked Zhansan to persuade everyone to drive self's car.'

b. wo jiao Zhansan quan meigeren kai t<sub>i</sub> lai de [<sub>NP</sub>ziji de chezi]<sub>i</sub>  
I ask Zhansan persuade everyone drive come De self De car  
'self's car that I asked Zhansan to persuade everyone to drive over'

In (18b), *self's car* must have originated in the RC to be bound by *everyone*. Here we see that reconstruction with a reflexive NP is possible.

(19) Reconstruction with scope-bearing DPs not possible



wo hui zhengli meigeren dou hui kan de san-ben shu  
 I will arrange everyone all will read De three-CL book  
 'I will put the three books that everyone will read in order (same three books).'

In (19), the reading in which the DP *three books* has a lower scope than *everyone* is not available, i.e. it is not base-generated in the RC.

(20) Reconstruction with RCs possible

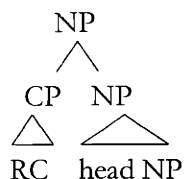
- a. wo xiwang meige xuesheng<sub>i</sub> dou neng ba wo gei ta<sub>i</sub>de shu dai lai.  
 I hope every student all can BA I give his book bring come  
 'I hope every student<sub>i</sub> can bring the book that I gave to him<sub>i</sub>.'
- b. ni hui kandao [<sub>NP</sub>[<sub>CP</sub>wo xiwang meige xuesheng<sub>i</sub> dou neng dai t<sub>i</sub> lai de]  
 [<sub>NP</sub>[<sub>CP</sub>wo gei ta<sub>i</sub> de] [<sub>NP</sub>shu]]].  
 you will see I hope every student all can BA his book bring come De  
 I give his De book  
 'You will see the book that I gave to him<sub>i</sub> that I hope every student<sub>i</sub> will bring.'

In (20b), *wo gei ta de shu* 'I give him De book' must have been base-generated in the RC *wo xiwang meige xuesheng dou neng dai \_ lai de* 'I hope every student all can BA his book bring De' in order for the pronoun *ta* 'him' to be bound by *meige xuesheng* 'every student.'

The fact that reconstruction with an [RC + head NP], i.e. *wo gei ta de shu* 'I give him De book' in (20b) is possible suggests that the head NP and the relative clause together still behave like an NP instead of a DP. This once again suggests

an adjunction structure. Thus, based on the last two arguments, Aoun and Li to appear posit the following syntactic representation for Chinese RCs.

(21) Chinese: adjunction structure



Now that we have established the syntactic representations for RCs in English and Chinese, let's turn to the derivation of relative constructions (head NP plus RC).

### 2.1.3.2 Derivation of Relative Constructions

#### 2.1.3.2.1 English Wh-Relatives: Operator Movement

It is generally assumed (Carlson 1977, Grosu and Landman 1998) that only one derivation (the Head-External Analysis, the Matching Analysis or the Extraction/Raising/Promotion Analysis) of the relative constructions is available in a particular language or even across languages.

However, Aoun and Li to appear show that both operator movement (the Head-External Analysis and the Matching Analysis) and head-raising (the Extraction/Raising/Promotion Analysis) are necessary for English relative constructions depending on whether reconstruction is available. If reconstruction is available, head-raising must be adopted. If reconstruction is unavailable, operator movement must be adopted.

In the case of RCs containing wh-pronouns, because head NP reconstruction is unavailable (as shown in (20) below, reconstruction is unavailable in relative constructions which use wh-pronouns but is available in relative constructions which do not), the head NP must have been base-generated outside of RC and so there is operator movement in the RC (but see footnote 15 in Chapter 4 of Aoun and Li to appear for an alternative explanation which attributes this difference to stylistic variations).

Since the type of RCs in English we concern ourselves with in the experiments we report in the following chapters contains wh-pronouns only, this is the only derivation (i.e. operator movement) of relative constructions in English that we will adopt in this thesis. For more discussions on other types of RCs, refer to Chapter 4 of Aoun and Li *to appear*.

(22) English wh-relatives: operator movement

- a. We admired the picture of himself<sub>i</sub> (that) John<sub>i</sub> painted in art class.
- b. We admired the picture of himself<sub>i</sub> (that) John<sub>i</sub> likes best.
- c. \*We admired the picture of himself<sub>i</sub> which John<sub>i</sub> painted in art class.
- d. \*We admired the picture of himself<sub>i</sub> which John<sub>i</sub> likes best.

### 2.1.3.2.2 Chinese RCs without Resumptive Pronouns: Head-Raising

As we have seen in section 2.1.3.1.1 and the examples in (23), reconstruction is available for Chinese relative constructions that do not contain resumptive pronouns. This means a head-raising analysis must be adopted. As we will see in

the online reading studies in Chapters 3 and 4, this analysis is compatible with the processing results.

(23) Chinese RCs without Resumptive Pronouns: Reconstruction Available

a. wo xiang kan [[ni shuo meigeren, hui dai t<sub>i</sub> huilai de] [ziji, de pengyou].]

I want see you say everyone will bring back De self De friend

'I want to see self's friend that you said that everyone would bring back.'

b. wo xiang kan [[ni shuo meigeren, hui dai t<sub>i</sub> huilai de [wo yijing jieshao gei ta, de pengyou].]

I want see you say everyone will bring back De I already introduce to him De friend

'I want to see the friend that I have introduced to him that you said everyone would bring back.'

#### 2.1.3.2.3 Chinese RCs with Resumptive Pronouns: Base-Generated Empty Operator

As discussed in section 2.1.2, Chinese RCs sometimes allow a resumptive pronoun in place of a gap. The question now is whether RCs containing resumptive pronouns allow reconstruction. Contrast the examples in (24) with (23) above. In (24), the gaps are replaced with resumptive pronouns and reconstruction is unavailable.

(24) Chinese RCs with Resumptive Pronouns: Reconstruction Unavailable

- a. \*wo xiang kan [[ni shuo meigeren; hui dai ta; huilai de] [ziji, de pengyou];]  
 I want see you say everyone will bring him back De self De friend  
 'I want to see self's friend that you said that everyone would bring back.'
- b. \*wo xiang kan [[ni shuo meigeren; hui dai ta; huilai de [wo yijing jieshao gei ta; de pengyou];]  
 I want see you say everyone will bring him back De I already introduce to him De friend  
 'I want to see the friend that I have introduced to him that you said everyone would bring back.'

As reconstruction is unavailable in RCs containing resumptive pronouns, this suggests that the head NP is base-generated outside of the RC, i.e. no head-raising takes place.

In addition, Aoun and Li argue that an empty operator that is co-indexed with both the resumptive pronoun and the head noun must be adopted. This empty operator is base-generated in [Spec, CP] (cf. in the case of adjunct relativization, Aoun and Li show that there is operator movement to [Spec, CP]). Evidence supporting the existence of the empty operator comes from the fact that RCs containing resumptive pronouns disallow a *wh*-interrogative inside them, e.g. (25b) and (26b), but allow non-interrogatives such as a proper name, e.g. (25c) and (26c). RCs containing gaps, on the other hand, do not have this restriction, as shown in (25a) and (26a). This suggests that in RCs containing resumptive pronouns, [Spec, CP] is already filled by an empty operator.

(25)

- a. shei xihuan [[shei dasuan qing ta, lai yanjiang de] zuojia,]?  
 who like who plan ask come talk De author  
 'Who likes the author that who planned to ask to come to talk?'
- b. \*shei xihuan [[shei dasuan qing ta, lai yanjiang de] zuojia,]?  
 who like who plan ask him come talk De author  
 'Who likes the author that who planned to ask him to come to talk?'
- c. shei xihuan [[Zhangsan dasuan qing ta, lai yanjiang de] zuojia,]?  
 who like Zhangsan plan ask him come talk De author  
 'Who likes the author that Zhangsan planned to ask him to come to talk?'

(26)

- a. shei kandao-le [[shei shuo ta, mingtian yao biao yan de] yanyuan,]?  
 who saw-perf. who say tomorrow will perform De actor  
 'Who saw the actor that who said would perform tomorrow?'
- b. \*shei kandao-le [[shei shuo ta, mingtian yao biao yan de]  
 yanyuan,]?  
 who saw-perf. who say he tomorrow will perform De  
 actor  
 'Who saw the actor that who said he would perform tomorrow?'

- c. shei kandao-le [[Zhangsan shuo ta, mingtian yao biao'yan de] yanyuan,]?'  
 who saw-perf. Zhangsan say he tomorrow will perform De actor  
 'Who saw the actor that Zhangsan said he would perform tomorrow?'

We now have a very interesting minimal pair: RCs with or without resumptive pronouns, which in turn means the absence or presence of an empty operator. This kind of distinction in syntactic representations makes distinct predictions regarding sentence processing. In Chapter 6, we present an online reading experiment to test exactly these predictions. As we will see, the results are also compatible with Aoun and Li's analysis.

## 2.2 Sentence Processing

An important goal in research on human sentence processing is to discover what kinds of information people use in the moment-by-moment comprehension of a sentence. Much recent research has demonstrated that information from a variety of different sources is used, including lexical information, syntactic information, real-world knowledge, and information about the discourse context (for recent reviews, see Gibson & Pearlmuter, 1998; Tanenhaus & Trueswell, 1995). An important empirical observation that demonstrates the importance of the use of syntactic (word-order) information in sentence comprehension is provided by the contrast between *nested* structures – structures which fall between the ends of a syntactic dependency – and non-nested structures (Chomsky & Miller 1963; see Gibson 1998, for a recent survey). For example, the English sentences in (27a)-(27c) are increasingly nested, and are of increasing complexity.

Sentence (27d) is a right-branching (non-nested) control for (27c), and it is correspondingly much easier to understand.

- (27)
- a. The reporter disliked the editor.
  - b. The reporter [ who the senator attacked ] disliked the editor.
  - c. The reporter [ who the senator [ who John met ] attacked ] disliked the editor.
  - d. John met the senator [ who attacked the reporter ] [ who disliked the editor ].

RCs are possible in most locations, but they are very difficult to comprehend when they modify the subject of another RC in an Subject-Verb-Object (SVO) language like English, such as the modification of “the senator” by “that John met” in (27c). The complexity of (27c) cannot be explained by lexical information (e.g., word frequencies), or by the real-world plausibility of the meaning of the sentence, or by the complexity of the discourse context, because all of these factors are the same in sentence (27d), and this sentence is much less complex. As a result, the complexity of a sentence like (27c) must be due to properties of the syntax of this sentence: the interaction of hierarchical structure and a complex word order (Note that with clear intonation breaks, sentences such as (27c) become easier to understand. However, the only method adopted in the experiments reported in this thesis is on-line reading and no audio stimuli are presented along with the reading stimuli. It would be interesting to conduct an experiment with audio stimuli and see if the differences in processing (27c) and (27d) can be reproduced.) While this much is known, it remains an open question how to quantify this complexity for the human sentence processing mechanism. The point of this chapter is to restrict the range of possibilities by examining the processing of RCs in Chinese.



A second complexity contrast is the contrast between object- and subject-extracted RCs in English (e.g. King and Just 1991; Gibson 1998), French (Holmes and O'Regan 1981) and other SVO languages, as in (28):

- (28) a. Object-extraction: The reporter [ who the senator attacked ]  
disliked the editor.  
b. Subject-extraction: The reporter [ who attacked the senator ]  
disliked the editor.

The greater complexity of object-extractions is found in a number of measures, including phoneme-monitoring, on-line lexical-decision, reading times, and response accuracy to probe questions (Hakes, Evans and Brannon 1976; Wanner and Maratsos, 1978; Holmes and O'Regan 1981; Ford 1983; Waters, Caplan, and Hildebrandt 1987; King and Just 1991). Like the nesting contrast, this effect is not driven by lexical frequencies, or real-world plausibility (because this is controlled between the two structures), or discourse context. The difference must be due to a difference in the complexity of the two word orders.

There are at least five word-order factors that have been proposed to explain these effects:<sup>3</sup>

1. Storage resources: the storage of incomplete head-dependencies in phrase structure (Yngve 1960, Chomsky and Miller 1963, Miller and Chomsky 1963, Miller and Isard 1964, Bever 1970, Kimball 1973, Wanner and Maratsos 1978, Hakuta 1981, MacWhinney 1987, Abney and Johnson 1991, Gibson 1991, 1998, 2000, Pickering and Barry 1991, Lewis 1993, 1996, Stabler 1994b). These theories attribute the

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<sup>3</sup> Note that these factors are not necessarily exclusive of one another. More than one could be in effect. In fact, Gibson 1998, 2000 explicitly proposes that both 1 and 2 apply together.

greater difficulty of the object-extractions to the fact that there are a larger number of temporarily incomplete dependencies in the processing of object-extractions. For example, according to the dependency locality theory (DLT, Gibson 1998, 2000), storage resources are required to keep track of the syntactic heads that are needed to form a grammatical sentence. There is a greater storage cost in processing the object-extraction in (28a) than the subject-extraction in (28b) as soon as the first word following the wh-pronoun “who” is processed in each. In particular, after processing “the reporter who the” in (28a), four syntactic heads are required to form a grammatical sentence: a noun for the determiner “the”, a verb for the main clause, a verb for the RC, and an empty noun category (i.e. a trace) associated with the wh-pronoun “who”. In contrast, only two heads are needed after processing the words “the reporter who attacked” in (28b): a noun for the object position of “attacked” and a verb for the main clause.

2. Integration resources: The integration of head-dependencies in phrase structure (Ford 1983, Gibson 1998, 2000). The process of integration consists of connecting an incoming word to its head or dependent in the current structure for the input. It has been demonstrated that the difficulty of performing an integration depends on the distance of the integration involved (Gibson, 1998; Grodner, Watson & Gibson, 2000; Pearlmutter & Gibson, 2001; Warren & Gibson, 2002). Object-extractions involve longer distance integrations than subject-extractions. In particular, the integrations at the embedded verb “attacked” in (28a) involve connecting the object position of the verb “attacked” to the wh-pronoun “who”, an integration that crosses the subject noun phrase (NP) “the senator”.

By contrast, the integration at the verb “attacked” in (28b) is more local, and is therefore hypothesized to consume fewer resources.

3. Differences in canonical vs. non-canonical word order (e.g. MacDonald and Christiansen 2002, cf. Bever 1970, Tabor, Juliano and Tanenhaus 1997, Mitchell et al., 1995). The word order in English is Subject-Verb-Object (SVO). This word order is present in a subject-extracted RC, e.g. *who attacked the senator*, such that the wh-pronoun “who” is the subject of the RC. In contrast, the word order in an object-extracted RC is non-canonical: OSV, e.g., *who the senator attacked*, hence the difficulty.
4. A theory based on accessibility of syntactic positions. This theory attributes the difference between the two extraction types to a difference in accessibility of subject- and object-extractions (Keenan & Comrie 1977; Keenan & Hawkins, 1987; cf. Dowty 1991; Hale, 2003). Subject position is more accessible than object position, and the contrast follows.
5. Perspective shift (MacWhinney 1977, 1982; MacWhinney & Pleh 1988; cf. Bever, 1970). Under this theory, processing resources are required to shift the perspective of a clause, where the perspective of a clause is taken from the subject of the clause. A subject-modifying object-extracted RC as in (28a) requires two perspective shifts: (1) from the perspective of the matrix subject to the subject of the RC and (2) from the perspective of the subject of the RC back to the matrix subject, after the RC is processed. Processing the subject-extracted RC in (28b) requires no perspective shifts, because the matrix subject is also the subject of the RC, so that both clauses come

from the same perspective. Thus the object-extraction is more complex than the subject extraction.

Chapter 3 examines on-line processing data from Chinese. Although Chinese is an SVO language, Chinese RCs precede their head nouns, unlike RCs in English and French, which follow their head noun. This difference in word order leads to different predictions among the five kinds of theories. In particular, the first three theories make different predictions from the last two theories in these constructions. Consider (29a) and (29b) below.

(29)

a. Chinese object extraction

fuhao yaoching *e*,de guanyuan, shinhuaibugui danshi shanyu yintsang  
 tycoon invite gen official have bad intentions but good at hiding  
 ‘The official who the tycoon invited has bad intentions but is good at  
 hiding them.’

b. Chinese subject extraction

*e*, yaoching fuhao de guanyuan, shinhuaibugui danshi shanyu yintsang  
 invite tycoon gen official have bad intentions but good at hiding  
 ‘The official who invited the tycoon has bad intentions but is good at  
 hiding them.’

The word *de* is a genitive marker in Chinese, which also serves as an RC marker (see section 2.1.1 for an earlier discussion of *de*). We have notated it as “gen” in the examples. For notational purposes, the empty subject and object positions are notated as empty categories, “*e*” for short.

According to a storage-based resource theory like the DLT, the subject-extracted RC in (29b) should be more complex than the object-extracted RC in (29a), in contrast to the results from English and French. After processing the first word in the subject-extraction RC (29b) – the verb *yaoqing* (“invite”) – the reader/listener realizes that an RC is being processed, because there is no subject for the verb.<sup>4</sup> As a result, a verb for the top-level sentence is needed, together with the RC genitive marker *de* and an NP object for the verb in the RC. Thus three syntactic heads are needed at this point. After the object noun *fubao* (“tycoon”) is processed, two syntactic heads are still needed: the main verb and the RC genitive marker. Processing the object-extraction in (29a) requires fewer predicted heads at each of these positions. In particular, after processing the first word in the object-extraction – the noun *fubao* (“tycoon”) – only a single head is predicted, a verb for the clause, because this could be the main clause of the sentence. After the next word is processed – the verb *yaoqing* (“invite”) – still only one head is predicted, a noun object of the verb. When the genitive marker *de* is processed next in both sentences, the storage cost for each structure is the same.

An integration-based resource theory also predicts that the subject-extracted RC should be more complex than the object-extracted RC in Chinese, but the on-line location of this difficulty is predicted to be later in the sentence. In particular, although there are storage differences through the RC, there are no integration

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<sup>4</sup> Chinese allows null pronominals in many positions, including subject position, but only in contexts where a topic is present. Null pronominals are rare and unpreferred in a null context, such as in these sentences. Thus people are more likely to assume an RC reading rather than a null pronominal reading. In addition, the sentence (29b) might potentially have an arbitrary pro reading, i.e. “pro<sub>arb</sub> inviting the tycoon/for pro<sub>arb</sub> /one to invite the tycoon.” However, this sort of construction has the tone of a universal statement and the lexical items and contexts in the experiment discourage that interpretation. In any case, even if the participants adopt either of these less likely analyses, the reference of the empty category in the subject position can only be resolved when the head noun is encountered. The predictions are similar regarding resource use.

distance differences in this region. But when the RC marker *de* and the head noun for the RC *guanyuan* (“official”) are processed, integration cost differences are predicted: The integration between the pre-verbal subject position of the RC (indicated by  $e_i$  in (29b)) and the noun *guanyuan* (“official”) in the subject-extraction (29b) is longer distance than the integration between the post-verbal object position of the RC (indicated by  $e_i$  in (29a)) and the noun *guanyuan* (“official”) in the object-extraction (29a).

Like the storage resource theories, the canonical word order theory predicts that the subject-extractions should be more complex than the object-extractions. The object-extracted RC sentence follows the canonical SV word order in its initial clause, before the genitive marker *de* is encountered. In the subject-extracted RC, a non-canonical word order is encountered initially – a verb without its subject – causing more difficult processing. Like the storage theory, this theory predicts that a processing effect will occur during the processing of the RC.

Unlike the resource theories and the canonical word order theory, the last two theories discussed above predict that Chinese RCs should be processed like English RCs, with the result that Chinese subject-extractions should be easier to process than Chinese object-extractions. The accessibility-based theory makes this prediction independent of the word order, because subjects are more accessible and are therefore easier to extract than objects. The perspective-shift theory makes this prediction because perspective is not shifted in processing a subject-extracted RC when it modifies a subject NP as in (29b), whereas perspective is shifted when an object-extracted RC modifies a subject NP, as in (29a).

The predictions as described above do not consider potential differences between the two structures due to temporary ambiguity. One such ambiguity should be

considered: The object-extracted RC is likely to be temporarily analyzed as the main clause. When the RC particle *de* is encountered, this analysis must be given up in favor of an RC analysis. There is no such temporary ambiguity in the subject-extraction (cf. see footnote 4). In particular, the subject-extracted RC is known to be an RC from the onset of the first verb, because there is no subject for this verb. As a result of this difference in temporary ambiguity across the two structures, a behavioral difference in support of the latter two theories would be difficult to interpret, because of the confounding influence of temporary ambiguity. By the same token, a behavioral difference in favor of the first three theories would be strong evidence for these theories, because such a difference would occur in spite of a potential temporary ambiguity effect in the opposite direction.

In the following chapter, we report a self-paced reading to test these predictions in Chinese. The unique properties of Chinese, i.e. that the RCs are pre-nominal and that there are no relative pronouns or overt complementizers in RCs, can potentially help us tease apart the five theories.

### **Chapter 3 Processing Chinese Relative Clauses - Unambiguous Structures**

This chapter presents the study documented by Hsiao and Gibson 2002, who investigate relative clauses in unambiguous structures. Research in the sentence comprehension literature has established that object-extracted relative clauses (RCs) are harder to process than subject-extracted RCs in subject-verb-object (SVO) languages such as English and French. This paper investigates the processing of relative clauses in Chinese using self-paced reading. Chinese is an SVO language like English, but RCs in Chinese precede their head nouns, unlike English. The results of the experiment demonstrate that subject-extractions are more complex than object-extractions in Chinese in both singly- and doubly-embedded RCs. This pattern of data supports resource-based and canonical/non-canonical (frequency) theories of RC complexity over accessibility-based theories or perspective shift theories.

#### **3.1 Hsiao and Gibson 2002: RC's Modifying Subjects**

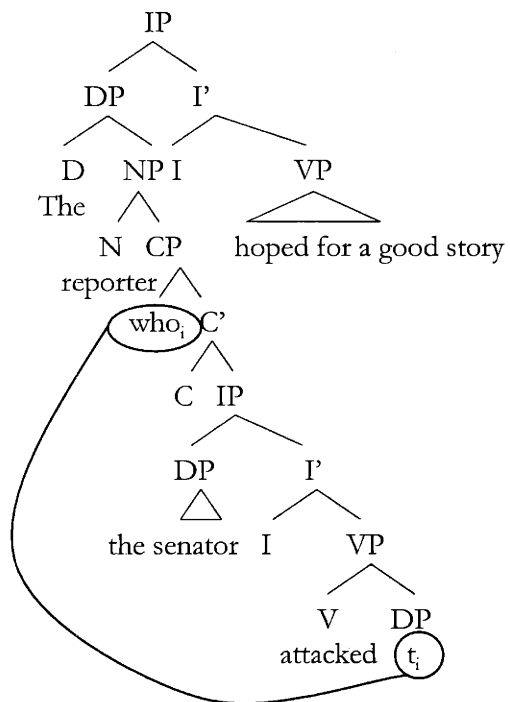
##### **3.1.1 Introduction**

As outlined in the previous chapter, object-extracted relative clauses (RCs) are harder to process than subject-extracted RCs in subject-verb-object (SVO) languages such as English and French (Ford, 1983; Holmes & O'Regan, 1981; King & Just, 1991; Gibson, 1998). For example, (1a) is harder to understand than (1b) (with corresponding trees immediately following the sentences):



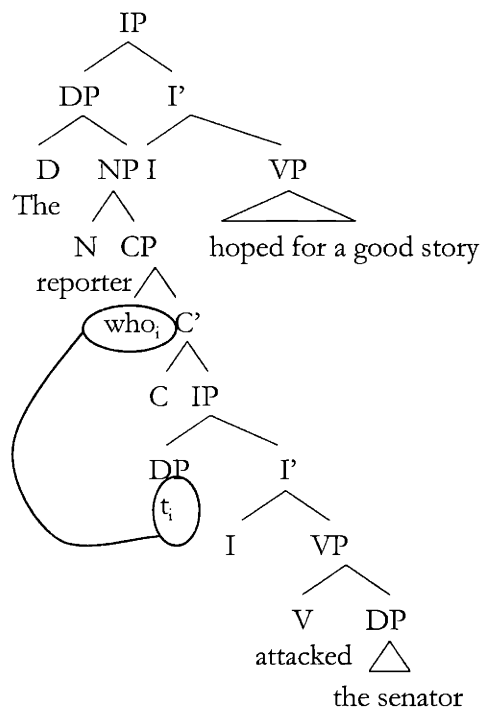
(1)

a. English object extraction

The reporter, [who<sub>i</sub> the senator attacked t<sub>i</sub>] hoped for a good story.

## b. English subject extraction

The reporter<sub>i</sub> [who<sub>i</sub> t<sub>i</sub> attacked the senator] hoped for a good story.



The greater complexity of object extractions is found in a number of measures, including phoneme monitoring, online lexical decision, reading times, and response accuracy to probe questions (Hakes, Evans & Brannon 1976; Wanner & Maratsos 1978; Holmes & O'Regan 1981; Ford 1983; Waters, Caplan, & Hildebrandt 1987; King & Just 1991). In addition, the volume of neural tissue activated (number of voxels) in the brain is greater in left-hemisphere language areas (Wernicke's area and Broca's area) for object extractions than for subject extractions (Stromswold et al. 1996; Just et al. 1996) and aphasic stroke patients cannot reliably answer comprehension questions about object-extracted RCs,

although they perform well on subject-extracted RCs (e.g., Caramazza & Zurif 1976; Caplan & Futter 1986).

Four classes of theories of this contrast are as follows:

1. Resource-based theories. These theories attribute the greater difficulty of the object-extractions to greater use of storage resources (Wanner & Maratsos, 1978; Gibson, 1991, 1998, 2000; Lewis, 1995) and / or greater use of integration resources (Ford, 1983; Gibson, 1998; 2000). For example, according to the dependency locality theory (DLT, Gibson, 1998; 2000), storage resources are required to keep track of the syntactic heads that are needed to form a grammatical sentence. There is a greater storage cost in processing the object-extraction in (1a) than the subject-extraction in (1b) as soon as the first word following the wh-pronoun “who” is processed in each. In particular, after processing “the reporter who the” in (1a), four syntactic heads are required to form a grammatical sentence: a noun for the determiner “the”, a verb for the outer clause, a verb for the inner clause, and an empty noun element associated with the wh-pronoun “who”. In contrast, only two heads are needed after processing the word “the reporter who attacked” in (1b): a noun for the object position of “attacked” and a verb for the outer clause.

A second component of resource cost under the DLT is provided by integration resources. The process of integration consists of connected an incoming word into the current structure. It has been demonstrated that the difficulty of performing an integration depends on the distance of the integration involved, such that longer distance

integrations consume more cost (Gibson, 1998; Grodner, Watson & Gibson, 2000; Pearlmutter & Gibson, 2001; Warren & Gibson, 2002). Object-extractions involve longer distance integrations than subject-extractions. In particular, the integrations at the embedded verb “attacked” in (1a) involve connecting the object position of the verb “attacked” to the wh-pronoun “who”, an integration that crosses the subject noun phrase (NP) “the senator”. By contrast, the integration at the verb “attacked” in (1b) is more local, and is therefore hypothesized to consume fewer resources.

2. A theory based on accessibility of syntactic positions. This theory attributes the difference between the two extraction types to a difference in accessibility of subject- and object-extractions (Keenan & Comrie 1977; Keenan & Hawkins, 1987; cf. Dowty 1991). Subject position is more accessible than object position, and the contrast follows.
3. Perspective shift (MacWhinney 1977, 1982; MacWhinney & Pleh 1988; cf. Bever, 1970). Under this theory, processing resources are required to shift the perspective of a clause, where the perspective of a clause is taken from the subject of the clause. A subject-modifying object-extracted RC as in (1a) requires two perspective shifts: (1) from the perspective of the matrix subject to the subject of the RC and (2) from the perspective of the subject of the RC back to the matrix subject, after the RC is processed. Processing the subject-extracted RC in (1b) requires no perspective shifts, because the matrix subject is also the subject of the RC, so that both clauses come from

the same perspective. Thus the object-extraction is more complex than the subject extraction.

4. Differences in canonical vs. non-canonical word order (e.g., MacDonald & Christiansen, 2002; cf. Bever, 1970; Tabor, Juliano & Tanenhaus, 1997; Mitchell et al., 1995). The word order in English is Subject-Verb-Object (SVO). This word order is present in a subject-extracted RC, e.g. *who attacked the senator*, such that the wh-pronoun “who” is the subject of the RC. In contrast, the word order in an object-extracted RC is non-canonical: OSV, e.g., *who the senator attacked*, hence the difficulty.

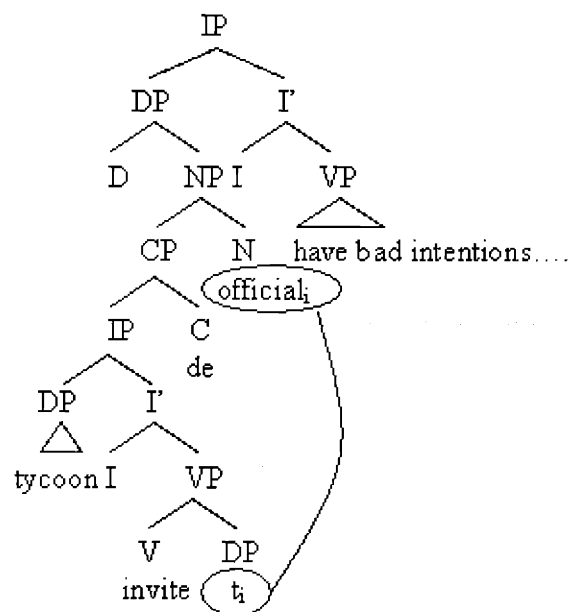
All four theories can account for the data from English and the other SVO languages that have been studied thus far. This paper examines data from Chinese. Although Chinese is also an SVO language, Chinese RCs precede their head nouns unlike RCs in English and French, which follow their head noun. This difference in word order leads to different predictions among the four kinds of theories. Consider (2a) and (2b) below with respect to the theories described above:

(2)

a. Chinese object extraction

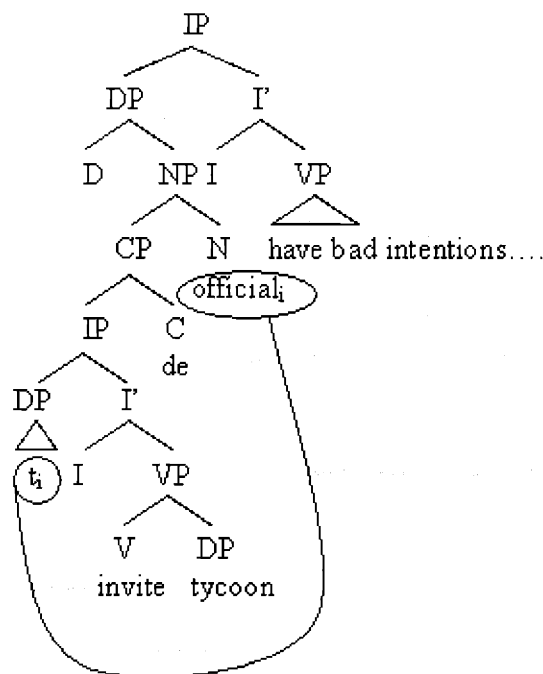
fuhao yaoching ti de guanyuan, shinhuaibugui danshi shanyu yintsang  
tycoon invite gen official have bad intentions but good at hiding

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



b. Chinese subject extraction

t<sub>1</sub> yaoqing fuhao de guanyuan, shinhuaibugui danshi shanyu yintsang  
 invite tycoon gen official have bad intentions but good at hiding  
 'The official who invited the tycoon has bad intentions but is good at  
 hiding them.'



According to resource theories like the DLT, the subject-extracted RC in (2b) should be more complex than the object-extracted RC in (2a), in contrast to the results from English and French. This prediction comes about for reasons of both storage and integration. After processing the first word in the subject-extraction RC (2b) – the verb *yaoqing* (“invite”) – the reader/listener realizes that an RC is being processed, because there is no subject for the verb.<sup>5</sup> As a result, a verb for the top-level sentence is needed, together with the RC genitive marker *de* and an NP object for the verb in the RC. Thus three heads are needed at this point. After the object noun *fuhao* (“tycoon”) is processed, two syntactic heads are still needed: the main verb and the RC genitive marker. Processing the

<sup>5</sup> Chinese allow null pronominals in many positions, including subject position, but only in contexts where a topic is present. Null pronominals are rare and unpreferred in a null context, such as in these sentences. Thus people are more likely to assume an RC reading rather than a null pronominal reading. See also footnote 4 above.

object-extraction in (2a) requires fewer predicted heads at each of these positions. In particular, after processing the first word in the object-extraction – the noun *fubao* (“tycoon”) – only a single head is predicted, a verb for the clause, because this could be the main clause of the sentence. After the next word is processed – the verb *yaoqing* (“invite”) – still only one head is predicted, a noun object of the verb. When the genitive marker *de* is processed next in both sentences, the storage cost for each structure is the same.

Integration costs are also larger for the subject-extracted RC than the object-extracted RC in Chinese. In particular, the integration between the empty element in subject position of the RC and the noun *guanyuan* (“official”) in the subject-extraction (2b) is longer distance than the integration between the empty element in object position of the RC and the noun *guanyuan* (“official”) in the object-extraction (2a). (These integrations may be mediated by an empty wh-pronoun, similar in meaning to “who” in English, which occurs between the empty position and the noun to which it refers.) Thus resource theories predict that the subject-extraction should be more difficult to process than object-extractions in Chinese.

Unlike resource theories, the second and third theories discussed above predict that Chinese RCs should be processed like English RCs, with the result that Chinese subject-extractions should be easier to process than Chinese object-extractions. The syntactic-position-based theory makes this prediction independent of the word order, because subjects are more accessible and are therefore easier to extract than objects. The perspective shift theory makes this prediction because perspective is not shifted in processing a subject-extracted RC when it modifies a subject NP as in (2b), whereas perspective is shifted when an object-extracted RC modifies a subject NP, as in (2a).



Like the storage resource theories, the canonical word order theory predicts that the subject-extractions should be more complex than the object-extractions. The object-extracted RC sentence follows the canonical SV word order in its initial clause, before the genitive marker *de* is encountered. In the subject-extracted RC, a non-canonical word order is encountered initially – a verb without its subject – causing more difficult processing. Like the storage theory, this theory predicts that a processing effect will occur during the processing of the RC.

The predictions as described above do not consider potential differences between the two structures due to temporary ambiguity. One such ambiguity should be considered: The object-extracted RC is likely to be temporarily analyzed as the main clause. When the RC particle *de* is encountered, this analysis must be given up in favor of an RC analysis. There is no such temporary ambiguity in the subject-extraction. In particular, the subject-extracted RC is known to be an RC from the onset of the first verb, because there is no subject for this verb. As a result of this difference in temporary ambiguity across the two structures, a behavioral difference in support of the latter two theories would be difficult to interpret, because of the confounding influence of temporary ambiguity. By the same token, a behavioral difference in favor of the first three theories would be strong evidence for these theories, because such a difference would occur in spite of a potential temporary ambiguity effect in the opposite direction.

In this chapter we used self-paced reading to test the predictions of the different theories.

### 3.1.2 Experiment

Two pairs of conditions were tested, as exemplified in (2) above and (3) below. The RCs to be compared in (2) are singly embedded, whereas the RCs in (3) are doubly embedded.

(3) a. Chinese doubly embedded object-extracted RC

fuhao<sub>i</sub> yaoching t<sub>i</sub> de faguan<sub>j</sub> gojie t<sub>k</sub> de guanyuan<sub>k</sub> shinhuaibugui

**N1 V1 de<sub>1</sub> N2 V2 de<sub>2</sub> N3 ...**

tycoon invite judge conspire official have bad intentions

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

b. Chinese doubly embedded subject-extracted RC

t<sub>i</sub> yaoching t<sub>k</sub> gojie faguan de fuhao<sub>k</sub> de guanyuan<sub>i</sub> shinhuaibugui

**V1 V2 N2 de<sub>1</sub> N1 de<sub>2</sub> N3 ...**

invite conspire judge tycoon official have bad intentions

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

We tested doubly embedded versions in addition to singly embedded versions because it was possible that the predicted effects might be difficult to measure in singly embedded versions; in singly embedded cases, there is a small difference in word order between the two types of RCs. The critical region of comparison in the singly embedded versions in (2) consists of the first three words: N1 V1 de/ V1 N1 de. The critical region in the doubly embedded versions in (3) consists of the first six words: N1 V1 de<sub>1</sub> N2 V2 de<sub>2</sub> / V1 V2 N1 de<sub>1</sub> N2 de<sub>2</sub>. Each of these

comparisons involves the same words in a different order, so lexical frequency is controlled overall. We controlled for plausibility using a norming study, as described below.

### 3.1.2.1 Theoretical Predictions

Resource theories predict that the object-extracted RCs in (2a) and (3a) should be less complex than the subject-extracted RCs in (2b) and (3b). The singly-embedded versions have been discussed above. Consider now the doubly embedded versions with respect to storage costs. After processing the two initial verbs of (3b), six heads are needed to form a grammatical sentence: one noun head for each of the two RCs, an NP object for the transitive verb *gojie* (“conspire with”), one genitive marker for each of the RCs, and a main verb for the sentence. In contrast, only at most two heads are ever required to form a grammatical sentence during the processing of the object-extraction in (3a): a noun and a verb, following either of the genitive markers. Integration costs are also higher for the subject-extractions than for the object-extractions: the integrations at the head nouns of the RCs are more local in the object-extractions than in the subject-extractions.

The accessibility and perspective-based theories make the opposite prediction as the resource theories: they predict that subject-extractions should be less complex than object-extractions, in both singly and doubly embedded versions.

Like the resource theories, the canonical word order theory predicts that object-extractions should be less complex than subject-extractions in the singly embedded versions. Furthermore, the canonical word order theory predicts that object-extractions should be less complex than subject-extractions in the doubly embedded versions, under the assumption that the word *de* (which usually

functions as a genitive marker in Chinese) functions as an RC pronoun in an RC.<sup>6</sup> In particular, under this assumption, the doubly embedded object-extracted RC consists of the elements Subject-Verb-Object Subject-Verb-Object, thus following SVO word order in each of the two RC clauses. In contrast, the doubly embedded subject-extracted RC consists of the elements Verb-Verb-Object-Subject-Object-Subject, which does not follow SVO word order in either RC.

### 3.1.3 Method

#### 3.1.3.1 Participants

A total of forty subjects participated in the experiment. Six are from MIT (Boston/Cambridge) and the surrounding community. Seven reside in Taiwan, but were attending a wedding in California at the time of experiment. The other twenty-seven are based in and around Los Angeles. All are native speakers of Mandarin Chinese spoken in Taiwan and use Mandarin Chinese daily (percentage of Chinese use: 50% - 100%). The subjects were naïve as to the purposes of the study. The average age for the subjects was 45.

#### 3.1.3.2 Materials

Twenty-four sets of sentence were constructed, each with the four conditions in (4) and (5). The sentences were presented in Chinese characters. An example of such a set is (6).

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<sup>6</sup> This is not necessarily the right assumption, but it gives the right processing results below. We are not aware of any existing analysis of Chinese RCs that assumes overt relative pronouns in Chinese and in particular analyzes *de* as a relative pronoun. As a matter of fact, Keenan (1985) conducted a cross-linguistic survey of RCs and concluded that no language with pre-nominal RCs has relative pronouns. Below we list references to analyses of Chinese RCs, none of which analyzes *de* as a relative pronoun: He (1996) treats *de* as a complementizer; Li & Thompson (1981) analyze it as a nominalizer; and Kayne (1994) treats it as an inflection marker. Refer to these papers for justifications of their analyses.

- (4) a. single embedded object-extracted RC  
 b. single embedded subject-extracted RC
- (5) a. double embedded object-extracted RC  
 b. double embedded subject-extracted RC
- (6) a. fuhao yaoching  $t_i$  de guanyuan<sub>i</sub> shinhuaibugui danshi shanyu  
 yintsang  
**N1 V1 de N2 V2...**  
 tycoon invite official have bad intentions but good at  
 hiding  
 ‘The official who the tycoon invited has bad intentions but is good  
 at hiding them.’
- b.  $t_i$  yaoching fuhao de guanyuan<sub>i</sub> shinhuaibugui danshi shanyu  
 yintsang  
**V1 N1 de N2 V2...**  
 invite tycoon official have bad intentions but good at  
 hiding  
 ‘The official who invited the tycoon has bad intentions but is  
 good at hiding them.’
- c. fuhao yaoching  $t_i$  de faguan<sub>i</sub> gojie  $t_k$  de guanyuan<sub>k</sub> shinhuaibugui  
**N1 V1 de1 N2 V2 de2 N3 V3...**  
 tycoon invite judge conspire official have bad  
 intentions  
 ‘The official who the judge who the tycoon invited conspired  
 with has bad intentions.’
- d.  $t_i$  yaoching  $t_k$  gojie faguan de fuhao<sub>k</sub> de guanyuan<sub>i</sub> shinhuaibugui  
**V1 V2 N1 de1 N2 de2 N3 V3...**  
 invite conspire judge tycoon official have bad intentions  
 ‘The official who invited the tycoon who conspired with the  
 judge has bad intentions.’

The target sentences were split into four lists balancing all factors in a Latin-Square design. Each list was combined with seventy-two fillers of various types. Because all sentences were presented in a null context, none of the fillers contained any null discourse-based pronominals. Thus it is unlikely that

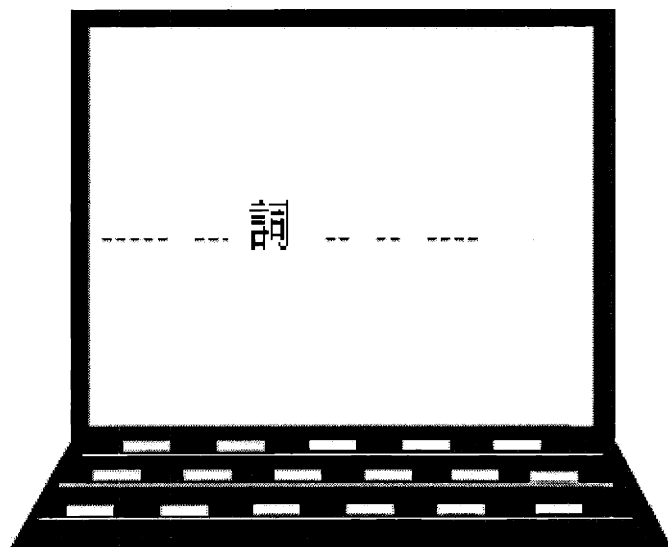
participants analyzed the target stimuli as containing such pronominals. Appendix A provides a complete list of the stimuli. The stimuli were pseudo-randomized separately for each participant so that at least one filler item intervened between two targets.

### **3.1.3.3 Procedure**

The task was self-paced, word-by-word reading using a moving window display (Just, Carpenter & Woolley, 1982). Linger 1.7 by Doug Rohde was the software used to run the experiments. All experiments were run on a single PC laptop.

Each trial began with a series of dashes marking the length and position of the words in the sentences, printed approximately a third of the way down the screen. Participants pressed the spacebar to reveal each word of the sentence. An example of what was presented to the participants on the monitor is given at the end of this section. A word in Mandarin Chinese may consist of any number of characters. These characters were presented together to the subjects. As each new word appeared, the preceding word disappeared. The amount of reading time (RT) the participant spent on each word was recorded as the time between keypresses. After the final word of each item, a comprehension question appeared which asked about information contained in the preceding sentence. Participants pressed one of two keys to respond “yes” or “no.” After an incorrect answer, a sentence in Chinese meaning “Sorry, your answer was incorrect” flashed briefly on the screen. No feedback was given for correct responses. Half of the comprehension questions for the items had correct answer as “yes” and half had “no” as the correct answer. Participants were asked to read sentences at a natural rate and to be sure that they understood what they read. They were told to answer the questions as quickly and accurately as they could and to take wrong answers as an indication to read more carefully. Before the main experiment, a

short list of practice items and questions was presented in order to familiarize the participant with the task.



### 3.1.4 Plausibility Norming Survey

A questionnaire was conducted in order to control for potential plausibility differences between the two pairs of conditions. 33 native Chinese-speaking participants from North America, Taiwan, Singapore and Hong Kong who did not take part in the self-paced reading experiment completed the survey. The items tested in this questionnaire consisted of the simple transitive clauses that made up each RC. For the singly-embedded versions, the materials consisted of one simple SVO clause in each version, as in (7), the control sentences for (2). For the doubly-embedded version, there were two simple clauses for each item, as in (8) and (9), corresponding to (3).

- (7) a. One clause object-extracted control: The tycoon invited the official.  
b. One clause subject-extracted control: The official invited the tycoon.
  
- (8) a. Two clause object-extracted control, verb 1: The tycoon invited the judge.  
b. Two clause subject-extracted control, verb 1: The official invited the tycoon.
  
- (9) a. Two clause object-extracted control, verb 2: The judge conspired with the official.  
b. Two clause subject-extracted control, verb 2: The tycoon conspired with the judge.

Participants rated the plausibility of these sentences on a scale of 1 (natural) to 7 (unnatural). They were asked to judge the naturalness in the real world of the events described in the sentences, that is, how likely they were to occur.

The results of the survey were that four of the twenty-four items were found to be significantly more plausible ( $p < .05$  by t-test) in one version. These four items were therefore omitted from the reading time analyses. The remaining twenty items were matched for plausibility across all versions (means: 2.55 for (4a), 2.54 for (4b), 2.62 for (5a), 2.50 for (5b), 2.67 for (6a), and 2.65 for (6b)). The plausibility ratings for each item are presented along with the items in Appendix A.



### 3.1.5 Results

The results were analyzed using Lingalyzer 1.11 written by Doug Rohde. The four items in which one version was less plausible than another were omitted from analyses, leaving 20 items to be analyzed. Three participants' data were omitted from the analyses because of poor comprehension question performance (< 67% accuracy overall). Two participants' data were omitted due to repeated interruptions during their testing sessions. In addition, three participants' data were excluded from the analyses due to slow reading times, two standard deviations slower than the mean. The overall mean reading time was 613 msec/word with standard deviation 197msec. Each of the three subjects whose data we omitted had mean RTs of over 1 second/word. These three subjects were among the older subjects in the group (their ages were 56, 65, and 69) and none of the three was familiar with using a computer, which probably contributed to their inefficiency. However, all effects that are reported as significant below are also significant under analyses which included these three subjects.

#### 3.1.5.1 Comprehension Question Performance

The percentages of correct answers for each condition are presented in Table 1. Although comprehension question performance was numerically better in the one-clause object-extracted sentences than in the one-clause subject-extracted sentences, this difference did not reach significance ( $F_s < 1.6$ ). In the two clause sentences, performance was better in the object-extracted versions, but only in the participants' analysis ( $F1(1,31) = 4.34$ ,  $MS_{\text{within}} = 0.034$ ,  $p < 0.05$ ;  $F2(1,19) = 2.36$ ,  $MS_{\text{within}} = 0.048$ ,  $p = 0.14$ ). Although comprehension performance in the target items was low (71.4% overall), this was probably because these items were very complex. Mean performance on the filler items was much better at 91.8 %.

1 clause object RC	1 clause subject RC	2 clause object RC	2 clause subject RC
75.2 (3.4)	70.4 (3.6)	75.2 (3.5)	65.0 (3.8)

Table 1. Mean (standard error) comprehension question performance in percent correct by condition

### 3.1.5.2 Reading Times

Because of the complexity of the target items, all items were analyzed regardless of whether comprehension questions were answered correctly. Analyses in which only correctly answered trials were analyzed revealed the same patterns. Figure 1 plots mean (standard error) raw reading times per word in the singly-embedded RCs in (2) by participants.

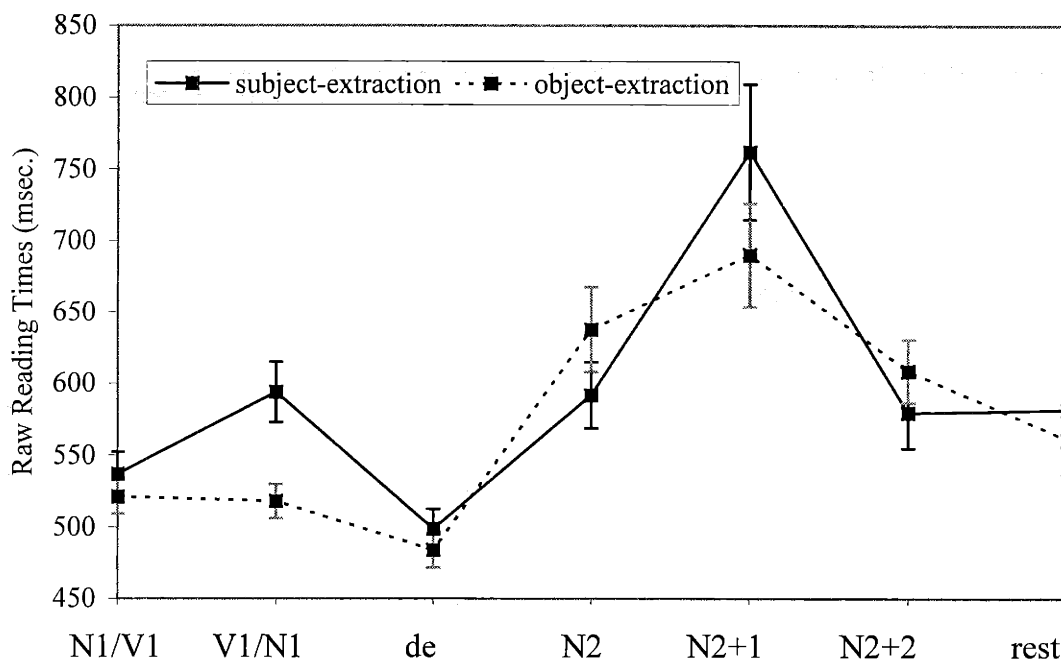


Figure 1. Plot of mean (standard error) raw reading times per word by region for the singly-embedded conditions in (2).

An analysis of variance for the first two words (N1 V1 / V1 N1) revealed a main effect both by participants and by items ( $F(1,31) = 9.49$ ,  $MS_{\text{within}} = 4234$ ,  $p = 0.004$  \*\*;  $F(1,19) = 10.15$ ,  $MS_{\text{within}} = 1999$ ,  $p = 0.005$  \*\*). There were no significant differences on the third word, the genitive marker *de* ( $F_s < 1$ ), nor on any subsequent region.

Turning now to the doubly embedded conditions, Figure 2 plots mean (standard error) raw reading times per word by region by participants.

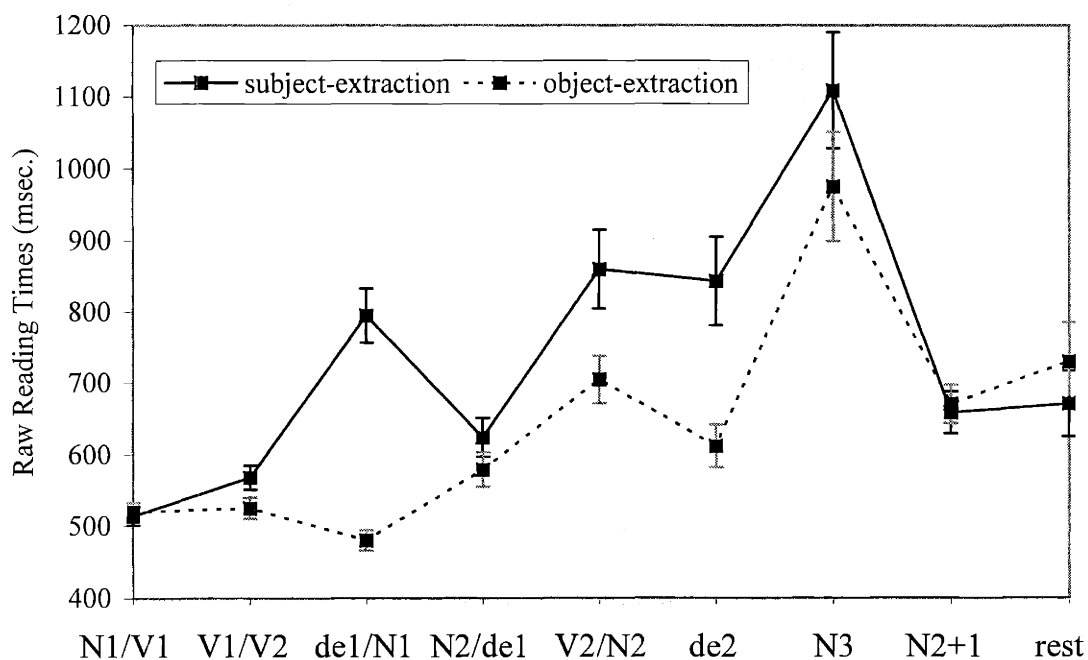


Figure 2. Plot of mean (standard error) raw reading times per word by region for the doubly embedded conditions in (3).

For the first two words, an analysis of variance revealed no significant effects ( $F_s < 1.3$ ). For the next two words, an ANOVA revealed that object-extractions were processed faster than subject-extractions ( $F_1(1,31) = 41.0$ ,  $MS_{\text{within}} = 10687$ ,  $p < 0.001$ ;  $F_2(1,19) = 29.1$ ,  $MS_{\text{within}} = 10888$ ,  $p < 0.001$ ). For the fifth and sixth words, an ANOVA revealed a similar effect ( $F_1(1,31) = 14.3$ ,  $MS_{\text{within}} = 30661$ ,  $p < 0.001$ ;  $F_2(1,19) = 14.4$ ,  $MS_{\text{within}} = 23276$ ,  $p = 0.001$ ). Over the first six words taken as a whole, object-extractions were read faster than subject-extractions ( $F_1(1,31) = 33.9$ ,  $MS_{\text{within}} = 5642$ ,  $p < 0.001$ ;  $F_2(1,19) = 20.4$ ,  $MS_{\text{within}} = 7527$ ,  $p < 0.001$ ).

Because the content of the regions being compared in the doubly-embedded conditions differed substantially at certain word positions (e.g., the genitive marked *de* is compared with a noun at the third word position), we also conducted an analysis of RTs that were adjusted for differences in word length. In order to do this, a regression equation predicting reading time from word length was constructed for each participant, using all filler and experimental items (Ferreira & Clifton, 1986; see Trueswell, Tanenhaus & Garnsey, 1994, for discussion). At each word position, the reading time predicted by the participant's regression equation was subtracted from the actual measured reading time to obtain a residual reading time. Mean word-by-word residual reading times computed across participants are plotted in Figure 3.

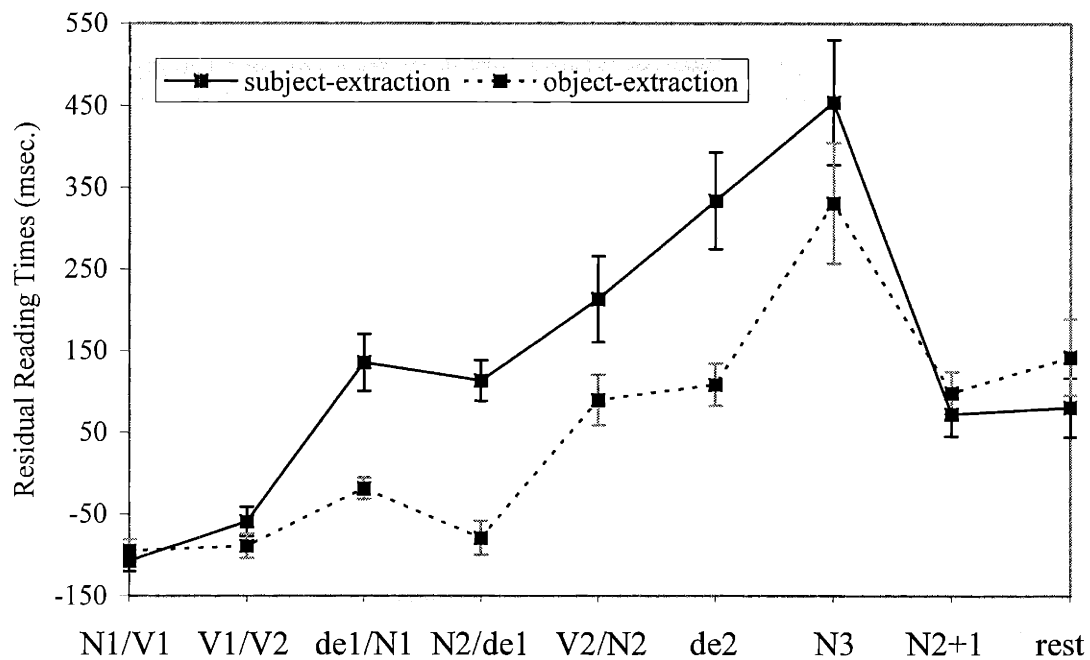


Figure 3. Plot of mean (standard error) residual reading times per word by region for conditions (c) and (d) by participants.

The results were similar for the analyses of residual RTs as compared to the analysis of raw RTs. An ANOVA in the first two words revealed no significant effects ( $F_s < 1.2$ ). The subject-extractions were read more slowly over positions three and four ( $F1(1,31) = 48.4$ ,  $MS_{\text{within}} = 9583$ ,  $p < 0.001$ ;  $F2(1,19) = 47.6$ ,  $MS_{\text{within}} = 5921$ ,  $p < 0.001$ ), and over positions five and six ( $F1(1,31) = 13.0$ ,  $MS_{\text{within}} = 30654$ ,  $p = 0.001$ ;  $F2(1,19) = 19.0$ ,  $MS_{\text{within}} = 15331$ ,  $p < 0.001$ ).

### 3.1.6 Discussion

The evidence that was gathered here demonstrates that subject-extracted RCs are more difficult to process than object-extracted RCs in Chinese, contrary to the results in the literature for the same constructions in other languages. The reaction time data in comparisons involving both singly and doubly embedded conditions provided the strongest evidence for this observation, with the response accuracy data providing some additional support.

These results are as predicted by storage-based resource theories and the canonical word order theory, but they clearly contradict the predictions of the accessibility theory and the perspective-shift theory.<sup>7</sup> The predictions of the integration-based theory were also not ratified. Critically, these results demonstrate that there is nothing intrinsically easy about extracting from subject

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<sup>7</sup> But see Ishizuka, Nakatani and Gibson 2003 for a study on Japanese, which uses pre-nominal RCs and is head-final. The results show that in both singly-embedded and doubly-embedded structures, subject-extractions were read faster than object-extractions. They discussed three types of theories: Resource-based theories, a theory based on accessibility of syntactic positions and the depth-of-embedding hypothesis, e.g. Structural Distance Hypothesis proposed by O'Grady et al, 2000. According to the Structural Distance Hypothesis, the distance traversed by a syntactic operation, calculated in terms of the number of nodes crossed, determines a structure's relative complexity. Thus, in the two examples below, object-extraction crosses 2 nodes: IP and VP while subject-extraction crosses only 1 node: IP.

- (1) Object-extraction: Structural distance: 2 nodes (IP, VP)

*The reporter who [<sub>IP</sub> the statesman [<sub>VP</sub> attacked e]] had a bad reputation.*

- (2) Subject-extraction: Structural distance: 1 node (IP)

*The reporter who [<sub>IP</sub> e attacked the statesman] had a bad reputation.*

Their results strongly support the Structural Distance Hypothesis over resource-based theories, which raises interesting issues such as why resource-based theories cannot account for all languages (as we have shown, they seem to work for most SVO languages including Chinese).

position: Depending on the word order in the main clause and in a relative clause, extraction from object position can be easier to process in some circumstances. We discuss the resource theories and the canonical-word-order theory in turn below.

First, consider the storage-based resource theory, in particular the on-line storage theory proposed by Gibson 1998, 2000, in which there is a storage cost associated with predicting syntactic heads. This theory correctly predicts the contrast between subject- and object-extractions in both singly- and doubly-embedded structures. Furthermore, this theory correctly predicts the locus of the effect, during the processing of each RC. Not all storage-based resource theories can explain these results. In particular, the theory of Lewis 1996 proposes that there is an interference cost associated with maintaining multiple incomplete phrase-structure dependencies only when they are the same kind of syntactic dependency. In particular, incomplete subject-verb dependencies interfere with one another, but not with other incomplete dependencies. Although this theory can account for the results of the comparisons involving the doubly embedded structures, it does not account for the results of the comparisons involving the singly embedded structures. In particular, there is at most one incomplete dependency of any single type during the processing of the singly-embedded subject-extracted RC, the same as during the processing of the object-extracted RC. Thus a storage cost theory based on predicted heads in which different kinds of predictions cause additive difficulty fares better on the singly-embedded structures than a theory in which interference cost only accumulates when multiple incomplete dependencies of the same kind are present.

The integration-distance resource theory correctly predicted that object-extractions should be less complex than subject-extractions in Chinese, but the locus of this effect was not correctly predicted, especially in the singly-embedded



structures. In particular, the integration-distance theory predicts no differences during the processing of the RC, and it predicts a difference at the head noun, the point at which people are connecting the positions in the RC to the head noun. But no difference was observed in this region, contrary to prediction. The processing difference that was observed during the RC is more consistent with the prediction of the storage-based resource theory.

The second theory that can successfully account for the results presented here is the canonical word order theory. Under the assumption that the word *de* serves as an RC pronoun, this theory correctly predicts that object-extracted RCs should be processed more easily than subject-extracted RCs in Chinese, for both singly- and doubly-embedded constructions (but see footnote 6 for some alternative analyses of *de* from the syntax literature). It remains an open question how to formalize this theory so that it makes more detailed predictions. One version of this kind of theory is a frequency-based theory, such that people have less difficulty with word orders that they encounter more frequently: the canonical word orders. If stated purely in terms of tabulating frequencies of input (e.g., the tuning theory of Mitchell et al., 1995), such a comprehension theory makes no prediction about what kinds of word orders could serve as canonical, or about what kinds of attachment preferences people might have when faced with ambiguity: Any word order could serve as canonical, and any structure may be preferred over any other in the face of ambiguity (see Gibson & Schütze, 1999; Desmet & Gibson, in press; for further discussion of such theories).<sup>8</sup> Alternatively, a canonical-word-order comprehension theory may be driven in part by architectural limitations, which may constrain the processability of different word orders and attachment preferences. Connectionist systems

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<sup>8</sup> It is possible that there are no such constraints on comprehension, but that a theory of production constrains the kinds of word orders and ambiguity preferences that are produced (MacDonald, 1999).

provide examples of this kind of model (e.g., Tabor, Juliano & Tanenhaus, 1997; Chater & Christiansen, 1999; Rohde, 2002). The architecture of such a system may then give rise to a resource theory, such as the storage- or integration-based theories discussed above (Gibson, 1998). Because some versions of a canonical word order theory consist of different levels of analysis of resource theories, it may be impossible to provide evidence that demonstrates that one theory is correct and the other is wrong. Rather, aspects of both may turn out to be correct. Relatedly, these kinds of theories make the same predictions with respect to many phenomena, including the behavioral data discussed here. Specifically, the current results do not provide evidence relevant to distinguishing the canonical-word-order theory from resource-based theories.

One prediction of a frequency-based canonical word order theory that is worthy of discussion is that there should be a correlation between (1) structural frequencies in corpora and (2) behavioral measures such as reading times. Thus, in order for a frequency-based theory to be correct, Chinese object-extracted RCs should be more frequent in the input than corresponding subject-extracted RCs. Note that this prediction is also consistent with a resource theory, so such a prediction would not distinguish the theories. In particular, a resource-based theory is consistent with this prediction because the kinds of structures that are difficult to process will tend to be produced less often. In any case, this is a prediction that needs to be evaluated, and we will discuss this issue in Chapter 5 *Corpora Analysis*.

The results of the current study are interesting for two additional reasons. First, the advantage for object-extracted RCs over subject-extracted RCs occurred in spite of the fact that there is a potential temporary ambiguity in the object-extraction, but not in the subject-extraction. These results therefore provide an important data point in formalizing theories of sentence reanalysis (see e.g.,

Fodor & Ferreira, 1998; Grodner et al., in press; Sturt, Pickering & Crocker, 1999). In particular, the lack of difficulty associated with this ambiguity suggests that a main clause structure for the initial string of the object-extracted RC is probably used in the construction of the RC structure. This is possible because no re-structuring in thematic role assignments is needed in the switch from main clause to embedded clause. Furthermore, the phrase structure associated with a main clause analysis of an initial Subject-Verb sequence is the same phrase structure as is present in a relative clause.

Second, these results also provide evidence relevant to the syntactic representation of Chinese RCs. In particular, the fact that subject-extracted RCs incur more processing difficulty than object-extracted RCs in Chinese makes an analysis unlikely in which there is an empty operator on the left of the RC, mediating between the head noun for the RC to the right and the empty position inside the RC. Such an analysis would make the structure of RCs more similar across languages, but is not compatible with the current data. If there were such a position, and integrations to it incurred a processing cost (as they do in English), then there would be no processing advantage for object-extractions over subject-extractions in Chinese. The fact that there is such an advantage makes it likely that there is no empty operator initiating Chinese RCs. As discussed in Chapter 2, this is the analysis proposed by Aoun and Li to appear and the results from processing studies are compatible with their analysis.

## **Chapter 4 Processing Chinese Relative Clauses – Ambiguous Structures**

Chapter 3 discusses processing relative clauses in unambiguous structures. The following chapter presents a study in which the relative clauses modify objects and as such temporary ambiguity arises in the case of object-extracted RCs (see below). This contrasts with the case of subject extraction where there is less ambiguity. It will be shown that despite ambiguity in object extraction, subject-extracted RCs in object position nonetheless incur more processing difficulty throughout.

### **4.1 RC's Modifying Objects**

#### **4.1.1 Introduction**

We have seen in Chapter 3 that in unambiguous structures, subject-extracted RCs have a higher processing load possibly due to higher storage costs. In this study, we look at ambiguous structures, i.e. RCs modifying objects, and investigate how ambiguity is resolved.

There are several issues central to the discussion of syntactic ambiguity resolution. First of all, what kind of information is used to resolve ambiguity (see Gibson 2003, Gibson and Pearlmuter 1998, Tanenhaus and Truswell 1995, MacDonald, Pearlmuter and Seidenberg 1994)? For example, syntactic information has been shown to play an important role in ambiguity resolution, e.g. when an SV sequence is encountered, a main clause analysis (in which the V is analyzed as a main verb) is preferred over a reduced relative analysis (in which the V is analyzed as a past participle), hence the difficulty in processing the following two sentences (Ferreira and Clifton 1986, Frazier 1979).

(1) The dog walked to the park chewed the bone. (cf. The dog that was walked to the park chewed the bone.) (Gibson 2003)

(2) The horse raced past the barn fell. (cf. The horse that was raced past the barn fell.) (Bever 1970)

An early hypothesis to explain this syntactic preference was proposed by Frazier 1979, 1987. The assumptions are that the sentence processor is serial, i.e. only one representation at each parser state is retained, and modular, i.e. syntactic information is used before other information. In addition, two principles are at work: Minimal Attachment and Late Closure. Under Minimal Attachment, incoming material is attached into the phrase-marker being constructed using the fewest nodes consistent with the well-formedness rules of the language. Late Closure attempts to attach incoming material to the clause/phrase currently being processed. The preference exemplified in (1) and (2) comes from attaching the verb to the existing main clause structure instead of constructing an additional RC structure.

A more recent theory such as the DLT (Gibson 1998, 2000) explains the preference in (1) and (2) in the following way. The ambiguity is initiated at the point of processing the first verb. If the verb is analyzed as the main clause verb (SV) and the verb is intransitive, e.g. *raced* and *walked* in the examples, no more syntactic heads are required. On the other hand, if a reduced relative clause analysis is pursued, more syntactic heads are needed: a verb for the main clause and possibly a modifier for the reduced relative. Thus, the main verb analysis is preferred.

Other kinds of information have also been shown to play a role in ambiguity resolution. For example, Trueswell, Tanenhaus and Garnsey 1994 (cf. Ferreira & Clifton 1986) demonstrate that plausibility information can be manipulated so

that structural biases such as the one illustrated in (1) and (2) in which a main verb interpretation is preferred over a reduced relative interpretation are minimized. For example,

(3) The evidence examined by the lawyer turned out to be unreliable.

(4) The defendant examined by the lawyer turned out to be unreliable.

In (3), plausibility information strongly discourages a main verb interpretation, i.e. *the evidence* being the agent of the verb *examine*. In (4), on the other hand, it is equally plausible for a defendant to be examined or to examine something. Eye-tracking measures show that participants do not experience measurable difficulty when processing (3), which is made unambiguous by plausibility information. On the other hand, participants do experience difficulty when processing (4), which is compatible with either a main verb or a reduced relative interpretation. This shows that parsing preferences are to a certain degree governed by non-syntactic information.

In this chapter, I present an online reading study in which these issues are explored in the context of Chinese syntactic ambiguity resolution (see Wu 1989 for a discussion of parsing issues related to garden path sentences in Chinese and Lee 1995 for a typology of Chinese garden path sentences). Consider the two sentences in (5).

(5)

a. Chinese object-extracted RC in object position (ambiguous)

danshenhan anlien                      kuafu chauxiao de laochunu  
 bachelor    secretly has a crush on widow    make fun of de spinster  
 'The bachelor secretly has a crush on the spinster who the widow  
 made fun of.'

b. Chinese subject-extracted RC in object position (unambiguous)

danshenhan anlien                      chauxiao kuafu de laochunu  
 bachelor    secretly has a crush on make fun of widow de spinster  
 ‘The bachelor secretly has a crush on the spinster who made fun of  
 the widow.’

In (5a), the temporary ambiguity arises because when the subjects read the second noun phrase *kuafu* ‘widow,’ they could analyze it either as the object of the main verb *anlien* ‘secretly has a crush on,’ i.e. ‘the bachelor secretly has a crush on the widow’ or as the subject of the object relative clause. The ambiguity goes away when the second verb *chauxiao* ‘make fun of’ is encountered.

In (5b), on the other hand, there is no ambiguity, as when the second verb *chauxiao* ‘make fun of’ is encountered, it is clear that what follows is a relative clause. The two verbs do not form a serial/complex verb, so there is no ambiguity in parsing this sentence.

#### 4.1.2 Experiment

Three pairs of conditions were tested. The first pair of conditions was the same as the first pair of conditions tested in Hsiao and Gibson 2002, i.e. singly subject-extracted RCs versus singly object-extracted RCs in unambiguous subject position, as exemplified in (6) in Chapter 3. Since Hsiao and Gibson 2002 was the first study in Chinese relative clause processing, we wanted to try to replicate the results.

(6)

a. Chinese object-extracted RC in subject position

kuafu chauxiao    t<sub>i</sub> de laochunu<sub>i</sub> anlien                      danshenhan  
 widow make fun of    de spinster secretly has a crush on bachelor

‘The spinster who the widow made fun of secretly has a crush on the bachelor.’

b. Chinese subject-extracted RC in subject position

*e*, chauxiao      kuafu de laochunu, anlien      danshenhan  
 make fun of widow de spinster secretly has a crush on bachelor

‘The spinster who made fun of the widow secretly has a crush on the bachelor.’

The second pair of conditions tested subject-extracted RCs versus object-extracted RCs in object position, as exemplified in (5). All the object-extracted RCs had a plausible subject (e.g. *kuafu* ‘widow’ in (5a)) that could also be analyzed as the object of the matrix verb (e.g. ‘the bachelor secretly has a crush on the widow’) in addition to the correct analysis (e.g. ‘the bachelor secretly has a crush on the spinster’). We also conducted a related plausibility norming survey to make sure the two events are equally plausible across all items (see section 4.1.4 below for more details).

The third pair of conditions tested object-extracted RCs in object position with plausible versus implausible subjects, as exemplified in (7). The implausible subject helps to resolve the ambiguity in favor of the RC reading, as it does not make much sense to interpret the implausible subject as the object of the matrix verb. We were interested in finding out if the implausibility would prevent the participants from positing the garden path analysis, i.e. an analysis that is based only on syntactic preference, as reported in Trueswell, Tanenhaus and Garnsey 1994. In particular, Grodner, Gibson and Tunstall 2002 show that when the difference between the resource use of the alternative analyses is large enough, experimental participants prefer the less costly garden path analysis even if plausibility information strongly favors the more costly analysis.





that make predictions regarding ambiguity resolution are resource-based theories and the canonical/non-canonical (frequency) word order theory.

According to the DLT, we expect subject-extracted RCs in the object position to incur more processing difficulties than object-extracted RCs in the object position due to higher storage use, independent of ambiguity. However, as there is temporary ambiguity in the case of object-modifying RCs, it would be interesting to see how ambiguity and extraction type interact. Let's now look at word-by-word predictions. After processing the third word (the noun) in object-extracted RCs such as (5a), no syntactic head is needed because the words thus far could be interpreted as an SVO sentence. In (5b), on the other hand, 4 syntactic heads are needed at this point: a noun for the transitive matrix verb, a noun for the transitive RC verb, the RC marker *de* and a head noun. In addition, we expect ambiguity to cause some temporary processing difficulty in processing object-extracted RCs in the object position. In (5a), when the second noun phrase *kuafu* 'widow' is encountered, the preference is to analyze this noun phrase as the object of the matrix verb, as under this analysis no syntactic head is needed after processing this word. The alternative analysis in which this noun phrase is analyzed as the subject of a following RC would require 3 syntactic heads: a verb for the RC, the RC marker *de* and a head noun. Thus, resource-based theories would predict that experimental participants initially pursue a garden path analysis. However, as soon as the fourth word is processed, they would realize that they had posited a wrong analysis and a reanalysis would be necessary. This would cause temporary processing difficulty. It is not clear, however, how much this temporary processing difficulty will be, i.e. does it exceed the general higher resource use in processing subject-extracted RCs at some point?

The canonical/non-canonical (frequency) word order theory predicts more difficulty associated with processing subject-extracted RCs in the object position

simply because the word order SV in object-extracted RCs is canonical whereas the word order VO in subject-extracted RCs, a verb without its subject, is non-canonical. However, the temporary ambiguity in object-extracted RCs comes into play here, i.e. the  $SV_1[RC\ SV_2]$  can be analyzed as  $SV_1O\ V_2$ . Once again, it is not clear what the prediction here would be. As  $V_1$  is transitive, the analysis  $SV_1O\ V_2$  would seem to be the preferred choice, as  $SV_{transitive}O$  is the most canonical, but soon after it would be clear that this is the wrong analysis. At this point, reanalysis needs to take place. If this is the path taken by the experimental participants, we would expect to see that object-extracted RCs are easier to process in the beginning of the RCs and then incur more difficulty shortly after due to reanalysis.

Finally, let's look at the third pair of conditions. Once again, theories based on accessibility of syntactic positions or perspective shift do not apply.

Canonical/non-canonical (frequency) theory would predict that the condition containing a plausible RC subject to be more difficult, as it makes it possible to pursue the SVO analysis, hence the temporary processing difficulty afterwards when reanalysis takes place.

Resource-based theories make similar predictions. The condition containing a plausible RC subject (i.e. example (7)) is predicted to be more difficult, as participants would favor the garden path analysis SVO initially since this analysis would require no syntactic head after processing the third word in contrast to the alternative analysis where 3 syntactic heads would be needed if the second noun is analyzed as the subject of the following RC (a verb for the RC subject, the relative clause marker *de* and the head noun). The other condition in which the RC subject is an implausible object for the matrix verb is predicted to be easier to process because plausibility information strongly discourages the SVO analysis

(Trueswell, Tanenhaus and Garnsey 1994). However, as the difference in the number of syntactic heads needed under the two analyses is 3, which is substantial, syntactic preference might still dominate even though plausibility information favors the more costly RC analysis (Grodner, Gibson and Tunstall 2002).

### **4.1.3 Method**

#### **4.1.3.1 Participants**

Two groups of subjects participated in this experiment. The first group had a total of forty subjects. The average age for this group was 36. All of them reside in Taiwan and use Chinese exclusively. The subjects were naïve as to the purposes of the study.

The second group had a total of twenty-five subjects. The average age for the subjects was 37. The subjects are based in Toronto but travel often to Taiwan. All are native speakers of Mandarin Chinese spoken in Taiwan and use Mandarin Chinese daily (percentage of Chinese use: 50% - 100%). The subjects were naïve as to the purposes of the study.

#### **4.1.3.2 Materials**

Twenty sets of sentence were constructed, each with the 5 conditions in (8)-(10), typed in Chinese characters.

- (8) a. object-extracted RC in subject position  
b. subject-extracted RC in subject position
  
- (9) a. object-extracted RC in object position (plausible RC subject)  
b. subject-extracted RC in object position

- (10) a. object-extracted RC in object position (plausible RC subject)
- b. object-extracted RC in object position (implausible RC subject)

This experiment consisted of a 2x2 design crossing position of the RCs (subject versus object) with extraction type (subject versus object). In addition, there was one additional condition manipulating the plausibility of the RC subject for the condition of the object-extraction in object position.

The target sentences were split into five lists balancing all factors in a Latin-Square design. Each list was combined with seventy-two fillers of various types. The fillers presented to the first group of participants did not include many simple SVO sentences. For the second group, on the other hand, 1/3 of the filler sentences were simple SVO sentences with continuation so the subjects would not analyze SVO sequences as SV followed by the subject of the relative clauses, which were the target sentences ((9a), (10a) and (10b)). As we discuss below, the results were very different and provide important insights.

Appendix B provides a complete list of the stimuli. The stimuli were pseudo-randomized separately for each participant so that at least one filler item intervened between two targets.

#### **4.1.3.3 Procedure**

The procedure was the same as the one used in the online reading experiment reported in Chapter 3.

#### **4.1.4 Plausibility Norming Survey**

A questionnaire was conducted in order to control for potential plausibility differences between the two conditions in each pair. Forty native Chinese-speaking participants residing in Taiwan who did not take part in the self-paced

reading experiment completed the survey. The items tested in this questionnaire consisted of the simple transitive clauses that made up each RC and the simple transitive clauses that included the matrix subject, matrix verb and one of the two nouns in the RC.

(11)

- a. Object-extracted RC control: The widow made fun of the spinster.
- b. Subject-extracted RC control: The spinster made fun of the widow.

(12)

- a. Ambiguous plausible object control: The bachelor secretly has a crush on the widow. (garden path analysis)
- b. Ambiguous plausible object control: The bachelor secretly has a crush on the spinster.

(13)

- a. Ambiguous plausible object control: The bachelor secretly has a crush on the spinster.
- b. Ambiguous implausible object control: The bachelor secretly has a crush on the hot soup.

We wanted to make sure the two conditions in (12) were equally plausible so we would see how the temporary ambiguity influences processing of the object-extracted object RCs sentences.

On the contrary, we wanted to make sure the two conditions in (13) have very different ratings, with (13b) much more implausible than (13a). This way, we could reduce the temporary ambiguity and discourage the garden path analysis.

Participants rated the plausibility of these sentences on a scale of 1 (natural) to 7 (unnatural). They were asked to judge the naturalness in the real world of the events described in the sentences, that is, how likely they were to occur. Once again, we needed to make sure the events described in (11a) and (11b) were equally plausible; likewise, the plausibility ratings for (12a) and (12b) should be similar. In (13), on the other hand, since we designed for (13b) to be implausible, plausibility rating for (13b) should be higher than that of (13a).

The results of the survey showed that all twenty items were matched for plausibility across all versions (means: 2.35 for (11a), and 2.34 for (11b); 2.47 for (12a), 2.50 for (12b); 2.47 for (13a), and 4.16 for (13b)). (11a) and (11b) were equally plausible, (12a) and (12b) were also equally plausible, and (13a) was much more plausible than (13b) in all items, as expected.

#### **4.1.5 Results and Discussions**

The results were analyzed using Lingalyzer 1.11 written by Doug Rohde.

For the first group of participants, two participants' data were omitted from the analyses because of poor comprehension question performance (< 67% accuracy overall). Overall accuracy for the remaining thirty-eight participants had a mean of 93.6%. However, all effects that are reported as significant below are also significant under analyses that included these two subjects.

For the second group of participants, two participants' data were omitted from the analyses because their comprehension question performances were worse than all the other participants (75% and 76.4% compared to the other twenty-three participants, who had the accuracy of 86.1% or higher). These two subjects were older (their ages were 53 and 63 while the other twenty-three subjects had

an average age of 35.4). Overall accuracy for the remaining twenty-three participants had a mean of 93.7%. Similarly, all effects that are reported as significant below are also significant under analyses that included these two subjects.

#### 4.1.5.1 Comprehension Question Performance

The percentages of correct answers for each condition are presented in Tables 2 through 7. These include results from both groups of participants.

object-extracted subject RC	subject-extracted subject RC
79.6 (3.3)	71.7 (3.7)

Table 2. Mean (standard error) comprehension question performance in percent correct by condition for the first group of participants (Taiwan).

object-extracted subject RC	subject-extracted subject RC
77.2 (4.4)	72.8 (4.7)

Table 3. Mean (standard error) comprehension question performance in percent correct by condition for the second group of participants (Toronto).

When RCs occurred in subject position, although comprehension question performance was numerically better in the one-clause object-extracted sentences than in the one-clause subject-extracted sentences, this difference did not reach significance ( $F_1(1, 37) = 3.17, p = 0.08$ ;  $F_2(1, 19) = 1.70, p = 0.21$  for the first



group and  $F_s < 1$  for the second group). This is essentially the same finding as reported in Hsiao and Gibson 2002.

Let's now turn to the next pair of conditions, i.e. when the relative clauses occurred in object position.

object-extracted object RC (plausible RC subject)	subject-extracted object RC (unambiguous)
72.4 (3.6)	65.8 (3.9)

Table 4. Mean (standard error) comprehension question performance in percent correct by condition for the first group of participants (Taiwan).

We see a similar pattern with the first group of participants, namely that questions regarding subject-extracted object RCs were harder to answer, even though the difference did not reach significance ( $F_s < 1.3$ ).

object-extracted object RC (plausible RC subject)	subject-extracted object RC (unambiguous)
60.9 (5.1)	65.2 (5.0)

Table 5. Mean (standard error) comprehension question performance in percent correct by condition for the second group of participants (Toronto).

Interestingly, with the second group of participants, we observe the opposite pattern when the RCs occurred in object position. Participants answered questions better regarding subject-extracted object RCs. This might be due to ambiguity in object-extracted object RCs. Once again, the numerical difference did not reach significance ( $F_s < 1$ ).

Note that the comprehension question performance for object-extracted object RCs was very low, i.e. 60.9%, which is not much higher than chance level. This could suggest that the second group of participants in general did not understand this type of sentences. It is very possible that they posited a wrong analysis in the beginning due to the ambiguity and never reanalyzed the sentence and as a result they could not answer the questions correctly.

The first group of participants seemed to understand object-extracted object RCs better. This could be because they did not have many filler sentences that were similar to the target sentences, i.e. sentences starting with Noun Verb Noun. Consequently, when they encountered Noun Verb Noun, they were more likely to analyze the second noun as the subject of the relative clauses and not as the object of the main verb. Due to the lack of similar filler sentences, the effects of the temporary ambiguity were probably not as strong for this group of participants.

Let's now turn to the third pair of conditions, i.e. object-extracted object RCs with plausible versus implausible subjects.

object-extracted object RC (plausible RC subject) 72.4 (3.6)	object-extracted object RC (implausible RC subject) 85.5 (2.9)
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Table 6. Mean (standard error) comprehension question performance in percent correct by condition for the first group of participants (Taiwan).

object-extracted object RC (plausible RC subject) 60.9 (5.1)	object-extracted object RC (implausible RC subject) 79.3 (4.2)
--	--

Table 7. Mean (standard error) comprehension question performance in percent correct by condition for the second group of participants (Toronto).

For both groups of participants, if the object RC contained an implausible subject and as such the garden path analysis is discouraged, comprehension question performance was even better, i.e. 85.8% for the first group and 79.3% for the second group. The difference was significant ( $F(1, 37) = 9.39, p < 0.005$ ;  $F(1, 19) = 8.97, p < 0.01$  for the first group and  $F(1, 22) = 11.31, p < 0.005$ ;  $F(1, 19) = 5.68, p < 0.05$  for the second group.)

The fact that comprehension performance in the target items was low (75% and 71.1% for the two groups, respectively) was probably because the items were complex. Mean performance on the filler items was much better at 93.6% for the first group and 93.7% for the second.

#### 4.1.5.2 Reading Times

Because of the complexity of the target items, all items were analyzed regardless of whether comprehension questions were answered correctly. Figures 4 and 5 plot mean RTs per word in the singly-embedded subject RCs for the two groups of subjects. As only the first three words, the RCs, consisted of the critical region and reading times increased considerably on the last word in both conditions and the difference was not significant, I included only the first five words in the two figures below.

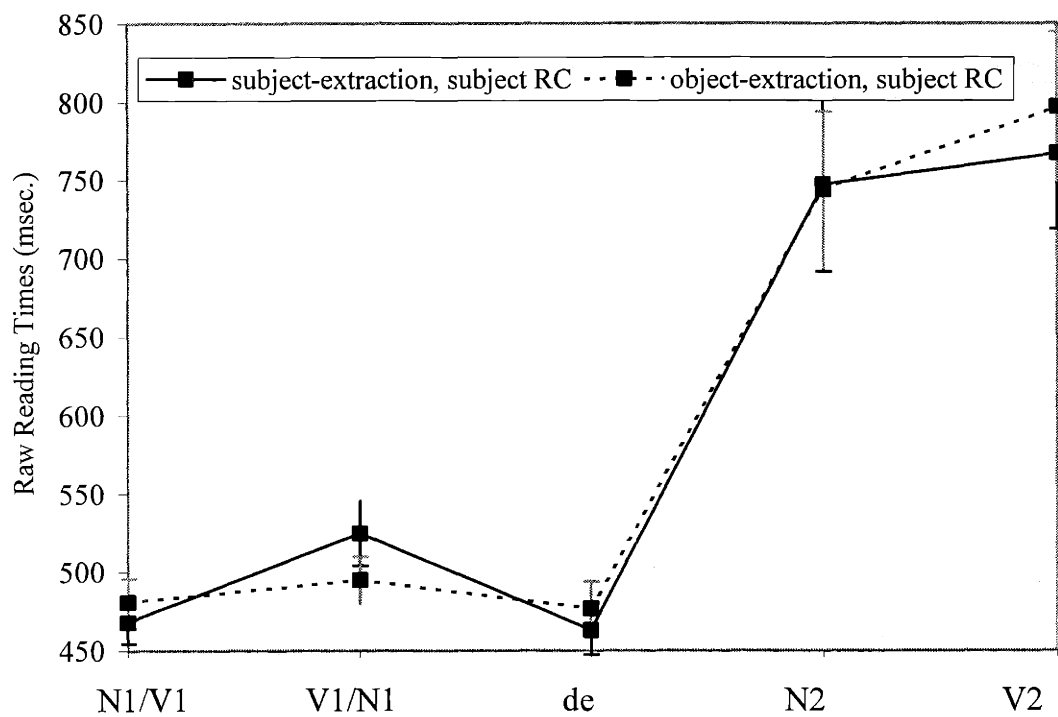


Figure 4. Plot of mean (standard error) raw reading times per word by region for the subject-modifying RCs for the first group of participants (Taiwan).

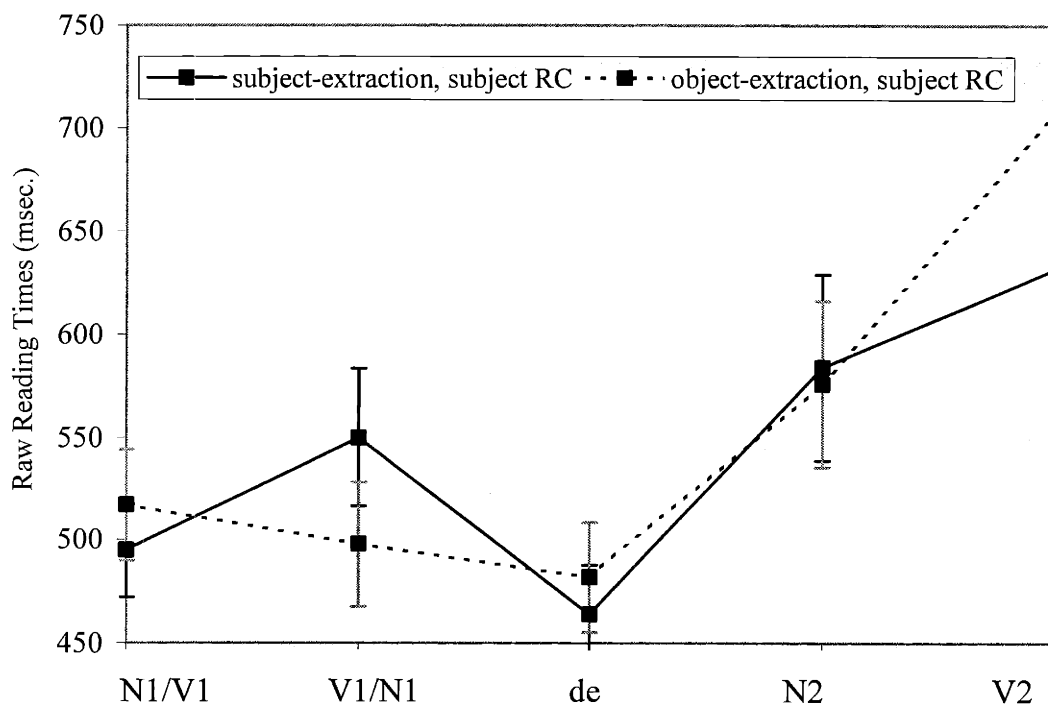


Figure 5. Plot of mean (standard error) raw reading times per word by region for the subject-modifying RCs for the second group of participants (Toronto).

Subject-extraction RCs were processed numerically slower than object-extracted RCs during the RCs, similar to the findings in Hsiao and Gibson 2002. However, an ANOVA for the second word revealed no significant difference ( $F_1(1, 37) = 2.71, p = 0.11$ ;  $F_2(1, 19) = 1.26, p = 0.27$  for the first group and  $F_s < 1$  for the second group of participants). We suspect that because all the target items in this experiment were similar in terms of structural complexity, i.e. all were singly embedded structures, the difference between subject-extractions and object-

extractions was not easy to measure. In Hsiao and Gibson 2002, on the other hand, because of the presence of the doubly embedded structures, which were much more difficult, the participants may have been reading even less complex structures more carefully.

Turning now to RCs in object position, Figures 6 and 7 plot mean RTs per word by region by participants.

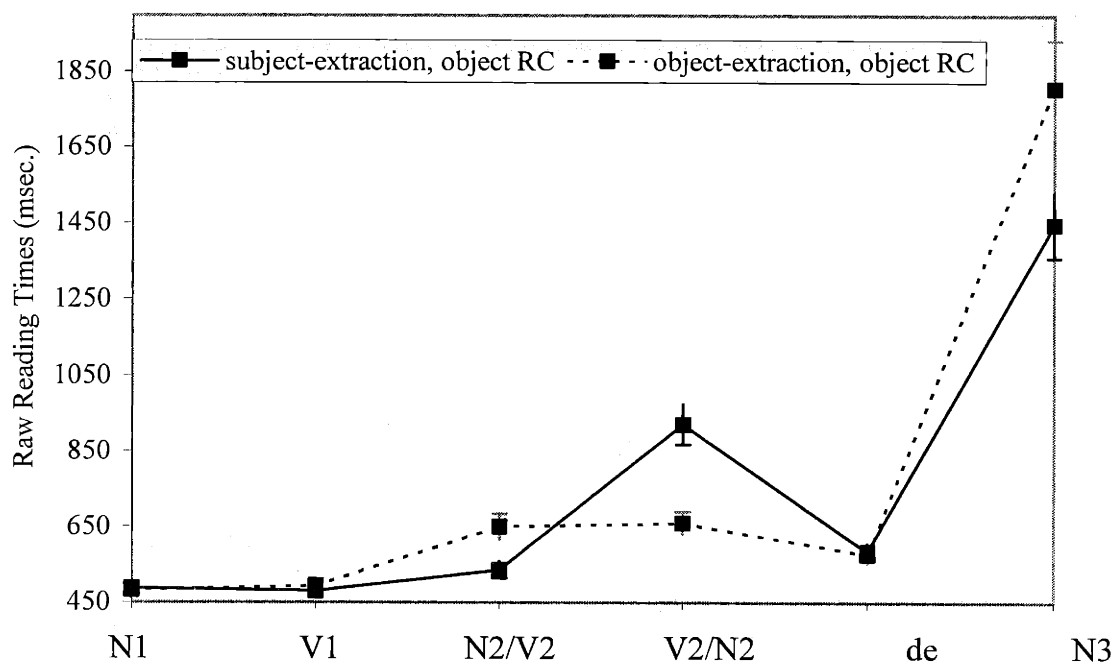


Figure 6. Plot of mean (standard error) raw reading times per word by region object-modifying RCs for the first group of participants (Taiwan).

Surprisingly, the first group of participants read the third words in object-extraction object RCs significantly slower ( $F1(1, 37) = 13.0, p < 0.001$ ;  $F2(1, 19) = 4.9, p < 0.05$ ). This is surprising because if the sequence Noun Verb Noun were to be analyzed as Subject Verb Object, i.e. the garden path analysis, the participants would be expected to read this type of sentences faster than sentences starting with Noun Verb Verb, where the second verb incurs more processing difficulty. This suggests that as the participants were not given many filler sentences starting with Noun Verb Noun, they were already expecting Noun Verb followed by the subject of the relative clause. It is possible that they did not posit the garden path analysis and so were already reading slowly on the third words because of the resources needed to process the immediately following relative clauses.

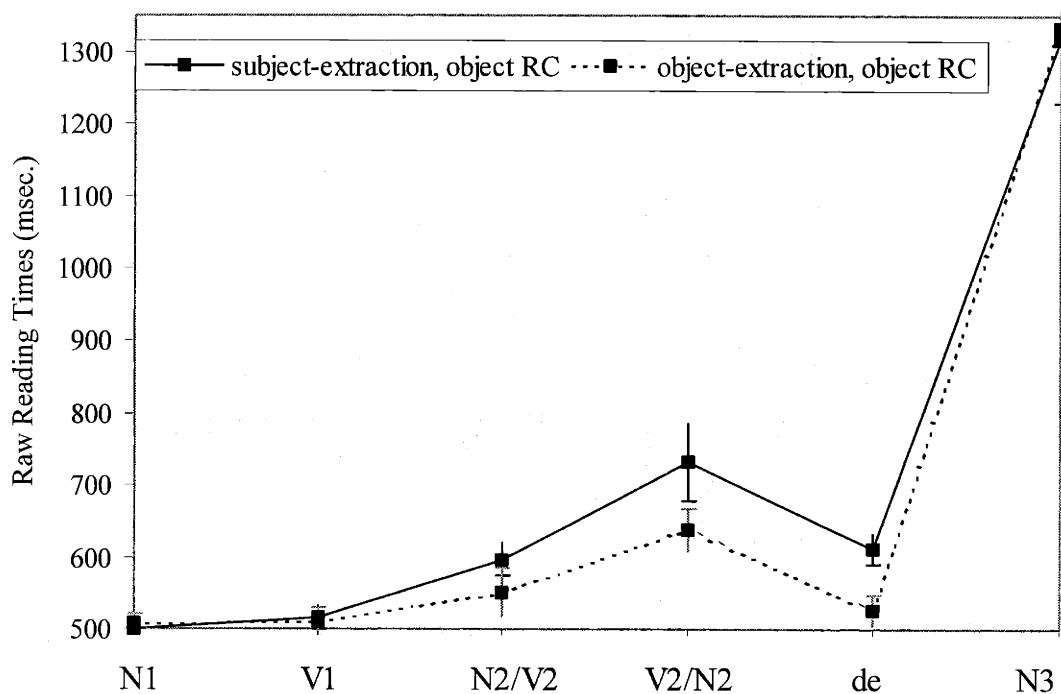


Figure 7. Plot of mean (standard error) raw reading times per word by region object-modifying RCs for the second group of participants (Toronto).

On the contrary, for the second group of participants, despite temporary ambiguity in the case of object-extracted RCs, subject-extracted RCs incur more processing difficulty throughout. There were no significant effects over the first two word regions ( $F_s < 0.3$ ). An ANOVA for the next three words revealed that object-extractions were processed faster than subject-extraction in the participants' analysis ( $F_1(1, 22) = 7.4, p = 0.01$ ;  $F_2(1, 19) = 2.8, p = 0.1$ ).



Let's now turn our attention to the third pair of conditions, i.e. object-extracted object RCs containing either plausible or implausible subjects. Figures 8 and 9 plot mean RTs per word by region by participants.

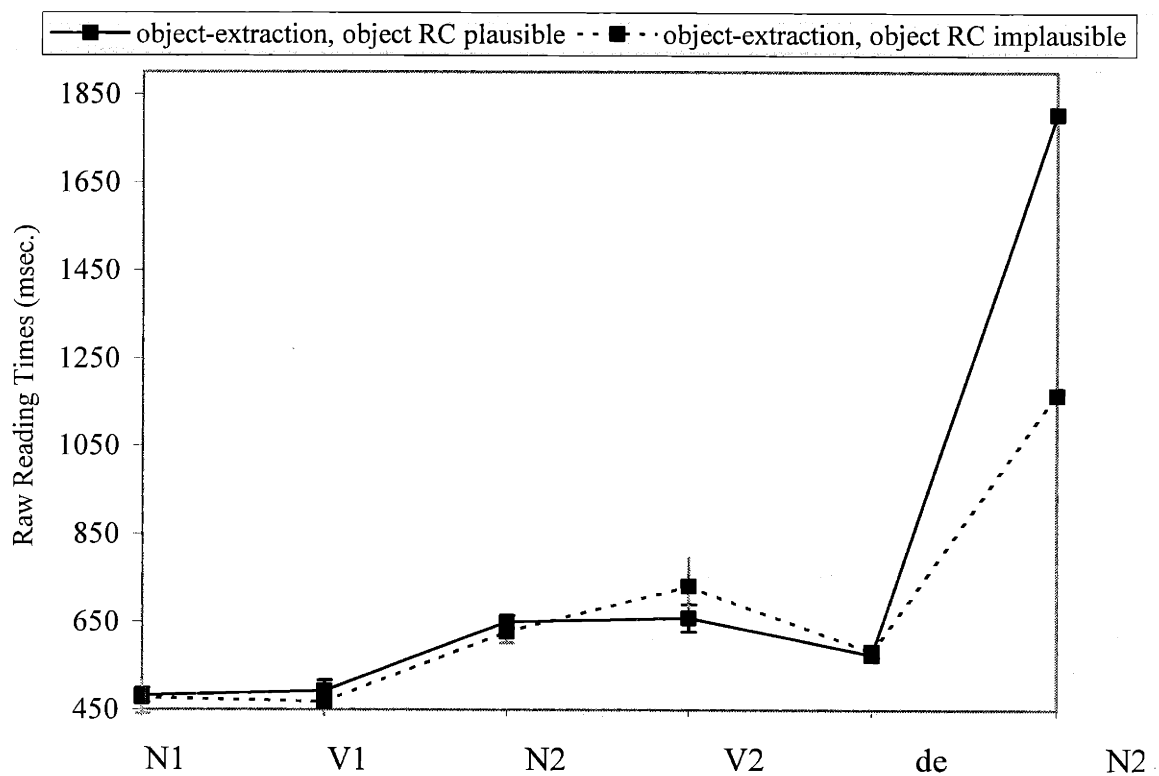


Figure 8. Plot of mean (standard error) raw reading times per word by region object modifying RCs with plausible versus implausible subjects for the first group of participants (Taiwan).

For the first group of participants, the differences between these two types of sentences were not significant except for the end of the sentences, where the object-extracted object RCs containing plausible subjects had slower reading times ( $F1(1, 37) = 16.1, p < 0.0005$ ;  $F2(1, 19) = 17.9, p < 0.0005$ ). Once again, this suggests that the first group of participants did not posit the garden path analysis and as such the plausibility/implausibility of the relative clause subjects did not have a major impact.

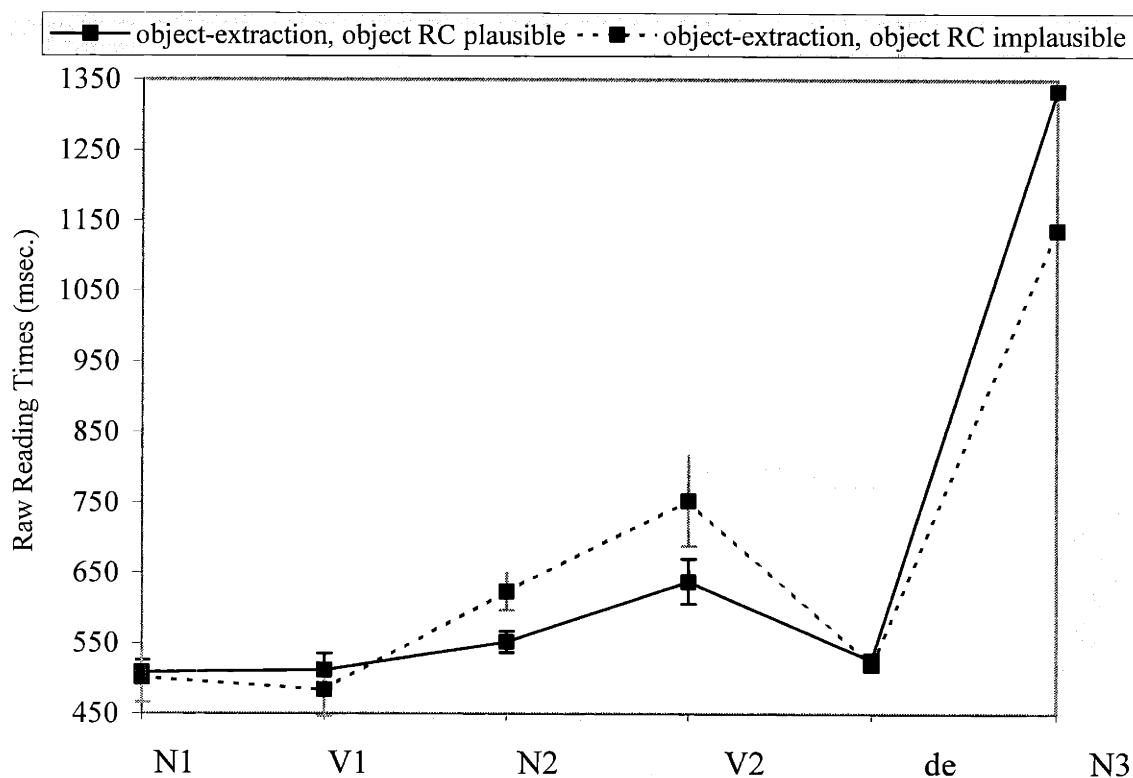


Figure 9. Plot of mean (standard error) raw reading times per word by region object modifying RCs with plausible versus

implausible subjects for the second group of participants (Toronto).

Turning to the second group of participants, if the relative clause contains an implausible subject and as such the garden path analysis under which N2 is interpreted as the object of V1 is discouraged, interestingly object RCs containing implausible subjects were processed slower than object RCs containing plausible subjects. An ANOVA for the first two words revealed no significant effects ( $F_s < 0.2$ ). This is expected, as the first two words were identical. For the next three words, an ANOVA revealed significant effects in the items' analysis ( $F_1(1, 22) = 2.6, p = 0.1$ ;  $F_2(1, 19) = 4.3, p = 0.05$ ).

The fact that RCs containing implausible subjects were harder to process than RCs containing plausible subjects suggests that despite the implausibility in analyzing the subject of the RC (N2) as the object of the matrix verb V1, this group of participants still initially analyzed N2 as the object of V1, hence the slower processing time.

#### **4.1.6 Summary**

To sum up, the general pattern we have observed here is that subject-extracted RCs were processed slower than object-extracted RCs when the RCs occurred both in subject and in object positions.

As in Chapter 3, we see that subject-extracted RCs in subject position had slower reading times and the question comprehension performance was poorer. Resource-based theories attribute this difficulty to the higher storage costs associated with processing subject-extracted RCs. The canonical/non-canonical (frequency) theory attributes this difficulty to the non-canonical word order, VO without a subject, associated with subject-extracted RCs. Both theories are

compatible with the findings reported here. In Chapter 5, we will conduct a corpus analysis to tease these two theories apart.

When RCs occurred in object position, once again subject-extracted RCs had much slower reading times in general in spite of the temporary ambiguity. However, as the second group of participants did worse (a low 60.9 accuracy) in answering questions regarding object-extracted RCs containing plausible subjects even though they read these sentences faster, it is very likely that the participants posted a wrong analysis due to the ambiguity and never recovered from that. They incorrectly analyzed the subject of the relative clause as the object of the main verb even though the rest of the sentence did not make sense under this analysis. Consequently they did not answer the questions correctly.

As the first group of participants were given very few filler items resembling the target sentences, the results suggest that they did not posit the garden path analysis.

It is likely, however, that the difference between the two groups of participants could be related to the environments they are in, i.e. the first group of participants are exposed to Chinese (Mandarin Chinese and Taiwanese) exclusively whereas the second group of participants are in an English-speaking environment even though they use Chinese predominantly. This could contribute to the fact that the second group of participants did not really understand object-extracted RCs in the object position. It will be interesting if we reverse the items presented to the participants and see if we still get the same pattern in understanding this condition pair.

When the object-extracted object RCs contained implausible subjects, the second group of participants processed them slower than they processed object-extracted object RCs containing plausible subjects. The purpose of the implausible subjects

was to discourage the garden path analysis under which the subject of the relative clause would be incorrectly analyzed as the object of the main verb. However, the fact that participants had slower reading times with these sentences suggests that they nonetheless posited the wrong analysis initially despite the implausibility, similar to the results reported in Grodner, Gibson and Tunstall 2002. Interestingly, they seemed to realize the initial analysis was wrong and went through reanalysis, as the question comprehension performance was much better (accuracy of 79.3%) than the low question comprehension performance in the case of object-extracted object RCs containing plausible subjects (accuracy of 60.9%). This suggests that they did understand these sentences.

The results from the first group of participants once again showed no significant differences. This is most likely because they did not posit the garden path analysis.

## Chapter 5 Corpora Analysis

It has been noted that in many cases, resource-based theories and canonical/non-canonical (frequency) theories are both compatible with data from sentence processing studies (Mitchell et al. 1995, Gibson and Schütze 1999, Desmet and Gibson in press, Gibson, Schütze and Salomon 1996). In the studies under investigation here, resource-based theories account for the fact that subject-extracted RCs in Chinese incur more processing difficulty by attributing it to more resource usage in processing subject-extracted RCs. Canonical/non-canonical (frequency) theories can also account for this fact because the canonical word order SV is present in object-extracted RCs whereas the non-canonical word order VO is present in subject-extracted RCs. In most cases, the canonical word order is also the more frequent word order found in corpus analysis. The greater processing difficulty associated with subject-extracted RCs is due to the less frequent word order. Thus, even though the explanations from both groups of theories differ greatly, they both account for the data successfully. As a result, it is very difficult to tease these two theories apart.

The results from the online reading experiments presented in Chapters 3 and 4 are consistent with resource theories. In order to evaluate the canonical/non-canonical (frequency) word order theories, it is necessary to spell out the structures the theories are sensitive to. For example, Mitchell et al 1995's theory tabulates frequencies of different syntactic structures, e.g. subject-extracted RCs versus object-extracted RCs. The results presented in Chapters 3 and 4 may also be consistent with this frequency-based theory as long as subject-extracted RCs, which have the non-canonical word order VO, occur less frequently and hence more difficulties would be expected to be associated with processing subject-extracted RCs. In this chapter, we are interested in finding out whether subject-

extracted RCs do indeed occur less frequently than object-extracted RCs. To achieve this, we have analyzed the UPenn Chinese Treebank 3.0 corpus.

However, we should keep in mind that there are potentially an infinite number of frequency theories. A theory that tabulates frequencies of single clause word orders (cf. MacDonald and Christiansen 2002), e.g. SVO, VO, etc, would not be tested by the corpus analysis in this chapter.

### 5.1 LDC UPenn Chinese Treebank 3.0

The Chinese Treebank 3.0 is published by Linguistic Data Consortium (LDC) and consists of 325 data files written in simplified Chinese with syntactic bracketing. These 325 files contain about 100k words and were taken from Xinhua newswire and were written between 1994 and 1998.

### 5.2 Results (All Matching Structures)

All instances of relative clauses were carefully examined. Only occurrences of argument relativization were counted – adjunct relativization (e.g. *the reason why he left*) was excluded. Passive sentences were excluded. Simple phrases that lack copula verbs, e.g. prepositional phrases (e.g. ‘The company in China’ versus ‘The company that is in China’) or adjectival phrases (e.g. ‘The big company’ versus ‘The company that is big’) that could be analyzed as reduced subject-extracted RCs were also excluded.

In total, 882 instances were found in the corpus, 375 (42.52%) of which were object-extracted RCs. The remaining 507 (57.48%) instances were subject-extracted RCs.

object-extraction	subject-extraction
375	507
42.52%	57.48%

Table 8. Occurrences and percentages of object-extraction versus subject-extraction (LDC UPenn Chinese Treebank 3.0, all matching structures).

According to frequency theories, the fact that subject-extracted RCs are harder to process is expected to be due to fewer occurrences of subject-extracted RCs compared with object-extracted RCs. However, given that we have found more instances of subject-extracted RCs in the corpus, frequency theories now face problems in explaining the greater difficulties associated with processing subject-extracted RCs. Thus, even though subject-extracted RCs occur more frequently than object-extracted RCs, they are more difficult to process.

### 5.3 Results (Filtered Structures)

The RCs included in the analysis reported in the previous section were heterogeneous in that the verbs in the RCs could be either transitive or intransitive, the subjects and objects of the RCs consisted of various kinds of noun phrases: (definite, indefinite, animate, inanimate, human, non-human, pronouns, proper names, empty categories such as *pro*), etc. We thus conducted several finer classifications of the occurrences of the RCs found in the previous analysis to see if subject-extracted RCs still occur more frequently than object-extracted RCs.

The experimental items from the online reading experiments reported in Chapter 3 and 4 (first condition pair) only contained RCs which have transitive verbs, definite human subjects and definite human objects.



We found only 6 instances of RCs that matched this description. All of them were subject-extracted RCs in the subject position. 4 of the head NPs are proper names. 3 of the objects in the RCs are proper names. 1 of the objects in the RCs is a pronoun.

object-extraction	subject-extraction
0	6
0%	100%

Table 9. Occurrences and percentages of object-extraction versus subject-extraction (LDC UPenn Chinese Treebank 3.0, filtered structures).

The fact that there were so few instances of RCs matching the experimental items could be related to the nature of the corpus we used. All the data files were news articles, so most NPs were inanimate proper names such as names of government institutions, regulations, city names, etc. We suspect that if we had used a corpus of different genre, for example, short stories, there would be more instances of RCs that met the criteria. Obviously, a more extensive corpus analysis needs to be conducted which includes a wider variety of writing styles and also a larger number of samples. The results reported here are only preliminary and need to be refined more carefully. Alternatively, it is possible that RCs with animate subjects and objects are rare in general (see Rohde 2002, Gordon et al. 2002 for discussions on the infrequent occurrences of RCs with animate subjects and objects in English).

Nonetheless, subject-extracted RCs once again occurred much more frequently than object-extracted RCs when we applied a filter. This finding is not compatible with Mitchell's frequency theory.

#### **5.4 Discussions**

The goal of this chapter is to test whether there is a correlation between (1) structural frequencies in corpora and (2) behavioral measures such as reading times, which is the underlying assumption of a frequency-based canonical word order theory. In order for this theory to be correct, Chinese object-extracted RCs should be more frequent in the input than corresponding subject-extracted RCs. The reasoning is that because object-extracted RCs occur more often in Chinese, they are easier to process. However, a corpus analysis of the LDC UPenn Chinese Treebank 3.0 found overwhelming more instances of subject-extracted RCs (57.48% subject-extraction versus 42.52% object-extraction for all matching structures and 100% subject-extraction versus 0% object-extraction for filtered structures). This finding undermines the validity of Mitchell's frequency theory in explaining the difference between processing subject-extracted and object-extracted RCs in Chinese. The fact that subject-extracted RCs are harder to process is not explainable under this frequency-based theory, as they occur more frequently.

Resource-based theories, on the other hand, are consistent with the findings reported in Chapters 3 and 4 as well as the frequency data reported in this chapter.

## Chapter 6 Presence/Absence of Empty Relative Operator – Resumptive Pronouns

### 6.1 Aoun and Li to appear: A Recap

As discussed in Chapter 2, Aoun and Li to appear posit distinct syntactic representations and derivations of relative constructions in Chinese depending on whether the RCs contain resumptive pronouns or gaps. The reasoning is as follows: RCs containing gaps allow reconstruction and as such a head-raising analysis must be adopted. RCs containing resumptive pronouns, on the other hand, disallow reconstruction and thus an empty operator must be adopted. This empty operator is base-generated in [Spec, CP] and is co-indexed with the resumptive pronoun and the head noun. The head noun is also base-generated in the surface position. Consider (1) and (2) below.

(1) laoben xinren t<sub>i</sub> de gongchengshi, hen renzhen  
 boss trust engineer very hard  
 'The engineer who the boss trusts works very hard.'

(2) laboen xinren ta<sub>i</sub> de gongchengshi, hen renzhen  
 boss trust him engineer very hard  
 'The engineer who the boss trusts works very hard.'

(1) involves direct NP movement 'gongchengshi' to Head (no empty relative operator) whereas in (2), the Head is base-generated and there is an empty relative operator in [Spec, CP] that's co-indexed with 'ta.'

## 6.2 Introduction

Thus, according to Aoun and Li to appear, relative clauses containing resumptive pronouns have a base-generated empty operator in [Spec, CP]. Relative clauses containing simply gaps, i.e. no resumptive pronouns, on the other hand, do not have an empty operator. This is the analysis we have been assuming throughout this thesis. If their analyses of relative clauses are correct, we should be able to see differences in processing these two types of relative clauses. This is the purpose of the study we present in this chapter. It will be shown that the results from online reading experiments support their analyses to a certain degree.

## 6.3 Experiment

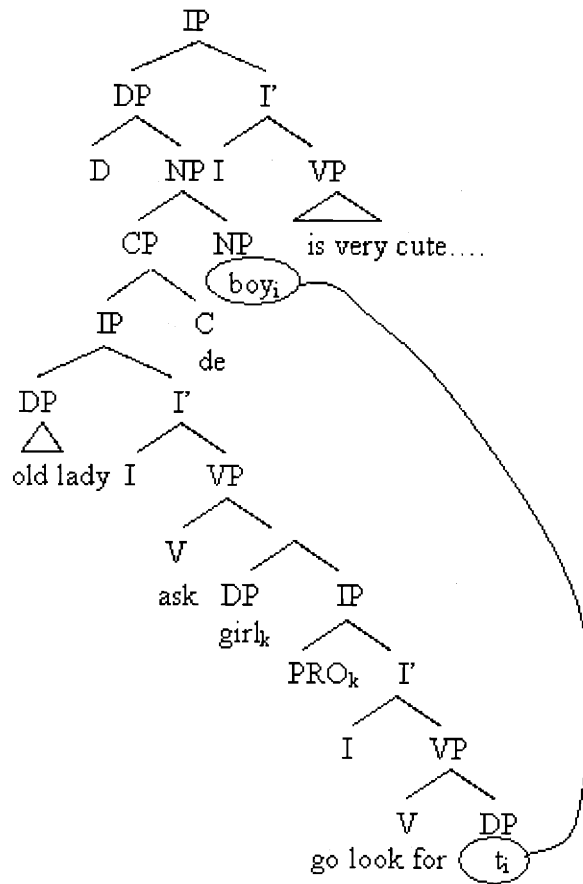
Two pairs of conditions were tested, as exemplified in (3) and (4) below (syntactic trees representing these sentences follow immediately).

(3)

a. RCs with gaps in the lower object position

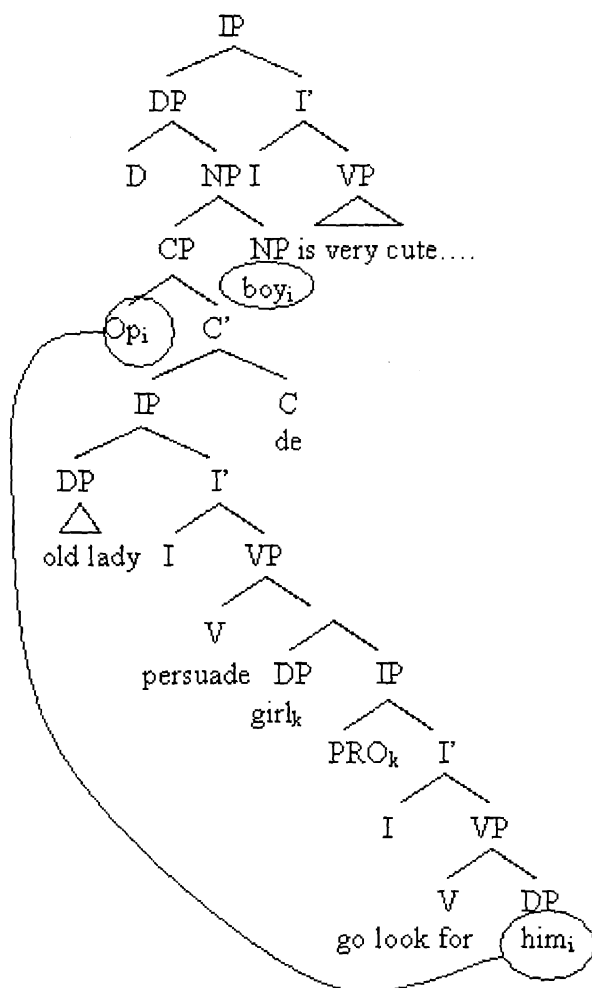
laotaitai yaoqiu nuhai chu chao  $t_i$  de nanhai, hen keai  
 old lady ask girl go look for de boy very cute

'The boy who the old lady asked the girl to look for is very cute.'



- b. RCs with resumptive pronouns in the lower object position

laotaitai yaoqiu nuhai chu chao    **ta**<sub>i</sub> de nanhai, hen keai  
 old lady ask    girl    go look for him de boy    very cute  
 'The boy who the old lady asked the girl to look for is very cute.'



The difference between (3a) and (3b) is that in (3b), there is a resumptive pronoun in place of the gap. As the writing system distinguishes male from female third person singular pronouns, we made sure the third noun phrase, e.g. 'boy', always had a different gender from the previous two noun phrases, e.g. 'old lady' and 'girl.' That way, when the pronoun is encountered, we can be sure that the participants will not interpret the pronoun to mean either of the two previous noun phrases.

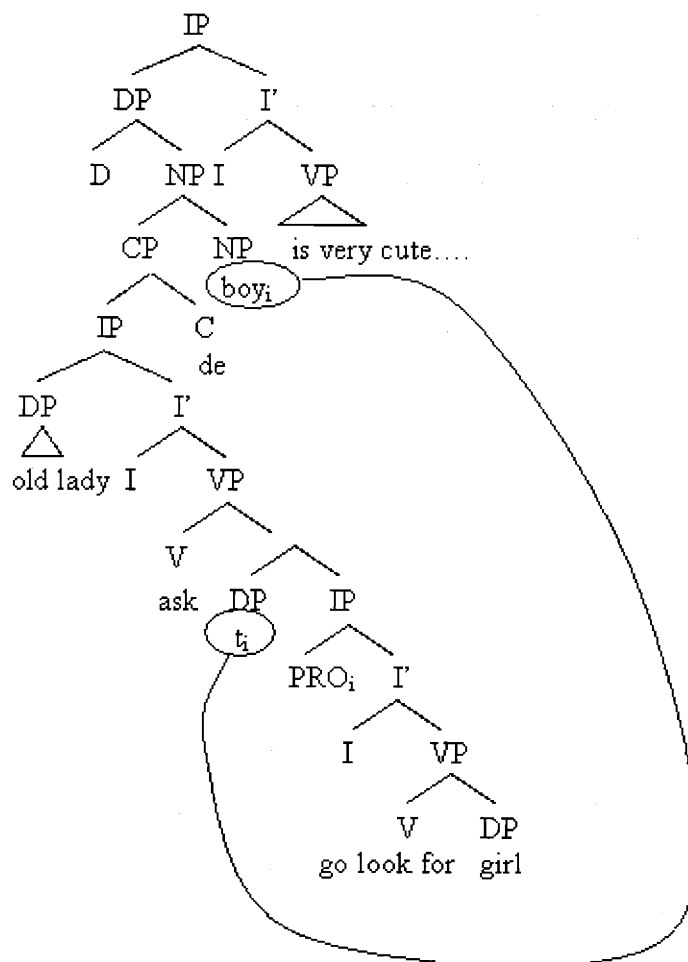
Note also that the empty operator occurs on the left hand side in the tree diagram above, i.e. we are assuming that [Spec, CP] position is on the left, as it is in English. Given that topicalization (an A-bar movement to [Spec, CP]) is leftward in Chinese, it is reasonable to assume that [Spec, CP] is on the left. If the empty operator is indeed on the left, we expect additional processing costs in RCs with resumptive pronouns but not in RCs with gaps due to the extra resources needed to link the empty operator with the resumptive pronoun as well as with the head noun. However, it is conceptually possible that this is not the case and that the specifier actually occurs on the right. If the empty operator is on the right, on the other hand, integrations will be extremely local (i.e. the only intervening material between the resumptive pronoun and the empty operator is the functional word *de* and there is no intervening material between the empty operator and the head noun) and the difference in processing RCs with or without resumptive pronouns might be minimal.

(4)

- a. RCs with gaps in the higher object position

laotaitai yaoqiu t<sub>i</sub> chu chao nuhai de nanhai, hen keai  
 old lady ask go look for girl de boy very cute

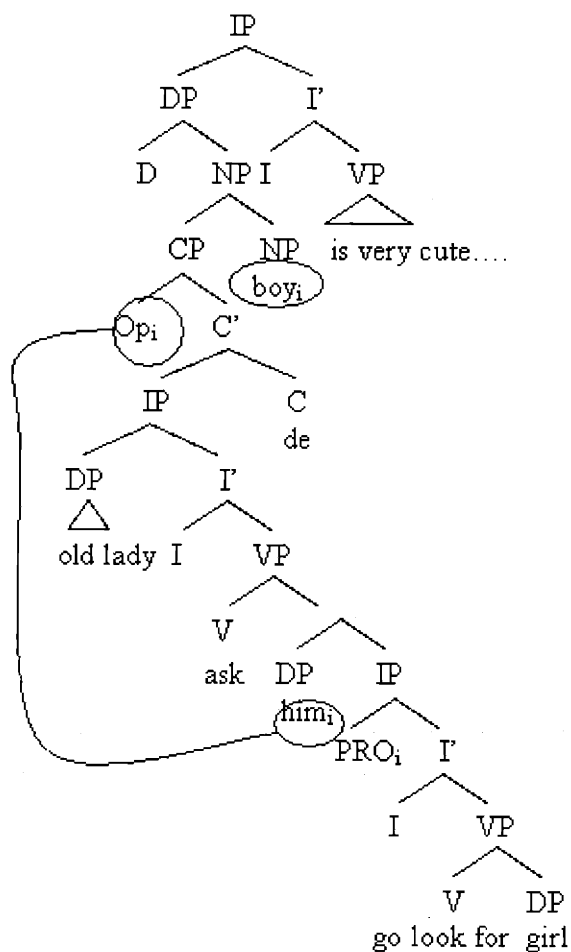
‘The boy who the old lady asked to look for the girl is very cute.’



- b. RCs with resumptive pronouns in the higher object position

laotaitai yaoqiu **ta**, chu chao nuhai de nanhai, hen keai  
 old lady ask him go look for girl de boy very cute  
 'The boy who the old lady asked to look for the girl is very cute.'





As mentioned in Chapter 2, resumptive pronouns in the subject position are generally considered unacceptable. We have thus included a control verb in this pair of conditions instead. In so doing, we can manipulate the higher object as some sort of a pseudo-subject so that we can contrast the distance in this pair of conditions with the ones in (3).

In both of the condition pairs, because the sentences are presented in a null context and the resumptive pronoun has a different gender than its two preceding noun phrases, the referent for the resumptive pronoun is restricted to

be the head noun. However, it would be interesting to include a condition in which the resumptive pronoun has a referent already present in the discourse, e.g. in a preceding sentence that serves as context information. An example for such a condition would be: “The little boy<sub>i</sub> did not come to school today. The old lady persuaded the girl to go look for him<sub>i</sub>.” This would show how pronouns are processed in general.

### 6.3.1 Theoretical Predictions

Since we have seen from the online reading studies in Chapters 3 – 4 and the corpus analysis in Chapter 5 that resource-based theories are the only theories compatible with data from Chinese, in this chapter we limit our discussion to this type of theory only. As we can see from the tree diagrams above, relative clauses containing resumptive pronouns in the lower object position, e.g. (3b), are predicted to be harder to process due to the additional resources needed to link the empty operator with the resumptive pronoun and also to somehow link this relationship with the head noun (more discussions on this issue to follow). Relative clauses containing the gaps, on the other hand, should be easier to process, as the only intervening material between the trace and its head noun is the function word *de*. In addition, there is no empty operator in this structure that needs to be related to the gap and the head noun. PRO is present in both conditions so should not incur additional resources in either case.

Similarly, (4b) is predicted to be harder to process due to the empty operator. Here, however, the differences between the two conditions might not be as big, as the distance between the gap and the head noun in (4a) crosses more lexical categories, i.e. ‘go look for girl.’

## **6.4 Method**

### **6.4.1 Participants**

Forty subjects participated in this experiment. Their average age was 36. All are native speakers of Mandarin Chinese. The subjects reside in Taiwan and use Chinese exclusively. They were naïve as to the purposes of the study.

### **6.4.2 Materials**

Twenty-four sets of sentences were constructed, each with the four conditions in (3) and (4). The sentences were typed in Chinese characters. The target sentences were split into four lists balancing all factors in a Latin-Square design. Each list was combined with seventy-two fillers of various types. Appendix C provides a complete list of the stimuli. The stimuli were pseudo-randomized separately for each participant so that at least one filler item intervened between two targets.

### **6.4.3 Procedure**

The procedure was the same as the one used in the online reading experiments reported in Chapters 3 and 4.

## **6.5 Plausibility Norming Survey**

A questionnaire was conducted in order to control for potential plausibility differences between the two condition pairs. Forty native Chinese-speaking participants residing in Taiwan who did not take part in the self-paced reading experiment completed the survey. The items tested in this questionnaire consisted of the two events described in the two condition pairs. Notice that the two conditions in (3) describe the same event, the only difference being the presence of a gap or a resumptive pronoun. Likewise, the two conditions in (4)

describe the same event as well. An example for the conditions in (3) and (4) in the questionnaire is given in (5) below.

(5)

- a. The old lady asked the girl to go look for the boy.
- b. The old lady asked the boy to go look for the girl.

Participants rated the plausibility of these sentences on a scale of 1 (natural) to 7 (unnatural). They were asked to judge the naturalness in the real world of the events described in the sentences, that is, how likely they were to occur.

The results of the survey showed that all the experimental items were well-designed in terms of plausibility. All twenty-four items were matched for plausibility across all versions (means: 2.90 for (5a) and 3.24 for (5b)). The plausibility ratings for each item are presented along with the items in Appendix C.

## 6.6 Results

The results were analyzed using Lingalyzer 1.11 written by Doug Rohde. Two participants' data were omitted from the analyses because of poor comprehension question performance (< 67% accuracy overall). Overall accuracy for the remaining thirty-eight participants had a mean of 93.6%.

### 6.6.1 Comprehension Question Performance

The percentages of correct answers for each condition are presented in Tables 10 and 11 below. Although comprehension question performance was numerically better in the lower gap sentences than in the lower resumptive sentences, the difference did not reach significance ( $F_1(1, 37) = 3.61, p = 0.07$ ;  $F_2(1, 19) =$

2.75,  $p = 0.11$ ). In the higher gap/resumptive sentences, on the other hand, we observe the opposite pattern, though the difference did not reach significance, either ( $F_s < 1$ ).

lower gap	lower resumptive
79.8 (2.7)	71.9 (3.0)

Table 10. Mean (standard error) comprehension question performance in percent correct by condition lower gap/resumptive pronoun.

higher gap	higher resumptive
60.5 (3.2)	62.7 (3.2)

Table 11. Mean (standard error) comprehension question performance in percent correct by condition higher gap/resumptive pronoun.

The mean comprehension question performances were too low, i.e. close to chance level, for the higher gap/resumptive sentences. I conducted an informal survey on the grammaticality of these sentences and people in general found it more difficult to understand this type of sentences. We suspect that this is related to the unacceptability of resumptive pronouns in the subject position. This might have contributed to the low comprehension question performances. We thus leave out this condition pair in the discussion, as the low comprehension question performances makes it hard to interpret the results.

### 6.6.2 Reading Times

Figure 10 plots mean RTs per word for the lower gap/resumptive conditions. We leave the higher gap/resumptive conditions out of the discussion due to the low comprehension performance, as mentioned earlier.

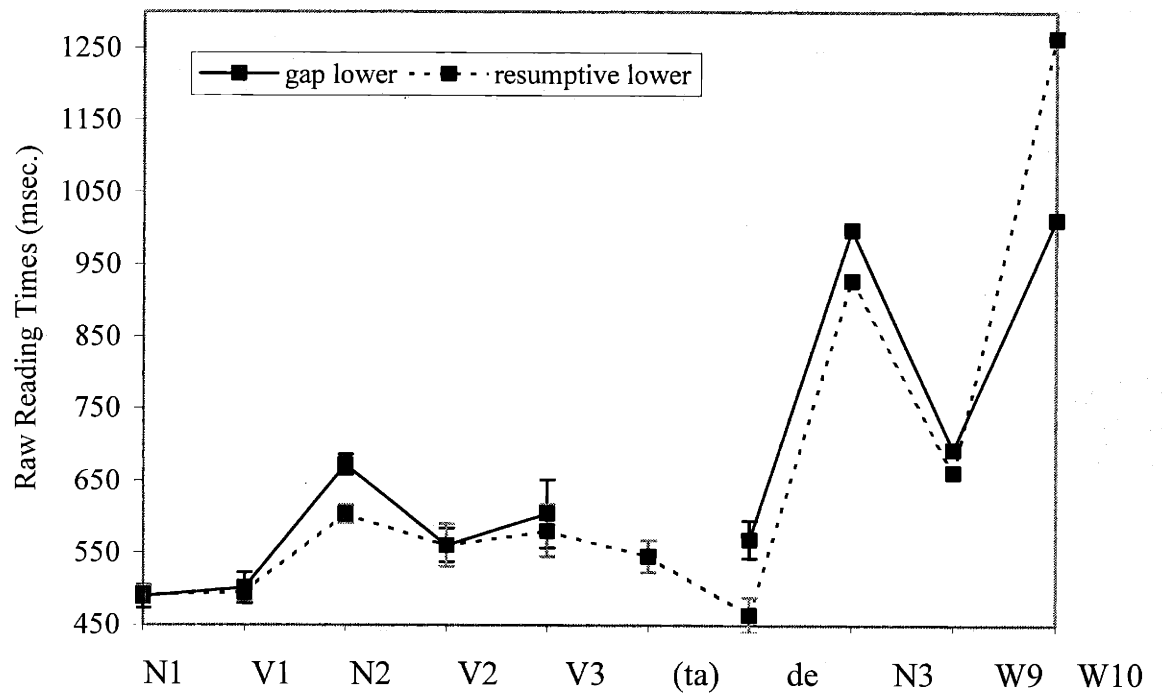


Figure 10. Plot of mean (standard error) raw reading times per word by region (lower gap/resumptive pronoun)

An ANOVA for the first five words revealed no significant effects ( $F_s < 1.4$ ), as these words were identical (the difference at the third word was not significant, i.e.  $F_s < 3.2$ ).

ANOVA at the seventh word *de* revealed significant effects ( $F_1(1, 37) = 12.0, p < 0.001$ ;  $F_2(1, 19) = 15.1, p < 0.001$ ). Here, the sentences containing gaps in the lower object position were processed slower because when *de* was encountered, there was still an object missing. On the other hand, sentences containing resumptive pronouns were complete in the sense that there was a lexical object *ta*. It was not clear, however, at this point what the reference for *ta* was – it could be the head noun of the RC or something else.

For the next two words, the differences did not reach significance ( $F_s < 1.0$  at the eighth word and  $F_s < 1.1$  at the ninth word).

At the end of the sentence, the sentences that contained resumptive pronouns had significantly slower reading times ( $F_1(1, 37) = 5.8, p < 0.05$ ;  $F_2(1, 19) = 4.7, p < 0.05$ ). This is consistent with the results from comprehension question performances, where questions regarding lower resumptive sentences were harder to answer. This finding is consistent with Aoun and Li's theory about RCs. Processing difficulty associated with RCs containing resumptive pronouns most likely comes from integration costs, as the linking between the empty operator, the head noun and the resumptive pronoun needs to take place after the head noun is encountered.

## 6.7 Discussion

Even though data from Chinese relative clause processing support Aoun and Li's theory in general, the evidence is not very convincing in the case of higher gap/resumptive conditions due to the low comprehension question performance. In the case of lower gap/resumptive conditions, results from both online and

offline data support Aoun and Li's theory, namely that RCs containing resumptive pronouns are harder to process than RCs containing gaps. This finding suggests that the empty operator is more likely to be on the left, as the difference in processing these two types of sentences is significant. Resource-based theories attribute this difference to additional integration costs associated with linking the empty operator to the head noun and the resumptive pronoun.

A further step then is to figure out how the empty operator is to be related to the resumptive pronoun and the head noun. There are two components: pronominal integration (i.e. the reference of the resumptive pronoun needs to be established) and syntactic integration (i.e. the empty operator needs to be posited and linked to both the resumptive pronoun and the head noun). However, the empty operator can only be posited after the RC marker *de* is encountered. Consider the sentence in (3b). The IP 'The old lady persuaded the girl to go look for him' is a complete sentence. Participants can realize that this is part of an RC when *de* is encountered. At this point, there was no valid referent for the pronoun 'him' because either 'the old lady' or 'the girl' would require a female pronoun and there was no other referent in the discourse, given that this sentence was presented to them in a null context. Consequently, they needed to posit an empty operator in [Spec, CP], which has the same index as the pronoun 'him.' Both the empty operator and the pronoun needed to be kept active, as their reference could not be determined at this point. As soon as the head noun 'boy' was encountered, it was linked to the empty operator. The reference of the pronoun 'him' was also established through co-indexation with the empty operator. Thus, in processing RCs with resumptive pronouns, in addition to the integration costs associated with linking the empty operator to the head noun and the resumptive pronoun, there is also some additional storage cost necessary to keep the empty operator and the resumptive pronoun active in memory.



The processing results reported in this chapter are compatible with Aoun and Li's analysis of Chinese RCs, namely that RCs containing resumptive pronouns are harder to process because they involve a more complex syntactic derivation which requires an empty operator mediating between the head noun and the resumptive pronoun. Such an empty operator is not present in RCs containing gaps. Processing the empty operator incurs additional integration and storage costs.

## Chapter 7 Discussions and Conclusions

This thesis examines the syntax and processing of relative clauses in Mandarin Chinese and explores interaction between the two areas.

Three online reading experiments were conducted with the goals of filling in the gap in the sentence processing literature on Chinese sentence processing and to provide a better understanding of processing RCs across languages, as Chinese RCs possess special properties, i.e. they are prenominal even though Chinese is an SVO language like English and French, which have been studied extensively. The first online reading experiment as documented in Chapter 3 shows that in unambiguous sentential subject position, subject-extracted RCs are more difficult to process than object-extracted RCs in Mandarin Chinese, i.e. lower comprehension question performance and slower reading times in RCs. This is contrary to the findings reported for other SVO languages. In these languages, object-extractions have been reported to be more difficult to process. Furthermore, theories based on accessibility of syntactic positions (Keenan and Comrie 1977, Keenan and Hawkins 1987, Dowty 1991) or perspective shift (MacWhinney 1977, 1982, MacWhinney and Pleh 1988, Bever 1970), which are compatible with findings from other SVO languages, are shown to be incompatible with data from Chinese. On the other hand, resource-based theories and canonical/non-canonical (frequency) word order theories can successfully account for data from Chinese in addition to that from other SVO languages. Thus, studies on Chinese RCs help evaluate processing theories and their ability to account for data in a broader context.

The second online reading experiment as documented in Chapter 4 explores syntactic ambiguity resolution in Mandarin Chinese, in particular, how syntactic information (garden path) and plausibility information influence processing. It is

shown that with the second group of participants subject-extracted RCs in object position are harder to process throughout despite temporary ambiguity in the case of object-extracted RCs in object position. It is also shown that even though plausibility information was manipulated to help resolve ambiguity, participants still initially posited the garden path. This is compatible with results reported in Grodner, Gibson and Tunstall 2002 where the correct analysis is much more costly than the garden path analysis.

In Chapter 5, a corpus analysis of the UPenn Chinese Treebank 3.0 was conducted to test the predictions of frequency-based theories (one version of the canonical/non-canonical word order theories, Mitchell et al. 1995, Gibson and Schütze 1999, Gibson, Schütze and Solomon 1996, Desmet and Gibson in press). Under these theories, people have less difficulty with word orders that they encounter more frequently, namely, the canonical word orders. As Chinese subject-extracted RCs have a non-canonical word order, given that they are harder to process, frequency-based theories would predict that they occur less frequently in the corpus than object-extracted RCs. However, the corpus study shows that these predictions are not borne out, namely that there are more instances of subject-extracted RCs than object-extracted RCs in the corpus. Thus, there is no correlation between structural frequencies in corpora and behavioral measures such as reading times, as predicted by frequency theories.

The third online processing experiment as documented in Chapter 6 tests predictions of Aoun and Li's syntactic theory of Chinese relative clauses. Under their analysis, RCs containing gaps are derived by head-raising and there is no empty operator mediating between the head noun and the gap. On the other hand, RCs containing resumptive pronouns require the presence of an empty operator. Thus, RCs containing resumptive pronouns are predicted to be harder

to process due to the additional resources needed to link the empty pronoun with the resumptive pronoun and also with the head noun. Data from the online reading experiment is compatible with their analysis: RCs containing resumptive pronouns are harder to process, i.e. lower comprehension question performance and slower reading times at the end of sentences. This kind of discovery is meaningful because we are able to test if a syntactic theory makes correct predictions outside the domain of standard syntactic evidence.

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## Appendix A

### Experimental Items

1.
  - a. 助教質疑的學生很不高興所以四處投訴 (2.18)  
 zhujiao zhiyi e<sub>i</sub> de xuesheng<sub>i</sub> hen bugaoxing suoyi sichu tousu  
 TA question student very unhappy thus everywhere complain  
 ‘The student who the TA has doubts about is very unhappy and thus complains to everyone.’
  - b. 質疑助教的學生很不高興所以四處投訴 (2.61)  
 e<sub>i</sub> zhiyi zhujiao de xuesheng<sub>i</sub> hen bugaoxing suoyi sichu tousu  
 question TA student very unhappy thus everywhere complain  
 ‘The student who has doubts about the TA is very unhappy and thus complains to everyone.’
  - c. 助教質疑的教授輔導的學生很不高興 (3.39) (1.79)  
 zhujiao zhiyi e<sub>i</sub> de jiaoshou<sub>i</sub> fudao e<sub>k</sub> de xuesheng<sub>k</sub> hen bugaoxing  
 TA question professor advise student very unhappy  
 ‘The student who the professor who the TA has doubts about advises is very unhappy.’
  - d. 質疑輔導助教的教授的學生很不高興 (2.58) (2.18)  
 e<sub>i</sub> zhiyi e<sub>k</sub> fudao zhujiao de jiaoshou<sub>k</sub> de xuesheng<sub>i</sub> hen bugaoxing  
 question advise TA professor student very unhappy  
 ‘The student who has doubts about the professor who advises the TA is very unhappy.’
2.
  - a. 老闆信任的工程師工作很認真效率又高 (2.09)  
 laoben xinren e<sub>i</sub> de gongchengshi<sub>i</sub> gongzuo hen renzhen xiaolu you gao  
 boss trust engineer work very hard efficiency also high  
 ‘The engineer who the boss trusts works very hard and is also very efficient.’
  - b. 信任老闆的工程師工作很認真效率又高 (2.45)  
 e<sub>i</sub> xinren laoben de gongchengshi<sub>i</sub> gongzuo hen renzhen xiaolu you gao  
 trust boss engineer work very hard efficiency also high  
 ‘The engineer who trusts the boss works very hard and is also very efficient.’
  - c. 老闆信任的秘書喜歡的工程師工作很認真 (2.12) (2.64)  
 laoben xinren e<sub>i</sub> de mishu<sub>i</sub> xihuan e<sub>k</sub> de gongchengshi<sub>k</sub> gongzuo hen renzhen  
 boss trust secretary like engineer work very hard  
 ‘The engineer who the secretary who the boss trusts likes works very hard.’
  - d. 信任喜歡秘書的老闆的工程師工作很認真 (2.45) (2.33)  
 e<sub>i</sub> xinren e<sub>k</sub> xihuan mishu de laoben<sub>k</sub> de gongchengshi<sub>i</sub> gongzuo hen renzhen  
 trust like secretary boss engineer work very hard  
 ‘The engineer who trusts the boss who likes the secretary works very hard.’
3.
  - a. 教授認識的作家很有名著作也很多 (2.24)

jiaoshou renshi e<sub>i</sub> de zuojia<sub>i</sub> henyoming zhuzuo ye henduo  
 professor know writer very famous works also very many  
 ‘The writer who the professor knows is very famous and has written many works  
 (books).’

b. 認識教授的作家很有名著作也很多 (2.12)

e<sub>i</sub> renshi jiaoshou de zuojia<sub>i</sub> henyoming zhuzuo ye henduo  
 know professor writer very famous works also very many  
 ‘The writer who knows the professor is very famous and has written many works  
 (books).’

c. 教授認識的記者訪問的作家很有名 (2.76) (1.70)

jiaoshou renshi e<sub>i</sub> de jizhe<sub>i</sub> fangwen e<sub>k</sub> de zuojia<sub>k</sub> henyoming  
 professor know reporter interview writer very famous  
 ‘The writer who the reporter who the professor knows interviewed is very famous.’

d. 認識訪問教授的記者的作家很有名 (2.39) (2.12)

e<sub>i</sub> renshi e<sub>k</sub> fangwen jiaoshou de jizhe<sub>k</sub> de zuojia<sub>i</sub> henyoming  
 know interview professor reporter writer very famous  
 ‘The writer who knows the reporter who interviewed the professor is very famous.’

4.

a. 聲樂家讚美的指揮家很有天份但是也很驕傲 (2.06)

hengyuejia zanmei e<sub>i</sub> de zhihuejia<sub>i</sub> hen you tienfen danshi ye hen jiaobao  
 opera singer praise conductor very have talents but also very prideful  
 ‘The conductor who the opera singer praised is very talented but is also very prideful.’

b. 讚美聲樂家的指揮家很有天份但是也很驕傲 (2.03)

e<sub>i</sub> zanmei shengyuejia de zhihuejia<sub>i</sub> hen you tienfen danshi ye hen jiaobao  
 praise opera singer conductor very have talents but also very prideful  
 ‘The conductor who praised the opera singer is very talented but is also very prideful.’

c. 聲樂家讚美的作曲家推薦的指揮家很有天份 (1.79) (2.39)

shengyuejia zanmei e<sub>i</sub> de zuoqujia<sub>i</sub> tuijian e<sub>k</sub> de zhihuejia<sub>k</sub> hen you tienfen  
 opera singer praise composer recommend conductor very have talents  
 ‘The conductor who the composer who the opera singer praised recommended is very  
 talented.’

d. 讚美推薦作曲家的聲樂家的指揮家很有天份 (2.03) (2.15)

e<sub>i</sub> zanmei e<sub>k</sub> tuijian zuoqujia de shengyuejia<sub>k</sub> de zhihuejia<sub>i</sub> hen you tienfen  
 praise recommend composer opera singer conductor very have talents  
 ‘The conductor who praised the opera singer who recommended the composer is very  
 talented.’

5.

a. 店員不喜歡的經理站在門口招攬生意 (2.03)

dianyuan buxihuan e<sub>i</sub> de jingli<sub>i</sub> zhan zai dianmenkou zhaolan shengyi  
 clerk dislike manager stand store entrance try to attract business  
 ‘The manager who the clerk dislikes is standing by the store entrance.’

- b. 不喜歡店員的經理站在門口招攬生意 (2.33)  
 e<sub>i</sub> buxihuan dianyuan de jingli<sub>i</sub> zhan zai dianmenkou zhaolan shengyi  
 dislike clerk manager stand store entrance try to attract business  
 ‘The manager who dislikes the clerk is standing by the store entrance.’
- c. 店員不喜歡的顧客認識的經理站在門口 (2.55) (2.15)  
 dianyuan buxihuan e<sub>i</sub> de guke<sub>i</sub> renshi e<sub>k</sub> de jingli<sub>k</sub> zhan zai dianmenkou  
 clerk dislike customer know manager stand store entrance  
 ‘The manager who the customer who the clerk dislikes knows is standing by the store entrance.’
- d. 不喜歡認識顧客的店員的經理站在門口 (2.33) (2)  
 e<sub>i</sub> buxihuan e<sub>k</sub> renshi guke de dianyuan<sub>k</sub> de jingli<sub>i</sub> zhan zai dianmenkou  
 dislike know customer clerk manager stand store entrance  
 ‘The manager who dislikes the clerk who knows the customer is standing by the store entrance.’
- 6.
- a. 市長打擾的議員整天講電話因為事情多 (2.61)  
 shichang daorao e<sub>i</sub> de yiyuan<sub>i</sub> zhengtian jiang dianhua yinwei shiching duo  
 mayor disturb senator talk on the phone all day because things many  
 ‘The senator who the mayor disturbed talks on the phone all day because there are many things to do.’
- b. 打擾市長的議員整天講電話因為事情多 (2.06)  
 e<sub>i</sub> daorao shichang de yiyuan<sub>i</sub> zhengtian jiang dianhua yinwei shiching duo  
 disturb mayor senator talk on the phone all day because things many  
 ‘The senator who disturbed the mayor talks on the phone all day because there are many things to do.’
- c. 市長打擾的律師辯護的議員整天講電話 (2.91) (2.21)  
 shichang daorao e<sub>i</sub> de lushi<sub>i</sub> bianhu e<sub>k</sub> de yiyuan<sub>k</sub> zhengtian jiang dianhua  
 mayor disturb lawyer defend senator talk on the phone all day  
 ‘The senator who the lawyer who the mayor disturbed defends talks on the phone all day.’
- d. 打擾辯護市長的律師的議員整天講電話 (2.70) (2.27)  
 e<sub>i</sub> daorao e<sub>k</sub> bianhu shichang de lyshi<sub>k</sub> yiyuan<sub>i</sub> zhengtian jiang dianhua  
 disturb defend mayor lawyer senator talk on the phone all day  
 ‘The senator who disturbed the lawyer who defends the mayor talks on the phone all day.’
- 7.
- a. 老太太遇見的女孩頭髮很長而且也長得很漂亮 (2.06)  
 laotaitai yujian e<sub>i</sub> de nuhai<sub>i</sub> toufa hen chang erqie ye chang de hen piaoliang  
 old lady meet girl hair very long and also look very beautiful  
 ‘The girl who the old lady met has very long hair and is also very beautiful.’
- b. 遇見老太太的女孩頭髮很長而且也長得很漂亮 (1.85)  
 e<sub>i</sub> yujian laotaitai de nuhai<sub>i</sub> toufa hen chang erqie ye chang de hen piaoliang



meet old lady girl hair very long and also look very beautiful  
 ‘The girl who met the old lady has very long hair and is also very beautiful.’

- c. 老太太遇見的送報童假裝沒看見的女孩頭髮很長 (2.09) (3.03)  
 laotaitai yujian e<sub>i</sub> de songbaotong<sub>i</sub> jiazhung meikanjian e<sub>k</sub> de nuhai<sub>k</sub> toufa hen chang  
 old lady meet newspaper boy pretend not to see girl hair very long  
 ‘The girl who the newspaper boy who the old lady met pretends not to see has very long hair.’
- d. 遇見假裝沒看見老太太的送報童的女孩頭髮很長 (2.55) (2.91)  
 e<sub>i</sub> yujian e<sub>k</sub> jiazhung meikanjian laotaitai de songbaotong<sub>k</sub> de nuhai<sub>i</sub> toufa hen chang  
 meet pretend not to see old lady newspaper boy girl hair very long  
 ‘The girl who met the newspaper boy who pretends not to see the old lady has very long hair.’

## 8.

- a. 歌手羨慕的演員想往其它方面發展可是沒機會 (2.21)  
 geshou xianmu e<sub>i</sub> de yanyuan<sub>i</sub> xiang wang quta fangmian fazhan keshi mei jihuei  
 singer envy actor want to explore other areas but no opportunity  
 ‘The actor who the singer envies wants to explore other areas but hasn’t had opportunities (to do so).’
- b. 羨慕歌手的演員想往其它方面發展可是沒機會 (2.30)  
 e<sub>i</sub> xianmu geshou de yanyuan<sub>i</sub> xiang wang quta fangmian fazhan keshi mei jihuei  
 envy singer actor want to explore other areas but no opportunity  
 ‘The actor who envies the singer wants to explore other areas but hasn’t had opportunities (to do so).’
- c. 歌手羨慕的導播提拔的演員想往其它方面發展 (2.45) (1.64)  
 geshou xianmu e<sub>i</sub> de daobo<sub>i</sub> tiba e<sub>k</sub> de yanyuan<sub>k</sub> xiang wang quta fangmian fazhan  
 singer envy producer promote actor want to explore other areas  
 ‘The actor who the producer who the singer envies promoted wants to explore other areas.’
- d. 羨慕提拔歌手的導播的演員想往其它方面發展 (2.18) (2.15)  
 e<sub>i</sub> xianmu e<sub>k</sub> tiba geshou de daobo<sub>k</sub> de yanyuan<sub>i</sub> xiang wang quta fangmian fazhan  
 envy promote singer producer actor want to explore other areas  
 ‘The actor who envies the producer who promoted the singer wants to explore other areas.’

## 9.

- a. 大伯拜訪的鄰居家境不好常需要朋友幫忙 (2.58)  
 dabo baifang e<sub>i</sub> de linju<sub>i</sub> jiajing bu hao chang xuiyao pengyou bangmang  
 uncle visit neighbor financially not in a good condition often need friend help  
 ‘The neighbor who (my) uncle visited is financially not in a good condition and often needs friends to help them.’
- b. 拜訪大伯的鄰居家境不好常需要朋友幫忙 (2.39)  
 e<sub>i</sub> baifang dabo de linju<sub>i</sub> jiajing bu hao chang xuiyao pengyou bangmang  
 visit uncle neighbor financially not in a good condition often need friend help

‘The neighbor who visited (my) uncle is financially not in a good condition and often needs friends to help them.’

- c. 大伯拜訪的老人家不理會的鄰居家境不好 (2.55) (3)  
 dabao baifang  $e_i$  de laorenchia bulihue  $e_k$  de linju $_k$  jiajing bu hao  
 uncle visit old person ignore neighbor financially not in a good condition  
 ‘The neighbor who the old person who (my) uncle visited ignores is financially not in a good condition.’
- d. 拜訪不理會大伯的老年人的鄰居家境不好 (2.55) (2.94)  
 $e_i$  baifang  $e_k$  bulihue dabao de laorenchia $_k$  de linju $_i$  jiajing bu hao  
 visit ignore uncle old person neighbor financially not in a good condition  
 ‘The neighbor who visited the old person who ignores (my) uncle is financially not in a good condition.’

10.

- a. 郵差撞到的送花童背著很多東西走路東倒西歪 (3.61)  
 youchai zhuangdao  $e_i$  de songhuationg $_i$  beizhe hen duo dongsi zoulu dongdaoxiwai  
 mailman collide into flower boy carry a lot of stuff walk not in a straight line  
 ‘The flower boy who the mailman collided into was carrying a lot of stuff and was not walking in a straight line.’
- b. 撞到郵差的送花童背著很多東西走路東倒西歪 (3.58)  
 $e_i$  zhuangdao youchai de songhuationg $_i$  beizhe hen duo dongsi zoulu dongdaoxiwai  
 collide into mailman flower boy carry a lot of stuff walk not in a straight line  
 ‘The flower boy who collided into the mail man was carrying a lot of stuff and was not walking in a straight line.’
- c. 郵差撞到的路人尋找的送花童背著很多東西 (3.21) (4.58)  
 youchai zhuangdao  $e_i$  de luren $_i$  xunchao  $e_k$  de songhuationg $_k$  beizhe hen duo dongsi  
 mailman collide into pedestrian look for flower boy carry a lot of stuff  
 ‘The flower boy who the pedestrian who the postman collided into was looking for was carrying a lot of stuff.’
- d. 撞到尋找郵差的路人的送花童背著很多東西 (3.15) (3.76)  
 $e_i$  zhuangdao  $e_k$  xunchao youchai de luren $_k$  de songhuationg $_i$  beizhe hen duo dongsi  
 collide into look for mailman pedestrian flower boy carry a lot of stuff  
 ‘The flower boy who collided into the pedestrian who was looking for the mail man was carrying a lot of stuff.’

11.

- a. 私家偵探跟蹤的警探想知道真相所以很積極 (3.33)  
 sijiazhentan genzong  $e_i$  de jingtan $_i$  xiang zhidao zhenxiang suoyi hen jijī  
 private detective follow detective want to know the truth thus very aggressive  
 ‘The police detective who the private detective followed wants to know the truth and is thus very aggressive.’
- b. 跟蹤私家偵探的警探想知道真相所以很積極 (3)  
 $e_i$  genzong sijiazhentan de jingtan $_i$  xiang zhidao zhenxiang suoyi hen jijī

follow private detective detective want to know the truth thus very aggressive  
 ‘The police detective who followed the private detective wants to know the truth and is thus very aggressive.’

- c. 私家偵探跟蹤的線民畏懼的警探想知道真相 (2.48) (2.64)  
 sijiazhentan genzong e<sub>i</sub> de xianmin<sub>i</sub> weiju e<sub>k</sub> de jingtān<sub>k</sub> xiang zhidao zhenxiang  
 private detective follow informer fear detective want to know the truth  
 ‘The police detective who the informer who the private detector followed feared wants to know the truth.’
- d. 跟蹤畏懼私家偵探的線民的警探想知道真相 (2.18) (3.06)  
 e<sub>i</sub> genzong e<sub>k</sub> weiju sijiazhentan de xianmin<sub>k</sub> de jingtān<sub>i</sub> xiang zhidao zhenxiang  
 follow fear private detective informer detective want to know the truth  
 ‘The police detective who followed the informer who fears the private detective wants to know the truth.’

12.

- a. 小丑模仿的喜劇演員很受群眾歡迎常被要求簽名 (2.03)  
 xiaochou mofang e<sub>i</sub> de xijuyanyuan<sub>i</sub> hen shou qunchong huanying chang bei yaoqiu qianming  
 clown imitate comedian be very popular with the public often passive ask autograph  
 ‘The comedian who the clown imitates is very popular with the public and is often asked to autograph.’
- b. 模仿小丑的喜劇演員很受群眾歡迎常被要求簽名 (2.06)  
 e<sub>i</sub> mofang xiaochou de xijuyanyuan<sub>i</sub> hen shou qunchong huanying chang bei yaoqiu qianming  
 imitate clown comedian be very popular with the public often passive ask autograph  
 ‘The comedian who imitates the clown is very popular with the public and is often asked to autograph.’
- c. 小丑模仿的政治家不欣賞的喜劇演員很受群眾歡迎 (2.18) (2.76)  
 xiaochou mofang e<sub>i</sub> de chengchijia<sub>i</sub> buxinshang e<sub>k</sub> de xijuyanyuan<sub>k</sub> hen shou qunchong huanying  
 clown imitate politician not like comedian be very popular with the public  
 ‘The comedian who the politician who the clown imitates does not like is very popular with the public.’
- d. 模仿不欣賞小丑的政治家的喜劇演員很受群眾歡迎 (1.58) (2.88)  
 e<sub>i</sub> mofang e<sub>k</sub> buxinshang xiaochou de chengchijia<sub>k</sub> de xijuyanyuan<sub>i</sub> hen shou qunchong huanying  
 imitate not like clown politician comedian be very popular with the public  
 ‘The comedian who imitates the politician who does not like the clown is very popular with the public.’

13.

- a. 鋼琴師很受不了的小提琴家脾氣不好對人大吼大叫 (3.64)  
 gangchinshi hen shoubuliao e<sub>i</sub> de xiaotichinjia<sub>i</sub> pichi buhao duiren dahodajia  
 pianist cannot stand violinist have a bad temper to people yell loudly  
 ‘The violinist who the pianist cannot stand has a bad temper and yells loudly at people.’
- b. 很受不了鋼琴師的小提琴家脾氣不好對人大吼大叫 (3.70)  
 e<sub>i</sub> hen shoubuliao gangchinshi de xiaotichinjia<sub>i</sub> pichi buhao duiren dahodajia  
 cannot stand pianist violinist have a bad temper to people yell loudly  
 ‘The violinist who cannot stand the pianist has a bad temper and yells loudly at people.’
- c. 鋼琴師很受不了的小喇叭手追求的小提琴家脾氣不好 (3.24) (2.85)  
 gangchinshi hen shoubuliao e<sub>i</sub> de xiaolabashou<sub>i</sub> zhuiqui e<sub>k</sub> de xiaotichinjia<sub>k</sub> pichi buhao  
 pianist cannot stand trumpeter court violinist have a bad  
 temper  
 ‘The violinist who the trumpeter who the pianist cannot stand is courting has a bad  
 temper.’
- d. 很受不了追求鋼琴師的小喇叭手的小提琴家脾氣不好 (3.33) (2.82)  
 e<sub>i</sub> hen shoubuliao e<sub>k</sub> zhuiqui gangchinshi de xiaolabashou<sub>k</sub> de xiaotichinjia<sub>i</sub> pichi buhao  
 cannot stand court pianist trumpeter violinist have a bad  
 temper  
 ‘The violinist who cannot stand the trumpeter who is courting the pianist has a bad  
 temper.’
- 14.
- a. 屠夫瞧不起的清潔工衣服總是很髒身上也有股怪味道 (3.70)  
 tufu chiabuchi e<sub>i</sub> de chingjiegong<sub>i</sub> yifu zongshi hen zang shenshang ye you gu guaiweidao  
 butcher despise cleaning person clothes always very dirty have also smell funny  
 ‘The cleaning person who the butcher despises, his clothes are always very dirty and he  
 also smells funny.’
- b. 瞧不起屠夫的清潔工衣服總是很髒身上也有股怪味道 (3.76)  
 e<sub>i</sub> chiabuchi tufu de chingjiegong<sub>i</sub> yifu zongshi hen zang shenshang ye you gu guaiweidao  
 despise butcher cleaning person clothes always very dirty have also smell funny  
 ‘The cleaning person who despises the butcher, his clothes are always very dirty and he  
 also smells funny.’
- c. 屠夫瞧不起的搬運工人討厭的清潔工衣服總是很髒 (3.73) (3.91)  
 tufu chiabuchi e<sub>i</sub> de banyungongren<sub>i</sub> tauyen e<sub>k</sub> de chingjiegong<sub>k</sub> yifu zongshi hen zang  
 butcher despise mover detest cleaning person clothes always very  
 dirty  
 ‘The cleaning person who the mover who the butcher despises, his clothes are always  
 very dirty.’
- d. 瞧不起討厭搬運工人的屠夫的清潔工衣服總是很髒 (3.76) (3.85)  
 e<sub>i</sub> chiabuchi e<sub>k</sub> tauyen banyungongren de tufu<sub>k</sub> de chingjiegong<sub>i</sub> yifu zongshi hen zang  
 despise detest mover butcher cleaning person clothes always very  
 dirty

‘The cleaning person who despises the butcher who detests the mover, his clothes are always very dirty.’

15.

- a. 明星愛上的詩人充滿不切實際的幻想整天做白日夢 (2.73)  
 mingshing aishang  $e_i$  de shiren $_i$  chongman buqieshiji de huanshiang zhangtian zuo bairimong  
 superstar fall in love with poet have unrealistic expectations all day daydream  
 ‘The poet who the superstar fell in love with has unrealistic expectations and daydreams all the time.’
- b. 愛上明星的詩人充滿不切實際的幻想整天做白日夢 (2.58)  
 $e_i$  aishang mingshing de shiren $_i$  chongman buqieshiji de huanshiang zhangtian zuo bairimong  
 fall in love with superstar poet have unrealistic expectations all day daydream  
 ‘The poet who fell in love with the superstar has unrealistic expectations and daydreams all the time.’
- c. 明星愛上的模特兒崇拜的詩人充滿不切實際的幻想 (2.18) (2.88)  
 mingshing aishang  $e_i$  de moteer $_i$  chongbai  $e_k$  de shiren $_k$  chongman buqieshiji de huanshiang  
 superstar fall in love with model adore poet have unrealistic expectations  
 ‘The poet who the model who the superstar fell in love with adores has unrealistic expectations.’
- d. 愛上崇拜明星的模特兒的詩人充滿不切實際的幻想 (2.58) (2.24)  
 $e_i$  aishang  $e_k$  chongbai mingshing de moteer $_k$  de shiren $_i$  chongman buqieshiji de huanshiang  
 fall in love with adore superstar model poet have unrealistic expectations  
 ‘The poet who fell in love with the model who adores the superstar has unrealistic expectations.’

16.

- a. 寡婦嘲笑的老處女很想交男朋友整天要人幫她作媒 (3.48)  
 guafu chaoshiao  $e_i$  de laochunu $_i$  henshiang jiao nanopengyou zhengtian yaoren bang ta zuo mei  
 widow laugh at spinster desire to have a boyfriend all day want people help her match making  
 ‘The spinster who the widow laughs at desires to have a boyfriend and wants people to set her up with someone all the time.’
- b. 嘲笑寡婦的老處女很想交男朋友整天要人幫她作媒 (3.48)  
 $e_i$  chaoshiao guafu de laochunu $_i$  henshiang jiao nanopengyou zhengtian yaoren bang ta zuo mei  
 laugh at widow spinster desire to have a boyfriend all day want people help her match making  
 ‘The spinster who laughs at the widow desires to have a boyfriend and wants people to set her up with someone all the time.’
- c. 寡婦嘲笑的無賴喜歡調戲的老處女很想交男朋友 (3.24) (2.48)

guafu chaoshiao e<sub>i</sub> de wulai<sub>i</sub> xihuan tiaosi e<sub>k</sub> de laochunu<sub>k</sub> henshiang jiao nanpengyou  
 widow laugh at rotter like to flirt with spinster desire to have a boyfriend  
 ‘The spinster who the rotter who the widow laughs at likes to flirt with desires to have a boyfriend.’

- d. 嘲笑喜歡調戲寡婦的無賴的老處女很想交男朋友 (3.24) (2.42)

e<sub>i</sub> chaoshiao e<sub>k</sub> xihuan tiaosi guafu de wulai<sub>k</sub> de laochunu<sub>i</sub> henshiang jiao nanpengyou  
 laugh at like to flirt with widow rotter spinster desire to have a boyfriend  
 ‘The spinster who laughs at the rotter who likes to flirt with the widow desires to have a boyfriend.’

17.

- a. 流氓威脅的逃犯害怕被警察抓整天提心吊膽 (2.61)

liumang weixie e<sub>i</sub> de taufan<sub>i</sub> hai pa bei jingcha zhua zhengtian tishindiaodan  
 scamp threaten fugitive be scared of getting caught by the police all day worried  
 ‘The fugitive who the scamp threatened is scared of getting caught by the police and is worried all the time.’

- b. 威脅流氓的逃犯害怕被警察抓整天提心吊膽 (2.85)

e<sub>i</sub> weixie liumang de taufan<sub>i</sub> hai pa bei jingcha zhua zhengtian tishindiaodan  
 threaten scamp fugitive be scared of getting caught by the police all day worried  
 ‘The fugitive who threatened the scamp is scared of getting caught by the police and is worried all the time.’

- c. 流氓威脅的小偷陷害的逃犯害怕被警察抓 (2.55) (2.55)

liumang weixie e<sub>i</sub> de xiaotao<sub>i</sub> xienhai e<sub>k</sub> de taufan<sub>k</sub> hai pa bei jingcha zhua  
 scamp threaten thief plot against fugitive be scared of getting caught by the police  
 ‘The fugitive who the thief who the scamp threatened plotted against is scared of getting caught by the police.’

- d. 威脅陷害小偷的流氓的逃犯害怕被警察抓 (2.85) (2.55)

e<sub>i</sub> weixie e<sub>k</sub> xienhai xiaotao de liumang<sub>k</sub> de taufan<sub>i</sub> hai pa bei jingcha zhua  
 threaten plot against thief scamp fugitive be scared of getting caught by the police  
 ‘The fugitive who threatened the scamp who plotted against the thief is scared of getting caught by the police.’

18.

- a. 富豪邀請的官員心懷不軌但是善於隱藏 (1.48)

fuhao yaoqing e<sub>i</sub> de guanyuan<sub>i</sub> shinhuaibugui danshi shanyu yintsang  
 tycoon invite official have bad intentions but good at hiding  
 ‘The official who the tycoon invited has bad intentions but is good at hiding them.’

- b. 邀請富豪的官員心懷不軌但是善於隱藏 (1.76)

e<sub>i</sub> yaoqing fuhao de guanyuan<sub>i</sub> shinhuaibugui danshi shanyu yintsang  
 invite tycoon official have bad intentions but good at hiding  
 ‘The official who invited the tycoon has bad intentions but is good at hiding them.’

- c. 富豪邀請的法官勾結的官員心懷不軌 (1.91) (2.27)  
 fuhao yaoqing e<sub>i</sub> de faguan<sub>i</sub> gojie e<sub>k</sub> de guanyuan<sub>k</sub> shinhuaibugui  
 tycoon invite judge conspire official have bad intentions  
 ‘The official who the judge who the tycoon invited conspired with has bad intentions.’
- d. 邀請勾結法官的富豪的官員心懷不軌 (1.76) (2.06)  
 e<sub>i</sub> yaoqing e<sub>k</sub> gojie faguan de fuhao<sub>k</sub> de guanyuan<sub>i</sub> shinhuaibugui  
 invite conspire tycoon judge official have bad intentions  
 ‘The official who invited the tycoon who conspired with the judge has bad intentions.’

## 19.

- a. 居民協助的軍官受傷了被送往醫院 (1.97)  
 jumin xiechu e<sub>i</sub> de junguan<sub>i</sub> shoushang le bei song wang yiyuan  
 resident assist soldier get hurt perfe. passive send to hospital  
 ‘The soldier who the resident assisted got injured and was sent to the hospital.’
- b. 協助居民的軍官受傷了被送往醫院 (2.06)  
 e<sub>i</sub> xiechu jumin de junguan<sub>i</sub> shoushang le bei song wang yiyuan  
 assist resident soldier get hurt perfe. passive send to hospital  
 ‘The soldier who assisted the resident got injured and was sent to the hospital.’
- c. 居民協助的難民憎恨的軍官受傷了 (2.45) (3)  
 jumin xiechu e<sub>i</sub> de nanmin<sub>i</sub> zenghen e<sub>k</sub> de junguan<sub>k</sub> shoushang le  
 resident assist refugee hate soldier get hurt perf.  
 ‘The soldier who the refugee who the resident assisted hates got injured.’
- d. 協助憎恨難民的居民的軍官受傷了 (2.06) (2.97)  
 e<sub>i</sub> xiechu e<sub>k</sub> zenghen nanmin de jumin<sub>k</sub> de junguan<sub>i</sub> shoushang le  
 assist hate refugee resident soldier get hurt  
 ‘The soldier who assisted the resident who hates the refugee got injured.’

## 20.

- a. 司機報怨的乘客總是大聲喧嘩很令人受不了 (2.27)  
 siji baoyuan e<sub>i</sub> de chengke<sub>i</sub> zongshi daoshengxuanhua hen lingren shoubuliao  
 driver complain about passenger be always very loud very for people intolerable  
 ‘The passenger who the driver complained about is always very loud and people can’t stand it.’
- b. 報怨司機的乘客總是大聲喧嘩很令人受不了 (1.79)  
 e<sub>i</sub> baoyuan siji de chengke<sub>i</sub> zongshi daoshengxuanhua hen lingren shoubuliao  
 complain about driver passenger be always very loud very for people intolerable  
 ‘The passenger who complained about the driver is always very loud and people can’t stand it.’
- c. 司機報怨的收票員不理會的乘客總是大聲喧嘩 (2.64) (2.91)  
 siji baoyuan e<sub>i</sub> de shoupiaoyuan<sub>i</sub> bulihue e<sub>k</sub> de chengke<sub>k</sub> zongshi daoshengxuanhua  
 driver complain about ticket collector ignore passenger be always very loud  
 ‘The passenger who the ticket collector who the driver complained about ignored is always very loud.’

- d. 報怨不理會收票員的司機的乘客總是大聲喧嘩 (1.79) (3.24)  
e<sub>i</sub> baoyuan e<sub>k</sub> bulihue shoupiaoyuan de siji<sub>k</sub> de chengke<sub>i</sub> zongshi daoshengxuanhua  
complain about ignore ticket collector driver passenger be always very loud  
'The passenger who complained about the driver who ignored the ticket collector is  
always very loud.'



## Appendix B

### Experimental Items

# e2 1 a

助教質疑的學生支持教授

TA have doubts about de student support professor

"The student who the TA has doubts about supports the professor."

# e2 1 b

質疑助教的學生支持教授

have doubts about TA de student support professor

"The student who has doubts about the TA supports the professor."

# e2 1 c

教授支持助教質疑的學生

professor support TA have doubts about de student

"The professor supports the student who the TA has doubts about."

# e2 1 d

教授支持質疑助教的學生

professor support have doubts about TA de student

"The professor supports the student who has doubts about the TA."

# e2 1 e

校車接送的學生支持教授

school bus pick up de student support professor

"The student who the school bus picks up supports the professor."

# e2 1 f

教授支持校車接送的學生

professor support school bus pick up de student

"The professor supports the student who the school bus picks up."

# e2 2 a

老闆信任的工程師喜歡秘書

boss trust de engineer like secretary

"The engineer who the boss trusts likes the secretary."

# e2 2 b

信任老闆的工程師喜歡秘書

trust boss de engineer like secretary

"The engineer who trusts the boss likes the secretary."

# e2 2 c

秘書喜歡老闆信任的工程師

secretary like boss trust de engineer

"The secretary likes the engineer who the boss trusts."

# e2 2 d

秘書喜歡信任老闆的工程師

secretary like trust boss de engineer

"The secretary likes the engineer who trusts the boss."

# e2 2 e

石頭打到的工程師喜歡秘書

stone hit de engineer like secretary

"The engineer who the stone hit likes the secretary."

# e2 2 f

秘書喜歡石頭打到的工程師

secretary like stone hit de engineer

"The secretary likes the engineer who the stone hit."

# e2 3 a

教授認識的作家批評記者

professor know de writer criticize reporter

"The writer who the professor knows criticized the reporter."

# e2 3 b

認識教授的作家批評記者

know professor de writer criticize reporter

"The writer who knows the professor criticized the reporter."

# e2 3 c

記者批評教授認識的作家

reporter criticize professor know de writer

"The reporter criticized the writer who the professor knows."

# e2 3 d

記者批評認識教授的作家

reporter criticize know professor de writer

"The reporter criticized the writer who knows the professor."

# e2 3 c

新聞報導的作家批評記者

news report de writer criticize reporter

"The writer who was in the news criticized the reporter/who the news talked about."

# e2 3 f

記者批評新聞報導的作家

reporter criticize news report de writer

"The reporter criticized the writer who was in the news/who the news talked about."

# e2 4 a

聲樂家讚美的指揮家推薦作曲家

opera singer praise de conductor recommend composer

"The conductor who the opera singer praised recommended the composer."

# e2 4 b

讚美聲樂家的指揮家推薦作曲家

praise opera singer de conductor recommend composer

"The conductor who praised the opera singer recommended the composer."

# e2 4 c

作曲家推薦聲樂家讚美的指揮家

composer recommend opera singer praise de conductor

"The composer recommended the conductor who the opera singer praised."

# e2 4 d

作曲家推薦讚美聲樂家的指揮家

composer recommend praise opera singer de conductor

"The composer recommended the conductor who the opera singer praised."

# e2 4 e

畫像描繪的指揮家推薦作曲家

drawing sketch de conductor recommend composer

"The conductor who the drawing sketches recommended the composer."

# e2 4 f

作曲家推薦畫像描繪的指揮家

composer recommend drawing sketch de conductor

"The composer recommended the conductor who the drawing sketches."

# e2 5 a

店員不喜歡的經理認識顧客

clerk dislike de manager know customer

"The manager who the clerk dislikes knows the customer."

# e2 5 b

不喜歡店員的經理認識顧客

dislike clerk de manager know customer

"The manager who dislikes the clerk knows the customer."

# e2 5 c

顧客認識店員不喜歡的經理

customer know clerk dislike de manager

"The customer knows the manager who the clerk dislikes."

# e2 5 d

顧客認識不喜歡店員的經理

customer know dislike clerk de manager

"The customer knows the manager who dislikes the clerk."

# e2 5 e

廣告公司騷擾的經理認識顧客

ad/marketing company harass de manager know customer

"The manager who the marketing company harasses knows the customer."

# e2 5 f

顧客認識廣告公司騷擾的經理

customer know ad/marketing company harass de manager

"The customer knows the manager who the marketing company harasses."

# e2 6 a

市長打擾的議員拜訪律師

mayor bother de congressman visit lawyer

"The congressman who the mayor bothered visited the lawyer."

# e2 6 b

打擾市長的議員拜訪律師

bother mayor de congressman visit lawyer

"The congressman who bothered the mayor visited the lawyer."

# e2 6 c

律師拜訪市長打擾的議員

lawyer visit mayor bother de congressman

"The lawyer visited the congressman who the mayor bothered."

# e2 6 d

律師拜訪打擾市長的議員

lawyer visit bother mayor de congressman

"The lawyer visited the congressman who bothered the mayor."

# e2 6 e

民意調查支持的議員拜訪律師

poll support de congressman visit lawyer

"The congressman who the poll supported visited the lawyer."

# e2 6 f

律師拜訪民意調查支持的議員

lawyer visit poll support de congressman

"The lawyer visited the congressman who the poll supported."

# e2 7 a

老太太遇見的女孩纏著男孩

old lady meet de girl be attached to boy

"The girl who the old lady met is attached to the boy."

# e2 7 b

遇見老太太的女孩纏著男孩

meet old lady de girl be attached to boy

"The girl who met the old lady is attached to the boy."

# e2 7 c

男孩纏著老太太遇見的女孩

boy be attached to old lady meet de girl

"The boy is attached to the girl who the old lady met."

# e2 7 d

男孩纏著遇見老太太的女孩

boy be attached to meet old lady de girl

"The boy is attached to the girl who met the old lady."

# e2 7 e

飛盤打到的女孩纏著男孩

Frisbee hit de girl be attached to boy

"The girl who the Frisbee hit is attached to the boy."

# e2 7 f

男孩纏著飛盤打到的女孩

boy be attached to Frisbee hit de girl

"The boy is attached to the girl who the Frisbee hit."

# e2 8 a

歌手羨慕的演員巴結導播

singer envy de actor bribe director

"The actor who the singer envies bribed the director."

# e2 8 b

羨慕歌手的演員巴結導播

envy singer de actor bribe director

"The actor who envies the singer bribed the director."

# e2 8 c

導播巴結歌手羨慕的演員

director bribe singer envy de actor

"The director bribed the actor who the singer envies."

# e2 8 d

導播巴結羨慕歌手的演員

director bribe envy singer de actor

"The director bribed the actor who the singer envies."

# e2 8 e

雜誌攻擊的演員巴結導播

magazine attack de actor bribe director

"The actor who the magazine attacked bribed the director."

# e2 8 f

導播巴結雜誌攻擊的演員

director bribe magazine attack de actor

"The director bribed the actor who the magazine attacked."

# e2 9 a

大伯拜訪的鄰居取笑路人

uncle visit de neighbor laugh at pedestrian

"The neighbor who uncle visited laughed at the pedestrian."

# e2 9 b

拜訪大伯的鄰居取笑路人

visit uncle de neighbor laugh at pedestrian

"The neighbor who visited uncle laughed at the pedestrian."

# e2 9 c

路人取笑大伯拜訪的鄰居

pedestrian laugh at uncle visit de neighbor

"The pedestrian laughed at the neighbor who uncle visited."

# e2 9 d

路人取笑拜訪大伯的鄰居

pedestrian laugh at visit uncle de neighbor

"The pedestrian laughed at the neighbor who visited uncle."

# e2 9 e

噪音吵醒的鄰居取笑路人

noise wake up de neighbor laugh at pedestrian

"The neighbor who the noise woke up laughed at the pedestrian."

# e2 9 f

路人取笑噪音吵醒的鄰居

pedestrian laugh at noise wake up de neighbor

"The pedestrian laughed at the neighbor who the noise woke up."

# e2 10 a

郵差撞到的送花童跟著小狗

mailman bump into de flower delivery boy follow dog

"The flower boy who the mailman bumped into followed the dog."

# e2 10 b

撞到郵差的送花童跟著小狗

bump into mailman de flower delivery boy follow dog

"The flower boy who bumped into the mailman followed the dog."

# e2 10 c

小狗跟著郵差撞到的送花童

dog follow mailman bump into de flower delivery boy

"The dog followed the flower boy who the mailman bumped into."

# e2 10 d

小狗跟著撞到郵差的送花童

dog follow bump into mailman de flower delivery boy  
 "The dog followed the flower boy who bumped into the mailman."

# e2 10 e

大雨淋濕的送花童跟著小狗

heavy rain make wet de flower boy follow dog  
 "The flower boy who the heavy rain made wet followed the dog."

# e2 10 f

小狗跟著大雨淋濕的送花童

dog follow heavy rain make wet de flower boy  
 "The dog followed the flower boy who the heavy rain made wet."

# e2 11 a

私家偵探跟蹤的警探尋找線民

private detective secretly follow de detective look for informer  
 "The detective who the private detective secretly followed looked for the informer."

# e2 11 b

跟蹤私家偵探的警探尋找線民

secretly follow private detective de detective look for informer  
 "The detective who secretly followed the private detective looked for the informer."

# e2 11 c

線民尋找私家偵探跟蹤的警探

informer look for private detective secretly follow de detective  
 "The informer looked for the detective who the private detective secretly followed."

# e2 11 d

線民尋找跟蹤私家偵探的警探

informer look for secretly follow private detective de detective  
 "The informer looked for the detective who secretly followed the private detective."

# e2 11 e

槍彈擊傷的警探尋找線民

bullet wound de detective look for informer  
 "The detective who the bullet wounded looked for the informer."

# e2 11 f

線民尋找槍彈擊傷的警探

informer look for bullet wound de detective  
 "The informer looked for the detective who the bullet wounded."

# e2 12 a

喜劇演員模仿的小丑不欣賞政治家

comedian imitate de clown not care for politician  
 "The clown who the comedian imitated does not care for the politician."

# e2 12 b

模仿喜劇演員的小丑不欣賞政治家

imitate comedian de clown not care for politician  
 "The clown who imitated the comedian does not care for the politician."

# e2 12 c

政治家不欣賞喜劇演員模仿的小丑

politician not care for comedian imitate de clown

"The politician does not care for the clown who the comedian imitated."

# e2 12 d

政治家不欣賞模仿喜劇演員的小丑

politician not care for imitate comedian de clown

The politician does not care for the clown who imitated the comedian."

# e2 12 e

香蕉皮絆倒的小丑不欣賞政治家

banana peel trip de clown not care for politician

The clown who the banana peel tripped does not care for the politician.

# e2 12 f

政治家不欣賞香蕉皮絆倒的小丑

politician not care for banana peel trip de clown

The politician does not care for the clown who the banana peel tripped."

# e2 13 a

鋼琴師受不了的小提琴家追求小喇叭手

pianist cannot stand de violinist chase trumpeter

"The violinist who the pianist cannot stand is chasing the trumpeter."

# e2 13 b

受不了鋼琴師的小提琴家追求小喇叭手

cannot stand pianist de violinist chase trumpeter

"The violinist who cannot stand the pianist is chasing the trumpeter."

# e2 13 c

小喇叭手追求鋼琴師受不了的小提琴家

trumpeter chase pianist cannot stand de violinist

"The trumpeter is chasing the violinist who the pianist cannot stand."

# e2 13 d

小喇叭手追求受不了鋼琴師的小提琴家

trumpeter chase cannot stand pianist de violinist

"The trumpeter is chasing the violinist who cannot stand the pianist."

# e2 13 e

音樂感動的小提琴家追求小喇叭手

music touch de violinist chase trumpeter

"The violinist who the music touched is chasing the trumpeter."

# e2 13 f

小喇叭手追求音樂感動的小提琴家

trumpeter chase music touch de violinist

"The trumpeter is chasing the violinist who the music touched."

# e2 14 a

屠夫討厭的搬運工人瞧不起清潔工

butcher detest de mover despise cleaning person

"The mover who the butcher detests despises the cleaning person."

# e2 14 b

討厭屠夫的搬運工人瞧不起清潔工

detest butcher de mover despise cleaning person

"The mover who detests the butcher despises the cleaning person."

# e2 14 c

清潔工瞧不起屠夫討厭的搬運工人

cleaning person despise butcher detest de mover

"The cleaning person despises the mover who the butcher detests."

# e2 14 d

清潔工瞧不起討厭屠夫的搬運工人

cleaning person despise detest butcher de mover

"The cleaning person despises the mover who detests the butcher."

# e2 14 e

大箱子壓到的搬運工人瞧不起清潔工

big box fall on de mover despise cleaning person

"The mover who the big box fell on despises the cleaning person."

# e2 14 f

清潔工瞧不起大箱子壓到的搬運工人

cleaning person despise big box fall on de mover

"The cleaning person despises the mover who the big box fell on."

# e2 15 a

畫家愛上的詩人追求音樂家

painter fall in love with de poet pursue musician

"The poet who the painter fell in love with is pursuing the musician."

# e2 15 b

愛上畫家的詩人追求音樂家

fall in love with painter de poet pursue musician

"The poet who fell in love with the painter is pursuing the musician."

# e2 15 c

音樂家追求畫家愛上的詩人

musician pursue painter fall in love with de poet

"The musician is pursuing the poet who the painter fell in love with."

# e2 15 d

音樂家追求愛上畫家的詩人

musician pursue fall in love with painter de poet

"The musician is pursuing the poet who fell in love with the painter."

# e2 15 e

小說描寫的詩人追求音樂家

novel describe de poet pursue musician

"The poet who the novel describes is pursuing the musician."

# e2 15 f

音樂家追求小說描寫的詩人

musician pursue novel describe de poet

"The musician is pursuing the poet who the novel describes."

# e2 16 a

寡婦嘲笑的老處女暗戀單身漢

widow make fun of de spinster secretly love bachelor

"The spinster who the widow made fun of secretly loves the bachelor."

# e2 16 b

嘲笑寡婦的老處女暗戀單身漢

make fun of widow de spinster secretly love bachelor



"The spinster who made fun of the widow secretly loves the bachelor."

# e2 16 c

單身漢暗戀寡婦嘲笑的老處女

bachelor secretly love widow make fun of de spinster

"The bachelor secretly loves the spinster who the widow made fun of."

# e2 16 d

單身漢暗戀嘲笑寡婦的老處女

bachelor secretly love make fun of widow de spinster

"The bachelor secretly loves the spinster who made fun of the widow."

# e2 16 e

熱湯燙傷的老處女暗戀單身漢

hot soup burn de spinster secretly love bachelor

"The spinster who the hot soup burned secretly loves the bachelor."

# e2 16 f

單身漢暗戀熱湯燙傷的老處女

bachelor secretly love hot soup burn de spinster

"The bachelor secretly loves the spinster who the hot soup burned."

# e2 17 a

流氓威脅的逃犯陷害小偷

rascal threaten de fugitive plot against thief

"The fugitive who the rascal threatened plotted against the thief."

# e2 17 b

威脅流氓的逃犯陷害小偷

threaten rascal de fugitive plot against thief

"The fugitive who threatened the rascal plotted against the thief."

# e2 17 c

小偷陷害流氓威脅的逃犯

thief plot against rascal threaten de fugitive

"The thief plotted against the fugitive who the rascal threatened."

# e2 17 d

小偷陷害威脅流氓的逃犯

thief plot against threaten rascal de fugitive

"The thief plotted against the fugitive who threatened the rascal."

# e2 17 e

槍聲嚇壞的逃犯陷害小偷

gunfire scare de fugitive plot against thief

"The fugitive who the gunfire scared plotted against the thief."

# e2 17 f

小偷陷害槍聲嚇壞的逃犯

thief plot against gunfire scare de fugitive

"The thief plotted against the fugitive who the gunfire scared."

# e2 18 a

富豪邀請的官員勾結法官

tycoon invite de official conspire with judge

"The official who the tycoon invited conspired with the judge."

# e2 18 b

邀請富豪的官員勾結法官

invite tycoon de official conspire with judge  
 "The official who invited the tycoon conspired with the judge."  
 # e2 18 c  
 法官勾結富豪邀請的官員  
 judge conspire with tycoon invite de official  
 "The judge conspired with the official who the tycoon invited."  
 # e2 18 d  
 法官勾結邀請富豪的官員  
 judge conspire with invite tycoon de official  
 "The judge conspired with the official who invited the tycoon."  
 # e2 18 e  
 稅法懲罰的官員勾結法官  
 tax law punish de official conspire with judge  
 "The official who the tax law punished conspired with the judge."  
 # e2 18 f  
 法官勾結稅法懲罰的官員  
 judge conspire with tax law punish de official  
 "The judge conspired with the official who the tax law punished."  
  
 # e2 19 a  
 居民協助的軍官憎恨難民  
 resident help de soldier detest refugee  
 "The soldier who the resident helped detests the refugee."  
 # e2 19 b  
 協助居民的軍官憎恨難民  
 help resident de soldier detest refugee  
 "The soldier who helped the resident detests the refugee."  
 # e2 19 c  
 難民憎恨居民協助的軍官  
 refugee detest resident help de soldier  
 "The refugee detests the soldier who the resident helped."  
 # e2 19 d  
 難民憎恨協助居民的軍官  
 refugee detest help resident de soldier  
 "The refugee detests the soldier who helped the resident."  
 # e2 19 e  
 防彈衣保護的軍官憎恨難民  
 bulletproof vest protect de soldier detest refugee  
 "The soldier who the bulletproof best protects detests the refugee."  
 # e2 19 f  
 難民憎恨防彈衣保護的軍官  
 refugee detest bulletproof vest protect de soldier  
 "The refugee detests the soldier who the bulletproof vest protects."  
  
 # e2 20 a  
 司機報怨的乘客不理會收票員  
 driver complain about de passenger ignore ticket collector  
 "The passenger who the driver complained about ignored the ticket collector."  
 # e2 20 b

報怨司機的乘客不理會收票員

complain about driver de passenger ignore ticket collector

"The passenger who complained about the driver ignored the ticket collector."

# e2 20 c

收票員不理會司機報怨的乘客

ticket collector ignore driver complain about de passenger

"The ticket collector ignored the passenger who the driver complained about."

# e2 20 d

收票員不理會報怨司機的乘客

ticket collector ignore complain about driver de passenger

"The ticket collector ignored the passenger who complained about the driver."

# e2 20 e

風景感動的乘客不理會收票員

scenery touch de passenger ignore ticket collector

"The passenger who the scenery touched ignored the ticket collector."

# e2 20 f

收票員不理會風景感動的乘客

ticket collector ignore scenery touch de passenger

"The ticket collector ignored the passenger who the scenery touched."

# e2 21 a

小女生偷親的小男生碰見老師

little girl kiss de little boy bump into teacher

"The little boy who the little girl kissed bumped into the teacher."

# e2 21 b

偷親小女生的小男生碰見老師

kiss little girl de little boy bump into teacher

"The little boy who kissed the little girl bumped into the teacher."

# e2 21 c

老師碰見小女生偷親的小男生

teacher bump into little girl kiss de little boy

"The teacher bumped into the little boy who the little girl kissed."

# e2 21 d

老師碰見偷親小女生的小男生

teacher bump into kiss little girl de little boy

"The teacher bumped into the little boy who kissed the little girl."

# e2 21 e

籃球打到的小男生碰見老師

basketball hit de little boy bump into teacher

"The little boy who the basketball hit bumped into the teacher."

# e2 21 f

老師碰見籃球打到的小男生

teacher bump into basketball hit de little boy

"The teacher bumped into the little boy who the basketball hit."

# e2 22 a

丈夫辜負的太太責怪父母

husband betray de wife blame parents

"The wife who the husband betrayed blamed the parents."

# e2 22 b

辜負丈夫的太太責怪父母

betray husband de wife blame parents

"The wife who betrayed the husband blamed the parents."

# e2 22 c

父母責怪丈夫辜負的太太

parents blame husband betray de wife

"The parents blamed the wife who the husband betrayed."

# e2 22 d

父母責怪辜負丈夫的太太

parents blame betray husband de wife

"The parents blamed the wife who betrayed the husband."

# e2 22 e

電話吵醒的太太責怪父母

telephone awaken de wife blame parents

"The wife who the phone awoke blamed the parents."

# e2 22 f

父母責怪電話吵醒的太太

parents blame telephone awaken de wife

"The parents blamed the wife who the phone awoke."

# e2 23 a

官員勒索的候選人奉承商人

official blackmail de candidate suck up to businessman

"The candidate who the official blackmailed sucked up to the businessman."

# e2 23 b

勒索官員的候選人奉承商人

blackmail official de candidate suck up to businessman

"The candidate who blackmailed the official sucked up to the businessman."

# e2 23 c

商人奉承官員勒索的候選人

businessman suck up to official blackmail de candidate

"The businessman sucked up to the candidate who the official blackmailed."

# e2 23 d

商人奉承勒索官員的候選人

businessman suck up to blackmail official de candidate

"The businessman sucked up to the candidate who blackmailed the official."

# e2 23 e

雞蛋打到的候選人奉承商人

egg hit de candidate suck up to businessman

"The candidate who the egg hit sucked up to the businessman."

# e2 23 f

商人奉承雞蛋打到的候選人

businessman suck up to egg hit de candidate

"The businessman sucked up to the candidate who the egg hit."

# e2 24 a

老師問候的家長感謝校長

teacher greet de parents thank principal

"The parents who the teacher greeted thanked the principal."

# e2 24 b

問候老師的家長感謝校長

greet teacher de parents thank principal

"The parents who greeted the teacher thanked the principal."

# e2 24 c

校長感謝老師問候的家長

principal thank teacher greet de parents

"The principal thanked the parents who the teacher greeted."

# e2 24 d

校長感謝問候老師的家長

principal thank greet teacher de parents

"The principal thanked the parents who greeted the teacher."

# e2 24 e

福利金救濟的家長感謝校長

welfare money help de parents thank principal

"The parents who the welfare money helped thanked the principal."

# e2 24 f

校長感謝福利金救濟的家長

principal thank welfare money help de parents

"The principal thanked the parents who the welfare money helped."

## Appendix C

### Experimental Items

# e3 1 a

教授說服助教去質問的女學生成績不錯 (3.25)

professor convince TA go question de female student grades good  
"The female student who the professor convinced the TA to go question has good grades."

# e3 1 b

教授說服助教去質問她的女學生成績不錯(3.25)

professor convince TA go question her de female student grades good  
"The female student who the professor convinced the TA to go question has good grades."

# e3 1 c

教授說服去質問助教的女學生成績不錯 (4.38)

professor convince go question TA de female student grades good  
"The female student who the professor convinced to go question the TA has good grades."

# e3 1 d

教授說服她去質問助教的女學生成績不錯(4.38)

professor convince her go question TA de female student grades good  
"The female student who the professor convinced to go question the TA has good grades."

# e3 2 a

女秘書懇求女工程師去拜訪的老闆令人畏懼 (3.18)

female secretary beg female engineer go visit de boss make people  
intimidate  
"The boss who the female secretary begged the female engineer to go visit intimidates people."

# e3 2 b

女秘書懇求女工程師去拜訪他的老闆令人畏懼 (3.18)

female secretary ask female engineer go visit him de boss make people  
intimidate  
"The boss who the female secretary begged the female engineer to go visit intimidates people."

# e3 2 c

女秘書懇求去拜訪女工程師的老闆令人畏懼 (4.33)

female secretary ask go visit female engineer de boss make people  
intimidate  
"The boss who the female secretary begged to go visit the female engineer intimidates people."

# e3 2 d

女秘書懇求他去拜訪女工程師的老闆令人畏懼 (4.33)

female secretary ask him go visit female engineer de boss make people  
intimidate  
"The boss who the female secretary begged to go visit the female engineer intimidates people."

# e3 3 a

教授要求記者去批評的女作家很有名 (3.43)

professor request reporter go criticize de female writer very famous  
 "The female writer who the professor requested the reporter to criticize is very famous."

# e3 3 b

教授要求記者去批評她的女作家很有名 (3.43)

professor request reporter go criticize her de female writer very famous  
 "The female writer who the professor requested the reporter to criticize is very famous."

# e3 3 c

教授要求去批評記者的女作家很有名 (3.95)

professor request go criticize reporter de female writer very famous  
 "The female writer who the professor requested to criticize the reporter is very famous."

# e3 3 d

教授要求她去批評記者的女作家很有名 (3.95)

professor request her go criticize reporter de female writer very famous  
 "The female writer who the professor requested to criticize the reporter is very famous."

# e3 4 a

作曲家強迫聲樂家去讚美的女指揮家有天份 (3.95)

composer force opera singer go praise de female conductor have talents  
 "The female conductor who the composer forced the opera singer to praise has talents."

# e3 4 b

作曲家強迫聲樂家去讚美她的女指揮家有天份 (3.95)

composer force opera singer go praise her de female conductor have talents  
 "The female conductor who the composer forced the opera singer to praise has talents."

# e3 4 c

作曲家強迫去讚美聲樂家的女指揮家有天份 (4.05)

composer force go praise opera singer de female conductor have talents  
 "The female conductor who the composer forced to praise the opera singer has talents."

# e3 4 d

作曲家強迫她去讚美聲樂家的女指揮家有天份 (4.05)

composer force her go praise opera singer de female conductor have talents  
 "The female conductor who the composer forced to praise the opera singer has talents."

# e3 5 a

媽媽說服阿姨去看的朋友剛買房子 (2)

mother convince aunt go see de friend bought house

"The friend who the mother convinced the aunt to go see bought a house."

# e3 5 b

媽媽說服阿姨去看他的朋友剛買房子 (2)

mother convince aunt go see him de friend bought house

"The friend who the mother convinced the aunt to go see bought a house."

# e3 5 c

媽媽說服去看阿姨的朋友剛買房子 (2.7)

mother convince go see aunt de friend bought house

"The friend who the mother convinced to go see the aunt bought a house."

# e3 5 d

媽媽說服他去看阿姨的朋友剛買房子 (2.7)

mother convince him go see aunt de friend bought house

"The friend who the mother convinced to go see the aunt bought a house."

# e3 6 a

馬戲團長鼓勵小丑去模仿的女演員很受歡迎 (1.58)

head of the circus encourage clown go imitate de actress very popular

"The actress who the head of the circus encouraged the clown to go imitate is very popular."

# e3 6 b

馬戲團長鼓勵小丑去模仿她的女演員很受歡迎 (1.58)

head of the circus encourage clown go imitate her de actress very

popular

"The actress who the head of the circus encouraged the clown to go imitate is very popular."

# e3 6 c

馬戲團長鼓勵去模仿小丑的女演員很受歡迎 (2.55)

head of the circus encourage go imitate clown de actress very popular

"The actress who the head of the circus encouraged to go imitate the clown is very popular."

# e3 6 d

馬戲團長鼓勵她去模仿小丑的女演員很受歡迎 (2.55)

head of the circus encourage her go imitate clown de actress very

popular

"The actress who the head of the circus encouraged to go imitate the clown is very popular."

# e3 7 a

女律師勸阻女市長去收買的縣長很有勢力 (3.3)

female lawyer dissuade female mayor go bribe de the head of the county very powerful

"The head of the county who the female lawyer dissuaded the female mayor to go bribe is very powerful."

# e3 7 b

女律師勸阻女市長去收買他的縣長很有勢力 (3.3)

female lawyer dissuade female mayor go bribe him de the head of the

county very powerful



"The head of the county who the female lawyer dissuaded the female mayor to go bribe is very powerful."

# e3 7 c

女律師勸阻去收買女市長的縣長很有勢力 (3.4)

female lawyer dissuade go bribe female mayor de the head of the county very powerful

"The head of the county who the female lawyer dissuaded to go bribe the female mayor is very powerful."

# e3 7 d

女律師勸阻他去收買女市長的縣長很有勢力 (3.4)

female lawyer dissuade him go bribe female mayor de the head of the county very powerful

"The head of the county who the female lawyer dissuaded to go bribe the female mayor is very powerful."

# e3 8 a

醫生建議實習生去協助的護士很笨 (2.18)

doctor suggest intern go assist de nurse very stupid

"The nurse who the doctor suggested the intern to go assist is very stupid."

# e3 8 b

醫生建議實習生去協助她的護士很笨 (2.18)

doctor suggest intern go assist her de nurse very stupid

"The nurse who the doctor suggested the intern to go assist is very stupid."

# e3 8 c

醫生建議去協助實習生的護士很笨 (1.85)

doctor suggest go assist intern de nurse very stupid

"The nurse who the doctor suggested to go assist the intern is very stupid."

# e3 8 d

醫生建議她去協助實習生的護士很笨 (1.85)

doctor suggest her go assist intern de nurse very stupid

"The nurse who the doctor suggested to go assist the intern is very stupid."

# e3 9 a

總統命令軍官去找的女情報員下落不明 (3.03)

president order soldier go look for de female spy whereabouts unclear

"The female spy who the president ordered the soldier to look for has unclear whereabouts."

# e3 9 b

總統命令軍官去找她的女情報員下落不明 (3.03)

president order soldier go look for her de female spy whereabouts unclear

"The female spy who the president ordered the soldier to look for has unclear whereabouts."

# e3 9 c

總統命令去找軍官的女情報員下落不明 (2.8)

president order go look for soldier de female spy whereabouts unclear

"The female spy who the president ordered to look for the spy has unclear whereabouts."

# e3 9 d

總統命令她去找軍官的女情報員下落不明 (2.8)

president order her go look for soldier de female spy whereabouts unclear

"The female spy who the president ordered to look for the soldier has unclear whereabouts."

# e3 10 a

老太太要求女孩去找的男孩很可愛 (2.75)

old lady ask girl go look for de boy very cute

"The boy who the old lady asked the girl to look for is very cute."

# e3 10 b

老太太要求女孩去找他的男孩很可愛 (2.75)

old lady ask girl go look for him de boy very cute

"The boy who the old lady asked the girl to look for is very cute."

# e3 10 c

老太太要求去找女孩的男孩很可愛 (2.28)

old lady ask go look for girl de boy very cute

"The boy who the old lady asked to look for the girl is very cute."

# e3 10 d

老太太要求他去找女孩的男孩很可愛 (2.28)

old lady ask him go look for girl de boy very cute

"The boy who the old lady asked to look for the girl is very cute."

# e3 11 a

老先生鼓勵單身漢去追求的單身女孩很有身價 (1.45)

old man encourage bachelor go pursue de single girl very desirable

"The single girl who the old man encouraged the bachelor to pursue is very desirable."

# e3 11 b

老先生鼓勵單身漢去追求她的單身女孩很有身價 (1.45)

old man encourage bachelor go pursue her de single girl very desirable

"The single girl who the old man encouraged the bachelor to pursue is very desirable."

# e3 11 c

老先生鼓勵去追求單身漢的單身女孩很有身價 (2.28)

old man encourage go pursue bachelor de single girl very desirable

"The single girl who the old man encouraged to pursue the bachelor is very desirable."

# e3 11 d

老先生鼓勵她去追求單身漢的單身女孩很有身價 (2.28)

old man encourage her go pursue bachelor de single girl very desirable

"The single girl who the old man encouraged to pursue the bachelor is very desirable."

# e3 12 a

經理人介紹主持人去連絡的女歌手住在天母 (2.38)

agent introduce show host go contact de female singer live in Tienmu

"The female singer who the agent introduced the show host to contact lives in Tienmu."

# e3 12 b

經理人介紹主持人去連絡她的女歌手住在天母 (2.38)

agent introduce show host go contact her de female singer live in Tienmu

"The female singer who the agent introduced the show host to contact lives in Tienmu."

# e3 12 c

經理人介紹去連絡主持人的女歌手住在 天母 (2.35)

agent introduce go contact show host de female singer live in Tienmu

"The female singer who the agent introduced/suggested to contact the show host lives in Tienmu."

# e3 12 d

經理人介紹她去連絡主持人的女歌手住在天母 (2.35)

agent introduce her go contact show host de female singer live in Tienmu

"The female singer who the agent introduced/suggested to contact the show host lives in Tienmu."

# e3 13 a

大人訓練小男孩去親近的小貓生性害羞 (2.65)

adult train little boy go get close to de cat personality shy

"The cat that the adult trained the little boy to get close to is very shy."

# e3 13 b

大人訓練小男孩去親近它的小貓生性害羞 (2.65)

adult train little boy go get close to it de cat personality shy

"The cat that the adult trained the little boy to get close to is very shy."

# e3 13 c

大人訓練去親近小男孩的小貓生性害羞 (3.4)

adult train go get close to little boy de cat personality shy

"The cat that the adult trained to get close to the little boy is very shy."

# e3 13 d

大人訓練它去親近小男孩的小貓生性害羞 (3.4)

adult train it go get close to little boy de cat personality shy

"The cat that the adult trained to get close to the little boy is very shy."

# e3 14 a

美女誘惑女同性戀法官去陷害的官員有名有勢 (3.73)

beautiful woman seduce lesbian judge go frame de official famous powerful

"The official who the beautiful woman seduced the lesbian judge to frame is very famous and powerful."

# e3 14 b

美女誘惑女同性戀法官去陷害他的官員有名有勢 (3.73)

beautiful woman seduce lesbian judge go frame him de official famous powerful

"The official who the beautiful woman seduced the lesbian judge to frame is very famous and powerful."

# e3 14 c

美女誘惑去陷害女同性戀法官的官員有名有勢 (4.15)

beautiful woman seduce go frame lesbian judge de official famous  
powerful

"The official who the beautiful woman seduced to frame the lesbian judge is very famous and powerful."

# e3 14 d

美女誘惑他去陷害女同性戀法官的官員有名有勢 (4.15)

beautiful woman seduce him go frame judge de official famous powerful

"The official who the beautiful woman seduced to frame the lesbian judge is very famous and powerful."

# e3 15 a

囚犯設計監獄官去懷疑的女警衛非常正直 (3.63)

prisoner trick prison head go suspect de female prison guard very candid

"The female prison guard who the prisoner tricked the prison head to suspect is very candid."

# e3 15 b

囚犯設計監獄官去懷疑她的女警衛非常正直 (3.63)

prisoner trick prison head go suspect her de female prison guard very candid

"The female prison guard who the prisoner tricked the prison head to suspect is very candid."

# e3 15 c

囚犯設計去懷疑監獄官的女警衛非常正直 (3.98)

prisoner trick go suspect prison head de female prison guard very candid

"The female prison guard who the prisoner tricked to suspect the prison head is very candid."

# e3 15 d

囚犯設計她去懷疑監獄官的女警衛非常正直 (3.98)

prisoner trick her go suspect prison head de female prison guard very candid

"The female prison guard who the prisoner tricked to suspect the prison head is very candid."

# e3 16 a

指揮家邀請鋼琴師去陪奏的女提琴家才華洋溢 (2.35)

conductor invite pianist go accompany de female violinist talent full

"The female violinist who the conductor invited the pianist to go accompany is full of talents."

# e3 16 b

指揮家邀請鋼琴師去陪奏她的女提琴家才華洋溢 (2.35)

conductor invite pianist go accompany her de female violinist talent full

"The female violinist who the conductor invited the pianist to go accompany is full of talents."

# e3 16 c

指揮家邀請去陪奏鋼琴師的女提琴家才華洋溢 (2.55)

conductor invite go accompany pianist de female violinist talent full

"The female violinist who the conductor invited to go accompany the pianist is full of talents."

# e3 16 d

指揮家邀請她去陪奏鋼琴師的女提琴家才華洋溢 (2.55)

conductor invite her go accompany pianist de female violinist talent full

"The female violinist who the conductor invited to go accompany the pianist is full of talents."

# e3 17 a

製片家聘請音樂家去啓發的女編劇很難相處 (2.95)

producer hire musician go inspire de female screenwriter hard get along with

"The female screenwriter who the producer hired the musician to inspire is hard to get along with."

# e3 17 b

製片家聘請音樂家去啓發她的女編劇很難相處 (2.95)

producer hire musician go inspire her de female screenwriter hard get along with

"The female screenwriter who the producer hired the musician to inspire is hard to get along with."

# e3 17 c

製片家聘請去啓發音樂家的女編劇很難相處 (3.23)

producer hire go inspire musician de female screenwriter hard get along with

"The female screenwriter who the producer hired to inspire the musician is hard to get along with."

# e3 17 d

製片家聘請她去啓發音樂家的女編劇很難相處 (3.23)

producer hire her go inspire musician de female screenwriter hard get along with

"The female screenwriter who the producer hired to inspire the musician is hard to get along with."

# e3 18 a

流氓慫恿毒販去陷害的妓女前科累累 (2.35)

rascal tempt drug dealer go plot against de prostitute criminal record bad

"The prostitute who the rascal tempted the drug dealer to go plot against has bad criminal records."

# e3 18 b

流氓慫恿毒販去陷害她的女前科累累 (2.35)

rascal tempt drug dealer go plot against her de prostitute criminal record bad

"The prostitute who the rascal tempted the drug dealer to go plot against has bad criminal records."

# e3 18 c

流氓慫恿去陷害毒販的妓女前科累累 (2.58)

rascal tempt go plot against drug dealer de prostitute criminal record bad

"The prostitute who the rascal tempted to go plot against the drug dealer has bad criminal records."

# e3 18 d

流氓慫恿她去陷害毒販的妓女前科累累 (2.58)

rascal tempt her go plot against drug dealer de prostitute criminal record bad

"The prostitute who the rascal tempted to go plot against the drug dealer has bad criminal records."

# e3 19 a

檢察官慫恿議員去勒索的女法官通知警方 (4.6)

prosecutor tempt senator go blackmail de female judge inform police

"The female judge who the prosecutor tempted the senator to go blackmail informed the police."

# e3 19 b

檢察官慫恿議員去勒索她的女法官通知警方 (4.6)

prosecutor tempt senator go blackmail her de female judge inform police

"The female judge who the prosecutor tempted the senator to go blackmail informed the police."

# e3 19 c

檢察官慫恿去勒索議員的女法官通知警方 (4.68)

prosecutor tempt go blackmail senator de female judge inform police

"The female judge who the prosecutor tempted to go blackmail the senator informed the police."

# e3 19 d

檢察官慫恿她去勒索議員的女法官通知警方 (4.68)

prosecutor tempt her go blackmail senator de female judge inform police

"The female judge who the prosecutor tempted to go blackmail the senator informed the police."

# e3 20 a

廚師要求收銀員去幫忙的女服務生待客親切 (3.63)

chef ask cashier go help de waitress treat guest friendly

"The waitress who the chef asked the cashier to go help is friendly to guests."

# e3 20 b

廚師要求收銀員去幫忙她的女服務生待客親切 (3.63)

chef ask cashier go help her de waitress treat guest friendly

"The waitress who the chef asked the cashier to go help is friendly to guests."

# e3 20 c

廚師要求去幫忙收銀員的女服務生待客親切 (3.63)

chef ask go help cashier de waitress treat guest friendly

"The waitress who the chef asked to go help the cashier is friendly to guests."

# e3 20 d

廚師要求她去幫忙收銀員的女服務生待客親切 (3.63)

chef ask her go help cashier de waitress treat guest friendly

"The waitress who the chef asked to go help the cashier is friendly to guests."

# e3 21 a

畫商支持畫家去接洽的模特兒收入高 (2.4)

art dealer support painter go get in touch with de model income high  
 "The model who the art dealer supported the painter to get in touch with has high income."

# e3 21 b

畫商支持畫家去接洽她的模特兒高 (2.4)

art dealer support painter go get in touch with her de model income high

"The model who the art dealer supported the painter to get in touch with has high income."

# e3 21 c

畫商支持去接洽畫家的模特兒收入高 (3.13)

art dealer support go get in touch with painter de model income high  
 "The model who the art dealer supported to get in touch with the painter has high income."

# e3 21 d

畫商支持她去接洽畫家的模特兒收入高 (3.13)

art dealer support her go get in touch with painter de model income high

"The model who the art dealer supported to get in touch with the painter has high income."

# e3 22 a

老闆阻止建築師去批評的女裝潢師經常耍大牌 (3.4)

boss stop architect go criticize de female interior decorator often bad attitude

"The female interior decorator who the boss stopped the architect from criticizing has a bad attitude."

# e3 22 b

老闆阻止建築師去批評她的女裝潢師經常耍大牌 (3.4)

boss stop architect go criticize her de female interior decorator often bad attitude

"The female interior decorator who the boss stopped the architect from criticizing has a bad attitude."

# e3 22 c

老闆阻止去批評建築師的女裝潢師經常耍大牌 (3.48)

boss stop go criticize architect de female interior decorator often bad attitude

"The female interior decorator who the boss stopped from criticizing the architect has a bad attitude."

# e3 22 d

老闆阻止她去批評建築師的女裝潢師經常耍大牌 (3.48)

boss stop her go criticize architect de female interior decorator often bad attitude

"The female interior decorator who the boss stopped from criticizing the architect has a bad attitude."

# e3 23 a

哥哥控制弟弟去監視的妹妹個性驕縱 (3.4)

older brother control younger brother go spy on de younger sister  
personality spoilt

"The younger sister who the older brother controlled the younger brother to spy  
on is spoilt."

# e3 23 b

哥哥控制弟弟去監視她的妹妹個性驕縱 (3.4)

older brother control younger brother go spy on her de younger sister  
personality spoilt

"The younger sister who the older brother controlled the younger brother to spy  
on is spoilt."

# e3 23 c

哥哥控制去監視弟弟的妹妹個性驕縱 (3.35)

older brother control go spy on younger brother de younger sister  
personality spoilt

"The younger sister who the older brother controlled to spy on the younger  
brother is spoilt."

# e3 23 d

哥哥控制她去監視弟弟的妹妹個性驕縱 (3.35)

older brother control her go spy on younger brother de younger sister  
personality spoilt

"The younger sister who the older brother controlled to spy on the younger  
brother is spoilt."

# e3 24 a

國稅局懷疑商人去勾結的女會計師消滅罪證 (2)

IRS suspect businessman go conspire with de female accountant destroy  
evidence

"The female accountant who the IRS suspected the businessman to conspire with  
destroyed the evidence."

# e3 24 b

國稅局懷疑商人去勾結她的女會計師消滅罪證 (2)

IRS suspect businessman go conspire with her de female accountant  
destroy evidence

"The female accountant who the IRS suspected the businessman to conspire with  
destroyed the evidence."

# e3 24 c

國稅局懷疑去勾結商人的女會計師消滅罪證 (2.68)

IRS suspect go conspire with businessman de female accountant destroy  
evidence

"The female accountant who the IRS suspected to conspire with the businessman  
destroyed the evidence."

# e3 24 d

國稅局懷疑她去勾結商人的女會計師消滅罪證 (2.68)

IRS suspect her go conspire with businessman de female accountant  
destroy evidence

"The female accountant who the IRS suspected to conspire with the businessman  
destroyed the evidence."