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Processing of syntactic and anaphoric gap-filler dependencies in Korean : evidence from self-paced reading time, ERP and eye-tracking experiments

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Processing of Syntactic and Anaphoric Gap-Filler Dependencies in Korean: Evidence from Self-Paced Reading Time, ERP and Eye-Tracking Experiments

A dissertation submitted in partial satisfaction of the

Requirements for the degree Doctor of Philosophy

in

Linguistics and Cognitive Science

by

Nayoung Kwon

Committee in charge:

Professor Robert Kluender, Co-Chair
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Professor Victor Ferreira
Professor Grant Goodall
Professor Marta Kutas
Professor John Moore

2008

The dissertation of Nayoung Kwon is approved, and it is acceptable in quality and form for publication on microfilm:

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Co-Chair

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University of California, San Diego

2008

DEDICATION

I dedicate this dissertation to my mother, Jungja Kim,

who has never stopped pursuing her dreams, yet

has never failed to find happiness in what she already has.

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Nayoung Kwon, Maria Polinsky, Robert Kluender & Marta Kutas. Subject/object processing asymmetries in Korean relative clauses: Evidence from reading time and ERP data. (In preparation)

Nayoung Kwon, Robert Kluender, Maria Polinsky & Marta Kutas. Processing advantages of subject gaps in syntactic and anaphoric gap-filler dependencies: Evidence from reading time and ERP data. (In preparation)

The dissertation author is the primary investigator and author of these papers.

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ABSTRACT OF THE DISSERTATION

Processing of Syntactic and Anaphoric Gap-Filler Dependencies in Korean:
Evidence from Self-Paced Reading Time, ERP and Eye-Tracking Experiments

by

Nayoung Kwon

Doctor of Philosophy in Linguistics and Cognitive Science

University of California, San Diego, 2008

Professor Robert Kluender, Co-Chair
Professor Maria Polinsky, Co-Chair

This dissertation explores the processing of syntactic (1) and anaphoric gap-filler dependencies (2) in Korean relative and adjunct clauses ('because' clauses), using event-related brain potentials (ERPs), self-paced reading times, and eye-tracking.

(1) [$_{RC}$ __$_i$ senator-ACC attacked-REL] reporter-NOM error-ACC admitted.
'The reporter who attacked the senator admitted the error.

(2) [$_{BECAUSE}$ __$_i$ senator-ACC attacked-BECAUSE] reporter-NOM error-ACC admitted.
'Because he$_i$ attacked the senator, the reporter$_i$ admitted the error.'

Following a discussion of different syntactic analyses of Korean relative clauses (especially *wh*-movement and unconditional binding of null arguments) in Chapter 2 and

an overview of previous experimental studies (Chapter 3), Chapter 4 investigates the processing of syntactic dependencies using Korean subject (SRs) and object relative clauses (ORs). The results show a processing advantage of SRs over ORs, supporting processing models based on the *accessibility hierarchy* (Keenan & Comrie, 1977) and the *phrase-structural distance hypothesis* (O'Grady, 1997). Furthermore, the ERP results show that at the head noun, where the gap and filler are associated, ORs elicit an anterior negativity compared to SRs, similar to the pattern found in English relatives. This effect is attributed to higher working memory load for gap-filler association in ORs.

Chapter 5 investigates the processing of backward anaphoric and syntactic long-distance dependencies; the goal is to investigate possible similarities and differences in underlying cognitive/neural processes. The results show that the processing of anaphoric dependencies is also sensitive to grammatical constraints defined in terms of the accessibility hierarchy or hierarchical structural distance. In the ERP experiment, both syntactic and anaphoric object dependencies elicit a LAN effect compared to control sentences at the matrix subject position. This is taken to suggest that in both types of dependencies, gap-filler association is immediate. However, compared to anaphoric dependencies, syntactic dependencies elicited a larger LAN effect. At the next word, relative to syntactic dependencies, anaphoric dependencies elicited a sustained LAN effect that continued through the end of the clause. The different time-course of these (left) anterior negativities was taken to suggest different gap-filler association requirements for syntactic versus anaphoric dependencies.

These results are discussed in light of the syntactic analyses in Chapter 2.

Chapter 1: Introduction

1.1 Overview

This dissertation explores the processing of long-distance dependencies in different types of constructions. Long-distance dependencies can arise when a linguistic element is displaced from its canonical position. In psycholinguistic terminology, a displaced argument such as *the reporter* in (1.1) is called a filler, and the position where the extraction was made from is called a gap (Fodor, 1978).

(1.1) Filler-gap dependencies
The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.
FILLER GAP

Proper interpretation of a relative clause requires a mutual dependency between the filler and the gap: the filler must be interpreted in the gap position for its thematic role assignment and the gap position must receive referential identity from the filler. In the sense that there is a dependency between the displaced element (filler) and its canonical position (gap), this type of long-distance dependency is specifically called a filler-gap dependency (Fodor, 1978).

There are both forward and backward syntactic long-distance dependencies. For example, in English, relative clauses are postnominal, and thus the filler always precedes its associated gap, creating a forward (i.e., filler-gap) syntactic dependency (1.2). On the other hand, Korean has prenominal relatives, and the gap always precedes its associated filler, forming a backward syntactic (i.e., gap-filler) dependency (1.3).

(1.2) Forward syntactic dependency

The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.
filler gap

(1.3) Backward syntactic dependency

[uywon-i	__	kongkeykha-n]	kica-ka	calmot-ul	siinhayssta
senator-NOM		attacked-REL	reporter-NOM	error-ACC	admitted
	GAP		FILLER		

'The reporter who the senator attacked admitted error.'

Aside from these syntactic dependencies, there can also be long-distance dependencies between two linguistic elements in their canonical positions, i.e., without any displacement. For example, coindexation between a pronoun and its antecedent (1.4) instantiates a long-distance dependency. I will hereafter refer to this type of long-distance dependency as an anaphoric dependency. Like syntactic dependencies, anaphoric dependencies can be both forward and backward, as shown in (1.4) and (1.5).

(1.4) Forward anaphoric dependency

When the boy was fed up, he visited the girl very often.
ANTECEDENT PRONOUN

(1.5) Backward anaphoric dependency (van Gompel & Liversedge, 2003)

When he was fed up, the boy visited the girl very often.
PRONOUN ANTECEDENT

As illustrated above, there are four different types of dependencies: forward syntactic, backward syntactic, forward anaphoric, and backward anaphoric. While the processing of forward syntactic dependencies has been studied in detail, little work has been done that compares them with other types of long-distance dependencies. However, an important question to ask for a fuller understanding of human language processing is whether the processing strategies of long-distance dependencies in different constructions are similar and if so, in what aspects and to what degree they are similar. To that end, this dissertation investigates the processing strategies involved in backward syntactic and backward anaphoric dependencies in Korean relative and *–se* 'because' adjunct clauses, comparing the results with those of forward syntactic dependencies in English relative clauses. The issues involved in these comparisons are outlined in Sections 1.2 and 1.3.

1.2 Subject and Object Processing Asymmetry

In English, the processing of long-distance dependencies in object relative clauses (ORs) as in (1.6) has been studied using various experimental methods (reading time: King & Just, 1991; ERP: King & Kutas, 1995; fMRI: Just et al., 1996, Caplan et al., 2002; Cooke et al., 2001; PET: Stromswold et al,. 1996; Caplan et al. 1998, 1999, 2000; eye-tracking: Traxler et al., 2002) and has been found to make greater demands on working memory resources than the processing of subject relative clauses (SRs), as in (1.7).

(1.6) Object relative
The reporter$_i$ who the senator harshly attacked ___$_i$ admitted the error.

(1.7) Subject relative
The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.

(King & Just, 1991: 581)

In addition, this processing asymmetry found in English between subject/object relatives has been confirmed in other languages with forward syntactic dependencies (Dutch: Frazier, 1987; German: Schriefers et al., 1995; Mecklinger et al., 1995; Romance: Frauenfelder et al., 1980; Holmes & O'Regan, 1981; Cohen & Mehler, 1996; Gouvea et al., 2002; Hebrew: Arnon, 2005, 2006).

To explain the processing advantage of subject over object relatives in English and possibly in other languages, various hypotheses have been proposed: the accessibility hierarchy (Keenan & Comrie, 1977), perspective shift (MacWhinney, 1982), phrase-structural complexity (O'Grady, 1997; cf. Hawkins, 2004), linear filler-gap distance (Gibson, 2000), statistical regularity of word order (MacDonald & Christiansen, 2002), and similarity effects of NPs (Gordon et al., 2001). All of these accounts make the same prediction for English: SRs should be easier to process than ORs. However, these predictions differ for backward syntactic dependencies in Korean subject (1.8) and object relative clauses (1.9).

(1.8) SRs in backward syntactic dependencies

[$\_\__i$	pyencipcang-ul	hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
	editor-ACC	threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor met a journalist yesterday.'

(1.9) ORs in backward syntactic dependencies

[pyencipcang-i	$\_\__i$	hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
editor-NOM		threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who the editor threatened met a journalist yesterday.'

In other words, while processing models that rely on assumed language universals (i.e., the *accessibility hierarchy* and the *phrase-structural distance hypothesis*) predict the same asymmetry for all configurational languages, models that calculate processing difficulty based on surface features (i.e., surface word order and linear distance) predict different patterns of processing asymmetry for syntactic dependencies with different word orders. Accordingly, the processing of backward syntactic dependencies should have implications for processing models based primarily on forward syntactic dependencies.

In addition, this dissertation investigates how typological surface differences map onto cognitive/neural mechanisms underlying the processing of long-distance dependences. In particular, given that ERPs (event-related brain potentials) can provide qualitative information with millisecond temporal precision, a comparison of the neuro/cognitive processes underlying the processing of filler-gap dependencies with different filler-gap ordering (i.e., forward syntactic dependencies as in English relatives and backward syntactic dependencies as in Korean relatives) using ERPs should further our understanding of independent factors contributing to language comprehension.

In summary, I explore the following questions in Chapter 4, using self-paced reading time, eye-tracking and ERP methodologies.

(i) Which of these accounts proposed for English is most appropriate as a universal processing strategy?

(ii) To what extent are the neuro/cognitive operations underlying the processing of forward syntactic dependencies in post-nominal relative clauses (in which a head noun precedes the relative clause, as in English) similar to those underlying the processing of backward syntactic dependencies in pre-nominal relative clauses (in which a relative clause precedes its head noun, as in Korean)?

1.3 Backward Syntactic and Anaphoric Dependencies

Based on the experimental results described in the previous section, the second series of experiments further compares the parsing of backward syntactic and anaphoric dependencies using relative and *–se* 'because' adjunct clauses in Korean.

In forward syntactic dependencies, a filler always precedes its gap, as repeated below from (1.2).

(1.10) Forward syntactic dependency
The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.
FILLER GAP

Accordingly, the preceding filler along with a relative pronoun strongly signals the presence of a relative clause, and the parser actively predicts a possible gap position. The *active filler strategy* describes this filler-driven dependency in the processing of relative clauses in English.

(1.11) Active filler strategy (AFS)
When a filler has been identified, rank the option of assigning it to a gap above all other options.

(Frazier & Clifton, 1989: 95)

Similarly, previous studies have suggested that the processing of backward anaphoric dependencies is also driven by an active search mechanism, just as syntactic dependencies are (Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007). Thus, when the parser encounters an overt pronoun, it actively searches for a potential antecedent. When the morphological features of the potential antecedent are not compatible with those of the available pronouns, as in (b) below, processing slow downs.

(1.12) van Gompel and Liversedge (2003), Experiment 1
(a) When he was fed up, the boy visited the girl very often. (gender matched)
(b) When he was fed up, the girl visited the boy very often. (gender mismatched)

However, while these results provide clear evidence for similar parsing of anaphoric and syntactic dependencies, English does not allow a direct comparison between these two types of dependencies, due to the word order differences. Therefore, more fine-grained information on processing similarity/dissimilarity is not obtainable. Thus, in the second series of experiments, I further investigate the similarities and dissimilarities of processing these two types of long-distance dependencies in Korean, where direct comparison of these two types of dependencies is possible. To that end, I investigate the processing of relative clauses (i.e., backward syntactic dependencies) and –*se* 'because' adjunct clauses (i.e., backward anaphoric dependencies) with subject and object gaps, as shown below.

(1.13) Backward subject syntactic dependency

___$_i$	Mary-lul	koyongha-n	Tom$_i$ -un	yumyenghaysi-ess-ta
	Mary-ACC	employ-REL	Tom-TOP	get.famous-PST-DECL

'Tom who hired Mary got famous'

(1.14) Backward object syntactic dependency

Mary-ka	___$_i$	koyongha-n	Tom$_i$ -un	yumyenghaysi-ess-ta
Mary-NOM		employ-REL	Tom-TOP	get.famous-PST-DECL

'Tom who Mary hired got famous'

(1.15) Backward subject anaphoric dependency

___$_i$	Mary-lul	koyongha-n	Tom$_i$ -un	yumyenghaysi-ess-ta
	Mary-ACC	employ-because	Tom-TOP	get.famous-PST-DECL

'Because (he$_i$) hired Mary, Tom$_i$ got famous'

(1.16) Backward object anaphoric dependency

Mary-ka	___$_i$	koyongha-n	Tom$_i$ -un	yumyenghaysi-ess-ta
Mary-NOM		employ-because	Tom-TOP	get.famous-PST-DECL

'Because Mary hired (him$_i$), Tom$_i$ got famous.'

The goal of the first experiment is to compare the processing profiles of backward syntactic and anaphoric dependencies in terms of the subject/object processing asymmetry. That is, the experiment investigates whether anaphoric dependencies also exhibit a subject/object asymmetry similar to syntactic dependencies, and if so, whether there is any difference in the processing profiles of the two types of dependencies. In fact, subject/object gap processing asymmetry has been solely investigated in syntactic dependencies. In view of this, the investigation of a potential subject/object asymmetry in anaphoric dependencies should also have implications for processing models developed based entirely on syntactic dependencies.

In addition, in the second experiment, I further investigate to what extent cognitive/neural processes underlying backward syntactic and anaphoric dependencies are similar to each other. This is done by comparing the processing of ORs (1.14) and adjunct clauses with object argument-drop (1.16) using ERP methodology. In particular, given different coindexation requirements of the gap and filler in syntactic dependencies (i.e., syntactic licensing) and gap-antecedent in anaphoric dependencies (i.e., semantic licensing), the investigation of the processing of the anaphoric and syntactic dependencies should further understanding of parsing strategies underlying long-distance dependencies in general.

In summary, the two specific questions I consider are as follows:

i) Does the subject/object processing asymmetry that has been found for syntactic dependencies emerge in backward anaphoric dependencies (argument-drop sentences) as well?

ii) If so, to what extent are the cognitive/neural processes underlying long-distance dependencies in different constructions the same?

1.4 Dissertation Chapter Overview

The organization of the dissertation is as follows:

Chapter 2 first presents a grammatical description of Korean relative clauses. Syntactic analyses of relative clauses in general are then discussed in terms of head NP raising, *wh*-operator movement, and matching analyses, along with unselective binding and gapless adposition analyses. Using primary linguistic data, including judgments collected using magnitude estimation, I argue that the Korean relative clause construction is best accounted for under a null argument analysis.

Chapter 3 presents background material in relation to long-distance dependencies and experimental methodologies. Previous experimental findings on syntactic and anaphoric dependencies are explored. In addition, a detailed introduction to various processing models is presented. Finally, a general overview of ERP experimental methodology and language-related ERP components is given.

Chapter 4 focuses on investigating the processing of Korean relative clauses with various head noun types (subject, object, and possessive) and gap types (subject and object) using reading time experiments. The results of a corresponding ERP experiment focused on SRs and ORs with possessive head nouns are also presented. Based on the reading time and ERP responses to ORs in comparison to SRs, I argue that backward syntactic dependencies in Korean relatives show a processing advantage for SRs, just as forward syntactic dependencies in English relatives do. I also propose that processing models based on language universals such as *phrase-structural distance* and the *accessibility hierarchy* serve as a universal processing constraint on filler-gap dependencies.

Chapter 5 compares the processing of backward syntactic and anaphoric dependencies using Korean relative and adjunct clause sentences with subject and object gaps. Experimental results of the self-paced reading time study show that object gap sentences are harder to process than subject gap sentences, regardless of long-distance dependency type. This result is taken to indicate that a similar parsing constraint (i.e., *phrase-structural distance* and *accessibility hierarchy*) applies to both syntactic and anaphoric dependencies. In addition, the reading time and ERP results show that the processing of backward anaphoric dependencies is driven by the active search mechanism, just as syntactic dependencies are. Different parsing strategies, however, were also observed. This was attributed to different gap-filler/antecedent association requirements in syntactic and anaphoric dependencies.

Chapter 6 concludes.

Chapter 2: Syntactic Analysis of Relative Clauses

This chapter provides a brief introduction to Korean grammar and present syntactic analysis of Korean relative clauses.

2.1 Description of Korean Relative Clauses

2.1.1 Basic Korean Grammar

2.1.1.1 Word Order

Korean is a head-final language with Subject-Object-Verb (henceforth, SOV) word order. Verbs are not inflected for the grammatical categories of their arguments. Instead, grammatical roles of clause constituents are indicated by case marking (some researchers treat these markers as postposition, cf. Sohn, 1999). The case system includes nominative (-*i/ka*), accusative (-*ul/lul*), genitive (-*uy*), dative (-*ey/eykey*), goal (-*ey/eykey*), locative (-*ey/eyse*), source (-*ulopwuthe/eyse*), and instrumental (-*ulo*) markers.

(2.1) sensayngnim-i ku haksayng-ul cohahanta
teacher-NOM that student-ACC like
'The teacher likes the student.'

2.1.1.2 Agglutination

Korean is an agglutinative language. Inflectional suffixes are attached to verbs, marking subject honorification, tense/aspect, modal, addressee honorific, mood and sentence type – but not person or number agreement – in the order given (for further information on these sentence enders, see Sohn, 1999).

(2.2) sensayngnim-kkyse cohaha-si-ess-kyess-sup-ni-ta
teacher-HON.NOM like-SUBJ.HON-PST.TENSE-MODAL-ADDR.HON-MOOD-DECL
'The teacher must have liked (it).'

In the example above, the rightmost marker (*-ta*) indicates the illocutionary force of the sentence and can only occur in root clauses. The suffix *-ni*/(*nu*)*n-* expresses indicative mood in declaratives and interrogatives. In this sentence (2.2) the modality suffix *-kyess-* indicates the speaker's conjecture. Finally, there are two different slots for the honorific markers, *-sup-* (indicating politeness towards the addressee) and *-si-* (politeness toward the referent of the subject).

2.1.1.3 Scrambling

Although the canonical word order is SOV, word order is not fixed. As long as the verb is in the sentence-final position, scrambling is freely allowed, as shown in (2.3).

(2.3) Scrambling in a main clause

'John ate the meal in a hurry at school.'

a.	John-i	hakkyo-eyse	pap-lul	ppalli	mek-ess-ta
	John-NOM	school-from	meal-ACC	in.a.hurry	eat-PST-DECL
b.	John-i	hakkyo-eyse	ppalli	pap-lul	mek-ess-ta
c.	John-i	pap-lul	ppalli	hakkyo-eyse	mek-ess-ta
d.	John-i	pap-lul	hakkyo-eyse	ppalli	mek-ess-ta
e.	John-i	ppalli	hakkyo-eyse	pap-lul	mek-ess-ta
f.	John-i	ppalli	pap-lul	hakkyo-eyse	mek-ess-ta
g.	hakkyo-eyse	pap-lul	ppalli	John-i	mek-ess-ta
h.	hakkyo-eyse	pap-lul	John-i	ppalli	mek-ess-ta
i.	hakkyo-eyse	ppalli	John-i	pap-lul	mek-ess-ta
j.	hakkyo-eyse	ppalli	pap-lul	John-i	mek-ess-ta
k.	hakkyo-eyse	John-i	pap-lul	ppalli	mek-ess-ta
l.	hakkyo-eyse	John-i	ppalli	pap-lul	mek-ess-ta
m.	pap-lul	ppalli	John-i	hakkyo-eyse	mek-ess-ta
n.	pap-lul	ppalli	hakkyo-eyse	John-i	mek-ess-ta
o.	pap-lul	John-i	hakkyo-eyse	ppalli	mek-ess-ta
p.	pap-lul	John-i	ppalli	hakkyo-eyse	mek-ess-ta
q.	pap-lul	hakkyo-eyse	ppalli	John-i	mek-ess-ta
r.	pap-lul	hakkyo-eyse	John-i	ppalli	mek-ess-ta
s.	ppalli	John-i	hakkyo-eyse	pap-lul	mek-ess-ta
t.	ppalli	John-i	pap-lul	hakkyo-eyse	mek-ess-ta
u.	ppalli	hakkyo-eyse	pap-lul	John-i	mek-ess-ta
v.	ppalli	hakkyo-eyse	John-i	pap-lul	mek-ess-ta

w.	ppalli	pap-lul	John-i	hakkyo-eyse	mek-ess-ta
x.	ppalli	pap-lul	hakkyo-eyse	John-i	mek-ess-ta

Scrambling in Korean is not restricted to main clauses. It is also allowed within an embedded clause, as in (2.4).

(2.4) Scrambling within an embedded clause
'Tom said that Bob met Mary.'

a.	Tom-i	[Bob-i	Mary-lul	manna-ss-ta-ko]	malhay-ss-ta
	Tom-NOM	[Bob-NOM	Mary-ACC	meet-PST-DECL-COMP]	say-PST-DECL
b.	Tom-i	[Mary-lul	Bob-i	manna-ss-ta-ko]	malhay-ss-ta

If, as a result of scrambling, the verb would not be in sentence final position, the result is ungrammatical as in (2.5).

(2.5) Scrambling of a verb

a.	*John-i	ppalli	pap-lul	mek-ess-ta	hakkyo-eyse

2.1.1.4 *Pro*-drop

Korean is a *pro*-drop language, in which arguments can be omitted, as shown in (2.6) and (2.7). In these examples, the subject and object are dropped, respectively.

(2.6)	*pro*	Mary-lul	manna-ss-ta
		Mary-ACC	meet-PST-DECL

'(Someone) met Mary.'

(2.7)	John-i	*pro*	manna-ss-ta
	John-NOM		meet-PST-DECL

'John met (someone)'

The referent of *pro* can be identified in a given context, as shown in (2.8), where *pro* can be coindexed with the topic, *Yenghuy*.

(2.8) ‘Yenghuy came home. And (she) ate meal.’
Yenghuy$_i$-ka cip-ey wassta. kuliko *pro*$_i$/kunye$_i$-nun pap-ul mekessta.
Y-NOM home-to came And *pro*/she-TOP meal-ACC ate

Alternatively, it can refer to people in general (without specific referents) (2.9).

(2.9) *pro* referring general people
pro Seoul-eyse-nun cha-lul cosimsulepkey wuncenhayyaha-n-ta
Seoul-at-TOP car-ACC carefully should.drive-IN-DECL
‘One should drive a car carefully in Seoul.’

Both subject- and object-drop are frequent in Korean. According to Y.J. Kim (2000), the subject-drop rate is 69% in spoken language and 49% in written language, and the object-drop rate is 46% in spoken language.[1]

In addition, a null expletive is also used when describing weather, temperature, distance, as in (2.10) to (2.12).

(2.10) *pro* in weather expressions
pro hwachangha-ta
be_clear-DECL
‘It is clear.’

(2.11) *pro* in temperature expressions
pro chwup-ta
be_cold-DECL
‘It is cold.’

(2.12) *pro* in distance
pro mel-ta
be_distant-DECL
‘It is far.’

[1] The object-drop rate in written corpora has not yet been fully researched. However, a small scale corpus study using a movie magazine in the Seyjong corpus (2002) with 26,749 *ejel* – a unit in writing that is typically composed of at least one free morpheme and additional dependent morpheme(s) –revealed that within relative clauses, 6% of objects were omitted (14 out of 251 instances).. On the other hand, 42% of

2.1.2 Prenominal Relative Clauses

In Korean, embedded clauses come before the main clause, and this applies to relative clauses as well. Thus, unlike in English, relative clauses in Korean precede the head noun (2.13).

(2.13) Prenominal relative clauses

[__$_i$	Yenghuy-lul	hakkyo-eyse	mannan]	sensayngnim$_i$
	Y-ACC	school-at	met	teacher

'the teacher who met Yenghuy at school'

2.1.3 Relative Clause Ender

Korean relative clauses lack a relative pronoun, a typological feature associated with prenominal relatives (Downing, 1978; Keenan, 1985). Instead, an adnominal marker is suffixed to the relativized verb to signal that the clause modifies a noun. The form of the adnominal marker differs depending on the linguistic environment. If it occurs after a syllable ending with a vowel, -*n* is used (2.14). If it occurs after a syllable ending with a consonant, -*un* is used (2.15). Finally, if it occurs after a prospective suffix, ZERO ø is used (2.16) (Sohn, 1999).

(2.14) Adnominal marker –*n* in relative clause

[__$_i$	Yenghuy-lul	hakkyo-eyse	manna-**n**]	sensayngnim$_i$
	Y-ACC	school-at	meet-**ADN**	teacher

'the teacher who met Yenghuy at school'

(2.15) Adnominal marker –u*n* in relative clause

[__$_i$	Yenghuy-lul	hakkyo-eyse	mak-**un**]	sensayngnim$_i$
	Y-ACC	school-at	stop-**ADN**	teacher

'the teacher who stopped Yenghuy at school'

---

subjects were omitted within relative clauses (i.e., 62 out of 108 instances). For a discussion of detailed procedures of this corpus study, please refer to Section 4.2.1.7.2.

(2.16) Adnominal marker ZERO in relative clause

[$\_\_\_{}_i$	Yenghuy-lul	hakkyo-eyse	manna-**l-ø**]	sensayngnim$_i$
	Y-ACC	school-at	meet-PRS-**ADN**	teacher

'the teacher who will meet Yenghuy at school'

In addition to the adnominal marker, relative clauses are also marked for tense/aspect. Accordingly, an adnominal marker along with its preceding tense/aspect and/or mood suffixes comprises the relative clause ender. Relative clause enders for verbs and adjectives (i.e., underlined parts in Table 2-1) are inflected slightly differently from each other for each tense/aspect/mood combination, as shown in Table 2-1.

Table 2-1 Relative clause enders

tense/aspect/mood	verbs	adjectives
(2.17) non-past	mek-nu-n eat-IN-ADN	coh-un be.good-ADN
(2.18) past	mek-un eat-ADN	
(2.19) prospective	mek-ul eat-PRS	coh-ul be.good-PRS
(2.20) past prospective	mek-ess-ul eat-PST-PRS	coh-ass-ul be.good-PST-PRS
(2.21) retrospective	mek-te-n eat-RT-ADN	coh-te-n be.good-RT-ADN
(2.22) past retrospective	mek-ess-te-n eat-PST-RT-ADN	coh-ass-te-n be.good-PST-RT-ADN

(modified from Sohn, 1999: 240)

However, the use of a relative clause ender (i.e., tense/aspect/mood marker + adnominal marker) is not exclusive to relative clauses. For example, in (2.23), the same ender is used to mark the sentential complement of the head noun *fact* (i.e., *fact*-CP).

(2.23) *fact*-CP clause

[*pro*	Yenghuy-lul	hakkyo-eyse	manna-nun]	sasil
	Y-ACC	school-at	meet-REL	fact

'the fact that (someone) meets Yenghuy at school'

2.1.4 Structural Ambiguity of a Gap

A gap in Korean is temporarily ambiguous as being part of a relative clause or as a dropped argument. For example, the sentence fragment in (2.24) could turn out to involve argument-drop in a simple clause, as in (2.25), or in a complex sentence, as in (2.26). Alternatively, it could be a part of a relative clause, as in (2.27).

(2.24) Structural ambiguity of a gap

[__	Yenghuy-lul	hakkyo-eyse...]			
	Y-ACC	school-at			

(2.25) *Argument-drop in a simple clause*

[*pro*	Yenghuy-lul	hakkyo-eyse	manna-ss-ta]		
	Y-ACC	school-at	meet-PST-DECL		

'(Someone) met Yenghuy at school.'

(2.26) *Argument-drop in a complex sentence*

[$pro_{i/k}$	Yenghuy-lul	hakkyo-eyse	manna-se]	Tom_i-un	tanghwangsulewe-ss-ta
	Y-ACC	school-at	meet-since	Tom-TOP	be.embarrassed-PST-DECL

'Since ($he_{i/k}$) met Yenghuy at school, Tom_i felt embarrassed.'

(2.27) A gap in relative clause

[$\_\_ _i$	Yenghuy-lul	hakkyo-eyse	manna-**n**]	$sensayngnim_i$	
	Y-ACC	school-at	meet-**REL**	teacher	

'the teacher who met Yenghuy at school'

Additionally, since a relative clause ender is also used for a sentential complement clause (2.23), the ambiguity of a gap as part of a relative clause or a dropped argument is not resolved until the head noun position, as can be seen in the comparison of (2.23) and (2.27).

2.1.5 Noun Phrase Accessibility Hierarchy in Korean

Based on data from approximately fifty languages, Keenan and Comrie (1977) proposed a *noun phrase accessibility hierarchy*, as shown in (2.28).

(2.28) Accessibility hierarchy
subject > direct object > indirect object > oblique > genitive > object of comparison

This hierarchy was proposed to represent the degree of accessibility to relative clause formation from different grammatical positions. That is, if a language allows relativization on a certain grammatical position, all the grammatical positions to its left allow relativization, while grammatical positions to its right do not necessarily do so. Furthermore, Keenan and Comrie (1977, 1979) discussed two different relativization strategies: the gap strategy, where the extraction position of a head noun is marked with a silent gap, as in (2.29), and the resumptive pronoun strategy, where the extraction position of the head noun is filled with a pronominal element, as in (2.30).

(2.29) Gap strategy
The reporter [who ___ attacked the senator]

(2.30) Resumptive strategy
This is the reporter [that the senator doesn't know who *he* attacked]

In discussing Korean, Keenan and Comrie (1977, 1979) suggested that Korean allows relativization up to the genitive position in the hierarchy, but it does not allow relativization of objects of comparison. Specifically, it was suggested that NPs that rank higher than genitives in the hierarchy such as subjects, direct objects, indirect objects, and obliques are relativized using the gap strategy, as shown in (2.31) to (2.34).

(2.31) Relativization of a subject: gap strategy

[__	Mina-lul	po-n]	namca
	Mina-ACC	saw-ADN	man

'the man who saw Mina'

(2.32) Relativization of a direct object: gap strategy

[Mina-ka	__	po-n]	namca
Mina-NOM		saw-REL	man

'the man who Mina saw'

(2.33) Relativization of an indirect object: gap strategy

[Mina-ka	na-lul	__	sokayhaycwu-n]	namca
Mina-NOM	I-ACC		introduce-REL	man

'the man to whom Mina introduced me'

(2.34) Relativization of an oblique: gap strategy

[Mina-ka	__	ppangkalwu-lul	thelenay-n]	chayksang
Mina-NOM		breadcrumbs-ACC	brushed.down-REL	desk

'the desk from which Mina brushed down breadcrumbs'

On the other hand, for genitives (i.e., NPs that rank low in the hierarchy), Keenan and Comrie suggested that they are relativized using the pronoun strategy rather than the gap strategy, as shown in (2.35) and (2.36) (Keenan & Comrie, 1977: 74).

(2.35) Relativization of a genitive: the resumptive pronoun strategy

[<u>ku/caki-uy</u>	kay-ka	chongmyenha-n]	namca
he/self-GEN	dog-NOM	smart-REL	man

'the man whose dog is smart

(2.36) Relativization of a genitive: gap strategy

*[__	kay-ka	chongmyenha-n]	namca
	dog-NOM	smart-REL	man

'the man whose dog is smart

For objects of comparison (i.e., NPs that rank lowest in the hierarchy), neither of the strategies can be used, since objects of comparison do not allow relativization in Korean, as shown in (2.37) and (2.38).

(2.37) Relativization of objects of comparison: the gap strategy

*[Mina-ka	__	te	chongmyenha-n]	namca
Mina-NOM		more	smart-REL	man

'the man who Mina is smarter than'

(2.38) Relativization of objects of comparison: the resumptive pronoun strategy

*[Mina-ka	ku/caki-pota	te	chongmyenha-n]	namca
Mina-NOM	he/self-than	more	smart-REL	man

'the man who Mina is smarter than'

In short, relativization in Korean can be summarized as follows:

Table 2-2 Keenan and Comrie (1977): Accessibility hierarchy in Korean

	subject	direct object	indirect object	oblique	genitive	object of comparison
gap strategy	+	+	+	+	−	−
resumptive pronoun strategy	−	−	−	−	+	−

+: allowed; −: not allowed

In fact, grammatical judgments can show slight divergence from the suggested pattern in Keenan and Comrie (1977). Some speakers allow the use of the gap strategy for relativization of genitive NPs, in addition to the resumptive pronoun strategy, especially with kinship terms such as *sibling*, as shown in (2.40).[2]

(2.39) Relativization of a genitive using a gap strategy

?[__	kay-ka	chongmyenha-n]	namca
	dog-NOM	smart-REL	man

'the man whose dog is smart

(2.40) Relativization of a genitive using a gap strategy

[__	tongsayng-i	uysa-i-n]	namca
	younger.sibling-NOM	doctor-is-REL	man

'the man whose younger sibling is a doctor'

[2] It is not clear, however, whether sentences (2.39) and (2.40) are derived from their counterpart double nominative construction. For example, the possibility of relativizing the first NP *namca* 'man' in (i) to derive sentence (2.40) is explored in Han and Kim (2004).

i)	namca-ka	tongsayng-i	uysa-i-ta
	man-NOM	sibling-NOM	doctor-is-DECL

'The man, his brother is a doctor.'

On the other hand, some speakers allow the pronominal strategy in relativizing obliques (2.41) in addition to the gap strategy (2.34).

(2.41) Relativization of an oblique: the pronoun strategy

[Mina-ka	keki-eyse	ppangkalwu-lul	thelenay-n]	chayksang
Mina-NOM	there-from	breadcrumbs-ACC	brushed.down-REL	desk

'the desk from which Mina brushed down breadcrumbs'

In addition, since obliques in Keenan and Comrie (1977) are actually defined as NPs that denote arguments of the main predicate (e.g., *the chest* in *John put the money in the chest*) (Keenan & Comrie, 1977: 66) but not as NPs that have more adverbial roles (e.g., *Chicago* in *John lives in Chicago* or *that day* in *John left on that day*) (Keenan & Comrie, 1977: 66), when the obliques of more adverbial functions are examined, slightly different patterns emerge. For example, for NPs denoting time and place, the gap strategy is preferred, as shown in (2.42) and (2.43).

(2.42) Relativization of an oblique (time)

[Mina-ka	__/*kuttay	yehayng-ul	ttena-n]	cinan	yelum
Mina-NOM	__/*then	travel-ACC	leave-REL	last	summer

'last summer when Mina left for travel'

(2.43) Relativization of an oblique (place)

[Mina-ka	__/?keki-eyse	Mary-lul	manna-n]	kongwon
Mina-NOM	__/?there-at	M-ACC	introduce-REL	park

'the park where Mina met me'

For NPs expressing manner and instrument, the resumptive pronoun strategy is preferred, as shown in (2.44) and (2.45).

(2.44) Relativization of an oblique (manner)

[Mina-ka	?__/ku kes-ulo	hakkyo-ey	thonghakha-n]	pesu
Mina-NOM	?__/that thing-with	school-to	go.to.school-REL	bus

'the bus by which Mina went to school'

(2.45) Relativization of an oblique (instrument)
[Mina-ka ?__/ku kes-ulo mos-ul pakk-un] mangchi
Mina-NOM ?__/that thing-with nail-ACC hit-REL hammer
'the hammer with which Mina hit the nail'

For NPs expressing reason, different relativization strategies seem to be preferred with different head nouns. For sentences with *iyu* 'reason' as their head noun, the gap strategy is preferred, while for sentences with other head nouns such as *somwun* 'rumor', the pronoun strategy is preferred.[3]

(2.46) Relativization of an oblique (reason)
[Mina-ka __/?ku ttaymwun-ey Mary-lul melliha-n] iyu
Mina-NOM __/?that reason-for M-ACC keep.at.a.distance-REL reason
'the reason for which Mina kept Mary

(2.47) Relativization of an oblique (reason)
[Mina-ka *__/ku ttaymwun-ey Mary-lul melliha-n] somwun
Mina-NOM *__/that reason-for M-ACC keep.at.a.distance-REL rumor
'the rumor for which Mina kept Mary at a distance'

In summary, the following revisions can be made to Table 2-2 with regard to obliques.

	subject	direct object	indirect objectz	oblique	genitive	object of comparison
gap strategy	+	+	+	+/−	+/−	−
resumptive pronoun strategy	−	−	−	+/−	+/−	−

+: allowed; −: not allowed

[3] However, the reason for this is not clear. One possibility could be that the semantics of *iyu* 'reason' clearly indicates the relationship between the head noun and the relative clause, while the semantics of *somwun* 'rumor' does not, and hence the resumptive pronominal element within the relative clause is required to clarify the relationship between the head noun and the relative clause. In addition, it has been noted that reason adverbials are likely to be base generated in a very high position in the clause (Rizzi, 1990), possibly easing the interpretation of the relation between the head noun and the relative clause. This is an area for further research.

Furthermore, relativization strategies (i.e., gap strategy vs. resumptive pronoun strategy) interact with the degree of recursion. For example, NPs whose grammatical relations are higher in the accessibility hierarchy (i.e., subject, direct object and indirect object) can be relativized using both the pronominal and gap strategies when the embedding is recursive, as shown from (2.48) to (2.50).

(2.48) Relativization of subject within an embedded clause
[Mary-ka [**__/ku-ka** mikwuk-ulo ttenassta-ko] sayngkakha-n] sensayngnim
[M-NOM [__/he-NOM America-to left-COMP] think-REL] teacher
'the teacher who [Mary thought [that __ left for America]]'

(2.49) Relativization of direct object within an embedded clause
[Mary-ka [Tom-i **__/ku-lul** kosohayssta-ko] sayngkakha-n] wuncensa
[M-NOM [T-NOM __/he-acc sued-COMP] think-REL] driver
'the driver whom [Mary thought [that Tom sued __]]'

(2.50) Relativization of indirect object within an embedded clause
[Mary-ka [Tom-i **__/ku-eykey** senmwul-lul ponayssta-ko] sayngkakha-n] haksayng
[M-NOM [T-NOM __/he-to present-ACC sent-COMP] think-REL] student
'the student whom [Mary thought [that Tom sent __ a present]]'

Accordingly, a final revision can be made to Table 2-2.

Table 2-3 Relativization from main and embedded clauses in Korean

		subject	direct object	indirect object	oblique	genitive	object of comparison
relativization from main clause	gap strategy	+	+	+	+/–	+/–	–
	resumptive pronoun strategy	–	–	–	+/–	+/–	–
relativization from embedded clause	gap strategy	+/–	+/–	+/–	+/–	+/–	–
	resumptive pronoun strategy	+/–	+/–	+/–	+/–	+/–	–

In fact, in some accounts, the gap strategy is equated with the use of a null resumptive pronoun. For example, Japanese allows argument drop, and the gap within the relative clause is considered to be this null argument (Comrie, 1998; Matsumoto, 1997) (see Section 2.3.2 for details). Since Korean also allows argument drop, as presented in Section 2.1.1.4, the logic that was applied to Japanese seems to be valid for Korean as well. In Section 2.3.2, however, I show that a gap in Korean relative clauses is not a null resumptive pronoun.

In summary, overall, relativization in Korean is consistent with the accessibility hierarchy of Keenan and Comrie (1977). In addition, it was shown that the degree of accessibility interacts with the type of relativization strategy. That is, NPs that rank higher in the accessibility hierarchy (i.e., subjects, direct objects and indirect objects) are more likely to be relativized using the gap strategy. On the other hand, NPs that rank lower in the accessibility hierarchy (i.e., genitives and some obliques) are more likely to be relativized using the resumptive pronoun strategy. Finally, it was also shown that when relativization is formed on arguments within the embedded clause, even NPs that are higher in the accessibility hierarchy (i.e., subjects, direct objects and indirect objects) can be relativized using the resumptive pronoun strategy.

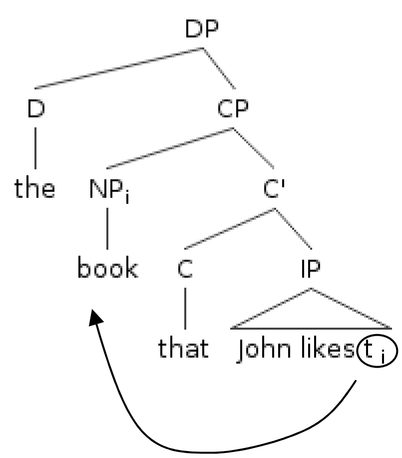
2.2 Existing Analyses of English Relative Clauses

This section presents syntactic analyses that have been proposed for English relative clauses—these analyses will then be assessed in their application to Korean. The three types of analyses presented are head NP raising, *wh*-operator movement and matching analysis.

2.2.1 Head NP Raising (Promotion) Analysis

In the raising analysis, the head NP is directly linked with the relative clause-internal position by movement (Afarli, 1994; Bhatt, 2002; Bianchi, 2000; Brame, 1968; Kayne, 1994; Schachter, 1973; Vergnaud, 1974). This view has recently received renewed attention since Kayne (1994). In Kayne's version of this analysis, the head NP raises to the specifier position of the complementizer phrase (i.e., Spec of CP), which serves as a complement to the D (determiner) of a head noun, leaving a trace within relative clause (2.51).

(2.51) Raising of head noun
[$_{DP}$ the [$_{CP}$ [$_{NP}$ book]$_i$ that [John likes t$_i$]]

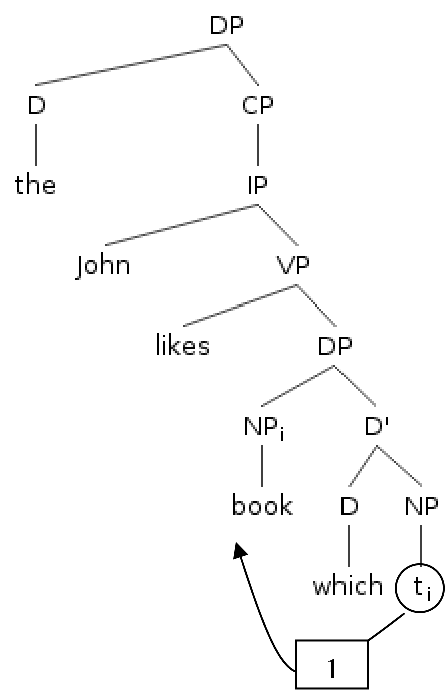


When a relative clause has a relative pronoun, *which*, as in (2.52), the derivation proceeds in two steps.

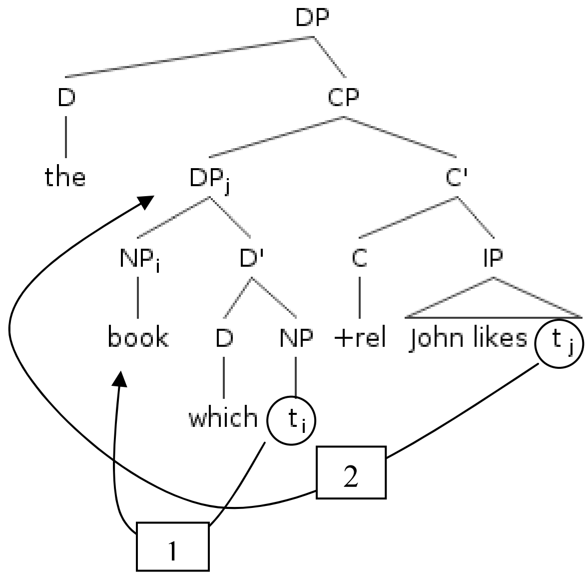
(2.52) Relative clause with a relative pronoun
the book ***which*** John likes

First, the NP complement of D within the relative clause moves to Spec of DP, as shown in (2.53). Then the DP within the relative clause moves to the Spec of CP, as shown in (2.54).

(2.53) First step of the two-step derivation
[$_{DP}$ the [$_{CP}$ John likes [$_{DP}$ [$_{NP}$ book]$_j$ [which t_j]]]]



(2.54) Second step of the two-step derivation
[$_{DP}$ the [$_{CP}$ [$_{DP}$ [$_{NP}$ book]$_j$ [which t_j]]$_i$ [$_C$ John likes t_i]]



The raising analysis is mainly supported by the observation that the head NP is interpreted as if it were in the gap position within the relative clause. Below I present evidence in support of this analysis in terms of the distribution of idiom chunks, sentences involving anaphors and Principle B and C violations, and interpretations of adjectival modifiers.

The argument based on the distribution of idiom chunks relies on the assumption that idioms are interpreted in the lexicon as a constituent (Chomsky, 1993; Marantz, 1984), and thus interpretation is local. In other words, elements comprising idioms should be in a local relation to each other at the level of interpretation (i.e., in the minimalist framework, LF) for the idiomatic interpretation. Thus the idiomatic reading in (2.55) and (2.56) is taken to suggest that *track* and *headway* appear as complements of *keep* and *make,* respectively, inside the relative clause, and this would provide a strong argument for the raising analysis.

(2.55) The careful *track* that she's keeping of her expenses pleases me.
(Schachter, 1973)

(2.56) Mary praised the *headway* that John made.
(Hulsey & Sauerland, 2006)

The second argument is based on binding effects. In English, an anaphor in a head noun NP (e.g, *himself* from '*the picture of himself*') can be bound by an NP inside the relative clause (i.e., *John*), as shown in (2.57).

(2.57) I saw the picture of *himself*$_j$ that John$_j$ liked.

In the raising analysis, this is accounted for in terms of reconstruction. That is, the head NP, *the picture of himself*, undergoes reconstruction into the trace position inside the relative clause, where the antecedent, *John* c-commands the anaphor, *himself,* as shown in (2.58).[4]

(2.58) I saw [the picture of *himself*]$_j$ that John liked t$_j$.

[4] Under Reinhart & Reuland (1993)'s analysis, these sentences contain logophors and not anaphors, and thus do not provide support for the raising analysis. In other words, Ns (i.e., *picture*) lack an external argument (i.e., subject) and thus, given the definitions below, do not form a syntactic predicate. Since a SELF anaphor in (2.58) is an argument of a head which does not form a syntactic predicate, it is logophoric.

a. The syntactic predicate: the syntactic predicate formed of (a head) P is P, all its syntactic arguments, and an external argument of P (subject).
b. The syntactic argument: the syntactic arguments of P are the projections assigned θ-role or Case by P.
c. A predicate is reflexive iff two of its arguments are coindexed.
d. A predicate (formed of P) is reflexive-marked iff either P is lexically reflexive or one of P's arguments is as SELF anaphor.

(Reinhart & Reuland, 1993: 678)

The third argument in support of the raising analysis comes from Principle B (2.59) and Principle C (2.60) violations.

(2.59) *the portrait of him$_i$ that John$_i$ painted.
(2.60) *?the portrait of John$_i$ that he$_i$ (thinks that Mary) painted.[5]
(Alexiadou et al., 2000)

Given that the pronoun *him* in (2.59) is not c-commanded by *John* within the relative clause, sentence (2.59) does not seem to violate Principle B. Likewise, given that the personal name NP *John* in (2.60) is seemingly out of the scope of the pronoun *he* within the relative clause as well, sentence (2.60) does not seem to violate Principle C. However, the ungrammaticality of (2.59) and (2.60) under the co-indexed interpretation of *him* and *John* in (2.59) and *John* and *he* in (2.60) suggests that the head noun NPs in these sentences are interpreted in the gap position within the relative clauses, leading to violation of Principles B and C, respectively, as shown in (2.61) and (2.62).

(2.61) *<u>[the portrait of him$_i$]</u>$_j$ that John$_i$ painted t$_i$.

(2.62) *?<u>[the portrait of John$_i$]</u>$_j$ that he$_i$ (thinks that Mary) painted t$_j$

The final argument in favor of the raising analysis comes from the interpretation of adjectival modifiers. Bhatt (2002) notes that sentences (2.63) and (2.64) are ambiguous between low and high readings of the adjectival modifiers.

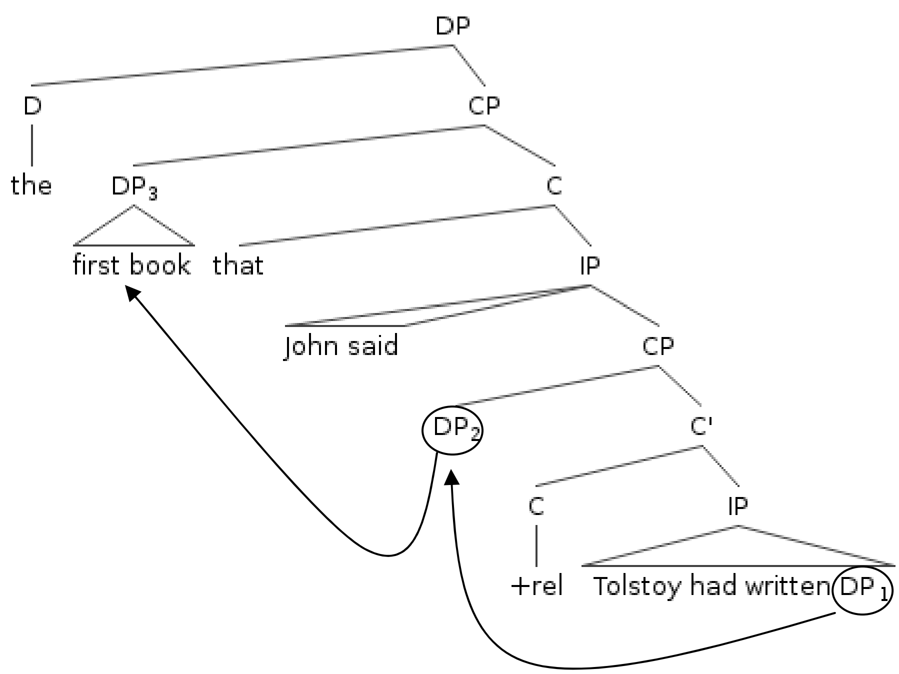
[5] The grammaticality of Principle C violation varies among different authors. While Alexiadou et al. evaluate this sentence as ungrammatical and take the ungrammaticality as a supporting argument for the raising analysis, the same construction is rated as grammatical and used to support the matching analysis in Hulsey and Sauerland (2006).

(2.63) the first book that John said Tolstoy had written
Low reading: 'X is the first book that Tolstoy wrote'
High reading: 'X is the first book about which John said that Tolstoy has written X'

(2.64) the only book that John said that Tolstoy had written
Low reading: 'X is the only book that Tolstoy wrote'
High reading: 'X is the only book about which John said that Tolstoy has written X'

In the raising analysis, this ambiguity between low and high readings is accounted for in terms of structural positions that the head NP takes in the course of the derivation. That is, the head NP originates inside the relative clause and moves to its surface position, forming a movement chain. Thus, depending on which copy of the head NP is interpreted, both low and high readings are obtained. For example, in (2.65), when *first book* is interpreted in the DP_1 position, the low reading is obtained, while the high reading is obtained when *first book* is interpreted in the DP_2 position.

(2.65) Derivation of sentence (2.63)



In summary, in the raising analysis, the head noun NP originates in a position within the relative clause and moves to its surface position, forming a movement chain. This analysis is mainly supported by reconstruction effects. That is, the connectivity between the head NP and the gap position within the relative clause, as in the case of idiom chunks, anaphor distribution, Principle B and C violations and scopal readings of adjectival modifiers, requires the interpretation of head noun NPs within the relative clause, motivating the raising analysis.

2.2.2 Wh-movement (Operator-movement) Analysis

In this analysis, the head NP does not originate inside the relative clause, but rather is base-generated outside of the relative clause (Chomsky, 1977; Montague, 1974; Partee, 1975; Quine, 1960). Yet relative clauses are still analyzed as involving movement, such that the *wh*-constituent undergoes movement to Spec of CP and adjoins to the head NP, as in (2.66).

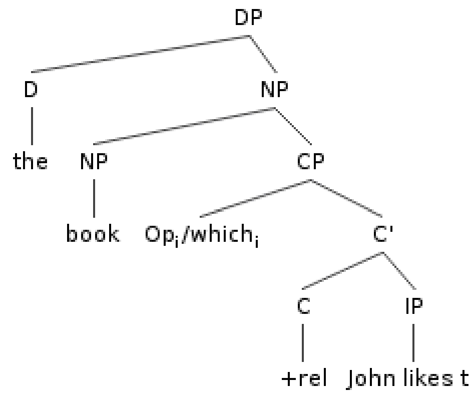
(2.66) [$_{DP}$ the book [$_{CP}$ which$_i$ [$_{C}$ [$_{IP}$ John likes t$_i$]]]]

When there is no overt *wh*-constituent as in (2.67) and (2.68), a silent *wh*-operator (Op) undergoes covert movement to Spec of CP (Chomsky, 1981).

(2.67) [$_{DP}$ the book [$_{CP}$ Op$_i$ [$_{C}$ that [$_{IP}$ John likes t$_i$]]]]
(2.68) [$_{DP}$ the book [$_{CP}$ Op$_i$ [$_{C}$ [$_{IP}$ John likes t$_i$]]]]

The interpretation of a relative clause is achieved by the predication relation between the external head noun and adjoined relative CP (Browning, 1987; Chomsky, 1977; Chomsky, 1982). The proposed structure is presented in (2.69).

(2.69)



This analysis is mostly supported by the parallelism between *wh*-questions and relative clauses (Chomsky, 1977). That is, like *wh*-interrogatives, relative clauses exhibit the properties of unbounded dependencies. Apart from performance constraints like limitations on working memory capacity, this movement, in principle, is unbounded both in *wh*-interrogatives (2.70) and in relative clauses (2.71).

(2.70) [$_{CP}$ What$_i$ was he reading t_i]?
[$_{CP}$ What$_i$ did you say [$_{CP}$ that he was reading t_i]]?
[$_{CP}$ What$_i$ does she believe [$_{CP}$ that you said [$_{CP}$ that he was reading t_i]?]]
[$_{CP}$ What$_i$ do they think [$_{CP}$ that she believes [$_{CP}$ that you said [$_{CP}$ that he was reading t_i]]]]?

(2.71) [$_{CP}$ the book which$_i$ he was reading t_i]
[$_{CP}$ the book which$_i$ you said [$_{CP}$ that he was reading t_i]]
[$_{CP}$ the book which$_i$ she believes [$_{CP}$ that you said [$_{CP}$ that he was reading t_i]?]]
[$_{CP}$ that book which$_i$ they think [$_{CP}$ that she believes [$_{CP}$ that you said [$_{CP}$ that he was reading t_i]]]]

In addition, relative clauses, just like *wh*-interrogatives, show sensitivity to the island constraints noted by Ross (1967). Ross argued that despite the seemingly "unbounded" movement of *wh*-phrase, there are constraints on its distribution, such that *wh*-phrases cannot be extracted from a complex NP, indirect question, coordinate structure, possessive NP or sentential subject, as shown in (2.72) to (2.76).

(2.72) John made the claim that he read Jane Eyre.
?What$_i$ did John make the claim that he read t$_i$?

(2.73) She knows which question they answered in a rude way.
*How$_i$ does she know which question they answered t$_i$?

(2.74) Mary ordered cheese cake and soda.
*What$_i$ did Mary order t$_i$ and soda?

(2.75) John saw Mary's brother.
*Whose$_i$ did John see t$_i$ brother?

(2.76) That John passed the test surprised his family.
*What$_i$ did that John passed t$_i$ surprise his family?

Similarly, relative clauses are also subject to these constraints.

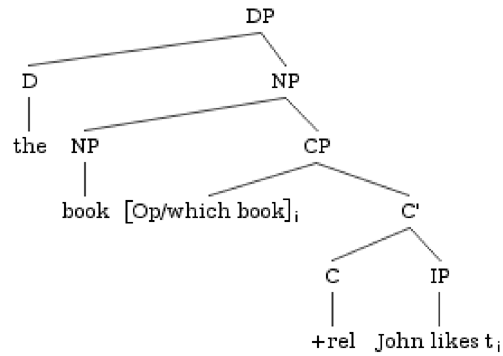
(2.77) ?The book which$_i$ John made the claim that he read t$_i$ is Jane Eyre.
(2.78) *?The way [by which]$_i$ she knows which question they answered t$_i$
(2.79) *The dessert which$_i$ Mary ordered t$_i$ and soda was cheese cake.
(2.80) *The man whose$_i$ John saw t$_i$ brother was Mary.
(2.81) *The test which$_i$ John passed t$_i$ surprised his family was actually very easy.

To summarize, in the *wh*-movement analysis, the head NP is base-generated external to the relative clause and thus is not a part of a movement chain. Instead, only the operator is analyzed to undergo movement.

2.2.3 Matching Analysis

The matching analysis is similar to the early form of the *wh*-movement analysis (Carlson, 1977). In this analysis, as in the *wh*-movement analysis, the external head is base-generated outside of the relative clause CP. However, unlike the *wh*-movement analysis (but similar to the raising analysis), the matching analysis postulates an internal representation of the external head within the relative clause, which is phonologically deleted by ellipsis (Chomsky, 1965; Lees, 1965; Sauerland, 1998, 2000).

(2.82) The book [$_{CP}$ [Op/which $_{book}$]$_i$ John likes t$_i$]



The matching analysis is motivated by the observation that although it is necessary to interpret the head internal to the relative clause, the external head NP is also necessary. One argument for the matching analysis comes from binding effects. It has been noted that although an anaphor in a head NP can be bound by an NP within a relative clause (2.83), a referential NP within the same environment does not lead to a Principle C violation (2.84) (Hulsey & Sauerland, 2003; Sauerland, 2000). The absence of a Principle C violation in a relative clause (2.84) contrasts with a *wh*-question sentence (2.85), where reconstruction leads to ungrammaticality of the sentence, due to a Principle C violation.

(2.83) Mary liked the picture of himself$_i$ that John$_i$ sent

(2.84) Which is the picture of John$_i$ that he$_i$ likes?

(2.85) *Which picture of John$_i$ does he$_i$ like?

The absence of a Principle C violation cannot be accounted for by the raising analysis, since the absence of the effect suggests that the head noun is external to the relative clause. On the other hand, the binding of the reflexive in (2.83) cannot be accounted for by the external head noun hypothesis, either, since the binding effect suggests that the head NP is internal to the relative clause. Thus, these data are taken to support a matching analysis.[6]

The second piece of evidence for the matching analysis comes from the interpretation of idioms. There are cases where idioms are licensed external to relative clauses, as in (2.86) and (2.87).

(2.86) We made headway that was sufficient.
(Bhatt, 2002)

(2.87) John pulled the strings which got Bill the job.
(Aoun & Li, 2003)

While this example cannot be handled in the raising analysis, Bhatt (2002) argues that it can be handled in the matching analysis: (2.86) and (2.87) have an external head, and thus due to this local distribution of idiom chunks, idiomatic readings become available.

In summary, in the matching analysis, an empty operator raises to the initial position of the relative clause and semantically mediates the relationship between the relative clause and the head noun. There is, however, an internal representation of the external head NP within the relative clauses, and this is deleted by ellipsis.

2.2.4 Summary

In this section I presented three different analyses of relative clauses that assume movement: head NP raising, *wh*-movement and matching analyses. A comparison of the results is provided in Table 2-4.

[6] See Sauerland (2000) for a discussion of different reconstruction effects of Principles A and C.

Table 2-4 English RC Analyses and Supporting Evidence

Tests	Head NP Raising	*Wh*-movement	Matching
Idiomatic interpretation within the relative clause	√		
SELF anaphor binding	(√)		
Principle B	√		
Principle C	√		√
Interpretation of adjectival modification	√		
Head NP external to RC		√	√
Island sensitivity	√	√	
Idiomatic interpretation within the main clause		√	√

In fact, although these analyses differ from each other mainly in terms of the dependency formation between the head NP and the relative clause, it has been suggested that they are not mutually exclusive. For example, Bhatt (2002) and Hulsey & Sauerland (2006) argue that relative clauses are structurally ambiguous between head-raising and matching structures, while Aoun & Li (2003) argue for both operator-movement and raising. This suggests that two or more analyses could be responsible for the derivation of relative clauses in English. Accordingly, although these analyses focus on different characteristics of English relative clauses, there seems to be general agreement on the strong interpretational dependency between the head NP and the gap position within the relative clause, and the head NP and its argument position within the main clause. In addition, these analyses converge on a movement analysis of relative clauses, although they differ in the nature of the proposed movement (i.e., head NP vs. *wh*-movement). In the next section, I discuss Korean relative clauses, focusing on these analyses.

2.3 Syntactic Analysis of Korean Relative Clauses

In this section, I present an analysis of Korean relative clauses, as in (2.88).

(2.88) Korean relative clause

[$\_\_{}_i$	Mina-lul	po-n]	salam$_i$-un	Jwunho-i-ta
	Mina-ACC	saw-REL	person-TOP	Jwunho-is-DECL

'The person who saw Mina is Jwunho'

Analyses of Korean relative clauses have been controversial due to apparent differences from English. As noted above, there is a close resemblance between relative clauses (2.88) and *fact*-CP clauses (2.89) in Korean.

(2.89) Korean *fact*-CP clause

[__	Mina-lul	po-n]	sasil-i	palkhyeci-ess-ta
	Mina-ACC	saw-REL	fact-NOM	is.known.PST-DECL

'The fact that (someone) saw Mina became known'

In addition, Korean has gapless relative clauses, typically referred to as pseudo-relatives, as in Japanese (Kim, 1998a).

(2.90)

[sayngsen-i	tha-nun]	naymsay
fish-NOM	burn-REL	smell

'The smell of fish burning'

(2.91)

[ku-ka	swukcey-lul	an-ha-n]	kyelkwa
he-NOM	homework-ACC	not-do-REL	consequence

'The consequence of his not doing homework'

Most importantly, Korean relatives exhibit apparent insensitivity to island constraints. For example, Korean also seems to allow relativization out of another relative clause. Since this is a violation of the complex NP constraint, the grammaticality of sentences (2.92) and (2.93) has been taken to indicate that Korean relative clauses do not involve movement.

(2.92) [[_$_i$ _$_j$ nolayha-nun] moksoli$_j$-ka coh-un] ku salam$_i$-iumak sensayng-ita
sing-ADN voice-NOM be.good-REL that person-NOM music teacher-is
'That person who the voice with which (he) sings is good is a music teacher.'

(2.93) [Mira-ka [__$_i$ __$_j$ cacwu ka-nun] swulcip$_j$-ul alkoiss-nun] namca$_i$
Mira-NOM often go-ADN bar-ACC know-REL man
'a man$_i$ who Mira knows the bar that (he$_i$) often goes'

To account for this peculiar phenomenon of Korean relatives compared to English, at least three syntactic analyses have been proposed: gapless adposition, an embedded clause with argument-drop, and a movement analysis. In the following sections, I present each of these analyses in order to determine which analysis best accounts for Korean relative clauses. Before I discuss these analyses, however, I would like to show that the raising and matching analyses (discussed in section 2.2 above) are untenable in Korean.

2.3.1 Raising and Matching Analyses

The raising analysis of relative clauses is based on the movement of the head NP: the head NP originates in the embedded clause and raises to the Spec of CP (see Section 2.2.1). By contrast, in the matching analysis, the head noun is base-generated external to the relative clause, but there is also a representation of it within the relative clause (see Section 2.2.3). Thus, these two analyses are similar to each other in assuming a direct relationship between the head NP and the gap position within the relative clause. In this section, I show that Korean relative clauses do not involve head NP movement (contrary to the predictions of the raising analysis) nor do they contain a representation of the head noun within the relative clause (contrary to the predictions of the matching analysis). Evidence comes from idiomatic readings and the interpretation of adjectival modifiers.

The idea behind the idiomatic reading argument is that if the head noun originates in the relative clause (raising analysis) or if there is a representation of the head noun within the relative clause (matching analysis), an idiomatic reading of the head noun will be available as if it were in the relative clause (cf. the English data above in section 2.2.1). In Korean, however, the head noun does not provide an idiomatic reading within the relative clause. For example, 'drinking seaweed soup' in Korean (2.94) is an idiomatic expression, meaning that someone fails in an examination or in an election (2.96). When the sentence is relativized, however, it loses its idiomatic reading and only the literal meaning remains (2.95).

(2.94) Miyekkwuk-ul masi-ta
Sea.weed.soup-ACC drink-DECL
Lit. '(Someone) drinks seaweed soup'
Idiom: 'fail in an examination or election'

(2.95) Kim hwupo-nun senke-eyse miyekkwuk-ul masi-ess-ta
Kim candidate-TOP election-at sea.weed.soup-ACC drink-past-DECL
'Candidate Kim failed in the election.'

(2.96) #[Kim hwupo-ka $\_\__i$ senke-eyse masi-n] miyek.kwuk$_i$
Kim candidate-NOM election-at drink-REL sea.weed.soup
'The seaweed soup that Candidate Kim drank in the election'
*'The failure that Candidate Kim experienced in the election'

The reading contrast between and (2.97) and (2.98) illustrates the same point.

(2.97) pal-eps-nun mal-i chen-li ka-n-ta
foot-not.have-REL horse-NOM thousand.li go-PRES-DECL
Lit. 'A horse without feet goes a thousand li (1 *li* ≒ 0.4 km)'
Idiom: 'Word spreads fast (and so be careful what you say)'

(2.98) #[$\_\__i$ chen-li ka-nun] pal-eps-nun mal$_i$
thousand-li go-REL foot-not.have-REL horse
'a horse without feet which goes a thousand li'

Thus, the idiomatic reading test shows that the head NP does not originate in the relative clause, nor is there a representation of the head NP within the relative clause.[7]

The second argument against the raising and matching analyses comes from the interpretation of adjectival modifiers. The idea is that if the head NP originates (or has a representation) within the relative clause, adjectival modifiers receive readings associated with each structural position that the head noun occupies in the derivation (see Sections 2.2.1 and 2.2.3; Bhatt, 2002). In English, this effect is manifested in an adjectival modifier receiving both low and high interpretations (2.99).

(2.99) the first book that John said Tolstoy had written
Low reading: 'X is the first book that Tolstoy wrote'
High reading: 'X is the first book about which John said that Tolstoy has written X'

---

[7] Some idioms seem to maintain idiomatic interpretations even after relativization. For example, sentence (ii) still retains the idiomatic reading of '*Rags to riches*' in (i) after relativization.

i) kaychen-eyse yong nan-ta
sewer-from dragon rises-DECL
'Lit: A dragon rises from a sewer'
'Rags to riches'

ii) K ssi-nun [__ kaychen-eyse na-n] yong-i-ta
K Mr.-TOP sewer-from rise-REL dragon-be-DECL
'Mr. K is a person of 'rags to riches'
http://paper.findall.co.kr/

These expressions, however, have very limited usages. For example, in sentence (iii), the same idiomatic expression loses its idiomatic readings after relativization.

iii) *?Yenghuy-nun [__ kaychen-eyse na-n] yong-eykey kyenguy-lul phohyenhay-ssta
Y-TOP sewer-from rise-REL dragon-to respect-ACC expressed
'Yenghuy showed the dragon from a sewer her respect.'

This limited usage suggests that the (underlined) expression in (ii), *kaychen-eyse na-n yong-i-ta,* is also an idiomatic expression, while the (underlined) expression in (iii), *kaychen-eyse na-n yong-eykey*, is not. Accordingly, the example (ii) does not serve as a strong argument for the raising analysis.

In contrast, Korean adjectival modifiers are unambiguous and receive a high reading only, as shown in (2.100), suggesting that the head noun neither originates nor has a representation within the relative clause.

(2.100) [[Tolstoy-ka ssessta-ko] John-i malhay-ss-ten] chespen ccay chayk
Tolstoy-NOM wrote-COMP John-NOM said-PST-REL first.time book
'the first book about which John said that Tolstoy had written'

In summary, the lack of idiomatic readings and the availability of only the high interpretation of adjectival modifiers suggest that the head noun does not originate and does not have a representation within the relative clause in Korean. Therefore, Korean relative clauses are not compatible with either the raising analysis or the matching analysis.

2.3.2 Noun Modifying Clause (Gapless Adposition) Analysis

In the gapless adposition analysis, relative clauses are taken to be purely sentential modifiers that are licensed by their semantic/pragmatic relation with the head, as shown in English examples (2.101) and (2.102) (Comrie, 1998; Matsumoto, 1997; Yoon, 1993, 1995).

(2.101) Dickens is one of the few authors [that/where I'd rather watch the video]
(2.102) I haven't been to a party yet [that I haven't gotten home the same night]

The main claims of this analysis are that relative clauses do not involve any movement in the derivation, and that they are simply noun-modifying clauses. The major support for this analysis comes from the apparent similarity among relative clauses (2.103), *fact*-CP clauses (2.104) and *pseudo-relatives* (2.105).

(2.103) Matsumoto (1997): relative clauses
[[hon-o katta] gakusei]
book-ACC bought student
'the student$_i$ who$_i$ t_i bought a book'

(2.104) Matsumoto (1997): *fact*-CP clauses
[tikyuu-ga marui] zizitu
earth-NOM round fact
'the fact that the earth is round'

(2.105) Comrie (1998): *pseudo-relative*
[dareka-ga doa-o tataku] oto
someone-NOM door-ACC knock sound
'the noise of someone knocking at the door'

The point is that since subject-drop is possible in Japanese, as in (2.106), the relative clause*, hono-o katta* 'book-ACC bought' is grammatical and complete on its own, and any grammatical and complete sentence can be used as a noun-modifying clause.

(2.106) hon-o katta
book-ACC bought
*'bought a book'

The analysis, however, imposes one important constraint on the relation between a relative clause and its head NP. That is, given that the proper interpretation of relative clauses requires the active use of linguistic and non-linguistic context and real-world knowledge, as suggested in the several plausible interpretations in (2.107), the relation between the relative clause and the head NP should be semantically and/or pragmatically licensed.

(2.107) Matsumoto (1997)
[[hon-o katta] gakusei]
book-ACC bought student
'the student (who) bought a book'
'the student (from whom) (someone) bought a book'
'the student (for/to whom) (someone) bought a book'

A similar claim has been made for Korean on the basis of the similarities between a typical relative clause (2.111) and pseudo-relatives (2.108) to (2.110) (Yoon, 1993, 1995). Noting that pseudo-relatives do not have a gap and thus cannot be accounted for by the standard movement analysis, Yoon (1993, 1995) suggests that Korean relatives are licensed by the semantic/pragmatic relationship between an eventuality in a relative clause and its head noun.

(2.108) Pseudo-relative in Korean[8]

[sayngsen-i	tha-nun]	naymsay
fish-NOM	burn-REL	smell

'the smell of fish burning'

(2.109) Pseudo-relative in Korean

[thayphwung-i	cinaka-n]	huncek
typhoon-NOM	passed.by-REL	debris

'the debris from a typhoon's passing'

(2.110) Pseudo-relative in Korean

[komwu-ka	tha-nun]	naymsay
rubber-NOM	burn-REL	smell

'the smell of rubber burning'

(2.111) Relative clause in Korean

[$\_\_\__i$	na-lul	salangha-n]	sphai_i
	I-ACC	love-REL	spy

'the spy who loved me'

Thus, in Yoon's analysis, as long as the semantic/pragmatic relationship is familiar and maximally salient, relative clause formation is licensed.

---

[8] Pseudo-relatives do not have corresponding non-relative clauses since they do not leave a gap within the relative clause as shown below.

*namsay-ka	sayngsen-i	than-ta
smell-NOM	fish-NOM	burn-DECL

'the smell, fish burns'

(2.112) Condition for R-relation in Korean:
R-relation must be familiar and maximally salient

(Yoon, 1995: 419)

To support this argument, Yoon presents the following sentence as grammatical.

(2.113)	[John-i	kyelsekha-n]	yenghwa
	John-NOM	was.absent-REL	movie

‘the movie for which John skipped the class’

(Yoon, 1995: 420)

According to him, (2.113) is grammatical in a context where the head noun is the cause of the eventuality of the relative clause, meaning that John was absent for a class because he went to watch a movie instead. In addition to the fact that the grammaticality judgment for the intended meaning is not necessarily shared by other native speakers, this simple semantic/pragmatic approach has further problems. (2.114) is considered to be unacceptable by Yoon since the relation between the head noun ‘bagel’ and the eventuality of the relative clause is not appropriate.

(2.114)	#[Mary-ka	John-ul	ccilu-n]	bagel
	Mary-NOM	John-ACC	stabbed-REL	bagel

‘a bagel such that Mary stabbed John’

However, considering that relative clause formation conditions are defined in terms of semantics/pragmatics, and thus would be context-sensitive, we could imagine a situation where ‘bagel’ becomes the cause of the event represented by the relative clause. For example, in a situation where Mary and John are the sole survivors of a plane crash on an uninhabited island without much food left, the last bagel could be the reason that Mary stabbed John. Even under this more plausible situation, (2.114) does not sound any better.

A more serious problem with this analysis comes from long distance relative clause formation.

(2.115) *[Yenhuy-ka [sayngsen-i thanta-ko] malha-n] naysay
Y-NOM fish-NOM burn-COMP said-REL smell
'the smell that Yenghuy said that the fish burns'

(2.116) [Yenhuy-ka [na-lul salanghanta-ko] malha-n] sphai
Y-NOM I-ACC love-COMP said-REL spy
'the spy that Yenghuy said that loves me'

Sentences (2.115) and (2.116) are the respective long distance relativizations of (2.108) and (2.111). While (2.116) is still grammatical after long distance relativization, (2.115) is not. This shows that gapless relative clauses such as (2.108) to (2.110) are different from typical relative clauses as in (2.111).

This observation is further supported by facts of coordination (Lee, 2004). A typical or a pseudo-relative clause can both be conjoined with a relative clause of the same type as in (2.117) and (2.118). However, as shown in (2.119), coordination of a typical clause and a pseudo-relative clause is not acceptable.

(2.117) [John-i $\underline{\quad}_i$ ilk-un] kuliko [Mary-ka $\underline{\quad}_i$ kiekha-nun] chayk
J-NOM read-REL and M-NOM remember-REL book
'the book that John read and Mary remembers'

(2.118) [sayngsen-i tha-nun] kuliko [koki-ka ssek-nun] naymsay
fish-NOM burn-REL and meat-NOM rot-REL smell
'the smell of the fish burning and the meat rotting'

(2.119) *[John-i $\underline{\quad}_i$ cohaha-nun] kuliko [sayngsen-i tha-nun] naymsay
J-NOM like-REL and fish-NOM burn-REL smell
'the smell that John likes and fish burns'

(Lee, 2004: 155-156)

In addition, pseudo-relatives can be formed only on head nouns with a certain semantic class, while typical relatives do not have such a constraint (Kim, 1998a; Nam, 1996). The head nouns are typically perception nouns which are related to vision, audition, taste, or feeling (Lee, 2004).

(2.120) namsay 'smell', soli 'sound', mas 'taste', mosup 'figure', casay 'posture', nukkim 'feeling', huncek 'trace', kwangkyeng 'scene/sight', phwungkyeng 'scenery', etc.
(Lee, 2004: 155)

Therefore, pseudo-relatives are different from typical relatives and cannot be used as critical evidence in the analysis of typical relative clauses.

2.3.3 *Wh*-operator Movement vs. Argument-drop Analyses

In this section, I compare the *wh*-operator movement analysis of Korean relative clauses with an analysis that treats the relative clause as embedded clause with argument drop. Under the first analysis, relative clauses involve operator movement, as in English, and the trace bound by this null relative operator, as in (2.121) (Han, 1992; Han & Kim, 2004; D.W. Yang, 1987; H.K. Yang, 1990 among others).

(2.121) [$_{RC}$ Op$_i$ hyengsa-ka t$_i$ enceyna sinloyha-n] kica$_i$
detective-NOM always trust-REL reporter
'the reporter that the detective has always trusted'

In the alternative analysis, Korean relative clauses are analyzed as embedded clauses with argument drop. Specifically, relative clauses do not involve any movement (Y. Kang, 1986; Sohn, 1980; cf. Choo, 1994; Japanese: Fukui & Takano, 2000; Murasugi, 1991). Instead, a null pronominal is base-generated *in situ* and is unselectively A'-bound by a head noun or a null operator, as shown in (2.122).

(2.122) [$_{CP}$ Op$_i$ hyengsa-ka *pro*$_i$ enceyna sinloyha-n] kica$_i$
detective-NOM always trust-REL reporter
'the reporter that the detective has always trusted'

Below, I compare predictions of these two analyses in the context of sensitivity to island constraints and weak crossover effects, by replacing a gap within the relative clause with an overt pronoun, and suggest that the results are more compatible with the argument-drop analysis than the movement analysis.

2.3.3.1 Island Constraints

The first test that I examine involves island constraints. The null-argument analysis of relative clauses does not assume movement. Thus, it predicts that Korean relative clauses should not be subject to island constraints. On the other hand, the movement analysis predicts that Korean relative clauses should be subject to island constraints. In fact, as presented below, Korean relatives present mixed results in terms of sensitivity to island constraints. That is, while all corresponding English sentences are unacceptable, Korean relative clauses are unacceptable only when relativizing out of a coordinate structure (2.123). On the other hand, relativization out of other relative clauses (2.124) and *fact*-CP complements (2.125) does not render the sentences ungrammatical.

(2.123) Relativization out of coordination
English: *The dessert [which$_i$ Mary ordered [t$_i$ and soda]] was cheese cake.
Korean: *[$_{RC}$ hyengsa-ka [$_{NP}$ __$_i$ cankwan-ul] sinloyha-n] kica$_i$
detective-NOM secretary-ACC trust-REL reporter
'the reporter$_i$ that the detective trusted t$_i$ and the secretary'

(2.124) Relativization out of a relative clause
English: *the child$_i$ [who the puppy$_j$ [that t$_i$ liked] t$_j$ died]

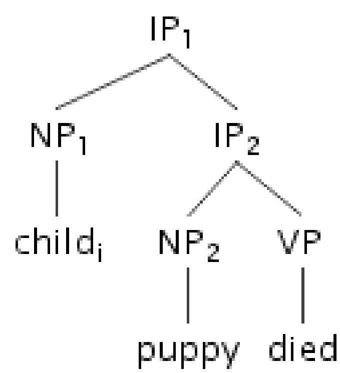
Korean: [$_{RC1}$ [$_{RC2}$ __$_i$ __$_k$ cohaha-nun] kangaci-ka$_k$ cwuk-un] ai$_i$
like-REL puppy-NOM die-REL child
'the child whose puppy that he liked died'

(2.125) Relativization out of a *fact*-CP complement
English: *?The book [which$_i$ John made a [claim that he read t$_i$]] is Jane Eyre.

Korean: [[$_{NP}$ John-i __$_i$ cakkokha-n sasil-i] pimil-i-n] kok$_i$
J-NOM compose-REL fact-NOM secret-is-REL song
'the song$_i$ that the fact John composed t$_i$ is secret'

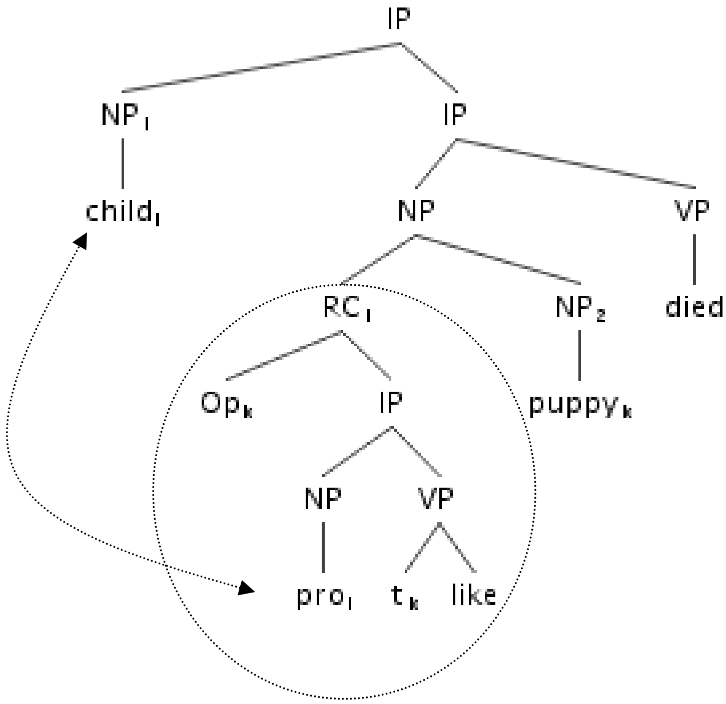
While the apparent insensitivity to island constraints in (2.124) and (2.125) poses a problem for the movement analysis, Han & Kim (2004) provide an account, claiming that double relatives like (2.124) are derived from a double nominative construction, and thus are not problematic for the movement analysis. In their analysis, NP$_1$ first adjoins to IP in the double nominative construction (2.126), where both NPs are nominative-marked.

(2.126) [$_{IP}$ [$_{NP1}$ ai-ka] [$_{IP}$ [$_{NP2}$ kangaci-ka] cwukessta]
child-NOM puppy-NOM died
'The child, the puppy died (on him).'



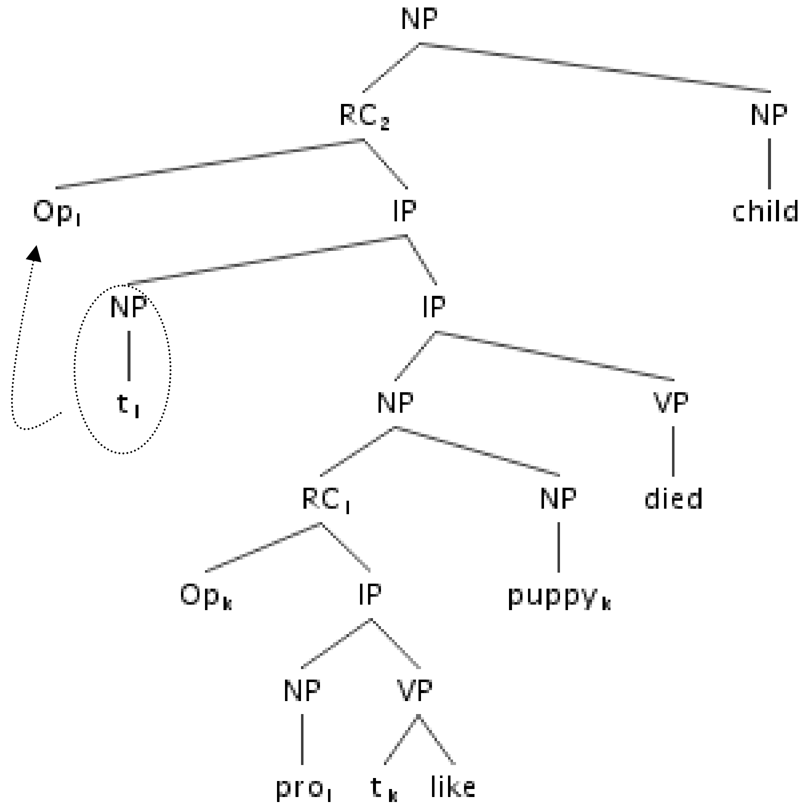
The adjoined NP 'the child' is then coindexed with the null argument in a relative clause modifying NP$_2$ as in (2.127).

(2.127) [$_{IP}$ [$_{NP1}$ ai-ka$_i$ [$_{IP}$ [$_{RC}$ pro$_i$ t$_k$ cohaha-nun] [$_{NP2}$ kangaci-ka$_k$] cwukessta]]]
kid-NOM like-REL puppy-NOM died
'As for the kid, the dog that he liked died'



In the apparent double relativization, it is the NP1 in the Spec of the higher IP that undergoes relativization, as shown in (2.128). Thus there is no island violation and the grammaticality of the sentence is accounted for.

(2.128) [RC1 t_i [IP [RC2 pro_i t_k cohaha-nun] kangaci-ka$_k$ cwuk-un] ai$_i$]
like-REL puppy-NOM died-REL kid$_i$
'As for the kid, the dog that he liked died'



Likewise, relativization out of a *fact*-CP clause (2.125) has a corresponding double nominative construction, from which a relative clause could be derived.

(2.129) Relativization out of a *fact*-CP complement and double nominative (DN)

RC: [[NP John-i _$_i$ cakkokha-n sasil-i] pimil-i-n] kok$_i$
J-NOM compose-REL fact-NOM secret-is-REL song
'the song$_i$ that the fact John composed t_i is secret'

DN: ?ku kok-i [NP John-i _$_i$ cakkokha-n sasil-i] pimil-i-ta
that song-NOM J-NOM compose-REL fact-NOM secret-is-DECL
'That song, the fact John composed it is secret'

However, Han and Kim's analysis does not account for the insensitivity of Korean island constraints without a corresponding double nominative construction, as shown in (2.130) to (2.132).

(2.130) Relativization out of an indirect question and double nominative (DN)
RC: [Tom-i [Q nay-ka etten cilmwun-ul _$_i$ cwunun-ci] a-nun] haksayng$_i$
Tom-NOM I-NOM which question-ACC gave-Q know-REL student
'the student [who]$_i$ Tom knows which question I gave t$_i$'

DN: *haksayng$_i$-i Tom-i [Q nay-ka etten cilmwun-ul _$_i$ cwunun-ci] an-ta
student-NOM Tom-NOM I-NOM which question-ACC give-NMLZ know-DECL

(2.131) Relativization out of a genitive NP and double nominative (DN)
RC: [John-i [NP _$_i$ tongsayng-ul] po-n] salam-un Mary-i-ta
John-NOM brother-ACC see-REL person-TOP Mary-is-DECL
'The man whose$_i$ John saw t$_i$ brother was Mary.'

DN *salam-i John-i [NP _$_i$ tongsayng-ul] po-ass-ta
person-NOM John-NOM brother-ACC see-PST-DECL

(2.132) Relativization out of a sentential subject and double nominative (DN)
RC: [[NP John-i _$_i$ thongkwaha-n kes-i] on kacok-ul nollakeyha-n]
John-NOM pass-REL that-NOM all family-ACC surprised-REL
sihem-un maywu swuywu-ess-ta
test-TOP very easy-PST-DECL
'The test which$_i$ John passed t$_i$ surprised his family was actually very easy.'

DN: *sihem-i [NP John-i _$_i$ thongkwaha-n sasil-i] on kacok-ul
test-NOM John-NOM pass-REL fact-NOM all family-ACC
nollakeyhaysstа
surprised-REL

Thus far, the only island constraint that Korean relative clauses can not violate is relativizing out of a coordinate structure. All other island violations seem acceptable, so the end result is that Korean shows a very low sensitivity to island constraints. Since the null argument analysis predicts that Korean relative clauses should not be subject to island constraints, the insensitivity to island constraints in (2.130) to (2.132) provides some support for the null argument analysis over the movement analysis.

	Null argument analysis	*Wh*-movement analysis
Island constraints	√	

2.3.3.2 Weak Crossover

The second test applied here is weak crossover (WCO). WCO is a constraint on movement that occurs when *wh*-movement crosses over a coindexed pronoun so that the trace of the operator is preceded by the coindexed pronoun but they don't c-command each other (Postal, 1971).

(2.133) *Wh*-operator: *Who$_i$ did his$_i$ mother greet?
(2.134) Quantifier: *His$_i$ mother greeted everyone$_i$.

The WCO effect has been interpreted in terms of the Bijection Principle (Koopman & Sportiche, 1982), which dictates a one-to-one relationship between an operator and a variable.[9] For example, in (2.133) and (2.134), for one operator there are two variables: a coindexed pronoun and the trace of the *wh*-word, or quantifier, as illustrated in (2.135) and (2.136). Thus the sentences are not grammatical.

(2.135) *Wh*-operator: *who$_i$ [did his$_i$ mother greet t$_i$]?
(2.136) Quantifier: *everyone$_i$ [his$_i$ mother greeted t$_i$]

Korean exhibits WCO effects as well. Therefore, when a *wh*-word occurs after its coindexed pronoun, as in (2.138) and (2.140), the result is ungrammatical due to LF movement of the *wh*-word crossing the coindexed pronoun. This is in contrast to the grammaticality of (2.137) and (2.139), where LF movement of the *wh*-word does not cross over the coindexed pronoun.

(2.137) *Wh*-word in subject position
nwu$_i$-ka ku$_i$-uy emeni-lul cohahapni-kka?
who-NOM he-GEN mother-ACC like-Q
'Who$_i$ likes his$_i$ mother?'

(2.138) *Wh* -word in object position
*ku$_i$-uy emeni-ka nwukwu$_i$-lul coahapni-kka?
he-GEN mother-NOM who-ACC like-q
'Who$_i$ does his$_i$ mother like?'

(2.139) Quantifier in subject position
kak sonyen$_i$-i ku$_i$-uy emeni-lul towa-tuly-ess-ta
each boy-NOM he-GEN mother-ACC help-give-PAST-DECL
'Each boy$_i$ helped his $_i$mother'

(2.140) Quantifier in object position
*ku$_i$-uy emeni-ka kak sonyen$_i$-ul towa-cwu-ess-ta
he-GEN mother-NOM each boy-ACC help-give-PAST-DECL
'His$_i$ mother helped each boy$_{i.}$'

However, WCO effects in Korean are sensitive to linear order and hierarchical prominence and, thus, the effect disappears under scrambling (see Bresnan, 1998 for the detailed discussion): if the *wh*-word or quantifier in an object position precedes the coindexed pronoun due to scrambling, the sentence becomes acceptable. Thus the corresponding scrambled sentences of examples (2.138) and (2.140) no longer pose any problems, as shown in (2.141) and (2.142).

(2.141) Scrambled sentence of sentence (2.138)
nwukwu$_i$-lul ku$_i$-uy emeni-ka cohahapni-kka?
who-ACC he-GEN mother-NOM like-Q
'Who does his mother like?'

[9] See Georgopoulos (1991) for a discussion of the WCO effect in terms of an empty category principle (ECP; Chomsky, 1981) with canonical government (Kayne, 1983).

(2.142) Scrambled sentence of sentence (2.140)

kak	sonyen-ul	ku-uy	emeni-ka	towa-cwu-ess-ta
each	boy-ACC	he-GEN	mother-NOM	help-give-PAST-DECL

‘His$_i$ mother helped each boy$_i$’

Therefore, the crucial observation is that WCO is not a fully reliable diagnostic even in root clauses.

Given the WCO effects described above, I discuss different predictions for subject relatives (2.143) and object relatives (2.144) with regard to WCO under the movement analysis of relative clauses.

(2.143) subject relative clause

[__$_i$	ku$_i$-uy	emeni-lul	seltukha-n]	haksayng$_i$
	he-GEN	mother-ACC	persuaded-REL	student

‘a student$_i$ who persuaded his$_i$ mother’

(2.144) object relative clause

[ku$_i$-uy	emeni-ka	__$_i$	seltukha-n]	haksayng$_i$
he-GEN	mother-NOM		persuaded-REL	student

‘a student$_i$ who his$_i$ mother persuaded’

That is, in the LF representation of subject relative clauses with operator movement, the operator does not move across the coindexed pronoun. Thus, no WCO effect is predicted for subject relative clauses, as seen in (2.145).

(2.145) Subject relative clause after LF movement

[Op$_i$ [t$_i$	**ku**$_i$-uy	emeni-lul	seltukha-n]]	haksayng$_i$
	he-GEN	mother-ACC	persuaded-REL	student

‘a student$_i$ who persuaded his$_i$ mother’

In contrast, in object relative clauses, the operator moves across the coindexed pronoun and thus the coindexed pronoun precedes (but does not c-command) the trace of the operator, as shown in (2.146). Thus a classic WCO effect is predicted in object relative clauses.

(2.146) object relative clause after LF movement

[Op$_i$	[**ku**$_i$-uy	emeni-ka	t$_i$	seltukha-n]]	haksayng$_i$
	he -GEN	mother-NOM		persuaded-REL	student

'a student$_i$ who his$_i$ mother helped'

This suggests that if relativization involves movement in Korean, acceptability for object relative clauses (2.144) should be much lower than for subject relative clauses (2.143). On the other hand, the null argument analysis does not predict such asymmetry in acceptability between subject and object relative clauses, since relativization does not involve movement.

To test these hypotheses, I conducted a questionnaire study, comparing subject and object relative clauses. In addition to the overt pronoun *ku* 'he', two other types of variables were included: a null argument (*pro*) and a reflexive *caki* 'self', as shown below.

(2.147) subject relative clause

[__$_i$	ku$_i$/pro$_i$/caki$_i$-uy	emeni-lul	seltukha-n]	haksayng$_i$
	he/pro/self-GEN	mother-ACC	persuade-REL	student

'a student$_i$ who persuaded his$_i$/(pro$_i$)/self$_i$'s mother'

(2.148) object relative clause

[ku$_i$/pro$_i$/caki$_i$-uy	emeni-ka	__$_i$	seltukha-n]	haksayng$_i$
he/pro/self-GEN	mother-NOM		persuade-REL	student

'a student$_i$ who his$_i$/(pro$_i$)/self$_i$'s mother helped'

This was to prevent any possible confound associated with the use of different pronominal elements. That is, although Korean has overt pronouns corresponding to English 'she' and 'he', these overt pronouns (i.e., *kunye* and *ku*, respectively) are actually rarely used. Instead, Korean employs argument drop in cases where English would use overt pronouns. On the other hand, *caki* 'oneself' was included in the questionnaire since it can be used as a resumptive pronoun in relative clauses (Y. Kang, 1986).

Thirty sets of subject and object relative clause sentences were included in the questionnaire study, and ten Korean native speakers participated. They were instructed to rate a sentence on a 1-5 scale (1: acceptable − 5: unacceptable under the coindexed interpretation).

Overall results averaging the ratings by ten subjects are presented below.

Table 2-5 WCO effects of subject and object relative clauses

	overt pronoun	null pronominal	reflexive	average
SR	3.17	1.54	1.25	1.98
OR	3.15	2.13	2.29	2.52

(1: acceptable; 5: unacceptable)

Overt pronouns are dispreferred in both subject and object relative clauses (3.17 vs. 3.15, respectively). As mentioned above, these pronouns are rarely used. Additionally, as discussed below, it is possible that an overt pronoun in Korean is not a true pronoun. It is not surprising, then, that sentences with overt pronouns are dispreferred. On the other hand, sentences with a reflexive or a null pronominal received better acceptability in general in both subject and object relatives. WCO in relative clauses is known to be very subtle (Lasnik & Stowell, 1991), which could account for the better acceptability ratings in sentences with a null pronominal or a reflexive. However, there was difference in acceptability between WCO in subject vs. object relatives, due to a better acceptability of subject relatives in general (1.98 vs. 2.52). This difference was statistically significant as shown by student's t-tests for the average ratings of SR vs OR, collapsed across all three conditions, (1.98 vs. 2.52) [$t(9) = 38.06$, $p < .0002$], SR vs OR with a null pronominal [$t(9) = 18.33$, $p < .002$] and SR vs OR with a reflexive [$t(9) = 20.51$, $p < .001$]. Thus it seems that object relative clauses show the WCO effect while subject relative clauses do not, as predicted by the operator movement hypothesis.

However, as mentioned above, WCO effects in Korean are sensitive to linear order and hierarchical prominence (Bresnan, 1998). Therefore, although object relative clauses showed the WCO effect, as predicted by the movement analysis, the fact that the WCO effects in Korean can be handled without assuming movement suggests that the effects from the WCO test in object relative clauses cannot be used as strong evidence for the movement analysis.

	Null argument analysis	*Wh*-movement analysis
Island constraints	√	
WCO	√(?)	√(?)

2.3.3.3 Replacing a Gap with an Overt Pronoun

The third test involves replacing the gap within a relative clause with an overt pronoun. In Korean, a dropped argument can be replaced by an overt pronoun, as repeated below from (2.8).

(2.149) 'Yenghuy came home. And (she) ate meal.'
Yenghuy$_i$-ka cip-ey wassta. kuliko $\boxed{\textit{pro}_i\text{/kunye}_i\text{-nun}}$ pap-ul mekessta.
Y-NOM home-to came And $\boxed{\textit{pro}\text{/she-TOP}}$ meal-ACC ate

Thus, the logic behind this test is that if a gap within a relative clause is indeed a dropped argument, replacing it with an overt NP should not render the sentence unacceptable. On the other hand, the *wh*-operator movement analysis predicts that replacing the gap with an overt NP will render the sentence unacceptable because a trace cannot be replaced with an overt NP. The result seems to support the movement analysis: the sentence becomes ungrammatical, as shown in (2.150) and (2.151), when an overt NP occurs in the gap position.

(2.150)	[RC hyengsa-ka	__*i*	enceyna	sinloyha-n]		kica*i*
	detective-NOM		always	trust-REL		reporter
	'the reporter who the detective always trusted'					
(2.151)	*[RC hyengsa-ka	ku-lul*i*	enceyna	sinloyha-n]		kica*i*
	detective-NOM	he-ACC	always	trust-REL		reporter

Defending the null argument analysis, Y. Kang (1986) accounts for the ungrammaticality of (2.151) in terms of a Principle B violation. In his account, *ku* 'he' is a resumptive pronoun, and he assumes that there should be at least two maximal projections (either S' or NP in his terms) between the pronoun and its binder. With these assumptions, he argues that the ungrammaticality of (2.151) is because the pronoun *ku* 'he' is *locally* bound by the head NP 'reporter', which is base-generated in Spec of CP, violating Principle B, as shown in (2.152).

(2.152) Principle B violation in Y. Kang's analysis of (2.151)

*[S' …	ku*i*	…]	kica*i*
	he		reporter

However, Y. Kang's analysis is not without problems either.

If Y. Kang's argument that sentence (2.151) is unacceptable because of a Principle B violation were correct, no resumptive pronoun should be allowed in the same environment. However, as shown in Section 2.1, a resumptive pronoun can in fact occur without an additional S' or NP between the pronoun and its binder when relativizing obliques, as shown in (2.153).

(2.153) Relativization of an oblique: gap strategy

[Mina-ka	<u>ku-ttaymuney</u>	sulpheha-n]	namca
Mina-NOM	he-because	be.sad-REL	man

'the man because of whom Mina was sad'

The second argument against Y. Kang's analysis comes from the binding of dropped arguments. In his analysis, a gap in a relative clause is dropped argument.

(2.154) Y. Kang's analysis of (2.150)

[$_{S'}$ …	*pro*$_i$ …]	kica$_i$
		reporter

Since the null pronominal in Korean is also sensitive to Principle B, as shown in (2.155), his analysis should provide an account of why dropped argument itself does not violate Principle B.

(2.155)

*kica-ka	*pro*$_i$/ku$_i$-lul	kkwum-eyse	po-ass-ta
reporter-NOM	*pro*$_i$/ku$_i$-ACC	dream-at	see-PST-DECL

'*The reporter$_i$ saw (him$_i$)/him$_i$ in his dream'

In other words, if Y. Kang rules out the overt pronominal in (2.151) based on a Principle B violation, his analysis should address why a null argument in the same environment does not violate Principle B. Alternatively, his analysis needs to address the question of different binding domains for resumptive pronouns and dropped arguments in Korean, which at this point, seems to be purely an implicit assumption.

Y. Kang relies on the assumption that the head noun in Korean relative clauses is base-generated in the Spec of CP, and that therefore, the overt pronominal *ku* 'he' in a relative clause leads to a Principle B violation. However, the discussion above (section 2.3.1) has demonstrated that the head noun in a Korean relative clause occurs in the main clause. Under this analysis sentence (2.151) does not violate Principle B, since the pronoun *ku* 'he' is not bound in its binding domain.

Since a Principle B violation can not be used to explain the unacceptability of (2.151), in which a gap was replaced with the pronoun *ku* 'he', another possibility must be considered. Here it is important to note that there has been controversy over whether the overt pronoun *ku* 'he' is actually a bound variable in Korean. While Kang (1988a) argues that *ku* 'he' can be used as a bound variable based on sentence (2.156), Hong (1985) and Lee (2001) argue that *ku* 'he' cannot be construed as a variable, based on sentences like (2.157) and (2.158).[10]

(2.156) Kang (1988a: 194-5)

nukuna$_i$	[ku$_i$-lul	ccocha-o-nun	salam-ul]	silhha-n-ta
everyone	he-ACC	chase-come-REL	person-ACC	dislike-PRES-DECL

'Everyone$_i$ hates the person who chases him$_i$.'

(2.157) Kang (1988a: 193)

??nukuna$_i$	[ku$_i$-ka	hyunmyungha-ta-ko]	sayngkakha-n-ta
everyone	he-NOM	wise-DECL-COMP	think-PRES-DECL

'Everyone$_i$ thinks the he$_i$ is wise.'

(2.158) Lee (2001: 152)

*nwu-ka$_i$	ku$_i$-uy	chinkwu-lul	pinanhay-ss-ni?
who-NOM	he-GEN	friend-ACC	criticize-PST-DECL

'Who$_i$ criticized his$_i$ friend?'

The fact that in some cases *ku* cannot be construed as a bound variable suggests the possibility that the gap in a relative clause cannot be replaced with an overt pronoun, *ku* 'he', because *ku* 'he' is not a bound variable in relative clauses.

Although given this possibility, the unacceptability of sentence (2.159) as repeated from (2.151) could be accounted for, this amounts to saying that there are two kinds of relative clauses in Korean: one with a gap bound by an operator (2.159) and the other with an overt pronoun (possibly coindexed with the head noun, since it cannot be bound by an operator) (2.160).

(2.159) *[$_{RC}$ hyengsa-ka ku-lul$_i$ enceyna sinloyha-n] kica$_i$
detective-NOM he-ACC always trust-REL reporter
'the reporter who the detective always trusted'

(2.160) Relativization of an oblique: gap strategy
[Mina-ka ku$_i$-ttaymuney sulpheha-n] namca$_i$
Mina-NOM he-because be.sad-REL man
'the man because of whom Mina was sad'

This possibility is supported by the acceptability of (2.161), a coordinate structure.

(2.161) Relativization out of a coordinate structure
[Min-ka __$_i$ salangha-ko Mary-ka ku$_i$ -lopwuthe swuhak-ul paywu-nun] namca$_i$
Mina-NOM love-and Mary-NOM he-from math-ACC learn-REL man
'the man$_i$ whom Mina loves __$_i$ and Mary learns math from (him$_i$)'

In (2.161), the first conjunct uses a gap strategy and the second conjunct uses a pronoun strategy. Thus, *the parallelism constraint on operator binding* (2.162) in Safir (1985) predicts that sentence (2.161) should be unacceptable if both the gap and the overt pronoun *ku* 'he' are bound by the same operator. This is because in this constraint, variables bound by the same operator should be identical to each other in terms of [α lexical].

[10] As pointed out in Kang (1998a), *ku* was fairly recently introduced as a personal pronoun in Korean, derived from a demonstrative meaning 'that'.

(2.162) *The parallelism constraint on operator binding*
If O is an operator and x is a variable bound by O, then for any y, y a variable of O, x and y are [α lexical][11].

Following *the parallelism constraint on operator binding*, the fact that the sentence is acceptable suggests that the binders of the gap and of the overt pronoun *ku* 'he' in (2.161) are different. While this is an area for further research, for our purposes it can be stated that the constraints on an overt pronoun in place of the gap in relative clause fail to distinguish between the movement analysis and unselective binding of a null argument analysis.

The summary of the diagnostics that we have used to distinguish between the two analyses is given in Table 2-6.

Table 2-6 Evaluation of null argument and wh-movement analyses

	Null argument analysis	*Wh*-movement analysis
Island constraints	√	
WCO	√(?)	√(?)
Use of overt pronoun	√(?)	√(?)

The theoretical evidence summarized above does not clearly support one analysis over the other. In light of this lack of clarity, experimental evidence will be examined which will be able to distinguish between these theoretical possibilities and determine the syntactic nature of the gap in Korean relative clauses.

[11] [α lexical] denotes phonetic realization: an overt pronoun is [+ lexical] while a gap is [- lexical].

2.3.4 Summary

In this section, I presented a syntactic analysis of Korean relative clauses. In Section 2.3.1, I argued that Korean relative clauses are not compatible with matching and raising analyses by showing that the head NPs in Korean relatives do not originate and do not have a representation within the relative clause on the basis of idiomatic readings and the interpretation of adjectival modifiers. In Section 2.3.2, I showed that Korean relatives should not be analyzed as gapless adposition constructions on the basis of the differences between pure gapless adposition structures and regular relative clauses in terms of long-distance relative clause formation, coordination and semantic constraints on head nouns. In Section 2.3.3, I showed that the syntactic analysis of Korean relative clauses vacillates between the null argument analysis and the *wh*-movement analysis. While weak crossover data and replacement by an overt pronominal are equally compatible and problematic for both analyses, there is some support for the null argument analysis coming from island effects. The experimental evidence which will be discussed below will help us further distinguish between the competing analyses.

Chapter 3:
Background in Long-Distance Dependencies and Methodology

The notion of dependency between two (or more) constituents is an integral concept in the grammar. Dependency can simply signal a grammatical relationship between a verb and its argument, as in (3.1).

(3.1) Abkhaz

a-xác'a	a-p̄ħoə̀a	a-šoqo'ə̀	ø-lə̀-y̱-te-yt'
the-man	the-woman	the-book	it-to.her-he-gave-Finite

'The man gave the book to the woman.'

(Nichols, 1986)

Alternatively, dependency can signal a relationship between two positions in a clause, as in the following example.

(3.2) Who$_i$ did John meet ___ $_i$?

In (3.2), the *wh*-word appears at the beginning of the sentence despite its role as the direct object. Conventionally, such a fronted *wh*-word is called a filler and the location from which the *wh*-word was extracted is called a gap. For proper interpretation of sentences, a displaced linguistic element (i.e., filler) is interpreted at its site of origin (i.e., gap). In the sense that there is a dependency between a filler and its gap, this type of long-distance dependency is specifically called a filler-gap dependencies (Fodor, 1978).

In fact, filler-gap dependency can be found in various linguistic constructions with syntactic displacement of a linguistic element into another structural position: for example, *wh*-questions (3.2) and (3.3)a, relative clauses (3.3)b, topic structures (3.3)c, and scrambled sentences (3.3)d.

(3.3) Forward filler-gap dependencies

(a) My brother wanted to know <u>who$_i$</u> Ruth will bring us home to __$_i$ at Christmas.
(Stowe, 1986)

(b) The reporter$_i$ who the senator attacked ___$_i$ admitted the error.
(King & Just, 1991; King & Kutas, 1995)

(c) Sam$_i$ I am ___$_i$
(Dr. Seuss, 1960)

(d)

Sam$_i$-ul	Mary-ka	___$_i$	mannassta
Sam-ACC	Mary-NOM		met

'Mary met Sam.'

Particularly, the examples above are referred to as forward filler-gap dependencies since a displaced element (i.e., filler) precedes its sites of origin (i.e., gap). However, filler-gap dependencies can also manifest in the reverse order (i.e., backward filler-gap dependencies), where a gap precedes its filler, as in (3.4).

(3.4) Backward filler-gap dependencies

[uywon-i	__$_i$	kongkyekha-n]	kica-ka	silswu-lul	incenghayssta
senator-NOM		attack-REL	reporter-NOM	error-ACC	admitted

'The reporter$_i$ who the senator attacked admitted the error.'

However, displacement is not a necessary condition for dependency formation. That is, there can also be long-distance dependencies between two linguistic elements in their canonical positions. For example, coindexation between *Yenghuy* and a pronoun, *kunye* 'she' in (3.5) is an example of a dependency without displacement. Such dependencies are anaphoric in nature.

(3.5) ‘Yenghuy came home. And (she) ate a meal.’

Yenghuy$_i$-ka	cip-ey	wassta.	kuliko	kunye$_i$-nun	pap-ul	mekessta
Y-NOM	home-to	came.	And	she-TOP	meal-ACC	ate

Like syntactic dependencies, anaphoric dependencies can be both forward (3.6) and backward (3.7).

(3.6) Forward anaphoric dependencies
When the boy$_i$ was fed up, he$_i$ visited the girl very often.

(3.7) Backward anaphoric dependencies
When he$_i$ was fed up, the boy$_i$ visited the girl very often.

That is, given that a linguistic element that provides referential information precedes a linguistic element in need of reference, example (3.6) illustrates a forward anaphoric dependency. On the other hand, example (3.7) illustrates a backward anaphoric dependency in that a linguistic element in need of reference precedes an element that provides such referential information.

Among the different types of long-distance dependencies, forward filler-gap dependencies (3.3) have been studied the most and are consequently best understood. In contrast, backward dependencies have not received much attention until recently. Given that sentence processing theories have been developed mostly on the basis of experimental results for forward filler-gap dependencies, experimental results for backward dependencies should have important implications for these processing models.

In this section, I first discuss previous findings from studies of forward filler-gap dependencies, focusing mainly on the asymmetry evident in the processing of subject and object gaps. This is followed by an introduction to the processing theories that have been proposed to account for this asymmetry. Then I present research on the subject and object gap asymmetry in backward filler-gap dependencies before discussing previous research on anaphoric dependencies. Finally, in Section 3.4, a background of ERP methodology is presented along with major language-processing-related ERP components and previous ERP research on filler-gap dependencies.

3.1 Processing of Forward Filler-Gap Dependencies

The processing of forward filler-gap dependencies has largely been characterized as being subject to an active search mechanism. In other words, encountering a displaced element triggers the prediction of a gap in the first possible position, without waiting for specific structural information (Active Filler Strategy: Frazier & Clifton, 1989).

(3.8) Active Filler Strategy (AFS)
When a filler has been identified, rank the option of assigning it to a gap above all other options.

(Frazier & Clifton, 1989: 95)

This effect is accounted for in terms of the parser's preference to identify the gap position of a filler as soon as possible, and is illustrated by the following globally ambiguous example in (3.9).

(3.9) Who did Fred tell Mary left the country?

Although both interpretations (3.10) and (3.11) are logically possible, it was found that the reading of (3.11) is strongly preferred (Frazier & Clifton, 1989). In other words, the parser prefers to assign the filler to a gap as soon as possible, and the first possible gap position is the direct object immediately following the verb. Thus, the parser prefers to encounter a gap rather than *Mary* at this position.

(3.10) Who$_i$ did Fred tell Mary ___$_i$ left the country?
(3.11) Who$_i$ did Fred tell ___$_i$ Mary left the country?

The *filled gap effect* (Stowe, 1986) provides additional evidence for the *active filler strategy*. That is, when there is an overt pronoun, such as *us*, in the presumed gap position (i.e., object of *bring*), processing slows down, as manifested by slower reading times at *us* in (3.12) than in (3.13).

(3.12) Filled-gap experiment sentence
My brother wanted to know <u>who</u> Ruth will bring <u>*us*</u> home to __ at Christmas.
(3.13) No-gap control sentence
My brother wanted to know <u>if</u> Ruth will bring <u>*us*</u> home to Mom at Christmas.
(Stowe, 1986)

Importantly, it was found that gap postulation is sensitive to grammatical constraints (Phillips, 2006; Pickering et al., 1994; Stowe, 1986). That is, the parser does not postulate a gap position inside a syntactic island (i.e., inside NP in (3.14)), and accordingly, a *filled gap effect* was not observed at *Greg's* in (3.14) compared to (3.15) (Stowe, 1986).

(3.14) The teacher asked <u>what</u> [$_{NP}$ the silly story about *Greg's* older brother] was supposed to mean.
(3.15) The teacher asked <u>if</u> [$_{NP}$ the silly story about *Greg's* older brother] was supposed to mean.

In addition to the predictive search mechanism evident in the processing of filler-gap dependencies, filler-gap dependencies have also long been discussed in the context of a subject and object gap processing asymmetry, in an attempt to investigate general processing mechanisms. The roots of the discussion of center-embedded and right-branching structures is found in Miller and Chomsky (1963). Center embedding refers to a structure where a constituent *X* is embedded in another constituent *Y*, with material in *Y* to both the left and right of *X* (Miller & Chomsky, 1963). One example of center embedding is that of English object relative clauses (ORs) as in (3.16).

(3.16) [$_X$ The salmon that [$_Y$ the man that [$_Z$ the dog chased] smoked] fell].

The observation is that center-embedded ORs (3.17) are more difficult to process than their counterpart right-branching subject relative clauses (SRs), as in (3.18).

(3.17) The student who the professor who the scientist collaborated with advised copied the article.
(3.18) The scientist collaborated with the professor who advised the student who copied the article.

Because the two sentences involve the same words and the same thematic relationships, this difference in processing difficulty cannot be attributed to a difference in lexical or thematic relationships. Noting this, Miller and Chomsky discuss the asymmetry in terms of limitations on short-term memory capacity. That is, the processing asymmetry was accounted for in terms of the number of incomplete syntactic structures that the parser needs to hold in working memory. In center-embedded ORs, as in (3.17), the embedded clause interferes with the completion of the clause in which it is embedded. Thus, the incomplete information of the higher clause needs to be stored in memory, taking up working memory resources. On the other hand, in right-branching SRs, such as in (3.18), there is no such interruption effect of the embedded clauses on the processing of higher clauses.

The incomplete dependency hypothesis also predicts a similar processing asymmetry between center-embedded SRs and ORs, as in (3.19) and (3.20).

(3.19) The reporter who harshly attacked the senator admitted the error.
(3.20) The reporter who the senator harshly attacked admitted the error.

That is, while head nouns in both SRs and ORs need to be stored in working memory in order to be associated with the main verb, there is an additional incomplete dependency (i.e., a dependency between the head noun and the embedded verb) that must be stored in working memory in ORs but not in SRs, where the head noun is associated with the embedded verb relatively early.

In fact, this SR/OR processing asymmetry is a very robust generalization, as has been confirmed in studies using **various experimental methodologies** (name-recalling and comprehension tests: Wanner & Maratsos, 1978; reading time: King & Just, 1991; Gibson et al., 2005; ERP: King & Kutas, 1995; Müller, King, & Kutas, 1997; fMRI: Just et al., 1996; Caplan et al., 2002, 2008; Chen et al., 2006; Cooke et al., 2002; Constable et al., 2004; PET: Stromswold et al., 1996; Caplan et al., 1998, 1999, 2000; eye-tracking: Traxler et al., 2002), **in languages with forward filler-gap dependencies other than English**: (Dutch: Frazier, 1987; German: Schriefers et al., 1995; Mecklinger et al., 1995; French: Frauendelder et al., 1980; Holmes & O'Regan, 1981; Cohen & Mehler, 1996; Hungarian: MacWhinney & Pleh, 1988), **in specific populations** (individuals with high vs. low working memory capacity: King & Just, 1991; elderly: Zurif et al., 1995; Caplan et al., 2003; aphasic patients: Caplan & Futter, 1986; Grodzinsky, 1989; Lukatela et al., 1995; Parkinson's disease patients: Grossman et al., 2002; amnesic patients: Shapiro et al., 1992) and **in first and second language acquisition** (first language acquisition: Tavakolian, 1978; de Villiers et al., 1979; Sheldon, 1974; Lempert & Kinsbourne, 1980; Friedmann & Novogrodsky, 2004; Diessel & Tomassello, 2005; second language acquisition: Doughty, 1991; Eckman, Bell, & Nelson, 1988; Gass, 1979; Hamilton, 1994; O'Grady et al., 2003).

Despite the clear results across many studies, the cause of this asymmetry is still controversial. That is, in addition to the incomplete dependency hypothesis discussed in Miller & Chomsky (1963) (and also in Gibson, 2000), there are many other accounts proposed. These include processing models based on particular linguistic structural features (MacWhinney, 1982; Keenan & Comrie, 1977; O'Grady, 1997), as well as on general cognitive constraints such as working memory load, memory decay or memory representation and retrieval (Gibson, 1998, 2000; Gordon, Hendrick & Johnson, 2001; Lewis, Vasishth & Van Dyke, 2006), or frequency/probability (Hale, 2006; MacDonald & Christiansen, 2002; Levy, 2008). These processing models are presented in detail in Section 3.2.

On the other hand, some other studies have argued that the apparent processing asymmetry between SRs and ORs is not due to any intrinsic difference between the two constructions, but rather to animacy and/or frequency (Gennari & MacDonald, 2008; Hale, 2001, 2006; Kidd, Brandt, Lieven & Tomasello, 2007; MacDonald & Christiansen, 2002; Mak, Vonk & Schriefers, 2002; Levy, 2008; Reali & Christiansen, 2007). For example, it has been pointed out that SRs are more frequent than ORs, and the subject/object processing asymmetry could be explained in terms of frequency (86% SR vs. 13% OR in the Brown corpus of the English Penn Treebank http://www.cis.upenn.edu/˜treebank/, Hale, 2001). Likewise, Mak et al. (2002) argued that animacy is the most important factor for the distribution of SRs and ORs, based on a corpus study of Dutch and German and a reading time study. In the reading time experiment, they compared the processing of SRs and ORs in Dutch, varying the animacy of objects within relative clauses. They found a processing asymmetry between SRs and ORs when the object within the relative clause was animate. However, no such difference was found when the object was inanimate. Based on these results, they argued for a semantically driven analysis of relative clauses: the parser uses semantic information to process relative clauses.

In contrast, Traxler et al. (2002) argued that subject/object processing asymmetry cannot be due simply to plausibility or semantic confusion. In a series of eye-tracking experiments, the authors manipulated the plausibility of experimental sentences so that only one of the two critical noun phrases could be the plausible subject of the relative clause. For example, in the sentences in (3.21), a policeman can arrest a thief but a thief cannot arrest a policeman. Likewise, robbing is typically assumed to be associated with a thief rather than a policeman. The question was whether this plausibility manipulation (i.e., making assignment of thematic roles easier) would reduce the subject/object processing asymmetry.

(3.21) The policeman that arrested the thief was known to carry a knife.
The thief that the policeman arrested was known to carry a knife.
The thief that robbed the policeman was known to carry a knife.
The policeman that the thief robbed was known to carry a knife.
(Traxler et al., 2002: 76)

The results showed that the plausibility manipulation facilitates the processing of ORs during reanalysis. However, it was also found that ORs still took more time to read than SRs, suggesting that this subject/object processing asymmetry is not due to semantic confusion.

In summary, research on the processing of forward filler-gap dependencies has suggested that forward filler-gap dependencies are driven by an active search mechanism that forces the parser to actively search for a gap upon encountering a filler, and this search process is subject to grammatical constraints. In terms of processing models, the subject/object processing asymmetry in forward filler-gap dependencies is one of the most robust findings. This asymmetry has been replicated with diverse experimental methods and populations, and likewise, diverse processing models have been proposed to account for this asymmetry, as will be introduced in Section 3.2 and tested in Chapter 4.

3.2 Processing Theories Based on Forward Filler-gap Dependencies

This section presents an overview of the processing theories proposed to account for the processing advantage of subject gaps in English. Eight proposals are presented: the dependency locality theory, based on working memory costs of storage and integration (Gibson, 2000), the filler-gap domain hypothesis (Hawkins, 2004), the structural distance hypothesis (O'Grady, 1997), the accessibility hierarchy (Keenan & Comrie, 1977), similarity-based interference (Gordon, Hendrick, & Johnson, 2001), statistical regularity of word order (MacDonald & Christiansen, 2002) and probabilistic models (Hale, 2006; Levy, 2008).

3.2.1 Dependency Locality Theory (Gibson, 2000)

Dependency locality theory (DLT) is a theory of computational resource use in sentence processing. Gibson (2000) identifies two important factors of computational resource load in parsing a sentence: storage of the structure built thus far, and integration of the current word into the structure built thus far. Each of these two factors will be discussed in turn.

3.2.1.1 Storage-Based Resource Theory

Gibson (2000) argues that each syntactic head required to make the input string grammatical has an associated storage cost. He assumes that the minimum number of syntactic heads for a grammatical sentence is two: a verb for the predicate and a noun for the subject of the sentence.

(3.22) DLT Storage Cost
1 memory unit (MU) is associated with each syntactic head required to complete the current input as a grammatical sentence.

(Gibson, 2000: 114)

To show how DLT storage costs work, an example is provided below in English ORs.

(3.23) Storage costs of English ORs

Storage	the	reporter	who	the	senator	attacked	disliked	the	editor	Total
cost (MU)	2	1	3	4	3	1	1	1	0	16

(Gibson, 2000: 114)

Two syntactic heads are required for a grammatical sentence at the sentence-initial determiner *the* (i.e., a noun and a verb). Therefore, the storage cost is 2 MUs. When the parser reaches the first noun, *reporter,* just one more head (i.e., a verb) is required and the storage cost is 1 MU. At the relative pronoun, *who,* 3 syntactic heads are required: an empty category to be associated with *who*, a verb for the predicate of the relative clause, and a verb for the predicate of the main clause. Therefore the storage cost is 3 MUs. At the determiner position within the relative clause, another head noun is required, so the total storage cost rises to 4 MUs. At *senator,* one of the required heads is satisfied, bringing the total MUs back to 3, and *attack* satisfies another required syntactic head. In addition, the empty category associated with *who* is also satisfied at this position, so the storage cost returns to 1 MU, as the predicate of the main clause has not yet been encountered. This requirement is satisfied at the verb of the main clause, *dislike*. Because *dislike* is a transitive verb, however, it requires a direct object, and the storage cost remains at 1 MU. When the determiner is reached, a noun is required and the last NP, *editor*, satisfies this last requirement.

Comparing the storage costs of ORs in (3.23) and SRs in (3.24), the crucial difference is at the embedded predicate region, *attacked.* At the preceding relative pronoun, *who*, the MU was 3 because three syntactic heads are required to complete the string as a grammatical sentence: an empty category to be associated with *who*, a verb for the predicate of the relative clause, and a verb for the predicate of the main clause. In SRs, at the next word, *attacked,* two of these requirements (i.e., an empty category and an embedded predicate) are satisfied, but one more MU for the direct object is required, since *attack* is a transitive verb. The MU at this word position is thus 2. At the next word, *the¸* a noun and the main verb are still required and the MU at this position remains at 2. At *senator*, one of these requirements is satisfied, leaving the MU at 1. The rest of the computation is identical to that of ORs in (3.23).

(3.24) Storage costs of English SRs

Storage cost (MU)	The	reporter	who	attacked	the	senator	disliked	the	editor	Total
	2	1	3	2	2	1	1	1	0	13

The computation of storage costs in ORs and SRs in (3.23) and (3.24) thus shows that the *storage-based dependency locality theory* predicts the processing difficulty of ORs in comparison to SRs to fall within the relative clause region.

3.2.1.2 Integration-Based Resource Theory

Gibson identifies several components in the integration process: 1) structural integration involving a head-dependent relation and linking pronouns to their proper antecedents, 2) discourse integration, and 3) evaluating the plausibility of the resultant discourse structure in the current context.

The difficulty of discourse integration depends on the accessibility of the referent of the NP in the discourse. Gibson argues that pronouns referring to focused entities or individuals are highly accessible and therefore do not engage many computational resources. On the other hand, he argues that elements new to the discourse engage more resources. In short, he assumes that the head noun of an NP and the head verb of a VP that are new to the discourse will require more computational resources in discourse processing.

The complexity of structural integration depends on the distance or locality between the two elements being integrated. The distance is calculated on the basis of new discourse referents.

(3.25) *DLT Simplified Discourse Processing Cost*
Discourse processing cost (the cost associated with accessing or constructing the discourse structure for the maximal projection of the input word head *h2*): 1 energy unit (EU) is consumed if *h2* is the head of a new discourse referent; 0 EUs otherwise.

(Gibson, 2000: 104)

(3.26) *DLT Structural Integration cost*
The structural integration cost associated with connecting the syntactic structure for a newly input head *h2* to a projection of a head *h1* that is part of the current structure for the input is dependent on the complexity of the computations that took place between *h1* and *h2*. For simplicity, it is assumed that 1 EU is consumed for each new discourse referent in the intervening region.

(Gibson, 2000: 105)

In terms of the subject/object asymmetry in relative clause processing, the *dependency locality theory* predicts that ORs will incur a higher processing cost than SRs due to more intervening discourse referents between a filler and its gap (i.e., longer distance in terms of locality of the two) as shown in (3.27) and (3.28).

(3.27) Object relative clause: The reporter$_i$ [who$_i$ the senator attacked t$_i$] disliked the editor.

(3.28) Subject relative clause: The reporter$_i$ [who$_i$ t$_i$ attacked the senator] disliked the editor.

To be more specific, the actual integration-based processing difficulty for English SRs and ORs is presented in (3.29) and (3.30). In ORs, the parser relates a gap (i.e., the object of the verb *attack*) with the *wh*-filler, crossing the subject of the relative clause (i.e., *senator*). In contrast, in SRs, the integration of a gap (i.e., the subject of the verb *attack*) with the *wh*-filler is more local, thus reducing EUs (i.e., processing difficulty) in integrating a filler with its gap.

(3.29) Integration costs of English ORs

	The	reporter$_i$	who$_i$	the	senator	attacked	t$_i$	disliked	the	editor	Total EUs
*D	0	1	0	0	1	1	0	1	0	1	
**S	0	0	0	0	0	0	2	2	0	0	
Total	0	1	0	0	1	1	2	3	0	1	9

*D: EU for discourse referents; **S: EU for structural integration

(3.30) Integration costs of English SRs

	The	reporter$_i$	who$_i$	t$_i$	attacked	the	senator	disliked	the	editor	Total EUs
*D	0	1	0	0	1	0	1	1	0	1	
**S	0	0	0	0	0	0	0	2	0	0	
Total	0	1	0	0	1	0	1	3	0	1	7

*D: EU for discourse referents; **S: EU for structural integration

Therefore, both the *storage-based* and the *integration-based dependency locality theories* predict the processing advantage of SRs over ORs, as observed in the processing literature.

3.2.2 **Filler-gap Domain Hypothesis** (Hawkins, 2004)

Hawkins, in support of the performance-grammar correspondence hypothesis, argues that the size of the filler-gap domain shows the complexity of the structure, illustrating that variation in the grammatical complexity is correlated with processing efficiency. The main arguments of the *filler-gap domain* hypothesis are presented below.

First, the filler is co-indexed with a subcategorizer rather than with a gap within the relative clause. Therefore, *papers* in (3.27) is coindexed with *write,* its subcategorizer in the relative clause.

(3.31) papers$_i$ [that students write$_i$]

Second, the size of the filler-gap domain depends on the distance between the filler and the subcategorizer, and this determines the complexity of the structure.

(3.32) Filler-Gap Domain (FGD)
An FGD consists of the smallest set of terminal and nonterminal nodes dominated by the mother of a filler and on a connected path that must be accessed for gap identification and processing; for subcategorized gaps the path connects the filler to a co-indexed subcategorizer and includes, or is extended to include, any additional arguments of the subcategorizer on which the gap depends for its processing; for nonsubcategorized gaps the path connects the filler to the head category that constructs the mother node containing the co-indexed gap; all constituency relations and cooccurrence requirements holding between these nodes belong to the description of the FGD.

(Hawkins, 2004)

Note that when the gap is in a position that requires another argument to co-occur, the filler-gap domain should be extended to include that argument as well. This means that when the gap is in the subject position, the gap does not require the filler-gap domain to be extended at all, as in (3.33). In contrast, when the gap is in the object position, the subject should also be included in the filler-gap domain because an object requires that a subject co-occur, as in (3.34).

FGD (FGD: bold and underlined)
(3.33) SR: **students$_i$ [that write$_i$** papers]
(3.34) OR: **papers$_i$ [that students write$_i$**]

This means that in English, while the filler-gap domain of ORs always includes the subject, the filler-gap domain of SRs does not include the object, and hence the processing advantage of SRs over ORs.

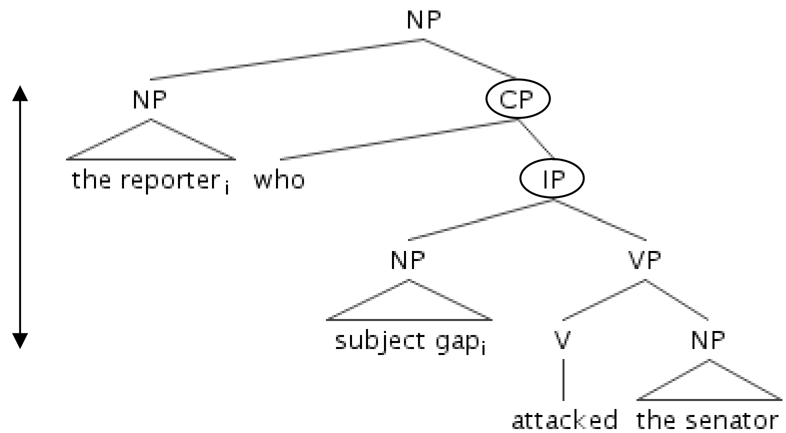
3.2.3 **Phrase-Structural Distance Hypothesis** (O'Grady, 1997)

O'Grady explains the advantage of SRs over ORs in terms of the different structural distance between a gap and its filler in SRs and ORs: the subject gap is closer to the head noun than the object gap is.

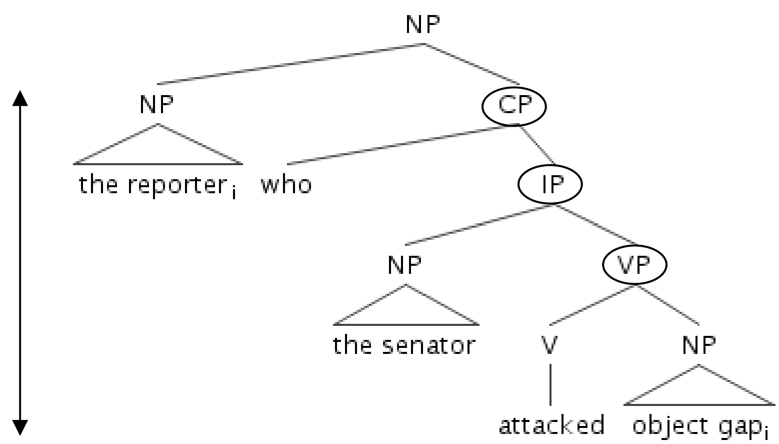
(3.35) A structure's complexity increases with the number of XP categories (S, VP, etc.) between a gap and the element with which it is associated.

(O'Grady, 1997: 136)

(3.36) Tree structure of SRs



(3.37) Tree structure of ORs



As shown in (3.36) and (3.37), the phrase-structural distance between gap and filler is longer (i.e., has more intervening XPs) in ORs than in SRs. Thus the *phrase-structural distance hypothesis* predicts the processing disadvantage of ORs over SRs that has been found in the processing literature.

3.2.4 **Accessibility Hierarchy** (Keenan & Comrie, 1977)

Languages vary with respect to which NP positions can be relativized. However, after examining about fifty languages, Keenan and Comrie argued that this variation is not random, and proposed a universal constraint on relative clause formation. They proposed an *accessibility hierarchy* (AH), arguing that there is an ordering of grammatical relations such that if a language allows relativization on one grammatical position in this ordering then it must also allow relativization on all grammatical positions to the left of that position on the scale shown in (3.33).

(3.38) Accessibility hierarchy (AH)
subject > direct object > indirect object > oblique > genitive > object of comparison
(Keenan & Comrie, 1977: 66)

That is, if a language can relativize on obliques, it can also relativize on objects and subjects. If a language can relativize on objects, it can also relativize on subjects but not necessarily on obliques.

Moreover, Keenan and Comrie argued that the *'AH directly reflects the psychological ease of comprehension'* (Keenan & Comrie, 1977: 88). In other words, NPs higher in the accessibility hierarchy are argued to be easier to process. According to Keenan and Comrie, the psychological ease of comprehension is based on the notion of 'independent reference'. Subjects and head nouns are independently referring. On the other hand, the reference of an object is dependent on that of the subject. Therefore, in SRs, there is just one independent reference, because the reference of the subject and the head noun is identical. In other types of relative constructions, however, there are two independent references (subject and head noun). Thus, the *accessibility hierarchy* predicts that subject gap sentences are easier to process than other types of relative clauses (Keenan, 1975).

3.2.5 **Perspective Shift** (MacWhinney, 1982; MacWhinney & Pleh, 1988)

According to MacWhinney and Pleh, the subject of a clause determines the perspective of the clause (i.e., the attentional flow regulating language and thought). Under this theory, shifting the perspective of a clause requires additional processing resources. In other words, whenever the subject of the clause changes, more processing resources are required.

For example, in SS (subject head noun, subject gap), the same constituent serves as the subject in both clauses. Therefore, SS will not require any perspective shift, and will not require additional processing resources.

(3.39) SS (Subject head noun, Subject gap)
The reporter$_i$ [who t$_i$ attacked the senator] disliked the editor.

In contrast, SO (subject head noun, object gap) requires two perspective shifts. The parser needs to shift the perspective from the subject of the matrix clause to the subject of the embedded clause, and then back to the subject of the matrix clause.

(3.40) SO (Subject head noun, Object gap)

shift 1 shift 2

The reporter$_i$ [who the ↓senator attacked t$_i$] ↓disliked the editor.

For OS (object head noun, subject gap) and OO (object head noun, object gap), the parser needs to shift perspective only once: from the subject of the main clause to the subject of the embedded clause.

(3.41) OS (Object head noun, Subject gap)

The reporter disliked the editor$_i$ [who t_i attacked the senator].

(3.42) OO (Object head noun, Object gap)

The reporter disliked the editor$_i$ [who the senator attacked t_i].

Therefore, the *perspective shift theory* predicts the following order of difficulty of English relative clauses.

SS > {OO, OS} > SO

(MacWhinney & Pleh, 1988: 106)

3.2.6 Similarity Effect (Gordon et al. 2001)

Investigations of similarity models have provided support for the idea that the critical determinant of difficulty is not the amount of material that must be held in memory, nor the amount of time that it must be held, but rather that the similarity of the material determines the difficulty of processing by creating interference. Accordingly, this model accounts for the SR and OR asymmetry in terms of similarity-based interference in sentence processing. Gordon, Hendrick, and Johnson (2001) compared SR and OR sentences, matching or unmatching the type of NP1 (*the salesman* below) and NP2 (*the account, you and Bob* below).

(3.43) <u>The salesman</u> that <u>the accountant/you/Bob</u> contacted spoke very quickly.
(3.44) <u>The salesman</u> that contacted <u>the accountant/you/Bob</u> spoke very quickly.

They found that when the types of NP1 and NP2 were matched (e.g., both definite noun phrase description), the comprehension of ORs was much lower than that of SRs. However, when the types of two NPs differed, there was no difference in the comprehension of SRs and ORs. These results were interpreted to support the similarity-based interference in retrieval. That is, in OR clauses, both of the two NPs need to be stored and retrieved in working memory before the parser integrates either of them with a verb. Thus when the parser needs to retrieve an NP upon encountering a verb, the similarity of the two NPs can impair this process when the two NP types are the same. On the other hand, in SR clauses, NP1 is already integrated with the embedded verb before the parser receives NP2. Thus, the sentence is less susceptible to the similarity of the two NPs.

This *similarity-based interference* in retrieval hypothesis was redefined in Gordon, Hendrick, and Johnson (2004): similarity interference causes a processing difficulty in memory representation as well as retrieval (see Gordon et al., 2004 for the discussion).

3.2.7 Frequency

Ease of processing has long been associated with the amount of experience in language use (Corley & Crocker, 2000; Desmet, De Baecke, Drieghe, Brysbaert, & Vonk, 2006; Jurafsky, 1996; MacDonald, Pearlmuttter, & Seidenberg, 1994; Mitchell, Cuetos, Corley, & Brysbaert, 1995; Tabor, Juliano, & Tanenhaus, 1997). In the context of relative clause processing, I present frequency-based accounts in terms of statistical regularity (MacDonald, & Christiansen, 2002; Reali & Christiansen, 2007) and conditional probability (Hale, 2006; Levy, 2008).

3.2.7.1 Statistical Regularity of Word Order (MacDonald & Christiansen, 2002)

According to constraint-based models, sentence processing is constrained by a variety of probabilistic factors at the syntactic, semantic, and lexical levels. Accordingly, in these models, the processing asymmetry between SRs and ORs is accounted for in terms of the statistical regularity of word order: SRs are easier to process than ORs due to the fact that after relativization, canonical word order is maintained in SRs but not in ORs (MacDonald & Christiansen, 2002), as shown in (3.45) and (3.46).

(3.45) SR: SVO remains SVO after relativization
The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.
S V O

(3.46) OR: SVO becomes OSV after relativization
The reporter$_i$ who the senator harshly attacked ___$_i$ admitted the error.
O S V

3.2.7.2 Probabilistic Models: Entropy Reduction (Hale 2006) **& Surprisal** (Levy, 2008) **Models**

In information theory, entropy is defined as uncertainty about specified alternatives, and *entropy reduction* means the downward change in average uncertainty. Hale (2006) adopts this notion of entropy to account for sentence processing difficulty, assuming entropy to be the "uncertainty about the rest of the sentence". That is, the complexity of word-by-word processing is defined in terms of the informational contribution of each word (i.e., the conditional entropy of a grammatical continuation at each word position, constrained by the initial string), and words with more information about the sentence structure are harder to comprehend. In terms of processing filler-gap dependencies in relative clauses, Hale (2006) calculated and compared entropy reduction in relative clauses based on the adjunction (Chomsky, 1977) and promotion (Brame, 1976) analyses (for details of these analyses, see Chapter 2). He showed that when calculated in terms of entropy reduction based on the promotion analysis, the processing difficulty of English relatives was correlated with the *accessibility hierarchy* (Keenan & Comrie, 1977).[1]

Levy (2008) argues along similar lines for probabilistic, expectation-based accounts. In Levy's model, resource allocation is viewed as the source of processing difficulties, and is calculated in terms of *surprisal,* the negative log of the conditional probability. That is, processing difficulty at a given word is determined by "*the degree of update in the preference distribution over interpretations of the sentence that the word requires*" (Levy, 2008: 1168). In terms of relative clauses, the surprisal model attributes the processing advantage of SRs over ORs to the fact that SRs are more frequent and thus more expected than ORs. However, hypothesizing that surprisal has a major effect on word-by-word local processing, Levy notes the possibility that processing of non-local dependencies could be different from local processing.

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[1] A correlation between the *accessibility hierarchy* and processing difficulty defined by entropy reduction was not significant when entropy reduction was calculated with the adjunction analysis.

3.3 Processing Backward Filler-Gap Dependencies

In this section, I present recent studies that investigate the processing of backward filler-gap dependencies, mainly in Chinese and Japanese, languages with prenominal relative clauses. Overall, in contrast to the experimental results in English, which consistently showed a processing advantage for SRs, the experimental results in Chinese and Japanese have been mixed: while most studies found an advantage for SR processing (**Chinese**: C. Lin & Bever, 2006; Kuo & Vasishth, submitted; **Japanese**: Kanno & Nakamura, 2001; Miyamoto & Nakamura, 2003; Ishizuka et al., 2003; Ueno & Garnsey, 2008), there have been at least four studies that reported an OR processing advantage in comparison to SRs (**Chinese**: Hsiao & Gibson, 2003; Y. Lin & Garnsey, 2007; **Japanese**: Ishizuka et al., 2006; Nakamura, 2000; but see Kanno & Nakamura, 2001 for a criticism of Nakamura, 2000).

3.3.1 Processing of Studies of Chinese Relative Clauses

Like English, Chinese has SVO word order, but it also has prenominal relative clauses like those in Korean and Japanese (i.e., backward filler-gap dependencies). In addition, in RCs, the genitive marker *de* precedes the head noun, as shown in the following OR sentence.

<table>
<tr><td>senator attacked ___$_i$</td><td>de</td><td>reporter$_i$</td><td>disliked</td><td>editor</td></tr>
<tr><td>prenominal relative clause</td><td>GEN marker</td><td>head noun</td><td></td><td></td></tr>
<tr><td colspan="3">subject</td><td>verb</td><td>object</td></tr>
</table>

= The reporter who the senator attacked disliked the editor.

Hsiao and Gibson (2003) investigated the processing of singly and doubly embedded SRs and ORs in Chinese [(3.47) to (3.50)], using a self-paced reading time methodology.

(3.47) Singly embedded SRs
[[__$_i$ yaoching fuhao] de guanyuan$_i$ shinhuaibugui danshi shanyu yincang]
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.'

(3.48) Singly embedded ORs
[[fuhao yaoching __$_i$] de guanyuan$_i$ shinhuaibugui danshi shanyu yincang]
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.'

(3.49) Doubly embedded SRs
___$_i$ yaoching ___$_k$ gojie faguan$_k$ de fuhao de guanyuan$_i$
invite conspire judge tycoon official
shinhuaibugui
have bad intentions

'The official who invited the tycoon who conspired with the judge had bad intentions.'

(3.50) Doubly embedded ORs
fuhao yaoching ___$_i$ de faguan$_i$ gojie ___$_k$ de guanyuan$_k$
tycoon invite judge conspire official
shinhuaibugui
have bad intentions

'The official who the judge who the tycoon invited conspired with had bad intentions.'
(Modified from Hsiao & Gibson 2003)

The main findings of the experiments were that in singly embedded clauses, ORs were comprehended better and processed significantly faster than SRs within the relative clause region. However, there was no difference at the head noun or at subsequent regions. In doubly embedded clauses, the processing advantage of ORs was more apparent, persisting throughout the two embedded relative clause regions. The authors took these results to indicate that linear distance between gap and filler is the crucial variable in sentence processing (*dependency locality theory*: Gibson, 2000, for details, see Section 3.2).

Hsiao and Gibson's results, however, have been challenged because of confounding factors involving structural ambiguity (Lin & Bever, 2006) and failure of replication (Kuo & Vasishth, submitted). In discussing Hsiao and Gibson's experimental results in singly embedded clauses, Lin & Bever (2006) pointed out that out of twenty sets of sentences, seven verbs take sentential complements and thirteen verbs take verbal complements in addition to nominal objects. Thus, Lin and Bever argued that the verbs used in Hsiao and Gibson's experiment were syntactically ambiguous. This suggests that the source of the effects in Hsiao and Gibson (2003) is not clear, and thus cannot be solely attributed to the intrinsic differences between SRs and ORs. This concern is supported by the failure of replication and even opposite results reported in Kuo and Vasishth (submitted), where a reading time experiment using the same experimental sentences as in Hsiao and Gibson found that SRs are processed faster than ORs at the genitive marker *de* and the head noun.[2]

For the effects that Hsiao and Gibson found in doubly embedded sentences, Lin and Bever point out that double subject relatives involve center embedding, while the double object relatives involve a serial dependency, as shown in (3.51) and (3.52).

(3.51) Subject relative clauses embedded in subject relative clauses
$\_\_\__i$ invite $\_\_\__k$ conspire judge$_k$ DE tycoon DE official$_i$ have bad intentions

'The official who invited the tycoon who conspired with the judge had bad intentions.'

(3.52) Object relative clauses embedded in object relative clauses
tycoon invite $\_\_\__i$ DE judge$_i$ conspire $\_\_\__k$ DE official$_k$ have bad intentions

'The official who the judge who the tycoon invited conspired with had bad intentions.'

[2] The effects were significant in the participants analysis but not in the items analysis.

Since center embedding is more difficult to process than serial embedding (Miller & Chomsky, 1963), Lin and Bever argue that the comparison of doubly embedded SR and OR sentences in Hsiao and Gibson is not a valid comparison.

When Lin and Bever compared the processing of SRs and ORs, removing the problems of structural ambiguity and center vs. serial embedding (i.e., the concerns raised for interpretation of Hsiao & Gibson, 2003), there was a strong processing advantage for subject relatives.

3.3.2 Processing of Studies of Japanese Relative Clauses

Experimental results in Japanese have produced a rather consistent processing advantage for SRs, although there is at least one study that strongly argues for an OR advantage. Japanese is an SOV language and has prenominal relative clauses, as shown in the following object relative clause.

senator $\_\__i$ attacked	reporter$_i$	editor	disliked
prenominal relative clause	head noun		
subject		object	verb

= The reporter who the senator attacked disliked the editor.

In a reading time study, Miyamoto and Nakamura (2003) compared six types of relative clauses (2 gap types: subject and object gaps, 3 head noun types: topic, nominative, and accusative marked NPs).

(3.53) Relative clause region with subject and object gaps

[tosiyorino	obasan-o/ga	basutei-mede	miokutta]
elderly	woman-ACC/NOM	bus stop-to	accompanied

SR: ‘that accompanied the elderly woman’
OR: ‘that the elderly woman accompanied’

(3.54) Matrix clause region: topic and nominative marked head noun

onnanoko$_i$-wa/ga	nuigurumi-o	daiteita
girl-TOP/NOM	stuffy-toy-ACC	hugging
Topic/nominative:	'The girl [$_{RC\ ..}$] was holding a stuffed toy.'	

(3.55) Matrix clause region: accusative marked head noun

onnanoko$_i$- o	omawarusan-ga	yobitometa
girl-ACC	policeman-NOM	stopped
Accusative:	'The policeman stopped the girl [$_{RC\ ..}$].'	

The overall results showed that ORs were harder to process than SRs. While there was no difference between subject and object gap sentences in the accusative marked head noun condition, an OR processing disadvantage was clearly identified in the topic and nominative marked head noun conditions.

On the other hand, Ishizuka et al. (2006) argued that the longer reading times of ORs in earlier experiments (Miyamoto & Nakamura, 2003, Ishizuka et al., 2003) were due to a greater temporary structural ambiguity in ORs than in SRs: ORs, with a sentence-initial NP-NOM, are more likely to be interpreted as mono-clausal than are SRs, with a non-canonical sentence-initial NP-ACC. They hypothesized that when this confound of structural ambiguity is removed, SRs should be more difficult to process than ORs due to greater linear distance between filler and gap. Using preceding context as in (3.56), they forced a relative clause reading of their stimulus materials.

(3.56) Materials used in Ishizuka et al. (2006)
Preceding context:
A reporter interviewed a writer on a TV program. Then the writer interviewed another reporter for his new novel.

Taro:
'Which reporter is standing as a candidate in the election?'
Hanako:
SR: [__$_i$ writer-ACC interviewed] reporter$_i$ was it seems
'It seems to be the reporter who interviewed the writer'
OR: [writer-NOM __$_i$ interviewed] reporter$_i$ was it seems
'It seems to be the reporter who the writer interviewed'

The self-paced reading time results showed that SRs took longer to read than ORs as predicted, and the effect was significant at the embedded predicate ('interviewed' in the example) but not at the head noun position. However, these results are questionable for several reasons. In earlier studies of Japanese, a sentence-initial NP-ACC has been reported to cause a slowdown one word later in self-paced reading time experiments (Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008). Given this, the longer reading times for SRs at the embedded predicate position could be due to a spillover effect from the immediately preceding sentence-initial NP-ACC. This possibility is further supported by the fact that the effect was significant only at the embedded predicate ('interviewed' in the example) but not at the head noun position. Thus, this alternative account weakens the interpretation of the experimental results in Ishizuka et al. that subject relatives are more difficult to process than object relatives. The results of this study are further discussed in Chapter 4.

In summary, a subject/object processing asymmetry has also been observed in backward filler-gap dependencies. However, research in Chinese has produced rather mixed results, with some studies finding a processing advantage for SRs (C. Lin & Bever, 2006; Kuo & Vasishth, submitted), while others find an OR advantage (Hsiao & Gibson, 2003; Y. Lin & Garnsey, 2007). In Japanese, an SR processing advantage was rather consistently reported across different studies. Ishizuka et al. (2006) reported the opposite pattern (i.e., OR advantage) but several confounding factors were noted which require further investigation. These will be addressed in Chapter 4.

3.4 Processing Anaphoric Dependencies

Research on the processing of anaphoric dependencies has focused on the effects of grammatical constraints on on-line coreference: whether the parser coindexes anaphoric expressions (either pronouns or reflexives) with potential antecedents in inaccessible structural positions as well as in accessible positions. For example, using a cross-modal priming paradigm, Nicol and Swinney (1989) investigated whether on-line processing of pronouns and reflexives is subject to Principles A and B of the Binding theory (Chomsky, 1981) in forward anaphoric dependencies. That is, according to Principle A, the accessible antecedent for *himself* in (3.57)a is *doctor*, which occurs within the scope of the reflexive *himself,* while *boxer* and *skier* are inaccessible as antecedents. On the other hand, the reverse holds true for *him* in (3.57)b, where according to Principle B, *boxer* and *skier* are accessible antecedents, while *doctor* is now an inaccessible antecedent.

(3.57) Nicol and Swinney (1989)
(a) The boxer$_i$ told the skier$_j$ [that the doctor$_k$ for the team would blame himself$_{*i/*j/k}$ for the recent injury].
(b) The boxer$_i$ told the skier$_j$ [that the doctor$_k$ for the team would blame him$_{i/j/*k}$ for the recent injury].

The results showed that at *himself* in (3.57)a, there was a semantic priming effect of *doctor* but not of *boxer* or *skier*. At *him* in (3.57)b, the opposite pattern was observed: there was a semantic priming effect of *boxer* and *skier* but not of *doctor.* These results were taken to indicate that activation of potential antecedents for pronouns and reflexives is subject to syntactic constraints on coindexation (i.e., Principles A and B in this case) (Sturt, 2003; cf. Badecker & Straub, 2002; Kennison, 2003).

In fact, the effect related to Principle B (coreference of a pronoun with an antecedent in a structurally accessible position) suggests a pronoun-driven active search mechanism for an inter-sentential antecedent. That is, unlike a reflexive such as *himself*, a pronoun does not by nature require an inter-sentential antecedent (3.58).

(3.58) When the boy felt tired, she used to clean the house.

Thus, the parser could choose not to coindex the pronoun with a preceding potential antecedent. The different priming effects in accessible and inaccessible structural position, however, suggest that the parser prefers to coindex a pronoun with a preceding inter-sentential antecedent rather than with an unspecified referent.

Similar to the forward anaphoric dependencies in (3.57), processing of backward anaphoric dependencies has also been found to be driven by an active search mechanism (Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007). When a potential antecedent did not match the gender of the preceding pronoun, a gender mismatch effect was observed at the main verb position (van Gompel & Liversedge, 2003). Thus, in (3.59), conditions (c) and (d) were read more slowly than conditions (a) and (b) respectively.

(3.59) van Gompel and Liversedge (2003), Experiment 1
(a) When he was fed up, the boy visited the girl very often. (gender matched)
(b) When she was fed up, the girl visited the boy very often. (gender matched)
(c) When she was fed up, the boy visited the girl very often. (gender mismatched)
(d) When he was fed up, the girl visited the boy very often. (gender mismatched)

In addition, backward anaphoric dependencies are also found to be subject to grammatical constraints on coreference. When a potential antecedent occurs within the scope of the pronoun, violating Principle C, the gender mismatch effect does not occur. Thus, while there was a gender mismatch effect at *Russell* in (3.60)d (i.e., a condition without a Principle C violation) there was no corresponding slowdown at *Russell* in (3.60)b (i.e., a condition with a Principle C violation).

(3.60) Kazanina et al. (2007)

(a) Principle C violation/ gender matched

Because last semester she$_i$ was taking classes full-time while Kathryn was working two jobs to pay the bills, Erica$_i$ felt guilty.

(b) Principle C violation/ gender mismatched

Because last semester she$_i$ was taking classes full-time while Russell was working two jobs to pay the bills, Erica$_i$ felt guilty.

(c) No violation/ gender matched

Because last semester while she$_i$ was taking classes full-time Kathryn$_i$ was working two jobs to pay the bills, Russell never go to see her.

(d) No violation/ mismatch

Because last semester while she$_i$ was taking classes full-time Russell was working two jobs to pay the bills, Erica$_i$ promised to work part-time in the future.

In summary, it has been shown that processing of both forward and backward anaphoric dependencies is subject to syntactic constraints on coreference (Principle A, B and C), and is driven by an active search mechanism for potential inter-sentential antecedents.

3.5 ERP Methodology

In this section, I present an overview of ERP methodology along with previous findings on language-related ERP components.

3.5.1 ERP Overview

Successful language comprehension requires on-line processing of different sorts of information, such as phonology, morphology, syntax, semantics, pragmatics, etc. One of the techniques used to measure this on-line comprehension is examining ERPs (event-related brain potentials) in response to language materials. In this technique, the on-line electrical activity of the brain is measured in the form of the electroencephalogram (EEG) as recorded from electrodes on the scalp. The signal is only a few microvolts in amplitude. Thus it needs to be amplified, and certain ranges of frequencies in the scalp potentials are attenuated, ensuring that a continuous analog signal can be accurately represented by a series of discrete measurements at discrete time points. The usual sampling rate for studies on language processing is 200-250 Hz, which means that the output of the amplifier is recorded every 4 or 5 msec.

Finally, the recorded signals are averaged across single trials of the same experimental condition and across subjects in the time domain. The obtained ERPs include not only potentials due to the brain's activity in response to the experimental stimuli but also diverse artifacts such as muscle activity. The underlying assumption about averaging is that the brain activity irrelevant to the experimental stimuli is random in its timing, so averaging the signal across single trials and subjects in the time domain will cancel out irrelevant activity.

3.5.2 Language-related ERP Components

This section presents previous findings on the four main language-processing related ERP components: N400, P600, LAN (Left Anterior Negativity) and ELAN (Early Left Anterior Negativity).

3.5.3 N400

The best-studied language-related ERP component is the N400. This component was named after its characteristic negative-going voltage in the averaged ERP, peaking reliably around 400 ms post-stimulus onset. The N400 is observable across the scalp, but has the largest potential over the central and parietal midlines. In addition, its potentials are usually larger over the right side of the head than the left. Overall, research on the N400 has shown that N400 amplitude is an index of the difficulty of retrieving conceptual knowledge associated with an input, and the difficulty is associated with both the stored representation and the retrieval cues within the context (Kutas & Federmeier, 2000).

The N400 was first reported by Kutas and Hillyard (Kutas & Hillyard, 1980a, 1980b, 1980c). It was found that the amplitude of the N400 was larger for strong incongruity (e.g, *He took a sip from the transmitter*) than for moderate incongruity (e.g, *He took a sip from the waterfall*) (Kutas & Hillyard, 1980a). When sentences ended with semantically congruent words that were in a larger font size than the preceding words, the N400 component was not elicited. Instead, a late positive complex was elicited (P560 in Figure 3-1).

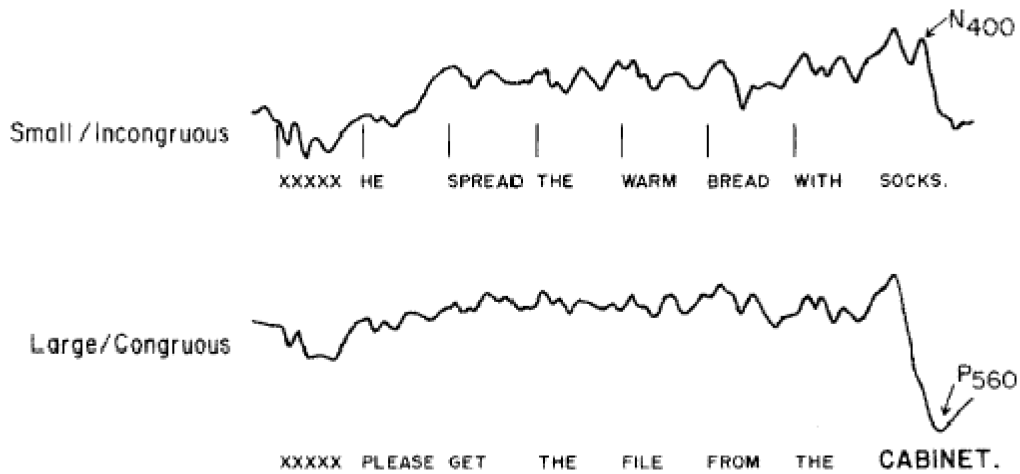

Figure 3-1 Kutas & Hillyard (1980c)

However, a semantic anomaly is not a necessary condition for eliciting an N400 response. Kutas and Hillyard (1984) found that the amplitude of the N400 varies as a function of cloze probability, which was defined as the proportion of subjects that choose to use a particular word to complete a certain sentence context (see also Kutas, Lindamood, & Hillyard, 1984). It was found that highly probable endings elicited a broad late positivity while improbable endings elicited an N400. Likewise, it was found that the amplitude of the N400 was smaller when the endings were semantically related to the best completion endings than when they were unrelated.

(3.61) Best completion: Don't touch the wet <u>paint</u>.
(3.62) Unrelated completion: Don't touch the wet <u>dog</u>.
(3.63) Best completion: He liked lemon and sugar in his <u>tea</u>.
(3.64) Related completion: He liked lemon and sugar in his <u>coffee</u>.

These results were taken to indicate that the amplitude of the N400 is dependent on the subject's expectancy of a word, and that the N400 reflects semantic activation rather than simple reaction to semantic incongruity (Kutas & Hillyard, 1984).

The argument that the N400 reflects people's expectancy of a word was also supported by an experiment which showed that the amplitude of the N400 became smaller with the linear function of the sentential position of the word (as long as the word position is not sentence-final): open-class words in sentence-initial positions elicited large N400s, and the amplitude decreased as sentential context provided additional semantic constraints for following words (Kutas, Van Petten, & Besson, 1988; Van Petten & Kutas, 1990, 1991). The results were interpreted to indicate that N400 amplitude is determined by the level of expectancy of a word from context and how easily the word can be integrated into the current context (Kutas & Hillyard, 1984; Kutas, Van Petten, & Besson, 1988; Kutas, Lindamood, & Hillyard, 1984; Van Petten, 1995, Van Petten, & Kutas, 1990).

In addition, it was found that sentential contexts are not a necessary condition to elicit an N400 response. In an experiment to investigate semantic priming using a lexical decision task, it was found that, compared to primed words, unprimed fillers elicit a negative-going wave that peaks at approximately 400 msec post stimulus onset (Bentin, McCarthy, & Wood, 1985). This semantic context effect has been demonstrated in printed, spoken and signed language (Holcomb & Neville, 1990, 1991; Kutas, Neville, & Holcomb, 1987; Neville, Mills, & Lawson, 1992).

The argument that the N400 can be elicited without sentential context is further supported by experimental results showing that N400 amplitude is sensitive to lexical characteristics. First, high frequency words elicit smaller N400s than low frequency words (Allen et al., 2003; Barber et al., 2004; Münte et al., 2001; Van Petten, 1993; Van Petten & Kutas, 1990, 1991). Second, closed class words elicit smaller N400s than open class words (King & Kutas, 1995; Münte et al., 2001; Neville, Mills, & Lawson, 1992; Van Petten & Kutas, 1991), even when controlled for frequency (Garnsey, 1985). Third, the amplitude of N400 is also sensitive to the concreteness of a word. Words denoting concrete concepts elicit larger N400 than words with abstract concepts (Kounios & Holcomb, 1994; Paller, Kutas, & Mayes, 1987; West & Holcomb, 2000). This suggests that larger N400s to open class words apparently have something to do with richer conceptual contents of open class words, as closed-class words with richer conceptual content also elicit larger N400-like activity than closed-class words with less conceptual content (Kluender & Kutas, 1993a; McKinnon & Osterhout, 1996) even when controlled for frequency. Fourth, N400 is sensitive to the eliciting word's orthographic neighbors. If one word can be changed into many other words easily by changing one letter, the word will elicit larger N400s than words with fewer neighbors (Holcomb et al., 2002). This effect was taken to indicate global semantic activation due to partial activation of words with near matches. Fifth, pseudo-words that comply with the phonological or orthographic rules of a language elicit an N400, and its amplitude is comparable to or larger than that of open class words. On the other hand, illegal nonwords do not produce an N400 (Holcomb & Neville, 1990). Finally, N400-like potentials have also been found in response to non-linguistic but meaningful stimuli including line drawings, photos, and environmental sounds (see Van Petten & Luka, 2006, for a review).

3.5.4 P600

Another ERP component that has been suggested to be related to language processing is the P600 (Osterhout & Holcomb, 1992). This component has also been called the late positive component (LPC) or the syntactic positive shift (SPS) (Hagoort et al., 1993). It is a positive-going wave with a post-stimulus onset of anywhere from 200 to 600 msec in the averaged ERP that usually continues throughout a single-word epoch and often extends into the next word. It is widely distributed across the scalp and usually shows a maximum in the centro-parietal region, though this can vary from study to study.

Within language contexts, the P600 was originally found to be sensitive to processing linguistic structures at the level of syntax (cf. Münte et al., 1997). A P600 has been elicited by many different morpho-syntactic anomalies: violations of phrase structure and subcategorization (Hagoort et al., 1993; Neville et al., 1991; Osterhout & Holcomb, 1992; Osterhout et al., 1994), of grammatical constraints on syntactic movements (Neville et al., 1991; McKinnon & Osterhout, 1996), of subject-verb number, gender and/or person agreement (Coulson et al., 1998a; Hagoort et al., 1993; Nevins et al., 2007; Münte et al., 1997), of antecedent-reflexive gender and number agreement (Osterhout & Mobley, 1995), and of determiner and noun agreement (Hagoort & Brown, 1999).

(3.65) Phrase structure violation
*The man admired Don's of sketch the landscape.
(Neville et al., 1991)

(3.66) Violation of constraint on movement
*What$_i$ was [$_{\text{NP}}$ a sketch of __$_i$] admired by the man?
(Neville et al., 1991)

(3.67) Violation of constraint on movement
*I wonder which of his staff members$_i$ the candidates was annoyed [$_{\text{ADJUNCT CL.}}$ *when* his son was questioned by ___$_i$]
(Neville et al., 1991)

(3.68) Subject-verb agreement violation
*Het verwende kind *gooien* het speelgoed op de grond.
(The spoilt child *throw* the toys on the floor.)
(Hagoort et al., 1993)

(3.69) Subcategorization violation
*The woman persuaded to answer the door.
(Osterhout & Holcomb, 1992)

(3.70) Antecedent-reflexive gender agreement violation
The successful woman congratulated *himself* on the promotion
(Osterhout & Mobley, 1995)

(3.71) Antecedent-reflexive number agreement violation
The hungry guests helped *himself* to the food
(Osterhout & Mobley, 1995)

However, the P600 is not specific to the processing of syntactic violations, as a P600 was also elicited by non-syntactic stimuli such as orthographic violations (e.g. Die Hexe benutzte ihren Behsen, um zum Wald zu fliegen. 'The witch used her *broome* to fly to the forest.') (Münte et al., 1998), especially when the word from which the pseudo-homophones is derived is highly predicted (e.g., "*In that library the pupils borrow* <u>*books/bouks*</u>") but not when the word is not expected (e.g., "*The pillows are stuffed with* <u>*books/bouks*</u>") (Vissers et al., 2006).

In addition, the P600 was elicited in response to the grammatical sentences with pragmatic/semantic violation (e.g., "*The fox that shot the poacher*": van Herten et al., 2006; "*The javelin has the athletes thrown*": Hoeks et al., 2004; "*For breakfast the eggs would bury*": Kuperberg et al., 2003; Kuperberg et al., 2007; "*The hearted meal was devouring*": Kim & Osterhout, 2005; "*Jennifer rode a small huge elephant*": Kemmerer et al., 2005). Given that the N400 has been found to be sensitive to the semantic incongruity, the elicitation of the P600 with the absence of an enhanced N400 (or with a reduced N400) to the semantic/pragmatic violation was puzzling and several different interpretations were put forth. First, the results were taken to suggest that the functional independency of syntactic and semantic systems (contra syntax-first processing models: Fodor, 1983; Ferreira & Clifton, 1986) (Kim & Osterhout, 2005) or the importance of lexico-semantic information (Hoeks et al., 2004) during on-line sentence processing. It was also suggested that the P600 is an index of monitoring process of conflicts between two interpretations derived by syntactic analysis and by a word-based plausibility heuristics (van Herten et al., 2006) or an index of thematic reanalysis or integration (Kuperberg et al., 2003, 2007).

Although it is difficult to pin down exactly what aspect of cognitive process P600 reflects, there are at least four different views. The first one is the view of the P600 as an index of syntactic reanalysis rather than initial structural analysis. Osterhout and Holcomb (1992) argued that a syntactic violation is not a necessary condition to elicit a P600, and that a grammatical sentence that is not consistent with the "preferred" structural analysis also elicits a P600. This was shown in Osterhout and Holcomb (1992) and Osterhout et al. (1994) using garden path sentences. For example, in (3.72), there is ambiguity regarding the structural status of *the defendant*. That is, it can be either a verbal complement in a simple sentence or it can be the subject of the complement clause.

(3.72) The judge believed *the defendant*
(a) and threw out the charges.
(b) was lying.

Osterhout et al. (1994) compared the processing of sentences with pure intransitive and transitive verbs, and with verbs that can be used as both transitive and intransitive verbs but have a statistical bias toward one over the other.

(3.73) Intransitive verb
The doctor hoped the patient was lying.

(3.74) Intransitive biased verb
The doctor believed the patient was lying.

(3.75) Transitive biased verb
The doctor charged the patient was lying.

(3.76) Transitive verb
The doctor forced the patient was lying.

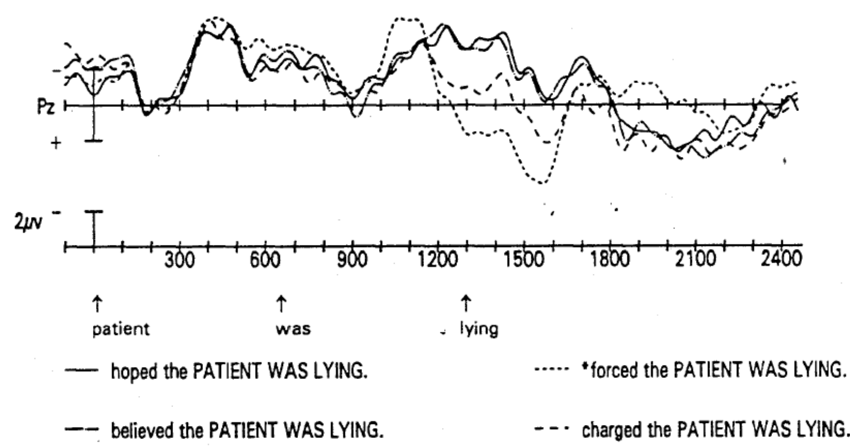

Figure 3-2 Osterhout et al. (1994), Figure 5

As shown in Figure 3-2, the amplitude of the P600 was modulated as a function of word-specific subcategorization bias, with the transitive verb condition showing the largest P600 amplitude, and the intransitive verb condition showing the smallest. The results were taken to suggest that subcategorization information based on the statistical cues of idiosyncratic verb usage rather than minimal attachment is the underlying mechanism of on-line structural analysis. In terms of the P600, Osterhout et al. (1994) interpreted the results as confirming the hypothesis that the P600 is sensitive to syntactic reanalysis due to a garden-path effect.

Osterhout et al. (1994) noted that this view has the advantage of accounting for the temporal relationship between the N400 and P600. In other words, given the modularist assumption that semantics is available after proper analysis of the structure of sentences (Fodor, 1983), the temporal relation of the N400 and P600 could be puzzling. Thus, the argument goes, treating the P600 as an index of structural reanalysis could resolve this temporal inconsistency.

On the other hand, Kaan et al. (2000) argued that the P600 reflects difficulty associated with syntactic integration difficulty. Their argument was based on an experiment which showed that grammatical and non-garden path sentences also elicited a P600. Specifically, they compared processing of sentences with *who, which* and *whether* as shown below.

(3.77) Emily wondered whether the performer in the concert had imitated a popstar for the audience's amusement.

(3.78) Emily wondered which popstar the performer in the concert had imitated for the audience's amusement.

(3.79) Emily wondered who the performer in the concert had imitated for the audience's amusement.

There was a larger positive response to the *who* and *which-N* conditions of (3.78) and (3.79) compared to the *whether* condition of (3.77) at the position where the *wh*-word is integrated with the verb (i.e., at the gap position). In addition, Kaan et al. (2000) showed that the positivity observed in the *who* condition has overlapping neural generators with the positivity elicited to agreement violations.[3] Based on these experimental results, Kaan et al. (2000) argued that the P600 reflects the underlying cognitive difficulty associated with syntactic integration in general rather than syntactic reanalysis.

Another view is argued by Münte et al. (1997). They claimed that the P600 is a neural index of a repair process that occurs upon the identification of a putative ungrammaticality. One important piece of evidence for this argument comes from the fact that the P600 is often accompanied by LAN. Given the natural assumption that detection should precede repair, LAN was suggested to be associated with detection and the P600 with repair processes. Another important aspect that Münte et al. (1997) discussed is the semantic sensitivity of the P600. They found that in a syntactic-prose with pseudowords, ungrammatical sentences (e.g. "Twe mullow grives freoly senks by the litune.") elicited LAN but not a P600. Based on these arguments, Münte et al. (1997) argued that the P600 is an index of repair involving semantic processing.

Another view is that the P600 is a domain-general brain response as a member of the P300 family (Pritchard, 1981) that is elicited by non-linguistic rare "odd ball" events (Coulson, et al., 1998a, 1998b; Gunter, Stowe, & Mulder, 1997; for a different view, see Osterhout, McKinnon, Bersick, & Corey, 1996; Osterhout & Hagoort, 1999). The P300 is a positive-going voltage deflection and its onset and peak latency vary depending on the demand of the tasks involved. The distribution shows a centro-parietal maximum. It is believed that the P300 reflects subjective resolution on the probability of events in the current context as well as the surprise value of the stimulus that is relevant to the task. In addition, the P300 is elicited only when the person is actively attending to the stimulus.

[3] This claim, however, is based on the marginal interactions at 2/29 electrodes tested individually. There

For example, the P300 is elicited in response to sporadically interspersed short tones among sequences of long tones to which the subject is attentive.

Given the previous findings that the factors that affect the amplitude of the P300 are probability and saliency (Picton, 1992), Coulson et al. (1998a) examined whether the P600 is a member of the P300 family by manipulating the saliency using different kinds of violations: subject-verb agreement violations and violations of overt case marking on pronouns.

(3.80) Case marking violation on pronouns
*The plane took *we* to paradise and back.
(3.81) Subject-verb agreement violation
*They suns themselves on the beach.

In addition, Coulson et al. (1998a) manipulated the local probability of ungrammatical sentences. In one test block, grammatical sentences accounted for 80% of events presented and thus were the probable event. In another test block, ungrammatical sentences accounted for 80% of events and were the probable event. The results clearly showed a dependency of P600 on the proportion manipulations of grammaticality of sentences, suggesting that the hypothesis that the P600 and P300 are related (but also see Stowe & Mulder, 1997; Hahne & Friederici, 1999 for similar results; Osterhout et al., 1996 for different results). First, the scalp distribution of the P600 and P300 were remarkably similar and statistically indistinguishable. Second, in the test block where an ungrammatical sentence was the probable event, the amplitude of the late positivity seen in response to the ungrammatical sentences was reduced. Third, more salient grammatical violations (case marking violations on pronouns) elicited larger P600 effects than subject-

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was no significant interaction in the omnibus ANOVA.

verb agreement violations. In fact, the view that the P600 is domain-general is further supported by the elicitation of the P600 in non-linguistic contexts (albeit rule-governed) such as music (Patel et al., 1998; Besson & Faïta, 1995; Janata, 1995), and arithmetic (Núñex-Peña & Honrubia-Serrano, 2004).

In summary, the underlying cognitive processes that the P600 reflects are not yet clearly understood. However, within meaningful sentence contexts, a morho-syntactic violation will elicit a P600 or, at the least, the P600 can be used to investigate sentence processing mechanisms.

3.5.5 Left Anterior Negativity (LAN)

Left anterior negativity (LAN) is a negative-going wave with an anterior spatial distribution, often but not always left-lateralized. In terms of the time course of the effect, LAN effects have been observed both in phasic and slow potential forms. Phasic LAN effects are often elicited within a 300-500 post-stimulus latency window and have been found to be left-lateralized in some studies (Kluender & Kutas, 1993a, 1993b), while some studies have found a bilateral effect (Fiebach et al., 2002; King & Kutas, 1995; Phillips et al., 2005), which may be larger over the left hemisphere. On the other hand, sustained anterior negativities can continue for several seconds and have been often found to be bilateral (King & Kutas, 1995; Phillips et al., 2005). In addition, some studies even reported larger amplitude over the right than the left hemisphere (Müller et al., 1997; Ueno & Kluender, 2003b).

Phasic LAN effects have been observed in response to both morphosyntactic violations and working memory load. For example, in addition to subcategorization and phrase structural violations (Münte et al., 1993; Neville et al., 1991; Rösler et al., 1993), LAN has been elicited to inflection/agreement violations (Kutas & Hillyard, 1983; Münte et al., 1993; Osterhout & Mobley, 1995), and case violations (Coulson et al., 1998a).

In terms of working memory load, the LAN has been elicited to *wh*-question sentences with filler-gap dependencies in comparison to structures without filler-gap dependencies (Felser et al., 2003; Fiebach et al., 2002; Kluender & Kutas, 1993a; Kluender & Münte, 1998; Phillips et al., 2005). For example, Kluender and Kutas (1993a, 1993b) observed a phasic LAN in response to *wh*-questions. They examined sentences like (3.82), and observed a negative ERP shift occurring about 300 ms post word onset for words directly following the syntactic 'gap' and 'filler' when compared to control words that did not follow a gap.

(3.82)

if-question:	Do you wonder	[if	they	caught	him	at	it by accident]?
wh-question:	Do you wonder	[who	they	caught	__	at	it by accident]?
		FILLER			GAP		

The LAN at the filler position was interpreted to be an index of higher working memory costs in storing a filler in working memory, to maintain the filler in working memory while continuing to process incoming words across the intervening distance between filler and gap requires extra working memory resources. On the other hand, the LAN at the gap position was associated with processing costs of retrieving the filler for filler-gap association (or for assigning the filler a theta role that is available at the gap position).

The LAN has been found in other types of filler-gap dependencies as well, including relative clauses (King & Kutas, 1995; Ueno & Garnsey, 2008), scrambled sentences (Rösler et al., 1998; Ueno & Kluender, 2003a) and topicalization sentences

(Felser et al., 2003). This issue is discussed further in Section 3.6. On the other hand, it was also noted that a filler-gap dependency is not a requirement for eliciting the LAN. For example, in Hoen & Dominey (2000), the LAN was associated with general neuro-cogntive computation of the predicted sequential representation.

Finally, the LAN as an index of working memory load is also observed in constructions that require higher-level inter-clausal evaluation. In Münte et al. (1998), a sustained LAN effect was elicited to 'before' sentences in comparison to 'after' sentences.

(3.83) After the scientist submitted the paper, the journal changed its policy.

(3.84) Before the scientist submitted the paper, the journal changed its policy.

Unlike 'after' sentences where two events are presented in real-world event order, in 'before' sentences, two events are presented in the reversed order. Thus processing of the 'before' sentences requires high-level event organization, which leads to higher working memory demand, and thus LAN.

3.5.6 Early Left Anterior Negativity (ELAN)

It has been shown that word category violations elicit a remarkably early ERP effect with a latency of 100 to 250 ms post-stimulus. Since this effect shows a pronounced left anterior negativity with early latency, it is called Early Left Anterior Negativity (ELAN).

The ELAN has been typically characterized in terms of on-line structure building in a processing model that emphasizes the role of syntax in initial processing (i.e., Phase 1 of Friederici, 2002; cf. Friederici, 1995). That is, during on-line sentence comprehension, the parser computes local phrase structure based on word category information from an incoming word, and ELAN is an index of a word category violation. For example, ELAN was observed in sentences containing possessive marked NPs followed by a preposition in the ungrammatical condition of (3.85)-b in comparison to its grammatical counterpart in (3.85)-a at the preposition *of* (Neville et al., 1991).

(3.85) Neville et al., (1991)
a. The scientist criticized a proof of the theorem.
b. The scientist criticized Max's of proof the theorem.

That is, in *Max's of proof*, *Max's* can only modify a noun phrase, and thus must immediately precede a linguistic element that can occur at the left edge of a noun phrase (i.e., a noun or an adjective modifying a noun). On the other hand, a preposition cannot occur at the left edge of a noun phrase as a part of it. Thus, at *of*, it is clear that *Max's of* violates phrase structure, leading to the ERP effects at that position. Similarly, ELAN was also found in English sentences containing possessive pronouns followed by a verb when they should be followed by a noun (e.g., **your write/you write*) (Münte et al., 1993), and in Japanese sentences where genitive marked NPs were followed by a verb when they should be followed by a noun (e.g., **two NP-GEN jump over/two NP-GEN cat-ACC jump over*) (Mueller et al., 2005).

More recently, it has been suggested that the amplitude of the ELAN can be modulated by the prediction of ungrammaticality based on the preceding context (Lau et al., 2006). Furthermore, it has been argued that not all word category violations lead to ELAN (e.g., 'the discovery was REPORT') and this could be due to the possibility that a limited set of closed class morphemes are identified in visual processing and the ELAN is the response to this visual input against the predicted input (Dikker et al., submitted).

3.6 Previous ERP Studies on Filler-Gap Dependencies

The processing of filler-gap dependencies has been investigated in *wh*-questions (Fiebach et al., 2002; Kaan et al., 2000; Kluender, 1998; Kluender & Kutas, 1993a, 1993b; Phillips et al., 2005), relative clauses (King & Kutas, 1995; Müller et al., 1997; Ueno & Garnsey, 2008), and scrambling constructions (Rösler et al., 1998; Ueno & Kluender, 2003a).

In general, the processing of filler-gap dependences has been assumed to cause additional processing difficulty, and this has been argued to be indexed by the LAN and P600. For example, King and Kutas (1995) compared SRs and ORs (3.86), and found a bilateral anterior slow negative-going potential to ORs in comparison to SRs after the onset of the relative pronoun. This effect continued throughout the relative clause region. Additionally, in word-by-word comparisons, immediately after the gap position they found a phasic LAN effect to ORs in comparison to SRs.

(3.86) King and Kutas (1995)

SR	The reporter [who FILLER	__ GAP	harshly	attacked	the senator		]	admitted the error
OR	The reporter [who FILLER	the	senator	harshly	attacked	__ GAP	]	admitted the error

King and Kutas interpreted the frontal negativity as indexing higher working memory costs for ORs than for SRs. That is, in the relative clause region of OR, the head noun needs to be stored in working memory without a thematic role, while in SRs, the head noun is immediately assigned a thematic role from the embedded verb. Since storing an NP without a thematic role imposes a burden on working memory (Gibson, 1990), this accounts for the slow potential in response to ORs within the relative clause region. On the other hand, King and Kutas attributed the LAN effect to ORs at the main clause verb position to multiple thematic role assignments in ORs. That is, in SRs, thematic role assignment by the embedded and main verbs occurs at different points of sentence processing (i.e. embedded verb: early relative clause region, main verb: at the main verb position), while in ORs, the head noun receives thematic roles from both the embedded and main verbs at approximately the same time (i.e., around the gap position), leading to an extra working memory burden in ORs at that position.

On the other hand, other studies have reported that processing of long-distance dependencies elicited a P600 effect (Gouvea, Phillips, & Poeppel, submitted; Kaan et al., 2000) or a combination of LAN and P600 effects (Fiebach et al., 2002; Phillips et al., 2005).

For example, in Kaan et al. (2000), comparison of three types of embedded questions (*who*, *which-N* and *whether* as in (3.87)) revealed a P600 effect to *wh*-question conditions (*who* and *which-N*) at the main verb, *imitated*, in comparison to the yes-no question condition (*whether* condition).

(3.87) Kaan et al. (2000)
i) *whether*
Emily wondered whether the performer in the concert had imitated a pop star for the audience's amusement.

ii) *who*
Emily wondered who the performer in the concert had imitated__ for the audience's amusement.

iii) *which-N*
Emily wondered which pop star the performer in the concert had imitated __ for the audience's amusement.

Based on these results, Kaan et al. argued that the P600 is an index of syntactic integration in general rather than syntactic reanalysis (Osterhout & Holcomb, 1992) (also see Fiebach et al., 2002 and Phillips et al., 2005 for similar results; Gouvea et al., submitted; for a detailed discussion).

In a recent study of Japanese relative clauses (backward filler-gap dependencies), Ueno & Garnsey (2008) showed that ORs in Japanese elicited (bilateral) anterior negativity in comparison to SRs. The effect started after the onset of the embedded verb, as in (3.88), and continued throughout the head noun position. Additionally, they found a slow positive-going potential to ORs with a centro-posterior maximum onsetting 500 ms after the head noun, which persisted across the rest of the sentence. This effect was taken as a variant of the P600.

(3.88) Ueno & Garnsey (2008)

a. Subject relatives

[shinninno	giin-o	hinanshita]	kisha-ni-wa	naganenno	aibou-ga
[new	senator-ACC	attacked]	reporter-DAT-TOP	long-term	colleague-NOM

ita.
existed
'The reporter who attacked the new senator had a long-term colleague.'

b. Object relatives

[shinninno	giin-ga	hinanshita]	kisha-ni-wa	naganenno	aibou-ga
[new	senator-NOM	attacked]	reporter-DAT-TOP	long-term	colleague-NOM

ita.
existed
'The reporter who the new senator attacked had a long-term colleague.'

Ueno & Garnsey argued that the LAN and P600 to ORs index higher working memory demand and syntactic integration difficulty in ORs, respectively, due to the longer phrase (as opposed to linear) structural distance between a filler and its gap.

Chapter 4: Processing of Syntactic Dependencies in Korean: SR vs. OR

4.1 Introduction

The goal of the experiments in this chapter is two-fold. The first is to test various processing models proposed to account for the processing asymmetry of subject and object relative clauses (SRs and ORs) in forward syntactic dependencies, as in English (see Chapter 3), based on a systematic comparison of the experimental results in a typologically distinct language that has backward syntactic dependencies. The second goal is to examine how the typological surface differences in filler-gap ordering map onto neuro/cognitive operations underlying the processing of filler-gap dependencies. For these purposes, the processing of SRs and ORs in Korean was investigated using self-paced reading time, eye-tracking and ERP (event-related brain potential) measures.

The processing asymmetry of SRs and ORs in forward-filler gap dependencies like (4.1) and (4.2) is one of the most robust effects attested in the psycholinguistic literature across different methodologies (**reading time**: King & Just, 1991; **ERP**: King & Kutas, 1995; **PET**: Stromswold et al., 1996; Caplan et al., 1998, 1999, 2000; **fMRI**: Just et al., 1996; Caplan et al., 2002, 2008; Chen et al., 2006; Cooke et al., 2002; Constable et al., 2004; **eye-tracking**: Traxler et al., 2002).

(4.1) SRs in forward-filler gap dependencies
The reporter who harshly attacked the senator admitted the error.

(4.2) ORs in backward-filler gap dependencies
The reporter who the senator harshly attacked admitted the error.

There have been many attempts to account for this phenomenon in terms of structural complexity and/or general cognitive processing mechanisms (Keenan &

Comrie, 1977; O'Grady, 1997; Hawkins, 2004; Gibson, 2000; Lewis et al., 2006; McDonald & Christiansen, 2002; MacWhinney, 1982; Hale, 2006; Levy, 2007) as presented in Chapter 3. All of these accounts make the same prediction for English: SRs are easier to process than ORs. Yet their predictions differ for typologically different languages with different surface word orders as in (4.3) and (4.4).

(4.3) SRs in backward-filler gap dependencies

[$\_\__i$	pyencipcang-ul	hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
	editor-ACC	threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor met a journalist yesterday.'

(4.4) ORs in backward-filler gap dependencies

[pyencipcang-i	$\_\__i$	hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
editor-NOM		threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who the editor threatened met a journalist yesterday.'

That is, while processing models that rely on presumed language universals (i.e., the *accessibility hierarchy* and the *phrase-structural distance hypothesis*) predict the same asymmetry for all configurational languages, models that calculate processing difficulty based on surface features (i.e., linear distance, canonical word order, and surface position of the subject) predict different patterns of processing asymmetry for languages with different word orders. Accordingly, by examining the processing of SR and OR in typologically distinct languages, it should be possible to evaluate the validity of these various processing models as universal parsing mechanisms. Moreover, we can further our understanding of independent factors contributing to language comprehension by investigating the nature of the neuro/cognitive operations that underlie the processing of filler-gap dependencies in typologically distinct languages with different filler-gap ordering by using event-related brain potentials. Thus, in this chapter, using self-paced reading time, eye-tracking and ERP methodologies, I explore the following questions:

(i) Which of these accounts proposed for English is most appropriate as a universal processing strategy?

(ii) To what extent are the neuro/cognitive operations underlying the processing of forward syntactic dependencies in post-nominal relative clauses (in which a head noun precedes the relative clause, as in English) similar to those underlying the processing of backward syntactic dependencies in pre-nominal relative clauses (in which a relative clause precedes its head noun, as in Korean)?

In Sections 4.2 and 4.3, I present self-paced reading time and eye-tracking experiments in an attempt to answer question (i). Section 4.4 presents the corresponding ERP experiment and addresses question (ii). A general discussion and conclusion follow.

4.2 Experiment 4.1: Self-paced Reading Time Experiment

To test various processing models proposed to account for the SR vs. OR processing asymmetry in English, a self-paced reading time experiment was conducted using Korean relative clauses, varying gap type (subject and object gap) and head noun type (subject, object and possessive head noun). A simpler version of the experimental sentences is presented in (4.5) through (4.10). As presented, regardless of head noun type, sentences with an accusative-marked NP within the relative clause are SRs while sentences with a nominative-marked NP in initial position are ORs.

(4.5) SS (subject head noun & subject gap)

[___$_i$	pheyncipcang-**ul**	hyeppakha-n]	chongcang$_i$-**i**	elonin-ul	manna-ss-ta
	editor-**ACC**	threaten-REL	chancellor-**NOM**	editor-ACC	meet-PST-DECL

‘The chancellor$_i$ [who ___$_i$ threatened the editor] met a journalist.’

(4.6) SO (subject head noun & object gap)

[pheyncipcang-**i**	___$_i$	hyeppakha-n]	chongcang$_i$-**i**	elonin-ul	manna-ss-ta
editor-**NOM**		threaten-REL	chancellor-**NOM**	editor-ACC	meet-PST-DECL

‘The chancellor$_i$ [who the editor threatened ___$_i$] met a journalist.’

(4.7) OS (object head noun & subject gap)

[___$_i$	pheyncipcang-**ul**	hyeppakha-n]	chongcang$_i$-**ul**	elonin-i	manna-ss-ta
	editor-**ACC**	threaten-REL	chancellor-**ACC**	editor-NOM	meet-PST-DECL

‘A journalist met the chancellor$_i$ [who ___$_i$ threatened the editor]’

(4.8) OO (object head noun & object gap)

[pheyncipcang-**i**	___$_i$	hyeppakha-n]	chongcang$_i$-**ul**	elonin-i	manna-ss-ta
editor-**NOM**		threaten-REL	chancellor-**ACC**	editor-NOM	meet-PST-DECL

‘A journalist met the chancellor$_i$ [who the editor threatened ___$_i$].’

(4.9) PS (possessive head noun & subject gap)

[___$_i$	pheyncipcang-**ul**	hyeppakha-n]	chongcang$_i$-**uy**	cip-eyse	phati-ka	yelyessta
	editor-**ACC**	threaten-REL	chancellor-**GEN**	house-at	party-NOM	was.held

‘A party was held at the chancellor$_i$’s house [who ___$_i$ threatened the editor].’

(4.10) PO (possessive head noun & object gap)

[pheyncipcang-**i**	___$_i$	hyeppakha-n]	chongcang$_i$-**uy**	cip-eyse	phati-ka	yelyessta
editor-**NOM**		threaten-REL	chancellor-**GEN**	house-at	party-NOM	was.held

‘A party was held at the chancellor$_i$’s house [who the editor threatened ___$_i$].’

On the other hand, regardless of gap type, subject head noun conditions have a nominative marked NP in the head noun position following the relative clause, object head noun conditions have an accusative marked NP in this position, and possessive head noun conditions a genitive-marked head noun. Thus, apart from the case marker on the sole NP argument remaining in the relative clause, SRs and ORs of the same head noun type have identical lexical items occurring in the same order, allowing a direct comparison of SR and OR sentences within head noun type. Moreover, the subject (4.5 and 4.6) and object (4.7 and 4.8) head noun conditions contain the exact same lexical items as well, and differ only in the case marking on the remaining argument in the relative clause and on the following head noun.

The predictions of the various processing models for Korean relative clauses are presented in the next section.

4.2.1 Predictions

In this section, I present predictions for the experimental constructions (4.5) to (4.10) made by the various processing models introduced in Chapter 3. For details of each processing model, see Chapter 3.

4.2.1.1 Dependency Locality Theory (DLT; Gibson, 2000)

4.2.1.1.1 Storage-Based Resource Theory

In *storage-based DLT*, each syntactic head required to grammatically complete the current input string takes up working memory resources. This hypothetical working memory cost is defined as a memory unit (MU). For example, for a Chinese SR like (4.11), Hsiao and Gibson (2003) assumed that readers realize that they are processing a relative clause at the sentence-initial verb position, because null pronominals are rare and dispreferred in contexts where a topic is not present.

(4.11) Subject relative clause in Chinese
[[t_i yaoching fuhao] de guanyuan$_i$ 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.'

Therefore, 3 MUs were postulated at this position: the verb for the main clause predicate, the relative clause marker *de,* and the NP associated with the relative clause verb *invite*. On the other hand, for an OR like (4.12), at the sentence-initial NP, only one syntactic head (1MU), the verb for the main clause predicate, is required.

(4.12) Object Relative clause
[[fuhao yaoching t_i] de guanyuan$_i$ 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.'

Similarly, SRs in Korean also begin non-canonically with an accusative case-marked NP as in Chinese SRs. However, ORs start canonically with a nominative case-marked NP.

(4.13) Object relative in Korean
[[ai-ka mek-un$_i$] ppang$_i$]
child-NOM eat-REL bread
'Bread that a child ate.'

(4.14) Subject relative in Korean
[[ppang-ul mek-un$_i$] ai$_i$]
bread-ACC eat-REL child
'A child who ate bread'

If one were to adopt the same assumptions for Korean that Hsiao and Gibson make for Chinese, namely that readers realize they are processing a relative clause already at the non-canonical sentence-initial position (Verb in Chinese, NP-ACC in Korean), the prediction for Korean would be the same as for Chinese. Thus, SRs would require 2 MUs (i.e., a RC verb and a main clause verb) and ORs would require 1 MU (i.e., a main clause verb) at the first NP position. This would then predict that SRs should be more difficult to process than ORs within the relative clause region.

However, the predictions for Korean will differ substantially if one instead assumes that when encountering the sentence-initial NP-ACC, readers analyze the sentence as one containing a dropped subject argument rather than as a relative clause. This is likely to be the case in Korean because subject drop is so prevalent in the language (Kim, 2000). If this is the case, then at the NP-ACC in a SR, one MU is required for a transitive verb to complete the current string as a grammatical sentence. At a sentence-initial NP-NOM in an OR, again one MU is required, but this time for an intransitive verb to complete a grammatical sentence. This means that the SR and OR will not differ from each other in processing difficulty within the relative clause region.

On the other hand, if readers analyze sentences with a sentence-initial NP-ACC as scrambled, SRs are predicted to be harder than ORs at the sentence-initial NP position. This is because at NP-ACC in SRs, 2 MUs are required for a subject and a predicate, while at NP-NOM in ORs, one MU is required for a verb to complete the sentence.

Processing of the main clause should not be influenced by RC type under any of the assumptions mentioned above. As long as the role of the head noun is the same in SRs and ORs, the required number of syntactic heads to complete the current string as a grammatical sentence is the same. For example, for SR and OR type sentences with subject heads, the storage cost is 1 MU at the head noun position: a verb for the predicate.

Thus the storage-based predictions for processing difficulty of subject and object relative clauses in Korean are as follows:

(4.15) Prediction of *storage-based DLT* for Korean

SR > OR (within the relative clause)	– RC reading
SR = OR (within the relative clauses)	– argument-drop reading
SR > OR (within the relative clause)	– scrambled reading
SR = OR (within the main clause)	

(>: harder to process)

4.2.1.1.2 Integration-Based Resource Theory

Integration-based DLT is based on the notion that structural integration (i.e., integration of linguistic elements in different structural positions), discourse integration, and evaluation of the plausibility of the current event in the discourse context take up working memory resources. This hypothetical working memory cost is defined as an energy unit (EU). In the experiments of this dissertation, the same content words are used for the SR and the OR sentences. Thus, discourse processing cost is controlled. Plausibility was also controlled by means of a norming study, which will be presented in Section 4.2.2. Therefore, the only factor that will make a prediction that distinguishes SR and OR sentences is the structural integration cost for both types of sentence.

DLT predicts that SR sentences should be more difficult than OR sentences in Korean. An illustration of the processing costs of SRs and ORs is given below. As can be seen in (4.16) and (4.17), the head noun is more distant from the subject position than from the object position of the relative clause. Therefore SR sentences should require more integration resources.

(4.16) Subject relative clauses

[__$_i$	pheyncipcang-ul	hyeppakha-n]	chongcang$_i$-i	enlonin-ul	manna-ss-ta
	editor-ACC	threaten-REL	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor met a journalist.'

(4.17) Object relative clauses

[pheyncipcang-i	__$_i$	hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
editor-NOM		threaten-REL	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who the editor threatened met a journalist.'

Thus the integration-based predictions for the processing difficulty of subject and object relative clauses in Korean are as follows:

(4.18) Prediction of *integration-based DLT* for Korean
SR > OR (at the head noun position)

4.2.1.2 Filler-Gap Domain Hypothesis (Hawkins, 2004)

The filler-gap domain hypothesis by Hawkins is based on the *performance-grammar correspondence hypothesis*. That is, the more complex the structure is, the more difficult it is to process. In terms of processing relative clauses, filler-gap domain (FGD) is defined in terms of the distance between a filler and its subcategorizor, including any argument that a gap requires to co-occur. This leads to a bigger filler-gap domain in ORs (i.e., filler, subcategorizor and subject in relative clauses) than SRs (i.e., filler and subcategorizor) in English (see Chapter 3 for further details). Yet Hawkins further states that when the role of the gap is ambiguous between SR and OR interpretations, the disambiguating argument should be included in the filler-gap domain, even when it is not required to co-occur with the gap. For example, in Korean and Japanese, languages with case markers and without verb agreement, the role of the head noun is cued by the case marker of the remaining NP within the RC. Thus, the filler-gap domain of an SR needs to be extended to include the object. Accordingly, the size of the filler-gap domain of SRs and ORs in these languages is the same: the filler-gap domains of both SRs and ORs include the subject and the object, as shown in (4.19) and (4.20).

(4.19) OR : subject is included in FGD because it is required to co-occur with object

[ai-ka	**mek-un$_i$]**	**ppang$_i$]**
child-NOM	eat-REL	bread

'Bread that a child ate.'

(4.20) SR: object is included in FGD because object disambiguates the role of the gap

[ppang-ul	**mek-un$_i$]**	**ai$_i$]**
bread-ACC	eat-REL	child

'A child who ate bread'

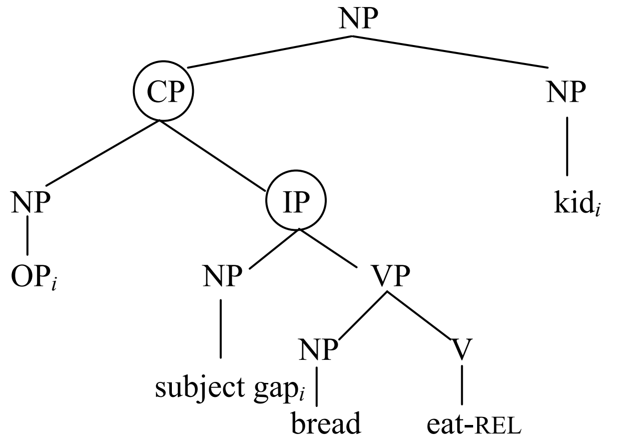
From Hawkins' argument that the size of the filler-gap domain determines the complexity of the structure, which will in turn be reflected in processing difficulty, it is predicted that in Korean, SRs and ORs will not show a processing asymmetry.

(4.21) Prediction of *filler gap domain* for Korean
SR = OR

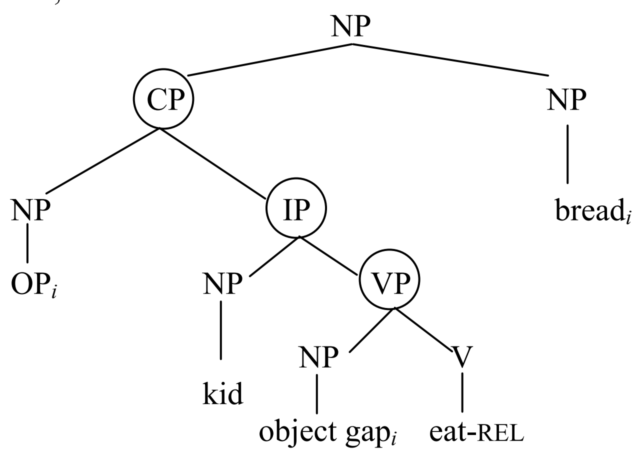
4.2.1.3 Phrase-Structural Distance Hypothesis (O'Grady, 1997)

In this model, processing difficulty is defined in terms of phrase-structural distance between a filler (head noun) and its gap. That is, the longer the structural distance between a gap and its filler, the more difficult the dependency is to process. As can be seen in (4.22) and (4.23), SRs are less complex than ORs in terms of the number of XPs that intervene between the head noun and the gap. Therefore, the same prediction will be made for Korean as for English: SRs will be processed more easily than ORs.

(4.22) SR: 2 XPs, ‘the child who ate bread’



(4.23) OR: 3 XPs, ‘the bread that the child ate’



(4.24) Prediction of *structural distance hypothesis* for Korean
OR > SR

4.2.1.4 Accessibility Hierarchy (Keenan & Comrie, 1977)

The *accessibility hierarchy* is based on the notion that the ‘*AH directly reflects the psychological ease of comprehension’* (Keenan & Comrie, 1977: 88). Thus, under the *accessibility hierarchy*, SRs will be easier to process than ORs for Korean, just as they are in English.

(4.25) Prediction of the *accessibility hierarchy* for Korean
OR > SR

4.2.1.5 Perspective Shift Hypothesis (MacWhinney 1982, MacWhinney & Pleh 1988)

The *perspective shift hypothesis* is based on the notion that subject marking is among certain "*reflexes of 'starting points' for cognition*" (MacWhinney, 2002: 691), and that switching perspectives (from that of the subject) causes processing difficulty. In Korean, as in English, a subject relative clause formed on a main clause subject head noun (SS) does not require any perspective shift, and therefore will not require additional processing resources.

(4.26) SS (subject head noun, subject gap)
[$\_\__i$ pheyncipcang-ul hyeppakha-n] **chongcang$_i$-i** enlonin-ul mannassta
editor-ACC threaten-REL chancellor-NOM journalist-ACC met
'The chancellor who threatened the editor met a journalist.'

On the other hand, SO (subject head noun, object relative clause), OS (object head noun, subject relative clause) and OO (object head noun, object relative clause) sentences require one perspective shift from the subject of the relative clause to the subject of the main clause.

(4.27) SO (subject head noun, object gap)
[pheyncipcang-i $\_\__i$ hyeppakha-n] **chongcang$_i$-i** enlonin-ul mannassta
editor-NOM threaten-REL chancellor-NOM journalist-ACC met
'The chancellor who the editor threatened met a journalist.'

(4.28) OS (object head noun, subject gap)
[$\_\__i$ pheyncipcang-ul hyeppakha-n] chongcang$_i$-ul **enlonin-i** mannassta
editor-ACC threaten-REL chancellor-ACC journalist-NOM met
'The journalist met the chancellor who threatened the editor.'

(4.29) OO (object head noun, object gap)
[pheyncipcang-i $\_\__i$ hyeppakha-n] chongcang$_i$-ul **enlonin-i** mannassta
editor-nom threaten-REL chancellor-ACC journalist-NOM met
'The journalist met the chancellor who the editor threatened.'

Thus, on this account, SS should be easier than SO, and OS and OO should not differ from each other.

With regard to PS (possessive head noun, subject gap) and PO (possessive head noun, object gap) sentences, these are also predicted to be equal in terms of processing difficulty. Because the head nouns are possessors, it is expected that perspective shift will occur in both cases from the subject of the relative clause to the subject of the main clause.

(4.30) PS (possessive head noun, subject gap)
[__$_i$ pheyncipcang-ul hyeppakha-n] chongcang$_i$-uy cip-eyse **totwuk-i** caphyessta
editor-ACC threaten-REL chancellor-GEN house-at thief-NO was.caught
'A thief was caught at the house of chancellor who threatened the editor.'

(4.31) PO (possessive head noun, object gap)
[pheyncipcang-i __$_i$ hyeppakha-n] chongcang$_i$-uy cip-eyse **totwuk-i** caphyessta
editor-NOM threaten-REL chancellor-GEN house-at thief-NOM was.caught
'A thief was caught at the house of chancellor who the editor threatened.'

Therefore, at the head noun position the following ranking is predicted.

(4.32) Prediction of *perspective shift hypothesis* for Korean
{SO, OS, OO, PS, PO} > SS

4.2.1.6 Similarity–Based Interference (Gordon et al., 2001, 2004, 2006; Lewis, 2006)

In the *similarity-based interference* account, the processing difficulty of ORs compared to SRs in English is attributed to the similarity of two linguistic items that need to be represented in and then retrieved from working memory (Gordon et al., 2001, 2004, 2006; cf. Lewis, 1996; Lewis at al., 2006). In Korean, the structural configuration in SRs and ORs is the same in regard to the sequence of NPs. In both SRs and ORs, NP-ACC/NOM is followed by the embedded verb.

(4.33) SR

[__$_i$	sonye-lul	cohaha-n]	sonyen$_i$-i	ttenassta
	girl-ACC	like-REL	boy-NOM	left

'The boy who liked the girl left'

(4.34) OR

[sonye-ka	__$_i$	cohaha-n]	sonyen$_i$-i	ttenassta
girl-NOM		like-REL	boy-NOM	left

'The boy who the girl liked left'

Thus, a similarity interference account based on structural configuration will not predict any processing asymmetry between SRs and ORs in Korean. However, in Korean, case markers provide a potential source of similarity (or distinctiveness) in working memory not present in English. Evidence from studies of similarity-based interference in Korean shows that sentence processing difficulty increases when two NPs in succession are both marked with nominative case (*–i/ka*) in comparison to when one of them is marked with the topic marker *–nun* (Nakayama, Lee, & Lewis, 2005).

The possible contribution of case marker similarity to subject vs. object gap processing differences in Korean varies with overall sentence structure. For subject head noun sentences as in (4.35) and (4.36), ORs lead to the presence of successive NPs with nominative case markers while SRs do not.

(4.35) Subject head noun, SR (SS): no similarity-based interference predicted

[__$_i$ NP-**ACC** Verb-REL] NP-**NOM**...

(4.36) Subject head noun, OR (SO): similarity-based interference predicted

[NP-**NOM** __$_i$ Verb-REL] NP-**NOM**...

For object head noun sentences, as in (4.37) and (4.38), SRs lead to the presence of successive NPs with accusative case markers while ORs do not.

(4.37) Object head noun: SR (OS): similarity-based interference predicted
[__$_i$ NP-**ACC** Verb-REL] NP-**ACC**...

(4.38) Object head noun, OR (OO): no similarity-based interference predicted
[NP-**NOM** __$_i$ Verb-REL] NP-**ACC**...

For possessive head noun conditions as in (4.39) and (4.40), neither SRs nor ORs lead to successive NPs with the same case marker, since the head noun is marked for genitive case.

(4.39) Possessive head noun, SR (PS): no similarity-based interference predicted
[__$_i$ NP-**ACC** Verb-REL] NP-**GEN**...

(4.40) Possessive head noun, OR (PO): no similarity-based interference predicted
[NP-**NOM** __$_i$ Verb-REL] NP-**GEN**...

Accordingly, increased processing difficulty due to successive NPs with the same case marking should result in a subject relative clause advantage for subject head noun constructions but an object relative clause advantage for object head noun sentences; there should be no subject/object asymmetry for sentences in which the head noun is a possessor.

(4.41) Prediction of similarity-based interference for Korean

subject head nouns:	SR advantage
object head nouns:	OR advantage
possessive head nouns:	no advantage

4.2.1.7 Frequency

In processing models based on frequency or probability, processing difficulty is affected by the language user's amount of experience in the language. Below, I present predictions based on two major versions of such an account.

4.2.1.7.1 Statistical Regularity of Word Order

Statistical regularity of word order is based on the notion that a frequent word order (e.g., canonical word order) facilitates the processing of complex structures such as filler-gap dependencies. That is, in English, SRs are processed faster than ORs because, after relativization, SRs maintain canonical word order while ORs do not. In Korean, however, neither SRs nor ORs maintain canonical word order after relativization: SOV is not maintained in either of the two constructions. Furthermore, neither of the constructions maintains a legitimate word order either.

(4.42) SR: SOV becomes OVS after relativization

[__$_i$	sonye-lul	cohaha-n]	sonyen$_i$-i	ttenassta
	girl-ACC	like-REL	boy-NOM	left
	O	V	S	

'The boy who liked the girl left'

(4.43) OR: SOV becomes SVO after relativization

[sonye-ka	__$_i$	cohaha-n]	sonyen$_i$-i	ttenassta
girl- NOM		like-REL	boy-NOM	left
S		V	O	

'The boy who the girl liked left'

Thus, an account based on statistical regularity of word order predicts no processing asymmetry between SRs and ORs in Korean.

(4.44) Prediction of statistical regularity of word order for Korean
SR = OR

4.2.1.7.2 Constructional Frequency

Here I report a corpus study where constructional frequencies were investigated using a small-scale corpus.[1] The operating assumption is that the more frequently particular constructions occur, the less processing difficulty there should be. In particular, in this corpus study, constructional frequencies for gap type (SR vs. OR), head noun type (subject, object, and possessive head), and six possible combinations of these two factors (SS, SO, OS, OO, PS, and PO) were investigated.

4.2.1.7.2.1 Methods

Materials

The target corpus consisted of text from a movie magazine with 26,749 *ejel*[2] in the Seyjong corpus (2002).

Procedure

Since the Seyjong corpus is tagged but not parsed, different types of RC sentences cannot be automatically retrieved. Thus all the sentences with adnominal markers were first retrieved and the outcome was manually examined for coding in terms of RC type (SS, SO, OS, OO, PS, or PO). Only RCs with transitive verbs were coded. This manual coding was examined by two additional linguistically trained people.

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[1] Full predictions based on a probabilistic model require research based on large-scale corpus data, which are not available for Korean at this point. Future research is needed in this regard.

[2] *Ejel* is a unit in writing that is separated by a space in a sentence. One *ejel* is typically composed of at least one free morpheme and additional dependent morpheme(s). For example, *kaswu-ka* 'singer-NOM' is one *ejel,* where a dependent morpheme, the nominative marker *–ka*, is attached to an independent morpheme, the noun *kaswu* 'singer'.

4.2.1.7.2.2 Results

The corpus results are presented at three different levels, in terms of gap type (SR vs. OR), head noun type (subject, object, vs. possessive head noun), and six different RC types (SS, SO, OS, OO, PS vs. PO, i.e. combinations of the two).

Frequency of SR vs. OR

There were 3219 clauses with adnominal markers out of 26,749 *ejels*. Out of the 3,219 clauses, a total of 359 clauses were relative clauses with transitive verbs, of which 251 were SR and 108 were OR. In other words, subject relative clauses with transitive verbs outnumbered object relative clauses by more than two to one.

Table 4-1 Experiment 4.1, Frequency of SR and OR

SR	OR
251	108

Frequency of head noun type

In terms of head noun types, RCs with subject head nouns (S-head) were most frequent, followed by RCs with possessive head nouns (P-head). RCs with object head nouns (O-head) were the least frequent. In other words, RCs with subject head nouns again outnumbered RCs with object head nouns by more than two to one.

Table 4-2 Experiment 4.1, Frequency of S-, O-, and P-head noun

S-head	O-head	P-head
189	75	95

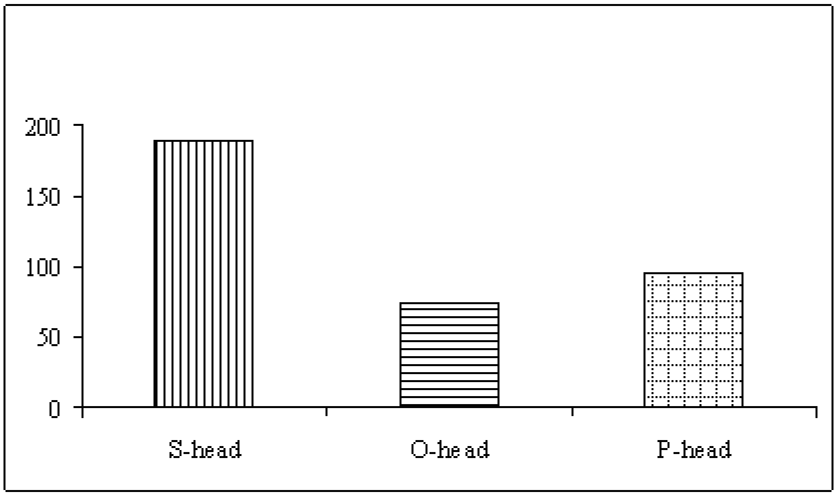

Figure 4-1 Frequency of S-, O-, and P-head noun

Frequency of the six combinations

The results were further examined in terms of the six different types of relative clauses. Among 359 relative clauses, the most and the least frequent constructions were SS (subject head, subject gap) and PO (possessive head, object gap) with 141 and 23 occurrences, respectively. PS (possessive head, subject gap) was the second most frequent construction. The other constructions did not show big differences. The frequency results for each construction are presented below.

Table 4-3 Experiment 4.1, Frequency of 6 constructions

SS	SO	OS	OO	PS	PO
141	48	38	37	72	23

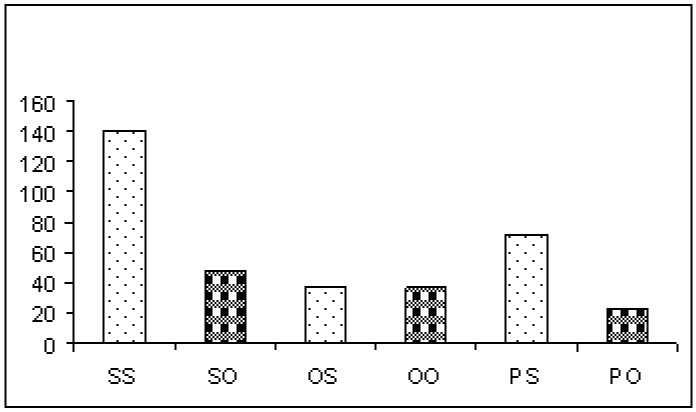

Figure 4-2 Exp 4.1, Frequency of 6 constructions

To summarize, the following observations were made with regard to the frequency of each construction.

i) Subject relatives are more than twice as frequent as object relatives.

ii) Relative clauses with a subject head noun are the most frequent while relative clauses with an object head noun are the least frequent, the former being more than twice as frequent as the latter. Relative clauses with a possessive head noun are more frequent than the relative clauses with an object head noun, but the difference is small.

iii) SS is the most frequent, followed by PS. PO was the least frequent. Frequency differences of other constructions (SO, OS, and OO) are small.

4.2.1.7.2.3 Predictions on processing difficulty

Based on the results presented in the preceding section, the following predictions on processing difficulty can be made.

i) Subject relatives should be processed faster than object relatives.

ii) Relative clauses with a subject head noun should be processed faster than relative clauses with object and possessive head nouns.

iii) SS should be processed the fastest among all the target constructions, followed by PS. PO should be the most difficult to process. In terms of SR and OR processing difficulty, SS should be processed faster than SO, and PS should be processed faster than PO. However, OS and OO should not differ from each other in terms of processing difficulty.

4.2.1.8 Summary of Predictions

In summary, the following predictions are made with regard to the difficulty of processing Korean relative clauses.

(1) If a sentence-initial NP-ACC triggers an immediate relative clause or scrambling analysis, *storage-based DLT* predicts that ORs should be easier to process than SRs within the relative clause region. However, there should be no difference in the main clause region of all corresponding SR vs. OR pairs.

(2) If a sentence-initial NP-ACC triggers an immediate argument drop analysis, *storage-based DLT* predicts that SRs and ORs should not differ in either the relative or the main clause regions of all corresponding pairs.

(3) *Integration-based DLT* predicts that ORs should be easier to process than SRs within the main clause region.

(4) The *filler gap domain hypothesis* and *statistical regularity of word order* predict that there should be no difference in processing difficulty between SRs and ORs.

(5) The *similarity-based interference hypothesis* predicts a SR advantage for

sentences with subject head nouns, an OR advantage for sentences with object head nouns, and no subject/object processing asymmetry for sentences with possessive head nouns.

(6) The *structural distance hypothesis* and *accessibility hierarchy* predict that SRs should be easier to process than ORs.

(7) The *perspective shift hypothesis* predicts that SS should be the easiest to process, and that SO, OS, OO, PS and PO should not differ from each other in terms of processing difficulty.

(8) Constructional frequency predicts that:

a. SRs should be processed faster than ORs;
b. RCs with subject head nouns should be processed faster than RCs with object or possessive head nouns; and
c. SS should be processed the fastest among all the target constructions, followed by PS. PO should be the most difficult to process. In terms of SR and OR processing difficulty, SS should be processed faster than SO, and PS should be processed faster than PO. However, OS and OO should not differ from each other.

These predictions are summarized in Table 4-4.

Table 4-4 Prediction by each processing theory for processing difficulty of SRs and ORs in Korean

		OR > SR	OR = SR	SR > OR
Storage-based DLT (RC & scrambling reading)			√ (main clause)	√ (relative clause)
Storage-based DLT (argument-drop reading)			√ (both main & relative clause)	
Integration-based DLT				√ (at head noun)
Structural distance hypothesis		√		
Accessibility hierarchy		√		
Filler gap domain hypothesis			√	
Perspective shift hypothesis		all other conditions > SS, SO = PS = PO = OS = OO		
Similarity-based interference		subject head nouns: OR > SR object head nouns: SR > OR: possessive head nouns: OR = SR		
Statistical regularity of word order			√	
constructional frequency	SR vs. OR	√		
	head noun	object & possessive > subject head nouns		
	SS, SO, OS, OO, PS, & PO	SO, OS, OO, and PO > PS > SS SO > SS; PO > PS; OO = OS		

>: harder to process

4.2.2 Norming Study

A norming study was conducted in order to control the naturalness of SRs and ORs, following Miyamoto and Nakamura (2003). This was done to ensure that the naturalness of the events denoted in the experimental sentences would not bias one interpretation over the other.

4.2.2.1 Methods

Participants

37 male high school students in Korea participated in the norming study. They were in their junior or senior year and planning on going on to college.

Materials

Sentences to be normed were created by replacing the gap with its associated head noun in each of the relative clauses, following Miyamoto and Nakamura (2003). For example, for the following SR (4.45) and OR (4.46) sentences, (4.47) and (4.48) were created.

(4.45) SR sentence

[$\_\_{}_i$	sinmwunsa-uy	pyencipcang-ul	noymwul	swuswu	hyemuy-lo
	newspaper-GEN	editor-ACC	bribe	taking	charge-for

hyeppakha-n]	chongcang$_i$ -i	enlonin-ul	manna-ss-ta
threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor of the newspaper for taking a bribe met a journalist yesterday.'

(4.46) OR sentence

[sinmwunsa-uy	pyencipcang-i	$\_\_{}_i$	noymwul	swuswu	hyemuy-lo
newspaper-GEN	editor-NOM		bribe	taking	charge-for

hyeppakha-n]	chongcang$_i$-i	enlonin-ul	manna-ss-ta
threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who the editor of the newspaper threatened for taking a bribe met a journalist yesterday.'

(4.47) Norming sentence made from SR

chongcang-i	ku	sinmwunsa-uy	pheyncipcang-ul	noymwul	swuswu
chancellor-NOM	that	newspaper-GEN	editor-ACC	bribe	receiving

hyemuy-lo	hyeppakhay-ss-ta
charge-for	threaten-PST-DECL

'The chancellor threatened the editor of the newspaper for taking a bribe.'

(4.48) Norming sentence made from OR

ku	sinmwunsa-uy	pheyncipcang-i	chongcang-ul	noymwul	swuswu
that	newspaper-GEN	editor-NOM	chancellor-ACC	bribe	receiving

hyemuy-lo	hyeppakhay-ss-ta
charge-for	threaten-PST-DECL

'The editor of the newspaper threatened the chancellor for taking a bribe.'

Design and Procedure

Participants saw one sentence from each stimulus SR and OR pair (e.g., (4.47) and (4.48)), and rated the naturalness of the sentences. The rating was based on a 5-point scale. The participants were asked to rate a sentence as 1 if it sounded natural, and as 5 if the sentence sounded strange. An example sentence is given below. The sentences were of course given in Korean in the experiment, but for ease of illustration, the English translation is provided in (4.49).

(4.49) 'The chancellor threatened the editor of the newspaper for taking a bribe.'
Please rate this sentence for its naturalness.

Sounds natural   Sounds strange

1   2   3   4   5

4.2.2.2 Results

The results of the study showed that the two types of relative clauses used in the experiment did not differ from each other in terms of naturalness [$t(36) = 2.94$, $p < .1$]. The means for naturalness were 2.72 for the sentences formed from SRs and 2.89 for the sentences formed from ORs.[3]

[3] The experimental stimuli are newspaper-style sentences and the relatively low acceptability ratings seem to be due to their complex structure and high-level vocabulary.

Based on the norming study results that SRs and ORs are not different from each other in terms of naturalness, a self-paced reading time experiment was conducted.

4.2.3 Reading Time Methods

4.2.3.1 Participants

24 native speakers of Korean participated in the experiment. Most of them were graduate students or postdocs at UCSD and had lived in the USA less than two years at the time of the experiment. They were naive about the purpose of the experiment.

4.2.3.2 Materials

The experiment had a 2 x 3 design, varying gap type (subject and object gap) and head noun type (S-, O- and P-head). Accordingly, there were six conditions: SS (subject head noun & subject gap), SO (subject head noun & object gap), OS (object head noun & subject gap), OO (object head noun & object gap), PS (possessive head noun & subject gap), and PO (possessive head noun & subject gap).[4] Among these, the SS, SO, PS and PO sentences had SOV word order. The OO and OS sentences had OSV word order, in which the object of the main clause was scrambled to the sentence-initial position to avoid a garden-path effect.

All six constructions used the same lexical items in the same order, with the exception of the final three words in the PS and PO constructions.[5] The meaning

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[4] The possessive head noun conditions (i.e., PS and PO) were structurally ambiguous, such that the relative clauses could be interpreted as modifying either the first or the second NP. To remove this ambiguity, only inanimate NPs were used as the second noun, whereas the relative clause requires a human head noun.

[5] In Korean, true adjectives are very rare and adjectival predicates are commonly used. When these adjectival predicates modify nouns, they are marked with an adnominal marker. Since, in this case, the

differences across these constructions were derived solely from the case markers, which are equivalent in length. Therefore, lexical frequency effects were automatically controlled across the six conditions. Scrambling may influence processing (Miyamoto, 2006; Ueno & Kluender, 2003), but because the main comparisons were between SS and SO (unscrambled sentence pair), between OS and OO (scrambled pair) and between PS and PO (unscrambled pair), there should be no confound due to scrambling in this study. Examples of each construction are given below. For ease of presentation, corresponding sentences are given first in English, followed by Korean examples.

Table 4-5 Exp 4.1, English translation of SR sentences

Subject relatives	
S-head (SS)	'The chancellor$_i$ [who ___$_i$ threatened the editor of the newspaper for taking a bribe] met a journalist yesterday.'
O-head (OS)	'Yesterday the journalist met the chancellor$_i$ [who ___$_i$ threatened the editor of the newspaper for taking a bribe].'
P-head (PS)	'A thief was caught at the chancellor$_i$'s house [who ___$_i$ threatened the editor of the newspaper for taking a bribe].'

Table 4-6 Exp 4.1, English translation of OR sentences

Object relatives	
S-head (SO)	'The chancellor$_i$ [who the editor of the newspaper threatened ___$_i$ for taking a bribe] met a journalist yesterday.'
O-head (OO)	'Yesterday the journalist met the chancellor$_i$ [who the editor of the newspaper threatened ___$_i$ for taking a bribe].'
P-head (PO)	'A thief was caught at the chancellor$_i$'s house [who the editor of the newspaper threatened ___$_i$ for taking a bribe].'

head noun was always the subject of the adjectival predicate, to prevent any possible priming effect in favor of the SR reading, the experimental sentences did not include any such adjectival predicates.

Table 4-7 Exp 4.1, Target constructions in RC region

Relative clause region							
	W1	W2	W3	W4	W5	W6	W7
SR/ OR	ku	sinmwunsa -uy	pheyncipcang -ul/i	noymwul	swuswu	hyumuy -lo	hyeppakha -n
	that	newspaper -gen	editor -acc/nom	bribe	taking	charge -for	threaten -rel
	subject/object of RC			adverbial phrase			RC verb

SR: '~ who threatened the editor of the newspaper for taking a bribe'
OR: '~ who the editor of the newspaper threatened for taking a bribe'

Table 4-8 Exp 4.1, Target constructions in main clause region

	Head noun	**Main clause region**		
	W8	W9	W10	W11
S-head	chongcang-i chancellor-NOM	elonin-ul journalist-ACC	ecey yesterday	mannassta met
O-head	chongcang-ul chancellor-ACC	elonin-i journalist-NOM	ecey yesterday	mannassta met
P-head	chongcang-uy chancellor-GEN	Cip-eyse house-at	totwuk-i thief-NOM	caphyessta be_caught

S-head: 'The chancellor met the journalist yesterday.'
O-head: 'The journalist met the chancellor yesterday.'
P-head: 'The thief was caught at the chancellor's house.'

40 sets of sentences were constructed using these SS, SO, OS, OO, PS, and PO structures. The target sentences were split into 6 lists using a Latin-square design. 40 filler sentences of the same length and of corresponding complexity to the target structures were constructed. Therefore, each of the six lists contained 40 target sentences

and 40 filler sentences. Filler sentences were interposed with target sentences so that no two target sentences appeared in a row.

A pilot experiment indicated that it was difficult for participants to read all 80 sentences in one sitting. Therefore, each of the 6 lists was sub-divided into halves. During the experiment, participants were given a break between the two subsections of the list they were being tested on.

4.2.3.3 Procedure

The experiment was run on PsyScope in a sound-attenuated booth, using a button box with three buttons. The middle yellow button was used as the NEXT button and the left green and right red buttons were used as YES and NO buttons, respectively. Stimulus presentation was word by word, self paced, and non-cumulative. Each trial began with a fixation cross in the center of the screen. When participants were ready for the next trial, they pressed the middle button, and the fixation cross was replaced by the first word of the sentence. To see the next word, participants pressed the middle button, and the first word was replaced with the next word in the center of the screen. The stimulus onset asynchrony from the appearance of one word to the next was recorded as the reading time of that word.

After the final word of each sentence, a yes/no comprehension question for the preceding sentence appeared on the screen. Participants indicated a yes or no answer to the question via a left or right button press, respectively. In most cases, the comprehension question targeted the content of the relative clause; cf. (4.50) and (4.51).

(4.50) Experimental sentence

[__$_i$	sinmwunsa-uy	pyencipcang-ul	noymwul	swuswu	hyemuy-lo
	newspaper-GEN	editor-ACC	bribe	taking	charge-for

hyeppakha-n]	chongcang$_i$ -i	enlonin-ul	manna-ss-ta
threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor of the newspaper for taking a bribe met a journalist yesterday.'

(4.51) Comprehension question

chongcang$_i$ –i	pyencipcang-ul	noymwul	swuswu	hyemuy-lo	hyeppakhaysupni-kka?
newspaper-GEN	editor-ACC	bribe	taking	charge-for	threaten-Q

'Did the chancellor threaten the editor for taking a bribe?'

However, when the verb in the relative clause was symmetric with respect to agent and patient (e.g. 'meet', 'become friends with'), the content of the main clause was questioned instead. Comprehension questions on filler sentences were based on 'who did what to whom'. There was a practice session with 8 sentences before the experiment.

4.2.3.4 Analysis

A commercially available statistical package (JMP IN) was used for analyzing the data. An omnibus ANOVA was performed with gap and head noun type as independent factors for both dependent measures (comprehension scores and reading times), with two levels of gap type (subject vs. object) and three levels of head noun type (subject vs. object vs. possessive).

The lexical items of the SS, PS, and OS conditions were identical within the relative clause region, as were the lexical items within the relative clause region of the SO, PO, and OO conditions. Therefore, in comparing reading times within the relative clause region, only gap type was used as an independent variable. However, both gap type and head noun type were used as independent variables in analyzing comprehension accuracy, and reading times in the main clause.

Data from three participants were excluded from the RT analysis due to low comprehension performance (50% correct in comparison to 82% in other participants). In addition, mean reading times and standard deviations for each sentential position were calculated for each participant, and reading times of more than three standard deviations were trimmed to the mean reading times of each participant at the affected sentential position; 2% of the total measurements were affected by this application.

4.2.4 Results

4.2.4.1 Comprehension Question Response

Accuracy scores for the comprehension questions are given below.

Table 4-9 Exp 4.1, Correct answer rate

SS	SO	OS	OO	PS	PO
89%	77%	87%	76%	89%	72%

There was a main effect of gap type [$F_1(1,20) = 25.3$, *MSE* = .139, p < .0001, $F_2(2,39) = 14.5$, *MSE* = .132, p < .0005] but not of head noun type [$F_1(1,20) =.252$, *MSE* = .144, n.s., $F_2(2,39) = .25$, *MSE* = .142, n.s.]. This was caused by the higher comprehension scores for sentences containing SRs (88%) than for sentences containing ORs (75%). There was no interaction between gap and head noun type [$F_1(1,20) =.369$, *MSE* = .14, n.s , $F_2(2,39) = .22$, *MSE* = .123, p < .n.s.].

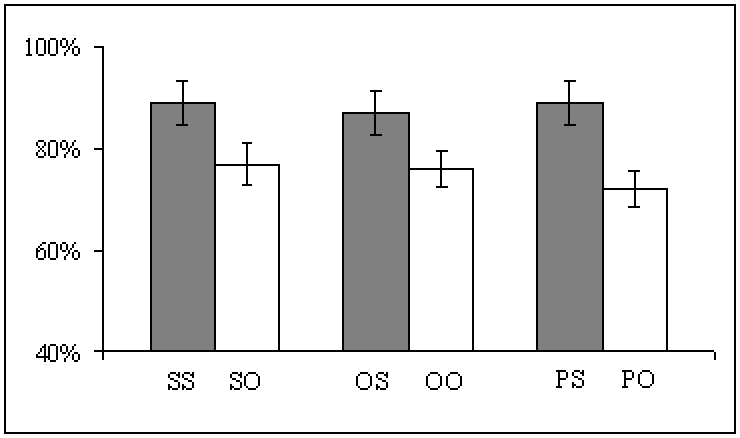

Figure 4-3 Exp 4.1, Comprehension accuracy scores

4.2.4.2 Reading Time Results

The overall pattern of the reading times for all conditions is presented below.

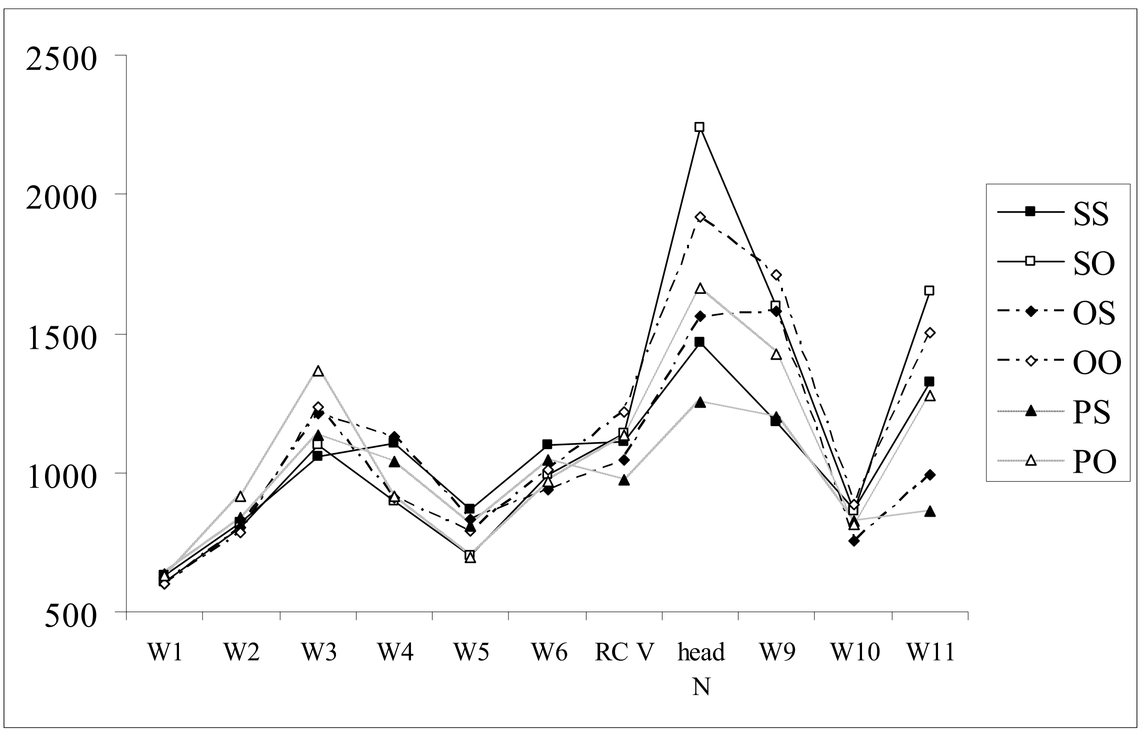

Figure 4-4 Exp 4.1, Overall reading time pattern (ms)

RTs within the relative clause region

RTs within the relative clause region are presented in Table 4-10 and Figure 4-5.

Table 4-10 Exp 4.1, Reading times within RC region

	W1	W2	W3	W4	W5	W6	W7
	that	NP-GEN	NP-ACC/NOM	adverbial phrases			V-REL
SR	623	820	1136	1091	836	1028	1043
OR	611	836	1233	908	730	992	1164

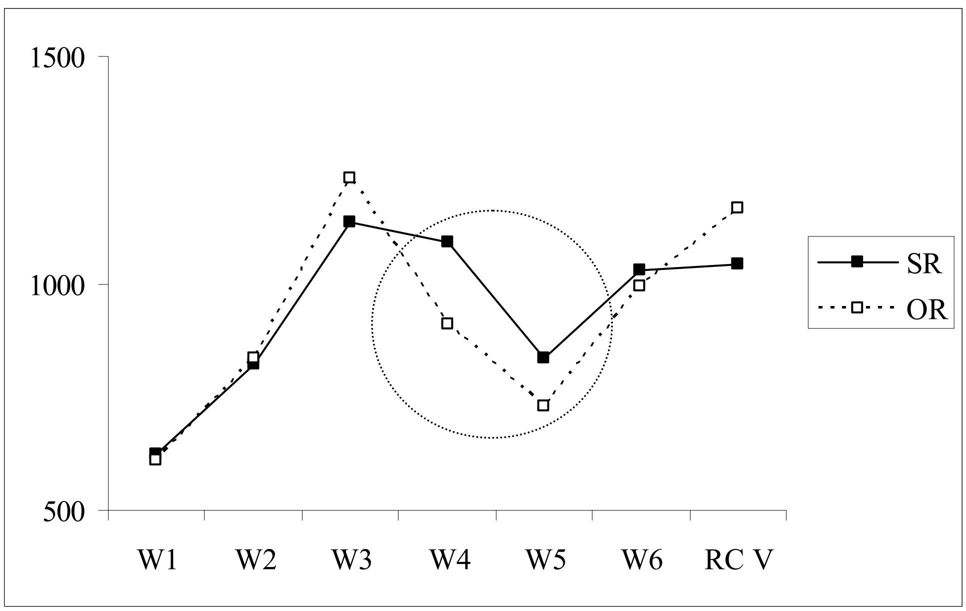

Figure 4-5 Exp 4.1, Reading times within the RC region

Significant reading time differences were found at W4 and W5 (adverbial phrase), with SRs taking longer at these sentence positions than ORs. At the embedded verb position, ORs were read more slowly than SRs. This effect was marginally significant in the items analysis but not in the participants analysis.

Table 4-11 Exp 4.1, Statistical results of reading times within the RC region

	by participants				by items			
	df	F_1	*MSE*	*p*	*df*	F_2	*MSE*	*p*
W4	1, 20	18.4	377060	.0003*	1, 39	16	515085	.0003*
W5	1, 20	4.6	215713	.04*	1, 39	6.45	337753	.01*
W7	1, 20	2.4	931041	.13	1, 39	3.7	1247308	.06

* $p < .05$

Reading times within the main clause region

Reading times and statistical analyses are presented by gap type, head noun type and interaction between gap and head noun type below.

Effect of gap type

Reading times by gap type within the main clause region are presented in Table 4-12 and Figure 4-6.

Table 4-12 Exp 4.1, RTs within the main clause region

	W8	W9	W10	W11
	head noun	NP	adverb	main verb
SR	1427	1319	817	1062
OR	1940	1577	856	1478

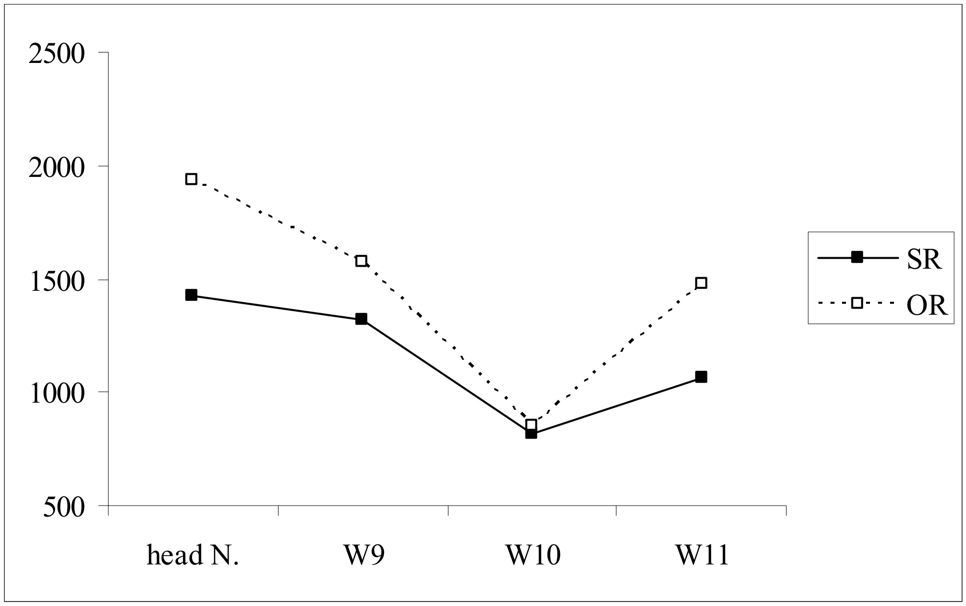

Figure 4-6 Exp 4.1, Mean reading times within the main clause region by gap type

There was a significant main effect of gap type at W8 (head noun), W9 (NP following the head noun), and W11 (sentence-final main verb), as shown in Table 4-13. SRs were read faster than ORs at these sentence positions.

Table 4-13 Exp 4.1, Statistical results by gap type within the main clause region

	by participants				by items			
	df	F_1	*MSE*	*p*	*df*	F_2	*MSE*	*P*
W8	1, 20	20.59	2099214	.001*	1, 39	4.88	2088767	.01*
W9	1, 20	8.52	2214754	.005*	1, 39	8.52	2214754	.005*
W11	1, 20	12.49	1375016	.002*	1, 39	12.8	1667640	.0009*

* p < .05

Effect of head noun type

RTs by head noun type within the main clause region are presented in Table 4-14 and Figure 4-7.

Table 4-14 Exp 4.1, Reading times by head noun type within the main clause region

	W8	W9	W10	W11
	head noun-NOM/ACC/GEN	NP	adverb	main verb
S-head	1852	1388	866	1489
O-head	1741	1646	822	1249
P-head	1457	1310	821	1072

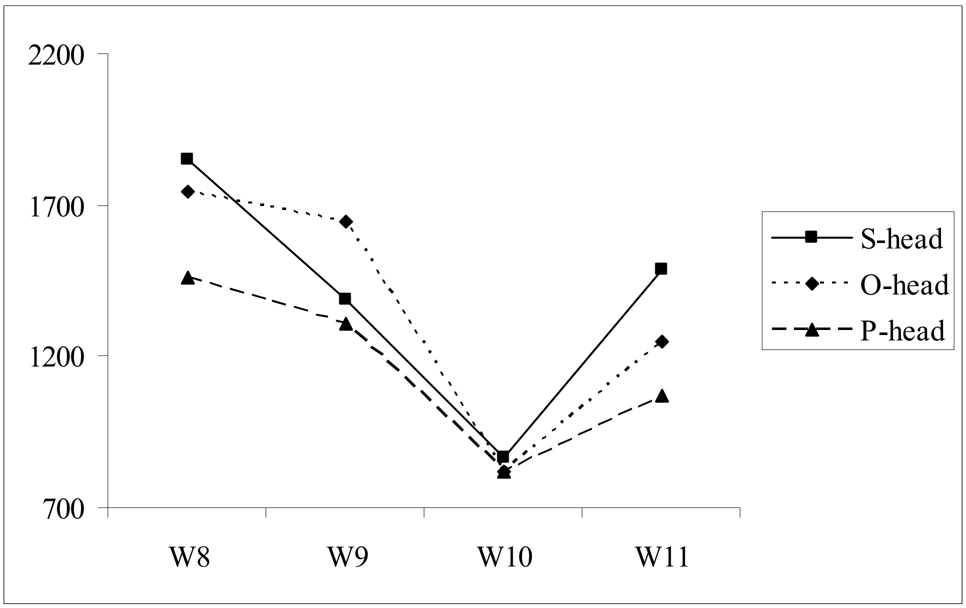

Figure 4-7 Exp 4.1, Reading times by head noun type within the main clause region

There was a main effect of head noun type at W8 (head noun). Tukey tests indicated that this effect was due to significantly faster reading times for the possessive head noun condition compared to the subject and object head noun conditions (.05 level).

From W9 on, the possessive head noun condition was excluded from the analysis since the lexical items in this condition differed from those in the other conditions at these sentence positions. Thus only the subject and object head noun conditions were included in the analysis. At W9, there was a marginal effect of head noun type. This was due to slower reading times for the object head noun conditions compared to the subject head noun conditions; this could be due to the presence of scrambling in the object head noun conditions. Previous research has shown that scrambling incurs extra working memory costs by creating an additional filler-gap dependency (Miyamoto, 2006; Ueno & Kluender, 2003a). In this experiment, the nominative-marked subject at W9 in the object head noun condition clearly signals that the construction involves scrambling, and this clear cue to an extra filler-gap dependency at this position could have caused the processing difficulty in the object head noun condition compared to the subject head noun condition. This effect will not be discussed further.

The statistical analysis at W11 was likewise based on a comparison of subject and object head conditions. There was a marginal effect of head noun type, due to the slightly longer reading times associated with subject head noun conditions than with object head noun conditions.

Table 4-15 Exp 4.1, Statistical results of reading times by head noun type in the main clause region

	by participants				by items			
	df	F_1	*MSE*	*p*	*df*	F_2	*MSE*	*p*
W8	1, 20	9.74	1843524	.0004*	2, 39	20.59	2099214	.001*
W9	1, 20	4.3	1806100	.051	1, 39	3.28	2521222	.07
W11	1, 20	3.09	1456688	.09	1, 39	3.86	1962354	.056

* p < .05

Interaction of gap and head noun type

RTs of the six conditions within the main clause region are presented in Table 4-16 and Figure 4-8.

Table 4-16 Exp 4.1, RTs of six conditions within the main clause regions

	W8	W9	W10	W11
SS	1467	1181	869	1327
SO	2238	1596	864	1650
OS	1562	1579	755	994
OO	1920	1713	888	1504
PS	1252	1197	827	865
PO	1662	1423	816	1279

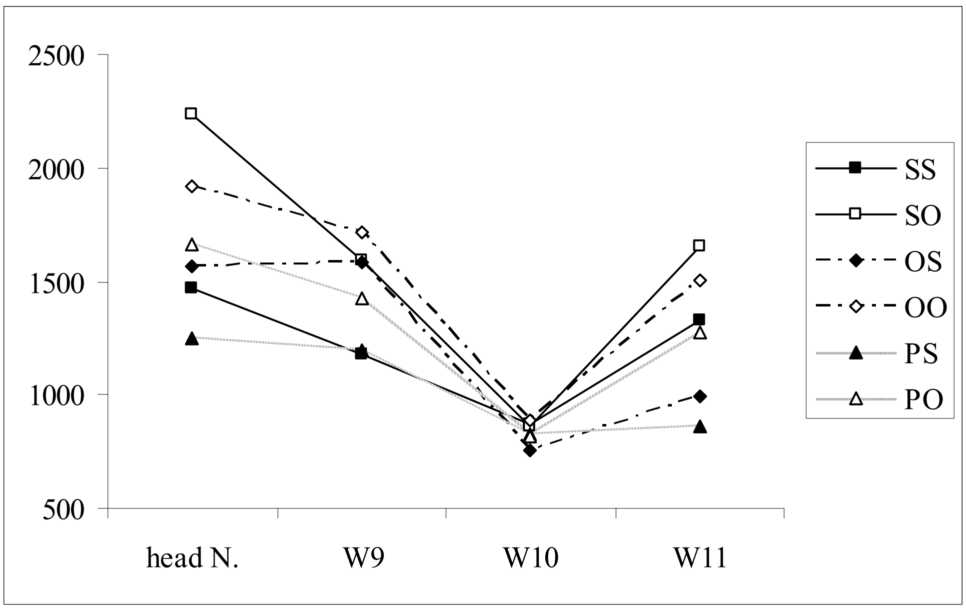

Figure 4-8 Exp 4.1, Reading times of all six conditions within the main clause region

There was an interaction of gap and head noun type at W8 (head noun position) as shown in Table 4-17. A pairwise comparison showed that, although all ORs took significantly longer to read than their counterpart SRs, SO (subject head noun, object gap) sentences took particularly longer to process, showing significantly longer reading times than even other ORs (i.e. OO and PO) at the .05 level. There was no interaction between head noun and gap type at W9, W10, or W11.

Table 4-17 Exp 4.1, Statistical results of the interaction of gap and head noun types

	by participants				by items			
	df	F_1	*MSE*	*p*	*df*	F_2	*MSE*	*p*
W8	1, 20	4.16	1749203	.02*	2, 39	3.38	2119942	.03*

* $p < .05$

4.2.4.3 Summary of Results

In general, ORs showed more processing difficulty than SRs, as measured by lower accuracy scores and longer reading times within the main clause region. On the other hand, within the relative clause region, SRs showed longer reading times. In addition, there was also an effect of head noun type such that, in general, sentences with possessive head nouns were read faster.

Comprehension

Correctly answered question rate	SR > OR

\> = higher accuracy scores

Reading times within the relative clause

RTs at W4	SR > OR
RTs at W5	SR > OR
RTs at W7 (RC Verb)	OR > SR (marginal in the item analysis only)

\> = longer reading times

Reading times within the main clause

	by gap type	by head noun type
RTs W8 (head noun)	OR > SR	S-, O-head > P-head
RTs W9	OR > SR	O-head > S-head (marginal)
RTs W11	OR > SR	

\> = longer reading times

4.2.5 Discussion

The goal of Experiment 4.1 was to investigate which of the processing models proposed for the SR/OR asymmetry in English is the most appropriate as a universal processing strategy. In this section, I evaluate each model based on the reading time results presented above.

4.2.5.1 Evaluation of Storage-Based DLT

Recall that predictions of *storage-based DLT* differ depending on assumptions about how the processor parses a SR at the sentence initial NP-ACC (see Chapter 3 for details). That is, if as Hsiao and Gibson claim for Chinese, readers realize they are processing a relative clause when they encounter a non-canonical sentence-initial element in a subject relative (i.e., in Chinese: verb; in Korean: NP-ACC), *storage-based DLT* predicts that SRs will be harder to process than ORs, with 3 MUs for SRs (relative and main clause verbs and head noun NP) and 1 MU for ORs (main clause verb). Likewise, if it is assumed that the processor will parse a SR as a scrambled sentence, with NP-ACC preceding its subject, again SRs are predicted to be more difficult to process than ORs, with 2 MUs for SR (subject and a main verb) and 1 MU for OR (a main verb). On the other hand, if it is assumed that the processor will parse a SR as a sentence with subject-drop, SRs and ORs are predicted to be equal in terms of processing complexity, with 1 MU for both SR and OR (a main verb). In short, depending on the assumptions one adopts, *storage-based DLT* predicts a processing advantage of ORs over SRs or no asymmetry between the two constructions. However, under any assumption, it does not predict a processing advantage of SRs over ORs.

The experimental results showed a processing advantage for OR sentences at W4 and W5 (right after the first NP-ACC/NOM) (for similar results in Japanese, see Miyamoto & Nakamura, 2003), seemingly providing support for *storage-based DLT* on a relative clause or scrambling reading of the SR, but not on an argument-drop reading.

However, the predictions of *storage-based DLT* for the main clause region were not supported. *Storage-based DLT* predicts that SRs and ORs should not differ from each other after the head noun. For example, at the head noun, the SS type and the SO type should both require one syntactic head, a verb for the main clause, and therefore the reading times of the two constructions are predicted not to differ from each other. However, RTs at W8, W9 and W11 showed that OR sentences were processed significantly more slowly than SR sentences. Thus, the overall results from the relative and main clause regions together do not support *storage-based DLT*.

The slow-down for SR sentences within the relative clause region still needs to be accounted for. One possibility is that this slow-down in SRs is associated with the processing costs of the non-canonical sentence-initial NP-ACC. However, although this possibility is compatible with the experimental results, an important question to ask would be why sentences with non-canonical word order would elicit processing difficulty. In an incremental parsing model, there is no delay in parsing, and the parser builds a structure with underspecified heads (i.e., projecting a syntactic head despite the lack of exact lexical and/or argument structure information) based on the available local information (Sturt & Crocker, 1996). For example, in head-final languages, such as Japanese and Korean, a verb (i.e., a head) comes relatively late in the clause, and case markers have been found to be one of the most informative cues to structure building

(Inoue, 1991; Yamashita, 1997; Kim, 1999; Miyamoto, 2002). In terms of processing SRs vs. ORs, while NP-NOM in ORs will lead to the building of a simple intransitive structure in accordance with *minimal attachment* (Frazier, 1987), in SRs, the parser will predict that the incoming verb is transitive, based on the accusative case marker of the sentence-initial NP, and postulate a gap in subject position. This more extensive structure building with limited information could lead to processing difficulty.

Alternatively, the slow-down could be due to the parser's expectation of a verb directly after the accusative-marked NP, as dictated by an adjacency constraint on direct objects (p.c. with E. Miyamoto). In English, a direct object is required to occur adjacent to its verb (adjacency requirement: Stowell, 1981). In Korean, however, word order is rather flexible as long as a verb occurs clause-finally. Yet, a small corpus study of a movie magazine (26,749 *ejels*; Seyjong corpus 2002) confirmed that there is a tendency for a direct object to occur adjacent to its verb: among 2,023 accusative-marked NPs found in the corpus, 1,684 accusative-marked NPs were immediately followed by a verb, while other sentence constituents intervened between the NP-ACC and the verb in the remaining 339 cases. The results suggest that although violable, the adjacency constraint seems to be operative in Korean. This suggests that the parser's expectation of a verb could have led to the slow-down in the relative clause region of SR sentences, especially when the NP-ACC was not immediately followed by a verb, as in Experiment 4.1. On the other hand, reading time results in Japanese (Ueno & Garnsey, 2008) suggest otherwise. Ueno and Garnsey also found a slow-down immediately after NP-ACC in the relative clause region of SRs. However, since there were no intervening constituents between the sentence-initial NP-ACC and the embedded verb in their materials, this slow-down at the embedded verb position cannot be due to an adjacency requirement.

Taken together, the slow-down in the relative clause region of SRs is most likely due to processing costs associated with structure building, based on the non-canonical sentence initial NP-ACC, and thus does not provide support for *storage-based DLT*.

4.2.5.2 Evaluation of Integration-Based DLT

Integration-based DLT did not correctly predict the results within the main clause either. In *integration-based DLT*, processing costs are defined in terms of the linear distance between linguistic elements in need of integration. Since the linear distance between filler (head noun) and gap is longer in SRs than in ORs in Korean, SRs were predicted to be more difficult to process than ORs at the head noun position. However, contrary to this prediction, the results showed that SR sentences were processed faster than OR sentences. Thus, *integration-based DLT* was not supported.

4.2.5.3 Evaluation of the Filler-Gap Domain Hypothesis (FGD)

The filler-gap domain hypothesis was not supported by the current study either. The filler-gap domain (FGD) hypothesis is based on the notion that there is a correspondence between grammar and performance, such that the complexity of linguistic units is a good predictor of processing difficulty. For example, in English, the FGD of ORs includes the head noun, subject and verb, while the FGD of SRs includes the head noun and verb. Since the size of the FGD is smaller in SRs, in English, SRs are predicted to be easier to process than ORs. On the other hand, in Korean, while the size of the FGD of ORs is the same as that in English (containing the head noun, subject, and verb), the FGD of SRs in Korean needs to extend to the object in addition to the head noun and verb. While English has subject-verb agreement and thus a verb can help disambiguate the role of a gap, in Korean, due to the lack of subject-verb agreement, the case marker of the object NP is the only way to disambiguate the role of the gap in a SR. Thus, the complexity of FGDs in Korean SRs and ORs does not differ. Accordingly, the FGD hypothesis predicts that SRs and ORs should be equally difficult to process. However, the results show that SRs are easier to process than ORs in all corresponding pairs (SS-SO, OS-OO, and PS-PO), and thus do not support the FGD hypothesis.

4.2.5.4 Evaluation of Phrase-Structural Distance

The *structural distance hypothesis* is defined in terms of phrase-structural distance between a gap and its filler (head noun). That is, the longer the structural distance between a gap and its filler is, the more difficult the dependency is to process. Since the phrase-structural distance between a gap and its filler is shorter in SRs than in ORs, SRs were predicted to be easier to process than ORs. The shorter reading times of SRs in the main clause region confirmed this prediction, supporting the phrase-structural distance account. Phrase-structural distance is further discussed in the General Discussion (Section 4.5).

4.2.5.5 Evaluation of the Accessibility Hierarchy

The accessibility hierarchy is based on a cross-linguistic generalization of relative clause formation, namely that any language that allows relative clause formation on a given grammatical role will allow relativization on a grammatical role to its left in the hierarchy.

(4.52) subject > object > obliques

Based on the notion that the '*AH directly reflects the psychological ease of comprehension'* (Keenan & Comrie, 1977: 88), the accessibility hierarchy predicts that SRs should be easier to comprehend than ORs. The experimental results in the main clause region confirmed this prediction: ORs were harder to process than SRs. The accessibility hierarchy is further discussed in the General Discussion as well (Section 4.5).

4.2.5.6 Evaluation of the Perspective Shift Hypothesis

The perspective shift hypothesis is based on the notion of attentional flow regulating language and thought. In this hypothesis, subject marking is among certain "*reflexes of 'starting points' for cognition*" (MacWhinney, 2002: 691), and switching perspectives (from that of the subject) causes processing difficulty. Accordingly, the perspective shift hypothesis predicted that SS relatives would be the easiest to process, and that the rest of the relative clause constructions would not differ from each other in terms of processing difficulty: SS relative clauses do not involve any perspective shift, while the other structures involve one instance of perspective shift.

This hypothesis could account for the processing advantage of SS sentences over SO sentences in the current experimental results. However, the perspective shift hypothesis cannot explain the advantage of PS over PO and OS over OO structures. Moreover, PS structures were processed faster than SS structures at the head noun, even though PS involves one perspective shift while SS does not involve any such shift. Additionally, similar results for SO structures in English and Korean cannot be accounted for under the perspective shift hypothesis. That is, in English, SO sentences are predicted to be the most difficult to process because they involve two instances of perspective shift; this is not the case in Korean, where SO sentences involve only one instance of perspective shift, just as in OS, OO, PS and PO structures. However, the results showed that SO structures were still the most difficult in Korean, just as in English. Therefore, the perspective shift theory was able to explain one result (the processing advantage of SS over SO), but no others.

4.2.5.7 Evaluation of Similarity-Based Interference

In the similarity-based account, the processing difficulty of a filler-gap dependency is defined in terms of the similarity of two linguistic items that need to be represented in memory (Gordon et al., 2004; cf. Lewis, 1996) and subsequently retrieved (Gordon et al., 2001; Lee et al., 2007). This similarity-based effect has been attested in the use of similar NP types in English (Gordon et al., 2001) and Korean (Lee et al., 2007) (e.g., description, personal name and pronoun), and of similar case markers in Korean (Nakayama et al., 2005, Kwon et al., submitted). In terms of processing filler-gap dependencies in Korean, case markers provide a potential source of similarity (or distinctiveness) in memory, and the possible contribution of case marker similarity to subject/object differences in Korean varies with different head noun types (see Section 4.2.1.6 for details). Accordingly, similarity-based interference made different predictions for SR vs. OR asymmetry in sentences with subject-, object- and possessive-head nouns (i.e., an interaction of gap and head noun types): a SR advantage for subject head noun constructions, an OR advantage for object head noun sentences, and no asymmetry for possessive head noun sentences.

(4.53)	subject head nouns:	SR advantage
	object head nouns:	OR advantage
	possessive head nouns:	no advantage

However, the results showed that ORs took longer to read in the subject-, object- and possessive-head noun conditions. Thus, at first blush, it appears that the similarity-based interference account is not consistent with the results. However, it should be noted that there were significant interactions between gap type and head noun type in the reading measures. That is, the subject/object processing asymmetry was greatest in subject head noun conditions and smallest in object head noun constructions. This raises the possibility that increased processing difficulty due to successive NPs with the same case marking contributed to the subject/object asymmetry triggered by phrase complexity (i.e., phrase-structural distance and accessibility hierarchy) in subject head noun constructions, but reduced the asymmetry in scrambled object head noun constructions, for which subject relatives were predicted to be more difficult than object relatives. This suggests that similarity effects and phrase structural complexity effects are not mutually exclusive, but rather that the similarity effect provides an additive effect to the main effect triggered by the phrase-structural complexity and/or psychological ease defined in the *accessibility hierarchy*.

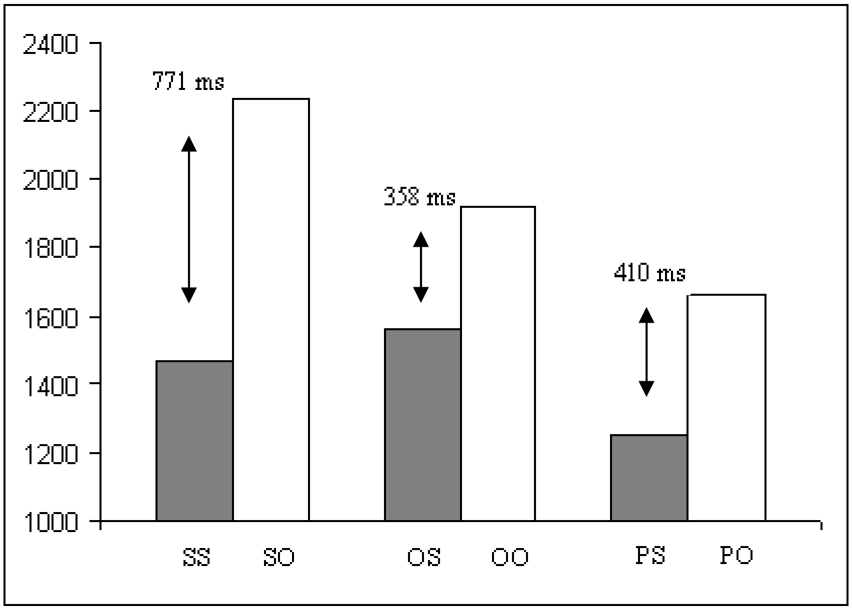

Figure 4-9 Exp 4.1, RTs at head noun

Overall, the results show that structural similarity encoded by case markers can trigger similarity-based interference.

4.2.5.8 Evaluation of Frequency

Statistical Regularity of Word Order

In English, SR sentences maintain canonical word order after relativization while OR sentences do not. Therefore, statistical regularity of word order can also account for the advantage of SRs over ORs. In Korean, however, statistical regularity of word order does not predict a SR/OR processing asymmetry because neither SRs nor ORs maintain canonical word order after relativization. Yet the processing of relative clauses in Korean was found to pattern with that of English relative clauses, such that SRs were easier to process than ORs. Therefore, the statistical regularity of word order hypothesis was not supported.

Frequency of Different RC types

The frequency of different RC types is partly consistent with the experimental results. In the corpus study, SR was found to be more frequent than OR (see Table 4-1), which is consistent with the overall experimental results. However, the corpus results regarding head noun frequency and more fine-grained types of RC frequency (SS, SO, OS, OO, PS and PO) were not compatible with the reading time results.

In the corpus study, subject head noun constructions were the most frequent, followed by possessive head noun constructions (see Table 4-2). Object head noun constructions were the least frequent, although the difference between object and possessive head noun constructions was small. Thus, subject head noun sentences were predicted to be processed faster than object and possessive head noun constructions. However, in the reading time results, it was the possessive head noun sentences that were read fastest at the head noun (W8) (see Figure 4-7). Subject and object head noun sentences were not different from each other at this position. Thus, predictions based on the frequency of the different types of head noun were not supported in the experiment.

In terms of the six different types of relative clauses, the SS construction was the most frequent, followed by the PS construction (see Table 4-3). The frequency of the SO construction was slightly higher than that of the OS and OO constructions, which did not differ from each other. The PO construction had the lowest frequency.

(4.54) Frequency, prediction, and results of six conditions

Frequency	SS > PS > SO > OS = OO > PO	(> = more frequent)
Prediction	PO > OS = OO > SO > PS > SS	(> = longer to read)
Results	SO > OO > PO > OS > SS > PS (2238) (1920) (1602) (1562) (1467) (1252 ms)	(> = longer to read)

Thus, SS constructions were predicted to be read fastest among all the constructions, followed by PS and SO. Additionally, since OS and OO did not differ in terms of frequency, OS and OO were predicted not to differ in terms of processing difficulty. Finally, the PO condition was predicted to be the most difficult due to its low frequency. However, the reading time results showed that the PS condition was read fastest, followed by the SS, a result that is not consistent with the frequency data. In addition, OS was read faster than OO even though the frequency of the two constructions did not differ. Finally, while the PO construction was the least frequent among the six conditions, it was the SO construction that showed the slowest reading times. The OO construction was also read more slowly than the PO construction. Thus, the experimental results did not support the predictions based on the frequency of the six constructions. The disassociation of frequency and processing difficulty has been attested in previous studies as well (Gibson & Schutze, 1999; Gordon et al., 2004; cf. Chomsky, 1957). This issue is also addressed in the General Discussion (Section 4.5).

In summary, a frequency-based account was only partially supported by the reading time results; the SR vs. OR asymmetry was correctly predicted, but predictions based on the frequency of different types of head nouns and the six different relative clause constructions were not supported.

4.2.5.9 Remaining Issue: Head Noun Type Effect within the Main Clause Region

At W8, the head noun position, there was a main effect of head noun type (see Figure 4-7). This effect remains to be accounted for. Although it is possible that similarity-based interference in the SO and OS conditions (see Section 4.2.5.7 for detailed discussion) could have caused longer reading times in the subject and object head noun conditions in comparison to the possessive head noun conditions, in fact, the reading times at W8 in SS (1467 ms) were also longer than in PS (1252 ms), and reading times for OO (1920 ms) were longer than for PO (1162 ms), even though none of these constructions involved a similarity effect. This shows that the similarity effect cannot be solely responsible for the different reading times of the various head noun types.

I suggest that the different reading times could be related to the role of the head noun in the main clause. The possessor's role in the main clause is not as important as that of the subject or object. Therefore, the information associated with the possessor could be backgrounded, reducing working memory costs. This is different from the subject and object head noun type sentences. All the information associated with the subject head nouns and the object head nouns should remain activated because they are active participants in the main clause (Frazier, 1990; Kluender, 2004). This could result in faster reading times of possessive head nouns than of subject and object head nouns. However, further research is needed to investigate this hypothesis.

4.2.6 Summary

To summarize, the results of Experiment 4.1 showed that ORs are more difficult to process than SRs, just as in English, supporting models based on *phrase-structural* *distance* and the *accessibility hierarchy*. Additionally, the results suggest that structural similarity due to similar case markers could trigger similarity-based interference effects, which are additive to the main effect of structural complexity. The experimental results, however, do not support the *storage*- and *integration-based DLT* or the *filler-gap domain hypothesis*. The *perspective shift hypothesis* and frequency are only partially supported. The implications of these findings are addressed in the General Discussion (section 4.5).

4.3 Experiment 4.2: Eye-Tracking Experiment

The overall results of the first experiment support accounts based on phrase structural complexity (O'Grady, 1997) and the accessibility hierarchy (Keenan & Comrie, 1977), and provide partial support for similarity–based interference (Gordon et al., 2001), but not for accounts based on linear distance (Integration-based DLT: Gibson, 2000). However, the absence of a linear distance effect could be due to the structural ambiguity inherent in Korean (and possibly in Japanese and Chinese as well). As discussed in Chapter 2, a missing argument in Korean is ambiguous between a relative clause gap (4.55) and *pro* (4.56), and this structural ambiguity has consequences for the calculation of the linear distance between a gap and its filler.

(4.55) Relative clause sentence

[$\_\__i$	pheyncipcang-ul	hyeppakha-n]	chongcang$_i$-i	elonin-ul	manna-ss-ta
	editor-ACC	threaten-REL	chancellor-NOM	editor-ACC	meet-PST-DECL

'The chancellor$_i$ [who $\_\_\__i$ threatened the editor] met a journalist.'

(4.56) Sentence with argument-drop

[$\_\__i$	pheyncipcang-ul	hyeppakha-n]	sasil$_k$-i	elonin-ul	koylophy-ess-ta
	editor-ACC	threaten-REL	fact-NOM	editor-ACC	bother-PST-DECL

'The fact$_k$ [who (someone$_i$) threatened the editor] bothered a journalist.'

Given the ubiquitousness of argument drop in Korean (subject: 69.4%; object: 52.8%, Y.-J. Kim, 2000), upon encountering a missing argument, the parser is likely to interpret the gap position as *pro* rather than as a relative clause gap. If so, since a filler (head noun) is obligatory only for a relative clause gap but not for *pro*, this structural ambiguity could be responsible for the absence of effects of linear distance of the gap and filler in Experiment 4.1.

In fact, in a previous self-paced reading time study in Japanese, Ishizuka, Nakatani, and Gibson (2006) argued that the longer reading times of ORs in earlier experiments (Miyamoto & Nakamura, 2003; Ishizuka et al., 2003) were due to the greater temporary structural ambiguity in ORs than in SRs: ORs, with a sentence-initial NP-NOM, are more likely to be interpreted as mono-clausal than SRs, which have a non-canonical sentence-initial NP-ACC. Ishizuka et al. (2006) further argued that without the confound of structural ambiguity, SRs should be more difficult to process than ORs due to greater linear distance between filler and gap. To test this hypothesis, they used preceding context to force a relative clause reading of their stimulus materials. The self-paced reading time results showed that ORs took longer to read than SRs as predicted, though the effect was significant at the embedded predicate ('interviewed' in the example) and not at the head noun position. The results were taken as evidence for linear distance as a major constraint on processing filler-gap dependencies.

(4.57) Materials used in Ishizuka et al. (2006)

Preceding context:
A reporter interviewed a writer on a TV program. Then the writer interviewed another reporter for his new novel.

Taro:
'Which reporter stands [is standing] as a candidate for [in] the election?'

Hanako:
SR: [$\_\__i$ writer-ACC interviewed] reporter$_i$ was it seems
'It seems to be the reporter who interviewed the writer'
OR: [writer-NOM $\_\__i$ interviewed] reporter$_i$ was it seems
'It seems to be the reporter who the writer interviewed'

However, these results are questionable for several reasons. First, ORs in Japanese are not particularly more ambiguous than SRs, according to the norming study results in Ueno and Garnsey (2008), where mono-clausal sentences with subject-drop were frequently produced even when there was no discourse context, suggesting that both subject and object relative clauses are subject to structural ambiguity (i.e., conflicting initial interpretations of a mono-clausal sentence as either argument-drop or a relative clause).[6] Second, longer reading times for SRs at the embedded predicate position could be due to a spillover effect from the immediately preceding sentence-initial NP-ACC, given that sentence-initial NP-ACC has repeatedly been reported to cause a slowdown one word later in self-paced reading times, both in Japanese and Korean (Japanese: Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008; Korean: Experiments 4.1 and 5.1). This interpretation is buttressed by the fact that the slowdown in SRs was present only at the embedded predicate, but not at the following head noun position. Alternatively, longer reading times at the embedded predicate in SRs could be due to the fact that the preceding discourse context related to SRs is mentioned earlier than the discourse context for ORs, and thus more prone to decay in memory. These alternative accounts weaken the interpretation of the experimental results in Ishizuka et al. as providing crucial support for the role of linear distance in processing pre-nominal relative clauses.

In Experiment 4.2, I tested linear distance accounts, controlling for these confounds. There were four conditions, varying gap type (subject vs. object relative clause), and preceding context (with and without preceding context). Following Ishizuka et al. (2006), context was given as a conversation between two people.[7] It introduced a

[6] Thanks to Mieko Ueno (personal communication) for pointing this out.
[7] The format of context was slightly modified from the format in Ishizuka et al. (2006) to promote a natural reading in Korean.

sentence describing two individuals involved in different events. The target relative clause was based on the information provided by this context.

(4.58) Context for SR
Minji: Two chancellors are being investigated.
[$_{event1}$ The first chancellor, he threatened the editor for taking a bribe], and [$_{event2}$ the other chancellor, he threatened the editor for embezzling public funds].

Swuni: I heard that according to the police report, one of the chancellors had met a journalist. Which chancellor met the journalist?

(4.59) SR Target construction

[$\_\__i$ sinmwunsa-uy	pyencipcang-ul	noymwul	swuswu	hyemuy-lo
newspaper-GEN	editor-ACC	bribe	taking	suspicion-with

hyeppakha-n]	chongcang$_i$ -i	enlonin-ul	mann-ass-ta
threaten-REL]	chancellor-NOM	journalist-acc	meet-PST-DECL

'The chancellor [who ___ threatened the editor for taking a bribe] met the journalist.'

(4.60) Context for OR
Minji: Two chancellors are being investigated.
[$_{event1}$ The first chancellor, the editor threatened him for taking a bribe], and [$_{event2}$ the other chancellor, the editor threatened him for embezzling public funds].

Swuni: I heard that according to the police report, one of the chancellors had met a journalist. Which chancellor met the journalist?

(4.61) OR Target construction

[sinmwunsa-uy	pyencipcang-i $\_\__i$	noymwul	swuswu	hyemuy-lo
newspaper-GEN	editor-NOM	bribe	taking	suspicion-with

hyeppakha-n]	chongcang$_i$ –i	enlonin-ul	mann-ass-ta
threaten-REL]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor [who the editor threatened ___ for taking a bribe] met the journalist.'

(4.62) Question format 1: [NP-nom NP-acc Verb]

enu	chongcang-i	enlonin-ul	mann-ass-sup-ni-kka?
which	chancellor-NOM	journalist-ACC	meet-PST-HON-IN-Q?

'Which chancellor met the journalist?'

(4.63) Question format 2: [NP-acc NP-nom Verb]

enlonin-ul	enu	chongcang-i	mann-ass-sup-ni-kka?
journalist-ACC	which	chancellor-NOM	meet-PST-HON-IN-Q?

'Which chancellor met the journalist?'

To control for the apparent processing cost associated with a sentence-initial NP-ACC, an adverbial phrase was inserted between the NP-ACC and the embedded predicate position. In addition, the presentation order of events related to the experimental sentences was counterbalanced: half of the experimental sentences in both the subject and object RC conditions were based on the first event, while the other half were based on the second event. The word order of the question was also controlled to prevent a possible syntactic priming effect (Bock, 1986; Pickering & Branigan, 1998; Hartsuiker & Westenberg, 2000), given that SRs start with NP-ACC while ORs start with NP-NOM. Half of the questions had the word order of NP-NOM NP-acc Verb, while the other half had NP-ACC NP-NOM Verb word order, as shown in (4.62) and (4.63). These factors were controlled across subject and object RC conditions. The experimental conditions also included corresponding subject and object RC experimental sentences without preceding context for a direct comparison between conditions with and without context.

4.3.1 Predictions

If the slowdown observed in ORs in previous studies is due to the greater structural ambiguity of ORs in comparison to SRs, and if linear distance between filler and gap is a major processing constraint in prenominal relative clauses, as argued in Ishizuka et al. (2006), then there should be an interaction of gap type with context. That is, when there is no preceding context, ORs should take longer to process than SRs; when there is preceding context, the asymmetry pattern should be reversed, with SRs exhibiting longer times than ORs. However, if phrase structural complexity and the accessibility hierarchy but not linear distance impose a major constraint on the processing of prenominal relative clauses, as suggested by Experiment 1, there should be no interaction of gap type and context, and ORs should show more processing difficulty than SRs regardless of the presence or absence of context.

4.3.2 Methods

4.3.2.1 Participants

36 native speakers of Korean at Korea University served as participants in the experiment. They received credit for an introductory psychology course for their participation. All had normal or corrected-to-normal vision.

4.3.2.2 Materials

32 sets of four experimental conditions (SR and OR, with and without context) in which the plausibility of SR vs. OR readings was controlled were taken from Experiment 4.1. These experimental sentences were distributed over four lists according to a Latin square design such that participants saw only one condition out of four in each experimental stimulus set.

4.3.2.3 Procedure and Analysis

Participants read a single sentence while wearing an EyeLink eye-tracker manufactured by Sensorimotoric Instruments (Boston, MA). The device was fully calibrated before the experiment began and the calibration was checked before each trial. The tracker sampled pupil location at a rate of 250 Hz.

Each trial started with a fixation point "*" and ended with a comprehension question. For stimulus sentences with context, the context was shown on the screen as a conversation between two people. Participants were instructed to press the space bar on the keyboard after they had finished reading the context sentences. The target sentence then appeared, after which participants pressed the space bar to see a true/false comprehension statement. True and false statements were distributed equally across the conditions, and all the comprehension questions focused on the content of the relative clause. Participants responded by pressing "/" for true and "z" for false. For sentences without context, the experimental procedures were the same as in Experiment 1. There were 6 practice trials.

Fixations of less than 80 ms were deleted unless the adjacent fixation fell on the same word. In this case, the fixations were incorporated into larger fixations (e.g., Rayner, 1975, 1978). Short fixations made up 2.6% of total fixations; 1.1% were deleted and 1.5% were combined with the adjacent fixation. Fixations longer than 800 ms were trimmed to 800 ms (0.1% of total fixations).

Gaze duration, regression path duration and rereading time measures were reported as online measures of sentence processing. Gaze duration is the sum of all fixations on a region before the eyes move out of the region to either the right or left (Rayner, 1998). This measure is generally regarded as a measure of initial sentence processing. Regression path duration is the sum of all fixations spent on the target and pre-target regions, from the first fixation in a target region to fixation to the right of the target region (Liversedge et al., 1998; Rayner & Duffy, 1986). This measure is known to be sensitive to the detection of processing difficulty. Rereading time counts all fixations, excluding the initial reading of a region (i.e., gaze duration).

4.3.3 Results

Table 4-18 Overall reading times and comprehension accuracy

	Gap type		Difference
	SR	OR	OR-SR
Context	6071 (.75)	6732 (.64)	661
No Context	8289 (.73)	9428 (.67)	1139

Overall reading times of the experimental sentences showed main effects of gap type [$F_1(1,35) = 23.75$, $MSE = 9{,}818{,}758$, $p < .001$; $F_2(1,31) = 15.85$, $MSE = 14{,}714{,}112$, $p < .001$] and of context [$F_1(1,35) = 53.22$, $MSE = 32{,}669{,}426$, $p < .001$, $F_2(1,31) = 101.36$, $MSE = 17{,}153{,}843$, $p < .001$]. Reading times were shorter for SRs than for ORs. Also, reading times were shorter when there was preceding context. The comprehension accuracy scores were higher for SRs than for ORs [$F_1(1,35) = 16.25$, $MSE = .16$, $p < .001$, $F_2(1,31) = 3.95$, $MSE = .04$, $p < .056$].

Gaze duration

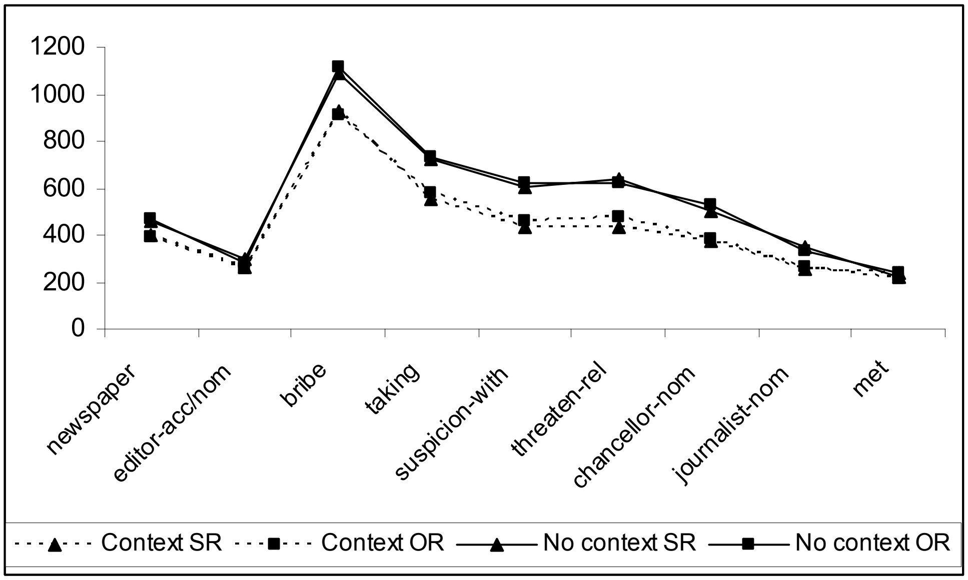

Figure 4-10 Exp 4.2, Gaze duration for SRs and ORs with and without context

In all regions except for the very last word, there were significant main effects of context. Gaze durations in these regions were significantly shorter when there was preceding context.[8] However, there was no effect of gap type in any region.

Regression path duration

Table 4-19 shows the regression path duration of SRs and ORs with and without context. Regression path durations were calculated for the embedded verb and head noun

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[8] These effects were significant at W1 [$F_1(1,35) = 12.48$, $MSE = 98{,}781$, $p < .001$, $F_2(1,31) = 16.20$, $MSE = 71{,}774$, $p < .001$], W2 [$F_1(1,35) = 7.07$, $MSE = 34{,}908$, $p < .05$, $F_2(1,31) = 4.41$, $MSE = 52{,}748$, $p < .05$], W3 [$F_1(1,35) = 50.99$, $MSE = 184{,}895$, $p < .001$, $F_2(1,31) = 62.20$, $MSE = 151{,}275$, $p < .001$], W4 [$F_1(1,35) = 55.05$, $MSE = 136{,}159$, $p < .001$, $F_2(1,31) = 93.41$, $MSE = 80{,}342$, $p < .001$], W5 [$F_1(1,35) = 64.62$, $MSE = 106{,}177$, $p < .001$, $F_2(1,31) = 69.19$, $MSE = 98{,}230$, $p < .001$], W6 [$F_1(1,35) = 69.29$, $MSE = 109{,}381$, $p < .001$, $F_2(1,31) = 116.65$, $MSE = 66{,}011$, $p < .001$], W7 [$F_1(1,35) = 52.24$, $MSE = 90{,}142$, $p < .001$, $F_2(1,31) = 85.41$, $MSE = 55{,}650$, $p < .001$], and W8 [$F_1(1,35) = 24.64$, $MSE = 60{,}196$, $p < .001$, $F_2(1,31) = 45.31$, $MSE = 34{,}995$, $p < .001$].

regions, as well as for the main clause object region occurring immediately after the head noun.

Table 4-19 Regression path duration for SRs and ORs with and without context

	Gap type	W6 threaten-REL	W7 chancellor-nom	W8 journalist-acc
Context	SR	651	843	1161
	OR	792	1080	1652
No context	SR	810	974	1191
	OR	880	1218	1682

Regression path duration of all three regions showed significant effects of gap type: the regression path duration for ORs was longer than for SRs.[9] Also, regression path durations were shorter in the embedded verb (W6) and head noun regions (W7) when there was preceding context.[10]

Re-reading times

The re-reading times of the four conditions are presented in Figure 4-11.

[9] The effect was significant in the embedded verb (W6) [$F_1(1,35) = 19.80$, $MSE = 161{,}010$, $p < .001$, $F_2(1,31) = 12.68$, $MSE = 251{,}380$, $p < .001$], head noun (W7) [$F_1(1,35) = 26.56$, $MSE = 625{,}791$, $p < .001$, $F_2(1,31) = 32.26$, $MSE = 515{,}780$, $p < .001$], and main clause object regions (W8) [$F_1(1,35) = 18.03$, $MSE = 3{,}850{,}970$, $p < .001$, $F_2(1,31) = 13.65$, $MSE = 5{,}089{,}564$, $p < .001$].

[10] The effect was significant in the embedded verb (W6) [$F_1(1,35) = 26.90$, $MSE = 164{,}301$, $p < .001$, $F_2(1,31) = 25.06$, $MSE = 176{,}127$, $p < .001$] and head noun regions (W7) [$F_1(1,35) = 6.35$, $MSE = 821{,}138$, $p < .05$, $F_2(1,31) = 10.68$, $MSE = 488{,}538$, $p < .01$].

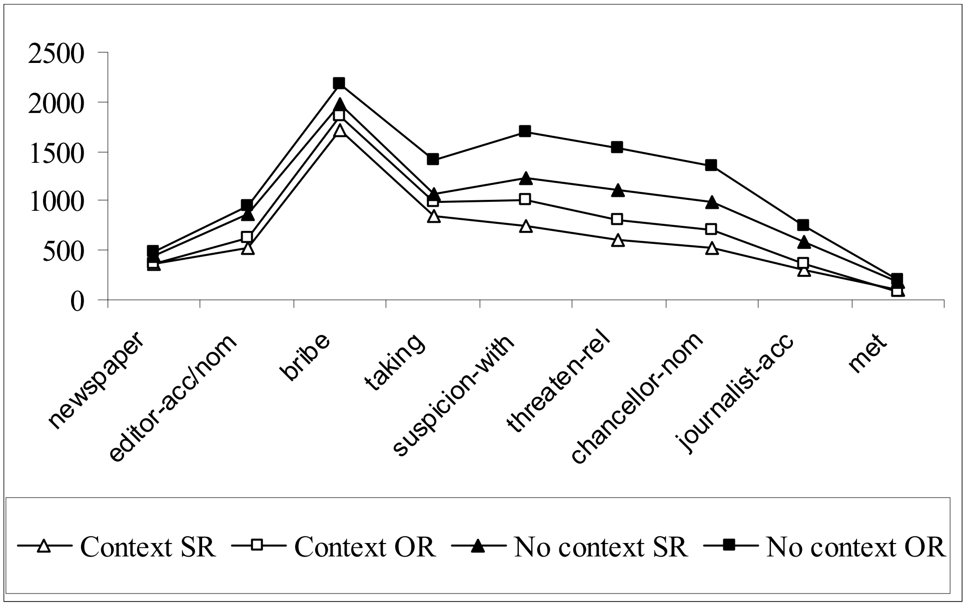


Figure 4-11 Re-reading times of SRs and ORs with and without context

In every region, rereading times were shorter with preceding context.[11] Also, the rereading times were shorter in SRs than in ORs from the second word of the sentence to the second–to-last word of the sentence (W2 to W8).[12] In the embedded verb region (W4), there was a significant interaction between gap type and context [$F_1(1,35) = 6.32$, MSE = 672,230, $p < .05$; $F_2(1,31) = 4.16$, MSE = 1,021,753, $p < .05$]. This interaction was due to

[11] These effects were significant at W1 [$F_1(1,35) = 8.11$, MSE = 365,196, $p < .01$; $F_2(1,31) = 11.96$, MSE = 247,706, $p < .01$], W2 [$F_1(1,35) = 20.35$, MSE = 1,478,601, $p < .001$; $F_2(1, 31) = 45.67$, MSE = 658,755, $p < .001$], in W3 [$F_1(1, 35) = 7.04$, MSE = 3,449,638, $p < .05$; $F_2(1, 31) = 8.86$, MSE = 2,743,514, $p < .01$], in W4 [$F_1(1, 35) = 16.51$, MSE = 1,848,727, $p < .001$; $F_2(1, 31) = 28.36$, MSE = 1,076,376, $p < .001$], in W5[$F_1(1, 35) = 40.91$, MSE = 2,333,478, $p < .001$; $F_2(1, 31) = 79.09$, MSE = 1,206,893, $p < .001$], in W6 [$F_1(1, 35) = 46.75$, MSE = 2,292,968, $p < .001$; $F_2(1, 31) = 109.86$, MSE = 975,784, $p < .001$], in W7[$F_1(1, 35) = 62.15$, MSE = 1,385,717, $p < .001$; $F_2(1, 31) = 128.18$, MSE = 671,919, $p < .001$], in W8 [$F_1(1, 35)$ = 40.27, MSE = 786,064, $p < .001$; $F_2(1, 31) = 129.42$, MSE = 244,587, $p < .001$], and in W9 [$F_1(1, 35)$ = 17.82, MSE = 147,088, $p < .01$; $F_2(1, 31) = 39.89$, MSE = 65,712, $p < .001$].

[12] These effects were significant at W2 [$F_1(1, 35) = 4.91$, MSE = 510,073, $p < .05$; $F_2(1, 31) = 3.18$, MSE = 788,049, $p < .085$], W3 [$F_1(1, 35) = 6.15$, MSE = 1,315,734, $p < .05$; $F_2(1,31) = 6.17$, MSE = 1,312,139, $p < .05$], W4 [$F_1(1,35) = 35.42$, MSE = 469,700, $p < .001$; $F_2(1,31) = 23.69$, MSE = 702,298, $p < .001$], W5 [$F_1(1,35) = 38.4$, MSE = 994,957, $p < .001$; $F_2(1,31) = 44.61$, MSE = 856,378, $p < .001$], W6 [$F_1(1,35)$ = 34.7, MSE = 785,938, $p < .001$; $F_2(1,31) = 35.79$, MSE = 761,999, $p < .001$], W7 [$F_1(1, 35) = 24.02$, MSE = 850,581, $p < .001$; $F_2(1,31) = 38.34$, MSE = 532,746, $p < .001$], and W8 [$F_1(1,35) = 14.18$, MSE = 224,692, $p < .001$; $F_2(1,31) = 18.00$, MSE = 176,984, $p < .001$].

the smaller subject/object asymmetry when there was preceding context compared to when there was no context.

4.3.4 Discussion

Recall that the linear distance account predicted a crossover interaction of gap type and context: when there was preceding discourse context, SRs were predicted to take longer to read than ORs (due to greater linear filler-gap distance), and when there was no preceding discourse, ORs were predicted to take longer to read than SRs due to greater structural ambiguity (Ishizuka et al., 2006). On the other hand, the phrase structural account (and the accessibility hierarchy) predicted that ORs should take longer to read than SRs regardless of the use of the context, and thus no crossover interaction of gap type and context was predicted. The rereading time results did show an interaction at the embedded verb. However, this effect was in the opposite direction from that predicted by the linear filler-gap distance account: ORs took longer to read than SRs both with context and without context, but this asymmetry was smaller when there was preceding context than when there was no preceding context. Although the smaller asymmetry in rereading times at the embedded predicate with context than without could be due to the effect of context on comprehension, this interaction does not provide support for linear/temporal distance accounts. This indicates that even when structural ambiguity is removed by forcing the RC reading, linear distance accounts do not act as a major constraint on processing pre-nominal RCs in Korean. Instead, these results provide further support for the phrase structural distance hypothesis and the accessibility hierarchy.

In relation to the experimental results reported in Ishizuka et al. (2006), although the use of a different methodology (eye-tracking in the current experiment vs. self-paced reading time in Ishizuka et al.) does not allow direct comparison between the two studies, the experimental results showed that gaze duration in the subject relative clause condition was slightly longer than that in the object relative clause condition right after NP-ACC, although the difference was very minimal (929 vs. 913 ms). This suggests that the slowdown in subject RCs in Ishizuka et al. could be due to a spillover effect from the immediately preceding NP-ACC.

In summary, the overall results provide support for the phrase structural distance hypothesis and accessibility hierarchy. The results, however, were not consistent with linear distance accounts either with or without preceding context.

4.4 Experiment 4.3: ERP experiment

Experiments 4.1 and 4.2 showed that, just as in English, object relatives (ORs) in Korean were harder to process than subject relatives (SRs), despite the surface differences. Yet the question remains how these typological surface differences map onto cognitive/neural mechanisms underlying the processing of long-distance dependences. In particular, I am interested in the possible similarities and dissimilarities involved in processing long-distance dependencies with different filler and gap ordering. Although quantitative measurements of both self-paced and eye-tracking reading times provide tentative cognitive evidence for on-line sentence processing, ERP measurements can in addition provide qualitative information with millisecond temporal precision. In view of this, in Experiment 4.3 my goal is to further our understanding of the similar and dissimilar parsing strategies involved in processing forward and backward syntactic dependencies by using ERP measures.

In fact, the reading time studies reported above (Experiments 4.1 and 4.2) already showed some similarities as well as dissimilarities in the processing of forward syntactic dependencies in English (4.64) and backward syntactic dependencies in Korean (4.65).

(4.64) English: forward syntactic dependency

The reporter	who	__ attacked the senator admitted the error.
FILLER		GAP

(4.65) Korean: backward syntactic dependency

[__	uywon-ul	kongkyekha-n]	kica-ka	silswu-lul	incenghayssta
	senator-ACC	attacked-REL	reporter-NOM	error-ACC	admitted
GAP			FILLER		

That is, both in forward (English relative clauses) and backward (Korean relative clauses) syntactic dependencies, ORs were more difficult to process than SRs, suggesting that linguistic structural complexity (i.e., the NP accessibility hierarchy and phrase-structural distance) are at play in both types of dependencies. Accordingly, it is expected that there will be ERP effects corresponding to the processing difficulty of structurally complex ORs compared to SRs in Korean, just as there were in English.

In terms of dissimilarities, forward dependencies have been characterized as filler-driven. That is, upon encountering a filler, the parser attempts to locate a gap as soon as possible without waiting for specific structural information (Active Filler Strategy: Frazier & Clifton, 1989), and thus a shorter distance between filler and gap is favored. By analogy, backward syntactic dependencies would be characterized as gap-driven. However, there is very little evidence for linear length-related effects in backward dependencies, as discussed in Experiments 4.1 and 4.2. In addition, it is not exactly clear how a silent linguistic element (i.e., a missing argument) in a backward syntactic dependency in Korean would necessarily trigger a search for an associated filler; it could just as well – or even more likely – be a dropped argument with no associated filler in the same sentence given that argument drop is so prevalent in Korean (Kim, 2000). Thus the question remains whether the parser immediately postulates a filler when it encounters (or identifies) a gap before it reaches the corresponding head noun (i.e., the actual filler). If the parser does postulate a potential filler for every gap it encounters, it would be important to investigate whether this produces the same kind of ERP effects as are observed in the processing of forward syntactic dependencies.

In sum, by comparing SRs and ORs in Korean using ERP methodology, I investigate the second of the two questions posed at the beginning of this chapter (cf. Japanese: Ueno & Garnsey, 2008):

> (ii) To what extent are the neuro/cognitive operations underlying the processing of forward syntactic dependencies in post-nominal relative clauses (in which a head noun precedes the relative clause, as in English) similar to those underlying the processing of backward syntactic dependencies in pre-nominal relative clauses (in which a relative clause precedes its head noun, as in Korean)?

In the next section, I first discuss in detail the specific predictions for Experiment 4.3. Experiment 4.3 itself (ERP experiment) and the General Discussion of Experiments 4.1, 4.2 and 4.3 follow.

4.4.1 Predictions

As mentioned earlier, the processing of forward syntactic dependencies (i.e., English relatives and *wh*-questions) has been characterized as filler-driven parsing, such that upon encountering a filler, the parser postulates a gap immediately, despite the temporary structural ambiguity of the gap (*active filler strategy*: Frazier & Clifton, 1989). Accordingly, successful understanding of the construction would involve the processes listed in (4.66), each of which has been shown to elicit reliable brain responses in previous ERP studies, as shown in (4.67).

(4.66) Processing of forward syntactic dependencies
- i) A filler (or incomplete dependency) needs to be maintained in working memory in expectation of a gap.
- ii) At the gap site, the filler needs to be reactivated.
- iii) The filler should be integrated with the gap.

(4.67) Neuro/cognitive indices of processes involved in forward syntactic dependencies
- i) Maintaining a filler in working memory has been shown to elicit a sustained anterior negativity, often (but not always) left-lateralized (King & Kutas, 1995; Fiebach et al., 2002; Phillips et al., 2005)
- ii) Associating a gap with a preceding filler (or filler reactivation) is typically seen as a transient left-lateralized anterior negativity (LAN) (Kluender & Kutas, 1993a, 1993b; King & Kutas, 1995; Ueno & Kluender, 2003a).
- iii) (*Wh*-)Filler gap integration at the gap site has been shown to be indexed by a P600 (Kaan et al., 2000; Fiebach et al., 2002; Phillips et al., 2005; Felser et al., 2003).

Accordingly, all things being equal, in an analogous backward syntactic dependency (i.e., a Korean relative clause) the following hypothesized procedures would be involved.

(4.68) Hypothesized processes involved in backward syntactic dependencies
- i) A gap (or incomplete dependency) needs to be maintained in working memory in an expectation of a filler.
- ii) At the filler site, the gap needs to be reactivated.
- iii) The gap should be integrated with the filler.

The question arises whether each of these processes will elicit the corresponding brain response that has been attested in forward syntactic dependencies as presented in (4.67). It should be noted however that these hypothetical processes are based on several assumptions. First, it is assumed that backward syntactic dependencies are gap-driven, such that upon encountering a gap, the parser postulates a filler. Second, it is also assumed that holding a gap in working memory requires additional working memory resources, just as holding a filler in working memory does. Yet given the rampant occurrence of *pro*-drop in Korean (Kim, 2002), it is not clear whether the parser will indeed postulate a filler upon encountering a gap. Additionally, it is also not clear whether holding a gap will require additional working memory resources. In fact, the reading time results in Experiment 4.1 and 4.2 seem to suggest otherwise. That is, if the parser postulates a filler immediately upon encountering a gap, and if holding a gap in working memory requires additional working memory resources, there should have been length-related effects in the reading time experiments (i.e., longer reading times of SRs than ORs, at least in the relative clause region), since the linear distance between gap and filler is longer in SRs than in ORs. However, there was no such linear length-related effect. All told, it is unlikely that the first hypothesized process (i) in (4.68), "maintaining a gap in working memory" in Korean will elicit ERP effects associated with additional working memory requirements, as "maintaining a filler in working memory" does in English and other West Germanic languages (cf. for a different view, see Ueno & Garnsey, 2008). In other words, it is predicted that the relative clause region in Korean will not elicit the typical ERP effects found in English relative clause filler-gap constructions. That is, in Korean, a longer filler-gap distance is NOT predicted to elicit a sustained effect of anterior negativity within the relative clause region, as a longer filler-gap distance does in English.

The filler-gap association effects outlined in (ii) and (iii) in (4.68), on the other hand, might be expected to cause similar difficulties both in forward and backward syntactic dependencies despite the reversed filler-gap ordering. This is supported by longer reading times in ORs than in SRs at filler-gap integration positions (i.e., Korean: at the head noun, Experiments 4.1 and 4.2; English: main verb, King & Just, 1991), pointing to increased processing difficulty. However, given that the nature of quantitative differences between SRs and ORs (i.e., longer reading times in ORs than in SRs) in Experiments 4.1 and 4.2 is not clear, two predictions can be made for the gap-filler integration position, in relation to the processes (ii) and (iii) in (4.68).

If the longer reading times for ORs are due to the processing difficulty associated with gap reactivation, or with the parser's efforts to search through memory for a gap to assign to a filler (i.e., process (ii) in (4.68)), it is predicted that a LAN would be elicited to ORs in Korean, as it was elicited to ORs in English compared to their SR counterparts. In considering this prediction, however, it should be noted that in English, the LAN effect has been attributed to reactivation or back-association of a filler which is distant from the gap site (Fiebach et al., 2002; Kluender & Kutas, 1993a, 1993b; Phillips et al., 2005). In Korean, a linear distance effect was not found to cause processing difficulty. Instead, structural complexity was suggested to be responsible for the subject/object asymmetry. Thus, the prediction of a LAN to ORs in Korean is based on the assumption that higher structural complexity (defined as greater hierarchical phrase structural distance between gap and filler) of ORs should incur higher working memory costs, just as greater linear distance did in English.

On the other hand, if the longer reading times to ORs are due to filler-gap integration (i.e., process (iii) in (4.68)), it is predicted that a P600 should be elicited in response to ORs as compared to SRs. In fact, ERP studies of relative clauses in English did not find such an effect (King & Kutas, 1995; Müller et al., 1997). Moreover, although an experiment in Japanese (Ueno & Garnsey, 2008) did find a sustained positivity to ORs, this effect differed substantially from the standard P600 in its morphology and time course. It is thus debatable whether this effect is indeed a variant of the P600 as the authors argued. Nonetheless, given the similarity in grammatical structure of Japanese and Korean, one might expect that ORs in Korean would also elicit corresponding effects in comparison to SRs.

If on the other hand the longer reading times for ORs in Experiments 4.1 and 4.2 are due to the processing difficulty associated both with gap reactivation and filler-gap integration, both a LAN and a P600 should be elicited in response to ORs compared to SRs (cf. Ueno & Kluender, 2003a for both LAN and P600 effects at gap sites of scrambled constituents in Japanese, i.e. in a forward filler-gap syntactic dependency).

Apart from effects related to processing filler-gap dependencies, it is also predicted that there will be some corresponding neural response to the slow-down in reading time reported in Experiment 4.1 for the relative clause region of SRs due to their apparently non-canonical word order. That is, SRs begin with an object rather than a canonical subject because the subject has been extracted, and in Experiment 4.1, there was a slow-down to SRs one word after the sentence-initial object. Accordingly, it is predicted that this slow-down will elicit corresponding ERP effects. ERP studies in German have shown that sentences starting with an object rather than a canonical subject elicit either a (L)AN (Matzke et al., 2002) or a broadly distributed negativity (Schlesewsky et al., 2003).[13] This effect was interpreted as indexing a higher working memory load for processing non-canonical word order, since non-canonical word order necessitates a more complex syntactic representation (Schlesewsky et al., 2003; see also Section 4.2.5.1 for relevant discussion regarding the situation in Korean, with reference

[13] An ERP experiment on scrambling in Japanese (Ueno & Kluender, 2003a) also elicited LAN, but since this comparison was based on ERP responses to words in different sentential positions, I will restrict the discussion to German studies with a similar experimental design (i.e., comparison of ERP responses to NPs with different case marking in the same linear position).

to Schlesewsky et al., 2003). Thus it is predicted that SRs will elicit a LAN within the relative clause region in comparison to ORs, due to non-canonical word order and the more complex structure building required as a result.

To summarize, SRs are predicted to elicit a LAN within the relative clause region. At the head noun position, ORs are predicted to elicit a LAN and/or a P600 (4.69).

(4.69) Summary of predictions

Processing backward syntactic dependencies in Korean relative clauses		
	Hypothesized processes	Hypothesized neuro/cognitive indices
(i)	A gap (or incomplete dependency) needs to be maintained in working memory in expectation of a filler	No effect
(ii)	At the filler site, a gap needs to be reactivated	ORs will elicit LAN at the head noun
(iii)	The gap should be integrated with a filler	ORs will elicit P600 at the head noun
(iv)	Sentence-initial non-canonical NP-ACC	SRs will elicit LAN at NP-ACC

To examine these predictions for the relative and main clause regions, ERP responses to SRs and ORs will be compared in the three regions presented below.

Table 4-20 Exp 4.3, Points of comparisons

relative clause region: LAN to SR?

[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo		
newspaper-GEN	publisher-ACC/NOM	secretly	political-with		
iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta	
exploit-REL	senator-GEN	office-to	gang-NOM	attacked	

head noun region: LAN and/or P600 to OR? main verb region

PS: 'Gangs attacked the senator's office who secretly took advantage of the publisher of the newspaper for political purposes'

PO: 'Gangs attacked the senator's office who the publisher of the newspaper secretly took advantage of for political purposes'

4.4.2 Norming Study

Before conducting the ERP experiment, a norming study was undertaken to control for the naturalness of the events denoted by SRs and ORs.

4.4.2.1 Methods

Participants

144 Korean native speakers participated in the norming study. At the time of the study, all participants were between the ages of 17 to 30 and were attending high school, college or graduate school in Korea (mean age=18). The high school students were in their senior year and planning on going on to college.

Materials

As in the norming study of the reading time experiment (Section 4.2.2), sentences were created by replacing the gap with its associated head noun in each of eight sets of

PS and PO conditions, (see materials, (4.73) and (4.74)). For example, for PS (4.73) and PO (4.74) sentences, (4.70) and (4.71) were created.

(4.70) Norming sentence made from PS

uywon-i	sinmwunsa-uy	sacang-ul	pimilliey	cengchicek-ulo	iyonghayssta
senator-NOM	newspaper-GEN	publisher-ACC	secretly	politically	exploit

'The senator secretly took advantage of the publisher of the newspaper for political purposes.'

(4.71) Norming sentence made from PO

sinmwunsa-uy	sacang-i	uywon-ul	pimilliey	cengchicek-ulo	iyonghayssta
newspaper-GEN	publisher-NOM	senator-ACC	secretly	politically	exploit

'The publisher of the newspaper secretly took advantage of the senator for political purposes.'

Design and Procedure

The norming study for the second ERP experiment (Chapter 5) was also conducted in the same set-up. The norming sentences were split into four lists using a Latin-square design. Participants saw one sentence from each PS and PO pair, (e.g., (4.70) or (4.71)), and rated the naturalness of the sentences. The rating was based on a 5-point scale. The participants were asked to rate a sentence as 1 if it sounded natural and as 5 if the sentence sounded strange. The example is illustrated in English in (4.72), but in the questionnaire Korean sentences were used.

(4.72) 'The senator secretly took advantage of the publisher of the newspaper for political purposes.'

Please rate this sentence for its naturalness.

Sounds natural   Sounds strange

1   2   3   4   5

4.4.2.2 Results

Three subjects did not complete the questionnaire questions related to the current experimental conditions and thus were excluded from the analysis. The means for plausibility were 2.5 for the sentences formed from SRs and 2.6 for the sentences formed from ORs.[14] A student's t-test showed that this difference was not significant [$t(140) = 2.59$, $p < .1$].

4.4.3 ERP Methods

4.4.3.1 Subjects

Twenty-two native Korean speakers participated in the study (female = 14, male = 8). At the time of the experiment, all participants were between the ages of 22 and 31 (mean: 25) and were enrolled in graduate school or in English classes at UCSD Extension. The average length of stay in the U.S. was 13 months (range of length of stay: 2 months to 3.5 years). All participants were right-handed with no neurological disorders and normal or corrected-to-normal vision. They received $10 per hour to participate in an experiment that lasted approximately three hours.

4.4.3.2 Materials

Among the six conditions in the self-paced reading time study, PS and PO constructions (4.73) and (4.74) were selected for the corresponding ERP experiment to control for perspective shift (MacWhinney & Pleh, 1988) and parallel grammatical function (Sheldon, 1974). In the *perspective-shift hypothesis*, the SS condition has an

[14] The experimental stimuli are newspaper-style sentences and the relatively low acceptability ratings seem to be due to their complex structure and high-level vocabulary.

advantage over other constructions because SS does not involve any change in subject (perspective). In terms of the parallel grammatical function hypothesis (Sheldon, 1974), SS and OO constructions have an advantage over SO and OS, respectively, since in the former, the head noun carries the same grammatical function in both main and relative clauses. PS and PO do not share this confound, since both constructions involve perspective shift and different grammatical roles for the head noun in the relative and main clauses.

(4.73) PS (Possessive head, Subject gap)

[sinmwunsa-uy	sacang-ul	pimilliey	cengchicek-ulo	iyongha-n]
newspaper-GEN	publisher-ACC	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

'Gangs attacked the senator's office who secretly took advantage of the publisher of the newspaper for political purposes'

(4.74) PO (Possessive head, Object gap)

[sinmwunsa-uy	sacang-i	pimilliey	cengchicek-ulo	iyongha-n]
newspaper-GEN	publisher-NOM	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

'Gangs attacked the senator's office who the publisher of the newspaper secretly took advantage of for political purposes'

Eighty sets of PS and PO conditions were constructed. The second ERP experiment reported in Chapter 5 was also run in the same experimental set-up due to a paucity of Korean speakers at UC San Diego. Thus eighty sets of object relative and adjunct clause sentences were added. Additionally, there were 210 sets of filler sentences. Filler sentences included grammatical sentences (4.75) along with ungrammatical counterparts (4.76) with headedness violations (i.e., **to-park* as opposed to *park-to*), congruous sentences (4.77) with incongruous counterparts (4.78), and unscrambled sentences (4.79) with scrambled counterparts (4.80), where a direct object was fronted to the beginning of the sentence. Since there were no previously reported ERP experiments in Korean, these types of sentences were chosen as fillers to elicit typical P600 ((4.76) vs. (4.75)), N400 ((4.78) vs. (4.77)) and LAN ((4.80) vs. (4.79)) effects to which the experimental results could be compared.[15]

(4.75) Grammatical sentence

emma-ka	ocen-ey	kongwon-ulo	sanchayk-ul	kasi-ess-ta
Mom-NOM	morning-at	park-to	walk-ACC	go-PST-DECL

'Mom went to the park for a walk.'

(4.76) Ungrammatical sentence: headedness violation

emma-ka	ocen-ey	ulo-kongwon	sanchayk-ul	kasi-ess-ta
Mom-NOM	morning-at	to-park	walk-ACC	go-PST-DECL

'Mom went to the park for a walk.'

(4.77) Congruous sentence

achim-ey	salamtul-i	pap-ul	mek-ess-ta
morning-in	people-NOM	rice-ACC	eat-PST-DECL

'In the morning, people ate a meal.'

(4.78) Incongruous sentence

achim-ey	salamtul-i	chayk-ul	mek-ess-ta
morning-in	people-NOM	book-ACC	eat-PST-DECL

'In the morning, people ate a book.'

(4.79) Unscrambled sentence

ku	yuchiwon-uy	woncang-i	hakwon-uy	nyencwung	hayngsa-ey
that	kindergarten-GEN	principal-NOM	school-GEN	annual	event-to

hakpwumotul-ul	chotayhay-ss-ta
parents-ACC	invite-PST-DECL

'The principal of the kindergarten invited the parents to the annual school event'

[15] See appendix section for the experimental results of these filler sentences.

(4.80) Scrambled sentence

hakpwumotul$_i$-ul	ku	yuchiwon-uy	woncang-i	hakwon-uy
parents-ACC	that	kindergarten-GEN	principal-NOM	school-GEN

nyencwung	hayngsa-ey	___$_i$	chotayhay-ss-ta
annual	event-to		invite-PST-DECL

‘The principal of the kindergarten invited the parents to the annual school event’

These sentences were split into two lists using a Latin-square design. Each list contained 370 sentences. These lists were divided into twelve sub-lists, of which ten lists contained thirty-one sentences and the remaining two lists contained thirty sentences. The sentences in each list were pseudo-randomized, such that sentences from the same condition would not occur in a row. In addition, the stimuli were presented in a different order for every participant. This was to prevent any possible confound associated with order-related effects.

4.4.3.3 Procedures

Subjects were run in a single session lasting about 2.5 hours, including preparation. Sentences were visually presented in Korean script in the center of a monitor screen, one *ejel* at a time. Each *ejel* was presented for 300 ms with a 500 ms stimulus onset asynchrony (SOA).[16] The interstimulus interval between sentences was 3000 ms and subjects were given as much rest as they wished between sets of lists. Yes/No

[16] Since there was no previous ERP experiment reported in Korean, the presentation rate was decided based on gaze durations in eye-tracking studies and the responses of four participants in pilot experiments. The average reading times of first pass reading per *ejel* in eye-tracking studies is about 400 ms (Kwangil Choi, Yoonhyoung Lee, and Youngjin Kim, personal communication). In pilot experiments, volunteers were presented with experimental sentences in blocks at different presentation rates (400 ms duration with 650 ms SOA, 300 ms duration with 500 ms SOA, and 200 ms duration with 400 ms SOA) and rated each presentation rate in terms of understanding of sentences and naturalness of reading speed. The presentation order of each block was different for each participant. It was reported that although participants could understand sentences at the fastest presentation rate (200 ms presentation with 400 ms SOA), they felt most comfortable and natural with presentation rates of 500 ms SOA. For the presentation rate of 400 ms duration with 650 ms SOA, they reported that the rate felt a bit slower than normal reading speed.

comprehension questions were presented at the end of every five sentences on average to maintain participants' attention. The comprehension questions focused on the content of the immediately preceding sentence. For example, the comprehension question (4.82) immediately followed the experimental sentence (4.81).

(4.81) Stimulus

[sinmwunsa-uy	sacang-ul	pimilliey	cengchicek-ulo	iyongha-n]
newspaper-GEN	publisher-ACC	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

'Gangs attacked the senator's office who secretly took advantage of the publisher of the newspaper for political purposes'

(4.82) Question

sinmwunsa-uy	sacang-i	uywon-ul	cengchicekulo	iyonghaysssupnikka?
newspaper-gen	publisher-nom	senator-acc	politically	exploited?

'Did the publisher of the newspaper take advantage of the senator?'

Each comprehension question appeared 1000 ms after the offset of the sentence-final word and remained on the screen until participants responded by pressing hand-held buttons. The response hand was counterbalanced to control for dominance. The next sentence started 2000 ms after the response. There was a practice session with seven sentences before the experiment.

4.4.3.4 Electrophysiological Recording

The electroencephalogram (EEG) was recorded from 26 tin electrodes mounted geodesically in an electro-cap. These sites included midline prefrontal (MiPf), left and right lateral prefrontal (LLPf and RLPf), left and right medial prefrontal (LMPf and RMPf), left and right lateral frontal (LLFr and RLFr), left and right medial frontal (LMFr and RMFr), left and right medial lateral frontal (LDFr and RDFr), left and right medial central (LMCe and RMCe), midline central (MiCe), left and right medial lateral central (LDCe and RDCe), left and right lateral temporal (LLTe and RLTe), left and right medial lateral parietal (LDPa and RDPa), midline parietal (MiPa), left and right lateral occipital (LLOC and RLOc), left and right medial occipital (LMOc and RMOc), and midline occipital (MiOc). Each electrode was referenced online to the reference electrode on the left mastoid. To monitor blinks and eye movements, electrodes were placed on the outer canthi and under each eye, and were referenced to the left mastoid. Impedances were kept below 5KΩ. The EEG was amplified with Nicolet amplifiers with a bandpass of 0.016 to 100 Hz, digitized at a sampling rate of 250 Hz.

4.4.3.5 Data Analysis

For phasic effects, measurements were taken of single-word averages, which consisted of 1000 ms epochs, including a 100 ms prestimulus baseline. For longer-lasting effects, measurements were taken of two-word averages, which consisted of 1700 ms epochs, including a 400 ms prestimulus baseline. Trials contaminated by excessive muscle activity, amplifier blocking, or eye movements were discarded offline before averaging. On average, 4% and 9% of trials were rejected for single- and two-word averages, respectively. The averaged data were algebraically re-referenced to the mean of the activity at the two mastoids. For purposes of visualization, ERP waves were smoothed using a low pass filter with a cutoff frequency of 7Hz.

The data were submitted to an overall ANOVA with repeated measures of experimental condition (SR vs. OR) and electrodes (26 levels). This analysis is referred to as the full analysis. In addition to the full analysis, a distributional analysis was conducted, including experimental condition (SR vs. OR), hemisphere (left vs. right), laterality (lateral vs. medial) and anteriority (4 levels: prefrontal vs. frontal vs. parietal vs. occipital) as factors. Electrodes included were left and right lateral prefrontal (LLPf and RLPf), left and right medial prefrontal (LMPf and RMPf), left and right lateral frontal (LLFr and RLFr), left and right lateral temporal (LLTe and RLTe), left and right medial lateral parietal (LDPa and RDPa), left and right lateral occipital (LLOC and RLOc), and left and right medial occipital (LMOc and RMOc). The configuration of the electrodes included in the analysis is presented in **Figure 4-12**. Furthermore, when it was necessary to corroborate small local effects, an ANOVA was performed on regions of electrodes (**frontal and lateral**: LLPf, LLFr, RLPf, RLFr; **frontal and medial**: LMPf, LDFr, RMPf, RMFr; **posterior and lateral**: LLTe, LLOc, RLTe, RLOc; **posterior and medial**: LDPa, LMOc, RDPa, RMOc). The Huynh-Feldt (1976) correction for lack of sphericity was applied, and corrected *p* values are reported with the original degrees of freedom.

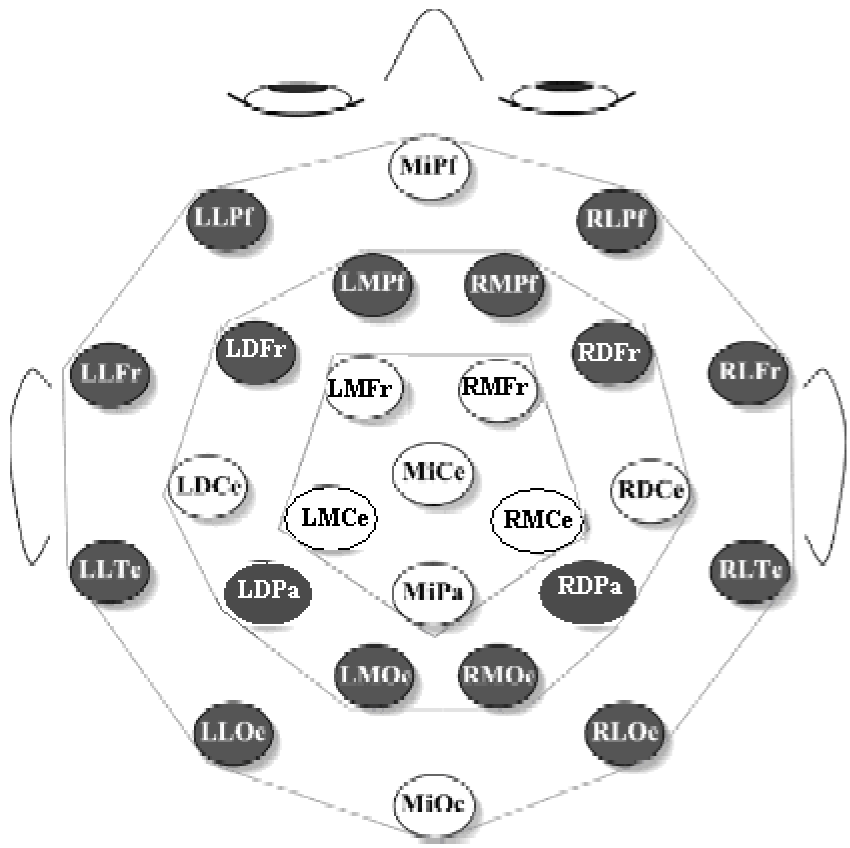
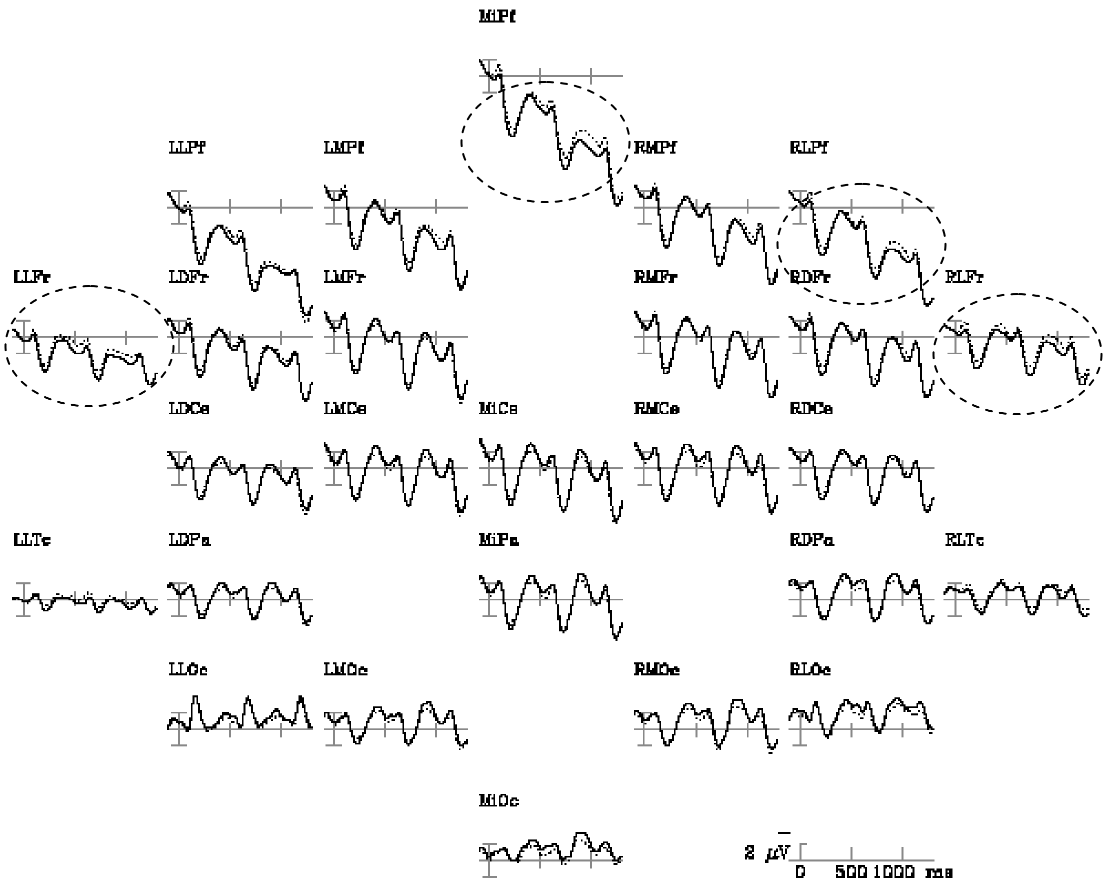


Figure 4-12 Configuration of electrodes included in statistical analysis
(layout adopted from Cowles, 2003)

4.4.4 Results

4.4.4.1 Relative Clause Region

Visual inspection of the data at W2 (SR: *publisher*-ACC; OR: *publisher*-NOM) revealed that ORs (*publisher*-NOM) showed a widespread frontal negativity, particularly at lateral electrodes, in comparison to the SR (*publisher*-ACC) condition. This effect continued throughout the response to W3, 'secretly'. Figure 4-13 shows ERP responses from W2 (*publisher*-ACC/NOM) to W4 (*politically*).



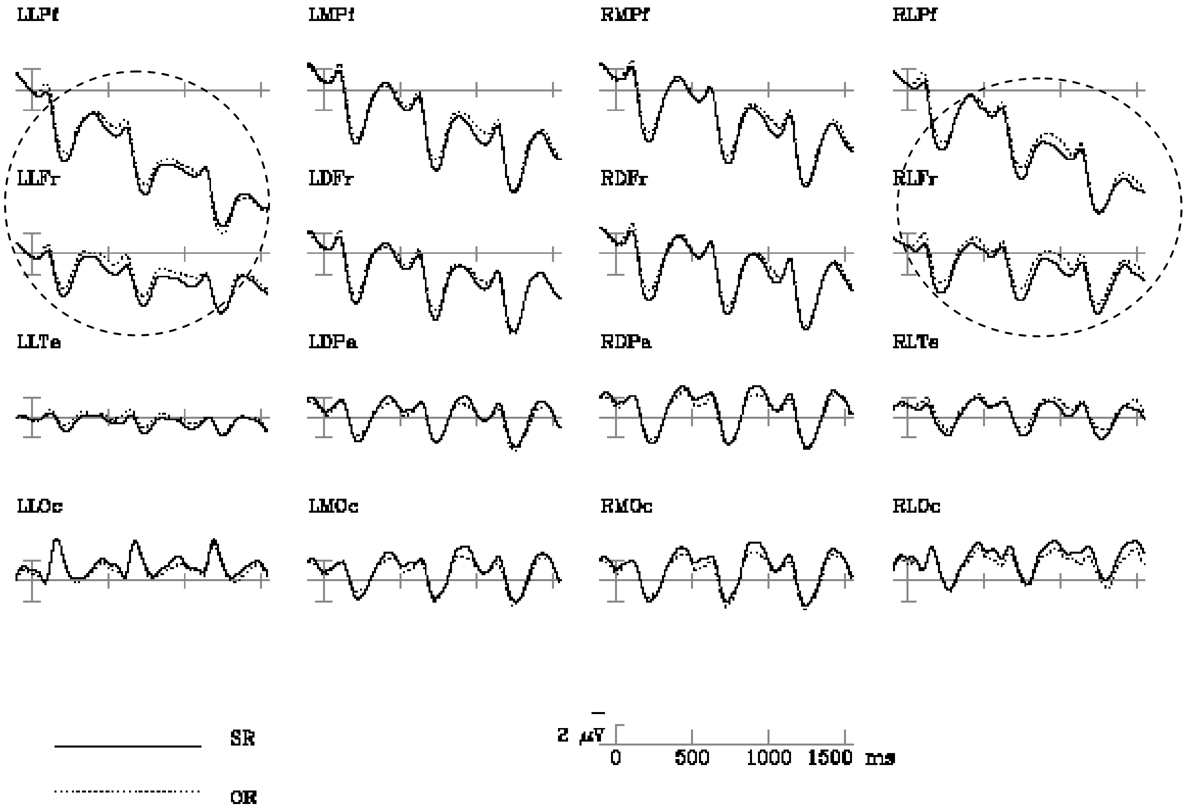
SR: publisher-ACC secretely politically

OR: publisher-NOM secretely politically

[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo	iyongha-n]
newspaper-GEN	publisher-ACC/NOM	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

Figure 4-13 Grand average ERP waveforms for SRs and ORs shown at all 26 electrodes sites



[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo	iyongha-n]
newspaper-GEN	publisher-ACC/NOM	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

Figure 4-14 Exp 4.3, Words 2, 3 and 4

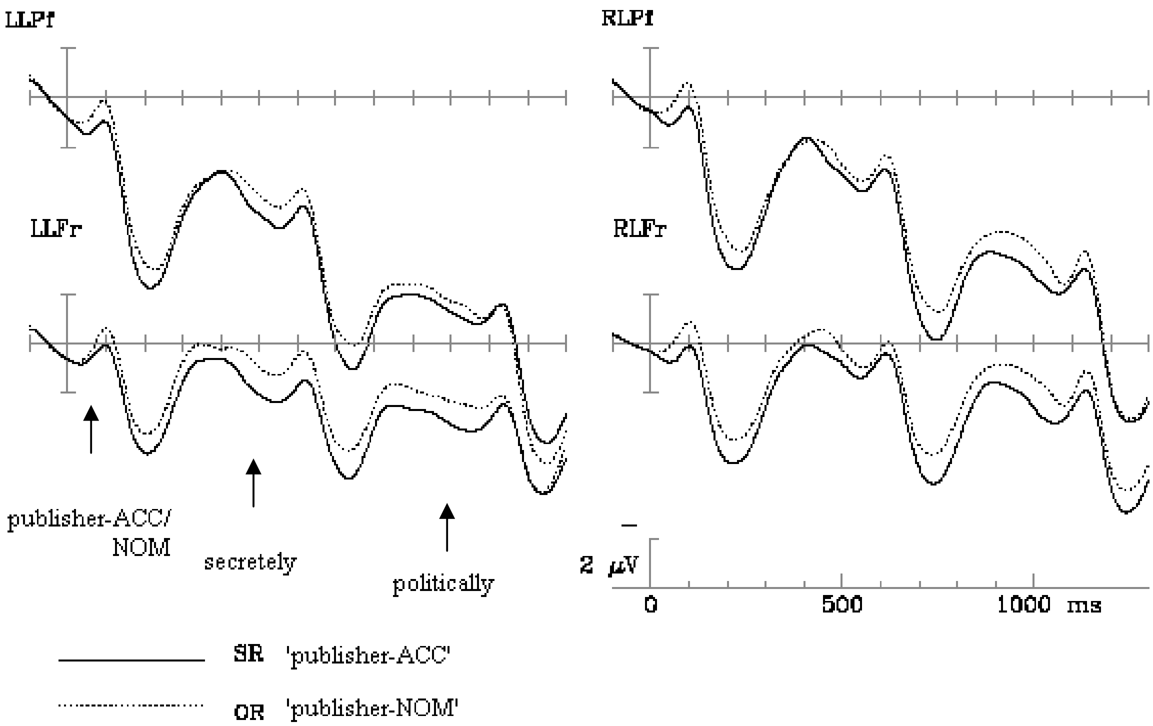


Figure 4-15 Exp 4.3, Words 2, 3, and 4, frontal region

To corroborate apparent early effects, mean voltage measures were taken in the N1 (80 to 120 ms) and P2 (150 to 250 ms) latency windows. These measures were subjected to both full and distributional omnibus ANOVA analyses. In the analysis of the 80 to 120 ms interval, there was no significant effect either in the full analysis (gap type x 26 electrodes) [$F(1,21) = 1.23$, $p < .3$] or in the distributional analysis (gap type x hemisphere x laterality x anteriority; see Figure 4-12 for included electrodes) (all $Fs < 2.5$). Since the effect around N1 was relatively small yet pronounced in the frontal lateral region, further statistical analyses were performed on the four regions of electrodes (see Section 4.4.3.5 for details). There was a marginal main effect of gap type in the frontal lateral region [$F(1,21) = 3.14$, $p < .09$]. This suggests that the OR condition (NP-NOM) began to elicit very early frontal negativity in lateral regions over both the right and left hemispheres. Moreover, in the omnibus ANOVA (gap type x hemisphere x laterality x anteriority) of the 150 to 250 ms interval, there was a significant main effect of gap type both in the full analysis [$F(1,21) = 5.14$, $p < .04$] and the distributional analysis [$F(1,21) = 5.83$, $p < .03$]. Additionally, to quantify the late effect, an analysis was conducted in the time window of 300 to 1100 ms, from the second half of *publisher*-NOM/ACC to 100 ms after *secretly.* In the full analysis, there was a significant interaction of gap type and electrodes [$F(25,525) = 3.05$, $p < .001$], and in the distributional analysis, there was a significant interaction of gap type and anteriority [$F(3,63) = 5.16$, $p < .03$]. There were no other significant results (all Fs < 1.6). These effects indicated that ORs elicited more negativity than SRs particularly at anterior regions. Marginal effects in the N1-P2 time window for the frontal lateral region indicated that this negativity to ORs tended to onset early, and significant interactions in the later time window of 300 to 1100 ms indicated that the anterior negativity became more pronounced as the epoch progressed.

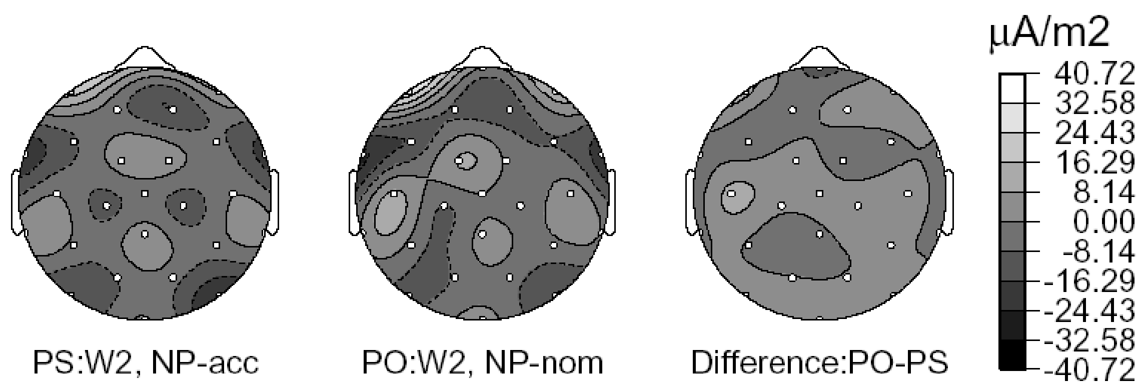


Figure 4-16 Exp 4.3, Isovoltage map at W2

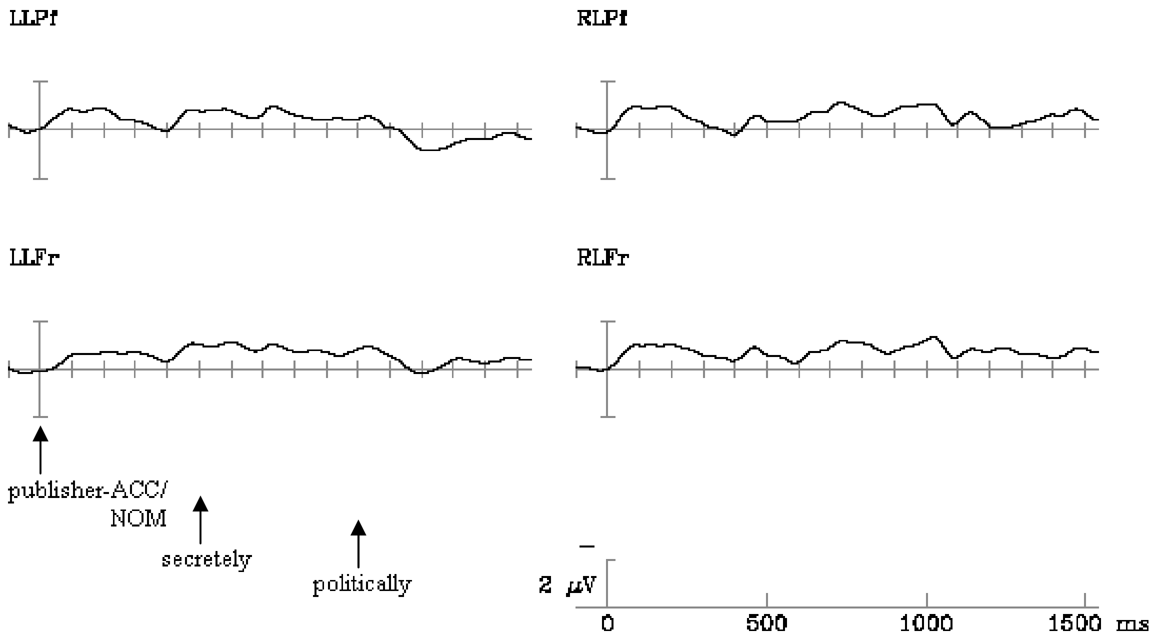
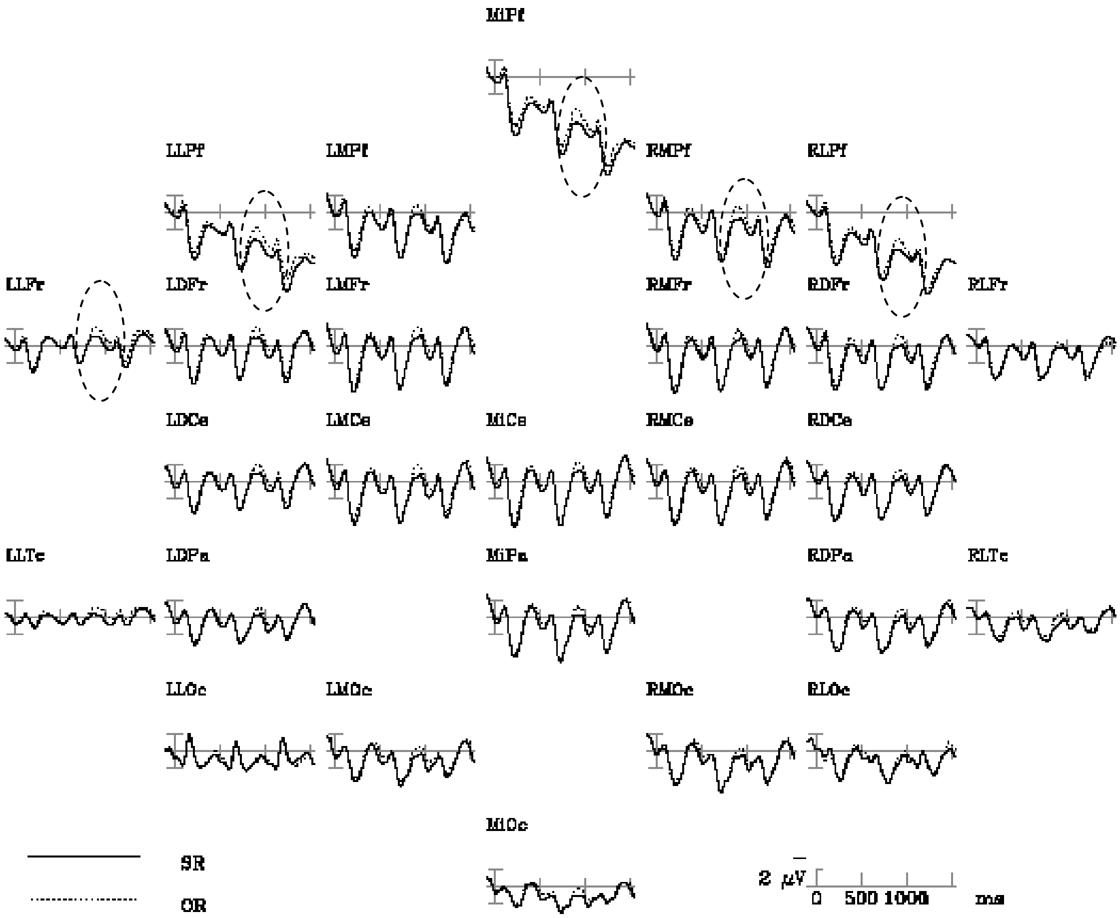


Figure 4-17 Exp 4.3, Difference waves (OR-SR) at Words 2, 3, and 4, frontal region

4.4.4.2 Main Clause Region

Head noun region

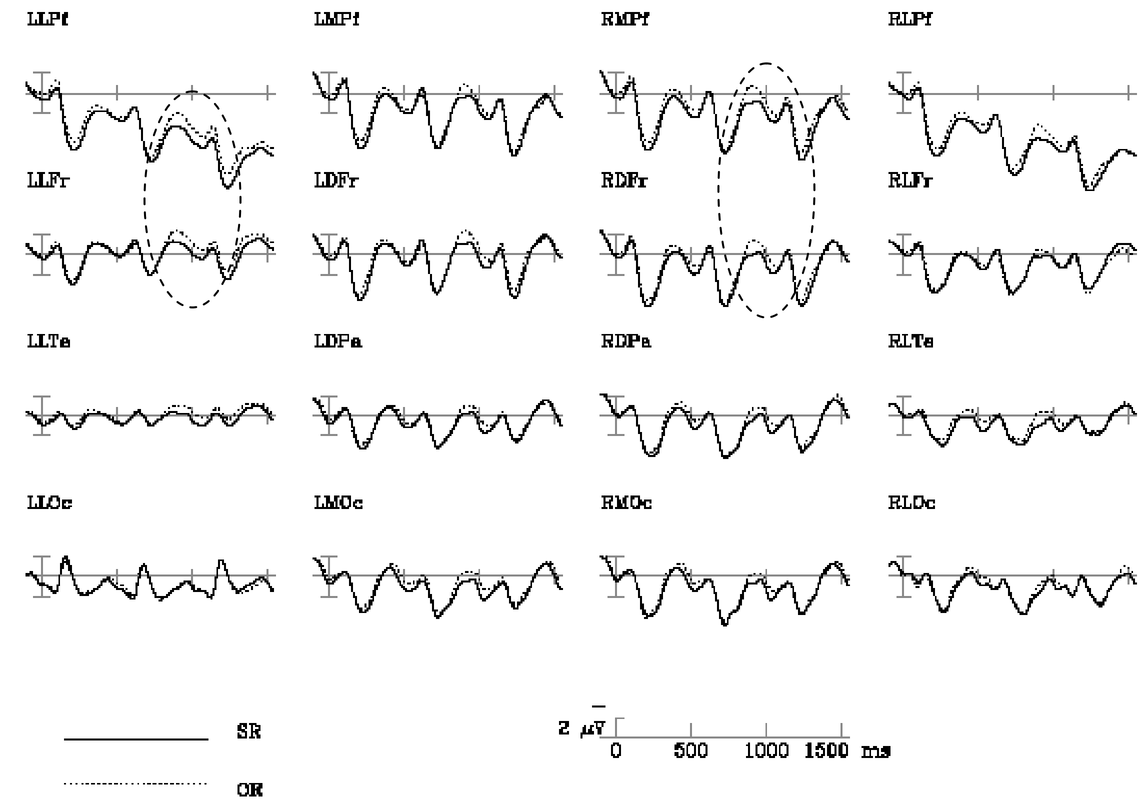
Visual inspection of the waveforms in response to the embedded verb and the following two words showed that the OR condition elicited a negative potential in comparison to the SR condition. The effect started approximately 300 ms post-stimulus onset of the embedded verb, but is clearly visible approximately 800 ms post-stimulus onset (i.e., 300 ms after the onset of the head noun) and lasted throughout the next word. It appeared larger over frontal sites (LLPf, RMPf, RLPf, MIPf and LLFr).



[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo
newspaper-GEN	publisher-ACC/NOM	secretly	political-with

iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
exploit-REL	senator-GEN	office-to	gang-NOM	attacked

Figure 4-18 Exp 4.3, Words 5, 6 and 7, 26 electrodes



[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo
newspaper-GEN	publisher-ACC/NOM	secretly	political-with

iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
exploit-REL	senator-GEN	office-to	gang-NOM	attacked

Figure 4-19 Exp 4.3, Words 5, 6 and 7

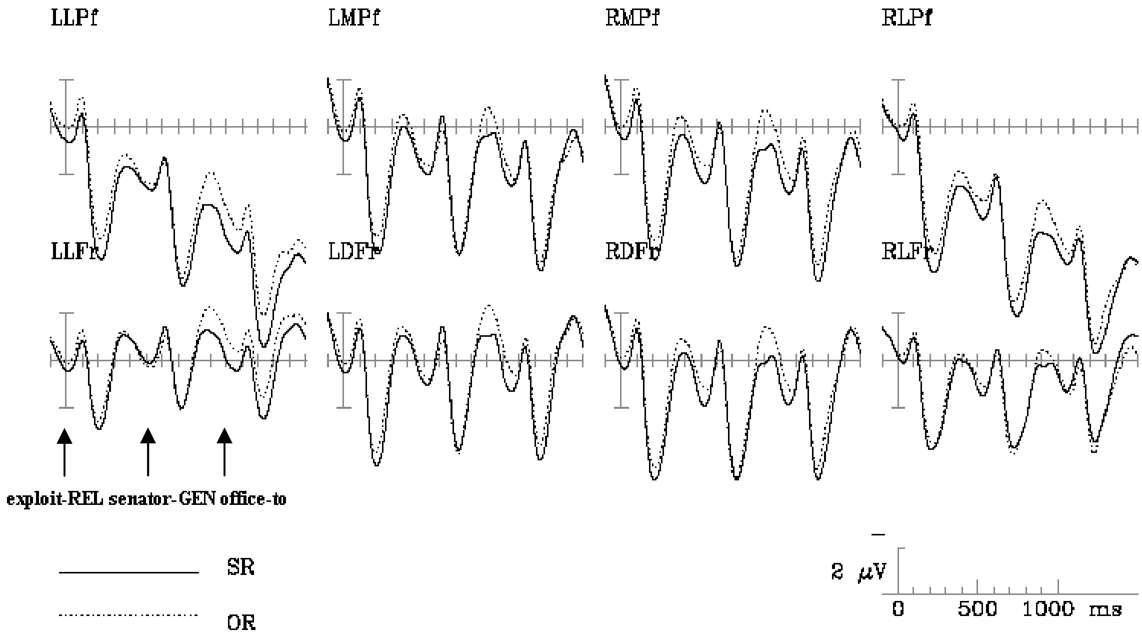


Figure 4-20 Exp 4.3, Words 5, 6, and 7, frontal region

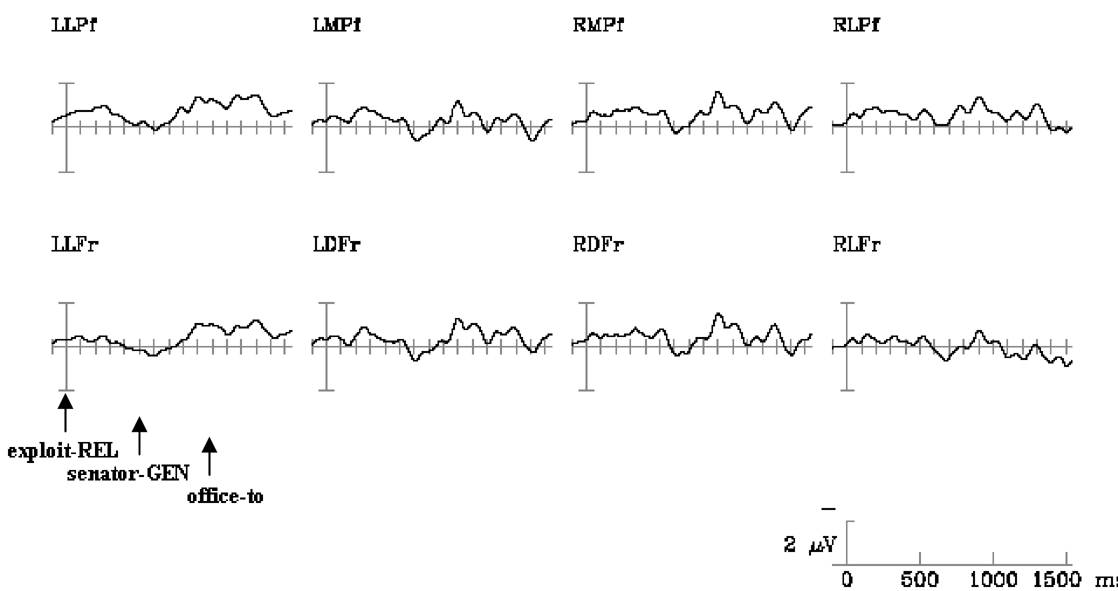


Figure 4-21 Exp 4.3, Difference waves (OR-SR) at Words 5, 6, 7, frontal region

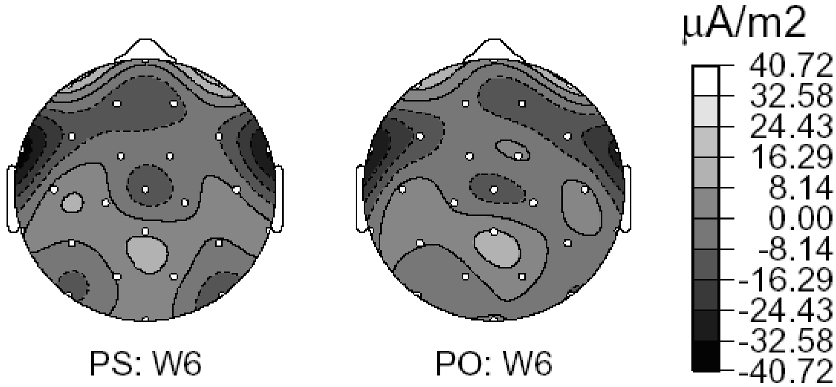


Figure 4-22 Exp 4.3, Isovoltage map, W6 (head noun)

In the distributional analysis on mean amplitude measurements between 300 and 600 ms post-stimulus onset of exploit-REL, there was a marginal main effect of gap type [F(1, 21) = 3.37, p < .08]. On the other hand, in the window of 800 and 1100 ms post-stimulus onset of exploit-REL (i.e., 300 to 600 ms post-stimulus onset of the head noun *senator-GEN*), there were a main effect of gap type [F(1,21) = 8.36, p < .01] in the full analysis and a significant main effect of gap type [F(1,21) = 8.87, p < .01] and a marginal interaction of gap type, hemisphere, laterality and anteriority [F(3,63) = 2.43, p < .07] in the distributional analysis. These effects were due to the more pronounced negativity to ORs compared to SRs, particularly in the left-lateral and right-medial sites in the anterior region. Other effects were not significant (all Fs < 1).

Main clause verb region

[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo
newspaper-GEN	publisher-ACC/NOM	secretly	political-with

iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
exploit-REL	senator-GEN	office-to	gang-NOM	attacked

There was no effect related to gap type in this region. SRs and ORs were not significantly different from each other in any time window.

4.4.5 Discussion

The goal of this ERP experiment was to investigate to what extent the cognitive/neural processes underlying the processing of post-nominal relative clauses (i.e., with the head noun preceding the modifying relative clause), as in English, are similar to those underlying the processing of pre-nominal relative clauses (i.e., with a relative clause preceding its head noun), as in Korean.

In fact, overall, Korean relative clauses elicited ERP effects quite similar to those elicited by English relatives (King & Kutas, 1995). As in English, ORs elicited a negative potential with an anterior maximum in comparison to SRs within the relative clause region. In the main clause region, Korean ORs elicited a negative potential with an anterior maximum, an effect similar to the finding in English relatives (i.e., a phasic LAN effect).

Table 4-21 Summary of results

anterior slow negative potential to ORs

[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo
newspaper-GEN	publisher-ACC/NOM	secretly	political-with

iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
exploit-REL	senator-GEN	office-to	gang-NOM	attacked

anterior negativity to ORs

PS: 'Gangs attacked the senator's office who secretly took advantage of the publisher of the newspaper for the political purpose'

PO: 'Gangs attacked the senator's office who the publisher of the newspaper secretly took advantage of for the political purpose'

These remarkably similar ERP responses to Korean and English relatives will be discussed in terms of both different and similar underlying cognitive processes.

4.4.5.1 Effects within the Relative Clause

It was predicted that SRs (*publisher-ACC*) would elicit an anterior negativity due to the processing difficulty associated with the sentence-initial non-canonical NP-ACC. However, the results showed that it was instead ORs (*publisher-NOM*) that elicited a sustained negativity. This effect is puzzling for the following reasons. First, ORs start with NP-NOM, instantiating a seemingly canonical sentence that begins with the subject. Second, although there was a tendency for ORs (NP-NOM) (1233 ms) to take longer to read than SRs (NP-ACC) (1136 ms) at the NP-ACC/NOM position in the reading time experiment (Experiment 4.1), this difference did not reach statistical significance, while the reversed reading time patterns at the next words (i.e., longer reading times for SRs than ORs) did reach significance (see Figure 4-5). Third, previous ERP experiments in German have shown that clauses starting with non-canonical objects elicit a LAN or a widespread negativity in comparison to clauses starting with the canonical subject (Schlesewsky et al., 2003; Rösler et al., 1998; Matzke et al., 2002). Given these factors, the slow potential with an anterior maximum in response to ORs within the relative clause region is surprising and needs to be accounted for.

Before discussing the significance of this effect further, it is important to check whether it is an artifact related to sentence-initial voltage drift. Due to methodological constraints, participants are requested not to blink or move during the presentation of stimuli. Although they were given a three-second period after every sentence during which they could blink, certain participants had trouble getting ready for the next sentence on time. For this reason, the sentence-initial position is typically avoided for critical words in the design of language ERP experiments. In the current experiment, the critical NP-ACC/NOM was presented as the second word to minimize any potential confound related to the sentence-initial position. Moreover, examination of the ERP response to the first word in SRs and ORs revealed that there was no difference between the two conditions at that point. It was only after the presentation of NP-ACC/NOM that the two conditions started to diverge, as shown in Figure 4-23.

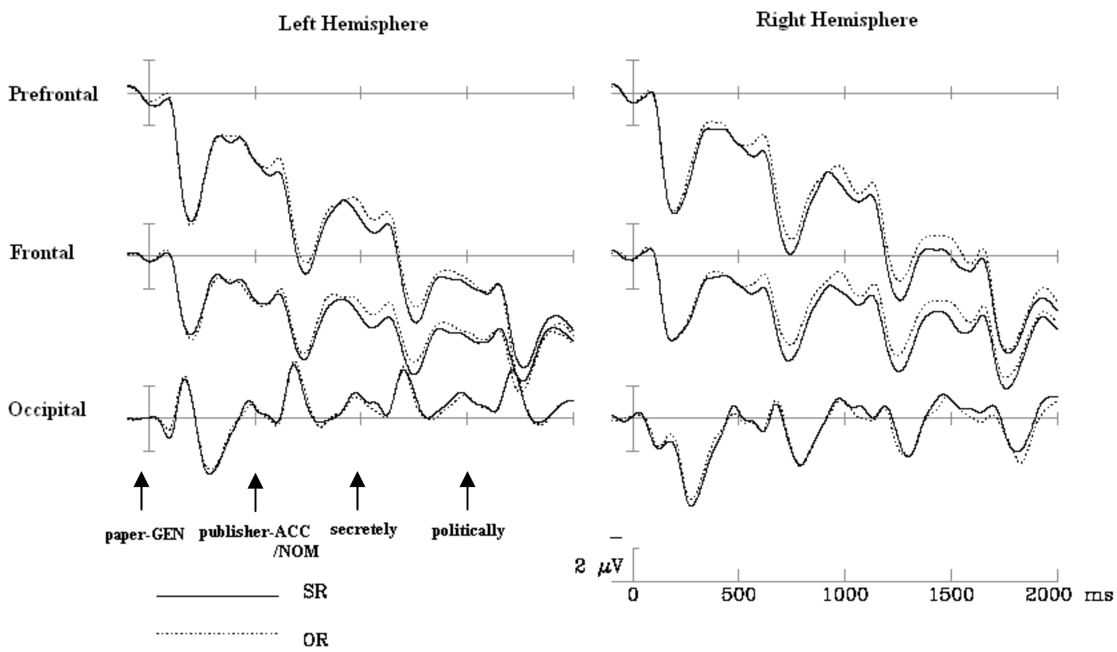


Figure 4-23 Exp 4.3, Words 1, 2, 3, 4

Thus, the response to ORs at W2 does not seem to be an artifact.

In terms of latency and scalp distribution, the continuous negativity appears similar to the left anterior negativity (LAN) (Kluender & Kutas, 1993a, 1993b). In general, the distribution of slow potential effects has varied across studies. For example, Kluender and Münte (1998) reported a left anterior maximum while Müller et al. (1997) reported a right anterior maximum. On the other hand, in Münte et al. (1997), the effect exhibited a symmetric centroparietal maximum. The effects in the current experiment showed a symmetrical anterior maximum as in King and Kutas' (1995) study of English relative clauses and Ueno and Kluender's (2003) study of Japanese scrambling. Thus, despite the variability in distribution across studies, it seems that the slow potential effects to ORs at W2 show compatible latency and scalp distribution with previous studies.

Now, returning to the question of what could be responsible for the anterior negative response to NP-NOM (OR) in comparison to NP-ACC (SR), I first address the issues related to the apparent (marginal) effect of very early negativity. The ELAN is typically associated with a word category violation, when the incoming word is not compatible with the word category required to complete a phrase structure (Friederici, 2002). For example, in an ERP study of Japanese, when a genitive marked NP was followed by a verb instead of a required noun, an effect of early negativity was observed (Müeller et al., 2005: *two NP-GEN **jump** over vs. two NP-GEN cat-ACC **jump** over). However, ELAN is not elicited in response to a less frequent but syntactically legal structure, even when this structure is strongly dispreferred. For example, Ainsworth-Darnell et al. (1998) compared '*Jill entrusted the recipe to **friends** before...'* with '*Jill entrusted the recipe **friends** before...*' but did not elicit an ELAN in response to *friends* in the second sentence. The absence of the ELAN was attributed to the possibility that the sentence can still turn out to be legal, as in '*Jill entrusted the recipe **friends** liked...*'

The current experiment, however, does not involve any word category violation. In both SRs and ORs, the first word is a genitive-marked NP. This NP-GEN needs to be followed by a noun, as it was in both conditions (i.e., SR: NP-GEN NP-ACC; OR: NP-GEN NP-NOM). Therefore, this cannot be a word category violation. The only difference between SRs and ORs is the case marker of the second noun. Nominative-marked NPs simply signal that the current noun phrase is likely to serve as a subject, while accusative-marked NPs signal that the current NP serves as an object. Otherwise, these NPs conform perfectly to Korean phrase structure. Thus, the effect does not seem to be related to word category or phrase structural violations.

Instead, the response to ORs (NP-NOM) could be due to the heavy noun phrases used in the stimulus materials (i.e., *newspaper-GEN publisher-NOM/ACC*, 'a publisher of a newspaper'). As mentioned before, in order to avoid the critical word occurring as the first word, the design used a genitive-marked NP as the first word preceding NP-ACC/NOM. Thus, the OR condition has 'NP-GEN NP-NOM' as W1 and W2 while SR has 'NP-GEN NP-ACC' as its W1 and W2. These phrases served as a sentence-initial subject and object in ORs and SRs, respectively. The question is whether a heavy subject is more difficult to process than a heavy object. Corpus results, however, suggest otherwise. A written corpus with 491,910 *ejels* from the Seyjong corpus (2002) was examined to investigate the frequency of heavy subjects and objects in sentence-initial position. It turned out that there were numerically more heavy subjects with more than one lexical item (1,741 occurrences) than heavy objects (1,542 occurrences). This suggests that, at least in terms of frequency, NP-GEN NP-ACC (SR) should have been more difficult or equally difficult to process compared to NP-GEN NP-NOM (OR). Thus, the anterior negativity to OR does not seem to be related to the processing difficulty of the heavy nominative-marked subject.

Alternatively, the ERP response to ORs (NP-NOM) could be related to the processing difficulty associated with a nominative-marked NP. A processing difficulty has been repeatedly attested when there is a single nominative marked NP, as well as when there is a sequence of nominative marked NPs (i.e., NP-NOM NP-NOM) (Korean: Kim, 1999; Kwon, 2008; Japanese: Inoue, 1991; Miyamoto, 2002; Yamashita, 1997). That is, nominative-marked NPs seem to be more salient than NPs with other case markers (Miyamoto, 2002). However, the sources of this difficulty have not been clearly identified.

Miyamoto (2002) accounts for these effects in terms of a clause boundary effect. That is, when there are multiple occurrences of nominative-marked NPs, the second nominative marker signals to the parser that it should posit a clause boundary at the second NP-NOM, and this causes processing difficulty. In the case of a single occurrence of a nominative-marked NP, Miyamoto suggests that the nominative-marked NP signals an inflection-related node with tense (an IP node in Government and Binding theory), and "*provides a fixed point around which other NPs in the sentence can be interpreted*" (Miyamoto, 2002: 340) (cf. pivot: Foley & Van Valin, 1984; relational figure (clause-level trajector): Langacker, 1991; sentence topic: Reinhart, 1982). In terms of the current experiment, this means that the anterior negativity in response to ORs is due to the processing costs related to projecting an inflection-related node at NP-NOM in ORs. Although this account seems to be compatible with the current experimental results, it is not without problems. First, it is not clear why an inflection-related node is not projected based on any other sentential arguments (e.g., a sentence-initial topic marked NP or an accusative-marked NP), given that the parser is predictive (Altman & Kamide, 1999; Kamide et al., 2003) and other sentential arguments also require an inflection-related node. Moreover, the consequence of this argument becomes serious when considering the frequent occurrence of subject drop in both Korean and Japanese. For example, in Korean, a corpus study shows that 70% of subjects are dropped in speaking (Kim, 2000). This means that in parsing these 70% subject-less clauses, the parser will delay the projection of an inflection-related node until the arrival of the clause-final verb. However, there have been many studies showing that the parser immediately projects a structure with an underspecified head (i.e., projecting a syntactic head despite the lack of exact lexical and argument structure information) cued by local information (Sturt & Crocker, 1996; Konieczny, 1996; Yamashita, 1994; Miyamoto, 2002; cf. Pritchett, 1991). Given this, a delay in the projection of an IP node in the absence of a nominative-marked NP does not seem plausible. Therefore, even though it is clear that a nominative-marked NP signals to the parser that an inflection node needs to be projected, other arguments should also be able to trigger the projection of an inflection node. Thus, the anterior negativity to NP-NOM in ORS in comparison to NP-ACC in SRs does not seem to be due to processing difficulty associated with the projection of an inflection-related node.

Alternatively, the processing difficulty associated with a nominative-marked NP could be due to the ambiguity of the thematic role. Accusative markers in Korean unambiguously signal the theme/patient role (e.g., *Yenguy* in (4.83)). On the other hand, the nominative marker is ambiguous. Although it typically marks agent (e.g., *Yenguy* in (4.84)), it can also mark experiencer (e.g., *Yenguy* in (4.84)) and theme (e.g., *paym* 'snake' in (4.85)), and this ambiguity is not resolved until the clause-final verb.

(4.83) *pro* Yenghuy-lul ttayly-ess-ta
Y-ACC hit-PST-DECL
'(Someone) hit Yenghuy.

(4.84) Yenghuy-ka hakkyo-ey ka-n-ta
Y-NOM school-to go-PRES-DECL
'Yenghuy goes to school.'

(4.85) Yenghuy-ka paym-i mwusep-ta
Y-NOM snake-NOM is.scared.of-DECL
'Yenghuy is scared of a snake.'

In relation to the thematic ambiguity of the nominative marker, there are two possible interpretations for the processing difficulty of nominative marked NP in ORs. First is that this ambiguity in NP-NOM (OR) could have caused a delay in thematic role assignment, while thematic role assignment was immediate in the case of an unambiguous NP-ACC (SR). Since holding NP-NOM (OR) without a thematic role in working memory requires extra working memory resources (Gibson, 1990), this could have caused a LAN effect in response to the ORs as it did in English (King & Kutas, 1995). However, this hypothesis does not seem plausible given the abundant experimental evidence that the parser is incremental. That is, despite this ambiguity, the parser immediately assigns a thematic role, which leads to processing difficulty when a reanalysis is necessary (garden path effects: Frazier & Rayner, 1982).

The second possibility is that although the parser would immediately assign a thematic role to the thematically ambiguous NP (NP-NOM), the processing of ambiguous NPs is more costly to working memory than the processing of unambiguous NPs (NP-ACC). However, previous ERP studies found a slight increase in negativity over central sites in response to ambiguous NPs compared to unambiguous NPs (Hopf, Bayer, Bader, & Meng, 1998).[17] Given this, the anterior negativity to OR does not seem to be attributable to the processing difficulty associated with NPs with thematic role ambiguity.

On the other hand, this effect could be due to the discourse function that is associated with the subject and nominative marker. Subjects often serve as a sentential topic (Givón, 1976; Keenan, 1987; Langacker, 1991; Reinhart, 1982), and thus they are often old information, and tend to be dropped (Kim, 2000). When they occur despite

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[17] In their experiment, this effect did not reach significance.

being old information, they tend to be marked with a topic marker (Choi, 1997). Thus, when the subject does occur with a nominative marker, which typically encodes new information in Korean (Choi, 1997), this would trigger the reader to pay extra attention to the subject. This seems plausible, given the importance of the subject in the clause. That is, the remaining part of the sentence predicates over the subject (cf. Reinhart, 1982), and successful processing of the subject-predication relation might require the subject to be more deeply processed than any other arguments, which could lead to extra working memory demands in ORs (NP-NOM) (cf. for processing difficulty of complex subjects in English, see Kluender, 2004).

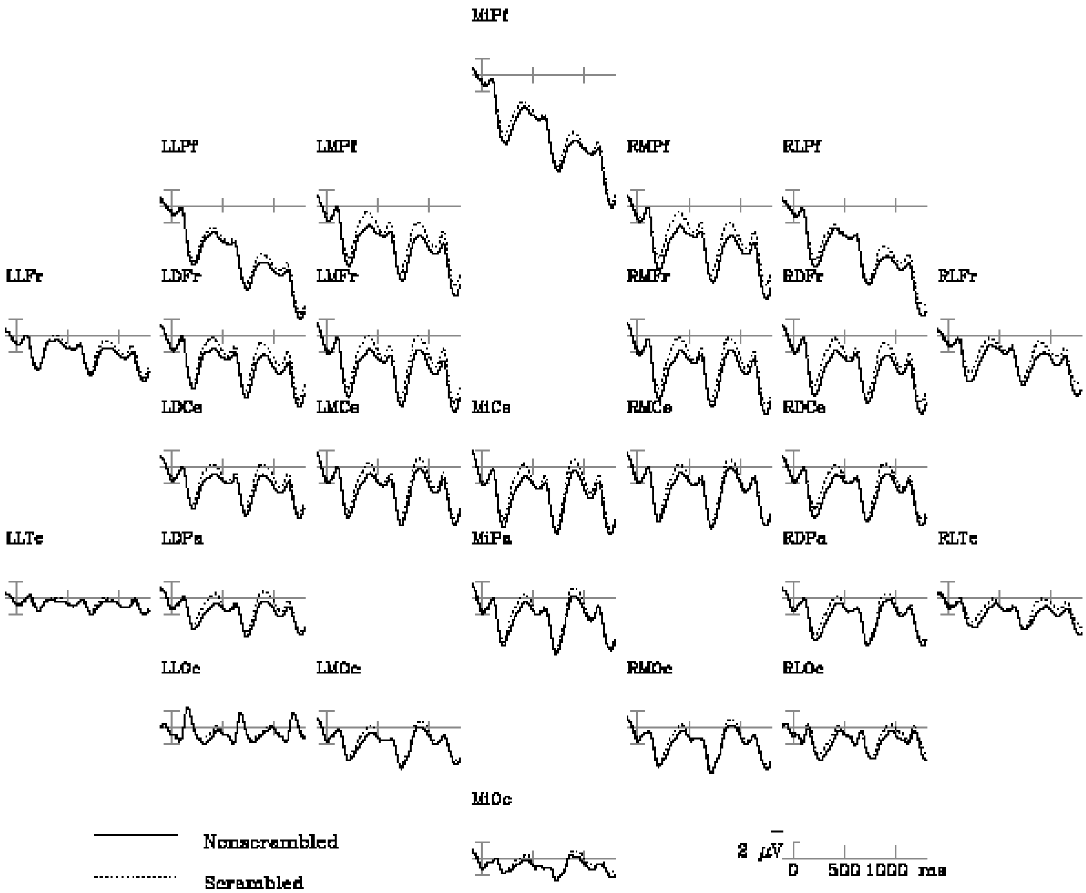
I next turn to the question of why there is no ERP effect corresponding to the slow-down in response to SRs within the relative clause region, as in Experiment 4.1 (see Ueno & Garnsey, 2008 for a comparable result in Japanese). One possibility is that non-canonical word order does not elicit processing difficulty. However, slower reading times to SRs (i.e., sentences starting with a non-canonical object) within the relative clause region suggest otherwise. Additionally, since this effect of a slow-down in the relative clause region of SRs was consistently observed in various studies (Experiment 4.1; Ueno & Garnsey, 2008; Miyamoto & Nakamura, 2003), it does not seem to be an artifact. Alternatively, it could be possible that the ERP response to the NP-NOM (ORs) condition described above overrode brain responses to the non-canonical word order (SRs) in the ERP measurements. This hypothesis is supported by the reading time patterns. In the reading time experiment, the slow-down in ORs (i.e., sentences starting with NP-NOM) was observed at the sentence-initial NP-NOM/ACC, even though the effect did not turn out to be significant. On the other hand, although the slower reading times to SRs (NP-ACC) in comparison to ORs (NP-NOM) were observed one word later, the effect looks like a spill-over effect from the previous word position (NP-ACC) (see Figure 4-5). What this means is that the response to non-canonical word order (SR) starts at the sentence-initial NP-ACC, but the response to the nominative-marked NP (OR) could have overridden the difficulty associated with non-canonical word order (SR) in the ERP measurements.

Overall, the ERP responses to the relative clause region in Korean were remarkably similar to effects seen in English. Both Korean and English relative clause regions elicit a symmetrical continuous anterior negativity in response to ORs compared to SRs. However, as discussed, different cognitive processes underlie these related effects. In English, the anterior negativity is attributed to holding a filler (or incomplete dependency) in working memory in expectation of unambiguous thematic role assignment (or a gap position); in Korean, there was no evidence for the processing difficulty associated with "holding a gap in working memory in an expectation of a filler". If so, SRs should have elicited greater anterior negativity, due to the longer filler-gap distance in SRs than in ORs. Instead, in Korean, the effect is attributed to a higher working memory load associated with processing a nominative-marked NP.

4.4.5.2 Effects within the Main Clause

The results revealed that in the main clause region, the head noun in ORs elicited anterior negativity in comparison to SRs. The effect started approximately 300 ms after the onset of the embedded verb and became clearly visible approximately 300 ms after the onset of the head noun. Although the effect was visible in all the electrodes, visual inspection and the statistical analysis support anterior predominance over both hemispheres. Overall, the latency and distribution is compatible with the (left) anterior negativity reported in previous ERP literature (Felser et al., 2003; Fiebach et al., 2002; King & Kutas, 1995; Kluender & Kutas, 1993a, 1993b; Phillips et al., 2005; Ueno & Kluender, 2003a; Ueno & Garnsey, 2008).

More importantly, the anterior negativity to ORs in comparison to SRs (Figure 4-18) closely resembles the typical (L)AN effect elicited by scrambled sentences with filler-gap dependencies (Figure 4-24). That is, as previously mentioned, since there were no previously reported ERP experiments in Korean, unscrambled sentences and their scrambled counterparts, where a direct object is fronted to the beginning of the sentence, were chosen as filler sentences so that a typical LAN effect could be obtained to which the experimental results could be compared. The results showed that scrambled sentences elicited symmetrical negativity with an anterior maximum relative to unscrambled sentences, as in Ueno and Kluender's (2003) study of Japanese scrambling. This effect appears similar to the effect to ORs in its distribution and latency, such that the negativity is visible approximately 400 ms post stimulus onset of the main clause subject NP-NOM and shows a symmetrical anterior maximum, as confirmed in the distributional analysis, with significant interactions of gap type, laterality and anteriority [$F(3,63) = 5.26$, $p < .0124$] and of gap type, hemisphere, laterality and anteriority [$F(3,63) = 3.61$, $p < .0183$]. Thus the results suggest that despite different filler-gap ordering, filler-gap association in Korean relative clauses elicit (L)AN, similar to English relative clauses (King & Kutas, 1995) and Japanese (Ueno & Kluender, 2003) and Korean scrambling sentences.



Unscrambled sentence

ku	yuchiwon-uy	woncang-i	hakwon-uy	nyencwung	hayngsa-ey
that	kindergarten-GEN	principal-NOM	school-GEN	annual	event-to

hakpwumotul-ul	chotayhay-ss-ta
parents-ACC	invite-PST-DECL

‘The principal of the kindergarten invited the parents to the annual school event’

Scrambled sentence

hakpwumotul$_i$-ul	ku	yuchiwon-uy	woncang-i	hakwon-uy
parents-ACC	that	kindergarten-GEN	principal-NOM	school-GEN

nyencwung	hayngsa-ey	___$_i$	chotayhay-ss-ta
annual	event-to		invite-PST-DECL

‘The principal of the kindergarten invited the parents to the annual school event’

Figure 4-24 LAN filler sentences: NP-NOM at W3 (unscrambled) and at W4 (scrambled sentence)

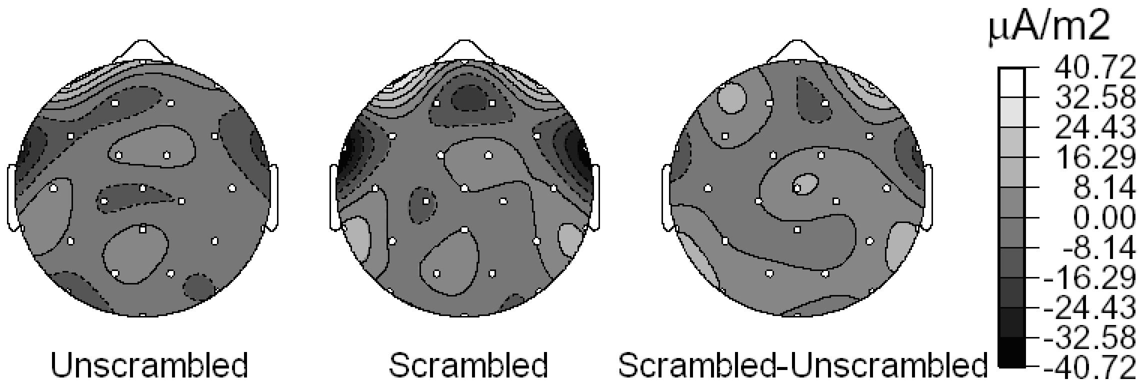


Figure 4-25 Isovoltage map at W3 (unscrambled) and W4 (scrambled) (LAN filler sentences)

The results are partially compatible with the predictions in Section 4.4.1. It was predicted that if the longer reading times for ORs in Experiments 4.1 and 4.2 were due to the parser's efforts to search for a gap through memory to assign to a filler, a LAN would be elicited in response to ORs. On the other hand, if the longer reading times for ORs were due to filler-gap integration, a P600 was predicted to be elicited in response to ORs. The presence of the anterior negativity but the absence of the P600 suggest that the effect at the head noun position is related to the working memory costs associated with gap retrieval for filler-gap association. That is, in Korean, the adnominal marker attached to the embedded verb signals that the current clause modifies the following noun. At the next word position, the head noun, the gap is retrieved and associated with its filler both in SRs and ORs. This gap retrieval for filler-gap association could require more working memory resources in ORs than in SRs, possibly due to higher linguistic complexity associated with object gaps than subject gaps as defined in terms of the *accessibility hierarchy* and/or *phrase-structural distance*.

However, it is also possible to account for the anterior negativity in Korean ORs in terms of incremental and predictive parsing (Sturt & Crocker, 1996; Konieczny, 1996;

Yamashita, 1994; Miyamoto, 2002; Altman & Kamide, 1999; Kamide et al., 2003; cf. Pritchett, 1991). Recent work has elaborated on the role of anticipation in sentence comprehension (Konieczny, 2000; Levy, 2008; Vasishth & Lewis, 2006). That is, although in terms of memory constraints (*dependency locality theory*; Gibson, 2000), processing difficulty is proportional to the linear distance between two linguistic elements (i.e., a locality effect), in terms of anticipation, earlier cues will enhance processing, suggesting that processing difficulty is inversely related to the linear distance between the cues and the expected elements (i.e., an anti-locality effect). Applying this notion to the processing of Korean relative clauses, assuming that parsing is incremental and predictive, the non-canonical sentence-initial NP-ACC in SRs will signal a missing subject, and accordingly a subject gap will be postulated at that position. In addition, the accusative marker of the sentence-initial NP would also signal that the incoming clause has a transitive verb, and accordingly, a transitive structure would be projected at the sentence-initial position, even before the arrival of the verb (cf. Kamide et al., 2003). Thus, in SRs, the transitive verb at the embedded verb position will be processed readily, and the parser only needs to revise the structure from mono-clausal to bi-clausal, as cued by the adnominal marker attached to the verb.

On the other hand, in ORs, there are no comparable cues to the representation of the structure until the embedded verb position. At the sentence initial NP-NOM, the parser will postulate an intransitive structure in accordance with *minimal attachment* (Frazier, 1978). It is at the embedded verb that the parser needs to postulate an object gap, project a transitive structure cued by the transitive verb at this position, and revise the structure from mono- to bi-clausal. Thus, due to the absence of cues, processing at the embedded verb could be difficult in ORs, as supported by the marginal gap type effect at this word position both in the self-paced reading time experiment (see section 4.2.4.2 for details) and the ERP experiment. At the next head noun position, gaps in both SRs and ORs will be co-indexed with the head nouns. These are schematically presented in (4.86).

(4.86) Hypothesized thematic role assignment within the relative clause region

subject gap postulation, projecting a transitive structure

mono- to bi-clausal reanalysis

SR

[sinmwunsa-uy	sacang-**ul**	pimilliey	cengchicek-ulo	iyongha-**n**]
newspaper-GEN	publisher-**ACC**	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

gap-filler association

'Gangs attacked the senator's office [(who) secretly took advantage of the publisher of the newspaper for political purposes]'

object gap postulation, projecting a transitive structure, mono- to bi-clausal reanalysis

OR

[sinmwunsa-uy	sacang-i	pimilliey	cengchicek-ulo	iyongha-**n**]
newspaper-GEN	publisher-NOM	secretly	political-with	exploit-REL

uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
senator-GEN	office-to	gang-NOM	attacked

gap-filler association

'Gangs attacked the senator's office [(who) the publisher of the newspaper secretly took advantage of for political purposes]'

This suggests that at the head noun, ORs could be more difficult to process, possibly because of the multiple processes occurring approximately at the same time (i.e., gap postulation, projecting a transitive construction, structural reanalysis from a mono-clausal structure to a bi-clausal structure and gap-filler association), in contrast to SRs, where some of these processes are already complete in the early relative clause region (i.e., gap postulation and projecting of transitive construction). Accordingly, although there was no ERP response to SRs associated with gap postulation and projection of a transitive structure early within the relative clause, possibly because such responses were overridden by the response to the nominative-marked NP, as discussed in the preceding section, these multiple processes around the head noun position could have caused an extra working memory load for filler-gap association in ORs, as indexed by anterior negativity in the ERP experiment and higher reading times in the reading time experiment. Yet, since ERP effect at the embedded verb position itself is only marginally significant (although there is a slight slowdown to ORs in the reading time experiment that is marginally significant in the items analysis), this interpretation needs to be further tested.

These interpretations suggest that the similar ERP effects in the main clause region in Korean (i.e., at the head noun) and English relatives (i.e., at the main verb) could indeed be for similar reasons. First, it is possible that in both English and Korean, filler-gap association consumes more working memory resources when the structure of a gap is more complex (defined either in terms of the *accessibility hierarchy* or *phrase-structural distance*). That is, an object gap is structurally more complex (in that it is more deeply embedded) than a subject gap both in English and Korean, and thus, processing of an object gap could have led to greater working memory load. Second, it is possible that in both English and Korean, filler-gap association consumes more working memory resources when more processes are involved at approximately the same time. That is, in

English, around the filler-gap association position (i.e., main verb position), fillers in ORs are assigned thematic roles by both the relative clause and the main clause verbs, while fillers in SRs are assigned a thematic role by the main verb only, since the thematic role assignment of the relative clause verb is already complete in the early relative clause region. Likewise, in Korean, more processes are involved in ORs at the filler-gap association position due to gap postulation, complex structure building and reanalysis to a bi-clausal structure, as shown in (4.86).

Although these two possibilities are indistinguishable from each other at this point, it should be noted that they are not mutually exclusive. That is, the SR/OR asymmetry could have been caused by linguistic complexity associated with processing an object gap as opposed to a subject gap, as defined by the *accessibility hierarchy* and the *phrase-structural distance hypothesis*, and this asymmetry could have been enhanced due to the late cues to structural representation in ORs. This possibility is supported by the prolonged difficulty within the main clause region of ORs in the reading time (Experiment 4.1 and 4.2) and ERP experiments.

4.5 General Discussion

In Experiment 4.1, I investigated the processing of SRs and ORs in Korean using reading time measures across different types of head nouns, including subject, object and possessive head nouns. The experimental results in Korean, where a gap precedes its filler (i.e., a backward syntactic dependency), were compared with the results in English, a typologically different language, where a filler precedes its gap (i.e., a forward syntactic dependency). The results supported processing models defined in terms of linguistic universals (i.e., the *accessibility hierarchy*: Keenan & Comrie, 1977; the *phrase-structural distance*: O'Grady, 1997), such that a gap with higher linguistic complexity (e.g., ORs) was harder to process.

The results partially supported the predictions of *similarity-based interference*. Recall that this account predicted a SR advantage for sentences with subject head nouns, an OR advantage for sentences with object head nouns, and no subject/object processing asymmetry for sentences with possessive head nouns. Although this was not the pattern of results found – there was instead a SR advantage for all three head noun types – the SR advantage was largest for subject head nouns, smallest for object head nouns, and intermediate for possessive head nouns (see Figure 4-9). Typically the similarity effect has been attested in terms of NP types (e.g., description, personal name and pronoun), but this result suggests that structural similarity encoded by similar case markers of successive NPs can also trigger similarity-based interference, which interacts with linguistic complexity as an additive effect to SR/OR asymmetry (Kwon et al., submitted).

However, the results did not support processing models defined in terms of surface grammatical features (i.e., the linear distance between filler and gap; canonical word order; surface position of subject). These results were taken to indicate that linguistic structural complexity defined in terms of linguistic universals serves as a universal parsing constraint. Overall, Experiment 4.1 suggested similar sentence processing mechanisms underlying postnominal relative clauses in English (i.e., forward syntactic dependencies) and prenominal relative clauses in Korean (i.e., backward syntactic dependencies).

Experiment 4.2 further investigated the processing asymmetry of SRs and ORs using an eye-tracking method. Given the inherent ambiguity between a relative clause gap and argument-drop in Korean (and in Japanese), it was pointed out that the absence of a linear distance effect could be due to this ambiguity (Ishizuka et al., 2006). Thus the goal of the experiment was to test a processing model based on linear distance (i.e., the *dependency locality theory*) by removing this structural ambiguity. For this purpose, context was used to force the relative clause reading. However, the results clearly suggested that regardless of context, ORs were harder to process than SRs, providing support for the *phrase-structural distance hypothesis* and the *accessibility hierarchy* but not for the *dependency locality theory,* confirming the conclusions of Experiment 4.1.

Subsequently, using ERP measures, Experiment 4.3 investigated to what extent the cognitive/neural processes underlying these two types of syntactic dependencies are similar or dissimilar. The results showed that Korean relative clauses elicited remarkably similar ERP responses to those elicited by English relatives. That is, a sustained anterior negativity was elicited in response to ORs in comparison to SRs within the relative clause region, and in the main clause region an anterior negativity was again elicited in response to ORs compared to SRs. Although the responses in the relative clause region are probably due to different factors (i.e., English: holding a filler without a thematic role in working memory; Korean: higher working memory demands associated with processing nominative-marked NPs), the similar responses in the main clause region could indeed be due to similar factors. Two possibilities were suggested: (a) greater working memory load for filler-gap association when there are multiple processes occurring at approximately the same time (i.e., English: multiple thematic role assignments; Korean: complex structure building and gap postulation), and (b) greater working memory load for filler-gap association when a gap is linguistically more complex (i.e., more deeply embedded or ranked lower on the *accessibility hierarchy*).

In evaluating the implications of these findings, I first address the *phrase-structural distance hypothesis* and the *accessibility hierarchy* before turning to *dependency locality theory* and (anti-)locality effects. A discussion of frequency-based accounts follows.

Experiments 4.1 and 4.2 provided solid support for the *phrase-structural distance hypothesis* and the *accessibility hierarchy*. ORs (i.e., a structure with a longer phrase-structural filler-gap distance and with a gap ranked low in the accessibility hierarchy) led to greater processing difficulty than SRs, as measured by longer reading times and sustained anterior negativity. Therefore, the current results along with results reported in languages with post-nominal relative clauses confirm phrase-structural complexity and the accessibility hierarchy as universal processing constraints on sentence comprehension. However, it should be noted that the source of the processing difficulty in these accounts is rather unclear. The *accessibility hierarchy*, as a cross-linguistic generalization on relative clause formation (see Chapter 3 for details), was originally accounted for in terms of processing (Keenan & Comrie, 1977; Keenan & Hawkins, 1987). Therefore, attributing the SR/OR processing asymmetry to the accessibility hierarchy seems to be a circular argument.

With regard to the *phrase-structural distance hypothesis*, although the processing difficulty could be defined in terms of the structural distance between filler and the gap, as suggested in O'Grady (1997), the experimental results thus far do not exclude the possibility that the processing of a more deeply embedded gap is the source of difficulty, regardless of the structural position of the filler. Further empirical experiments need to be carried out to investigate this possibility. However, what this means is that the *phrase-structural distance hypothesis* and the *accessibility hierarchy* are not distinguishable at this point.

Additionally, it was recently suggested that the *accessibility hierarchy* could be accounted for in terms of the number of syntactic nodes in the phrase structure of possible derivation (Hale, 2006). Using a complexity metric based on the notion of "conditional entropy of grammatical continuation" (i.e., uncertainty about the rest of the sentence given the words that have been processed so far; see Chapter 3 for details), Hale suggested that the *accessibility hierarchy* is correlated with the degrees of uncertainty during incremental comprehension.[18] That is, in this analysis, ORs have a higher degree of uncertainty with regard to grammatical continuation than SRs during intermediate states. Crucially, noting that the total number of derivation tree nodes correlates with the

[18] This correlation, however, is obtained based on a promotion analysis but not an adjunction analysis of relative clauses (see Chapter 2 for details of these analyses).

accessibility hierarchy, Hale suggested that a construction with longer possible sub-derivations is more difficult. This means that both the *accessibility hierarchy* and the *phrase-structural distance hypothesis* could be defined in terms of the complexity of a syntactic tree, suggesting the complexity of the mental representation of a structure as a source of processing difficulty.

The difference between Hale's complexity metric and O'Grady's phrase-structural distance hypothesis is that in the former, since uncertainty is the major source of the processing difficulty, only a structure with a potential long derivation is predicted to incur processing difficulty, while an unambiguous structure is predicted to incur no processing difficulty no matter how complex its syntactic structure. The *phrase-structural distance hypothesis*, on the other hand, does not distinguish processing difficulty associated with ambiguous and unambiguous structures. Yet despite differences in computing processing difficulty in relation to structural ambiguity, both accounts point to the important role of complexity of mental representations of a structure in sentence comprehension.

However, although this unified account seems appealing, further empirical data is required. In terms of the *phrase-structural distance hypothesis*, experiments should be conducted varying the structural position of the filler with the gap position held constant, to test whether the *phrase-structural distance hypothesis* is indeed distinct from the *accessibility hierarchy*. In terms of Hale's interpretation of the *accessibility hierarchy*, as he correctly acknowledged, one caveat is that while conditional entropy relies on the syntactic analysis of the relative clause construction, and thus commitment to a linguistic structure is required, the theoretical analysis is still controversial (see Chapter 2 for details). In addition, the conditional entropy account needs to be further tested in typologically different languages before it can fully account for the *accessibility hierarchy*. Particularly, given the importance of a promotion analysis (see Chapter 2) in eliciting the degree of uncertainty correlated with the *accessibility hierarchy* in English, it is important to test this account using a language like Korean that does not allow a promotion analysis (see Chapter 2 for details).

Although processing models based on a linear distance account have received extensive support from experimental results in languages with postnominal relative clauses, such models are not consistent with the current experimental results. One possible source of the differences could be the relative order of filler and gap. In filler-gap ordering, the filler needs to be stored in working memory in expectation of a gap: retaining semantic and/or phonetic information associated with the filler until the gap is encountered while processing additional sentence material occurring between the two requires additional working memory resources. Hence the longer the distance between filler and gap, the greater the processing load (Gibson, 1998, 2000). Alternatively, filler retrieval seems to be more prone to memory decay with longer temporal distance between filler and gap (Lewis et al., 2006). Thus, linear/temporal distance seems to be an important factor in processing filler-gap dependencies with filler-gap ordering.

By analogy, one might expect gap-filler dependencies to require storage of the gap (i.e., holding a slot open) in working memory and retrieval of that open slot when encountering an appropriate filler or subcategorizer. In this case, since a gap has no phonetic content of its own, the presence of a gap will be indirectly signaled by other local cues. For example, under incremental parsing (Sturt & Crocker, 1996; Miyamoto, 2002), a gap would be postulated at the non-canonical sentence-initial NP-ACC in SRs, while in ORs it is the argument structure of the embedded predicate that will signal a missing argument, as shown in (4.87) and (4.88).

(4.87) *Subject relative clause*

gap postulation

[___$_i$	uywon-ul	kongkyekha-n]	enlonin$_i$-i	yumyengha-ta
[___	senator-ACC	attack-REL]	journalist-NOM	is.famous-DECL

'The journalist who attacked the senator is famous.'

(4.88) *Object relative clause*

gap postulation

[uywon-i	___$_i$	kongkyekha-n]	enlonin$_i$-i	yumyengha-ta
[senator-NOM	___	attack-REL]	journalist-NOM	is.famous-DECL

'The journalist who the senator attacked is famous.'

This indicates that the linear/temporal distance between the locus of gap postulation and the head noun is still longer in SRs than in ORs, which predicts greater processing difficulty in SRs than in ORs if linear/temporal distance is an important factor.

However, as mentioned above, a gap does not have its own phonetic value. Moreover, thematic information associated with a gap does not come from the gap itself, but from the embedded subcategorizing verb, both in SRs and ORs, and referential information associated with a gap comes from the head noun. On this view, storing a potential gap in working memory may not cause processing difficulty. This in turn could account for why the linear/temporal distance between a gap and its filler does not seem to be an important factor in processing pre-nominal RCs in Korean (and possibly in Japanese as well).

In fact, the absence of a locality effect in the current study has implications for the on-going debate over the role of linear distance in sentence comprehension. In one view, represented by the *integration-based dependency locality theory* (Gibson, 2000), the longer linear distance between the linguistic elements in need of integration is viewed to incur a greater working memory load, thus causing processing difficulty (i.e., a locality effect). On the other hand, in the second view emphasizing the role of expectation, longer distance is viewed to facilitate processing (i.e., an anti-locality effect), as the context provided by the intervening material can help in sharpening the expectation of an upcoming word as to its location and identity (Konieczny, 2000; Levy, 2008; Vasishth & Lewis, 2006). With varying results in different studies (anti-locality effect: Konieczny, 2000; Vasishth & Lewis 2006; locality effect: Grodner & Gibson 2005), it is not clear which are the important factors in deciding which will turn out as a main effect.

However, one potential factor that has been suggested to trigger more of an anti-locality than a locality effect is preactivation or constraining of semantic and syntactic attributes of the predicted head by intervening material (Konieczny, 2000; Grodner & Gibson, 2005). This factor, in fact, could be related to the current experimental results as well. As mainly discussed in Experiment 4.3, a type of relative clause verb (i.e., transitive vs. intransitive verb) is signaled in SRs by the sentence-initial non-canonical NP-ACC, while in ORs there are no such cues to a transitive structure until the embedded verb position right before the head noun. Thus, at the following head noun position, gap-filler integration could have been more difficult in ORs due to the additional processing difficulty related to the (un)expectedness of sentence structure compared to SRs.

However, it should be noted that semantic/syntactic facilitation caused by intervening material and slow-down of processing created by long linear distance are not mutually exclusive. That is, although longer distance could indeed both facilitate and slow processing, these two effects could be weighted against each other, yielding experimental results where a stronger effect of the two is observed. Thus, in the current experiments, a processing facilitation effect due to greater distance (i.e., an anti-locality effect) could have outweighed processing difficulty associated with holding a gap in working memory (i.e., a locality effect), possibly because holding a gap in working memory incurs little working memory cost, if any. Since there is no clear effect at the relative clause verb (i.e., the expected head), this hypothesis is in need of further investigation. In addition, the range of possible interactions between factors triggering anti-locality and locality effects needs to be clarified.

I now turn to the disjunction of frequency and processing difficulty. Recently the field of psycholinguistics has witnessed great progress in statistical and probabilistic approaches to the study of language processing (Spivey-Knowlton & Sedivy, 1995; Jurafsky, 1996; McDonald & Christiansen, 2002; Hale, 2006; Levy, 2007; Reali & Christiansen, 2007). However, some studies have found clear dissociations between processing difficulty and the frequency of constructions (Gibson & Schütze, 1999; Gordon et al., 2004); likewise, the processing results of Experiment 4.1 are not completely compatible with frequency results either. In Experiment 4.1, using a small-scale corpus, frequency information was investigated at three levels: frequency of SRs and ORs, frequency of different head noun types (subject, object and possessive head nouns), and frequency of SRs and ORs with different head noun types (i.e., SRs and ORs with subject, object, and possessive head nouns). Some of the reading time results were compatible with frequency: SRs were much more frequent than ORs and accordingly, SRs were easier to process than ORs. However, the reading time results were not compatible with frequency at other levels. Possessive head noun sentences were read faster than subject head noun sentences, and object and subject head noun sentences did not differ from each other in terms of reading time despite the fact that subject head noun sentences are more frequent than both possessive and object head noun sentences. Similarly, at the most fine-grained level, although SRs with subject head nouns and ORs with possessive head nouns were the most and least frequent constructions, respectively, these were not the easiest and the most difficult constructions to process. SRs with possessive head nouns were the easiest to process (i.e., read the fastest) and ORs with subject head nouns were the most difficult to process (i.e., read the slowest).

It is possible that this disjunction could be attributable to the relatively small size of the corpus that was used in Experiment 4.1, given the well-known difficulty of justifying a particular corpus for analysis (Chomsky, 1957), and noted variations in frequency of a particular structure across corpora (Roland, Dick, & Elman, 2007, cf. Fox & Thompson, 1990). On the other hand, the results raise another concern about the statistical approach to the study of language processing: the grain problem (Mitchell et al., 1995). That is, language experience can facilitate sentence comprehension when relevant features are recorded and pattern-matched against the current linguistic input during language processing. The grain problem refers to the level of abstraction of linguistic experience for storage. When records are detailed (e.g., definite NP followed by PP vs. indefinite NP followed by a relative clause), there is a higher chance of a correct analysis of the current input. However, such a large amount of information could be costly to maintain. On the other hand, when records are coarse (e.g., NP followed by a modifier), even though this is easier to maintain, the analysis could be incorrect.

In terms of the current experiment, in which the processing difficulty of filler-gap dependencies was compatible with higher-order frequency (SR vs. OR) but not with a fine-grained level of analysis (SR vs. OR with subject, object, and possessive head nouns), the results might suggest that the “appropriate grain” for processing Korean relative clauses (i.e., storing units) is at this higher (or coarse) level. However, it is also possible that although the brain keeps track of both fine-grained and coarse levels of analysis, just as it is sensitive to the frequency of both individual lexical words and grammatical categories (Münte et al., 2001; Nobre & McCarthy, 1994; Olichney, Van Petten, Paller, Salmon, Iragui & Kutas 2000; Osterhout, Bersick, & McKinnon, 1997; King & Kutas, 1998), the factor examined in the current fine-grained analysis (i.e., grammatical roles of head noun within relative and main clauses) is simply not the information to which the sentence processor appears to be sensitive. Alternatively, it is also possible that fuller investigation based on probabilistic models would show that a more fined-grained level of analysis is required than the one used in Experiment 4.1 (Levy, 2007; Hale, 2006). At this point, it is not clear what underlies this disjunction of frequency and processing difficulty. Further research should be carried out using a larger corpus to explore these possibilities. Importantly, for a full fledged model, rather than simply showing comparability between frequency and processing results, research should also address issues regarding what determines the “appropriate grain” (cf. Mitchell et al., 1995; Townsend & Bever, 2001) or level of analysis.

4.6 Conclusion

The research questions of interest in this chapter were:

(i) Which of these accounts proposed for English is most appropriate as a universal processing strategy?

(ii) To what extent are the neuro/cognitive operations underlying the processing of forward syntactic dependencies in post-nominal relative clauses (in which a head noun precedes the relative clause, as in English) similar to those underlying the processing of backward syntactic dependencies in pre-nominal relative clauses (in which a relative clause precedes its head noun, as in Korean)?

The experimental results clearly showed a processing advantage for SRs over ORs in Korean, confirming the predictions of the *accessibility hierarchy* and the *phrase-structural distance hypothesis*. This, along with results from English, underscores the important role of complexity of mental representations of a structure in sentence comprehension, both in forward and backward syntactic dependencies.

The results of Experiment 4.3 showed that the ERP responses elicited by Korean relative clauses were remarkably similar to those elicited by English relative clauses. That is, within the relative clause region, a sustained anterior negativity was elicited to ORs compared to SRs, and in the main clause region, an anterior negativity was again elicited in response to ORs compared to SRs. In particular, similar responses in the main clause region were attributed to similar processes: (a) greater working memory load for filler-gap association when there are multiple processes occurring at approximately the same time (i.e., English: multiple thematic role assignments; Korean: complex structure building and gap postulation), and (b) greater working memory load for filler-gap association when a gap is linguistically more complex (i.e., more deeply embedded or ranked lower in the *accessibility hierarchy*).

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Nayoung Kwon, Yoonhyoung Lee, Peter C. Gordon, Robert Kluender & Maria Polinsky. Cognitive and linguistic determinants of the subject-object asymmetry: An eye-tracking study of pre-nominal relative clauses in Korean. (Submitted)

Nayoung Kwon, Maria Polinsky, Robert Kluender & Marta Kutas. Subject/object processing asymmetries in Korean relative clauses: Evidence from reading time and ERP data. (In preparation)

The dissertation author is the primary investigator and author of the papers.

Chapter 5:
Processing of Syntactic and Anaphoric Dependencies in Korean

5.1 Introduction

The goal of this chapter is to investigate the processing of long-distance dependencies in different types of constructions. Chapter 1 introduced various types of long-distance dependencies that differed on the basis of the relative surface order of linguistic elements that either provide (i.e., filler and antecedent) or require (i.e., gap and pronoun) referential information, and on the basis of nature of the dependency involved (i.e., syntactic vs. referential dependencies), as in (5.1) to (5.4). Chapter 3 then presented previous research on the processing of these structures.

(5.1) Forward syntactic dependencies
The reporter$_i$ [who the senator attacked __$_i$] admitted the error.

(5.2) Backward syntactic dependencies

[uywon-i	__$_i$	kongkeykha-n]	kica$_i$ -ka	calmot-ul	siinhayssta
senator-NOM		attacked-REL	reporter-NOM	error-ACC	admitted

'The reporter who the senator attacked admitted the error.'

(5.3) Forward anaphoric dependencies
[Because the boy$_i$ was fed up], he$_i$ visited the girl often.

(5.4) Backward anaphoric dependencies

[_$_i$	silhcung-i	na-se],	sonyen$_i$ -un	sonye-lul	cacwu	chacawa-ss-ta
[_$_i$	boredom-NOM	arise-because]	boy$_i$ -TOP	girl-ACC	often	come-PST-DECL

'Because he was fed up, the boy visited the girl often.'

An important question to ask for a fuller understanding of human language processing would be whether the parsing strategies for these different types of long-distance dependencies are similar and, if so, in what respect and to what degree they are similar. In addition, this investigation would have implications for processing models developed mostly on the basis of forward syntactic dependencies. In an attempt to address these issues, Chapter 4 investigated the processing of backward syntactic dependencies (5.2), mainly comparing the results with those of forward syntactic dependencies (5.1). The results suggested that similar processing mechanisms underlie the processing of forward and backward syntactic dependencies. That is, in both types of dependencies, there was a processing advantage for subject relatives (SRs) over object relatives (ORs), and this was taken to indicate that the processing of both types of syntactic dependencies is constrained by the phrase-structural complexity of the mental representations involved. Now, based on the findings in Chapter 4, this chapter investigates the processing of backward anaphoric dependencies (5.4), mainly comparing these with the processing of backward syntactic dependencies (5.2).

Previous research on backward anaphoric dependencies has suggested that some of the parsing strategies involved are similar to those underlying forward syntactic dependencies (see Chapter 3). It is important to note that syntactic dependencies are obligatory, in that a filler in a forward syntactic dependency obligatorily requires a gap position − as suggested by the ungrammaticality of a sentence without a corresponding gap (5.5) − while pronouns do not require intra-sentential antecedents (5.6).

(5.5) *My brother wanted to know who$_i$ Ruth will bring us home to Mom at Christmas.
(5.6) When she felt tired, the boy used to clean the house.

Yet despite apparent differences in the obligatoriness of the dependency, backward anaphoric dependencies have been found to be driven by the same active search mechanism (Aoshima, Yoshida, & Phillips, in press; Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007; van Gompel & Liversedge, 2003; Filik & Sanford, 2008; cf.

Ng & Fodor, to appear) as syntactic dependencies (Frazier & Clifton, 1989; Stowe, 1986). However, this search mechanism is constrained by a grammatical constraint on coreference (Kazanina et al., 2007), just as in syntactic dependencies (Stowe, 1986). Thus, a long-distance dependency is not formed between grammatical positions when the coindexation of the two positions leads to violation of syntactic constraints (e.g., Principles A, B, and C) (see Chapter 3 for details).

However, although these experiments provide clear evidence for similar parsing strategies in anaphoric and syntactic dependencies, due to word order differences, English does not allow a direct comparison of these two types of dependencies. In this chapter, I offer a more fine-grained investigation of the similarities and dissimilarities in processing mechanisms between these two types of long-distance dependencies by using Korean, in which direct comparison is possible.

For this purpose, in Experiment 5.1a, I compare the processing of SRs and ORs with the processing of sentences with subject and object *pro*-drop. Using reading times, I test whether the subject/object gap processing asymmetry attested for syntactic dependencies is also present in anaphoric dependencies. Such an asymmetry could be accounted for in terms of the phrase-structural complexity of dependency formation. In Experiment 5.1b, by comparing the processing of syntactic dependencies with argument-drop sentences without long-distance dependencies (i.e., *fact*-CP clauses), I further investigate the nature of the active search mechanism (Kazanina et al., 2007; van Gompel & Liversedge, 2003). In Experiment 5.2, the processing of ORs and of adjunct clauses with object argument-drop is compared using event-related potentials (ERPs) to investigate to what extent cognitive/neural processes underlying backward syntactic and anaphoric dependencies are similar to each other.

To summarize, this chapter addresses the following main questions:

i) Does the subject/object processing asymmetry that has been found for syntactic dependencies emerge in backward anaphoric dependencies (argument-drop sentences) as well?

ii) If so, to what extent are the cognitive/neural processes underlying long-distance dependencies in different constructions the same?

5.2 Experiment 5.1: Self-paced Reading Time

In Chapter 4, I suggested that the processing of backward syntactic dependencies is crucially constrained by the structural relation between a filler and its gap. In this chapter, I shift my focus to another type of long-distance dependency: backward anaphoric dependencies.

In Korean, a gap is temporarily ambiguous, either as part of a relative clause or as a dropped argument. For example, the gap in (5.7) can turn out to be a part of a relative clause as in (5.8), or a dropped argument, as in (5.9) and (5.10). Among these, the relative clause (5.8) is similar to an adjunct clause (5.10) in that both constructions instantiate long-distance dependencies. Thus, in both constructions, the gap is associated with the main clause subject '*teacher*'. However, the two constructions are different from each other in that while the relative clause (5.8) instantiates a syntactic dependency (i.e., a syntactically licensed long-distance dependency; see Chapter 2 for analyses of Korean relative clauses), the long-distance dependency in the adjunct clause (5.10) instantiates an anaphoric dependency (i.e., semantically licensed coindexation). The processing of these constructions is compared in Experiment 5.1a.

(5.7)	___	Tom-ul	hakkyo-eyse	manna...	
		Tom-ACC	school-at	meet....	
	'(Someone) meet Tom at school...'				
(5.8)	___$_i$	Tom-ul	hakkyo-eyse	manna-n	sensayngnim$_i$-un ...
		Tom-ACC	school-at	meet-REL	teacher-TOP...
	'The teacher who met Tom at school...'				

(5.9) *pro*$_i$ Tom-ul hakkyo-eyse manna-n sasil-ul sensayngnim$_i$-i
Tom-ACC school-at meet-REL fact-ACC teacher-NOM

siinhayssta
admit

'The teacher$_i$ admitted the fact that (he$_i$) met Tom at school.'

(5.10) *pro*$_i$ Tom-ul hakkyo-eyse manna-se, sensayngnim$_i$-un ...
Tom-ACC school-at meet-because, teacher-TOP...

'Because (he) met Tom at school, the teacher...'

On the other hand, the relative clause construction (5.8) and the *fact*-CP clause construction (5.9) are identical up through the embedded verb, which has an adnominal marker. This means that the ambiguity of the gap (i.e., a relative clause gap vs. a dropped argument in the sentential complement of the head noun) remains unresolved until the head noun position. Yet (5.8) and (5.9) are different from each other in that in the former, the head noun *'teacher'* serves as a filler for the gap while in the latter, the head noun *'fact'* cannot. Thus, while the relative clause sentence (5.8) instantiates a long-distance dependency, the *fact*-CP clause (5.9) does not. The processing of these constructions is compared in Experiment 5.1b.

5.2.1 Experiment 5.1a: Syntactic Dependencies vs. Anaphoric Dependencies

In this section, I am interested in comparing syntactic and anaphoric dependencies, using sentences with subject and object gaps in minimal pair relative and adjunct clauses (-*se* 'because'). Thus, the experiment has a 2 x 2 design: two gap types (subject vs. object) and two clause types (relative clause vs. adjunct clause). Simplified versions of the experimental sentences are presented in (5.11) to (5.14).

(5.11) Backward subject syntactic dependency

[___$_i$	Mary-lul	koyongha-n]	Tom$_i$ -un	yumyenghaysi-ess-ta
	Mary-ACC	employ-REL	Tom-TOP	get.famous-PST-DECL

'Tom who hired Mary got famous'

(5.12) Backward object syntactic dependency

[Mary-ka	___$_i$	koyongha-n]	Tom$_i$ -un	yumyenghaysi-ess-ta
Mary-NOM		employ-REL	Tom-TOP	get.famous-PST-DECL

'Tom who Mary hired got famous'

(5.13) Backward subject anaphoric dependency

[___$_i$	Mary-lul	koyongha-se]	Tom$_i$ -un	yumyenghaysi-ess-ta
	Mary-ACC	employ-because	Tom-TOP	get.famous-PST-DECL

'Because (he$_i$) hired Mary, Tom$_i$ got famous'

(5.14) Backward object anaphoric dependency

[Mary-ka	___$_i$	koyongha-se]	Tom$_i$ -un	yumyenghaysi-ess-ta
Mary-NOM		employ-because	Tom-TOP	get.famous-PST-DECL

'Because Mary hired (him$_i$), Tom$_i$ got famous.'

The structure of Korean allows all four constructions to employ the same lexical items in the exact same order. The only differences are the case markers attached to the NPs within the embedded clauses, and the adnominal and adjunct suffixes on the embedded clause verb. Sentences with an accusative-marked NP within the embedded clause are subject gap sentences, while sentences with a nominative-marked NP are object gap sentences. Sentences with adjunct suffixes are adjunct clauses and sentences with adnominal markers are relative clauses (in this experiment; see Experiment 5.1b).

Although the referents of dropped arguments can be reconstructed from the discourse context or have an arbitrary reading without specific reference, *pro* can also be bound by a sentential antecedent. For example, there is a strong tendency for the subject and object *pro* in (5.13) and (5.14) to be coreferential with the main clause subject, which would be expected if there is an active search mechanism in backward-anaphoric dependencies (Aoshima et al., in press; Kazanina et al,. 2007; van Gompel & Liversedge, 2003).

The first question here is whether there is a subject/object asymmetry in processing argument drop sentences (i.e., backward anaphoric dependencies), as there is in relative clauses (i.e. backward syntactic dependencies). If so, the next question is whether this processing asymmetry can also be accounted for in terms of linguistic structural complexity, as is the case with relative clauses, as discussed in Chapter 4.

In the next section, I first present a corpus study in which the frequency of the adjunct marker (-se) and the adnominal marker (-n) is investigated. Additionally, the frequency of sentences with subject and object gaps in *–se* clauses is discussed. Following this, I present the norming and reading time results, followed by the discussion.

5.2.1.1 Corpus study

The goal of this corpus study is two-fold. First, I examine the frequency of *–n,* the adnominal marker, and *–se,* the adjunct suffix. Second, I examine the frequency of each target construction. The frequency of relative clause constructions was already reported in Chapter 4. In this section, the frequency of *pro* constructions is examined using the same corpus that was used in Chapter 4, and the results are compared.

5.2.1.1.1 Methods

Materials

For the frequency of the adnominal marker, *–n*, and the 'because' adjunct suffix, *–se*, the Seyjong corpus (2002) with ten million *ejels* (for the definition of *ejel,* see footnote 2 in Chapter 4) was examined. This contains 90% written, 5% spoken and 5% semi-spoken texts (i.e., edited scripts for plays, soap operas and movies). For the frequency of subject and object *pro* in *–se* clauses, a small portion of the corpus (a movie magazine with 26,749 *ejels*) was examined.

Procedures

The Seyjong corpus is tagged but not parsed. Thus, for the frequency of the adnominal marker, all the sentences with an adnominal marker were able to be retrieved using regular expressions in a Seyjong corpus program. Likewise, for the *–se* adjunct suffix, all the clauses with a verb marked with *–se* were retrieved from the ten million *ejel*s in the Seyjong corpus.

For the frequency of subject and object *pro* constructions, all the clauses with a verb marked with *–se* were retrieved from the movie magazine section of the corpus with 26,749 *ejels* that was also used in Chapter 4 to determine the frequency of SRs and ORs. The resulting clauses were then manually sorted into sentences with subject and object *pro*. Only sentences with transitive verbs were encoded, as in the corpus study of SRs and ORs in Chapter 4. The manual coding was examined by two additional linguistically-trained individuals.

5.2.1.1.2 Results and Discussion

The corpus results showed that adnominal markers are more frequently used than the adjunct suffix *–se.* In the overall results, from among 10 million *ejels*, the total frequency of -*se* was 20,834 while the frequency of the adnominal marker was 184,916 after 18% of the corpus had been parsed, at which point the corpus software crashed and could not complete the task. Thus, it seems clear that the adnominal marker is vastly more frequent than the *–se* adjunct suffix[1]. As for the adnominal marker, 89,329 instances were identified, of which 48,323 instances were from scripts, and 41,006 from transcription. The corpus results are summarized in Table 5-1.

Table 5-1 Frequency of adjunct and adnominal marker

Spoken corpus (one million)			
-*se* adjunct marker		adnominal marker	
semi-spoken	transcribed	semi-spoken	transcribed
713	5,545	48,323	41,006
6,258		89,329	

In terms of subject and object *pro* in *–se* clauses, the results again showed a lower rate of occurrences compared to the frequency of SRs and ORs (which is repeated in Table 5-2 below from Chapter 4). A total of seventy-three *–se* clauses were identified from the movie magazine with 26,749 *ejels*. Among these, there were only thirty-six clauses with gaps, of which twenty-nine instances were subject *pro* clauses and seven instances were object *pro* clauses.

[1] It seems that *–se* has more colloquial (rather than formal) usage. This speculation is confirmed by the fact that the frequency of *–se* is much higher in the real spoken corpus (i.e., transcriptions of conversations or lectures; 5,545 instances) than in the semi-spoken (i.e., scripts of movies or soap operas; 713 instances) or in the written corpus. In Korean, there are other adjunct suffixes meaning 'because' such as *–umulo* and *–ttaymuney*, and other ways of encoding causality that can be used in writing.

Table 5-2 Frequency of adjunct and relative clauses

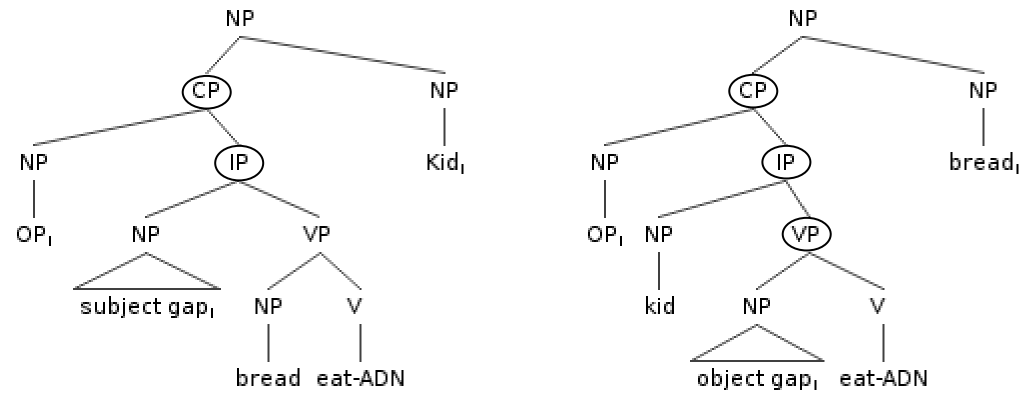
movie magazine (26,749 *ejels*)			
-*se* adjunct clauses		relative clauses	
subject *pro*	object *pro*	SR	OR
29	7	251	108
73 (36 with gap)		359	

Altogether, the results show that the –*se* construction occurs much less frequently than the relative clause construction, and that object gaps occur less frequently than subject gaps across the two constructions.

5.2.1.2 Predictions

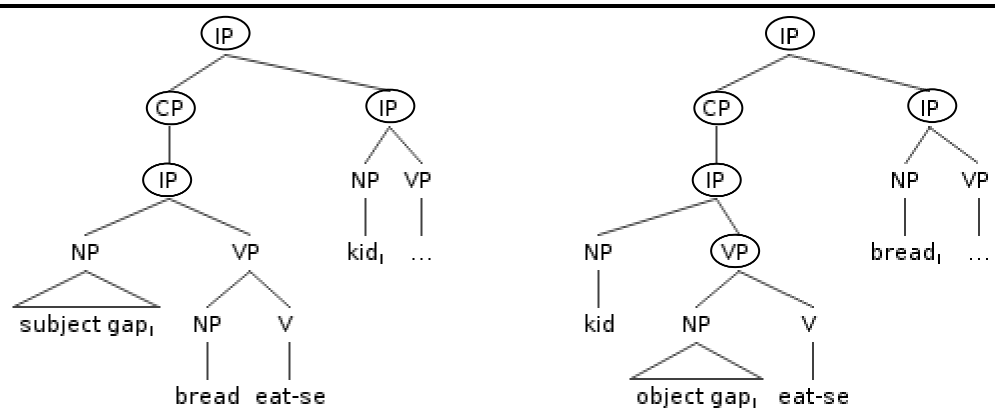
Initially, the *phrase-structural distance hypothesis* (O'Grady, 1997) and the *accessibility hierarchy* (Keenan & Comrie, 1977) were proposed for relative clauses. Yet given the minimally differing configurations of adjunct and relative clauses in the present experiment, these processing theories could be extended to make the following predictions for adjunct clauses as well.

(5.15) The phrase-structural distance between gap and coindexed element is longer in object than in subject gap conditions in both relative and adjunct clauses (i.e., regardless of the nature of the dependency, either syntactic or anaphoric) as shown Figure 5-1 and Figure 5-2. Thus, the *phrase-structural distance hypothesis* predicts that object gap sentences will be harder to process than subject gap sentences both in relative and adjunct clause constructions. In its strict application, the *phrase-structural distance hypothesis* also predicts that argument-drop sentences will be more difficult than relative clauses regardless of gap type (subject vs. object) because the structural distance is greater between a gap and its antecedent in an adjunct clause than between a gap and its filler in a relative clause.



subject relative clauses: 'the kid who ate bread'	object relative clauses: 'the bread who the kid ate'

Figure 5-1 Tree structure of SR and OR



subject drop sentences: 'Because (he$_i$) ate the bread, the kid$_i$...'	object drop sentences: 'Because the kid ate (it$_i$), the bread$_i$...'

Figure 5-2 Tree structure of subject and object gap adjunct clauses

(5.16) If the *accessibility hierarchy* can be construed as applying not only to syntactic gaps in relative clauses, but also to anaphoric gaps in the case of argument drop, then it should predict that object gap sentences will be harder to process than subject gap sentences regardless of clause type.

5.2.1.3 Norming study

The goals of the norming study were two-fold. The first goal was to control the naturalness of the subject and object gap sentences, following Miyamoto and Nakamura

(2003), and as in the preceding experiments (Chapter 4). The second goal was to control the referential identification of *pro* to ensure that *pro* in both subject and object positions can be equally interpreted as co-referential with the subject of the main clause.

5.2.1.3.1 Method

5.2.1.3.1.1 Materials

Stimulus sentences for the naturalness test were created by replacing the gap in the embedded clause with the coindexed matrix subject from thirty sets of experimental sentences, as in Miyamoto and Nakamura (2003). Thus, subject relative and subject *pro*-drop sentences (5.17) shared an identical norming sentence (5.18). Likewise, object relative and object *pro*-drop sentences (5.19) shared an identical norming sentence (5.20). For ease of illustration, examples of the manipulation are given below in English. On the actual questionnaire, sentences were given in Korean.

(5.17) Sentences with subject gaps
[$\_\__i$ hit the writer of the soap opera]$_{\text{REL/BECAUSE}}$ the actor$_i$ appeared on the front page of the newspaper.
'The actor who hit the writer of the soap opera appeared on the front page of the newspaper/Because he$_i$ hit the writer of the soap opera, the actor$_i$ appeared on the front page of the newspaper'

(5.18) Norming sentence for subject relative and subject *pro* sentences
'The actor hit the writer of the soap opera.'

(5.19) Sentences with object gaps
[the writer of the soap opera hit __ $_i$] $_{\text{REL/BECAUSE}}$ the actor$_i$ appeared on the front page of the newspaper
'The actor who the writer of the soap opera hit appeared on the front page of the newspaper/Because the writer of the soap opera hit him$_i$, the actor$_i$ appeared on the front page of the newspaper'

(5.20) Norming sentence for object relative and object *pro* sentences
'The writer of the soap opera hit the actor.'

For norming on the identification of the antecedent for dropped subject and object arguments, thirty sets of adjunct clauses with dropped arguments ((5.21) and (5.22)) were used.

(5.21) Subject *pro* sentence
'Because __ $_i$ hit the writer of the soap opera, the actor$_i$ appeared on the front page of the newspaper.'

(5.22) Object *pro* sentence
'Because the writer of the soap opera hit __ $_i$, the actor$_i$ appeared on the front page of the newspaper.'

5.2.1.3.1.2 Participants

Thirty-one male high school students in Korea participated in the norming study. They were in their junior or senior year and planning on going on to college.

5.2.1.3.1.3 Design and Procedure

The target sentences were split into four lists using a Latin-square design. Participants saw one sentence from each quadruple. For the measure of naturalness, fourteen participants were asked to rate a sentence as 1 if it sounded natural and as 5 if it sounded strange. An example sentence is given below in English.

(5.23) 'The actor hit the writer of the soap opera.'
☞ Please rate this sentence for its naturalness.

Sounds natural — Sounds strange

1 2 3 4 5

In addition, seventeen additional different participants were asked to identify the referents of missing arguments in the subject and object *pro* sentences. If participants thought that the missing argument was co-referential with the subject of the main clause, they were asked to rate the sentence as 1, and as 5 if they were not sure. An illustration of the norming study is given below in English.

(5.24) 'Because ___$_i$ hit the writer of the soap opera, the actor$_i$ appeared on the front page of the newspaper.'

☞ Who hit the writer of the soap opera?

the actor — not clear

1 2 3 4 5

5.2.1.3.2 Results

The results showed that five sets of subject and object gap type sentences differed significantly from the others in terms of naturalness [$t(13) = 6.65$, $p < .02$]. In the *pro* identification questions, six sets of subject and object *pro* sentences differed significantly from the others in the identification of missing arguments [$t(16) = 78.09$, $p < .0001$]. Thus, eleven sets of sentences in total were subsequently omitted from the experiment. Subject and object gap sentences in the remaining nineteen sets of sentences did not differ from each other in terms of naturalness [$t(13) = 3.1$, $p < .1$] (mean rate of subject gap sentences = 2.4 and mean rate of object gap sentences = 2.6). In addition, subject and object *pro* sentences did not differ from each other in terms of the identification of missing arguments [$t(16) = .04$, $p < .84$] (mean rate of subject *pro* = 2.5, mean rate of object *pro* = 2.6).[2]

5.2.1.4 Reading Time Methods

5.2.1.4.1 Participants

Twenty-three Korean native speakers participated in the experiment. At the time of the study, the participants were college students, graduate students or in post-doctoral positions at Korea University (17 males, 7 females; age range: 20 to 41 years old, mean age = 25). They were naive about the purpose of the experiment. After the experiment, they were compensated $8 an hour for their time.

5.2.1.4.2 Materials

There were nineteen sets of sentences in four conditions: subject relative, object relative, subject *pro*, and object *pro* sentences. Examples of each construction are given below, first in English translation and then in Korean.

[2] The experimental stimuli are newspaper-style sentences and the relatively low acceptability ratings seem to be due to their complex structure and high-level vocabulary.

(5.25) English translation of Experiment 5.1a

Subject gap sentences	
Subject relative	The actor$_i$ [who ___$_i$ hit the writer of the soap opera at the bar near the broadcast station] appeared on the front page of the newspaper.
Subject *pro* drop	[Because ___$_i$ hit the writer of the soap opera at the bar near the broadcast station], the actor$_i$ appeared on the front page of the newspaper

Object gap sentences	
Object relative	The actor$_i$ [who the writer of the soap opera hit ___$_i$ at the bar near the broadcast station] appeared on the front page of the newspaper
Object *pro* drop	[Because the writer of the soap opera hit ___$_i$ at the bar near the broadcast station], the actor$_i$ appeared on the front page of the newspaper

(5.26) Experimental sentences in Experiment 5.1a

Embedded clause region						
W1	W2	W3	W4	W5	W6	W7
ku	tulama-uy	kukcakka -lul/ka	pangsongkwuk	inkun	swulcip -eyse	phokhayngha -n/-se
that	soap opera -GEN	writer -ACC/NOM	broadcast station	vicinity	bar-at	hit -REL/-because
subject/object			adverbial phrase			embedded verb

Main clause region			
W8	W9	W10	W11
paywu-ka	sinmwun-uy	ilmyen-ul	cangsikhayssta
actor-NOM	newspaper-GEN	front_page-ACC	decorated
coindexed subject	matrix clause object		main verb

The sentences were split into four lists using a Latin-square design. 71 filler sentences of equal length and complexity as the target structure were added to the lists. The filler sentences included coordination, control constructions and relative clauses with garden path effects. Thus, each of the four lists contained 19 target and 71 filler sentences. Sentences were pseudo-randomized so that no two target sentences appeared in a row.

Each of the four lists was sub-divided into halves. Participants were given a break between the two sub-divided sections of the list they were being tested on.

5.2.1.4.3 Procedure

The procedure was identical to that of the first reading time study in Chapter 4. The experiment was run on PsyScope. Stimulus presentation was word by word, self-paced, and non-cumulative. After the final word of each sentence, a yes/no comprehension question for the preceding sentence appeared on the screen. In most cases, the comprehension question asked about the content of the relative and adjunct clauses. There was a practice session with 8 sentences before the experiment.

5.2.1.4.4 Analysis

A commercially available statistical package (JMP IN) was used for analyzing the data. Data from two participants were excluded from the analysis due to low comprehension scores (52% in comparison to 83% in other participants). An omnibus ANOVA was performed with gap type (subject vs. object) and clause type (relative vs. *pro*-drop adjunct) as independent factors for both dependent measures (comprehension scores and reading times).

5.2.1.5 Results

5.2.1.5.1 Comprehension Questions

Results from the comprehension questions are given below.

Table 5-3 Exp 5.1a, Comprehension accuracy

subject relative	object relative	subject *pro*	object *pro*
83%	80%	84%	76%

There was a marginal effect of gap type (subject vs. object gap) in the participants analysis but not the items analysis, as shown in Table 5-4. This is because subject gap type sentences were answered more correctly than object gap type sentences (84% vs. 78%). There was no main effect of clause type and no interaction of gap type and clause type

Table 5-4 Exp 5.1a, Statistical results for comprehension accuracy

	by participants			by items		
	$F1_{1,20}$	*MSE*	*p*	$F2_{1,18}$	*MSE*	*p*
subject vs. object	3.6	0.1437	.07	1.8	0.1427	.19
relative vs. *pro*	.22	0.1389	.6	.12	0.1375	.72
interaction	.16	0.1453	.69	.21	0.1111	.65

5.2.1.5.2 Reading Times

The overall reading time results for all conditions are presented below.

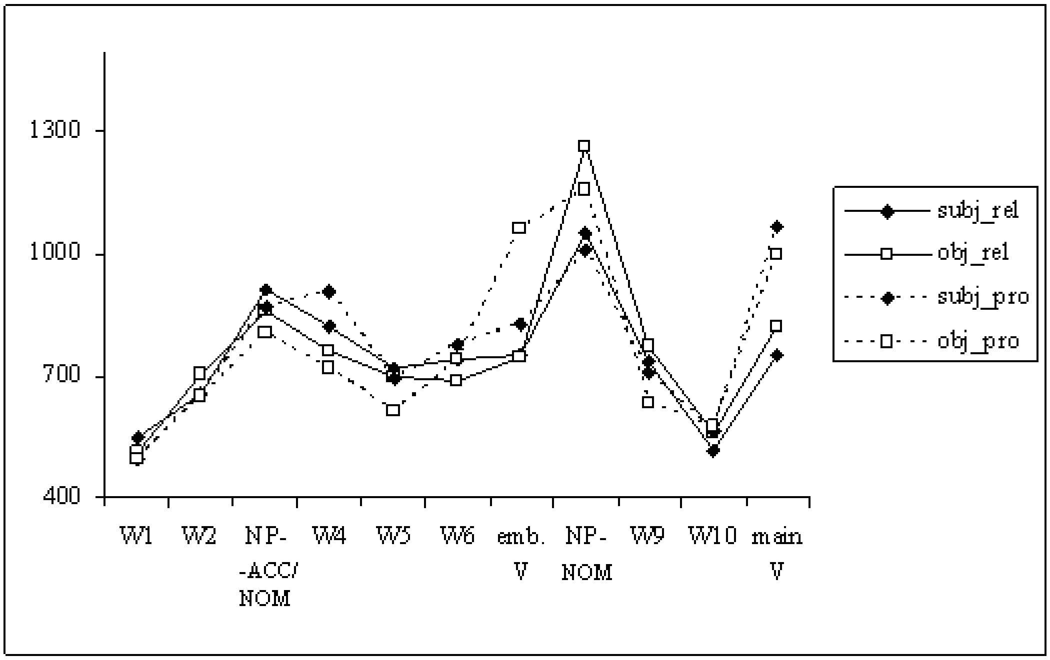


Figure 5-3 Exp 5.1, Overall reading times for relative clause and *pro*-drop sentences

RTs within the embedded clause region

Reading time results within the embedded clause region are presented in Table 5-5 and Figure 5-4.

Table 5-5 Exp 5.1a, Reading times for the embedded clause region

	W1	W2	W3	W4	W5	W6
subject gap	523	657	891	864	708	759
object gap	506	678	833	742	656	716

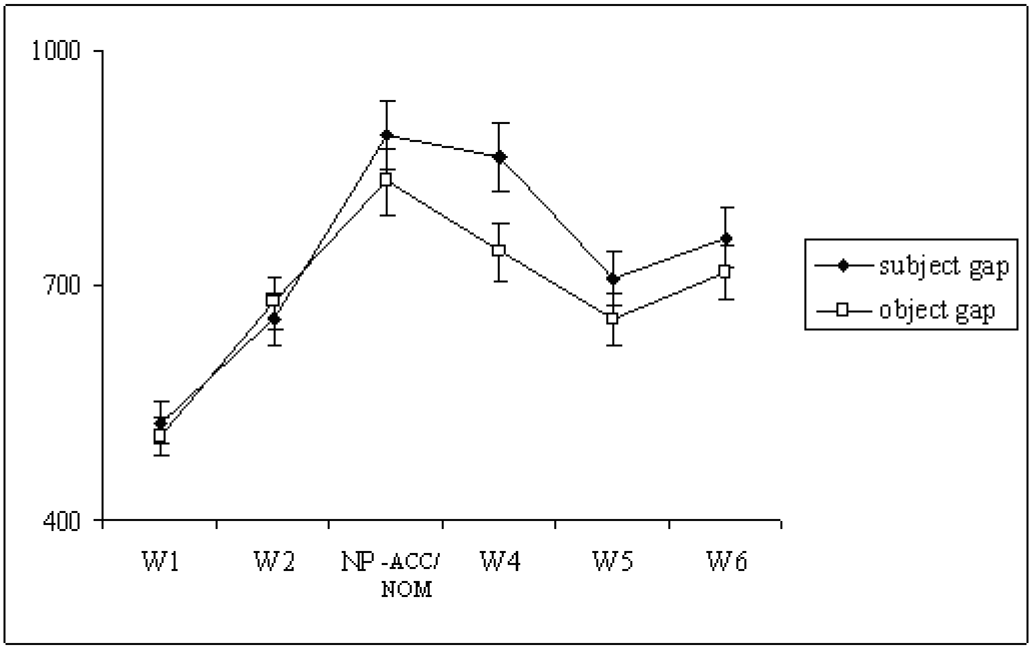


Figure 5-4 Exp 5.1a, Reading times up to embedded verb position

At W4, there was a main effect of gap type. Subject gap sentences took longer to read than object gap sentences (864 vs. 742 ms). The statistical analysis is shown in Table 5-6. There was no main effect of clause type and no interaction of gap type and clause type. The absence of an effect of clause type was expected, given that the relative and adjunct clause conditions do not differ from each other in this region.

Table 5-6 Exp 5.1a, Statistical analysis at W4

	by participants			by items		
	$F1_{1,20}$	*MSE*	*p*	$F2_{1,18}$	*MSE*	*p*
W4	9.1	155284	.007*	8.7	181444	.008*

RTs of the embedded verb and main clause region

From the embedded verb onward, both gap type (subject vs. object) and clause type (adjunct vs. relative clause) were used as independent variables. The reading times for the four conditions and the statistical results are presented in Tables 5-7 and 5-8 respectively.

Table 5-7 Exp 5.1a, Reading times for the main clause region

	emb. V	NP-NOM	W9	W10	main V
subject relative	753	1050	735	515	750
object relative	749	1263	773	562	820
subject *pro*	825	1008	712	564	1065
object *pro*	1060	1157	636	578	996

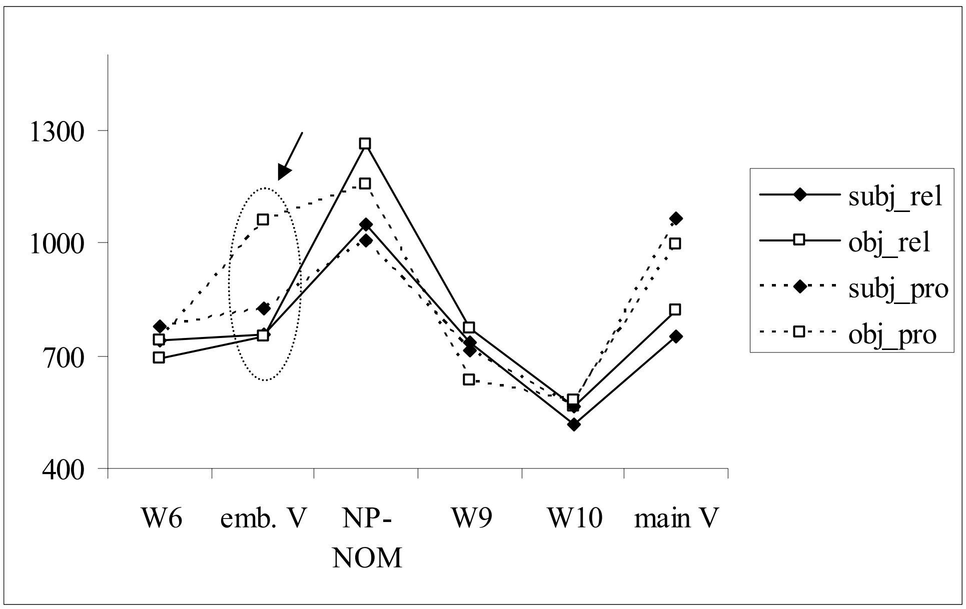


Figure 5-5 Exp 5.1a, Reading times for the embedded verb and the main clause

At W7, the embedded verb position, due to differing numbers of syllables for adjunct and adnominal suffixes, the statistical analysis was conducted on residual reading times calculated as a function of the number of syllables occurring at that position (Ferreira & Clifton, 1986). There was no main effect of gap type or of clause type. However, there was a significant interaction between the two. A Tukey test showed that this effect was due to the difference between subject *pro* and object *pro* sentences at the $p < .05$ level; subject and object relative clauses did not differ from each other at this position.

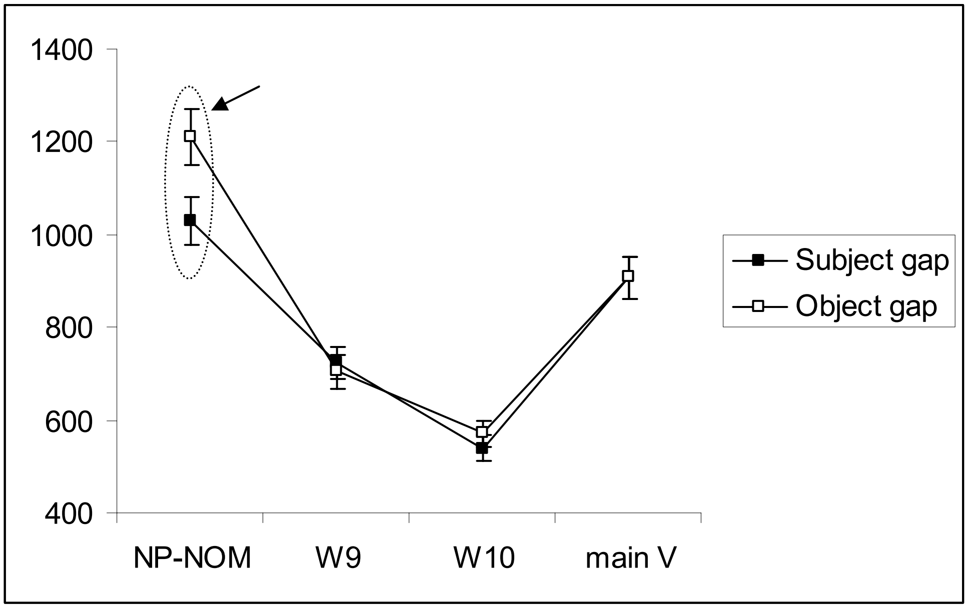


Figure 5-6 Exp 5.1a, Reading times by gap type for the main clause region

At W8, the matrix subject position (NP-NOM in Figure 5-6), there was a significant main effect of gap type (Table 5-8, W8): object gap sentences took longer to read than subject gap sentences (1210 vs. 1029 ms). There was no main effect of clause type, nor any interaction of gap type with clause type. A partial ANOVA comparing only relative clause subject (1050 ms) vs. object gaps (1263 ms) and adjunct clause subject (1007 ms) vs. object gaps (1157 ms), however, only show a marginal effect of gap type; [$F(1, 20) = 3.05$, $p < .09$] for relative clause conditions and [$F(1, 20) = 2.88$, $p < .1$] for adjunct clause conditions. This marginal effect could be due to a relatively smaller number of trials per subject (19 sets of experimental sentences vs. 40 sets in Experiment 4.1).

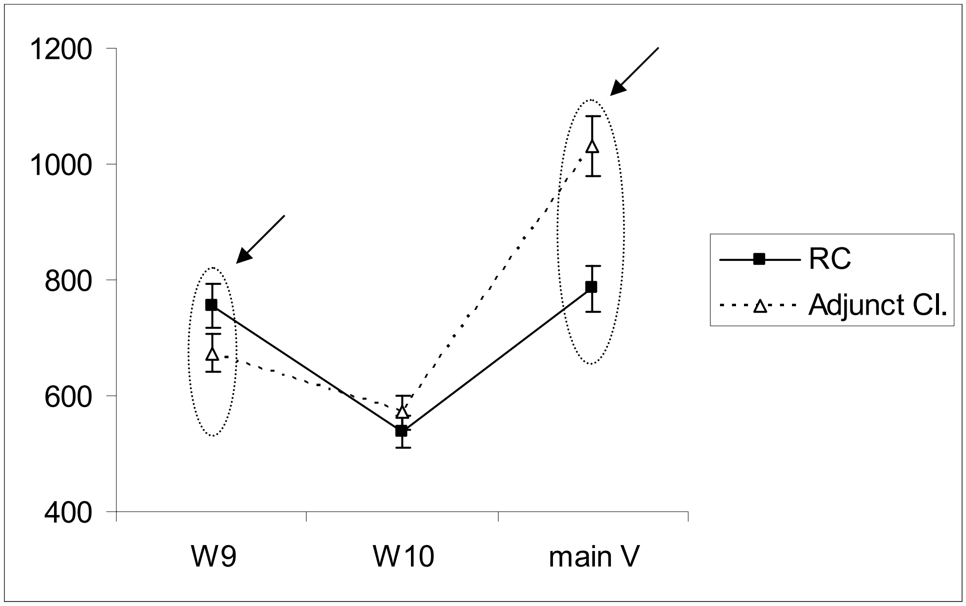


Figure 5-7 Exp 5.1a, Reading times by clause type for the main clause region

At W9, the word immediately following the matrix subject, there was a significant main effect of clause type in the participants analysis that was only marginal in the items analysis (Table 5-8, W9). Relative clauses took longer to read than adjunct clause sentences (754 vs. 674 ms). There was no interaction between gap type and clause type.

At W11, the main clause verb in sentence-final position, there was also a main effect of clause type (Table 5-8, W11). This effect, as opposed to that at W9, was caused by longer reading times for adjunct clause sentences compared to relative clause sentences (1031 vs. 785 ms). There was neither an effect of gap type nor an interaction between gap type and clause type.

Table 5-8 Exp 5.1a, Statistical analysis of main clause reading times

		by participants			by items		
		$F1_{1,20}$	*MSE*	*p*	$F2_{1,18}$	*MSE*	*p*
W7	subject vs. object	1.88	268659	.18	2.12	410619	.16
	relative vs. adjunct	.25	273800	.62	.26	412023	.61
	interaction	5.68	262029	.02*	1.82	386241	.19
W8	subject vs. object	4.82	453411	.04*	6.4	634774	.02*
	relative vs. adjunct	.45	462766	.5	.76	643469	.39
	interaction	.16	425866	.6	.16	584588	.69
W9	subject vs. object	1.32	124052	.26	.31	156378	.58
	relative vs. adjunct	5.2	121914	.03*	3.46	158209	.07
	interaction	1.58	121117	.22	1.62	152871	.21
W10	subject vs. object	2.08	60741	.16	1.42	67592	.24
	relative vs. adjunct	3.09	61230	.09	1.34	68393	.26
	interaction	.35	63264	.5	.29	65276	.59
W11	subject vs. object	.01	480367	.9	.002	583705	.9
	relative vs. adjunct	9.1	467576	.006*	7.4	558073	.01*
	interaction	1.09	449508	.3	.53	538591	.47

5.2.1.5.3 Summary of Results

Overall, participants showed more processing difficulty with object gap sentences than with subject gap sentences, as measured by lower correct response rates and longer reading times within the main clause region. On the other hand, within the embedded clause region, subject gap sentences took longer to read than object gap sentences. This result is consistent with the results of Experiment 4-1, in which subject relative clauses took longer to read than object relative clauses within the relative clause region, while the reverse reading time pattern was observed within the main clause region. Moreover, there was also an effect of clause type: relative and adjunct clauses showed processing difficulty at different regions of the sentence.

Comprehension

Correct response rate	subject gap > object gap

> = higher accuracy scores

Reading times within the embedded clause region

RTs at W4 (one word after NP-ACC/NOM)	subject gap > object gap

> = longer reading times

Reading times within the main clause region

RTs at W7 (embedded verb)	object *pro* > subject *pro*
RTs at W8 (matrix subject)	object gap > subject gap
RTs at W9 (after matrix subject)	relative > adjunct clause
RTs at W11 (final main verb)	adjunct > relative clause

> = longer reading times

5.2.1.6 Discussion

The goal of Experiment 5.1a was to investigate whether there is a subject/object gap processing asymmetry in backward anaphoric dependencies, just as there is in syntactic dependencies. The overall results show that the subject/object gap processing asymmetry is not restricted to syntactic dependencies, but can also be found in anaphoric dependencies as well, suggesting that similar parsing mechanisms underlie syntactic and anaphoric dependencies. However, the results also suggest some differences between these two types of dependencies. In discussing the implications of the experimental results, I first address the issues related to subject/object gap processing asymmetry before turning to the question of different parsing strategies for these two types of dependencies.

5.2.1.6.1 Subject/Object Asymmetry & Evaluation of Processing Models

Although in general the effects were somewhat weaker in this experiment than in Experiment 4.1, probably due to the smaller number of trials (19 vs. 40 sets of sentences), the processing asymmetry between subject and object gaps was confirmed regardless of clause type.

Within the embedded clause region, where adjunct and relative clauses were identical, subject gap sentences took longer to read than object gap sentences at W4. As discussed in Experiment 4.1, this effect is likely to be due to the processing difficulty associated with non-canonical word order, since non-canonical word order necessitates a more complex syntactic representation. That is, while sentences starting with NP-NOM (i.e., object argument-drop and object relative clauses) necessitate projection of a simple intransitive construction in accordance with *minimal attachment* (Frazier, 1978), sentences starting with NP-ACC (i.e., subject argument-drop and subject relative clauses) signal a more complex structure with at least a two-place predicate for the subject and object. Furthermore, since the subject is missing, a gap needs to be postulated at this position as well. Thus, these more complex structure building operations in subject gap sentences could be responsible for the slow-down observed at W4, the position right after the sentence-initial NP-ACC.

On the other hand, in the main clause region, object gap sentences took longer to read than subject gap sentences at W8, the coindexed matrix subject position, in both relative and adjunct clause sentences. The results therefore seem compatible with the *phrase-structural distance hypothesis* (O'Grady, 1997) and the *accessibility hierarchy* (Keenan & Comrie, 1977), suggesting that backward anaphoric dependencies are also constrained by the structural complexity of dependencies (either defined by the phrase-structural distance between gap and antecedent or by low ranking of the gap in the accessibility hierarchy), just as backward and forward syntactic dependencies were shown to be, as discussed in Chapter 4.

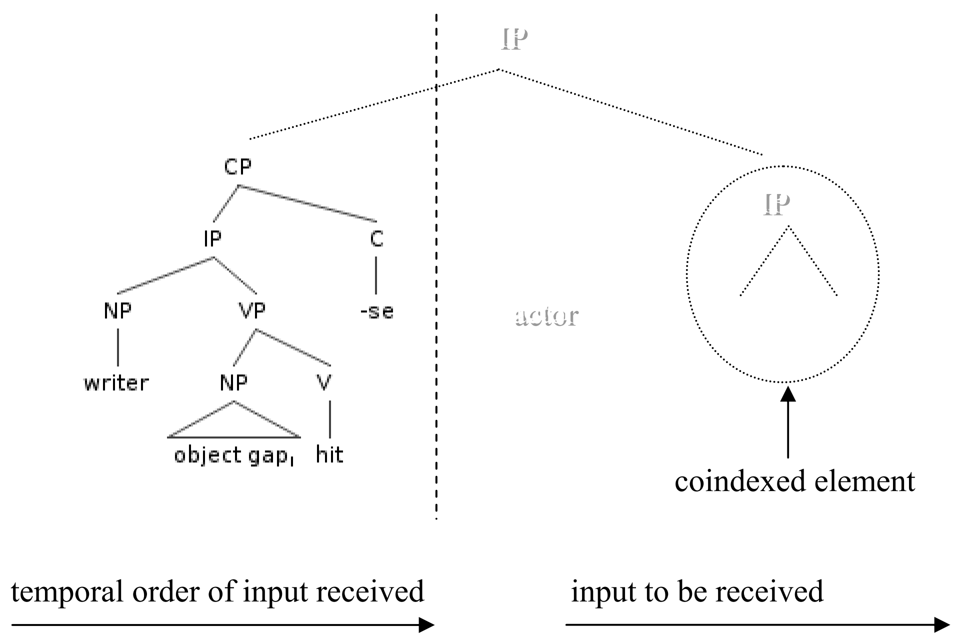
However, it should be noted that the *phrase-structural distance hypothesis* (O'Grady, 1997) is only partially supported by the experimental results. Due to longer phrase-structural distance between a gap and its antecedent, the *phrase-structural distance hypothesis* predicted that adjunct clauses would show more processing difficulty than relative clauses (cf. Figure 5-1 and Figure 5-2). Yet there was no systematic difference in processing difficulty between adjunct and relative clauses. Although at the embedded verb position, adjunct clauses showed longer reading times than relative clauses, this effect was restricted to the object drop adjunct clause condition, leading to an interaction of gap type and clause type in the statistical analysis. In addition, the effects at W9 (i.e., one word after the matrix subject position) and W11 (i.e., sentence-final position) showed opposite reading time patterns between the relative and adjunct clause conditions: at W9, relative clauses took longer to read than adjunct clauses, while at W11, adjunct clauses took longer to read than relative clauses. On the other hand, at the main clause subject position, at which a gap is associated with its filler/antecedent, there was no difference between the relative and adjunct clause conditions whatsoever. Thus, the absence of a systematic processing asymmetry between adjunct and relative clauses shows that although the *phrase-structural distance hypothesis* is supported by the subject/object processing asymmetry, it is only partially compatible with the overall results.

Now one remaining problem is to account for the different time-course of processing difficulty associated with the object *pro* and object relative clause conditions. The processing disadvantage of object argument-drop starts at the embedded verb position, while in the relative clause condition the effect is not evident until the matrix subject position. Since gap positions were manipulated to be identical across relative and adjunct clause conditions both linearly and structurally, this different processing profile cannot be due to the positional difference of the gap within the embedded clause. Moreover, the information about the argument structure of an embedded predicate should be available in both conditions equally. Two arguments are necessary to satisfy the argument structure requirement of the embedded clause predicate. At the embedded clause predicate position, however, only one argument position has been filled with an overt NP in both the relative and adjunct clause conditions. Therefore, the processing difference between the object relative and object *pro* conditions cannot be attributed to the argument structure of the embedded predicate either.

In fact, neither the *phrase-structural distance hypothesis* nor the *accessibility hierarchy* predicts this dissociation between the two clause types. That is, the *phrase-*

structural distance hypothesis calculates the complexity of a structure by counting the number of XPs (maximal projection) nodes between the gap and its associated element. At the embedded predicate position (W7), however, structural distance cannot be calculated because there is no element at this point in the sentence with which the gap can be associated, as shown in (5.27).

(5.27) Structure building at the embedded verb:



The *accessibility hierarchy* cannot account for this result at the embedded verb either. Even though the *accessibility hierarchy* could be extended to argument-drop, which could account for the processing difficulty at the embedded verb position in the adjunct clause condition, it does not provide n account of why only dropped object arguments show processing difficulties at the embedded verb position, while object relative clauses do not.

One possibility is that the difference in frequency of occurrence between object argument-drop adjunct clauses and relative clauses could be responsible for this processing difference. The corpus results suggested that the frequency of *–se* clauses is much lower than the frequency of the adnominal marker (6,258 vs. 89,329 out of one million *ejels*). Furthermore, the corpus results showed that object argument-drop in *–se* clauses is extremely rare compared to object relatives (7 vs. 108 out of 6,258 *ejels*). This extremely low frequency of dropped object arguments could have led to processing difficulty.

However, this frequency-based account cannot account for why subject argument-drop does not show the same processing difficulty at the embedded verb in comparison to subject relatives, despite its relatively low frequency in comparison to subject relatives (29 vs. 251 out of 6,258 *ejels*). Perhaps this is because in subject gap sentences, the information about the missing argument comes relatively early, possibly easing the processing difficulty associated with the low frequency of the construction. This differs from object gap sentences, in which the missing argument and the low-frequency adjunct suffix occur at the same time point of processing, thus causing extra processing difficulty.

In fact, a similar account has been put forward for the subject/object asymmetry of SRs and ORs in English. In English, while in SRs the missing argument comes relatively early, in ORs the missing argument and the main verb (i.e., thematic role assignment) occur approximately at the same time, causing extra working memory costs in processing ORs (King & Kutas, 1995). This suggests that simple frequency alone cannot account for the data.[3]

5.2.1.6.2 Dependency-Specific Processing

The experimental results have implications for the parsing of different types of long-distance dependencies. Specifically, the effects at W9 (i.e., longer reading times for the relative clause conditions in comparison to the adjunct clause conditions) and W11 (i.e., longer reading times for the adjunct clause conditions in comparison to the relative clause conditions) could be attributed to the nature of the different types of long-distance dependencies in question. That is, the main role of a relative clause is to modify the head noun, which is clearly indicated by the adnominal marker attached to the embedded verb. Therefore, a syntactically licensed gap within a relative clause is immediately and completely associated with the head noun (i.e., matrix subject). This association of the semantics conveyed by the relative clause with the head noun position could have caused extra processing difficulty, leading to the slowdown at W9, the NP immediately following the head noun.

On the other hand, the main role of *–se* 'because' is to encode causality: cause (the *–se* 'because' clause) vs. effect (the matrix clause). Thus, the role of the embedded clause does not end until the end of the sentence, at which point the parser could complete the integration of the semantics denoted in the two clauses for a sentence-level interpretation of causality. In terms of gap-antecedent association, the relation between a gap and the matrix subject in an anaphoric dependency is not syntactically licensed, but is

[3] It is possible that a more fine-grained probabilistic approach could account for the results (Hale, 2006; Levy, 2008).

semantically and pragmatically motivated. Thus, even though the parser might immediately associate the gap with the matrix subject under the influence of active search mechanisms (Aoshima et al., in press; Kazanina et al., 2007; van Gompel & Liversedge, 2003), it might continue to evaluate the inter-clausal relationship of the embedded and the main clauses to check the fit of the gap and the matrix subject with the causality interpretation. Therefore, the semantics conveyed in the adjunct clause are not wrapped up until the end of the sentence, and this could be responsible for the slow-down at W11 (the sentence-final word, the matrix predicate) in the adjunct clause condition.

5.2.1.6.3 Active Search Mechanisms

The slower reading times at the matrix subject position in adjunct clauses with object gaps also have implications for active search mechanisms (van Gompel & Liversedge, 2003; Kazanina et al., 2007). That is, unlike syntactic dependencies, a gap in an adjunct clause does not obligatorily require a sentence-internal antecedent. In addition, gap-antecedent association should be semantically/pragmatically licensed based on the interpretation of the inter-clausal relationship, which is not complete until the end of the sentence. However, upon encountering a potential antecedent (i.e., the matrix subject in this case), the parser immediately associated the gap with this antecedent, leading to slower reading times in the object gap than in the subject gap condition at the main clause subject. This suggests that backward gap-antecedent association in anaphoric dependencies is immediate, just as gap-filler association is in syntactic dependencies (Aoshima et al., in press; Kazanina et al., 2007; van Gompel & Liversedge, 2003).

5.2.1.7 Summary

To summarize, the results of Experiment 5.1a showed both similarities and differences in the parsing of syntactic and anaphoric dependencies. In terms of similarity, object gaps were more difficult to process than subject gaps in both argument-drop sentences (i.e., backward anaphoric dependencies) and relative clause sentences (i.e., backward syntactic dependencies). This result can be accounted for in terms of processing models based on language universals, such as the *phrase-structural distance hypothesis* (O'Grady, 1997) and the *accessibility hierarchy* (Keenan & Comrie, 1977). However, the fact that the adjunct clause conditions were not systematically more difficult to process than the relative clause conditions suggests that the *phrase-structural distance hypothesis* can only partially account for the experimental results.

On the other hand, the experimental results were also discussed in terms of corpus frequencies to account for the difference in time-course of the processing disadvantage for object gaps in argument-drop and relative clause sentences. It was suggested that simple corpus counts are partly compatible with the results but cannot account for the full range of data

The experimental results also had different implications for the parsing of relative clauses (i.e., syntactic dependencies) and adjunct clauses (i.e., anaphoric dependencies). In the relative clause conditions, a slow-down was observed at the word immediately following the head noun regardless of gap type (i.e., subject vs. object gap) in comparison to the adjunct clause conditions. On the other hand, in the adjunct clause conditions, a slow-down was observed at the sentence-final position in both subject and object gap sentences in comparison to the relative clause conditions. These effects were taken to suggest different roles for relative and *–se* clauses and different coindexation requirements for syntactically licensed syntactic dependencies (i.e., relative clauses) and semantically licensed anaphoric dependencies (i.e., adjunct clauses). In the relative clause conditions, the role of the relative clause is to modify the head noun and thus gap-filler association is immediate and complete at the head noun (i.e., the matrix subject position), leading to longer reading times at the NP immediately following the head noun. On the other hand, in the adjunct clause condition, the causal role introduced by the *–se* suffix does not end until the very end of the sentence. Similarly, gap-antecedent association in the adjunct clause conditions is immediate but subject to continuous evaluation of the semantic fit of this association through the end of the sentence, leading to longer reading times at the sentence-final matrix verb.

The main effect of a subject/object gap asymmetry at the matrix subject position was interpreted as suggesting that, just like syntactic dependencies, anaphoric dependencies are driven by an active search for a potential antecedent, such that the parser immediately associates a gap with its potential antecedent (van Gompel & Liversedge, 2003; Kazanina et al., 2007). In other words, even though the association of a gap and its antecedent in an anaphoric dependency should be semantically/pragmatically licensed on the basis of the inter-clausal interpretation, the parser immediately associated the gap with the potential antecedent at the matrix subject position, contributing to the subject/object asymmetry at that position.

5.2.2 Experiment 5.1b: *Fact*-CP vs. Syntactic Dependencies

The overall results of Experiment 5.1a showed that subject gap sentences are easier to process than object gap sentences regardless of dependency type. This effect was taken to support phrase structural complexity (O'Grady, 1997) and the accessibility of a gap (Keenan & Comrie, 1977) as universal constraints on the processing of both syntactic and anaphoric dependencies. In addition, the subject/object asymmetry at the matrix subject position regardless of dependency type (syntactic vs. anaphoric) was also taken to indicate that gap-antecedent association in the anaphoric dependencies is just as immediate as gap-filler association in syntactic dependencies, supporting the idea of active search mechanisms (Kazanina et al., 2007).

Yet given the ubiquitous nature of argument drop in Korean (subject: 69.4%; object: 52.8%, Y.-J. Kim, 2000) and the language's high tolerance for structural ambiguity (see examples (5.7) to (5.10)), the question remains how "active" this search process is. That is, it is not clear whether an antecedent is postulated as soon as the parser encounters a pronoun near the beginning of a sentence (or identifies a gap as in the current experiment), or whether it waits to posit an antecedent until a potential antecedent is actually encountered (or, alternatively, a structural predictor of an antecedent is encountered, such as a subordination marker that reliably signals the presence of an upcoming matrix subject that could potentially serve as an antecedent; see Kazanina et al., 2007 for discussion of the possible role of a structural predictor). It is important to note that the Korean adnominal marker, which has been glossed as "-REL" throughout the dissertation, is in fact not a reliable predictor of a head noun that can serve as an antecedent for the preceding gap in the embedded clause. This is because the same adnominal marker is used not only to mark relative clauses, but also as a subordinator for the sentential complements of abstract head nouns like 'fact' that are unsuitable as antecedents for preceding gaps. It is therefore important to investigate such cases in order to determine at which point in the parse an antecedent is postulated. If, on the one hand, the parser posits an antecedent before the head noun position, assuming that the embedded clause is a relative clause, this projection will need to be revised when the embedded clause turns out instead to be the sentential complement of a head noun that is not suitable as an antecedent for a missing argument. If, on the other hand, the parser waits until there is unambiguous evidence for the presence of a suitable antecedent at the head noun position, it would essentially be adopting a "last resort" strategy (Fodor, 1978), and this runs counter to current thinking about active search mechanisms (Kazanina et al., 2007). Furthermore, bear in mind that there can be other sources of structural ambiguity sentence-initially, as when a sentence begins instead with an adjunct clause containing a dropped argument, as in Experiments 5.1a and 5.2 of this chapter). This additional structural ambiguity further complicates the search process. Experiment 5.1b is thus designed to investigate these issues. In the experiment, I compare the processing of sentences in which the missing argument is either a relative clause gap (5.28) or a null pronominal in a *fact*-CP clause (5.29).

(5.28) Relative clause

[__$_i$	ku	sinmwunsa-uy	pheyncipcang-ul	noymwul	swuswu	hyumuy-lo
	that	newspaper-GEN	editor-ACC	bribe	taking	charge-for

hyeppakha-n]	salam$_i$-i	yeciepsi	alye-ci-ess-ta
threaten-REL	person-NOM	without.exception	reveal-PASS-PST-DECL

'The person$_i$ who ___$_i$ threatened the editor of the newspaper on suspicion of taking bribes was unequivocally revealed.'

(5.29) *Fact*-CP clause

[__$_i$	ku	sinmwunsa-uy	pheyncipcang-ul	noymwul	swuswu	hyumuy-lo
	that	newspaper-GEN	editor-ACC	bribe	taking	charge-for

hyeppakha-n]	sasil-i	yeciepsi	alye-ci-ess-ta
threaten-REL	fact-NOM	without.exception	reveal-PASS-PST-DECL

'The fact$_k$ that ___$_i$ threatened the editor of the newspaper on suspicion of taking bribes was unequivocally revealed.'

The two conditions are identical to each other up through the embedded verb marked with an adnominal marker. Both contain a gap in the subject position of the embedded clause. The two conditions, however, differ from each other at the head noun position: while in the RC condition, the gap can be integrated with the filler as part of complex noun phrase, in the *fact*-CP condition it is clear that the missing argument is a null pronominal, and the referent of this missing argument is not identified within the sentence. Importantly, sentences with subject gaps were used to give the parser a relatively early cue that an argument was missing, namely the non-canonical sentence-initial accusative-marked NP.

The predictions for this experiment are straightforward. If the parser postulates an antecedent anytime prior to encountering the actual head noun itself, this should cause processing difficulty in the *fact*-CP condition at the head noun position, when the head noun turns out to be unsuitable as an antecedent. Consequently, reading times should be longer in the *fact*-CP than in the relative clause condition. If the parser instead waits until it encounters a suitable head noun before positing an intra-sentential antecedent for the gap in the embedded clause, then gap-filler/antecedent association at the head noun position should consume processing resources. This should cause a slowdown in reading times for the relative clause condition relative to the *fact*-CP condition at the head noun.

5.2.2.1 Methods

5.2.2.1.1 Participants

35 native Korean speakers participated in the study. All had normal or corrected-to-normal vision. At the time of the experiment, participants were enrolled either in a short-term English language program or in graduate school at UCSD. They received $10 per hour for their participation in the experiment.

5.2.2.1.2 Materials

40 sets of experimental conditions like (5.28) and (5.29) were constructed. Between conditions, all the lexical words except for the head nouns were identical. Since the head nouns typically used in the *fact*-CP clauses are all high frequency words, similarly high frequency words were used as head nouns in the relative clause construction, to remove any processing effect associated with frequency. For RCs, the head nouns were *namca* ‘man’, *yeca* ‘woman’, *sonye* ‘girl’, *sonyn* ‘boy’, and *salam* ‘person’. For *fact*-CPs, the head nouns were *saken* ‘accident’, *sasil* ‘fact’, *sathay* ‘situation’, *iyaki* ‘story’, and *il* ‘occasion/job’. In the Sejong corpus (2002) with 10 million *ejel*, the average frequency of the RC head nouns was 12,154 (most frequent and least frequent words: *il* ‘occasion/job’ and *sathay* ‘situation’, with frequencies of 25,828 and 1,912 per million, respectively) while the average frequency of *fact*-CP head nouns was 10,732 (most frequent and least frequent words: *salam* ‘person’ and *sonye* ‘girl’, with frequencies of 45,955 and 589 per million, respectively). RC head nouns were slightly more frequent than *fact*-CP head nouns, but all the nouns used were of high frequency.

Two other relative clause studies with four and two conditions, respectively, were run concurrently with this experiment. The target constructions were split into eight lists according to a Latin-square design. There were 65 additional fillers consisting of simple and complex sentences. Overall, each list contained 70 non-relative and 40 relative clause sentences.

5.2.2.1.3 Procedures

The procedure was identical to Experiment 4-1 and 5-1a. There was a practice session with eight sentences.

5.2.2.1.4 Analysis

A commercially available statistical package (JMP IN) was used for analyzing the data. All 35 subjects were included in the RT analysis (mean accuracy 84%, with a range of 70% to 100%).

5.2.2.2 Results

5.2.2.2.1 Comprehension Questions

The two conditions did not differ from each other in comprehension accuracy scores. Both conditions showed a comprehension accuracy rate of 84%.

5.2.2.2.2 Reading Times

Embedded clause region

The two conditions used identical words in the embedded clause. Accordingly, there was no significant difference in reading time between the two conditions in this region (RC: 4239 ms vs. *fact*-CP: 4229 ms) [$F_1(1,34) = .004$, $MSE = 1{,}883{,}999$, $p < 0.94$; $F_2(1,39) = .048$, $MSE = 1{,}932{,}930$, $p < 0.83$].

Main clause region

Figure 5-8 shows the reading times in the main clause region.

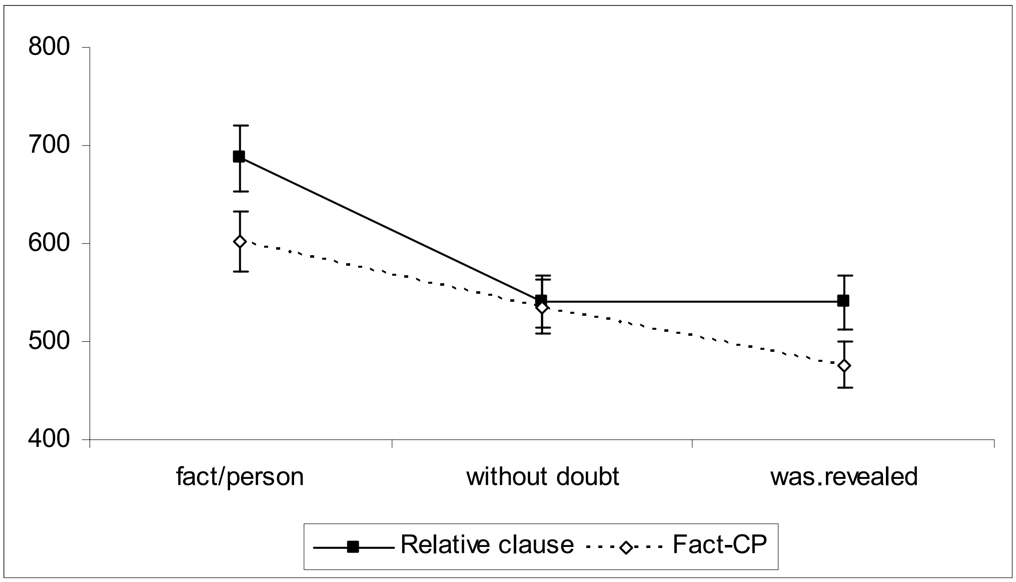


Figure 5-8 Exp 5.1b, Reading times in the matrix clause region

The head nouns in the two conditions were different and therefore of different length. Thus, the analysis was conducted on residual reading times (Ferreira & Clifton, 1986). Reading times were significantly longer in the relative clause condition than in the *fact*-CP condition [$F_1(1,34) = 4.18$, $MSE = 113{,}651$, $p < 0.05$; $F_2(1,39) = 4.73$, $MSE = 124{,}677$, $p < 0.05$]. At the sentence-final main verb position, reading times in the relative clause condition were again longer than in the *fact*-CP condition [$F_1(1,34) = 7.34$, $MSE = 57{,}493$, $p < 0.01$; $F_2(1,39) = 5.48$, $MSE = 58{,}792$, $p < 0.05$].

5.2.2.3 Discussion

Overall, the RC condition caused greater processing difficulty than the *fact*-CP condition, as evidenced by longer reading times at the head noun and the sentence-final main verb positions. Since the words used as head nouns in the *fact*-CP condition were slightly more frequent than the ones used in the relative clause condition, this effect cannot be due to frequency. Although it is possible that the longer reading times in the RC condition were due to the presence of a syntactic dependency, which is inherently more complex, the reading time profile of the *fact*-CP condition did not indicate any processing difficulty associated with the parser's efforts to find a "missing filler/antecedent" if it was in fact expecting a filler or an antecedent.

Since there was unfortunately no baseline condition (i.e., a *fact*-CP condition without a gap), the experiment cannot provide conclusive evidence against an active search mechanism. That is, while the *fact*-CP condition with a gap was read faster than the relative clause condition at the head noun position in this experiment, this could be for independent reasons. For example, as indicated above, it could be simply because the relative clause condition involves a syntactically licensed dependency between the head noun and the gap (and therefore requires greater processing resources), while no such dependency is possible in the *fact*-CP condition. What we do not know for certain is whether the *fact*-CP condition with a gap might still show a reading time slowdown at the head noun position when compared to a baseline *fact*-CP condition without a gap. This would indicate that the parser was actively searching for an antecedent for the gap in the gapped *fact*-CP condition, i.e. failing to find one rather than merely not bothering to look for one. The relative clause condition might then still be slower than the *fact*-CP condition with a gap at the head noun position, as per the account given above, resulting in a three-way difference. If instead the *fact*-CP conditions with and without gaps patterned together at the head noun position (i.e. if both were read faster than the relative clause condition to the same degree, resulting in an overall two-way difference), this would indicate that there had been no search on the part of the parser for a potential antecedent for the gapped position in the sentential complement. This would then constitute more conclusive evidence against an active search mechanism account for backward dependencies in Korean.

Nevertheless, the current experimental results along with the results in Experiment 5.1a may suggest that even though the parser may place a high priority on dependency formation upon encountering a potential antecedent, it does not exclude the possibility that there might not be a sentence-internal antecedent. This means that in backward dependencies, the parser might form the dependency whenever it can, but only when it is possible to do so.

5.2.2.4 Summary

Comparison of the processing of *fact*-CP clauses and of relative clauses showed that at the head noun and sentence-final positions, the relative clause condition took longer to read than the fact-CP condition. This effect was attributed to processing difficulty associated with forming a syntactic dependency, which is missing in *fact*-CP clauses. Moreover, no effect was observed that would correspond to the filler's search for a missing filler/antecedent in the *fact*-CP condition. Given that the experiment lacked a baseline condition (i.e., a condition without a gap), the absence of an effect cannot provide conclusive evidence against active search mechanisms discussed in Chapter 5-1a and Chapter 3. However, the results suggest that the active search mechanism underlying anaphoric dependencies could kick in only when the parser identifies a potential antecedent: when the parser identifies an NP, it prefers to associate it with a gap as a potential antecedent, but it does not exclude the possibility that there is no sentence-internal antecedent. Thus, the question of how actively this search mechanism is carried out is in need of further investigation.

5.3 Experiment 5.2: ERP experiment

As claimed in previous studies of anaphoric dependencies (Aoshima et al., in press; Kazanina et al., 2007; van Gompel & Liversedge, 2003), Experiment 5.1a suggested that the parser immediately associates the gap with its potential antecedent in anaphoric dependencies just as it does in syntactic dependencies, leading to the slower reading times in object gap sentences than in subject gap sentences at the matrix subject position. In addition, the results suggested that this gap-antecedent association in anaphoric dependencies is subject to evaluation until end of sentence end.

However, although quantitative measurements of self-paced reading time provide tentative cognitive evidence for on-line sentence processing difficulty, an ERP experiment can provide qualitative information about on-line sentence processing with millisecond temporal precision. Experiment 5.2 is thus designed to further our understanding of the processing of anaphoric and syntactic dependencies using ERPs. For this purpose, Experiment 5.2 compares the processing of two sub-conditions of Experiment 5.1a: object relative clauses and object argument-drop sentences ((5.30) and (5.31)).

(5.30) Object relative clause sentence

[$_{\text{EMB CL}}$ hwalang-uy	taypyo-ka	___$_i$	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-**n**]	hwaka$_i$-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-**REL**	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

'The painter who the representative of the gallery highly evaluated at the international exhibition gained the attention of the world.'

(5.31) Object argument-drop sentence

[$_{\text{EMB CL}}$ hwalang-uy	taypyo-ka	___$_i$	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-**se**]	hwaka$_i$-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-**because**	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

'Because the representative of the gallery highly evaluated (him$_i$) at the international exhibition, the painter$_i$ gained the attention of the world.'

As discussed in Experiment 5.1a, the only difference between the two constructions is that the embedded verb is marked with an adnominal marker in the relative clause (i.e., creating a syntactic dependency) and with an adjunct suffix in the adjunct clause (i.e., creating an anaphoric dependency). Yet in both cases, the gap within the embedded clause is associated with the matrix subject, licensed syntactically in the relative clause condition and semantically in the adjunct clause condition.

In this section, I compare object argument-drop and object relative clause sentences like (5.30) and (5.31) using ERP methodology. In so doing, I investigate the second of the two questions posed at the beginning of the chapter:

ii) To what extent are the cognitive/neural processes underlying long-distance dependencies in different constructions the same?

5.3.1 Predictions

In Experiment 4.2 in Chapter 4, I discussed the following possible processing operations involved in backward syntactic dependencies, repeated below in (5.32).

(5.32) Hypothesized processes involved in backward syntactic dependencies

i) A gap (or incomplete dependency) needs to be maintained in working memory in expectation of a filler.
ii) At the filler site, a gap needs to be reactivated.
iii) The gap should be associated with the filler.

There were no ERP effects related to (i) holding a gap in working memory in Experiment 4.2. Moreover, since the two conditions in Experiment 5.2 are identical to each other within the embedded clause region, there are no predictions either for the embedded clause region or for the maintenance of a gap in working memory.

On the other hand, the experimental results of Experiment 5.1a suggested potentially crucial ERP differences related to the processing of anaphoric and syntactic dependencies. That is, the relative clause condition elicited longer reading times at W9, the NP immediately following the head noun (i.e., matrix subject), and the adjunct clause condition elicited longer reading times at the sentence-final position. These reading time differences were related to different gap-filler/antecedent association requirements. Accordingly, it is predicted that there will be corresponding ERP effects associated with these reading time results, as discussed below.

At the matrix subject position, the parser will associate a gap in the embedded clause with the matrix subject as a filler or potential antecedent in both the relative and adjunct clause conditions. However, in the relative clause condition, there is an additional process: since the main role of the relative clause is to modify the head noun, the parser should also associate the semantics conveyed by the relative clause with the head noun. Accordingly, at the matrix subject position, the relative clause condition should incur higher working memory costs than the adjunct clause condition. Given the results of Experiment 4.2, in which higher working memory loads related to backward syntactic association elicited sustained anterior negativity, it is predicted that the relative clause condition will elicit left anterior negativity in comparison to the adjunct clause condition at the head noun position.

On the other hand, after the matrix subject position, the adjunct clause should incur higher working memory costs in comparison to the relative clause condition at sentence end. This is because, unlike the relative clause condition, in which gap-filler association is complete at the head noun position, in the adjunct clause condition the parser may continue to evaluate the inter-clausal relationship for the semantic fit of the gap with the potential antecedent. This hypothesis is supported by the results of Experiment 5.1, in which the adjunct clause conditions took longer to read than the relative clause conditions at the sentence-final position. In fact, a previous ERP study has showed that working memory demands associated with processing of higher-level inter-clausal evaluation elicited a slow negative left anterior potential (Münte et al., 1998). That is, in comparison to sentences in which two events are presented in real-world event order (i.e., *"After the scientist submitted the paper, the journal changed its polity"*), sentences in which events are presented in reverse chronological order (i.e., *"Before the scientist submitted the paper, the journal changed its polity"*) elicited left-lateralized slow negative potentials. Similarly, the adjunct clause condition in this experiment is predicted to cause higher working memory demands due to this continuous evaluation of the inter-clausal relationship. Thus, there should be an increase in (left) anterior negativity in response to the adjunct condition at sentence end.

Apart from the ERP effects associated with gap-filler/antecedent association, it is also predicted that there will be ERP effects related to the slower reading times at the embedded verb position of the object gap adjunct condition in Experiment 5.1a. The effect was attributed to the lower frequency of the object gap in -*se* 'because' adjuncts. In terms of ERP components, it has been shown that the N400 is sensitive to frequency such that less frequent words elicit a larger N400 than more frequent words (Allen, Badecker, & Osterhout, 2003; Barber, Vergara, & Carreiras, 2004; Münte, Wieringa, Weyerts, Szentkuti, Matzke, & Johannes, 2001; Van Petten, 1993; Van Petten & Kutas, 1990; Van Petten & Kutas, 1991). Furthermore, in addition to lexical frequency, findings in King and Kutas (1995) could point to the influence of constructional frequency. King and Kutas reported that object relative clauses elicited an N400 at the definite article in the early relative clause region (i.e., "The reporter who *the...*"). Noting that the effect was observed only in poor comprehenders but absent in good comprehenders, and that subject relatives are more frequent than object relatives, the authors attributed this effect to the low-cloze probability of an object relative sentence continuation. That is, poor comprehenders had a lower expectation for or discounted the possibility of an object relative clause continuation of the fragment "The reporter who". Likewise, given that the *–se* 'because' construction is much less frequent than constructions with *–n*, the adnominal marker, it is predicted that the *–se* 'because' adjunct clause condition may elicit an N400 in comparison to the relative clause condition.

To summarize, the following predictions were made.

(5.33) Predictions

i) At the embedded verb-REL/-because, the adjunct clause condition should elicit an N400 in comparison to the relative clause condition.

ii) At the matrix subject, the relative clause condition should elicit LAN in comparison to the adjunct clause condition.

iii) At sentence end, the adjunct clause condition should elicit (left) anterior negativity in comparison to the relative clause condition.

To examine these predictions, ERP responses to the adjunct and relative clause conditions will be compared in the three regions presented in Table 5-9.

Table 5-9 Points of comparison and summary of predictions

hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

matrix subject position: LAN to relative clause condition

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

embedded verb position:
N400 to adjunct clause condition

matrix clause:
increase in (left) anterior negativity to adjunct clause condition

Relative clause: 'The painter who the representative of the gallery highly evaluated at the international exhibition gained the attention of the world.'
Adjunct clause: 'Because the representative of the gallery highly evaluated (him$_i$) at the international exhibition, the painter$_i$ gained the attention of the world.'

5.3.2 Norming study

As in Experiment 5.1, the goal of the norming study was two-fold. The first goal was to control the naturalness of the relative and *pro*-drop sentences. The second goal was to control the referential identification of *pro* to ensure that *pro* would be interpreted as co-referential with the subject of the main clause.

5.3.2.1 Methods

The norming study was conducted in the same session as the norming study for the first ERP experiment, with the same participants. For details on participants, please refer to Section 4.3.2.

Materials

80 sets of object relative and object argument-drop sentences for the ERP experiment were used as target constructions in the norming study. An example is given in English below.

(5.34) Object relative clause
'The painter$_i$ who the representative of the gallery highly evaluated __$_i$ at the international exhibition gained the attention of the world.'

(5.35) adjunct clause with dropped object
'Because the representative of the gallery highly evaluated __$_i$ at the international exhibition, the painter$_i$ gained the attention of the world.

Procedures

Participants saw one sentence from each pair of object relative and argument-drop sentences. They were asked to rate a sentence as 1 if it sounded natural and as 5 if the sentence sounded strange, as shown in (5.36) and (5.37). If the sentence was an object *pro* sentence, the participants were additionally asked to rate the referential identity of the dropped object, as in (5.37).

(5.36) Norming example of relative clause sentence
'The painter$_i$ who the representative of the gallery highly evaluated __$_i$ at the international exhibition gained the attention of the world.'

☞ Please rate this sentence for its naturalness.

Sounds natural Sounds strange

1 2 3 4 5

(5.37) Norming example of -*se* 'because' adjunct clause
'Because the representative of the gallery highly evaluated __$_i$ at the international exhibition, the painter$_i$ gained the attention of the world.'

☞ Please rate this sentence for its naturalness.

Sounds natural | Sounds strange

1 2 3 4 5

☞ Who did the representative highly evaluate?

the painter | not clear

1 2 3 4 5

5.3.2.2 Results

Six subjects did not complete the questionnaire containing the current experimental conditions and were thus excluded from the analysis. Results showed that object relative and argument-drop clause sentences do not differ from each other in terms of naturalness [$t(137) = .29$, $p < .6$]. The means for naturalness were 3 for object relative clause sentences and 3.1 for object argument-drop sentences. The means for the reference identification of argument-drop sentences was 2.4. Considering that the reference of *pro* can never completely exclude an arbitrary reading, the results clearly showed that there is a preference in interpreting the gapped argument as the matrix subject.

5.3.3 ERP Methods

5.3.3.1 Participants

The ERP experiment was combined with the ERP experiment reported in Chapter 4 due to the paucity of available Korean speakers at UC-San Diego. For details of participants, please refer to Section 4.3.3.1.

5.3.3.2 Materials

Eighty sets of object relative (5.30) and object-argument drop adjunct clause constructions (5.31) were constructed. For details on fillers and presentation lists, please refer to Section 4.3.3.2.

5.3.3.3 Procedures

Please refer to Section 4.3.3.3 for details on procedures.

5.3.3.4 Electrophysiological Recording

Please refer to Section 4.3.3.4 for details on electrophysiological recording.

5.3.3.5 Data Analysis

For phasic effects, ,mean amplitude area measurements were taken of single-word averages, which consisted of 1000 ms epochs, including a 100 ms prestimulus baseline. For longer-lasting effects, measurements were taken of two-word and three-word averages, which consisted of 1400 ms epochs, including a 400 ms prestimulus baseline (2 x 500 ms SOA plus a 400 ms prestimulus baseline) and 2000 ms epochs, including a 500 ms prestimulus baseline (3 x 500 ms SOA plus a 500 ms prestimulus baseline). Trials contaminated by excessive muscle activity, amplifier blocking or eye movements were discarded offline before averaging. On average, 4%, 8% and 13% of trials were rejected for single-, two-, and three-word averages, respectively. The averaged data were algebraically re-referenced to the mean of the activity at the two reference electrodes. For purposes of visualization, ERP waves were smoothed using a low pass filter with a cutoff frequency of 7 Hz.

ANOVAs were calculated based on mean area voltage measurements in standard latency windows of 150 to 250 ms for P200 effects and of 300 to 600 ms for N400 and phasic LAN effects. In addition, long-lasting potentials were measured from 300 ms to 1100 post-onset of relevant sentence positions. The data were submitted to an overall ANOVA with repeated measures of experimental condition (SR vs. OR) and electrodes (26 levels). This analysis is referred to as the full analysis. In addition to the full analysis, a distributional analysis was conducted, including experimental condition (SR vs. OR), hemisphere (left vs. right), laterality (lateral vs. medial) and anteriority (4 levels: prefrontal vs. frontal vs. parietal vs. occipital) as in Experiment 4-3 in Chapter 4 (see Figure 5-9 for the electrodes included in the analysis). Additionally, a midline analysis was conducted with two within group factors, including clause type and four levels of anteriority (MiPf, MiCe, MiPa, and MiOc), as in Figure 5-10. The Huynh-Feldt (1976) correction for lack of sphericity was applied and corrected *p* values are reported with original degrees of freedom.

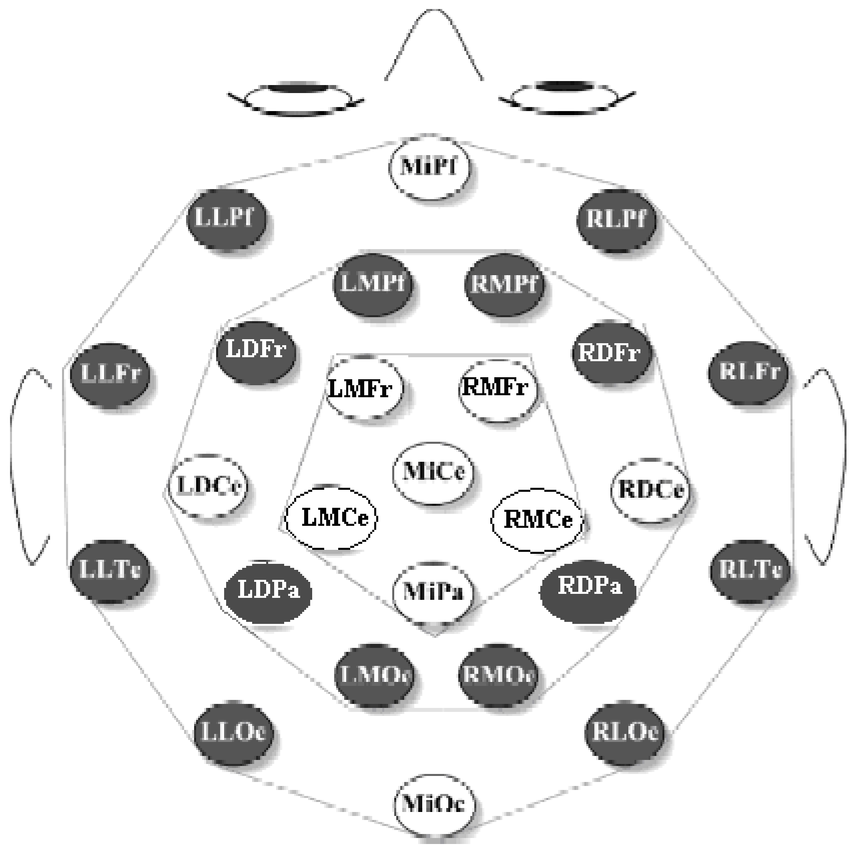


Figure 5-9 Configuration of electrodes included in distributional analysis
(layout adopted from Cowles, 2003)

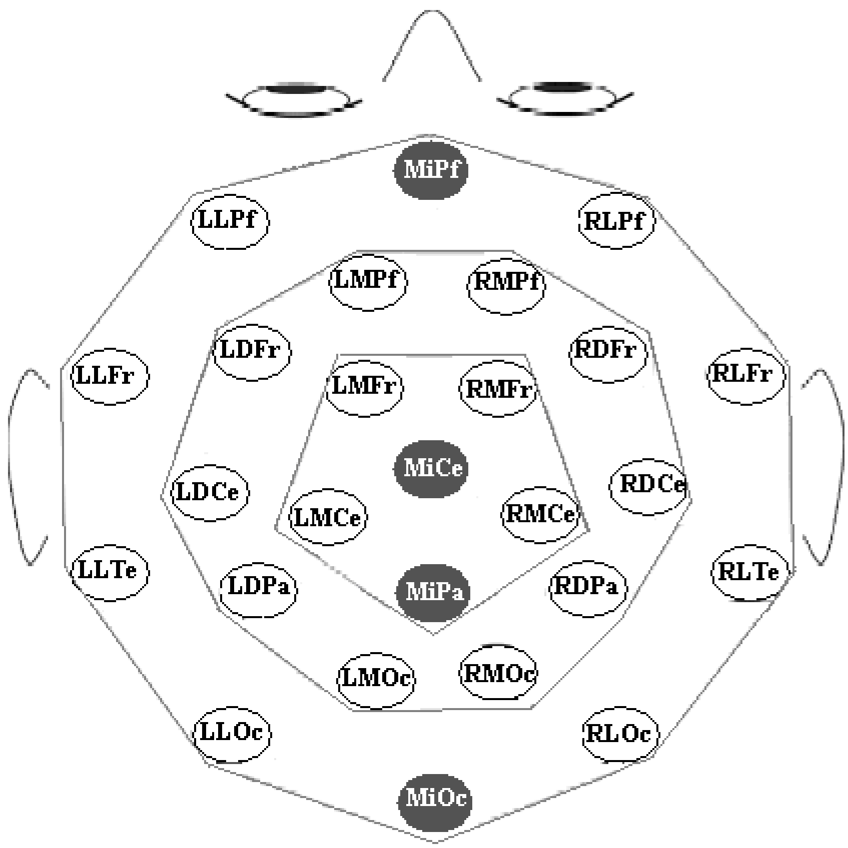
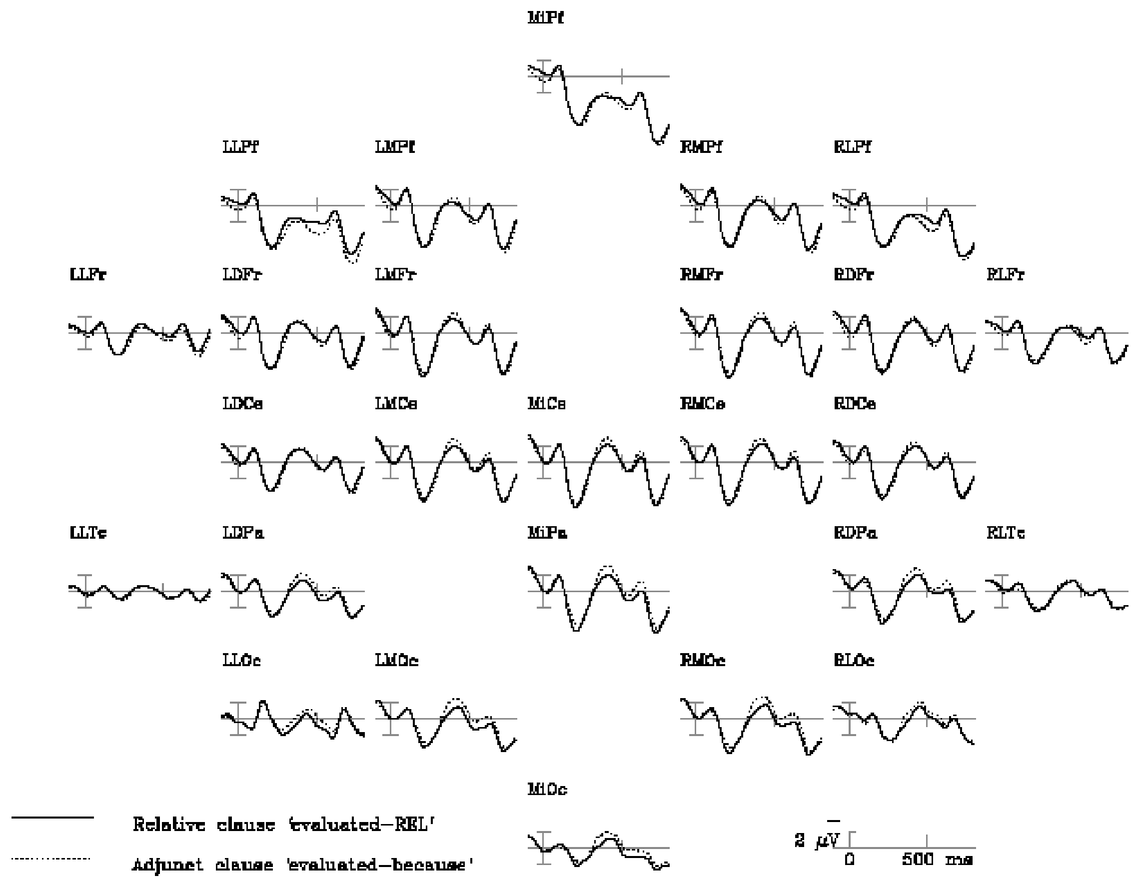


Figure 5-10 Configuration of electrodes included in midline analysis
(layout adopted from Cowles, 2003)

5.3.4 Results

5.3.4.1 Embedded Verb Region

On visual inspection, the ERP to the adjunct clause condition appeared to be more negative than that to the relative clause condition in the P200 region over the back of the head. Additionally, starting roughly around 300 ms post-stimulus onset, there was widespread negativity with a medial maximum in response to the adjunct clause condition compared to the relative clause condition.



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-11 Exp 5.2, W6 (V-REL/because) 0 to 800 ms

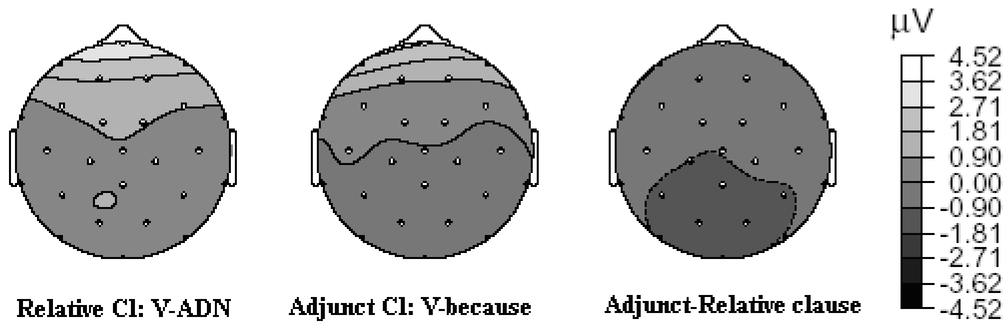
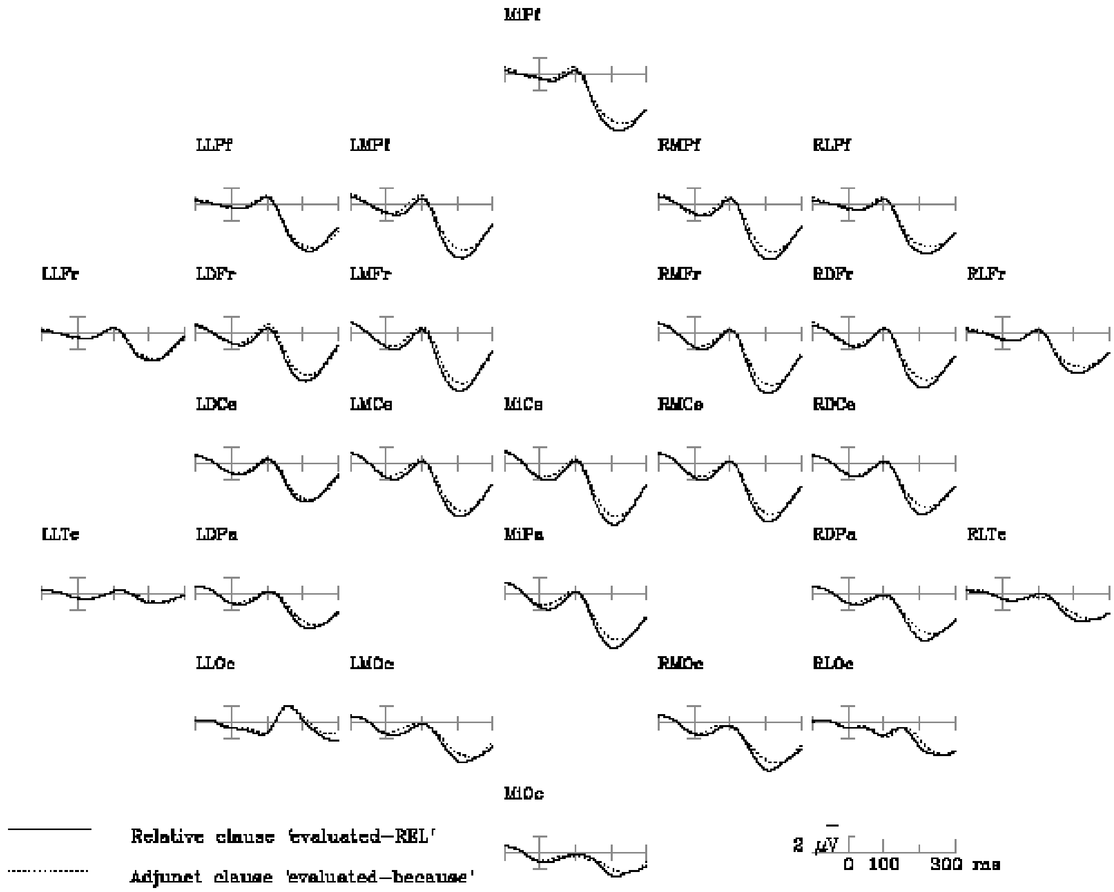


Figure 5-12 Exp 5.2, Isovoltage map at W6 (V-REL/because)[4]

Statistical analysis of mean amplitude measurements between 150 and 250 ms post-stimulus onset of the embedded verb corroborated the P200 difference. There was a significant main effect of clause type [$F(1,23) = 4.72$, $p < .04$] in the full analysis, and a significant main effect of clause type [$F(1,23) = 5.54$, $p < .03$] and a marginal interaction of clause type, hemisphere and laterality [$F(1,23) = 3.44$, $p < .08$] in the distributional analysis. This interaction was caused by the fact that the P200 response to the relative condition was more positive than that to the adjunct condition everywhere but left lateral electrodes, as can be seen in Figure 5-13. In addition, there was also a main effect of clause type [$F(1, 23) = 4.57$, $p < .04$] in the midline electrodes analysis.

[4] The isovoltage map is based on averaged data that were filtered with a digital bandpass filter of .1 to 10 Hz to reduce high-frequency noise.



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

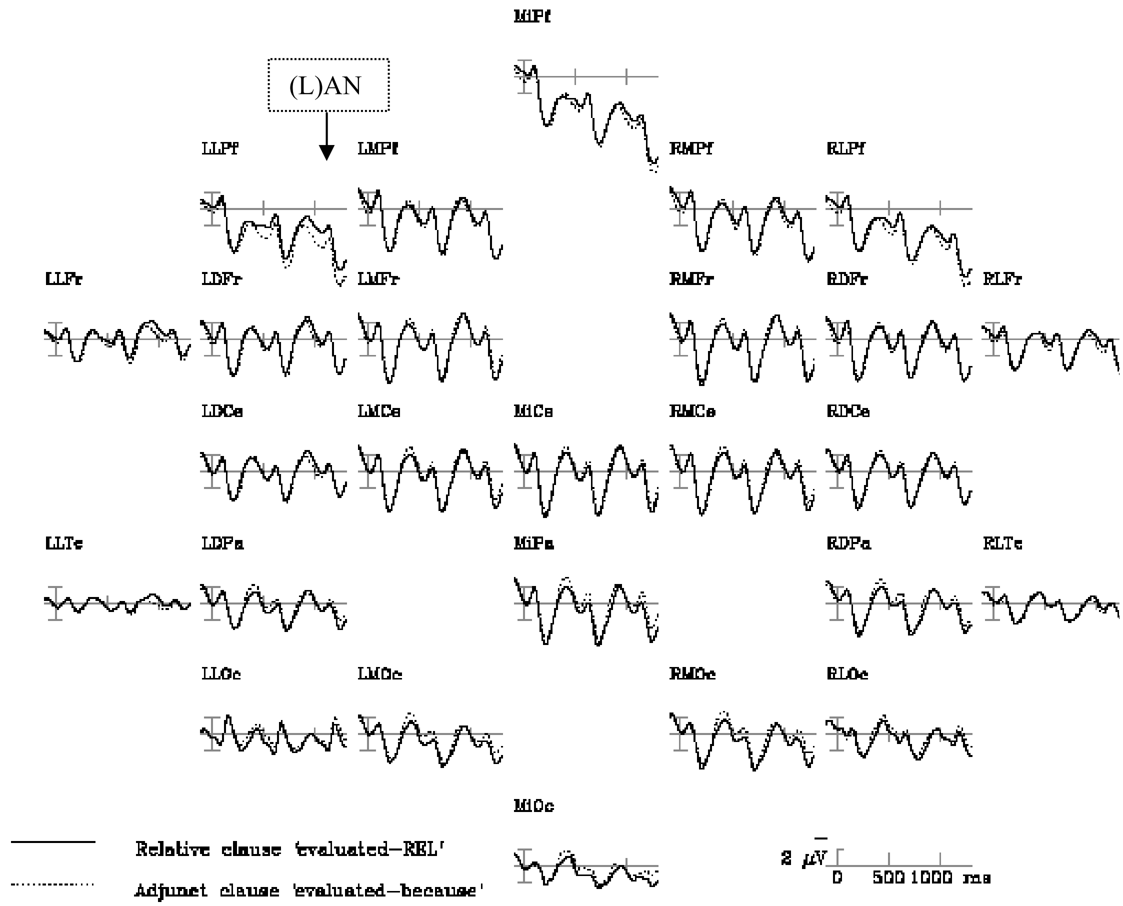
pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-13 Exp 5.2, W6 (V-REL/because) 150 to 250 ms

ANOVAs were then performed on mean amplitude measurements between 300 and 600 ms post-stimulus onset of the embedded verb, *'evaluated-REL/because*'. In the full analysis, there was a significant main effect of gap type [F(1, 23) = 5.61, p < .03]. In the distributional analysis, there was a significant main effect of gap type [F(1, 23) = 6.21 p < .02] and a significant interaction of gap type and laterality [F(1, 23) = 7.13, p < .01] due to the increased negativity in response to the adjunct condition, especially over the medial electrodes. In the midline electrodes analysis, there was similarly a main effect of clause type [$F(1,23) = 6.64$, $p < .02$].

5.3.4.2 Main Clause Subject Region

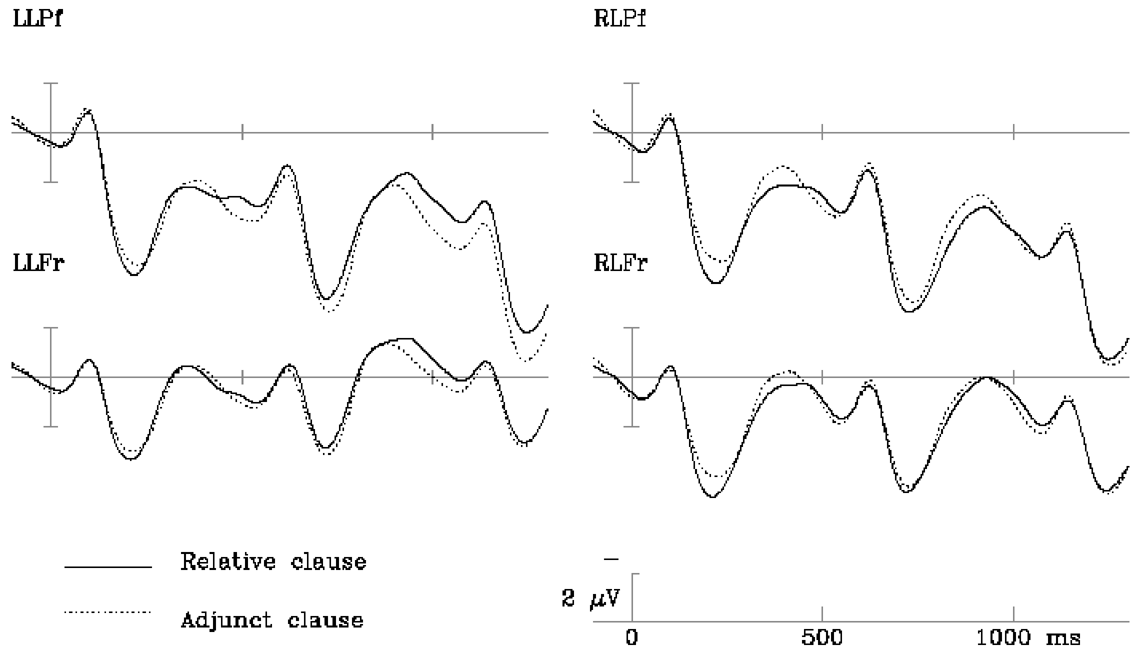
Visual inspection of the waveforms suggested that, compared to the adjunct clause condition, the relative clause condition elicited a negativity from roughly 400 to 600 ms post stimulus onset of the main clause subject, *painter-NOM* (W7). The effect appeared to be larger over left anterior regions.



hwalang-uy gallery-GEN | taypyo-ka representative-NOM | ___ | kwukceycek international | censihoy-eyse exhibition-at | nophi highly

pyengkahay-n/se evaluated-REL/because | hwaka-ka painter-NOM | seykan-uy world-GEN | cwumok-ul attention-ACC | pat-ass-ta receive-PST-DECL

Figure 5-14 Exp 5.2, W6 and W7 (V-REL/because NP-NOM)



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-15 Exp 5.2, W6 and W7 (V-REL/because NP-NOM), anterior regions

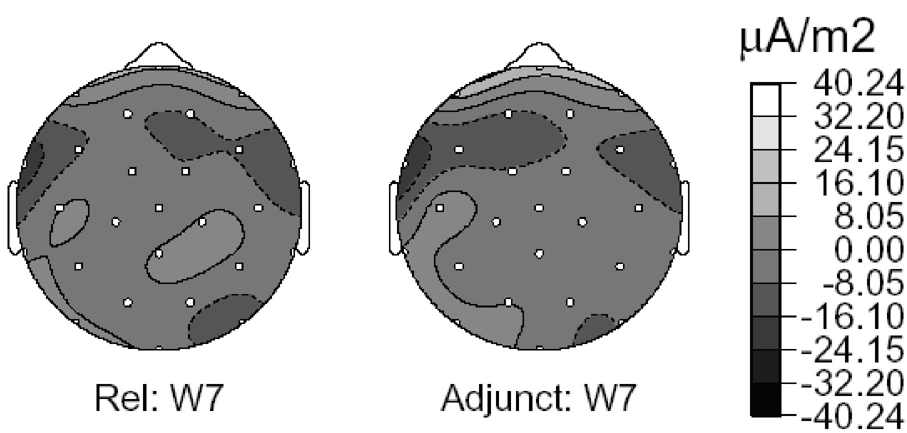
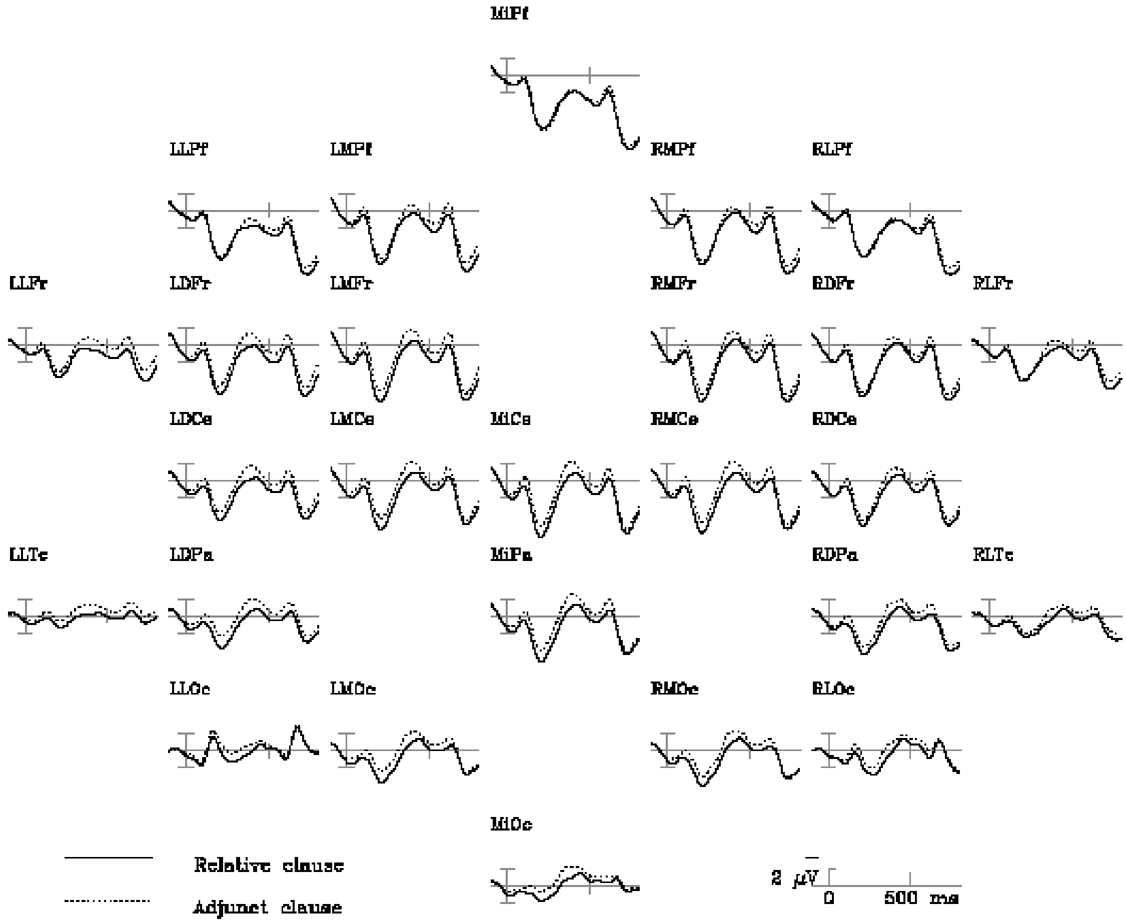


Figure 5-16 Exp 5.2, Isovoltage map at W7 (NP-NOM)

This observation was confirmed in the statistical analyses in the 800 to 1100 ms time window following the embedded verb, corresponding to 300 to 600 ms after the onset of W7, the main clause subject. There were a marginal interaction of clause type and electrodes [$F(25,575) = 2.61$, $p < .06$] in the full analysis, a marginal interaction of clause type and laterality [$F(1, 23) = 3.23$, $p < .08$] and a significant interaction of clause type and anteriority [$F(3,69) = 3.84$, $p < .03$] in the distributional analysis, and a marginal interaction of clause type and anteriority [$F(3,69) = 2.95$, $p < .06$] in the midline analysis. This interaction was due to a lateral maximum scalp distribution in anterior region.

5.3.4.3 Main Clause Region

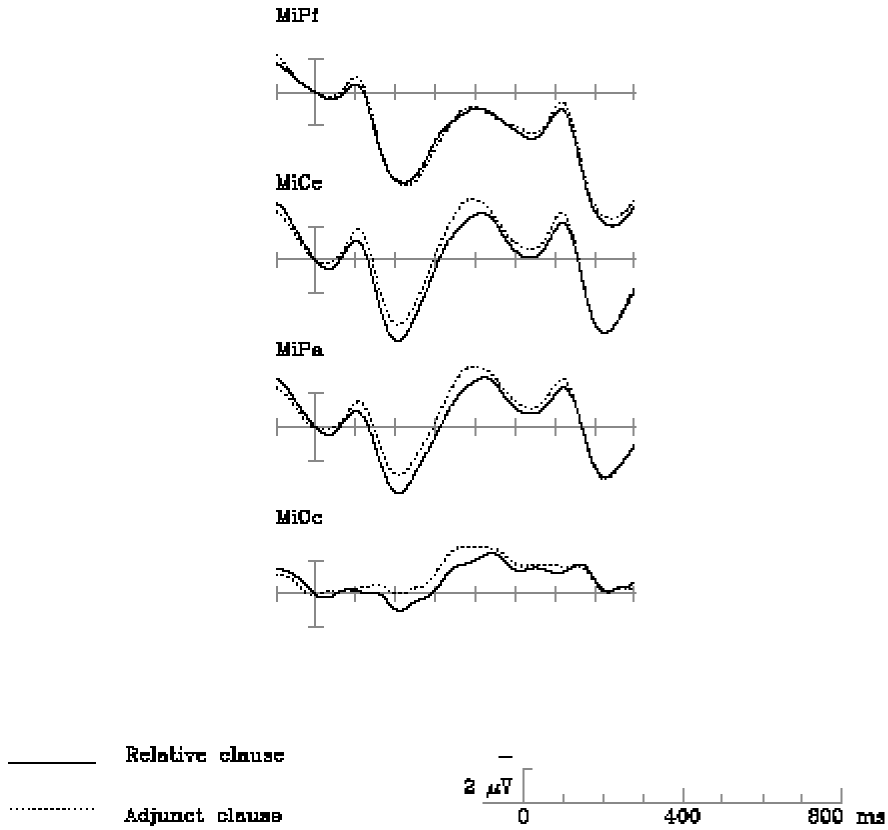
Visual inspection of waveforms at *seykan-uy,* 'world-GEN', one word after the main clause subject (i.e., W8), showed that the adjunct clause condition elicited widespread negativity in comparison to the relative clause condition. This negativity appeared to be a combination of an N400 effect in the 300 to 600 ms range and a longer-lasting left anterior negativity throughout the epoch.



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	$\boxed{\text{seykan-uy}}$	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	$\boxed{\text{world-GEN}}$	attention-ACC	receive-PST-DECL

Figure 5-17 Exp 5.2, W8 (NP-GEN)



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-18 Exp 5.2, W8 (NP-GEN), midline electrodes

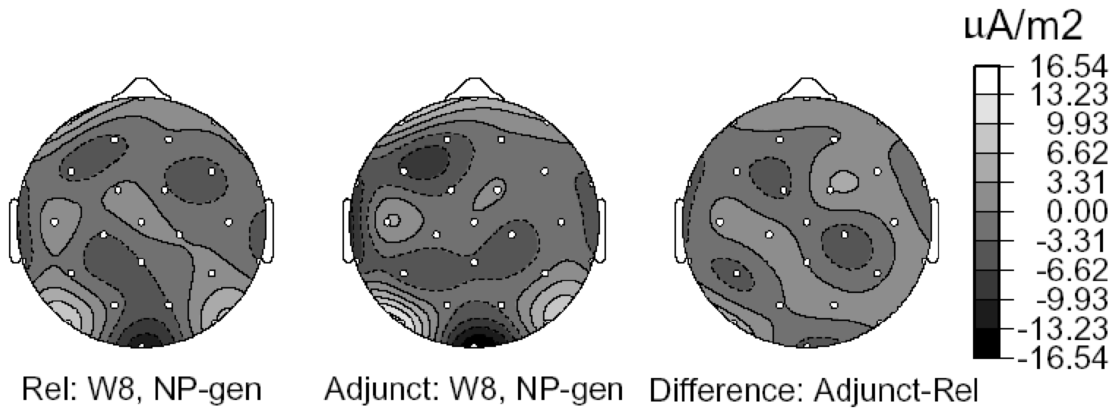
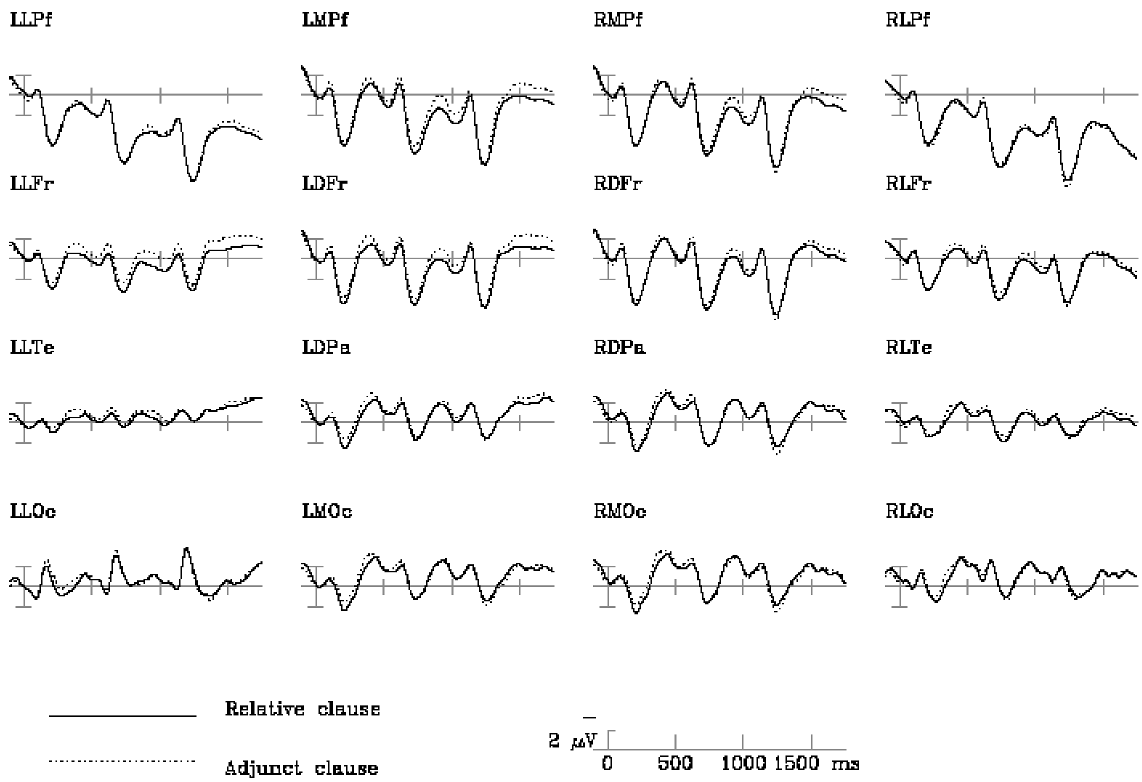


Figure 5-19 Exp 5.2, Isovoltage map at W8 (NP-GEN)

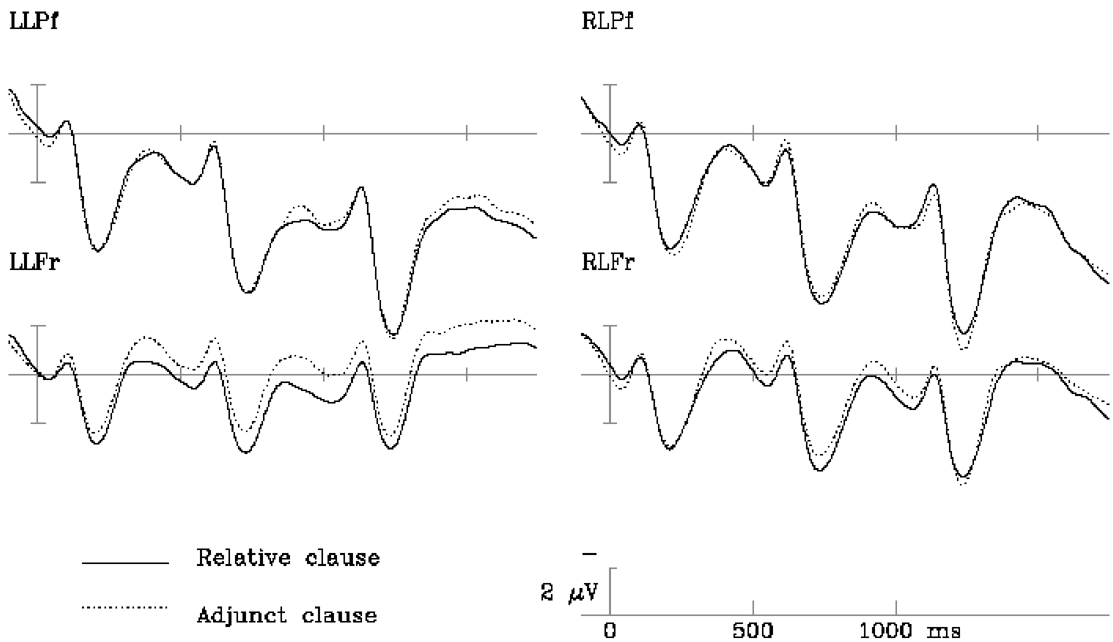
While the central and posterior negativity in response to the adjunct clause condition was not visible after roughly 600 ms, negativity over the left hemisphere with an anterior maximum continued in response to the following words through to the end of the sentence.



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-20 Exp 5.2, W8, W9, & W10



hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Figure 5-21 Exp 5.2, W8, W9, & W10, anterior regions

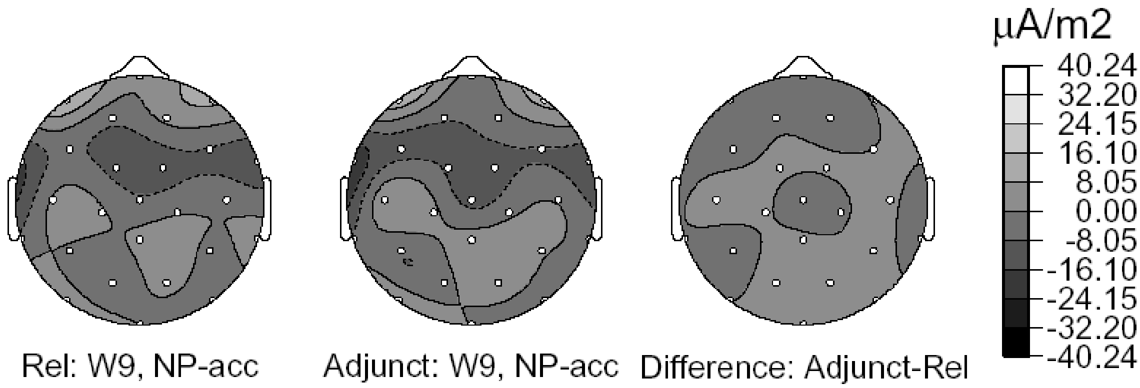


Figure 5-22 Exp 5.2, Isovoltage map at W9

To quantify these observations, analyses were performed on four time windows: 300 to 600 ms after onset of Word 8 (*world*-GEN), Word 9 (*attention*-ACC) and Word 10 (*received*), respectively, and 800 to 1600 ms after onset of Word 8 (*world*-GEN). In the full analysis in the 300 to 600 ms latency window of Word 8, there was a significant main effect of clause type [$F(1,23) = 7.46$, $p < .01$]. In the distributional analysis, there was again a significant main effect of clause type [$F(1,23) = 7.59$, $p < .01$] and also an interaction of clause type, hemisphere and anteriority [$F(3,69) = 4.02$, $p < .01$]. These results indicated that while the negativity to the adjunct clause was widespread over anterior regions, the difference was larger over the left than over the right hemisphere. On the other hand, over posterior regions, there was no laterality difference between the conditions. In other words, in contrast to the left-lateralized negativity at anterior electrodes in this latency window, the N400 response to the adjunct condition at posterior electrodes was not lateralized. In the midline analysis, there was thus a significant main effect of clause type [$F(1,23) = 5.5$, $p < .03$] and a marginal interaction of clause type and anteriority [$F(3,69) = 3.05$, $p < .09$], due to the larger negativity in response to the adjunct clause condition over central and posterior regions (i.e., the N400 response; cf. Figure 5-17 and Figure 5-18).

The long-lasting negativity in response to the adjunct clause condition was also confirmed in the statistical analyses in the latency window of 300 to 600 ms after onset of W9, with an interaction of clause type and electrodes [$F(25, 575) = 3.07$, $p < .01$] in the full analysis and with an interaction of clause type and anteriority [$F(3, 69) = 9.47$, $p < .02$] and an interaction of clause type, laterality and anteriority [$F(3, 69) = 3.33$, $p < .03$] in the distributional analysis, indicating that the negativity to the adjunct clause condition was larger over lateral anterior regions (see Figure 5-21). Similarly, the statistical analyses in the latency window of 300 to 600 ms after onset of W10 also confirmed the long-lasting negativity to the adjunct clause condition, with an interaction of clause type, hemisphere and anteriority [$F(3, 69) = 4.20$, $p < .02$], due to the larger negativity in response to the adjunct clause condition over left anterior regions (see Figure 5-21). Likewise, in the distributional analysis in the 800 to 1600 ms post onset of W8, there was a marginal interaction of clause type and anteriority [$F(3,69) = 2.53$, $p < .09$], due to the larger negativity in response to the adjunct clause condition over anterior region.

5.3.4.4 Summary of Results

The results of Experiment 5.2 are summarized in Table 5-10.

Table 5-10 Exp 5.2, Summary of results

hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

negativity with (left) anterior maximum to relative clauses

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

negativity with right medial maximum to adjunct clauses

sustained negativity with left anterior maximum to adjunct clauses

Relative clause: 'The painter who the representative of the gallery highly evaluated at the international exhibition gained the attention of the world.'
Adjunct clause: 'Because the representative of the gallery highly evaluated (him$_i$) at the international exhibition, the painter$_i$ gained the attention of the world.'

5.3.5 Discussion

The goal of Experiment 5.2 was to investigate to what extent the cognitive/neural processes underlying backward syntactic and anaphoric dependencies are the same. Particularly, given the results of Experiment 5.1a, I was interested in the neurocognitive processes underlying different gap-filler/antecedent association requirements in the syntactic (i.e., relative clause) and anaphoric (i.e., adjunct clause) dependencies. In this section, these issues will be discussed based on the experimental results summarized in the previous section.

I first discuss the widespread negativity to the adjunct clause condition at the embedded verb position, and the frontal negativity to the relative clause condition at the matrix subject position. Then, I consider the widespread negativity to the adjunct clause condition at NP-GEN, one word after the head noun, and the sustained frontal negativity to the adjunct clause at the last three words of the sentence.

5.3.5.1 Effects at the Embedded Verb Position

In response to the embedded verb, there was a widespread negativity with a medial maximum to the adjunct clause condition in comparison to the relative clause condition. The effect started roughly around 300 ms and reached its peak approximately 400 ms post-stimulus onset of the embedded verb. The isovoltage map in Figure 5-12 displaying the mean difference between the adjunct and relative clause conditions showed that the negative response to the adjunct clause condition was maximal over centro-parietal scalp. This effect seems to be similar to the N400 in its scalp distribution and latency (Kutas & Hillyard, 1980a; Kutas & Hillyard, 1980b).

The N400 effect has been shown to be sensitive to frequency among many other factors, such that the amplitude of the N400 varies inversely as a function of a frequency. That is, larger N400s are elicited in response to low frequency words relative to high frequency words (Allen, Badecker, & Osterhout, 2003; Barber, Vergara, & Carreiras, 2004; Münte, Wieringa, Weyerts, Szentkuti, Matzke, & Johannes, 2001; Van Petten, 1993; Van Petten & Kutas, 1990; Van Petten & Kutas, 1991) and to the less frequent structure in comparison to the more frequent structure (King & Kutas, 1995). Given this sensitivity of the N400 to frequency, it is not surprising to see that the much less frequent occurrence of *–se* (6258 occurrences out of one million *ejels*) or of *–se* clauses with object drop (7 occurrences out of 26,749 *ejels*) elicited a larger N400 when compared to the adnominal marker (89,329 occurrences out of one million *ejels*) or to object relative clauses (108 occurrences out of 26,749 *ejels*). In fact, this frequency hypothesis seems to be further supported by the larger P200 in response to the relative clause condition (see Figure 5-13). That is, early visual processing (approximately around ~150 ms post-stimulus onset) has been shown to manifest sensitivity to amount of experience, such that frequent words elicit larger P150s than low frequency words (Proverbio, Vecchi & Zani, 2004). Given this, the observed positivity to the relative clause in the early time widow (150 to 250 ms) could be related to the frequency difference between the adjunct suffix and the adnominal marker, providing support for the idea that the N400 to the adjunct clause could be due to differences in the frequency of occurrence of adjunct and relative clauses. Alternatively, this positivity to the relative clause condition could be due to the N400 difference which simply started early in the P200 region.

Yet the N400 effect could be related to still other factors besides frequency. For example, it has been reported that the amplitude of the N400 decreases with repetition (Rugg, 1990; Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991). In addition, the amplitude of the N400 has been found to be sensitive to semantic content, such that function words with rich semantic content elicit larger N400s than those with less semantic content (Kluender & Kutas 1993b; McKinnon & Osterhout, 1996). In terms of the current experiment, since Experiment 4-2 with two relative clause conditions was run in the same set-up as the current experiment, adnominal markers were repeated three times more often than the adjunct suffix. This could have possibly led to the relatively larger N400 to the adjunct clauses, since the repetition of adnominal markers could have reduced the amplitude of the N400 response to relative clauses. In addition, even though *–se* and *–n* are both function words, *-se* exhibits richer lexical semantics ('because'), while the adnominal marker simply signals the syntactic relation between the two clauses, such that the current clause modifies the following NP. Therefore, the richer semantic content of *–se* also could have caused a larger N400 to the adjunct clauses.

Thus, larger N400s to adjunct clause sentences at the embedded verb position could be due to lower (lexical or constructional) frequency, fewer repetitions, and/or rich lexical semantic content in comparison to relative clauses with adnominal markers. The current experiment does not provide an unequivocal answer as to which of these factors is the primary source of the N400 response to the adjunct clause construction. Of course, the effect could also be due to some combination of all these factors.

5.3.5.2 Effects at the Matrix Subject Position

At the matrix subject position, the relative clause condition elicited a phasic LAN-like effect. The effect was visible in the frontal region approximately 300 to 600 ms post stimulus onset of the matrix subject, showing its maximum over the left anterior region. The effect seems to be compatible with previous studies of LAN effects in its scalp distribution and latency (King & Kutas 1995; Kluender & Kutas, 1993a, 1993b; Kluender & Münte, 1998).

The LAN effect, together with the longer reading time results for relative clauses at the matrix subject position in Experiment 5.1, suggest that processing syntactic dependencies incurs more working memory costs than processing anaphoric dependencies at the gap-filler/antecedent association position. There are two logical possibilities. The first is that the gap is associated with the filler (i.e., matrix subject) only in relative clauses but not in adjunct clauses, and that working memory costs associated with this gap-filler association caused the LAN effect. This might be the case because gap-filler association is licensed in the syntax, where it is clearly cued by the adnominal marker. Gap-antecedent association in the anaphoric dependencies, on the other hand, is semantically licensed, and thus the parser could delay the association until it completes the semantic evaluation of the relationship of the two clauses at the end of the sentence. The second possibility is that the parser immediately associates a gap with the matrix subject in the adjunct clause construction − in accordance with an active search mechanism (van Gompel & Liversedge, 2003; Kazanina et al., 2007) − as well as in the relative clause construction. Then the higher working memory costs in the relative clause construction (as indexed by increased LAN) could be due to multiple processes occurring at the same time at the head noun position. That is, in addition to gap-filler association, the (matrix clause subject) argument in the relative clause condition is closed off, (i.e., the modifying clause is attached to it). This is not the case in the adjunct clause condition, where the embedded clause is closed off, but its relationship to the main clause is not yet fully determined at this point (i.e., at the matrix subject position). In other words, at the matrix subject position, gap and filler are associated in both conditions, but the embedded clause is also attached to the head noun (i.e., matrix subject) in the relative clause condition. This extra process could lead to more working memory demands in relative clauses than in adjunct clauses, as indexed by longer reading times and the LAN effect.

The reading time results in Experiment 5.1a and the ERP responses of the current experiment to both constructions support the second possibility. In the reading time experiment, adjunct clauses with object argument drop clearly patterned with object relative clauses at the matrix subject position, showing a large processing disadvantage compared to their subject gap counterpart sentences. This suggests that the parser immediately associated a gap with the potential antecedent at this position in the adjunct clause construction, just as in the relative clause construction. In addition, although the LAN effect was elicited in response to relative clauses when compared to adjunct clauses, the topographic distribution of the ERP responses to the relative and adjunct clause conditions in Figure 5-16 showed that both constructions exhibited negativity with a left anterior maximum. This suggests that the LAN effect related to gap-filler/antecedent association could be present in both constructions, although the LAN is larger in the relative clause construction, corresponding to the additional process of attaching the relative clause to the head noun argument and integrating the two semantically. To check this possibility, ERPs to the relative clause condition and adjunct clause condition were plotted against control sentences with equal structural complexity. Object relative clauses in Experiment 4.2 were used for this purpose. The comparison was made between ERP responses to W7 ('painter-NOM') of the current experiment and to W8 ('gang-NOM') of the control sentences (see Figure 5-23). Since the head noun position of the control sentences is W6, they do not involve any process directly related to gap-filler association at W8. Yet the sentences are compatible with the current experimental sentences in terms of sentential word position (W7 vs. W8) and in terms of linguistic complexity in that they all involve long-distance dependencies. This comparison shows that although the effect is bigger in the relative clause condition, adjunct clause constructions also showed a negativity with a left anterior maximum when compared to control sentences, as can be seen in Figure 5-23 through Figure 5-25.

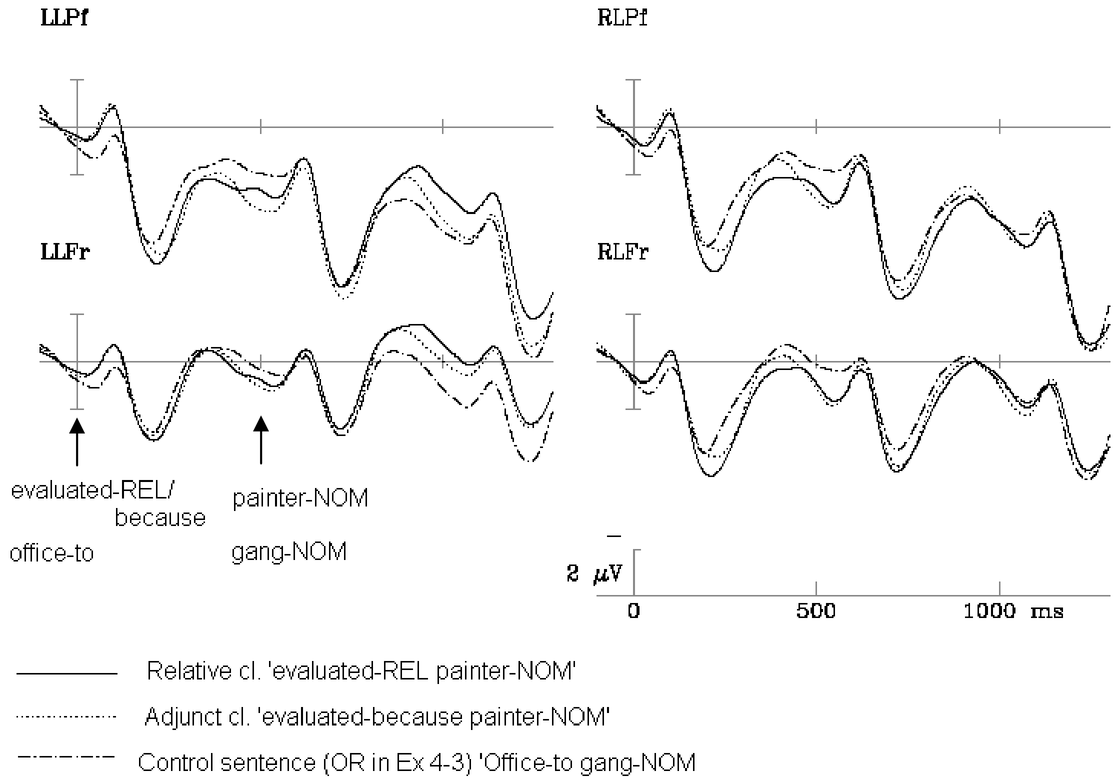


Figure 5-23 Exp 5.2, ERPs to W7 in comparison to control sentences

Experimental sentences

hwalang-uy	taypyo-ka	___	kwukceycek	censihoy-eyse	nophi
gallery-GEN	representative-NOM		international	exhibition-at	highly

pyengkahay-n/se	hwaka-ka	seykan-uy	cwumok-ul	pat-ass-ta
evaluated-REL/because	painter-NOM	world-GEN	attention-ACC	receive-PST-DECL

Control sentences (Object relative clauses in Experiment 4-2)

[sinmwunsa-uy	sacang-ul/i	pimilliey	cengchicek-ulo
newspaper-GEN	publisher-ACC/NOM	secretly	political-with

iyongha-n]	uywon-uy	samwusil-ey	kkangphay-ka	tulichyessta
exploit-REL	senator-GEN	office-to	gang-NOM	attacked

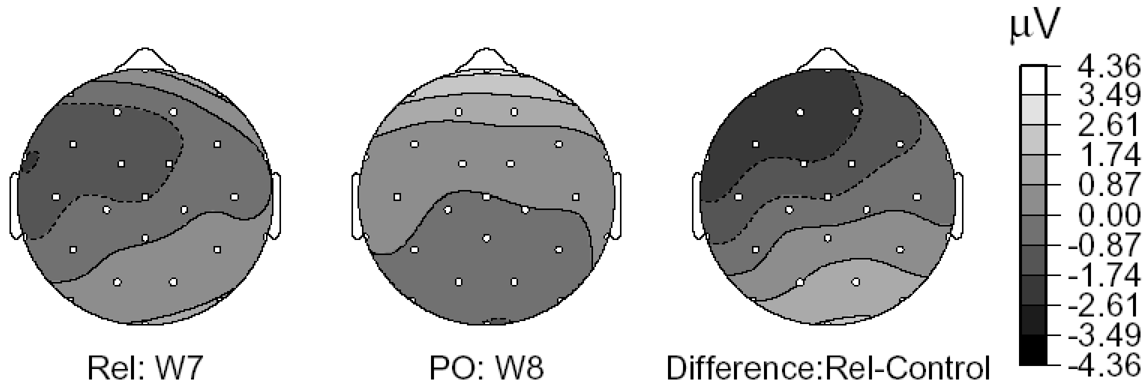


Figure 5-24 Exp 5.2, Isovoltage map of relative clauses vs. control sentences

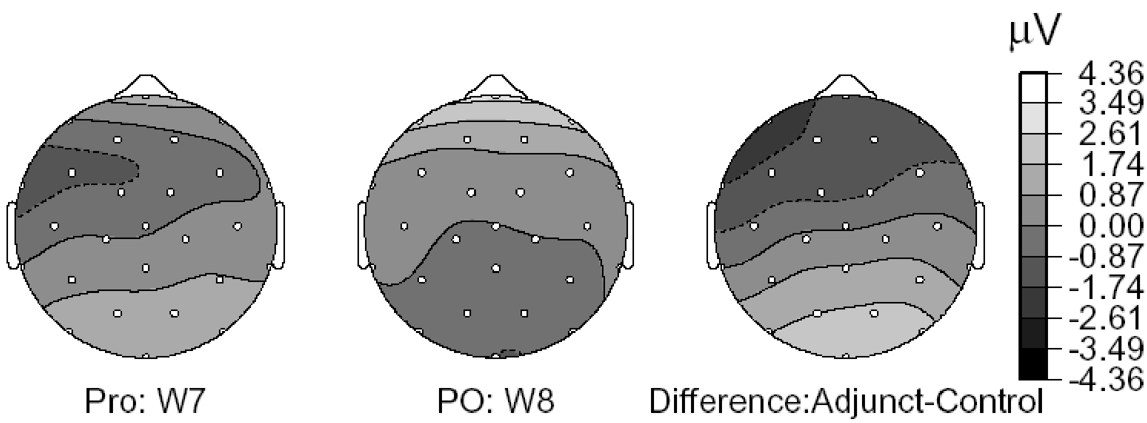


Figure 5-25 Exp 5.2, Isovoltage map of adjunct clauses vs. control sentences

This visual observation was corroborated by statistical analysis of mean amplitude area measurements in the 800 to 1100 ms time window post-stimulus onset of Word 6 in the adjunct clause condition (*evaluated-because*) and of W7 (*office-to*) in the control sentences (i.e., 300 to 600 ms post-stimulus onset of W7 *painter-nom* in the adjunct clause condition and W8 *gang-nom* in the control sentence). There was an interaction of condition (adjunct vs. control sentence) and anteriority [$F(3, 69) = 8.4$, $p < .001$] and an interaction of condition, hemisphere and anteriority [$F(3, 69) = 2.93$, $p < .04$] in the distributional analysis, reflecting the larger negativity in response to the adjunct clause condition relative to control sentences over left anterior regions.

In sum, the prediction that the relative clause condition would elicit a LAN effect in comparison to the adjunct clause condition was confirmed. In addition, the results suggest that the parser immediately associates a gap with the matrix subject position in both relative and adjunct clause constructions, in support of an active search mechanism (van Gompel & Liversedge, 2003; Kazanina et al., 2007).

5.3.5.3 Effects One Word after the Matrix Subject

The isovoltage maps displaying the mean difference between the adjunct and relative clause conditions at W8, the NP immediately following the matrix subject position (Figure 5-18), show negativity in response to the adjunct condition in both the frontal and centro-parietal regions. While this negativity could be simply one widespread negativity, different time-courses of the effect over different scalp regions suggest that it is likely to be two effects occurring at the same word position. That is, over the anterior region, the negativity lasted until the end of the sentence, while in the centro-parietal region, the effect was transient. Thus, it seems that W8 elicited both phasic and long-lasting effects with different scalp distributions. In this section, the phasic effect at the centro-parietal region is discussed. The long-lasting effect in the anterior region will be discussed in 5.3.5.4.

In addition to a sustained negativity over frontal regions beginning with W8, the matrix subject, NP-GEN immediately following the matrix subject elicited a transient negativity in the centro-parietal region. In terms of latency and the scalp distribution, this effect seems to be related to the N400 (Kutas & Hillyard, 1980a; Kutas & Hillyard 1980b, 1984).

In terms of the current experiment, the second clause (effect clause) starts with a NP-NOM. Thus, the parser could have expected an intransitive verb following this nominative-marked NP. Therefore, when a genitive NP appeared, this unpredicted continuation could have caused difficulty in associating the current input with context, leading to the larger N400 effect to the adjunct clause condition.

5.3.5.4 Effects from the Matrix Subject Position to Sentence End

In addition to the N400-like transient negativity in the centro-parietal region, the adjunct clause condition elicited a sustained negativity in comparison to the relative clause condition from W8 (one word after the matrix subject position) until the end of the sentence. This effect appeared to have a left frontal maximum.

This effect seems to be related to the ERP responses that have been observed in sentences that differ in working memory demands (Fiebach et al., 2002; King & Kutas, 1995; Kluender & Kutas, 1993a, 1993b; Müller, King, & Kutas, 1997). In particular, the scalp distribution closely resembles the findings in Münte et al. (1998), where sentences with higher working memory loads elicited a greater negativity over the left than the right hemisphere (i.e., an interaction of condition and hemisphere), and the effect seemed to show a left frontal maximum, just as in the current experiment.

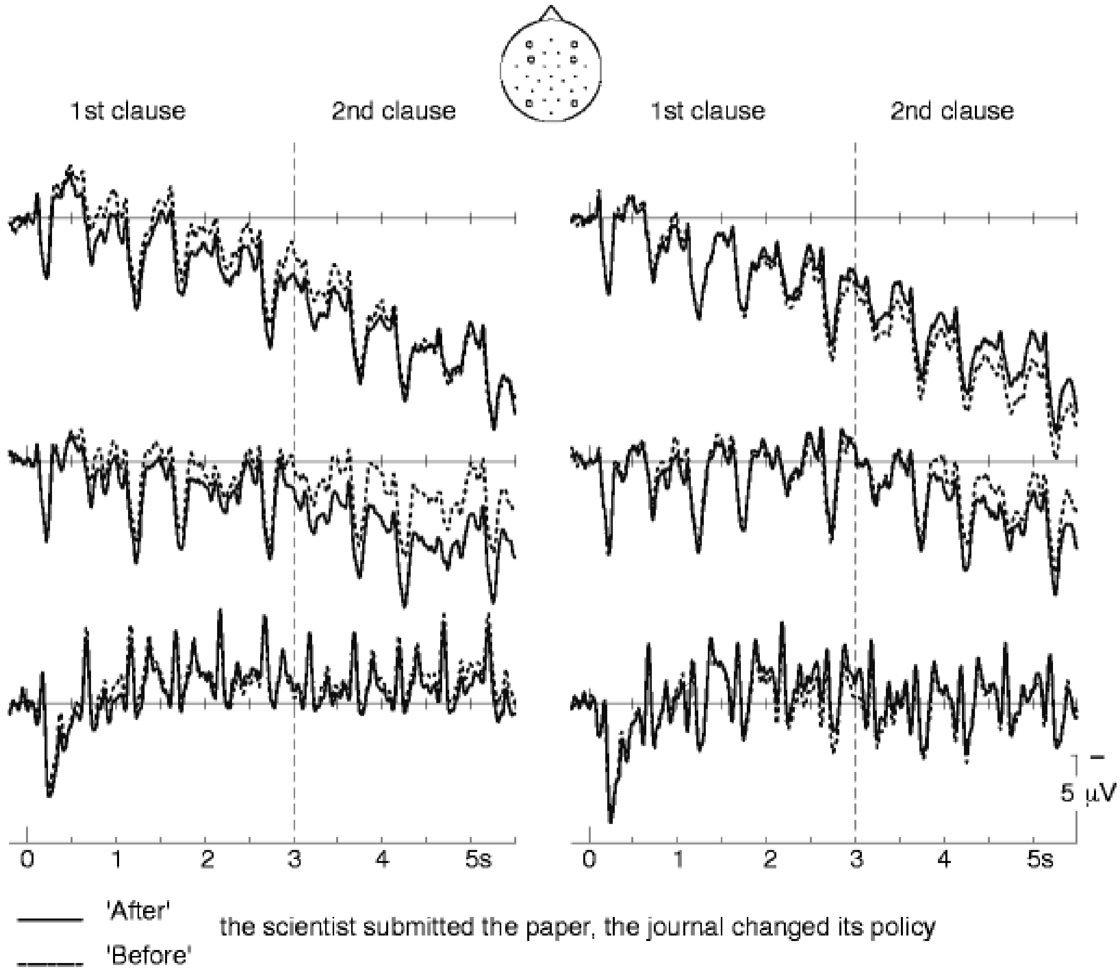


Figure 5-26 Münte et al. 1998

In addition to the similarity in scalp distribution, another reason to believe that the sustained negativity in the current experiment could be related to the findings in Münte et al. (1998) lies in the cognitive processes posited to underlie the processing of the sentences of interest. That is, considering that sentences in which events were expressed in reverse chronological order ('Before the scientists submitted the paper, the journal changed its policy') elicited a sustained left-lateralized negativity in comparison to sentences where events were expressed in chronological order ('After the scientists submitted the paper, the journal changed its policy.'), the effect in Münte et al. cannot be attributable to a syntactic violation or to filler-gap association. Rather, the effects were attributed to the computation of the discourse representation cued by real-world knowledge of the temporal order of events.

Similarly, proper understanding of causality in *-se* 'because' clauses in the current experiment requires discourse computation of the inter-clausal relationship between the main and embedded clauses. This is so because the gap-filler association in anaphoric dependencies is semantically or pragmatically driven, and thus the parser should continue to evaluate the semantic fit of a gap and the potential antecedent against real-world knowledge even after immediate association of a gap with its potential antecedent at the matrix subject position. This computation at the discourse level could be responsible for extra working memory demands in the adjunct clause condition, as indexed by the longer reading times in Experiment 5.1a and the sustained left-lateralized negativity in the current experiment.

5.4 General Discussion

In Experiment 5.1, I investigated the processing of relative and adjunct clauses using reading time measures across subject and object gaps. The experimental results for adjunct clauses (i.e., backward anaphoric dependencies) were compared with those for relative clauses (i.e., backward syntactic dependencies). The slower reading times in object gap than in subject gap sentences at the matrix subject regardless of clause type (i.e., adjunct vs. relative clause) suggested similar parsing strategies between syntactic and anaphoric dependencies; the processing of anaphoric dependencies was apparently constrained by structural complexity (as manifested in phrase structural complexity or the noun phrase *accessibility hierarchy*) just as the processing of syntactic filler-gap dependencies is. In addition, the results suggested that the parser immediately associates a gap with its potential antecedent, supporting the claim that the processing of anaphoric dependencies is driven by an active search mechanism, just as in the processing of syntactic dependencies (van Gompel & Liversedge, 2003; Kazanina et al., 2007).

In addition to these similarities, the results also imply that there are different processing strategies involved in these two different types of dependency. Regardless of gap type (subject vs. object), relative clauses elicited slower reading times one word after the matrix subject than adjunct clauses, while the reverse reading time patterns (i.e., adjunct clause sentences slower than relative clause sentences) were observed sentence-finally. These results were interpreted as suggesting that in relative clauses, the parser associates the semantics denoted by the relative clause with the head noun, leading to complete gap-filler association at the head noun position. In adjunct clauses, on the other hand, gap-antecedent association seems to be subject to the continuous inter-clausal evaluation of the semantic fit of a gap and its potential antecedent until the end of sentence. Alternatively, it is also possible that the gap-antecedent association was complete at the matrix subject position, and that the subsequent slower reading times in the adjunct clause condition were due to the processing of the inter-clausal relationship. However, since the antecedent of a gap is determined on the basis of the pragmatic/semantic interpretation of adjunct clause sentences, the parser cannot exclude the possibility that the inter-clausal relationship will not allow the matrix subject as an antecedent.

For example, sentences (5.38) and (5.39) are identical to each other up to the matrix subject position. However, the two sentences differ in terms of which matrix argument serves as an antecedent. While *Tom* is preferably interpreted as the antecedent for the gap in sentence (5.38), in sentence (5.39), it is *Jon* which serves as the antecedent for the gap. Thus, if the parser initially associated the gap with *Tom* in (5.39), it would need to revise this interpretation at the end of the sentence when the inter-clausal relationship becomes clear.

(5.38) Matrix subject as an antecedent

[Mina-ka	$\_\_{}_i$	silhehay-se]	Tom$_i$-i	phati-lul	ilccik	ttena-ss-ta
Mina-NOM		detest-because	Tom-NOM	party-ACC	early	leave-PST-DECL

‘Because Mina disliked (him$_i$), Tom$_i$ left the party early.’

(5.39) Matrix object as an antecedent

[Mina-ka	$\_\_{}_i$	silhehay-se]	Tom-i	Jon$_i$-ul	ilccik	ponay-ss-ta
Mina-NOM		detest-because	Tom-NOM	Jon-ACC	early	send-PST-DECL

‘Because Mina disliked (him$_i$), Tom sent back Jon$_i$ early.’

Thus, it seems that the two processes (i.e., evaluation of the semantic fit of a gap and its potential antecedent and evaluation of the inter-clausal relationship) should take place simultaneously. In terms of the experimental results, however, one caveat is the possibility that the participants may have developed a strategy of always associating a gap with the matrix subject: the matrix subject always served as the antecedent for a gap in the experiment stimuli, and there were no other stimulus or filler materials that forced participants to assign a gap to any other matrix clause position. To look into these possibilities, further research should be done with different grammatical arguments serving as possible antecedents for a gap.

The following ERP experiment (Experiment 5.2) provided supporting evidence for the similarities and dissimilarities in parsing strategy between backward syntactic and anaphoric dependencies seen in the reading time data. At the matrix subject position, relative clause sentences (i.e., syntactic dependencies) elicited a LAN in comparison to adjunct clause sentences (i.e., anaphoric dependencies). However, from one word after the matrix subject position through to the end of the sentence, adjunct clauses elicited a sustained left-lateralized negativity in comparison to relative clauses. These effects confirmed the existence of different parsing strategies for gap-filler/antecedent association in backward syntactic and anaphoric dependencies. Moreover, the ERP results also supported an active search mechanism in anaphoric dependencies. When ERP responses to the matrix subject in the relative and adjunct clauses were plotted against control sentences with comparable linguistic complexity, both relative and adjunct clauses showed a LAN effect in comparison to control sentences, suggesting that the parser associated a gap with its filler or antecedent in both constructions, thereby incurring higher working memory costs.

In evaluating the implications of these findings, I first address active search mechanisms. Then the results are discussed in light of the theoretical analysis of Korean relative clauses and the *accessibility hierarchy*. Finally, the discussion of the implications of the results for the LAN component follows.

5.4.1 Active Search Mechanisms

The results in Experiments 5.1a and 5.2 clearly indicated that the parser immediately associated the gap with its filler or potential antecedent at the matrix subject position. Yet the question remains how "active" this search process is. That is, although the results in Experiment 5.1b did not provide conclusive evidence against the active search hypothesis due to an unbalanced experimental design (i.e., lack of a condition with no gap in the embedded clause), the apparent absence of processing difficulty associated with the parser's failure to find a filler/antecedent in the *fact*-CP condition suggests that the parser might form a dependency whenever it can, but only when it can. In other words, upon encountering a potential antecedent, the parser places a priority on dependency-formation but might still entertain the possibility that there may be no intra-sentential antecedent at all. While further empirical data are required to investigate this possibility, at this point, it is clear that the parser immediately forms a dependency upon encountering a potential antecedent in anaphoric dependencies even before it evaluates the semantic fit between the gap and the potential antecedent.

Given this, the next question would be what motivates this dependency formation. Under a principle-based parsing account (e.g., Pritchett, 1988, 1992; Weinberg, 1993; Gibson, Hickok, & Schütze, 1994; Aoshima et al., 2003), the active search mechanism in forward syntactic dependencies (i.e., Active Filler Strategy: Frazier & Clifton, 1989) is interpreted as being motivated by the parser's desire to maximize the satisfaction of grammatical constraints. In other words, a gap is created because the filler needs a thematic role (Aoshima et al., 2003) or to establish thematic relations (Gibson et al., 1994). Yet it is not clear what motivates the active search mechanism in backward anaphoric dependencies. This is because, unlike in syntactic dependencies where the presence of a gap is integral for the grammaticality of the sentence, as shown in (5.40), the antecedent for an anaphor is not grammatically required, as shown in (5.41) (repeated from (5.5) and (5.6)).

(5.40) *My brother wanted to know who$_i$ Ruth will bring us home to Mom at Christmas.
(5.41) When she felt tired, the boy used to clean the house.

One possibility is that the active search mechanism in backward anaphoric dependencies is related to the parser's efforts to reduce the number of discourse entities. That is, a higher number of discourse entities creates higher working memory load (Gibson, 1998, 2000). Thus by associating a newly encountered discourse entity (i.e., a matrix subject in this case) with a preceding pronoun or a gap, the parser could reduce the number of discourse entities within a sentence that need to be held in working memory and thus reduce the working memory load. However, van Gompel and Liversedge (2003) and Kazanina et al. (2007) suggest that the active search mechanism is not related to the introduction of an additional discourse referent. This argument is based on the fact that while there was a gender mismatch effect at '*the boy*' and '*Russell*' in (5.42) and (5.43) following third person pronouns '*she/he*', no such effect was observed in control sentences with an indexical pronoun '*I*' (5.42) or a name '*Erica*' (5.43).

(5.42) van Gompel and Liversedge (2003), Experiment 2
(a) Gender matched
When he was at the party, the boy cruelly teased the girl during the party games.
(b) Gender mismatched
When she was at the party, the boy cruelly teased the girl during the party games.
(c) New referent
When I was at the party, the boy cruelly teased the girl during the party games

(5.43) Kazanina et al. (2007) Experiment 1
(a) No violation/ gender matched
Because last semester while she_i was taking classes full-time Kathryn_i was working two jobs to pay the bills, Russell never got to see her.
(b) No violation/ mismatch
Because last semester while she_i was taking classes full-time Russell was working two jobs to pay the bills, Erica_i promised to work part-time in the future.
(c) No violation/ name
Because last semester while Erica_i was taking classes full-time Russell was working two jobs to pay the bills, she_i promised to work part-time in the future.

Their logic is that if the association between the potential antecedent and a pronoun is due to the parser's efforts to reduce the number of discourse referents, and if the gender mismatch effect in (5.42) and (5.43) arises when this association is not possible, then there should be an equivalent processing difficulty in sentences with an indexical pronoun '*I*' as in (5.42) or a name '*Erica'* as in (5.43), where the newly added discourse referents, *the boy* and *Russell* cannot be associated with '*I*' or '*Erica*'.

Yet it should be noted that a different interpretation of the results is also possible. That is, the absence of the gender mismatch effect in (5.42) and in (5.43) could mean that the parser is sensitive to referential features of NPs and assigns potential antecedents to a gap or a pronoun only when these are in need of a referent, in an attempt to reduce the total number discourse referents. That is, since an indexical pronoun or name does not need to be assigned a referent, a non-coindexed reading is the preferred and predicted structure, which could account for the absence of the gender mismatch effect in (5.42)c and (5.43)c. On the other hand, in sentences with a referential pronoun (i.e., *she* or *he*), the pronoun can be assigned a real world referent in context. Thus, when the parser encounters a NP with referential properties, although it has a choice not to associate a newly encountered NP with a pronoun, it might prefer to associate the two since it would lead to a smaller number of discourse referents. Thus, the non-coindexed reading due to the gender mismatch in (5.42)b and (5.43)b could have led to processing difficulty because it is not a preferred structure. The current experimental results cannot answer the question of what motivates this active search mechanism. Therefore the question of whether the parser's efforts to reduce the number of discourse entities underlies the active search mechanism remains unanswered and awaits further research.

5.4.2 Implications on General Linguistic Theory

The results of Experiment 5.1a have implications for the generality of the *accessibility hierarchy*. The *accessibility hierarchy* was originally proposed as a constraint on relative clause formation (see Chapter 3 for details). However, the similarity of the subject/object processing asymmetry in relative and adjunct clauses suggests that the *accessibility hierarchy* could be extended to argument-drop phenomena.[5] However,

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[5] See Comrie (1974, 1989) and Keenan and Comrie (1977) for a discussion of the similarities of the accessibility hierarchy and the hierarchy of grammatical roles that the causee is likely to take in causative constructions. See also Ackerman and Moore (1999) for further discussion.

more cross-linguistic processing and descriptive linguistic research needs to be conducted to confirm this possibility.

At the same time, it was pointed out that the results in Experiment 5.1a are only partially compatible with the predictions of the *phrase-structural distance hypothesis*. That is, although a subject/object gap asymmetry was confirmed as predicted, adjunct clauses did not show any systematic processing difficulty over and above the processing demands evident in relative clauses. This lack of difficulty is contrary to a prediction based on the longer structural distance between a gap and its antecedent in adjunct clause sentences than between a gap and its filler in relative clause sentences. This absence of a systematic structural distance effect between the two dependency types suggests that the structural position of a gap is a more important factor in processing dependencies than the structural distance between a gap and its filler/antecedent, as discussed in the General Discussion of Chapter 4 (i.e., Section 4.5). That is, object relative clauses and object-drop sentences could be harder to process than subject relatives and subject-drop sentences because the object gap is structurally more deeply embedded than the subject gap, but not because the structural distance between the object gap and the filler/antecedent is greater than the distance between the subject gap and the filler/antecedent. In a sense, then, the *phrase-structural distance hypothesis* can actually be defined in terms of the structural position of a gap rather than in terms of the distance between a gap and its filler/antecedent. This in turn suggests that the *accessibility hierarchy* and the *phrase structural distance hypothesis* may not be inherently different from each other but rather notational variants of each other, and this actually has several desirable implications.

In linguistic work, two major approaches have been undertaken to investigate the role of language universals. In one approach, represented by Greenberg's work and the work inspired by his, a wide range of languages is examined, and concrete levels of analysis are set forth to explain cross-linguistic variation. In this approach, language universals are typically described in terms of interrelations amongst different linguistic properties. For example, the presence of a certain linguistic feature could imply the presence of another linguistic feature (i.e., implicational universals); certain linguistic features tend to co-occur with other features (i.e. universal tendencies); or the presence of certain linguistic features could entail the presence of another linguistic feature (i.e., absolute universals) (Comrie, 1989). In the second approach, as would be represented by Chomsky's work and the work inspired by his, language universals are investigated in terms of abstract representations that underlie surface variations across languages. Although the different bodies of research find quite different explanations for the proposed universals (e.g, **innateness:** Chomsky, 1965 vs. **emergentism** based on the interaction of language experience and general cognitive mechanisms: Ellis, 2000; Goldberg, 1999; Tomasello, 2003; O'Grady, 2005), they share similarities in the pursuit of abstract levels of analysis of cross-linguistic variation.

The *accessibility hierarchy* has been proposed as an instance of an absolute universal in the tradition of the database approach to language universals (i.e., the first approach in the discussion above) (Keenan and Comrie, 1977; see Comrie, 1989: 155 for the discussion of the scope of relevant linguistic structure in defining absolute universals vs. tendencies); the *phrase-structural distance hypothesis* was proposed in the tradition of the abstract approach (i.e., the second approach outlined above). The convergence of these two hypotheses suggests that the subject/object processing asymmetry is an inherent language universal predicted both by concrete and abstract analyses of cross-linguistic variation. However, given that one level of explanation can always be further accounted for by a deeper level of explanation, it should also be noted that this finding could be just the beginning of further investigation into how processing corresponds to language universals (Hawkins, 2004), defined either in terms of the hierarchy of a grammatical relations (i.e., grammatical relations as primitives; Perlmutter & Postal, 1977; Perlmutter, 1983) or a hierarchical tree structure (i.e., derived abstract representations).

5.4.3 Nature of the LAN Component

The experimental results also shed light on the LAN component. Two major environments where the LAN has been elicited are sentences with grammatical violations and those with complex structure (filler-gap dependencies). In terms of grammatical violations, the LAN has been elicited by phrase structural violations ('…*Max's of proof the theorem /a proof of the theorem*': Neville et al., 1991) and agreement violations ('*your write*': Münte, Heinze, & Mangun 1991).

However, since the current experimental sentences do not involve any grammatical violations in terms of phrase structure or agreement, I have discussed the LAN effect mainly in terms of the processing of a filler-gap dependency. There seems to be general agreement that the LAN effect elicited by the processing of a filler-gap dependency without structural violations is an index of higher working memory load (Kluender & Kutas, 1993a, 1993b; King & Kutas, 1995; Müller et al., 1997; Fiebach et al., 2002; Ueno & Kluender, 2003a, among others). Yet the sources of this higher working memory load have been defined in several ways. In one view, since the LAN effect has been typically found in sentences with filler-gap dependencies, the LAN has been associated with the cognitive resources required to maintain a displaced filler (or incomplete syntactic dependencies) in memory (Kluender & Kutas, 1993a, 1993b; King & Kutas, 1995; Fiebach et al., 2002; Phillips et al., 2005). In an alternative view, the LAN has been associated with the parser's backward search through memory for an appropriate discourse entity for dependency formation (Kluender & Kutas, 1993b).

The current experimental results seem to be most compatible with the backward search account. That is, in backward gap-filler dependencies like those in Korean relative clauses, a gap precedes its filler. The gap does not have phonetic values to store in working memory in expectation of a filler, and the semantic information that would signal the missing gap comes from the embedded verb right before the matrix subject position. Accordingly, there was no ERP effect associated with "holding a gap" in working memory within the embedded clause region, but the LAN effect was nonetheless elicited at the gap-filler association position (i.e., the matrix subject), which suggests higher working memory costs at this point. At the matrix subject, the parser needs to back-associate the filler with the preceding gap, and this process could be responsible for increased working memory costs. In addition, the results suggest that this search process is susceptible to the grammatical role of the gap (either defined in terms of hierarchical tree structure or a hierarchy of grammatical relations as in the *accessibility hierarchy*) rather than the linear distance between gap and filler, leading to a LAN effect in response to the object gap condition in Experiment 4-2 in Chapter 4. On the other hand, as a related but separate issue, the sustained LAN effect in response to the adjunct clause (i.e., an anaphoric dependency) that lasts from the matrix subject position until the end of the sentence could be an ERP index of pronoun resolution in anaphoric dependencies, which shows a different time-course of gap binding than in syntactic dependencies. Since there has been no previous ERP research investigating the processing of covert pronoun resolution, however, this result will require replication.

5.5 Conclusion

The research questions in this chapter were:

i) Does the subject/object processing asymmetry that has been found for syntactic dependencies emerge in argument-drop sentences with backward anaphoric dependencies as well?

ii) If so, to what extent are the cognitive/neural processes underlying long-distance dependencies in different constructions the same?

In answering the first question, the experimental results showed a subject/object processing asymmetry in argument-drop sentences with backward anaphoric dependencies, just as in sentences with backward syntactic (i.e., gap-filler) dependencies. This suggests that similar parsing strategies underlie the processing of backward anaphoric and syntactic dependencies. That is, the processing of backward anaphoric dependencies is sensitive to grammatical constraints defined in terms of language universals such as the *phrase-structural distance* hypothesis and the *accessibility hierarchy*, just as the processing of syntactic dependencies is.

In answering the second question, the results in Experiment 5.2 showed that syntactic (i.e., relative clauses) and anaphoric dependencies (i.e., adjunct clauses) showed similar yet differing processing profiles. In terms of similarities, both object syntactic and object anaphoric dependencies elicited a LAN effect in comparison to control sentences at the matrix subject position. This was taken to suggest that in both types of dependencies, gap-filler/antecedent association is immediate. In terms of differences, syntactic dependencies elicited a LAN effect at the matrix subject position relative to the anaphoric dependencies, while anaphoric dependencies elicited a LAN effect starting at the word after the matrix subject position through the end of the clause when compared to the sentences with syntactic dependencies. These differing time-courses of the LAN effect were taken to suggest different gap-filler/antecedent association requirements. In relative clauses, since gap-filler association is syntactically licensed, the parser immediately associates both the gap and the semantics denoted by the relative clause with the head noun, leading to higher working memory load at the matrix subject position than in the adjunct clause condition. On the other hand, in the adjunct clauses, gap-antecedent association is licensed by the semantics/pragmatics. Thus, although gap-antecedent association is immediate, the parser continues to evaluate the inter-clausal relationship to check the semantic fit of a gap with the potential antecedent until the end of the clause, leading to extra working memory in this region.

In conclusion, backward anaphoric and syntactic dependencies are similar in that their processing is constrained by syntactic constraints (i.e., defined in terms of hierarchical tree structure or a hierarchy of grammatical relations). However, the processing of backward anaphoric and backward syntactic dependencies is different in terms of gap-filler/antecedent association requirements and the subsequent time-courses of the association processing profile.

5.6 Acknowledgement

This chapter, in full, is being prepared for publication.

Nayoung Kwon, Robert Kluender, Maria Polinsky & Marta Kutas. Processing advantages of subject gaps in syntactic and anaphoric gap-filler dependencies: Evidence from reading time and ERP data. (In preparation)

The dissertation author is the primary investigator and author of the papers.

Chapter 6: Conclusion

In Chapter 2 I presented a syntactic analysis of Korean relative clauses. In particular, I showed that the syntactic analysis of Korean relative clauses vacillates between a null argument analysis and a *wh*-movement analysis. The goal of the experimental studies in Chapters 4 and 5 was therefore to compare the processing of long-distance dependencies in different types of constructions in Korean, with a view to helping decide among competing theoretical analyses of Korean relative clauses. Specifically, among the four different types of dependencies shown in (6.1) to (6.4) (i.e., forward syntactic, backward syntactic, forward anaphoric, and backward anaphoric dependencies), I focused on the processing of backward syntactic dependencies (6.2) and backward anaphoric dependencies (6.4), and how these compared to the processing of forward syntactic dependencies (6.1).

(6.1) Forward syntactic dependency
The reporter$_i$ who ___$_i$ harshly attacked the senator admitted the error.
FILLER GAP

(6.2) Backward syntactic dependency

[uywon-i	__	kongkeykha-n]	kica-ka	calmot-ul	siinhayssta
senator-NOM		attacked-REL	reporter-NOM	error-ACC	admitted
	GAP		FILLER		

'The reporter who the senator attacked admitted error.'

(6.3) Forward anaphoric dependency
When the boy was fed up, he visited the girl very often.
ANTECEDENT PRONOUN

(6.4) Backward anaphoric dependency (van Gompel and Liversedge 2003)
When he was fed up, the boy visited the girl very often.
PRONOUN ANTECEDENT

Given that most processing models have been developed with a goal of accounting for forward syntactic dependencies in English (or languages typologically similar to English), this research was designed to investigate the extent to which processing models represent universal parsing mechanisms, by examining to what degree they can account for cross-linguistic variation in dependency types. In addition, this research was motivated by an effort to further our understanding of general processing strategies underlying the parsing of long-distance dependencies. This was accomplished by comparing the processing of different types of dependencies – namely backward syntactic dependencies in relative clauses (6.5) and (6.6) and backward anaphoric dependencies in *–se* 'because' adjunct clauses (6.7) and (6.8) in Korean – to enhance our knowledge of independent factors contributing to sentence comprehension.

(6.5) Backward syntactic dependencies with subject gap

[__	uywon-ul	kongkeykha-n]	kica-ka	calmot-ul	siinhayssta
	senator-ACC	attacked-REL	reporter-NOM	error-ACC	admitted

'The reporter who the senator attacked admitted error.'

(6.6) Backward syntactic dependencies with object gap

[uywon-i	__	kongkeykha-n]	kica-ka	calmot-ul	siinhayssta
senator-NOM		attacked-REL	reporter-NOM	error-ACC	admitted

'The reporter who the senator attacked admitted error.'

(6.7) Backward anaphoric dependencies with subject gap

[$\_\_{i}$	pyencipcang-ul	hyeppakhay-se]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
	editor-ACC	threaten-because]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who threatened the editor met a journalist yesterday.'

(6.8) Backward anaphoric dependencies with object gap

[pyencipcang-i	$\_\_{i}$	hyeppakha-se]	chongcang$_i$ –i	enlonin-ul	manna-ss-ta
editor-NOM		threaten-because]	chancellor-NOM	journalist-ACC	meet-PST-DECL

'The chancellor who the editor threatened met a journalist yesterday.'

In this chapter, I first present a summary of the findings of each chapter. Then issues that have previously been discussed but which bear further discussion are presented. I conclude with some implications for future research.

6.1 Dissertation Summary

Chapter 2 presented a general grammatical sketch and various theoretical analyses of Korean relative clauses. It was observed that while English relatives have been argued to be ambiguous between head NP-internal analyses (head NP raising and the matching analysis) and a head NP-external analysis (*wh*-operator movement analysis) (Aoun & Li, 2003; Bhatt, 2002; Sauerland, 2004), Korean relatives are not compatible with head NP-internal analyses. The lack of idiomatic readings and the availability of only the high interpretation of adjectival modifiers suggest that the head noun does not originate and does not have a representation within the relative clause in Korean. In addition, previously proposed analyses of Korean relatives were discussed, including gapless adposition (Yoon, 1993, 1995), an embedded clause analysis with a null argument (Y.-S. Kang, 1986; H.-M. Sohn 1980) and *wh*-operator movement (D.-H. Yang, 1987; J.-I. Han, 1992; H.-K. Yang, 1990; Han & Kim 2004). I argued that Korean relatives should not be analyzed as gapless adposition constructions, since the two constructions differ in terms of how freely they participate in long-distance relative clause formation, the extent to which they can be coordinated and the semantic constraints on head nouns that they obey. In addition, I showed that the syntactic analysis of Korean relative clauses vacillates between the null argument analysis and the *wh*-movement analysis. While weak crossover data and replacement by an overt pronominal are equally compatible with and problematic for both analyses, there is some support for the null argument analysis coming from island effects.

Chapter 3 was a review of research on long-distance dependencies, various processing models and experimental methodologies. That is, previous research on the subject/object gap asymmetry in forward syntactic dependencies (King & Just, 1991; Frazier, 1987) was presented along with various processing models that have been proposed to account for this asymmetry: *dependency locality theory* (Gibson, 2000), *filler-gap domains* (Hawkins, 2004), the *phrase-structural distance hypothesis* (O'Grady, 1997), the *accessibility hierarchy* (Keenan & Comrie, 1977), the *perspective shift hypothesis* (MacWhinney, 1982), *similarity-based interference* (Gordon et al., 2001) and frequency-based models (MacDonald & Christiansen, 2002; Hale, 2006; Roger, 2007). The chapter also summarized previous research on backward anaphoric dependencies, focusing on the role of the active search mechanism of the parser in processing long-distance dependencies (Kazanina et al., 2007).

Chapter 4 investigated the processing of subject (SR) and object relative (OR) clauses in Korean in an attempt to answer the following questions:

(i) Which of these accounts proposed for English is most appropriate as a universal processing strategy?

(ii) To what extent are the neuro/cognitive operations underlying the processing of forward syntactic dependencies in post-nominal relative clauses (in which a head noun precedes the relative clause, as in English) similar to those underlying the processing of backward syntactic dependencies in prenominal relative clauses (in which a relative clause precedes its head noun, as in Korean)?

In answering the first question, the results of self-paced reading and eye-tracking studies clearly indicated that backward syntactic dependencies in Korean relatives, just like forward syntactic dependencies in English relatives, show a subject/object asymmetry. This suggests the presence of a universal parsing constraint based on the *accessibility hierarchy* and *phrase-structural distance*. The results also showed that similarity-based interference provides an additive effect to the main effect triggered by phrase-structural complexity and/or psychological ease as defined in the *accessibility hierarchy* proposal.

In answering the second question, the results also showed that backward syntactic dependencies in Korean relatives elicit remarkably similar ERP responses to those elicited by forward syntactic dependencies in English relatives, within both the relative and main clause regions. In both the main and relative clause regions, ORs elicited anterior negativity when compared to subject relatives. Although the effect within the relative clause region was attributed to different underlying cognitive processes from those involved in processing English relatives (i.e., the processing difficulty associated with a nominative marked NP vs. the processing difficulty associated with holding a filler without a thematic role in working memory), the effect at the head noun position was interpreted to be due to the same cognitive processes as in English relatives. That is, the effect was attributed to the higher working memory load associated with filler-gap association in ORs when a gap is structurally more embedded and/or when there are multiple simultaneous processes.

Comparing backward syntactic dependencies with backward anaphoric dependencies with subject and object gaps, Chapter 5 further investigated the following questions.

i) Does the subject/object processing asymmetry that has been found for syntactic dependencies emerge in argument-drop sentences with backward anaphoric dependencies as well?

ii) If so, to what extent are the cognitive/neural processes underlying long-distance dependencies in different constructions the same?

In answering the first question, the results showed that an asymmetry in subject/object processing is also found in backward anaphoric dependencies, just as it is in (forward and backward) syntactic dependencies. Thus at the coindexed matrix subject position, object gap sentences, as in (6.6) and (6.8), showed more processing slow-down than subject gap sentences, as in (6.5) and (6.7), regardless of dependency type.

In answering the second question, the results suggested similar but distinct cognitive processes underlying the processing of syntactic and anaphoric dependencies. In terms of similarities, both conditions elicited a left anterior negativity at the matrix subject when compared to filler sentences. This result was taken to suggest that the gap in both dependencies is associated with its filler/antecedent at that position, supporting the idea that the processing of anaphoric dependencies is driven by an active search mechanism. In terms of dissimilarities, syntactic dependencies elicited a larger LAN effect in comparison to anaphoric dependences at the matrix subject position. This suggests however that the back association of the filler with the preceding gap is similar in both types of dependencies, and is therefore indexed by a quantitative difference in amplitude. The two types of dependencies differ in that the preceding relative clause must be combined with its head noun in relative clause sentences to close off the matrix clause subject argument. This additional operation is not required in a backward anaphoric dependency, and this accounts for the larger LAN effect at the matrix clause subject position in backward syntactic dependencies. On the other hand, following the matrix subject position through the end of the sentence, the reverse pattern was observed: anaphoric dependencies elicited a sustained negativity in comparison to syntactic dependencies, which suggested some additional cognitive operation in the anaphoric condition not present in the syntactic condition. I hypothesized that this cognitive operation was the integration of the adjunct and matrix clauses required at sentence end to fix the reference of the missing argument in the adjunct clause. These ERP differences were consistent with the reading time results, which likewise showed a slowdown for relative clause sentences at the head noun/matrix subject position, followed by a slowdown for adjunct clause sentences at sentence end.

This suggests underlying different gap-filler and gap-antecedent association requirements in these constructions. That is, in syntactic dependencies (relative clauses), gap-filler association is syntactically motivated, and the parser immediately and completely associates both a gap and the semantics denoted by the relative clause with the filler. This should lead to higher working memory load at the matrix subject position than in the anaphoric dependencies. On the other hand, gap-antecedent association in anaphoric dependencies (adjunct clause sentences) is semantically and pragmatically motivated. Thus, even though the parser appears to associate a gap with its potential antecedent immediately at the matrix subject position, this association is susceptible to continuous evaluation, leading to greater working memory load in anaphoric dependencies following the matrix subject to the end of the sentence, as indexed by a sustained negativity with an anterior maximum in comparison to the syntactic dependencies.

6.2 Implications for Theoretical Analyses of Relative Clauses

While the syntactic evidence in Chapter 2 was also somewhat equivocal, the lack of island effects in Korean at least seemed to favor the null argument analysis of relative clauses. In the experimental data, we saw that the experimental results showed similar yet distinct behavioral (reading time) and cognitive/neural (ERP) patterns in processing backward syntactic and anaphoric dependencies. These different parsing strategies in relative and adjunct clauses might seem at first blush to be more consistent with the movement analysis of Korean relative clauses, where a gap in the relative clause is analyzed as a trace, an empty category distinct from a dropped argument (see Chapter 2 for details). However, it should be noted that (object) null arguments in both adjunct and relative clauses caused reading time slow-downs at the head noun position, and that both elicited LAN effects at the head noun position relative to control sentences. These were surprisingly consistent findings, and thus it was not the case that adjunct and relative clauses behaved in ways that were completely orthogonal to each other, either. In this sense, in terms of immediate gap-filler/antecedent association, gapped positions in adjunct and relative clauses seemed to exhibit very similar processing profiles. The other differences in the time course of processing bottlenecks between the two conditions were attributable to independent characteristics of the individual constructions: the lower frequency of occurrence of *–se* clauses with object drop than of object relative clauses in corpora, and the necessity of integrating an adjunct clause with the matrix clause at sentence end, while relative clauses can be fully integrated into overall sentence meaning as part of the head noun argument. Apart from these considerations, it is fair to conclude that null arguments in Korean adjunct and relative clauses behave very much alike during the immediate stages of gap-filler/antecedent association. Whether this is enough of a similarity to tip the balance in favor of a null argument analysis of relative clauses remains to be seen in future research, however.

6.3 Language Universals and Universal Parsing Mechanisms

Experimental results in Chapters 4 and 5 showed that both object relative clauses and adjunct clauses with object gaps were harder to process than their subject gap counterparts. However, Chapter 5 additionally showed that greater phrase-structural distance between filler and gap did not lead to greater processing difficulty when the gap position was held constant (i.e., subject argument drop sentences vs. subject relative clauses, and object argument drop sentences vs. object relative clauses). This absence of a structural distance effect was taken to suggest that the structural position of a gap is a more important factor in processing dependencies than the structural distance between a gap and its filler. That is, object relative clause sentences could be harder to process than subject relative sentences because the object gap is structurally more deeply embedded than the subject gap, and not because the structural distance between the object gap and the filler is greater than the distance between the subject gap and the filler. In this sense, an account based on phrase-structural complexity can actually be defined in terms of the structural position of the gap itself rather than in terms of the distance between a gap and its filler. This, in turn, suggests that the accessibility hierarchy and the phrase-structural distance hypothesis may be notational variants of each other. That is, both of them are based on assumed language universals, though they take different approaches to the notion of a language universal.

The *accessibility hierarchy* has been proposed as an instance of an absolute universal (Keenan & Comrie 1977), in the tradition of the database approach to language universals influenced by Greenberg's work. In his work and the work inspired by it, a wide range of languages are examined and concrete levels of analyses are set forth to explain cross-linguistic variation. On the other hand, the *phrase-structural distance hypothesis* was proposed in the tradition of the abstract approach represented by Chomsky's work and the work inspired by it, where language universals are investigated and defined in terms of the abstract representations that underlie cross-linguistic surface variation. Thus, the convergence of these two hypotheses suggests that the subject/object processing asymmetry is an inherent language universal that can be accounted for both by concrete and abstract analyses of cross-linguistic variation.

6.4 Linear Distance vs. Expectation

In the integration-based *dependency locality theory* (Gibson, 2000), a processing model defined in terms of memory constraints, structural integration complexity is proportional to the distance or locality between the two elements being integrated. In other words, the longer the linear distance is between the linguistic elements to be integrated, the greater the working memory load (i.e., a locality effect). On the other hand, in processing models emphasizing the role of expectation, greater distance is considered to facilitate processing (i.e., an anti-locality effect), as the context provided by the intervening material can help to sharpen the expectation of an upcoming word in terms of its location and identity (Konieczny, 2000; Levy, 2008; Vasishth & Lewis, 2006). Given the different experimental results from different studies (anti-locality effect: Konieczny, 2000; Vasishth & Lewis 2006; locality effect: Grodner & Gibson 2005), one possibility is that factors contributing to processing facilitation and to slow-down caused by long distances between elements in need of integration are both at work, and that these two effects are weighted against each other, yielding experimental results where the stronger of the two effects is observed at different points in the sentence.

For example, in the current experiments, the non-canonical sentence-initial NP-ACC in subject gap sentences (i.e., subject relative clauses and adjunct clauses with subject argument-drop) could have signaled the existence of a complex structure, while canonical NP-NOM in object gap sentences didn't. Thus, this early signal in subject gap sentences could have eased processing difficulty at the head noun position in comparison to object gap sentences (i.e., an anti-locality effect). On the other hand, since holding a gap in working memory causes little if any increase in working memory load (see Chapter 4 for discussion), the processing slow-down effect due to longer distance in object gap sentences (i.e., a locality effect) could have been minimal and outweighed by the anti-locality effect.

Although plausible, this hypothesis requires further investigation. First, it has yet to be fully investigated what kind of cues are effective in triggering anti-locality effects.

Second, it is not clear exactly how factors triggering anti-locality and locality effects interact with each other in incremental structure building.

6.5 Immediate but Cautious Incremental Parsing

The experiments in Chapter 5 suggest that backward syntactic and anaphoric dependencies are both driven by an active search mechanism such that the parser actively integrates a gap with a potential antecedent or filler immediately. However, different parsing strategies were also observed between backward syntactic and anaphoric dependencies. That is, in the relative clause sentences, since filler-gap association is syntactically licensed, the parser immediately associates both the gap and the semantics denoted by the relative clause with the head noun, leading to greater working memory load at the matrix subject position than in the adjunct clause condition. On the other hand, in the adjunct clauses, gap-antecedent association is licensed by semantics/pragmatics. Thus, although gap-antecedent association is immediate in accordance with first-resort strategies (Fodor, 1978), in which the parser does not wait for disambiguating information to make a filler-gap assignment (i.e., the *active filler strategy* in forward dependencies, Frazier & Clifton 1989; Stowe 1986; Garnsey et al. 1989), the parser continues to evaluate the inter-clausal relationship to check the semantic fit of a gap with the potential antecedent until the end of the clause, leading to extra working memory costs in this region. These different parsing strategies suggest that the parser is immediate but cautious, and maintains different degrees of commitment to a structural analysis as a result of being sensitive to different association requirements of gap and filler in relative clauses and gap and antecedent in adjunct clauses. The question of whether the parser sometimes actually holds off positing an antecedent for an earlier-occurring gap until an unambiguous antecedent becomes available in the parse string must await a replication of Experiment 5.1b for an unequivocal answer; see section 5.2.2.3.

6.6 Concluding Remarks and Research Implications

Overall, the dissertation contributes to a better understanding of sentence processing by investigating the universal parsing strategies that underlie typological variation and different types of long-distance dependencies. Specifically, the results have the following implications.

In terms of universal parsing strategies, the systematic evaluation of various parsing theories and the comparison of experimental results from typologically different languages provides critical evidence that phrase-structural complexity and the accessibility hierarchy act as universal constraints on the processing of different types of long-distance dependencies. Furthermore, the experimental results suggest that an account based on phrase-structural complexity can actually be defined in terms of the structural position of the gap itself rather than in terms of the distance between a gap and its filler, suggesting that the accessibility hierarchy and the phrase-structural distance hypothesis may constitute two different but compatible ways of looking at the exact same phenomenon (i.e., the notion of a language universal).

In terms of the cognitive/neural processes underlying the parsing of filler-gap dependencies, the experiments in this dissertation have shown that object relatives in comparison to subject relatives elicit a frontal negativity at the head noun in Korean backward syntactic dependencies, a result comparable to previous findings for forward syntactic dependencies in English (King & Kutas, 1995). These analogous ERP results between Korean and English relatives suggest similar cognitive/neural mechanisms underlying the processing of forward and backward syntactic dependencies, despite surface typological differences.

In terms of cognitive/neural indices of pronoun resolution, covert pronoun (*pro*) resolution in adjunct clauses elicited (left) anterior negativity, a response similar to that elicited in relative clauses, at both identical and divergent time points across the course of the sentence, suggesting a possible cognitive/neural index of pronoun resolution. These experimental data are consistent with Van Berkum, Brown and Hagoort (1999), where referentially ambiguous overt pronouns elicited a frontal negativity in comparison to referentially unambiguous pronouns (see Van Berkum, Koornneef, Otten, Nieuwland 2007 for a review). This suggests that the underlying cognitive mechanisms of overt and covert pronoun resolution are similar to each other despite apparent surface differences. However, since there have been no previous ERP studies investigating covert pronoun resolution prior to the present work, more cross-linguistic research is needed to confirm this result.

The experimental results also have implications for theoretical linguistics. In terms of language universals and typology, experimental results provide both support and challenges for the accessibility hierarchy (Keenan & Comrie, 1977). While the accessibility hierarchy predicted a subject/object asymmetry in syntactic dependencies, results from the processing of anaphoric dependencies suggest that the accessibility hierarchy needs to be extended to argument-drop as well, calling for further cross-linguistic descriptive and experimental research.

Theoretical linguists mainly concern themselves with the off-line mental representation of language. Thus, language users' intuitions about the (un)acceptability of sentences has been a primary method in studying the structure of language. With the development of experimental methodologies, however, we can now investigate on-line processing in the brain with fine spatial and/or temporal precision. It seems obvious that the study of language can benefit from both theoretical and experimental research. The vast amount of research accomplished in the realm of theoretical linguistics is an essential resource for understanding how we parse language at every level. In return, experimental results can lead to increased linguistic insights. While the experimental data presented in this dissertation were perhaps not able to distinguish unequivocally between competing theoretical analyses of Korean relative clauses, my hope is that the dissertation nonetheless showed clear avenues of research to pursue in order to find the ultimate answers to these questions. Moreover, I hope to have illustrated how the combination of theoretical linguistics and experimental science can allow us to achieve a better understanding of the mental representation of language.

APPENDICES

Appendix 1: P600 effect in response to the ungrammatical filler sentences compared to the grammatical filler sentences

Grammatical sentence

emma-ka	ocen-ey	kongwon-ulo	sanchayk-ul	kasi-ess-ta
Mom-NOM	morning-at	park-to	walk-ACC	go-PST-DECL

'Mom went to the park for a walk.'

Ungrammatical sentence: **headedness violation**

emma-ka	ocen-ey	ulo-kongwon	sanchayk-ul	kasi-ess-ta
Mom-NOM	morning-at	to-park	walk-ACC	go-PST-DECL

'Mom went to the park for a walk.'

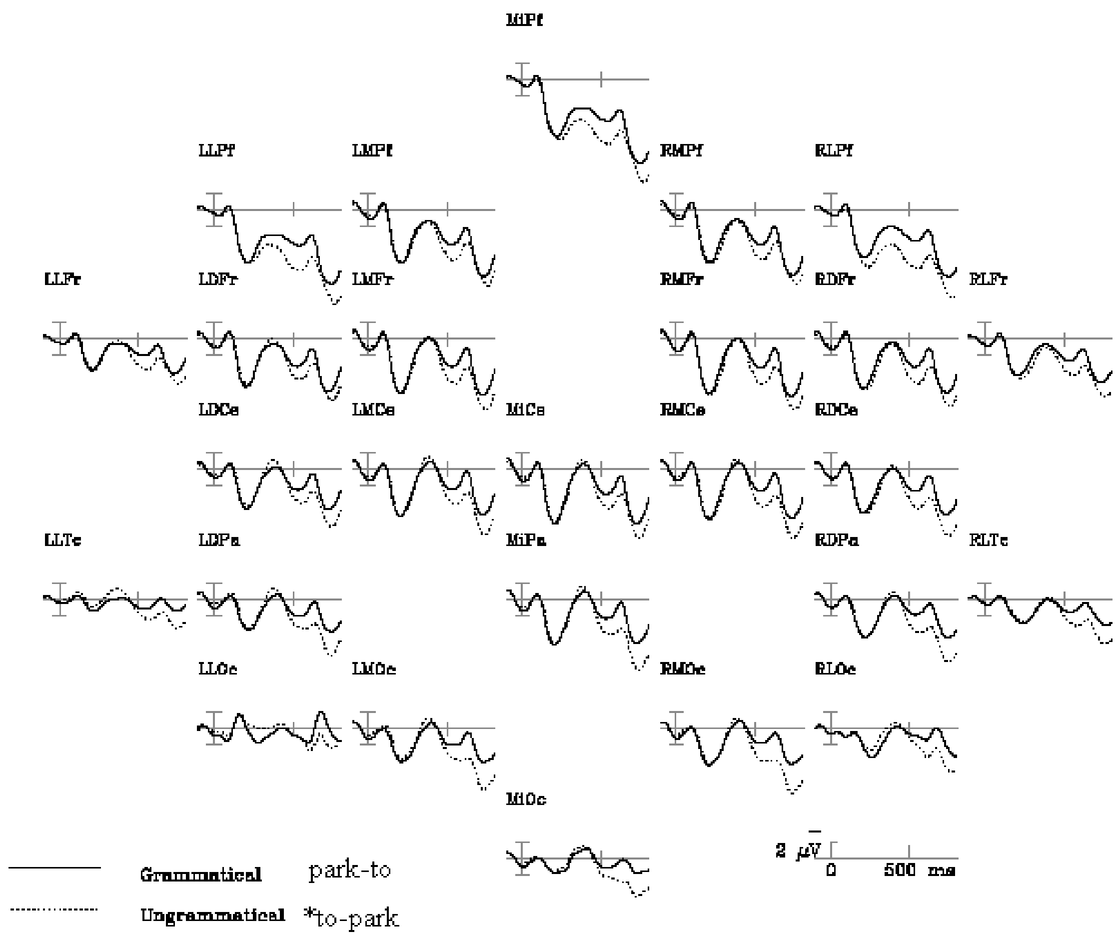

Figure Appendix-1 Grand average ERP waveforms for grammatical and ungrammatical sentences shown at all 26 electrodes sites

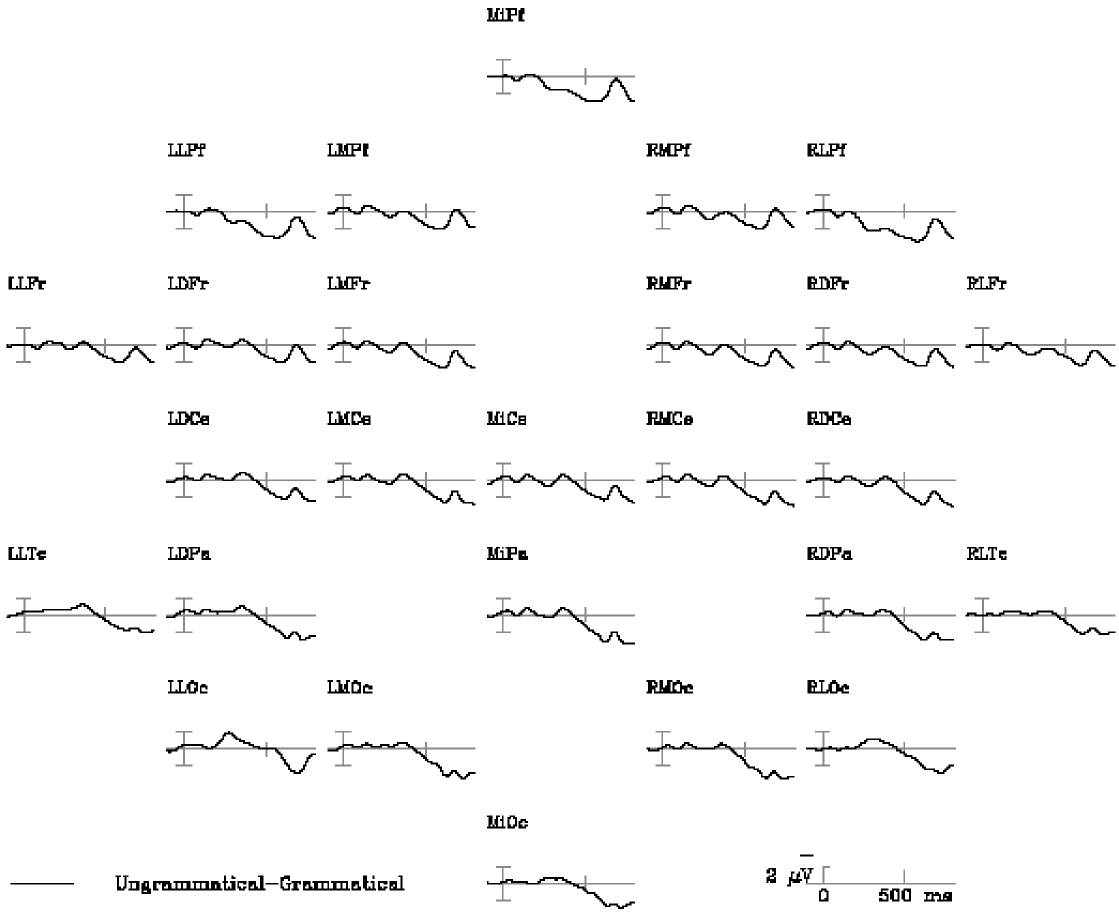

Figure Appendix-2 Difference waves (Ungrammatical - Grammatical) shown at all 26 electrodes sites

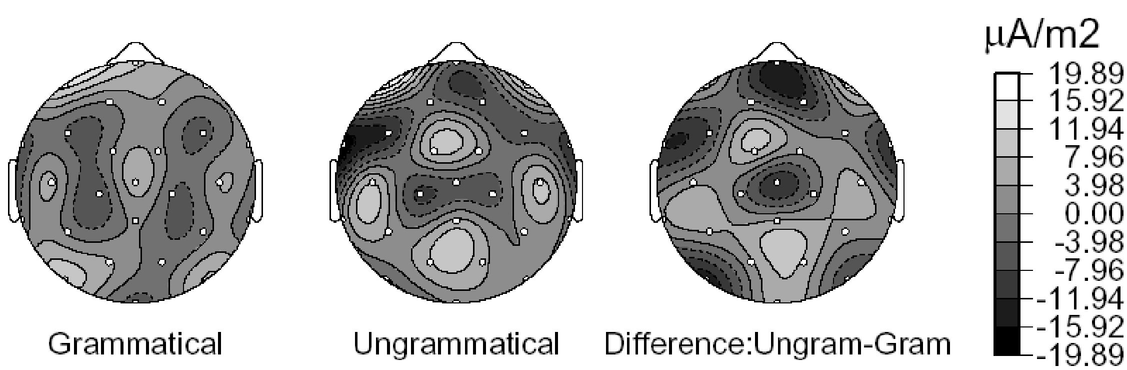

Figure Appendix-3 Isovoltage map of (un)grammatical sentences

- Main effect of grammaticality in the full analysis using all the 26 electrodes: [$F(1,23) = 17.88$, $p < .001$].

- **Appendix 2: N400 effect in response to the incongruous filler sentences compared to the congruous filler sentences**

Congruous sentence

achim-ey	salamtul-i	pap-ul	mek-ess-ta
morning-in	people-NOM	rice-ACC	eat-PST-DECL

'In the morning, people ate a meal.'

Incongruous sentence

achim-ey	salamtul-i	chayk-ul	mek-ess-ta
morning-in	people-NOM	book-ACC	eat-PST-DECL

'In the morning, people ate a book.'

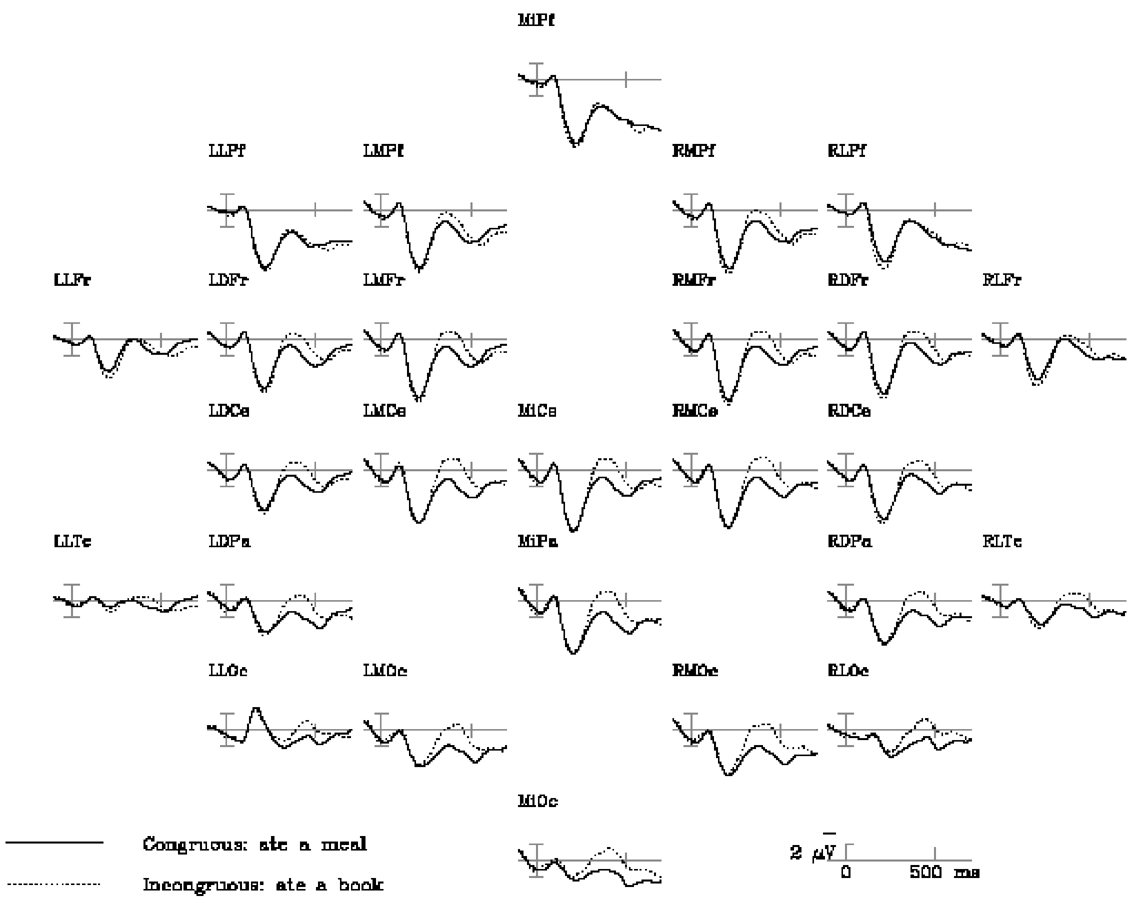

Figure Appendix-4 Grand average ERP waveforms for congruous and incongruous sentences shown at all 26 electrodes sites at the sentence-final verb position

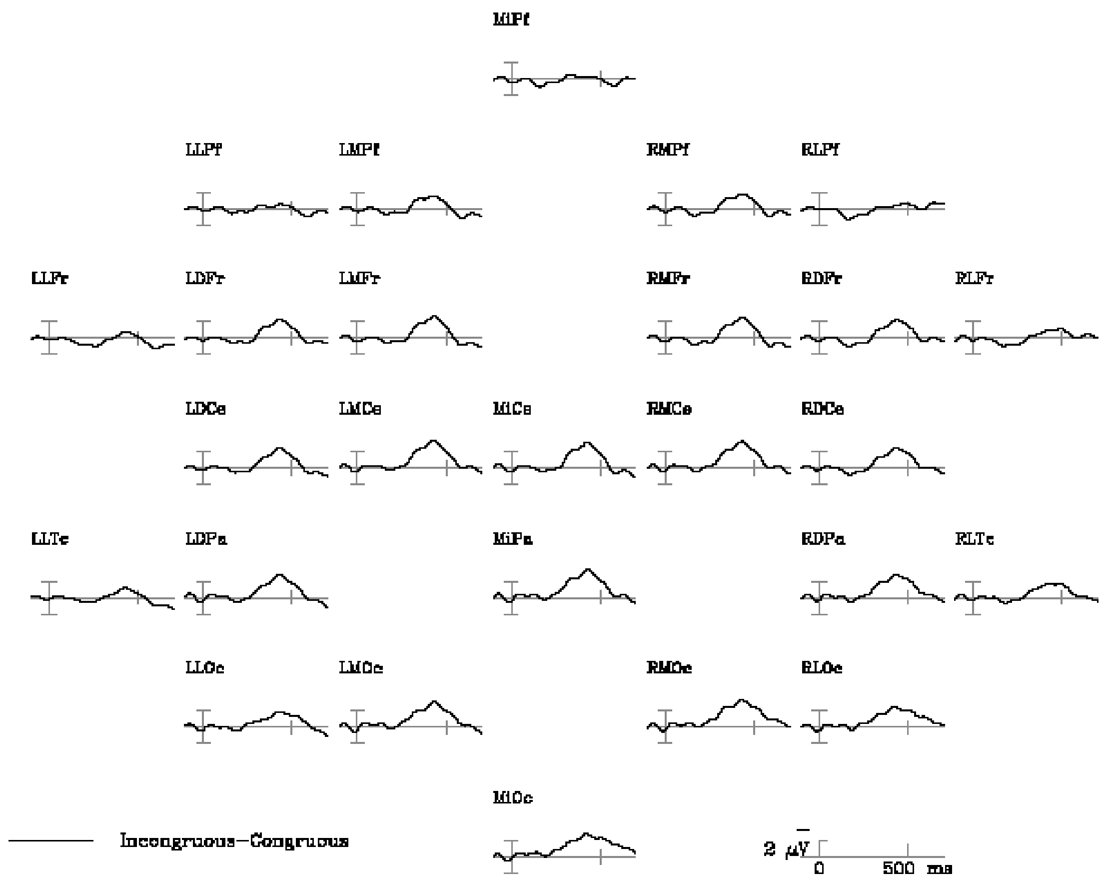

Figure Appendix-5 Difference waves (Incongruous – Congruous sentences) shown at all 26 electrodes sites at the sentence-final verb position

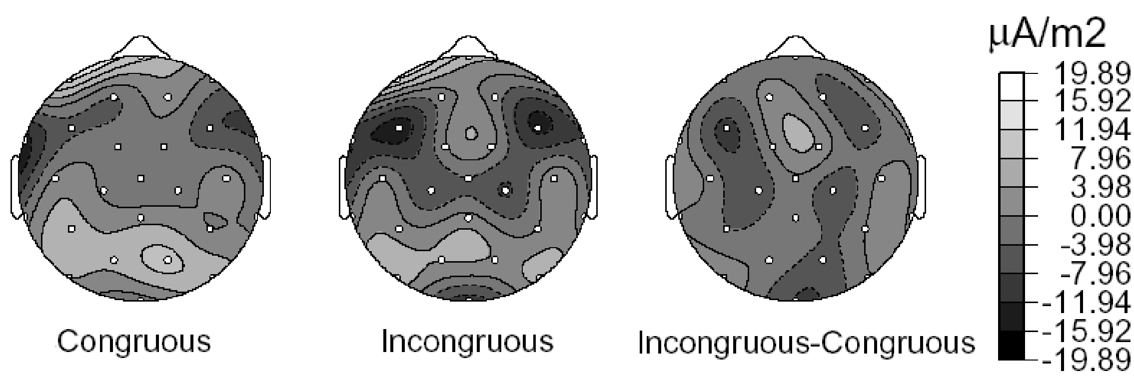

Figure Appendix-6 Isovoltage map of (in)congruous sentences

- Main effect of congruity in the full analysis using all the 26 electrodes: [$F(1,23) = 13.65$, $p < .001$]

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