# AMBIGUITY IN THE PROCESSING OF JAPANESE, KOREAN AND MANDARIN CHINESE RELATIVE CLAUSES

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**AMBIGUITY IN THE PROCESSING OF**

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**CHINESE RELATIVE CLAUSES**

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Abstract: Numerous models of sentence processing have been constructed through the lens of the processing of relative clauses (RC). In RC processing, there is a near universal phenomenon of subject-extracted relative clauses (SRCs) being easier to process and comprehend compared to their object-extracted relative clause (ORC) counterparts. Following this, many researchers have crafted hypotheses of processing in order to explain the processing asymmetry between SRCs and ORCs. Considering the amount of models to explain this effect, how is it possible to reconcile which models are valid accounts of processing in order to better unify sentence processing theory. A key method to empirically test models is to investigate them within a copious amount of languages with varying typological features to determine if a model can accurately predict processing in each language. In terms of RC processing, studies had classically investigated processing within European languages that were post-nominal (i.e., the RC follows the head noun it modifies). Accordingly, there has recently been a surge in studies investigating processing within prenominal languages (i.e., the RC precedes the head noun it modifies). In the current study, RC processing was investigated in three East Asian languages all of which have prenominal RC structures: Japanese, Korean, and Mandarin Chinese. However, all three of these languages have a confounding factor inherent to each language and their respective structures. Specifically, this factor is an initial clause-type ambiguity. In other words, since these languages lack relative pronouns or markers at the left edge of the clause (i.e., the start or boundary of the clause), a simple sentence (i.e., matrix clause) interpretation will be taken instead of an RC one. This misparse will continue until a viable cue to disambiguate the ambiguity of clause-type: The head noun in Japanese, the adnominal marker in Korean, and the relativizer in Mandarin. While recent studies have begun to use unambiguous RCs in these languages, there are a relatively few addressing it as an actual processing factor. Consequently, it is of empirical importance to investigate the manner in which ambiguity influences the processing of

RCs in each language to better explain how processing unfolds. As such, the main aim of this study was to investigate RC processing in each language as a factor of ambiguity to explain how processing mechanisms interact with one another. The current study utilized eye-tracking methods on native speakers of each of these languages. The results of the study revealed both language dependent and independent effects. Both Japanese and Mandarin were shown to be influenced by ambiguity, but Korean, on the other hand, revealed the same pattern of results for both ambiguous and unambiguous RCs. In Japanese and Korean ORCs were always more difficult to process regardless of ambiguity. In contrast, ambiguous RCs in Mandarin revealed SRC difficulty and unambiguous RCs demonstrated clear ORC difficulty. The observed effects for each of the languages were primarily found at the locus of disambiguation for each language. These results support hybrid models of processing where both working memory-constraints and probabilistic expectations interact during processing. Particularly for memory, Mandarin RCs were found to utilize a linear or temporal integration/retrieval metric while Japanese and Korean had better support for a structural metric. Furthermore, for each language, some level of similarity-interference was observed for ORCs showing additional effects of memory-constraints. For expectation-based processing, there was conclusive evidence that ORCs were more difficult to process due to their lower frequency. Additionally, these expectation effects grew stronger as the RC became less ambiguous. These above effects can all fit into cue-based retrieval models of processing. In other words, specific cues in the sentence are responsible for providing the correct interpretation of the clause (both within ambiguous and unambiguous contexts), raise or lower a word's or a structure's activation level, and trigger a retrieval process. In conclusion, RC processing should not be viewed under the scope of any single model of processing and instead should be understood as multiple interdependent factors.

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| | |
|---|---|
| ACC (in text) | Accusative |
| ACC (in tables) | Accuracy |
| ADJ | Adjective |
| ADN | Adnominal |
| ADV | Adverb |
| ASP | Aspect |
| CC | Complement Clause |
| CL | Classifier |
| CP | Complement Phrase |
| COMP | Complementizer |
| DAT | Dative |
| DCL | Deterimer + Classifier |
| DET | Determiner |
| DP | Determiner Phrase |
| DT | Dwell-Time |
| EEG | Electroencephalogram |
| EHRC | Externally-Headed Relative Clause |
| ERP | Event Related Potential |
| fMRI | Functional Magnetic Resonance Imaging |
| FF | First-Fixation Duration |
| FP | First-Pass Reading Time |
| FREQ | Frequency Phrase |
| GEN | Genitive |
| IHRC | Internally-Headed Relative Clause |

| | |
|---|---|
| IP | Inflection Phrase (Tense Phrase) |
| LOC | Locative |
| LOD | Locus of Disambiguation |
| LOI | Locus of Integration |
| NOM | Nominative |
| NP | Noun Phrase |
| OBSB | Object-Before-Subject-Bias |
| ORC | Object-Extracted Relative Clause |
| OP | Operator |
| RC | Relative Clause |
| REL | Relativizer |
| RI | Regression-In Proportion |
| RMS | Root-Mean-Square |
| RO | Regression-Out Proportion |
| RR | Re-Reading Time |
| RT | Reaction Time |
| SPEC | Specifier Position |
| SRC | Subject-Extracted Relative Clause |
| TOP | Topic |
| TP | Tense phrase (Inflection Phrase) |
| TT | Total Reading Time of the Sentence |
| VP | Verb Phrase |

# CHAPTER 1

# INTRODUCTION

## 1.1. Preface

Recently, studies dealing with relative clause processing have expended much effort in investigating non-European languages for the purpose of validating models of processing which formerly had primarily been investigated through the lens of European languages such as Dutch, English and German. In order to formulate a comprehensive model of processing, more languages with diverging typological features are needed. As such, within the past decade, the research done on relative clause processing in Mandarin Chinese, Korean and Japanese has substantially increased. It was soon discovered for these languages, however, that there is a confounding factor involved in relative clause processing, ambiguity. Due to the syntactic nature of these languages, relative clauses can be ambiguous in that initially, the parser may not correctly recognize the relative clause interpretation and because of this ambiguity, it makes it difficult to ascertain whether or not any processing effect found is reflective of a specific model or should be attributed to the presence of ambiguity itself. While there has been a recent trend to investigate relative clause processing in Mandarin, Korean and Japanese within unambiguous contexts (i.e., methods were used to increase the chance that a relative clause interpretation is initially taken), these studies chiefly used unambiguous contexts without a baseline comparison with an ambiguous context. Furthermore, since these studies had similar findings to the results found in ambiguous contexts, it is difficult to argue that the ambiguity context had any impacting influence on the processing of relative clauses. Nonetheless, ambiguity does likely impact the processing of relative clauses in these languages, but the precise manner in which processing is impacted has not yet been effectively shown.

Recent relative clause studies have typically addressed the factors of working memory resources and expectation-based processing resources to explain the subject/object asymmetry (i.e., the near universal pattern of results showing that subject-extracted relative clauses are easier to process than object-extracted relative clauses). Following current literature, these processing mechanisms are likely interactive when processing a sentence (i.e., a hybrid model of expectation-based and memory-based mechanisms). However, these factors are likely to only be interactive at specific loci where both factors are operational. At such a locus, the factor of ambiguity is most likely to enter the processing fray.

It is my claim that as ambiguity is attenuated (i.e., increasing the interpretation for an RC using pre-relative clause cues) expectation-based processing will become the principal processing factor since parser expectations are initially being made for an RC rather than another clause bearing the same surface structure (i.e., looking identical to a relative clause). Accordingly, the main purpose of this research is to compare relative clause processing, particularly working memory factors and expectation-based processing, in these languages as a factor of ambiguity.

This dissertation is divided into six chapters. The current chapter, Chapter 1, introduces relative clauses, relative clause processing theories, clause-type ambiguity for these East Asian relative clauses, and the general experimental guidelines (e.g., methods and research questions) for the current study and also a brief review of several previous studies. The following three chapters are individual studies for each language, and each chapter is a self-standing study. In other words, each chapter will have its own introduction, experiments, general discussion, and conclusion relevant for a given language. Accordingly, Chapter 1 only serves to introduce the basic themes for this dissertation; thus, more relevant information for any particular language can be found within the specific chapter covering it. First, Chapter 2 deals with Mandarin Chinese relative clause processing. Second, Chapter 3 covers Korean relative clause processing, and lastly, Chapter 4 finishes with the study on Japanese relative clause processing. Chapter 5 is a general discussion covering the main findings found in Chapters 2-4, and Chapter 6 concludes this dissertation.

## 1.2. Relative Clauses

A relative clause (RC) is a noun modifying subordinate clause (often residing in a complement phrase) which must use its head argument (i.e., what is being modified) as a grammatically dependent referent within the same clause (see example 1.1a). In this regard, an RC may be considered as an adjectival subordinate clause (Whaley, 1997), but with the head noun being co-indexed with a specific, yet covert referent within the RC. In example (1.1a) below, the head noun ‘$\text{reporter}_i$’ is co-indexed (i.e., co-referenced or bound) with the relative pronoun ‘$\text{who}_i$’ and the ‘$\text{GAP}_i$’ which exists only in deep structure (i.e., not seen or heard on the surface representation).

(1.1a) Subject-extracted relative clause (SRC)

The reporter$_i$ [$_{RC}$ who$_i$ GAP$_i$ criticized the mayor] interviewed the doctor.

For specific properties which constitute a relative clause, Kuno (1976, as reported in Na & Huck, 1993) proposed the *Thematic Constraint*: "RCs must be a statement about the head noun." Following Kuno, Na and Huck (1993, p. 197) proposed the *Argument Condition*: "A RC must contain an element E that the clause predicates something of, where E is either (A) a gap co-indexed with the clause head or (B) a nominal whose denotation is thematically subordinate to that of the head noun".

In this dissertation, only two types of RCs are discussed: Subject-extracted relative clauses (SRC) and object-extracted relative clauses (ORC). See examples (1.1c)-to-(1.1g) for examples of other types of relative clauses, and refer to the *World Atlas of Language Structures* (Dryer, 2013) for the RC types based upon the ordering of the head noun and the RC.

As evident in the SRC and ORC examples (1.1a, repeated) and (1.1b) below, both RC types are presented to contain *gaps* (e.g., 'GAP') in the underlying syntactic representation. RCs are often discussed in terms of *wh*-movement and filler-gap dependencies (Clifton & Frazier, 1989; Fodor, 1978, 1989; Ford, 1983), where the *filler* (i.e., the head noun, 'reporter') is the co-indexed element that fills the gap created at the trace of the *wh*-movement in order to receive case and grammatical assignment (Chomsky, 1977, 1981). Thus, these gaps appear at the loci of the trace where a relativizer has moved from to the left edge of the clause in [Spec, CP]; see Figure 1.1 for an illustration of *wh*-movement from a trace/gap position to [Spec, CP]. However, if the head noun is not co-indexed with the gap as in (1.1f), the sentence becomes ungrammatical since the head noun must have co-reference within the RC.

RCs differ from other complement clause structures such as a de facto expression (e.g., 'the fact that') that is not co-indexed with a referent inside the clause. Instead of assuming a specific grammatical function within the clause, the head would represent the overall semantic interpretation of the clause, but since it contains neither a gap nor a specific nominal thematically subordinate to the head, it should not be considered as an RC, see example (1.1g).

(1.1a) Subject-extracted relative clause (SRC)
The $reporter_i$ [$_{RC}$ $who_i$ $GAP_i$ criticized the mayor] interviewed the doctor.

(1.1b) Object-extracted relative clause (ORC)
The $reporter_i$ [$_{RC}$ $who_i$ the mayor criticized $GAP_i$] interviewed the doctor.

(1.1c) Indirect Object relative clause
The $reporter_i$ [$_{RC}$ $who_i$ the mayor sent a letter to $GAP_i$] interviewed the doctor.

(1.1d) Oblique relative clause
The $reporter_i$ [$_{RC}$ $who_i$ the mayor talked about $GAP_i$] interviewed the doctor.

(1.1e) Genitive relative clause (ORC)
The $reporter_i$ [$_{RC}$ $whose_i$ son criticized the mayor $GAP_i$] interviewed the doctor.

(1.1f) Ungrammatical object-extracted relative clause
*The $reporter_i$ [$_{RC}$ $who_j$ the mayor criticized $GAP_j$] interviewed the doctor.

(1.1g) Fact-clause
The reporter knew the fact [$_{CC}$ that the mayor criticized him] was newsworthy.

(1.1h) Reduced relative clause
The reporter [$_{RC}$ $OP_i$ the mayor criticized $GAP_i$] interviewed the doctor.

(1.1i) Subject-extracted relative clause with an intransitive verb (SRC)
The $reporter_i$ [$_{RC}$ $who_i$ $GAP_i$ is handsome] interviewed the doctor.

Looking at sentences (1.1a) and (1.1b), it can be seen that the relative pronoun originates from a deeper syntactic position within each RC structure at the gap or trace position. While the gap in (1.1a) is located in the subject position of the RC and modifies the head as the subject within the RC, the ORC (1.1b) has its gap in the object position making the head noun an object within the RC. Thus, the SRC (1.1a) and ORC (1.1b) can be compared by interpreting the head noun at the gap position, for example, [*the reporter* criticized the mayor] and [the mayor criticized *the reporter*]. The sentence (1.1f) is ungrammatical since the gap is not co-indexed with the head noun. Importantly, even in cases where the relative pronoun can be omitted as in example (1.1h), there is still a covert *wh*-operator involved in the *wh*-movement (Browning, 1987). This means that when a relativizer is not specified on the surface form, a *wh*-operator still exists in syntactic structure which has the capacity to carry out the functions of the relativizer. This movement is considered A-bar movement since the relativizer moves from an argument position to [Spec, CP] where it does not receive argument or case but instead assigns RC features to the clause.

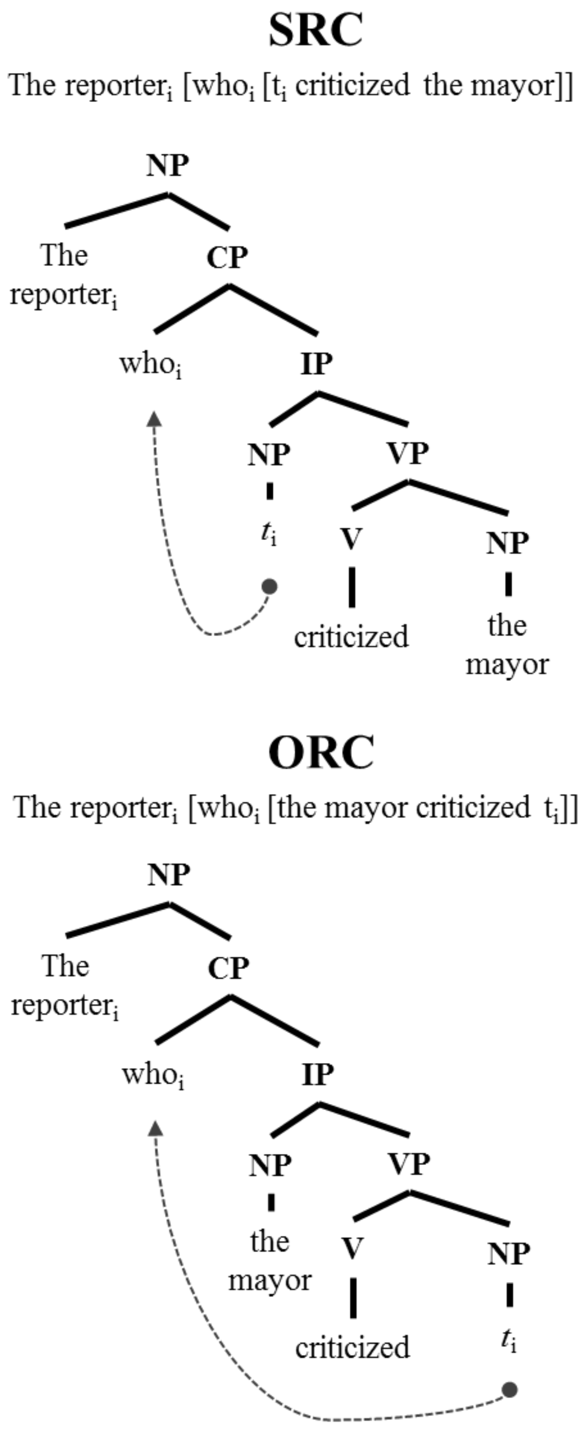



**Figure 1.1. Basic syntactic structure of English RCs**
The above is an abbreviated structure of RCs in English. While not shown, it is assumed that the subject originates from within the VP (VP-Internal Subject) and then moves to [Spec, IP]. Also, NPs are typically headed by DPs. These features are not shown here in order to have a more concise structure.

One important difference between ORCs and SRCs is that ORCs are naturally more complex, which Hawkins (1999) explains is derived from the structural complexity of the RC, or the number of syntactic nodes or syntactic dependencies required to create the relative clause. On this basis, an ORC requires one more syntactic node to create the relative clause than its SRC counterpart since SRCs can have an intransitive verb, while ORC verbs are required to be transitive (Hawkins, 1999), see example (1.1i).

## 1.2.1. Prenominal Relative Clauses

Dissimilar from the above English RC examples, which are post-nominal RCs (i.e., head-initial), RCs can also be prenominal (i.e., head-final). This is the case for Mandarin Chinese, Korean and Japanese RCs. In the sections below, a brief typological overview of relative clauses in Mandarin Chinese, Korean and Japanese is provided. See Figures 1.1-to-1.4 for a basic structural representation of RCs for each language.

### 1.2.1.1. Mandarin Chinese Relative Clauses

Mandarin Chinese, not to be confused with Cantonese Chinese or other Chinese languages, is a Subject-Verb-Object (SVO) language similar to English. In Mandarin, however, RCs are prenominal (i.e., head-final). Also, comparable to English, the difference between SRCs and ORCs on the surface level is determined by the word order of the clause (see Li & Thompson, 1981; Matthews & Yip, 2016). For SRCs the word order is VOS, and for ORCs it is SVO. This pattern of the ORC following the canonical order is divergent from most languages that have such a word order distinction making Mandarin quite rare. Furthermore, the pattern of being a prenominal language and being a verb-to-object language for RCs is also an uncommon pattern among world languages (Comrie, 2008; Dryer, 2005; Matthews & Yip, 2014; Matthews & Yip, 2016). Another difference with English is that in Mandarin, pronominal-drop (i.e., pro-drop) is permitted. These combined typological features makes Mandarin a particularly interesting language to investigate sentence processing in relation to RC processing. Refer to (1.2a) and (1.2b) for example RC sentences in Mandarin and Figure 1.2 for the basic structure of Mandarin RCs.

(1.2a) Subject-extracted relative clause (SRC)

指责市长的记者采访了医生

[$_{RC}$ GAP$_i$ *zhǐzé shìzhǎng de*] *jìzhě*$_i$ *cǎifǎng-le yīshēng*

[$_{RC}$ GAP$_i$ criticized mayor REL] reporter$_i$ interview-ASP doctor

'The reporter who criticized the mayor interviewed the doctor.'

(1.2b) Object-extracted relative clause (ORC)

市长指责的记者采访了医生

[$_{RC}$ *shìzhǎng zhǐzé* GAP$_i$ *de*] *jìzhě*$_i$ *cǎifǎng-le yīshēng*

[$_{RC}$ mayor criticized GAP$_i$ REL] reporter$_i$ interview-ASP doctor

'The reporter who the mayor criticized interviewed the doctor.'

In Mandarin, RCs are typically marked with the relativizer *DE* (的); however, other markers are sometimes used (Matthews & Yip, 2016; Sun, 2015). This relativizer should not be confused with relative pronouns such as 'that', 'which', 'who', and 'whom' since it actually carries no lexical meaning itself (Simpson & Wu, 1999, 2001). While the relativizer is not a head noun, in Mandarin it can stand by itself in headless RC constructions (Simpson & Wu, 1999, 2001). This means that there can be ellipsis of the head noun which is likely to be co-indexed with some referent previously addressed in the discourse. In this regard, the relativizer does have a nominalizing function, and according to Packard, Ye, and Zhou, (2011), the relativizer can even be integrated with the predicate despite it not carrying any specific lexical properties. Mandarin differs from both Korean and Japanese in that internally-headed relative clauses (IHRC) do not exist, while such a structure exists in Cantonese Chinese (see Chan, Matthews, & Yip, 2011).

As reported by Chen, Grove, and Hale (2012), SRCs are the more frequent RC structure in comparison to ORCs, in the corpora database Chinese Treebank 7.0 (See Xue, Nianwen, et al., 2010), obtaining 59% or 1,293 of the overall RC tokens. This difference was shown to be significant using a chi-square goodness of fit analysis, $\chi^2(1, N = 2{,}175) = 77.67$, $p < .001$. Yun et al. (2015) also investigated the distributions of RCs in Mandarin using the same Chinese Treebank 7.0, but reported slightly different distributions. However, the same pattern was found, that is, SRCs were more frequent. Accordingly in this dissertation, ORCs in Mandarin Chinese will henceforth be considered less frequent than SRCs in the sentence.

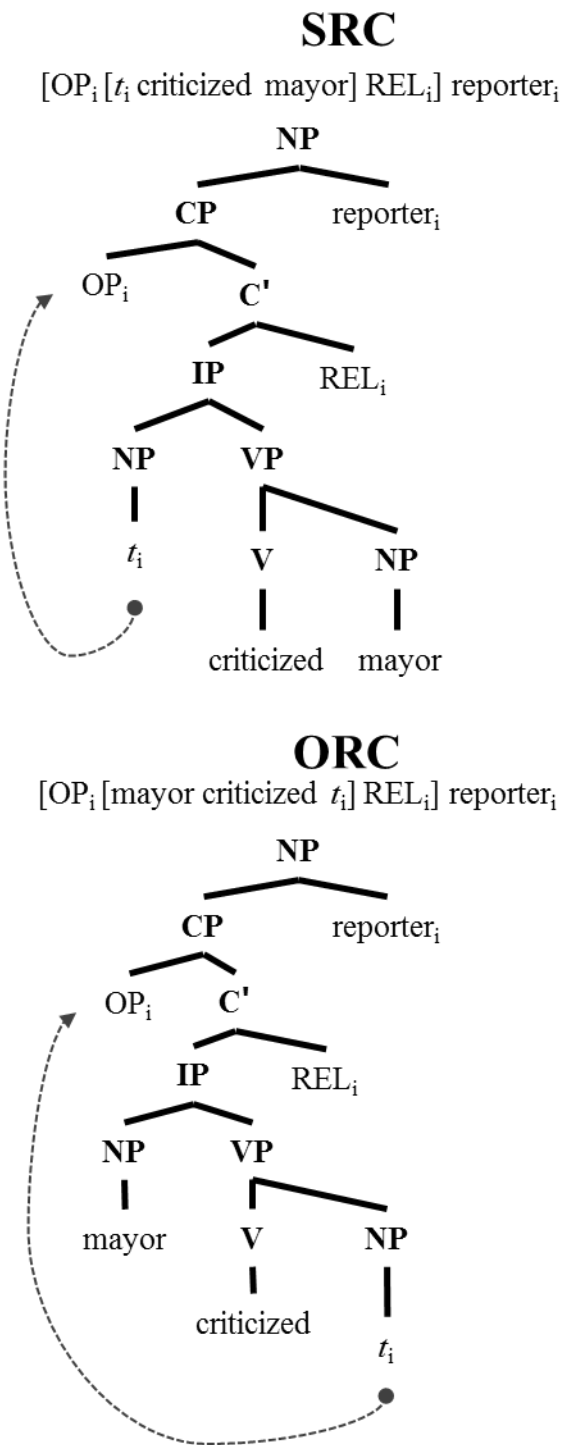



**Figure 1.2. Basic syntactic structure of Mandarin RCs**
The above are abbreviated structures of RCs in Mandarin. This structure assumes covert *wh*-operator movement from the trace position to [Spec, CP]. Also, the above structure assumes co-indexation with the relativizer as it has nominalizing properties. Yet, the relativizer does not move.

#### 1.2.1.2. Korean Relative Clauses

Korean is a SOV language that uses an adnominal marker suffixed to the embedded RC verb to mark it generally as an embedded clause (Lee, Madigan, & Park, 2016; O'Grady, 1991; Martin, 1992; Sohn, 2001). In Korean, to distinguish between ORCs and SRCs on the surface, the case marker suffixed to the RC noun acts as a cue for RC type. If the case marking is accusative, then the clause is an SRC. On the other hand, if the case marking is nominative, then it is an ORC. In the Korean language, both scrambling and pronominal drop operations are permitted. See (1.3a), (1.3b) and Figure 1.3 below for example RC sentences and structures in Korean.

(1.3a) Subject-extracted relative clause (SRC)
시장을 비난 한기자는 의사는 인터뷰했다.
[$_{RC}$ GAP$_i$ *sijang-eul binan han gijane-un*] *uisa-eun inteobyuhaessda*.
[$_{RC}$ GAP$_i$ mayor-ACC criticized-ADN] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who criticized the mayor interviewed the doctor.'

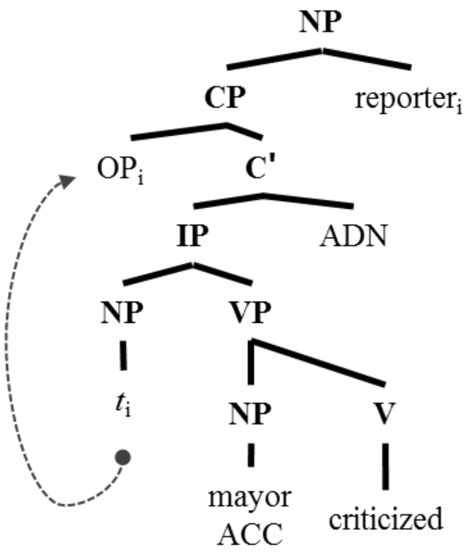
(1.3b) Object-extracted relative clause (ORC)
시장이 비난 한기자는 의사는 인터뷰했다.
[$_{RC}$ *sijang-i* GAP$_i$ *binanhan gijane-un*] *uisa-eun inteobyuhaessda*.
[$_{RC}$ mayor-NOM GAP$_i$ criticized-ADN] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who the mayor criticized interviewed the doctor.'

While Korean also has headless and internally-headed relative clause (IHRC) constructions in addition to the typical externally-headed relative clause (EHRC) constructions above, the adnominal marker cannot stand by itself like in headless Mandarin RCs. Instead, the complementizer marker *–kes* is required after the adnominal marker in such cases (Chung & Kim, 2003; Kim, 2004). Consequently, the adnominal marker has no nominalizing function and thus should not be able to integrate with the RC predicate as a lexical argument. Another minor difference specific to written Korean is that unlike Mandarin and Japanese, words are delimited by spaces as in written English.

In Korean, the distribution of RCs has already been reported by Kwon (2008). Using transitive verbs, she reported that SRCs (251 token counts) are more frequently found compared to ORCs (108 token counts) within the the Korean National Sejong corpus (see Kang & Kim, 2004; Kim, 2006) which is significant by a chi-square goodness-of-fit test, $\chi^2(1, N = 359) = 56.96$, $p < .001$. Yun et al. (2015) also investigated the distribution of RCs in Korean as well. Using the Korean Treebank 2.0

**SRC**

[OP$_i$ [$t_i$ mayor-ACC criticized] ADN] reporter$_i$




**ORC**

[OP$_i$ [mayor-NOM $t_i$ criticized]ADN] reporter$_i$

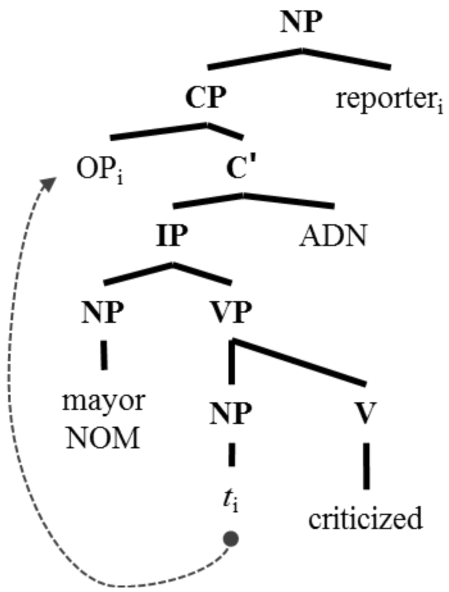



**Figure 1.3. Basic syntactic structure of Korean RCs**

The above is an abbreviated structure of RCs in Korean. This structure assumes *wh*-operator movement from the trace position to [Spec, CP].

(See Han et al. 2002), they reported the same finding as Kwon (2008) when comparing RCs that had transitive verbs and overt RC nouns. SRCs (467 token counts) were more frequent than ORCs (120 token counts) which is significantly different in terms of a chi-square goodness-of-fit-test, $\chi^2(1, N = 587) = 205.13$, $p < .001$. Since both investigations came to the same conclusion, ORCs in Korean will henceforth be considered less frequent than SRCs.

### 1.2.1.3. Japanese Relative Clauses

Japanese more closely resembles Korean in that the word order of the language is SOV, case-marker cues are used to distinguish RC types on the surface, and the language allows scrambling as well as pro-drop (see Murasugi, 2000; Tsujimura, 2007). Again, if the RC noun has accusative case marking, the clause will likely be an SRC, and if it has nominative case marking, the likely interpretation would be an ORC. See (1.4a), (1.4b) and Figure 1.4 for example RC sentences and structures in Japanese.

(1.4a) Subject-extracted relative clause (SRC)
市長を非難したレポーターは医師を面接した。
[$_{RC}$ GAP$_i$ *shichō-o hinanshita*] *repōtā*$_i$*-ha ishi-o mensetsushita*.
[$_{RC}$ GAP$_i$ mayor-ACC criticized] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who criticized the mayor interviewed the doctor.'

(1.4b) Object-extracted relative clause (ORC)
市長が非難したレポーターは医師を面接した。
[$_{RC}$ *shichō-ga* GAP$_i$ *hinanshita*] *repōtā*$_i$*-ha ishi-o mensetsushita*.
[$_{RC}$ mayor-NOM GAP$_i$ criticized] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who the mayor criticized interviewed the doctor.'

In contrast to Korean and Mandarin, modern Japanese lacks a relativizer or an adnominal marker at the RC verb for externally-headed relative clauses. Thus, the head noun itself acts as the first cue for the RC interpretation in the absence of discourse cues. Also, RCs in Japanese should not be confused with other structures for which markers such as the complementizer *–to* exist. While said structures are embedded clauses, they are not RCs since the head is not a grammatical argument within the RC itself, and thus these clause types do not fit the definition of RCs provided above. The only cases where RCs are marked in Japanese are when the clause is either internally-headed or headless. In both cases the clause is marked with the nominalizer *–no*, which

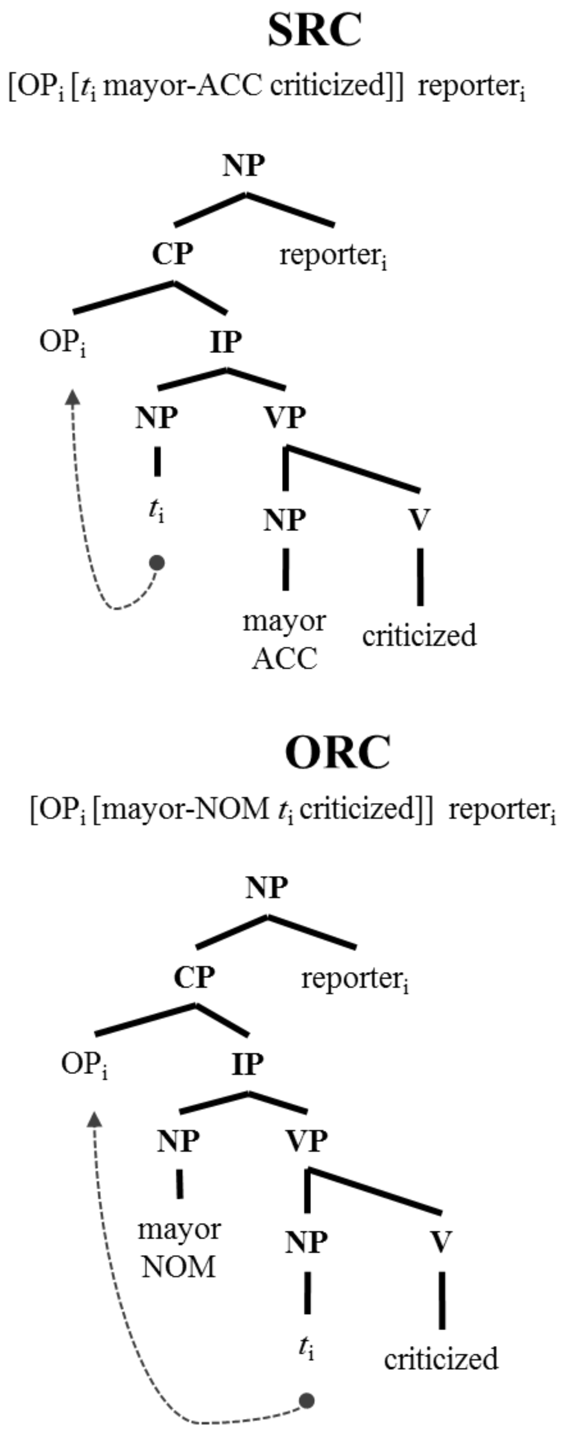



**Figure 1.4. Basic syntactic structure of Japanese RCs**
The above is an abbreviated structure of RCs in Japanese. This structure assumes *wh*-operator movement from the trace position to [Spec, CP].

should not be confused with the genitive function or event function of *–no* (Fuji, 1998, Ohara, 1992; Shimoyama, 1999).

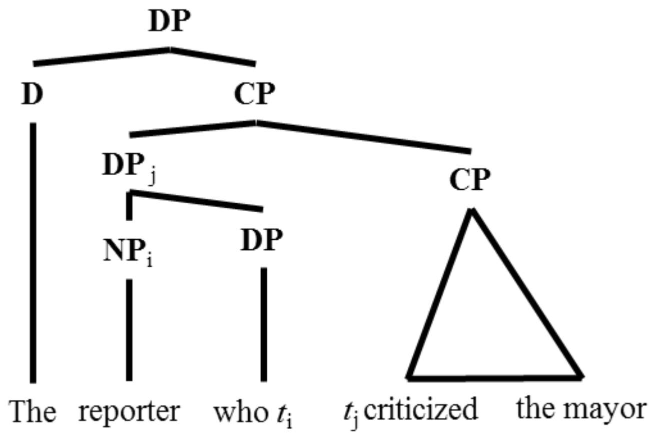
Collier-Sanuki (1993), using the same methods as Fox and Thompson (1990), analysed the distribution of RCs in Japanese from a data source of three novels translated into Japanese. She found that while the distribution of subject-relatives to object-relatives was similar, since object-relatives were composed of both direct and indirect objects (i.e., two different RC types), SRCs should be understood to occur more frequently when only comparing with the direct object relative clause type (i.e., ORC). Additionally, Collier-Sanuki (1993) found that similar to the previous English findings of Fox and Thompson (1990), RCs in Japanese more frequently use non-human head nouns. Similarly, Yun et al. (2015) also compared the distribution of RCs in Japanese from the Kyoto Corpus 4.0 (See Kurohashi & Nagao, 2003). Their investigation revealed that similar to the aforementioned study and to Korean and Mandarin, SRCs (537 token counts) are overwhelmingly more frequent than their ORC counterparts (116 token counts) in Japanese, which is significant by a chi-square goodness-of-fit-test, $\chi^2(1, N = 653) = 271.43$, $p < .001$. In fact, the only instance of SRCs being less frequent was limited to the subcategory of RCs having a gap and a pro-drop (i.e., either the subject or object was not overt) in the RC structure. Since both studies came to the same conclusion, I will henceforth follow the assumption that in Japanese, similar to that of most languages, SRCs occur more frequently than ORCs.

#### 1.2.1.4. A Gapped Relative Clause vs. a Non-Gapped Relative Clause

Above, it was assumed that RCs in these languages contain gaps as they do in English. While the relative clauses are often understood to contain gaps and *wh*-movement (Bugaeva & Whitman, 2016; Kaplan & Whitman, 1995; Whitman, 2013), other researchers, however, disagree with this claim. Some researchers have started following anti-symmetry syntactic models based upon leftwards head-raising within a determiner phrase (DP) structure (Kayne, 1994) rather than a compliment phrase (CP) in [Spec, NP] of the head noun; see Figure 1.5. In this dissertation, I will limit the discussion on syntactic models involving movement to those based on CP structures rather than DP ones. In other words, I propose that the underlying structure of RCs in these languages involve covert *wh*-movement of a *wh*-operator from the trace position to [Spec, CP]. However, this is by no means a definitive claim for the underlying syntactic structures.

# SRC

[$_{DP}$ The [$_{CP}$ [$_{DP}$ [$_{NPi}$ reporter] [$_{DPj}$ who t$_i$] [$_{CP}$ t$_j$ criticized the mayor]]]]




# ORC

[$_{DP}$ The [$_{CP}$ [$_{DP}$ [$_{NPi}$ reporter] [$_{DPj}$ who t$_i$] [$_{CP}$ criticized the mayor t$_j$]]]]

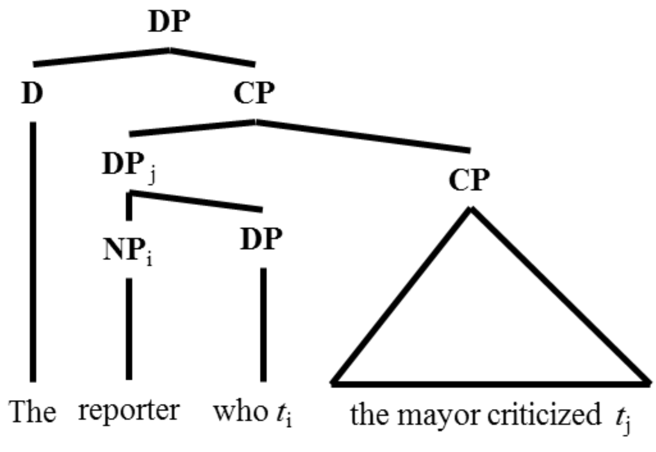



**Figure 1.5**. **Kayne's antisymmetry structure for English RCs**
The above are abbreviated structures for English RCs following antisymmetry.

On the other hand, some researchers do argue against movement. They (Comrie, 1996, 2002, 2007, 2008, 2010; Davis, 2006; Hoji, 1985; Kuno, 1973; Matsumoto, 1988, 1997; Miyamoto, 2010; Murasagi, 2000) instead argue that there is a pronominal-drop for either the subject or object instead of a gap formed either by *wh*-operator movement or head-raising movement. Besides the contention against movement, these claims are often framed by noting that since these languages have other similar clause structures that do not contain gaps resulting from movement (e.g., fact-clauses or pseudo-relative clauses), the RC structure should not contain a gap as well, in order to have a more unified account for structures in these languages (e.g., Comrie, 2010; Matsumoto, 1988). Furthermore, for Japanese in particular, Miyamoto (2010) argues that RCs in Japanese are not complement-phrases (i.e., CP) and are instead tense/inflection-phrases (i.e., TP/IP) since there are no overt clause markers to occupy [Spec, CP]. But then again, as mentioned above, even in cases where the relative pronoun is omitted in English, a null or covert operator is still assumed to exist (Browning, 1987). This could be the case for Japanese where unlike Korean which has an overt adnominal marker, Japanese exclusively utilizes null operators for EHRCs.

Since it is not the main focus of this paper to address the underlying syntactic nature of RCs for these languages (the structure is, however, relevant), I refer the reader to the above citations for evidence for and against gapped RCs. Accordingly, while I do side with gapped-RCs accounts for these languages since it is generally agreed upon by most that RCs involve some sort of movement (see Kayne, 1994; Whitman, 2013), I will admit there is a possibility that RCs in prenominal East Asian languages do not contain gaps. However, one shared feature irrespective of the syntactic interpretation for RCs is that the head noun is nevertheless co-indexed with some element, be it a gap or a pro-drop at the given grammatical position inside the RC.

An example of a structure which does not contain a gap is the pseudo-relative clause (i.e., the gapless RC). The key difference between gapped-RCs and pseudo-relatives is that there is no position within the clause that can be co-indexed with the head. As explained by Zhang (2008) for Mandarin, essentially RCs are the predicates that modify a head noun as the general subject of that predicate. For pseudo-RCs, in contrast, the head is the predicate and the pseudo-RC is the subject that licenses it. Therefore, the relationship between the two structures can be seen as direct opposites.

In English, such clauses would instead be realized as gerund prepositional phrases. For Mandarin, Korean and Japanese, while pseudo-relatives may appear similar to that of gapped-RC expressions, they have long been noted to be distinct from them. For arguments on how the two clauses diverge, refer to Zhang (2008) for Mandarin, Cha (1999) for Korean, and Whitman (2013) for Japanese. See below for examples.

(1.5a) English
*[The fish burning] smell…
The smell [of the burning fish]

(1.5b) Mandarin Chinese pseudo-relatives
鱼烧焦的味道…
[*yú shāojiāo DE*] *weidao*
[fish burn REL] smell/taste
'the fish burning smell'

(1.5c) Korean pseudo-relatives
물고기 타는 냄새…
[*mulgogi-ka tha-nun*] *naymsay*
[fish-nom burn-adn] smell
'the fish burning smell'

(1.5d) Japanese pseudo-relatives
魚が焼ける匂い…
[*sakana-ga yakeru*] *nioi*
[fish-nom burn] smell
'the fish burning smell'

# 1.3. Clause-Type Ambiguity

Ambiguity in terms of sentence processing often means there is an initial misunderstanding in the meaning for a word or phrase or that multiple interpretations of a word or phrase are possible. A classic example of lexical ambiguity would be, 'The man went to the bank.' Here, the word 'bank' can refer to either 'a financial institution' or 'the edge of a river'. For structural ambiguity, the classic example would be, 'The horse raced past the barn fell.' Here, there is a garden path effect (Frazier, 1987), which means that the mental parser would initially take an incorrect interpretation that needs to be corrected later down in the sentence. The incorrect reading here would be [$_S$ The horse raced past the barn.] (i.e., a simple sentence); however, upon reaching the word 'fell', the parser becomes aware of the incorrect interpretation and initiates a repair or restructuring process. I will refer to this point(s) in the sentence where the correct interpretation is prompted as *the locus of disambiguation*. At 'fell', a structural reanalysis must be made in order to parse the sentence correctly as [$_S$ The horse [$_{RC}$ (that was) raced past the barn] fell.] which contains a relative clause with the relative pronoun and passive voice auxiliary being omitted. Upon encountering ambiguity, there are multiple proposed parsing strategies based upon whether or not a singular interpretation was made, multiple parallel interpretations were made or a ranking of parallel interpretations was made (see Lewis, 2000 for a discussion of the issue of parsing strategies).

For prenominal RC languages including Mandarin Chinese, Korean and Japanese, RCs have a tendency to be initially ambiguous in terms of their clause structure. The reasoning for this is that unlike languages like English or Spanish, these languages lack a relative pronoun or marker to act as a cue for the mental parser to know it has entered a relative clause. As such, similar to the above example, without any cue, an initial misparse would occur for a simple sentence structure (i.e., a matrix clause). For each language, however, the locus of disambiguation occurs at different positions in the sentence. For Mandarin, the first possible cue prior to the head noun that would likely attenuate the clause-type ambiguity in an out-of-the-blue context (i.e., a discourse free context) would be the relativizer '*de*' [的] (though, other relativizers are sometimes used). As such, I claim that the relativizer position can serve as a locus of disambiguation. Admittedly, however, it is well known that '*de*' has many uses and that the relativizer can even be omitted. Thus, even at this point in the sentence, other structures using '*de*' are still possible; see examples (1.6b-d) below for a few possible structures based from the prefix string (1.6a). Furthermore, even at the head noun, a non-RC genitive interpretation is still possible (Ng & Wicha, 2014). Consequently, the relativizer or head noun may not always eliminate an incorrect simple matrix clause interpretation and some ambiguity may remain. Thus, it is generally agreed upon that the relativizer only has the potential to disambiguate (see Hsiao & MacDonald, 2013). As previously mentioned, the relativizer may be able to assume the role of the filler with the RC gap prior to the reading of the head noun (Packard et al., 2011). The importance of this is that the locus of disambiguation and the locus of integration (i.e., the point where the head noun integrates with the gap) have the potential to occur at the same locus within the sentence. In other words, at the relativizer, both the process of disambiguation and integration of filler-gap dependencies may occur.

(1.6a) Mandarin Prefix String
指责市长的
*zhǐzé shìzhǎng de*
criticize mayor REL

(1.6b) Mandarin SRC
指责市长的记者
$\text{GAP}_i$ *zhǐzé shìzhǎng de jìzhě*$_i$
$\text{GAP}_i$ criticize mayor REL reporter$_i$
'The reporter who criticized the mayor…'

(1.6c) Mandarin Genetive
指责市长的儿子
*zhǐzé shìzhǎng de* érzi
pro criticize mayor REL son
'(Someone) criticized the son of the mayor.'

(1.6d) Mandarin Fact Clause
指责市长的那件事
*zhǐzé shìzhǎng de nà jiàn shì*
pro criticize mayor REL fact
'The fact that (someone) criticized the mayor…'

For Korean, I assert that the locus of disambiguation can be the adnominal marker suffixed to the embedded RC predicate. Here, the contents of the RC should not be considered as belonging to a simple sentence structure for most cases. Similar to that of the relativizer in Mandarin, the adnominal marker can be used in other embedded structures in Korean; see examples (1.7b-d) below for a few possible structures based from the prefix string (1.7a). Consequently, an RC interpretation may still not be guaranteed at this locus. Yet, as I will mention in Chapter 3 concerning Korean, this may not be an issue since the statistical frequencies of Korean should favour the RC interpretation. In contrast to Mandarin, the adnominal marker does not satisfy the selectional restrictions of the RC predicate and thus cannot integrate with it or the gap. As previously mentioned, besides the head noun, the complementizer (or nominalizer) –*kes* may, however, be able to assume this function. The importance of this is that for Korean, the locus of disambiguation and integration will usually be found at different loci within the sentence.

(1.7a) Korean Prefix String

간호사를 좋아한
*kanhosalul cohahan*
nurse-ACC loved-ADN

(1.7b) Korean SRC

간호사를 좋아한 의사
*kanhosalul cohahan uysanun*
nurse-ACC loved-ADN doctor-TOP
'The doctor who who loves the nurse…'

(1.7c) Korean Resultative Clause

간호사를 좋아한결과는
*kanhosalul cohahan kyelkwanun*
pro nurse-ACC loved-ADN result-TOP
'The result that that (someone) loved the nurse…'

(1.7d) Korean Fact Clause

간호사를 좋아한 사실은
*kanhosalul cohahan sasilun*
pro nurse-ACC loved-ADN Fact-TOP
'The fact that (someone) loved the nurse…'

Lastly, in Japanese for typical EHRCs, the first disambiguating cue will usually be the head noun itself since Japanese lacks overt relative pronouns, relativizer markers or adnominal markers. Therefore, up to the embedded RC verb, multiple interpretations are possible; see examples (1.8b-d) below for a few possible structures based from the prefix string (1.8a). As such, I will assert that for standard cases, the head noun is the locus of disambiguation. Similar to Mandarin, the locus of disambiguation and integration have the potential to occur at the same locus in the sentence.

(1.8a) Japanese Prefix String

市長を非難した
*shichō-o hinanshita*
mayor-ACC criticized

(1.8b) Japanese SRC

市長を非難したレポーター
*shichō-o hinanshita repōtā*$_i$
mayor-ACC criticized reporter
'The reporter who criticized the mayor…'

(1.8c) Japanese Simple Clause
市長を非難した。
*shichō-o hinanshita*
pro mayor-ACC criticized
'(Someone) criticized the mayor.'

(1.8d) Japanese Heard Clause
市長を非難したと聞いた。
*shichō-o hinanshita to kiita*
pro pro mayor-ACC criticized COMP heard
'(Someone) heard that (someone) criticized the son of the mayor.'

(1.8e) Japanese Fact Clause
市長を非難した事実
*shichō-o hinanshita jijitsu*
pro mayor-ACC criticized fact
'The fact that (someone) criticized the mayor…'

Refer to Table 1.1 for a basic overview of typological features of these three languages with a base comparison with the English language.

**Table 1.1. Typology of English, Mandarin, Korean and Japanese RCs**

| Feature | English | Mandarin | Korean | Japanese |
|---|---|---|---|---|
| Word Order | SVO | SVO | SOV | SOV |
| Case Marking | No | No | Yes | Yes |
| Scrambling | No | No | Yes | Yes |
| pro | No | Yes | Yes | Yes |
| RC marker | Yes | Yes | Yes | No |
| Surface RC Cue | Word Order | Word Order | Case | Case |
| Frequencies | SRC>ORC | SRC>ORC | SRC>ORC | SRC>ORC |
| LOD | Relative Pronoun | Relativizer | Adnominal | Head Noun |
| LOI | Gap (at RC verb) | Relativizer/Head | Head Noun | Head Noun |
| EHRC | Yes | Yes | Yes | Yes |
| Headless EHRC | No | Yes | Yes | Yes |
| IHRC | No | No | Yes | Yes |

Note. pro refers to pronominal drop, LOD refers to locus of disambiguation, LOI refers to locus of integration, EHRC refers to externally-headed relative clause, and IHRC refers to internally-headed relative clause. Both English and Mandarin have movement operations. However, in relation to scrambling in Korean and Japanese, object movement in Mandarin is thought to be inherently different (Shyu, 2001). Thus, object movement is not included in the above typology and case marking is left out as well since the default condition in Mandarin lacks case marking.

## 1.4. Relative Clause Processing Theory

The focus of RCs in psycholinguistic studies has been primarily built upon the processing asymmetry between SRCs and ORCs, with SRCs having been shown to be inherently easier to process and comprehend (Hawkins, 1999; Keenan & Comrie, 1977; Keenan & Hawkins, 1987). The difficulty with ORCs has been documented across a range of languages having varying RC structures and using different experimental methodologies (see Table 1.2). Taken together, these studies on both post-nominal and prenominal RCs provide strong evidence that SRCs are universally easier to process and comprehend compared to ORCs. Thus, many researchers have tried to spell out models for RCs as a universal phenomenon for both acquisition and processing. One famous universal is the *Accessibility Hierarchy* (Keenan & Comrie, 1977). This theory specifies that since the gap position within the SRC is in a more syntactically accessible position, it is not only easier to process and comprehend but also acquired first before other types of RCs. Other offshoot models, following their framework, have often appeared; however, in terms of L1 acquisition, it is now known that this universal model does not exactly fit so well for these East Asian languages. This is because children of these languages are cable of producing SRCs and ORCs at the same stage of acquisition and can even begin producing ORCs first (see Hawkins, 2007). Thus, I argue that RC processing should not be seen in terms of a universal feature but rather as a coincidental consequence of processing mechanisms.

Though the studies shown in Table 1.2 all support the claim that ORCs are generally more difficult, explanations for this phenomenon are not yet well formed under a unified model. Below, I lay out several prominent processing theories and detail how they are proposed to function for each language.

### 1.4.1. Frequency-based Theories

Generally speaking, frequency-based theories (henceforth, *expectation-based processing*) are processing theories which are based upon the statistical regularities of the language, i.e., frequencies and collocations. Accordingly, they are probabilistic models of information-based processing. Below, I outline several prominent models, such as, the *Surprisal Theory*, the *Entropy-Reduction Hypothesis*, and other accounts. The surprisal theory and the entropy-reduction hypothesis are given more prominence

**Table 1.2. Previous studies showing ORC difficulties**

| Language | Type | Methodology | Reference |
|---|---|---|---|
| English | post-nominal | SPR, ET, ERP, fMRI | Chen, West, Waters, & Caplan, (2006); Gordon et al., (2001); Gordon et al., (2006); King & Kutas, (1995); Traxler et al., (2002) |
| Spanish | post-nominal | ET | Betancort, Carreiras, & Sturt, (2009) |
| French | post-nominal | PM | Frauenfelder, Segui, & Mehler, (1980) |
| German | post-nominal | SPR | Schriefers, Friederici, & Kuhn, (1995) |
| Dutch | post-nominal | SPR, ET | Frazier, 1987; Mak, Vonk, & Schriefers, (2002) |
| Mandarin | pre-nominal | SPR, ET | Jäger et al., (2015); Vasishth et al., (2013) |
| Korean | pre-nominal | SPR, ET, ERP | Kwon, Polinsky, & Kluender, (2006); Kwon, Gorden, Lee, Kluender, & Polinsky, (2010); Kwon, Kluender, Kutas, & Polinsky, (2013) |
| Japanese | pre-nominal | SPR, ERP | Miyamoto & Nakamura, (2003); Ueno & Garnsey, (2008) |

Note. SPR stands for self-paced reading, ET stands for eye-tracking
ERP stand for event related potentials, PM stands for phoneme monitoring
fMRI stands for functional magnetic resonance imaging

since surprisal theory is the popular model in current literature and entropy-reduction hypothesis is a deviation of this model created by the same researcher.

#### 1.4.1.1. Surprisal Theory

One of the more prominent expectation-based processing models is the *Surprisal Theory* (Hale, 2001; Levy, 2008). This expectation-based processing model follows the framework of incremental processing theory (Altmann & Kamide, 1999; Kamide, 2008) such that at each word in a prefix string (i.e., an incomplete string of words which has yet to form a sentence or clause), the parser actively makes predictions/expectations about how to continue the string in such a way that the expectation would grammatically complete the string using a minimalistic grammar (Hale, 2001). In other words, the mental parser will predict the simplest possible structure that can be consistent with the prefix string rather than predicting a more complex structure. In examples (1.9a) and (1.9b) below (Rayner & Pollatsek, 1989, p. 246), at the word 'the answer' in both cases, the mental parser would have parsed the word as a direct object. Since a period does not accompany the word, the parser would predict an additional phrase which does not add syntactic complexity to the prefix string. In (1.9a) 'by heart.' keeps the clause as a simple matrix clause and just modifies the predicate, thus satisfying the expectation. In contrast, 'was wrong.' adds syntactic complexity by adding an additional subordinate clause '(that) the answer was wrong.' to the matrix clause 'The girl knew', thus dashing the expectation of the clause remaining simple.

(1.9a) The girl knew the answer by heart.

(1.9b) The girl knew the answer was wrong.

These expectations are also based upon the statistical probabilities in which they appear for the said language. Given a prefix string of words, multiple alternative representations are made, each with a certain level of probable occurrence, thus allowing for a ranking of interpretations. Thus, surprisal is related to the entropy of a string being parsed. The basic premise of surprisal is that processing difficulty occurs due to the re-ranking of expectations or "disconfirmation of alternative continuations" (Chen et al., 2012, p. 31) at a given word situated in a string.

According to Levy (2008, pp. 1,332-1,335), surprisal acts as the "*causal bottleneck*" intervening between structural representations and comprehension difficulty. He argues that rather than expectations directly inducing difficulty, the calculations of structural representations are implicitly made during parsing and that cognitive effort is only expended at specific loci of disambiguation where processing resources must be re-allocated to revise expectations. Accordingly, for a given locus for which an expectation for more than one structure can be made, the structure with higher probability (i.e., frequency) would unquestionably be more expected than the less frequent one. Therefore, at a locus of disambiguation (i.e., where the structural representation is realized), when the parser encounters a structure with low probability (i.e., not expected or a dashed-expectation), processing difficulty should increase owing to the greater effort needed to revise expectations (Hale, 2001; Levy, 2008). In contrast, the more frequent structure would have less overall surprisal than the rarer structure, therefore, requiring fewer resources necessary to re-rank structural representations during disambiguation. Yet, when surprisal costs are equal regardless of the underlying structure, processing work is also expected to be equal. As a result, a complex and simple structure may require the same level of cognitive effort if the surrounding context generates the same level of surprisal at a given locus. Considering that ORCs are typically less frequent than SRCs, ORCs are assumed to engender greater processing difficulty. In the English language, the first word after the relativizer often denotes which RC type is being processed: A verb for SRCs and a noun or determiner article for ORCs. In fact, both Staub (2010) and Forster et al. (2009) found greater processing costs for ORCs at the article position using eye-tracking and maze methods respectively. See below for an example in English.

(1.10) English RC expectation

The reporter who…

[at the relative pronoun 'who', the parser is aware of the RC structure and would predict an SRC. Thus, following 'who', a verb/predicate would be expected. For the ORC condition, an article (e.g., 'a' or 'the') following the relative pronoun would be less expected.]

SRC: The reporter who… criticized

[Expected. No increase in processing difficulty.]

ORC: The reporter who… the

[Dashed-expectation or surprising. An increase in processing difficulty.]

While expectation-based processing models for surprisal are categorically more intricate than just frequency comparisons, the basic premise is often understood in such simplicity. Consequently, surprisal in this study is decidedly relevant in terms of clause-type ambiguity for the selected prenominal East Asian languages. Specifically, a comparison can be made at the locus of disambiguation for each language on the basis of the probable occurrence of each RC type. For Mandarin Chinese, Korean, and Japanese, ORCs are understood to occur less frequently in production than SRCs (for frequencies, see Yun et al., 2015). Thus, it is likely that an ORC would be more difficult to process since an SRC would have a higher expectation in the parser. For Mandarin, Chen et al. (2012) reported the surprisal predictions for ambiguous RCs. See Figure 1.6 below for the formula of surprisal.

$$surprisal\ (w_n) = \log_2 \frac{P(w_0 \ldots w_{n\text{-}1})}{P(w_0 \ldots w_n)}$$

**Figure 1.6. The surprisal theory**

The above formula for surprisal is taken from Chen et al. (2012). It is important to note, that while this basic formula is often described in slightly different terms by each researcher, the basic foundation of the formula remains the same. Here the surprisal for a word '$w_n$' is based upon the log ratio of two sets of probabilities. The numerator describes the probability of all possible structural representations for the prefix string up to $w_{n-1}$, while the denominator represents the level of surprisal in the string with $w_n$ integrated into the structure. Consequently, surprisal is high if there is ambiguity within the prefix string (i.e., $w_0 \ldots w_{n\text{-}1}$) and if the target locus $w_n$ provides a specific structural representation. Specifically, the numerator would reflect a large subset of probabilities while denominator would be minimal or one. The implication of this is that a more frequent structure would generate less surprisal than a less frequent structure. Thus, ORCs would incur greater surprisal than SRCs, unless the discourse favoured a particular RC interpretation. For instance, Roland et al. (2012) found that within normal or natural discourse, English ORCs were no more difficult to parse than SRCs.

### 1.4.1.2. Entropy-Reduction Hypothesis

Another influential model is the *Entropy-Reduction Hypothesis* (Hale, 2006; Yun et al., 2015). According to this model, difficulty in processing occurs due to the uncertainty of the structure. The uncertainty itself, however, does not cause processing difficulty. Instead, while parsing a sentence, when the structural representation moves from an uncertain one to a more certain or precise structure, this indicates that processing work has occurred. In other words, this may be viewed as processing work involved in eliminating possible interpretations. Thus, when comparing the reduction of uncertainty for the structure at each word between the SRC and ORC structures, ORCs are more difficult since the drop in entropy (or uncertainty) is larger at multiple loci in the sentence. In other words, the entropy level of the structure is calculated at each word and entropy reduction is defined by the difference between the two entropy values. Similar to that of surprisal theory, the word following the relativizer in English induces greater processing work for ORCs. However, the difference between the two theories is that here ORCs have fewer structural options in the prefix string whereas in surprisal difficulty is attributed to lower expectations. A simplified example of this can be seen below in English. The basic premise is that ORCs require a direct object GAP while SRCs do not require a direct object. Thus, SRCs have a greater range of options available to the interpretation compared with ORCs. Importantly, ORCs must contain a transitive argument while SRCs have either a transitive or intransitive argument modifying the head noun.

In fact, Yun et al. (2015) has outlined the entropy levels at each critical region for all three languages. While entropy-reduction and surprisal are similar probabilistic models, a principal difference between the two is that entropy-reduction is calculated between words (i.e., the entropy difference between two words or a word and its morphology) while surprisal is calculated based upon the target situated within a string (i.e., the collective entropy of the current string). Despite this difference, both models make similar predictions in that ORCs should be more difficult to parse at the locus of disambiguation. A notable difference, however, is that entropy-reduction also makes a prediction that ORCs should be more difficult to parse in all three languages prior to the locus of disambiguation. Following the framework laid out by Levy (2008), it appears that surprisal as he describes it would not necessarily make this prediction. Furthermore, there seems to be some contention between researchers on the validity of surprisal and entropy-reduction (c.f., Levy, et al., 2013). See Figure 1.7 below for the formula of entropy-reduction.

$$H(X) = -\sum_i p(x_i) \log_2 p(x_i)$$

$$ER(w_i) = \max(0, H_{i-1} - H_i)$$

**Figure 1.7. Entropy and entropy-reduction**

In the above formulas, the first formula describes the calculation of entropy as spelled out by Yun et al., (2015). Entropy $H$ reflects probabilities of syntactic options $p(x_i)$ which can grammatically complete the string. Thus, this reflects the uncertainty remaining in the syntactic structure of the prefix string. The second formula calculates the entropy-reduction (i.e., ER) as described by Hale (2006). Here, entropy-reduction reflects the change in entropy at the target $w_i$ between the preceding word's entropy level $H_{i-1}$ and the target word's entropy level $H_i$. Accordingly, similar to surprisal above, when preceding word has high entropy and the target word has relatively low entropy, the drop in entropy would be high. Hale (2006) and Yun et al. (2015) claim that these conditions would incur processing work at $w_i$. Therefore, the context in which a greater drop in entropy has occurred would be the condition with greater processing difficulties. As described by Yun et al., (2015), since subject-modified ORCs initially have greater entropy levels, the change in entropy at loci of disambiguation is greater than the changes in entropy for subject-modified SRCs.

#### 1.4.1.3. Canonical Word Order

A third approach is canonical word order facilitation. Macdonald and Christiansen (2002), claim that it is the interaction between the frequencies and the regularities of the language that guides processing. Thus, as a more frequent structure more closely resembles the canonical order of the language (or appears more regular), processing becomes easier. On the other hand, as a structure deviates from the canonical order and becomes less frequent, processing difficulty occurs. For example, in English, the canonical word order is SVO and the more frequent relative clause is the SRC which happens to bear SVO order. Thus, SRCs should be easier to process in this regard.

In summary, despite expectation-based processing theories being based within different frameworks, the predictions of each theory predict ORC difficulty. While only three theories are listed here, other accounts of processing based upon statistical distributions of a language exist.

### 1.4.2. Integration-based Accounts

As mentioned previously, relative clauses involve filler-gap parsing, meaning that the head noun and the gap position need to be integrated with one another so that the head noun can be properly interpreted at the gap position within the RC. Another factor is that, in the case of English, the head noun is retrieved at the gap position from working memory. In the case of prenominal languages, the gap position will likely need to be retrieved at the head noun. For integration/retrieval process (Chomsky, 1965; Gibson, 2000; Lewis & Vasishth, 2005), it is generally understood as a function of working memory and that the activation level of a referent in working memory will decay (i.e., decrease). While there are three main metrics to measure this decay (i.e., decay-metrics or distance-metrics), the general principle is that as more meaningful dependencies intervene between filler and gap, the activation level will continue to decay. And, as the activation level decreases, the processing work associated with the integration/retrieval of the referent will increase. These three metrics are linear-distance, temporal-distance, and structural-distance. A principal difference between structural-distance and the other metrics is that it is a language universal model to explain why SRCs are easier to process during integration. The other two metrics, in contrast, do not always predict an

SRC advantage (depending on how integration/retrieval is viewed). See the subsections below for each distance/decay-metric.

#### 1.4.2.1. Linear-Distance Metric

According to Gibson's (2000) *Dependency Locality Theory* (DLT), each meaningful syntactic dependency or discourse referent intervening between two co-indexed elements requires a mental unit in working memory which makes integration more difficult as the distance between the two dependents (the filler and the gap) increases. This results in an increased memory load. Gibson's DLT model for integration/retrieval is often described as the *linear* metric since intervening material is counted on the surface structure and not the syntactic structure. This would imply that even if an adjunct phrase intervened between two referents, there would be a cost in working memory to carry a co-indexed referent over this intervening material. In examples (1.11a) and (1.11b) below, the pronoun 'his$_i$' is co-indexed with its antecedent 'The general$_i$'. The syntactic distance between these two referents are the same in terms of syntactic structure since in example (1.11b) the adjunct prepositional phrase 'on the hill' is a sister of the head of the NP 'general'. Thus, this phrase does not increase the number of nodes intervening between the pronoun and its antecedent. However, in terms of surface linear distance, the distance between is of course greater in (1.11b) in comparison to (1.11a). Accordingly, the longer the distance between two referents co-indexed with each other, the greater it becomes to integrate the two.

(1.11a) [[The general$_i$] [looked at his$_i$ watch.]]

(1.11b) [[The [general$_i$ [on the hill]] [looked at his$_i$ watch.]]

As seen below, when defining distance in terms of syntactic structure, the costs of working memory are different. Gibson's DLT model also involves memory work for projecting future dependencies as well as maintaining the parsed structure in working memory. Similar to the explanation for expectation-based processing, the model assumes that at each word we are actively predicting the rest of the words that are needed to complete a grammatical sentence, which is not so different from surprisal theory discussed above. For each word predicted, a mental unit is needed. Thus, when more mental units are being used to predict the remainder of the sentence, more processing work is required. See Figure 1.8 for an illustration of the linear-distance metric.

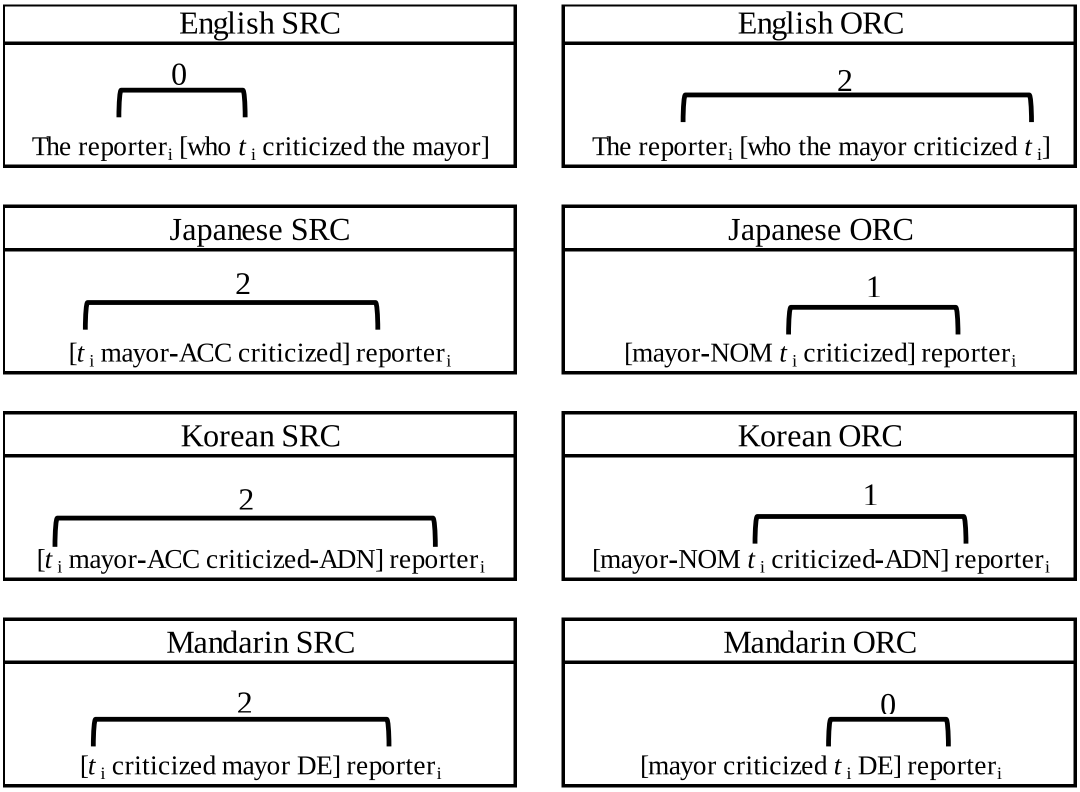



**Figure 1.8. Linear-distance for relative clauses**
The linear distance between the filler (or head noun) and the gap ($t_i$) is indicated by the length of the bracket lines. The number above the brackets indicates the number of memory units which represents the number of new discourse referents intervening between the filler and the gap. As seen above, function words and relative pronouns do not carry any mental units, as described by Gibson, (2000). While in English, ORCs would be more difficult as more intervening units exist between the filler and gap, the prediction is opposite for the other languages, assuming that integration does not involve the *wh*-operator as Gibson does.

### 1.4.2.2. Temporal-Distance Metric

In a similar vein to the DLT, Lewis and Vasishth's (2005; Vasishth & Lewis, 2006) *Activation-Based Model*, based within the scope of the *Adaptive Control of Thought–Rational* (ACT-R) model (Anderson, 1996), proposes that the decay of the initial activation in memory increases as a function of time (i.e., temporal locality). However, they contend that there is no processing cost associated with maintaining dependencies in working memory (which contrasts with Gibson's DLT) and that integration/retrieval does not invoke a reactivation of the co-indexed dependency. See Figure 1.9 below for an illustration of the temporal-distance metric.

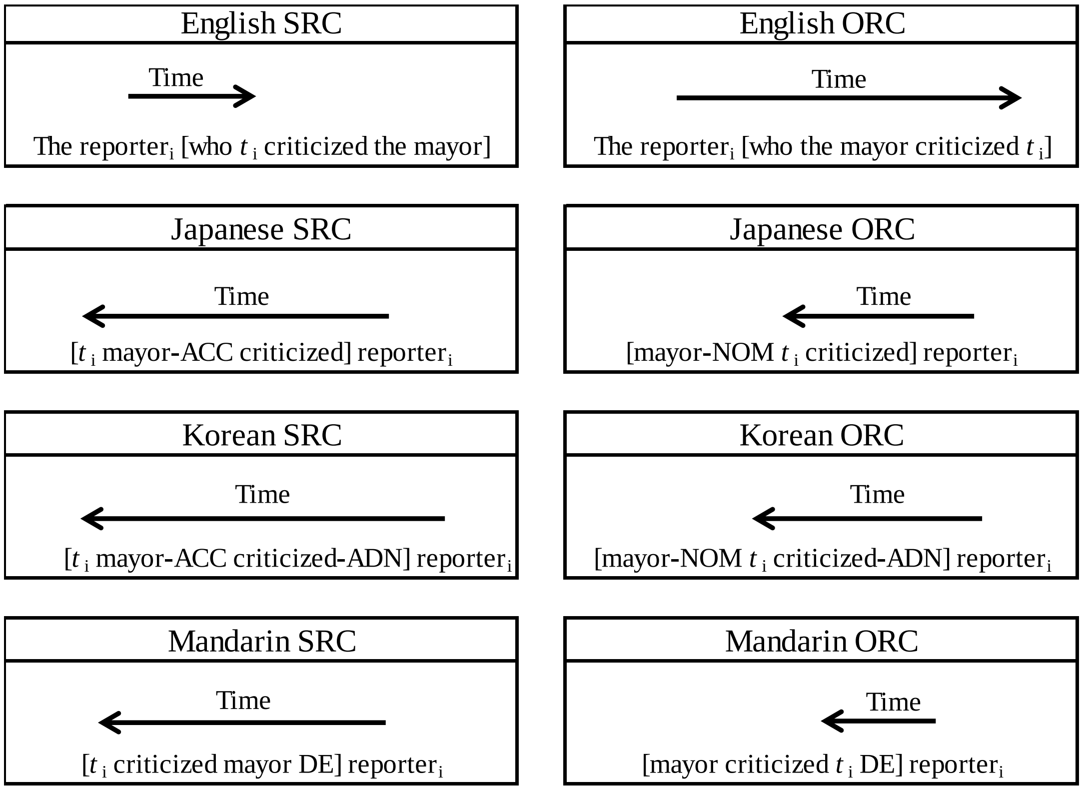



**Figure 1.9. Temporal-distance for relative clauses**
The temporal distance between the filler (or head noun) and the gap ($t_i$) is indicated by the length of the arrows. In English there is more temporal distance between the filler and gap, but for the other languages, this is reversed.

#### 1.4.2.3. Structural-Distance Metric

Lastly, the *Structural-Phrase Hierarchy* model (O'Grady, 1997), instead proposes that the decay in memory is attributed to the number of intervening phrases in a syntactic hierarchy (i.e., a syntactic tree). This means that decay occurs within the syntactical representation rather than the surface form. The implication of this model is that ORCs would always be more distant in terms of syntactic distance; therefore, this model is a universal. This model directly contrasts with those above since intervening material at the surface level, which does not intervene between two co-indexed dependencies in structure, does not impact the level of decay. See Figure 1.10 for an illustration of structural distance in Mandarin Chinese, English, Japanese and Korean.

For all three languages, there are contrastive predictions based upon the metric used to define the distance between the filler and gap. When defining distance by either the linear or temporal metric, SRCs are predicted to be more difficult. This is because the gap has more intervening dependencies on a linear plane in comparison to ORCs. This would contrast with a language like English which would instead have a prediction for ORCs being more difficult. On the other hand, when distance is defined by the number of syntactic phrases intervening between the filler and gap, ORCs are proposed to be more difficult since there would always be an additional intervening phrase in comparison to SRCs (i.e., a language universal).

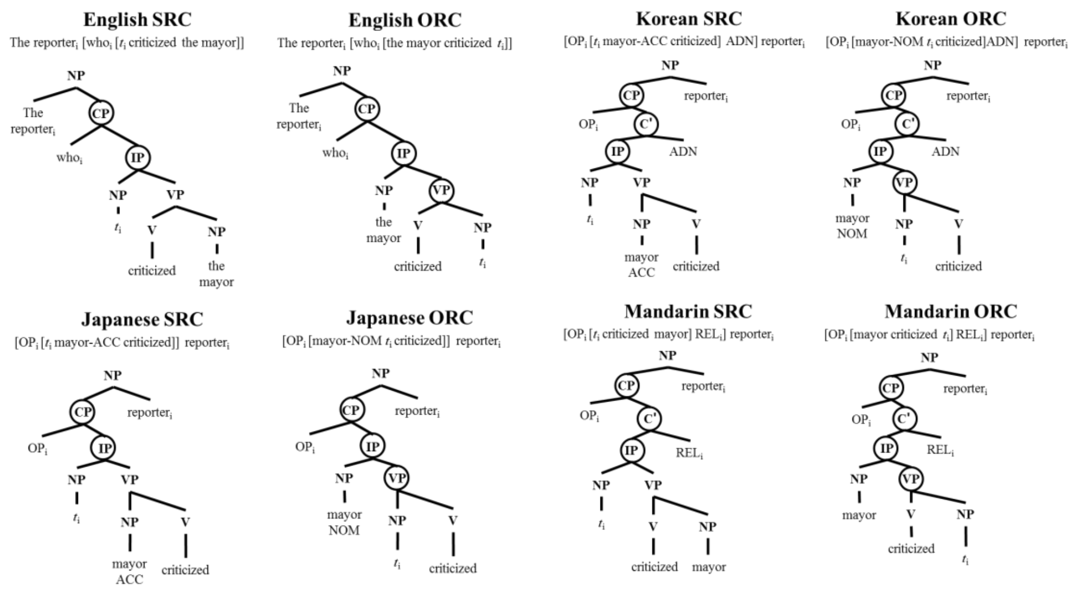



**Figure 1.10. Structural-distance for relative clauses**
The distance between the head noun and gap ($t_i$) for each RC structure is indicated by the number of phrases intervening between the two (circled).

It is important to note that the above predictions represent direct integration between the head noun and gap which is the popular manner of interpreting integration. This manner differs if integration of the filler-gap dependencies necessitates the head noun to integrate with the *wh*-operator which then integrates with the gap of the trace movement. If it is the latter, ORCs would always be more difficult. In other words, difficulty is engendered not by the distance between the head noun and gap, but instead the distance between the relativizer (or covert *wh*-operator) and the gap. See Figure 1.11.

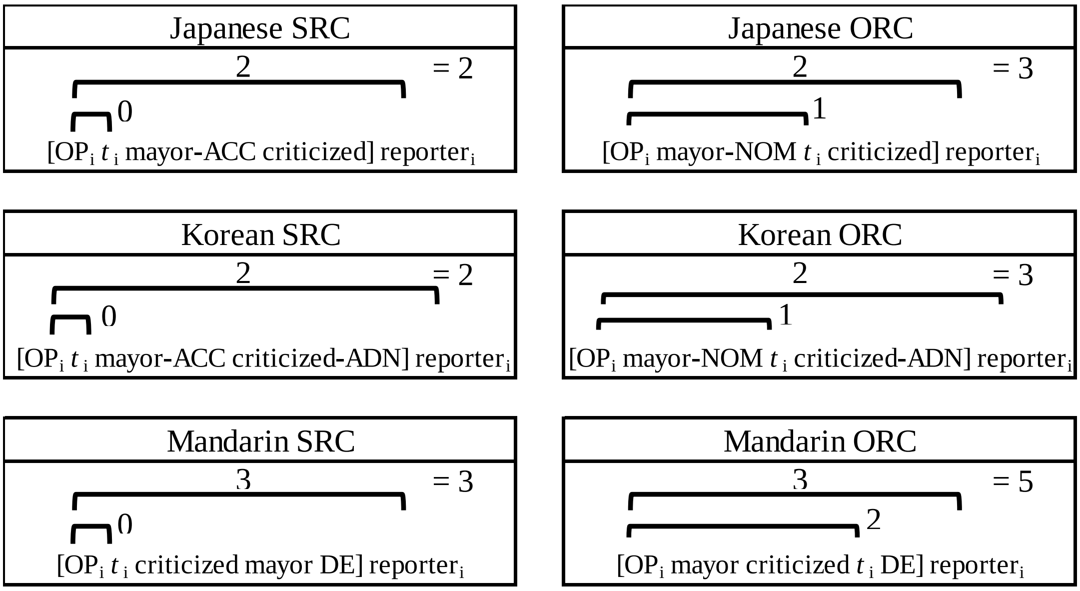



**Figure 1.11. Redefined Linear-distance for relative clauses**
The linear distance between the filler (or head noun) and the gap ($t_i$) is indicated by the length of the bracket lines. The number above the brackets indicates the number of memory units which represents the number of new discourse referents intervening between the filler and the gap. In the above Figure, I describe distance in terms of both the distance between the head noun and the *wh*-operator and the distance between the *wh*-operator and the gap of its trace movement.

## 1.4.3. Similarity-Based Interference Accounts

Another working memory account is *similarity interference*. While there are different accounts for similarity-based interference, I will limit the discussion to just two. For more detail on similarity interference see Jäger, Engelmann, and Vasishth (2017) or Lewis, Vasishth, and Van Dyke (2006).

Within Lewis and Vasishth's (2005; Vasishth & Lewis, 2006) *Memory Constraint Model / Cue-Based Retrieval Model*, there are interference effects in working memory. More specifically, when a retrieval of a specific referent is initiated (i.e., cue-based retrieval), interference from referents with matching or overlapping features can occur. Interference from these distractors can occur proactively or retroactively depending on the ordering of the target to be retrieved and its distractor. When two or more referents share overlapping features (e.g., animacy, syntactic position, gender, number), the activation level for each is lowered. While lowering of their activation level does not induce processing difficulty per se, the retrieval process will become more demanding as the activation level for the dependency is lowered.

The implication of this is that under their similarity-interference model, only the retrieval process at an item which initiates a retrieval (e.g., a personal pronoun, reflexive pronoun, or verb) is subject to processing difficulty. This aspect will differ from the second account below.

The other proposal relies less on activation-based constraints. According to Gordon and colleagues (Gordon et al., 2001; Gordon et al., 2006), there is difficulty with both storing/encoding and retrieving nouns when there are overlapping/matching features. Simply put, while reading sentences, we store and maintain noun dependencies with their assigned syntactic and semantic features in working memory for later reactivation and integration with their respective verbs. Accordingly, if two or more similar nouns are stored in memory, they may interfere with each other during the retrieval of one of them. This would also be modulated by how similar these nouns are. As they become more similar in gender, number, noun type, semantic or grammatical role, the larger the impact of the interference will become. Under Gordon's model, difficulty can occur both at the encoding and retrieval stages of processing.

For RC processing in English, ORCs have already been observed to be subject to interference effects (Gordon et al., 2001; Gordon et al., 2006). In fact, there may be a possibility that ORCs in general have a higher potential to have an interference effect than SRCs when the structure is a subject-modified RC (i.e., the subject of the matrix clause being modified). This is due to a crucial feature that both the RC noun and head noun share. This feature is the grammatical subject which has been shown to be a principal factor for similarity-interference (e.g., Patil, Vasishth, & Lewis, 2016; Van Dyke & McElree, 2011). See examples (1.12a-d) below for examples of similarity based interference. In comparison between examples (1.12a) and (1.12b), (1.12b) is predicted to have greater difficulty since both the head noun and RC noun are subjects of their respective clause while in (1.12a) the RC noun occupies the object position. Consequently, the overlapping features between NPs in (1.12b) induce processing difficulty. Similarly, in comparison of (1.12b) to (1.12d), (1.12b) is also predicted to be more difficult to parse. The reasoning for this is that in (1.12b) both the head noun and RC noun are profession/generic NPs while the RC noun is a pronoun in (1.12d). Again, these overlapping features in (1.12b) engender processing difficulty.

(1.12a) SRC with two profession/generic NPs
The officer who yelled at the reporter arrived late for work the next day

(1.12b) ORC with two profession/generic NPs
The officer who the reporter yelled at arrived late for work the next day

(1.12c) SRC with a profession/generic head NP and a pronoun RC NP
The officer who yelled at him arrived late for work the next day

(1.12d) ORC with a profession/generic head NP and a pronoun RC NP
The male officer who he yelled at arrived late for work the next day

I predict this to be similar for Mandarin, Korean, and Japanese. When both nouns are animate, ORCs should incur a greater processing cost due to similarity-interference in comparison to SRCs. For in situ subject-modified clauses, the RC noun would proactively interfere with the head noun for ORCs during the retrieval of the head at the matrix verb, and on the other hand, the head noun could retroactively interfere with the RC noun at the RC verb since in both cases the RC noun and head noun are subjects of their respective clauses. However, the retroactive interference should be observed during later re-readings of the RC since the head noun does not initially interfere with the RC noun during the first-reading. This is because the head noun is not integrated into the structure prior to the first-reading of the RC in prenominal RC languages. In other words, there can be no initial interference if only one noun is read and kept in memory.

### 1.4.4. The Object-Before-Subject-Bias

For RC processing in Japanese, Nakamura and Miyamoto (2012, 2013) claimed that both expectation and working memory are not critical factors of processing. Their motivation for this claim is built upon closure effects (Frazier & Fodor, 1978). For closure (Frazier & Fodor, 1978), the basic premise is that when the parser finishes a clause, the string is closed and the contents of the clause are then purged from working memory. English is a late-closure language which means that a clause will be kept open for possible modification. This explains the low-attachment preference in English, for instance, prepositional phrase attachment preferences. For example, the sentence ‘the man looked at the woman with the camera.’ is typically interpreted as ‘the woman with the camera’ rather than ‘the man looked with the camera’ even though both interpretations are grammatical. Considering that Japanese is an early-closure language (i.e., the parser prefers to close the clause at the earliest possible point), Nakamura and Miyamoto (2012, 2013) argued that upon reaching the embedded RC verb in Japanese, the clause would likely close early with the false interpretation of a simple matrix clause. Accordingly, when proceeding on to the head noun, there would be a garden path effect. Specifically, the mental parser would have to reinterpret the clause as an RC. However, integration of the filler-gap would not be possible since the RC contents would have already been dumped from working memory. As such, Miyamoto (2016) claimed that instead of integration, the head noun would likely link with the overall semantics of the clause.

Also, instead of working memory or expectation, Nakamura and Miyamoto (2012, 2013) claimed that ORC difficulties may be attributed to issues in thematic assignment. Their theory is called the *Object-Before-Subject-Bias* (OBSB). Under the framework of Tomlin's (1986) *Verb-Object Bonding Principle* (i.e., a transitive verb assigns the theta role of the direct object which then assigns the theta to the subject), ORCs in Japanese and Korean are more difficult since for ORCs the direct object is processed after both the subject and verb of the RC. Because of this, upon reading the head noun, the head would then need to interface back with the predicate to assign the theta role of the RC subject. In comparison, since the direct object is processed prior to the predicate in SRCs, the head can receive its agent role directly and does not need to interface back. Miyamoto (2016) claims that OBSB may or may not make a prediction for ORC difficulty in Mandarin Chinese since Mandarin was assumed to be a late-closure language (i.e., the parser prefers to keep a clause open for possible attachments to the clause).

(1.13) The importance of the object for the assignment of the subject's theta role
The man caught…
Theta Role Option 1: a ball ['the man' becomes <agent>]
Theta Role Option 2: a cold ['the man' becomes <experiencer>]

(1.14) Ordering of Thematic Arguments: Korean Examples
SRC: *Uywon-ul Kongyekha-n Gijaneun-i*
senator-ACC criticize-ADN reporter-NOM
[Theta role assignment: (1) the object 'senator' and then (2) the subject 'reporter'. In other words, the RC theta role for 'reporter' is immediately assigned.]

ORC: *Uywon-i Kongyekha-n Gijaneun-i*
senator-NOM criticize-ADN reporter-NOM
[Theta role assignment: (1) the object 'reporter' and then (2) the subject 'senator'. The RC theta role for 'senator' is assigned after reading 'reporter'.]

However, there are several issues with this proposal. First, if the clause is closed and the contents are purged from working memory and only an overall semantic interpretation is left, why then are ORCs more difficult? What is meant by this is that a crucial aspect of OBSB is that the object head needs to assign a theta role to the subject, but according to OBSB, the subject no longer exists in working memory. Thus, it is hard to imagine that difficulty would arise from this. Admittedly, the implication that closure may be blocking integration effects is an interesting claim. However, such a factor may not be so detrimental for normal reading. For example, normally when reading, one can simply re-read a clause or sentence, which would then re-insert the contents back into working memory. Accordingly, Nakamura and Miyamoto's account may be more limited to contexts in which re-reading is not possible, such as, moving-window tasks (i.e., only a single word or phrase is presented at a time on a monitor). For eye-tracking (i.e., the main methodology of this study), on the other hand, re-reading is typically allowed. Additionally, even Nakamura and Miyamoto (2013, p. 324) note that anticipatory resources may allow the assignment of the thematic role for the subject prior to the reading of the object. In other words, this theory may possibly be collapsed with expectation-based processing since it may be heavily reliant on frequencies and collocations. Thus, when an object is outside a verb's collocation prediction, processing difficulty would increase. However, this difficulty would then be attributed to both thematic assignment and dashed-expectations.

### 1.4.5. Other Processing Accounts

It goes without saying that the above processing theories are, of course, not an exhaustive list. Since there are far too many theories to cover in this dissertation, I have confined my attention to the aforementioned ones. However, that is not to say that other accounts are not potential factors, and by no means am I ignoring other accounts. Instead, I have judged them to be outside the focus for this study, and some models may even be collapsed with other theories. For this study, I am primarily concerned with relative clause theories of frequency-based accounts and working memory accounts. I include the OBSB since it is a relatively new theory with claims that frequency and working memory matter little to the RC processing in Japanese.

For a review of the processing predictions in each language made by each of the main processing account described above, see Table 1.3.

**Table 1.3. Predictions for RC difficulty in each language**

| | Languages | | |
|---|---|---|---|
| Theories | Japanese | Korean | Mandarin |
| Expectation-based processing | | | |
| RC | ORC | ORC | ORC |
| Simple Clause | ORC | ORC | SRC |
| | | | |
| Integration (without operator) | | | |
| Linear | SRC | SRC | SRC |
| Temporal | SRC | SRC | SRC |
| Structural | ORC | ORC | ORC |
| | | | |
| Integration (with operator) | | | |
| Linear | ORC | ORC | ORC |
| Temporal | ORC | ORC | ORC |
| Structural | ORC | ORC | ORC |
| | | | |
| Similarity interference | ORC | ORC | ORC |
| | | | |
| Object-Before-Subject-Bias | ORC | ORC | NA |

Note. Expectation has two sub-categories. The first is based on the expectations (or frequencies) of RCs. The second is based on the expectations (or frequencies of a simple matrix clause).
Integration is divided into two main categories. The first one (without operator) assumes that the relativizer or operator does not need to be reactivated for the integration procedure. Thus, the head noun will integrate directly with the gap. Therefore, the crucial predictions are based off of the distance between the head and gap. In contrast, integration (with operator) assumes that the operator must be reactivated. Since it is the operator being reactivated by the head noun, it integrates with its trace at the gap. Therefore, the crucial predictions are based off of the distance between the operator and the gap, not the head and gap.
NA stands for not available.

## 1.5. Current Study

Following previous research which claimed that processing factors are interrelated (Levy, Fedorenko, & Gibson, 2013), it is likely that working memory constraints (i.e., integration and similarity-interference) and expectation-based processing are interconnected factors during sentence processing. However, more evidence for this account is needed in other languages so that processing predictions based upon interrelated factors can become more generalized and less language specific.

In terms of whether ORCs or SRCs are more difficult, for Korean (Kwon, 2008; Kwon et al., 2010; Kwon et al., 2013; Kwon et al., 2006) and Japanese (Miyamoto & Nakamura, 2003; Nakamura & Miyamoto, 2012, 2013; Ueno & Garnsey, 2008), ORCs were found to be more difficult to process and comprehend. For Mandarin, on the other hand, a mixed pattern of results has been found sometimes showing ORC difficulty (Jäger et al., 2015; Lin, 2006; Lin & Bever, 2006, 2007; Lin, Fong & Bever, 2005; Vasishth, Chen, Li, & Guo, 2013) and other times SRC difficulty (Chen, Ning, Bi, & Dunlap, 2008; Gibson & Wu, 2013; Lin, 2014; Packard, Ye, & Zhou, 2011; Qiao, Shin, & Forster, 2012). While these past studies attributed the difficulties found during processing to a variety of factors, they did not explore the interconnectedness of processing and largely argued for a singular processing account. For the majority of past studies, RC processing was investigated within ambiguous contexts (i.e., the RC interpretation is not initially understood).

However, recently, there has been a trend to use unambiguous RCs, as the initial clause-type ambiguity was deemed problematic. However, for the majority of these recent studies (e.g., Arai & Kahraman, 2016; Arai,2017; Gibson & Wu, 2013; Jäger et al., 2015; Miyamoto & Tsujino, 2016), besides Kwon et al. (2010), ambiguity was not addressed as an independent factor of processing. This means processing has been chiefly investigated within an ambiguous or unambiguous context, and a comparison between contexts has seldom been made. In Kwon et al. (2010), when comparing ambiguous against unambiguous contexts, it was seen that the processing behaviour remained relatively the same. Accordingly, it is not yet known if ambiguity is a factor for RC processing in these languages. In order to determine the interrelations of processing factors and how they interact, the influence of ambiguity on these factors must be understood.

In the current study, RC processing in prenominal East Asian languages will was be investigated through the lens of ambiguity. For each language, eye-tracking methods will be used to empirically test the subject/object RC asymmetry as a factor of ambiguity, working memory, and expectation.

The overall purpose of this study is to determine which processing mechanisms are shared between these languages so that a better understanding of RC processing may be reached. It is my claim that working memory mechanisms and expectation-based processing are interactive processing factors rather than a singular processing factor explaining RC processing. In particular, I argue that both memory-based and expectation-based processing factors fluctuate the activation level of lexical and syntactic items during processing. Furthermore, I claim that specific cues are required to be integrated into the structure in order for the structure to be interpreted as an RC. Above, I described these cues as the locus of disambiguation for each language.

### 1.5.1. Research Questions

For this study, I set forth to address three general questions about relative clause processing in the Mandarin Chinese, Korean and Japanese languages:

i. Are ORCs more difficult to process than SRCs for each of the three languages?

   I ask this question to attest the universality of the SRC preference. However, considering that Mandarin has mixed findings, I ask the following question.

ii. Does (i) change as a factor of ambiguity?

   Since each language has initial-clause type ambiguity when lacking discourse preceding the RC, I ask whether ORC/SRC difficulty changes if cues are used to attenuate said ambiguity at the start of the RC in each language.

iii. Which processing models best account for the data? Are they influenced by ambiguity, and how are these factors related to each other?

   By collected data from both ambiguous and unambiguous RCs in each language, I ask which of the above processing models can accurately explain the data. In other words, by seeing changes in reading behaviour between ambiguity conditions, I will be able to better detail which processing mechanisms are active at specific loci and if these mechanisms interact with another. Overall, I ask this question to determine if RC processing in these languages can support a hybrid model of processing composed of both memory (i.e., integration and working memory) and expectation. Furthermore, since these factors are components of cue-based processing models, this question serves to determine if cue-based processing can accurately reflect RC processing in these languages.

### 1.5.2. Methods

In the following subsections, a brief overview the experimental methods used in Chapters 2-4 is provided. For more specific details, please refer to the sections within each chapter.

#### 1.5.2.1. Participants

Since this study was concerned with first language processing (L1), native speakers for each language were recruited. All participants were recruited from Nagoya University. These participants were undergraduate, graduate or research students at the time of the study. For the native Mandarin speakers of Chapter 2, all participants came from Mainland China, as opposed to Taiwan or other countries. For the Korean speakers of Chapter 3, all participants originated from South Korea.

#### 1.5.2.2. Experimental Items

Each chapter contains two experiments. The first experiment is composed of experimental items which are strictly ambiguous. In other words, participants should not initially understand the RC as an RC until the locus of disambiguation for each language. The second experiment, however, contained both ambiguous and unambiguous RCs. Unambiguous RCs may be better understood as an RC condition with attenuated ambiguity, since an initial RC interpretation cannot be fully guaranteed. This condition was created by introducing syntactic cues which would enhance the RC interpretation. Particularly, a demonstrative (or determiner + classifier in Mandarin) which also modified the head noun was inserted prior to the RC. While this may be slightly unnatural for Japanese and Korean, the structure should be grammatically permitted by the rules of each language. Particularly in Japanese, pre-RC demonstratives are thought to force a restrictive RC interpretation while the post-RC demonstrative can be restrictive or non-restrictive (Ishizuka, 2008), and this feature is understood to be the same in Korean (Kim, 1993, Sohn, 2001). Typically in Japanese and Korean, the demonstrative occurs after the RC and before the head. In order to prevent the demonstrative from being interpreted as modifying the RC noun, a temporal adjunct adverb was inserted at the start of the RC; as reported by Yun et al., (2015), temporal adjunct adverbs do not occur frequently inside RCs. Interestingly, Mandarin Chinese differs slightly from Japanese and Korean since restrictive RCs utilize post-RC demonstratives and the non-restrictive reading use pre-RC demonstratives (Huang, 1982; Ming, 2010). However, there has been some debate on restrictive RCs in Mandarin as some believe that any use of the determiner makes the clause restrictive (Lin, 2003). I do not predict this difference to be problematic. At most, the pre-RC cue should be more effective in Mandarin since it occurs more often (Ming, 2010).

#### 1.5.2.3. Eye-tracking Methods and Apparatus

To investigate RC processing in these languages, eye-tracking methods were adopted (Rayner, 1998). Briefly put, eye-tracking is a powerful tool to measure reading behaviour. Below, I provide general descriptions for eye-tracking methods, measures and the apparatus.

For sentence processing, eye-tracking is an experimental technique that involves capturing the eye-movements and fixation times made by participants in the reading of sentences. Eye-tracking has been shown to be sensitive to a wide range of linguistic phenomena including ambiguity and garden-path effects (Pickering & Traxler, 1998), lexical effects such as word frequency (Rayner & Duffy, 1986; Rayner, 1998; Yan, Tian, Bai & Rayner, 2006), semantic implausibility (Traxler & Pickering, 1996), and general syntactic difficulty, as in reflexive anaphora resolution (Badecker & Straub, 2002). Consequently, it has been proven to be an invaluable tool in psycholinguistic studies with eye-movements and corresponding reading times reflecting how we process and comprehend sentences.

The procedure of eye-tracking is relatively simple, see Figure 1.12 below.

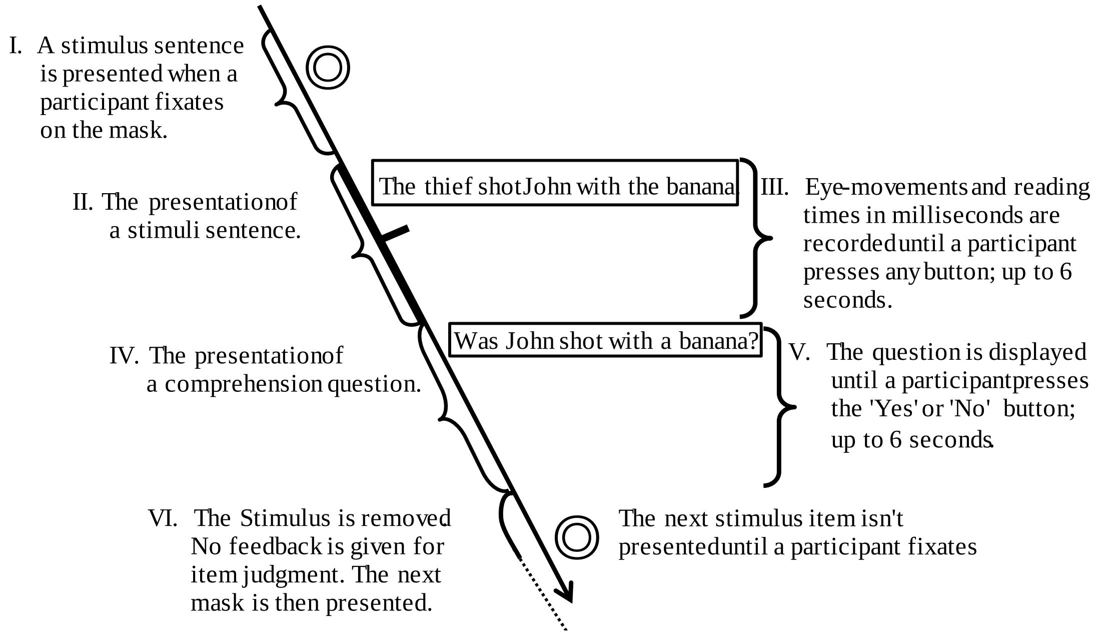



**Figure 1.12. General procedure for eye-tracking**
The solid black arrow line represents the time course duration of the trial. Each Roman numeral represents a particular stage in the presentation of a trial

The procedure starts off with a drift checking mask, in this case a large circle, being displayed on the left-middle side of the screen, approximately at the same horizontal and vertical coordinates at which the sentence will begin. This is done to ensure that the participant starts at the correct location of the sentence and also that the participant’s eye is correctly calibrated to the eye-tracking camera, since participants sometimes move during the experiment which causes their eye-gaze to drift from the calibration. When the participant fixates or looks at the mask, the proctor will press a button that removes the mask and presents the stimulus sentence, beginning at where the mask was. The sentence is displayed all at once and the participant is free to read the sentence normally. Depending on the task, researchers usually impose a time limit on the display of the sentence, in this case being six seconds or 6,000 milliseconds. However, it is important to set a time limit that allows the participant to read and comprehend the sentence fully without running out of time. When the participant is finished reading the sentence, they press a button on a feedback device that removes the stimulus sentence; yet, if they fail to press the button within the allotted time, the stimulus will be removed automatically. Under such a circumstance, it cannot be determined if the participant had finished reading the sentence; therefore, they had a *time-out* on the sentence. Usually such items are removed from later analyses. It can, however, be insightful to know if a particular condition elicits more time-outs just as a lower comprehension rating would be as well. It has been argued that eye-tracking does not require a secondary task (Roberts & Siyanova-Chanturia, 2013); however, eye-movement studies overwhelming use verification questions as insurance that the participant reads and comprehends the sentence. Accordingly, after completing the sentence, a comprehension question will be displayed where the sentence was, and the participant has to respond to it using a feedback device, usually a “Yes” or “No” button on a game-pad or designated keys on a keyboard. Similar to the display of the sentence, a time limit is also often imposed on the display of the question. After answering the question, feedback can be given or not. In this example, it is not. Subsequently, the drift checking mask is displayed again, indicating that the experiment has moved forward onto the next item. This will continue until the end of the experimental session with periodic breaks and eye re-calibrations depending on the length of the experiment.

As illustrated in Figure 1.13, a presented sentence can be broken up into multiple regions to analyse the data collected (R1-R5 for this example).

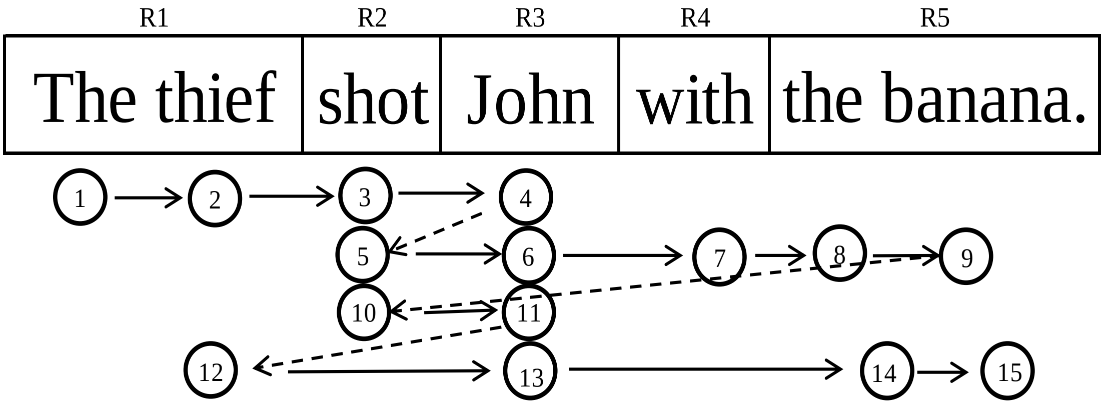



**Figure 1.13. An example of data collected by eye-tracking**
For the above sentence, the sentence is divided into five regions (i.e., R1-to-R5). Each circle represents an eye-fixation. The numerical value inside each circle represents the sequential order of each fixation. The forward solid arrow lines represent forward moving (left-to-right) eye-movements or saccades. The backwards dashed arrow lines represent regressive saccadic movements.

Taking a look at the example in Figure 1.13, it can be seen that actual reading is not a smooth process (Rayner, 1998; Staub & Rayner, 2007). Instead eyes move point to point between individual eye-fixations. These movements between fixations are called saccades (Rayner, 1998; Staub & Rayner, 2007) and can be forward moving saccades, as in the movement between the fixations 1 and 2 or backwards or regressive saccades as in between fixations 4 and 5. The average reading time for any given fixation during reading is between 200 and 300 milliseconds (Rayner, 1998). Accordingly, by averaging multiple fixations at a given word or phrase, eye-tracking can produce multiple measures of processing. It can also separate processing effects by time-course processing; in other words, early or late processing (Rayner, 1998; Clifton, Staub, & Rayner, 2006; Staub & Rayner, 2007). There are multiple measures of processing for eye-tracking. Below, I provide descriptions for several commonly used measures in relation to Figure 1.13.

The first measure of processing for a given word is *first-fixation duration,* which represents early indications of syntactic integration, lexical effects and semantic effects (Liversedge, Paterson, & Pickering, 1998). Yet, often a single fixation is not sufficient for longer words and for multiple words, so the *first-pass* reading time of a given word or phrase can be analysed. This measure represents all the fixations made in a region during the initial pass through the region before exiting the region in either direction. For example, fixations 8 and 9 in region R5. The measurements of first-fixation duration and first-pass reading often yield congruent results (Rayner, 1998), and as such, first-pass is also sensitive to lexical, semantic, and syntactic effects (Rayner, Warren, Juhasz, & Liversedge, 2004).

The next measure of processing often reported is *re-reading* time, such as fixations 5+10 in R2. This measure can represent general comprehension difficulty. However, sometimes there are many passes through a given region (as in region R3), so all the fixations within a region will be merged together as the total *dwell-time* reading, a mix of early and late processing. This is a measure that demonstrates overall processing difficulty and comprehension difficulty (see Roberts & Siyanova-Chanturia, 2013), and it is typically the only measure that self-paced reading (Just, Carpenter, & Woolley, 1982) and *Maze* task (Forster, Guerrera, & Elliot, 2009) can report. These methods are of moving-window design. This design typically only displays a single word or phrase at a time and moves only forward. Thus, these methods only allow a single measure of processing to be recorded. I believe this gives eye-tracking an advantage when recording reading.

Since eye-tracking can track regressive eye-movements, it can also record the regressive reading times at a region before moving onto the next region with a higher value. This is called *go-past* reading or *regressive-path duration*, and in this example it would be fixations 4, 5, and 6 for region R3. Regressive readings can be a demonstration that the parser is attempting to repair difficulties in the sentence, represent congruity issues in the sentence, or reflect higher order reading effects (Camblin, Gordon, & Swaab, 2007; Staub & Rayner, 2007). Gordon, Hendrick, Johnson, and Lee (2006) speculate that this measure may be more representative of early processing than late processing. Not only can regressive reading be tracked, but so can the regressive movements themselves. Accordingly, we can track the regression proportion ratio of eye-movements for movements both in and out of a region. For *regression-out* measures, this represents the likelihood that a regression is made out of a region during the first-pass through a region, whereas *regression-in* represents the total likelihood a regression is made back into a region. These points are indicative of the point in the sentence where the mental parser needs to make a repair and the word or phrase that is likely causing difficulty.

Lastly, eye-tracking can track the overall reading of the sentence as well (i.e., the *total reading time of the sentence*). In summary, these measures described above are only a slice of what eye-tracking can be used for, as there are many more possible measures, but since these are the measure I will focus on in this thesis, I have only covered these terms. With the eye-tracker EyeLink 1000 Core System (desktop Eyelink 1000 SR Research Ltd., Ontario, Canada), the eye-tracking technique has become much more reliable and robust, as this system is extremely accurate. In this study, the EyeLink 1000 Core System was used for all experiments.

#### 1.5.2.4. Experimental Tasks

Sentence processing studies overwhelmingly involve more than just simply reading sentences; accordingly, secondary tasks are given in addition to reading. An explanation for this is that as researchers, we want our participants to be paying attention to the sentence while they are reading; if not, how can we ascertain that they actually read the sentence? As such, the secondary task focuses on a certain aspect of the sentence that cannot be accomplished without reading the sentence. The two types of secondary task that will be discussed and utilized in this thesis are *verification tasks* and *plausibility tasks*. Verification tasks employ post-sentence comprehension questions that ask about specific information in the previously read sentence. After reading the sentence, the participant presses a button on a feedback device that allows them to move onto the question. The participant then proceeds onto answering the question using the same feedback device. See below for an example.

(1.15) Comprehension / Verification Probe

Sentence: 'The guard who the prisoner pushed was punished severely.'

Positive probe: 'Was the guard punished? Yes or No'

False probe: 'Was the prisoner punished? Yes or No'

In this example, the positive probe is accurate; the guard was punished, so the correct response would be 'yes'. For the false probe, on the other hand, since we cannot extrapolate that the prisoner was punished within the boundary of the sentence, the correct answer would be 'no'.

Contrary to verification, plausibility tasks involve making a sentential decision on whether the sentence read can exist in the real world for the given language without a paranormal interpretation; this task can have the decision be made during or after the display of the sentence. See below for an example.

(1.16) Plausibility Judgment

Plausible: 'The thief shot John with the shotgun.'

Implausible: 'The thief shot John with the banana.'

For the first sentence, the sentence is clearly plausible, as we can easily imagine thieves shooting people with guns; accordingly the participant would indicate on the feedback device using the 'Yes' or 'True' button after finishing reading the sentence. In comparison, the implausible sentence becomes an impossible sentence at the site of 'banana', as it is not a permissible semantic instrument of the verb shoot. Therefore, the participant would have to select the 'No' or 'False' button on the feedback device. Plausibility tasks can serve either of two functions. First, they can be used to compare the processing of plausible stimuli against implausible stimuli as in the example above, or they can be used as a means to distract participants from the purpose of the experiment by only using implausible items as fillers/distractors.

Even though these tasks use different methodologies, the main purpose is the same, to make sure the participant is reading the sentence so the results elicited reflect their reading behaviour.

In this introduction, I have covered RCs in Japanese, Korean and Mandarin Chinese as well as common RC processing theories and what predictions they make for each language. I have addressed ambiguity as being a factor that needs to be addressed for RC processing theories in these languages as well as highlighted my goal as to look at the interrelations of processing theories. The overarching purpose of comparing the processing in three languages is to provide a better account for the influence of ambiguity and the interrelatedness of processing mechanisms. In the following chapters (Chapters 2-4), individual case studies for Mandarin Chinese, Korean and Japanese are provided. These chapters are self-standing studies and may be read in any order. Chapter 5 then discusses the findings from these chapters in relation to each other.

# CHAPTER 2

# Ambiguity in Mandarin Chinese Relative Clause Processing

This chapter is modified from the study:

Mansbridge, M. P., Tamaoka, K., Xiong, K., & Verdonschot, R. G. (2017). Ambiguity in the processing of Mandarin Chinese relative clauses: One factor cannot explain it all. *PloS One*, *12*(6), e0178369.

This published work is a collaborative project designed by myself, Michael Patrick Mansbridge. The paper and its arguments were written primarily by me. Professor Katsuo Tamaoka and Dr. Rinus G. Verdonschot supervised the project, and both co-authors provided feedback during the writing process. Kexin Xiong was responsible for stimuli development for Experiment 1, and she also helped transform the items of Experiment 2. She also helped by providing a native speaker's interpretation. She also helped by translating and transcribing the stimuli items. For the eye-tracking experiments, I designed and built both experiments. Both Kexin Xiong and I proctored Experiment 1, and I along with a research assistant, proctored Experiment 2. For all the results of this Chapter, I did all the analyses.

# 2.1. Abstract

This study addresses the question of whether native Mandarin Chinese speakers process and comprehend subject-extracted relative clauses (SRC) more readily than object-extracted relative clauses (ORC) in Mandarin Chinese. Recently, this has been a hotly debated issue, with various studies producing contrasting results. Using two eye-tracking experiments with ambiguous and unambiguous RCs, this study shows that both ORCs and SRCs have different processing requirements depending on the locus and time course during reading. The results reveal that ORC reading was possibly facilitated by linear/temporal integration and canonicity. On the other hand, similarity-based interference made ORCs more difficult, and expectation-based processing was more prominent for unambiguous ORCs. However, it was found that even for unambiguous RCs in Mandarin, a cue was required to interpret the clause as an RC prior to any effect of expectation. In this study, this cue was the relativizer. Overall, RC processing in Mandarin should not be broken down to a single ORC (dis)advantage as explained by a singular processing mechanism (e.g., memory-constraints or expectation-based processing), but understood as multiple interdependent factors influencing whether ORCs are either more difficult or easier to parse depending on the task and context at hand. Simply, integration and canonical word/semantic order facilitate the processing of ORCs while expectation-based processing and similarity interference impede it.

**Keywords**: Mandarin Chinese, eye-tracking, relative clauses, integration, expectation, similarity-interference, ambiguity

# 2.2. Introduction

When comparing sentence processing strategies between languages, several cross-linguistic differences have been observed, making it unclear whether strategies differ across languages. Occasionally, competing models make dichotomous predictions for a certain language, for example, when processing relative clauses in Mandarin Chinese (henceforth “Mandarin”). In Mandarin, past studies are divided on their support for different contending models. In the present study, I employ eye-tracking to empirically investigate several relative clause processing models within different contexts to explore their interrelationships. First, I briefly introduce the topic of relative clauses, followed by several available processing accounts, and then discuss how these models might function in Mandarin.

### 2.2.1. Relative Clauses

In this paper only subject-extracted relative clauses (SRC) and object-extracted relative clauses (ORC) are discussed in relation to Mandarin Chinese. See examples (2.1a) and (2.1b) below.

(2.1a) Subject-extracted relative clause (SRC)
[$t_i$ *Zhĭzé Shìzhăng De*] *Jìzhĕ*$_i$ *Căifăng-Le LiNà*
[$t_i$ criticize mayor REL] reporter$_i$ interview-ASP Li Na
'The reporter$_i$ [who $t_i$ criticized the mayor] interviewed Li Na.'

(2.1b) Object-extracted relative clause (ORC)
[*Shìzhăng Zhĭzé* $t_i$ *De*] *Jìzhĕ*$_i$ *Căifăng-Le LiNà*
[mayor criticize $t_i$ REL] reporter$_i$ interview-ASP Li Na
'The reporter$_i$ [who the mayor criticized $t_i$] interviewed Li Na.'

Relative clauses (RC) are often discussed in terms of *wh*-movement and filler-gap dependencies (Clifton & Frazier, 1989; Frazier & Flores d'Arcais, 1989), where the *filler* is the co-indexed element that fills the *gap* created at the trace (i.e., $t_i$) of the *wh*-movement. For prenominal (i.e., head-final) Mandarin, not only are these general principles of filler-gap dependencies assumed to be consistent (c.f., Huang, Ya, & Li, 2009; Matthews & Yip, 2016), but also Zhang (2008) provides a framework detailing how gapped RCs are syntactically distinct from non-gapped pseudo-relative clauses. Furthermore, Su, Lee, and Chung (2007) showed that a subset of Mandarin speaking aphasic patients exhibited agrammatic comprehension for SRCs but not for ORCs. Along with previous findings, they argued that this effect is best explained by the *Trace-Deletion Hypothesis* (Grodzinsky, 1995). That is, without a gap for the head noun to fill, aphasics cannot comprehend SRCs, but are able to process ORCs due to their canonical agent-to-theme ordering. Considering these points, I opted to avoid any non-gapped interpretation for relative clauses in Mandarin.

In Mandarin, word order differences in relation to the RC and head noun ordering (e.g., post-nominal and prenominal) are relatively rare; ORCs are canonically

SVO while SRCs are non-canonically VOS. Typically in languages which have a canonical word order distinction between RC conditions, SRCs are found to be canonical. This makes Mandarin RCs relatively rare among languages, since they display an infrequent, reversed pattern (Comrie, 2008; Dryer, 2005). Additionally, Mandarin does not have a relative pronoun; instead, it typically marks the clause in a general manner with the relativizer "*De*" (Cheng & Sybesma, 2005, 2009; Matthews & Yip, 2016; Sun, 2015, Zhang, 2012) which can appear in numerous other constructions besides an RC (see Hsiao & MacDonald, 2013). Since Mandarin is a prenominal RC language and does not mark the RC at the left boundary, temporary ambiguity of clause type exists during the initial reading of the RC. This means that a matrix clause interpretation is often initially incorrectly taken instead of a correct RC interpretation. This ambiguity, however, can be resolved partially at the relativizer, where it becomes clearer that the current clause is likely not a matrix clause but instead is more likely an RC or another clause bearing a similar structure. It is worth noting that besides the RC interpretation, other clause types may also be available at the relativizer, such as appositives, fact-clauses or even pseudo-relative clauses. Accordingly, interpreting a clause as an RC may be best at the head noun for externally-headed RC constructions in Mandarin. This issue of clause-type ambiguity has been a major issue in the literature dealing with RC processing in East Asian languages.

### 2.2.2. Relative Clause Processing

The focus on RCs in psycholinguistic studies has been primarily built upon the processing asymmetry between SRCs and ORCs, specifically, that SRCs are seemingly easier to process and comprehend. According to Hawkins (1999), one explanation for why ORCs are more difficult is that they are inherently more structurally complex compared to SRCs. This difference has also been explained by language universal theories such as the *Noun Phrase Accessibility Hierarchy* (NPAH) (Keenan & Comrie, 1977; Keenen & Hawkins, 1987) which states that not only should SRCs be acquired first prior to ORCs, but also that the subject gap is in a more accessible syntactic position, thus making it easier to process and comprehend SRCs compared to ORCs. NPAH, however, was not supported for the L1 acquisition of Mandarin RCs by children (Chen & Shirai, 2015). The difficulty in processing ORCs has been documented across a range of varying languages using different experimental methodologies, and taken together this provides strong evidence for a cross-linguistic SRC advantage. Though these studies support the claim that ORCs are generally more difficult than SRCs, explanations for this phenomenon have not yet been formed under a single processing account. This is especially true in Mandarin. Currently, there is a heated debate surrounding the processing preference for RCs in Mandarin which started with the findings of Hsiao and Gibson (2003) who argued for an ORC advantage due to storage-based resources (i.e., memory load) within the RC structure (see Gibson, 2000). Since then, there have been numerous attempts to either refute these claims or provide support for the ORC advantage. Previous studies supporting an SRC advantage have used eye-tracking (Jäger, Chen, Li, Lin, & Vasishth, 2015) and self-paced reading (Lin & Bever, 2006; Lin, Fong, & Bever, 2005; Vasishth, Chen, Li, & Guo, 2013), and studies supporting an ORC advantage have used eye-tracking (Sung, Cha, Tu, Wu, & Lin, 2015; Sung, Tu, Cha, & Wu, 2016), event-related potentials (ERP) (Packard, Ye, & Zhuo, 2011; Sun, Hancock, Bever, Cheng, Schmidt, & Seifert, 2016), maze tasks (Qiao, Shen, & Forster, 2012), and self-paced reading (Chen, Ning, Bi, & Dunlap, 2008; Gibson & Wu, 2013; Lin, 2014). The amount of support for each claim using a variety of methods makes this issue highly contested. In the following sections, I describe several existing RC processing models as well as their diverging results or predictions on Mandarin RCs.

#### 2.2.2.1. Expectation-based Processing

Models involving statistical computations on either or both language frequencies and collocations can be divided into several different accounts. Briefly summarizing, *Surprisal* (Hale, 2001; Levy, 2008) involves confirming or refuting the parser's expectations at each word or phrase; *Entropy-Reduction Hypothesis* (Hale, 2006) involves the changes in uncertainty in the sentence; and *Canonicity* (MacDonald & Christiansen, 2002) involves the influence of both structural frequency and regularity from the canonical order of a language. Some researchers, however, have cautioned against adopting approaches looking at either too fine-tuned or coarse-grained distributions dealing with language exposure (Mitchell, Cuetos, Corley, & Brysbaert, 1995).

Under the general framework of expectation-based processing, sentence processing is seen as being guided and facilitated by the input of a language (i.e., language frequencies and exposure to said frequencies). Briefly stated, these models predict that: (1) A more common structure should be easier to initially construct compared to a less common structure, and (2) expectations of upcoming structures are based on language exposure. When these expectations are not met, processing difficulty arises (Hale, 2001; Levy, 2008). Since ORCs are typically observed to be less frequent in corpora than SRCs (see Chen, Grove, & Hale, 2012 for statistical frequencies and surprisal predictions and Yun, Chen, Hunter, Whitman, & Hale, 2015 for entropy reduction predictions for Mandarin), these models predict that ORCs should be more difficult to process, given that their structure is less expected. For temporarily ambiguous RCs, these predictions on the RC structural frequency cannot be established until the parser becomes aware of the RC structure. Considering that Mandarin RCs are ambiguous and that initial word order for ORCs is canonical, expectation can actually facilitate the initial reading of an ORC. This facilitation would occur up to the relativizer, where the expectation of a canonical ordered matrix clause would prospectively be disconfirmed. Here, ORCs would be more difficult than SRCs resulting from greater surprisal (Hale, 2001; Levy, 2008). Qiao, Shin, and Forster (2012) provided evidence of this account using the grammatical maze task (but this finding was not seen using the lexical maze task). They found an initial ORC advantage within the RC which was later reversed at the relativizer position. Vasishth, Chen, Li, and Guo (13), using self-paced reading, also revealed effects of an ORC disadvantage starting at the relativizer position which offers additional support for surprisal effects. Conversely, Packard, Ye, and Zhou (2011) and Sun, Bever, Cheng, Schmidt, and Seifert (2016) found greater P600 and N400 ERPs at the relativizer for ambiguous, subject-modified SRCs alluding to greater processing difficulty for SRCs in conflict with expectation-based processing. P600 ERPs (positive-going ERP reaching its wavelength peak around the 600 ms interval) have often been found to reflect difficulties in filler-gap dependencies as well as garden-path effects (e.g., Fiebach, Schlesewsky, & Friederici, 2001; Gouvea, Phillips, Kazanina, & Poeppel, 2007). N400 ERPS (negative-going ERP reaching its wavelength peak around the 400 ms interval) have often been shown to reflect difficulties word frequency and a word's relation to the semantic context (e.g., Dambacher, Kliegl, Hofmann, & Jacobs, 2006). Thus, the findings from these two studies alluded that SRCs engender greater processing difficulty due to greater demands during integration (i.e., P600 ERP) and difficulties with the word order as Sun et al. (2016) claimed (i.e., N400 ERP). However, these results do not completely negate other studies since parsing expectations may not always be observable.

On the other hand, if the RC is unambiguous (i.e., the parser correctly assumes an RC interpretation) then SRCs should be easier to parse. This has been corroborated by Jäger, Chen, Li, Lin, and Vasishth (2015) who demonstrated, using both self-paced reading and eye-tracking under an unambiguous context (i.e., syntactic cues were inserted to reduce the level of ambiguity), that reading times (RT) within the relative clause, excluding the relativizer, were significantly longer for ORCs. This compelling result demonstrates that if the reader is aware of an upcoming relative clause, SRCs will be easier to process in Mandarin. In contrast with the above finding, Gibson and Wu (2013), Lin (2014), and Vasishth et al. (2013) observed an opposing ORC advantage when using discourse to prime participants for an upcoming RC structure; however, both Lin (2014) and Vasishth et al. (2013) argued that this could be primarily attributed to canonical thematic priming.

#### 2.2.2.2. Memory-based Constraints

During sentence comprehension, the parser is constantly assigning case and thematic values to nouns as well as integrating each new syntactic dependency into the structure and reactivating linked words with their antecedents. At the gap position within the RC, the mental parser performs a search for the head noun dependency (i.e., the filler) to retrieve and integrate it with the gap. The difficulty surrounding integrating the filler with its co-indexed dependent is thought to result from the decay of a dependent's activation in memory (Gibson, 2000; Lewis & Vasishth, 2005). While it is generally agreed that activation will decay as more discourse referents are introduced into a structure, it is still unclear in which exact manner integration occurs.

One prominent model for integration is Gibson's (2000) *Dependency Locality Theory* (DLT). Within this model, Gibson describes each syntactic dependency as carrying a unit in working memory. This has an effect during the comprehension of a sentence because the parser is (i) constantly predicting the upcoming syntactic dependencies to complete a grammatical sentence (i.e., storage-based resources) and (ii) memory units also apply to the number of intervening referents between filler-gap dependencies. The particularities of DLT suggest that integration performs a strictly linear search in memory for a co-indexed referent and that integration can be assumed to be more difficult as the distance increases. In English, DLT predicts a greater processing demand for ORCs based on the number of intervening dependencies between the filler and gap, when positing the gap at the RC verb. However, this prediction is reversed for prenominal languages like Mandarin since the distance between filler-gap dependencies is greater for SRCs. For the storage-based component of DLT, an ORC advantage can initially be predicted in Mandarin if the clause is misconstrued as a canonical matrix clause, thus initially predicting fewer syntactic heads (Hsiao & Gibson, 2003; Qiao et al., 2012).

In a similar vein, Lewis and Vasishth's (2005) *Activation-Based Model*, based within the scope of the *Adaptive Control of Thought–Rational* (ACT-R) model (Anderson, 1996), proposes that the decay of the initial activation increases as a function of time (i.e., temporal locality). Vasishth and Lewis (2006) also contend that successive activations on the current input have the potentiality of creating *antilocality* effects such that a condition with a higher activation level will lead to anticipatory facilitation in reading speed. Concerning integration, the activation-based model makes similar predictions as DLT. Yet, these models differ from the *Structural-Phrase Hierarchy* model (O'Grady, 1997), which defines decay by the number of intervening syntactic phrases within a syntactic structure hierarchy. Since SRCs have fewer syntactic heads intervening between the filler and gap, ORCs would be more difficult during integration. See Figure 2.1 for an illustration of these models.

In support of DLT, Packard et al. (2011) found increased P600 ERP responses for the SRC condition at the relativizer and head noun in Mandarin and attributed it to a greater processing demand for SRCs during integration (Kan, Harris, Gibson, & Holcomb, 2000; Phillips, Kazanina, & Abada, 2005). They claimed that the relativizer has the potential to satisfy the categorical selectional restriction of the RC verb; as such, the relativizer can serve as a substitute for the filler during integration. This notion is also built upon evidence from Mandarin, as well as Korean and Japanese. These are languages which allow for null-head RC structures (Simpson & Wu, 1999, 2001) which could necessitate that the relativizer needs to generate a head NP and take upon the responsibilities of integration without carrying specific lexical information that the missing head would carry. As such, they suggested that even in headed RCs, the relativizer can still act in this manner. Similar to Packard et al. (2011), Sun et al. (2016)

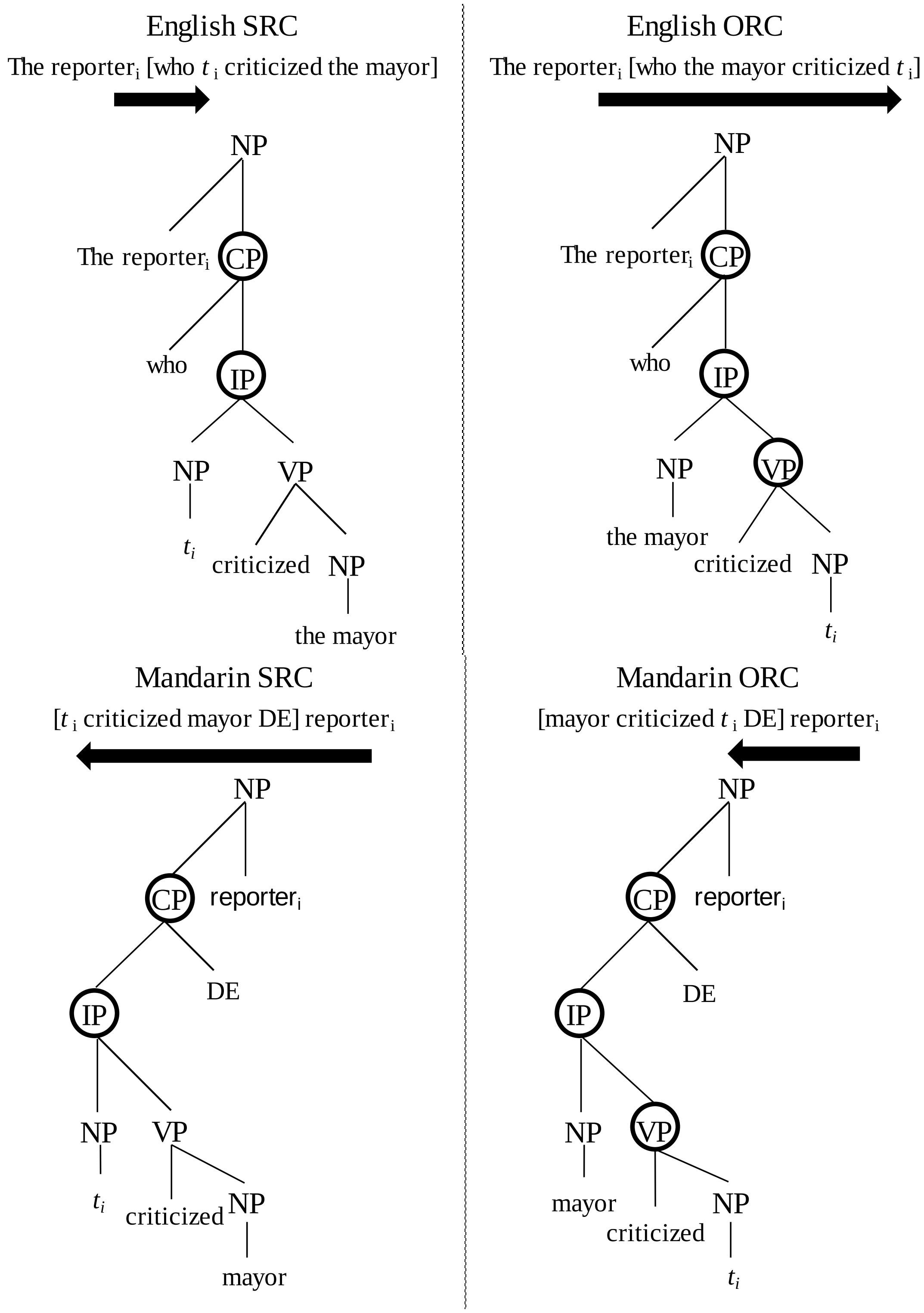



**Figure 2.1. Basic syntactic structure of SRCs and ORCs in English and Mandarin**
The linear/temporal integration metric is described by the black horizontal arrow (longer arrows indicate increased costs). The structural-phrase metric is described by the circles in in the syntactic structure (more circles indicate increased costs).

found an increased N400 at the relativizer and head noun for SRCs, which may suggest that the metrics of integration for Mandarin are indeed based on linear/temporal locality rather than locality in syntactic structure (O'Grady, 1997). Sun et al. (2016), however, instead argued that the surface canonical word order creates a garden path effect which only initially benefits ORCs. Using eye-tracking methods, it was shown that Sung, Cha, Tu, Wu, and Lin (2015) and Jäger et al. (2015) yielded conflicting results. Specifically, an ORC advantage was found in ambiguous RCs (Sung et al., 2015) while an ORC disadvantage was found in unambiguous RCs (Jäger et al. 2015). Considering the number of conflicting findings, more studies are needed to determine whether ORCs are easier to process due to integration or are only easier due to a garden path effect resulting from their similarity to the canonical order of Mandarin within ambiguous RCs.

Lewis and Vasishth (2005; Vasishth & Lewis, 2006) note a third interactive feature in their memory constraint model based upon the interference of similar referents being held in memory, i.e., *similarity-based interference* within the framework of *cue-based retrieval*. In relation to ACT-R (Anderson, 1996), it is described that the activation level of a given item is also influenced by the number of other items sharing overlapping features (e.g., animacy, syntactic position, gender, number) surrounding it within a sentence. As the number of similar items increases, the activation level for each of these items will decrease causing a *fan effect*. Upon encountering an item (e.g., a pronoun, reflexive, or verb) which necessitates a dependent with a specific set of cue features (e.g., +animate, +female, +singular, +subject), a *retrieval-cue* process will be initiated to select the grammatically correct antecedent matching the cue features in memory, i.e., the target item. This process will be more difficult if there are distractor items matching the cues which are, nevertheless, ungrammatical antecedents. A distractor item can either proactively or retroactively reduce the activation level of the target depending on whether it precedes or follows the target. While Lewis and Vasishth's model does not make a strong claim for similarity interference at the matrix verb for RC processing (they instead argued for stronger effects of similarity interference at the embedded RC verb in English (Lewis & Vasishth, 2005)), I consider that there is a possibility for it to occur in Mandarin despite the lack of subject-verb agreement features. Studies on similarity interference, however, have produced mixed findings, sometimes showing inhibition or facilitation depending on the context (see Jäger, Engelmann, & Vasishth, 2017 for a comprehensive meta-analysis overview).

In a recent study by Patil, Vasishth, and Lewis (2016), similarity interference was argued for the processing of reflexive anaphora in English despite previous notions of reflexive anaphoric binding in English arguing for a purely structural-based account (i.e., no violation to Binding Principal A: An anaphor must be bound by its antecedent in its local domain). Patil et al. (2015) argued that the lack of inhibitory interference effects in previous studies can be attributed to those studies using object-role distractors instead of subject-role ones when the antecedent required a +subject feature. Therefore, if the distractor shares the +subject feature, processing inhibition for similarity-based interference can be observed during the processing of reflexive anaphora. In terms of the processing differences between SRCs and ORCs, Gordon and colleagues (Gordon, Hendrick, & Johnson, 2001; Gordon, Hendrick, Johnson, & Lee, 2006) claimed that ORC difficulty at both the embedded and matrix clause verb may be explained by similarity interference. When using eye-tracking (Gordon et al., 2006), it was observed that ORC difficulty appeared within the RC and at the matrix verb. While they had tested for both RC condition and the effect of noun type (i.e., proper noun and general nouns), processing differences based on both were found only within the RC, and the matrix verb was only observed to have ORC difficulty. Thus, when a predicate necessitates a subject lacking agreement features beyond animacy, the subject within the ORC may still potentially provide an interference account at the matrix verb. Considering the importance of matching grammatical features for similarity-interference in other studies (Van Dyke & McElree, 2011), I argue that similarity-based interference should be extended to matrix predicates for Mandarin RC processing under this premise. Accordingly, since subject-modified ORCs in Mandarin have two grammatical subjects (i.e., RC and matrix clause subjects) prior to the matrix clause verb, I suggest that the RC subject should proactively cause a fan effect for the matrix clause subject. Therefore, when the matrix verb retrieves its subject using the retrieval-cues +subject and +animate, ORC sentences should be more difficult in comparison to SRC sentences since the SRC noun instead has the feature +object. Consequently, I suggest that similarity-based interference can predict ORC processing difficulty in Mandarin. For more detail on similarity interference see (Lewis, Vasishth, Van Dyke, 2006).

### 2.2.3. Current Study

Regarding RC processing in Mandarin, recent studies have revealed that the ORC advantage is primarily seen in ambiguous contexts while unambiguous contexts favour SRC processing. Yet, these studies have not fully addressed ambiguity as an experimental factor. Accordingly, the present study will further investigate the issue of ambiguity to provide a more detailed account of processing within ambiguous and unambiguous RCs. Two experiments were conducted. In Experiment 1, I set out to replicate previous findings within an ambiguous design using two different experimental tasks. In Experiment 2, I modify Jäger et al.'s (2015) items to either include the determiner + classifier phrase (i.e., attenuated ambiguity) or exclude it (i.e., ambiguous) to determine if ORCs are only facilitated in ambiguous contexts. As such, I explore the relevancy of canonicity, linear/temporal integration metrics, expectation-based processing and similarity interference for RC processing in Mandarin Chinese.

## 2.3. Experiment 1

For Experiment 1, using a strictly ambiguous RC structure, I sought to replicate recent eye-tracking findings that found that ORCs were easier to process than SRCs within the RC. I also sought to demonstrate that ORCs become more difficult to parse after the reading of the head noun as specified by similarity-based interference.

In Experiment 1, I employed both a plausibility judgment task (i.e., a sentential judgment task on the overall plausibility of the event denoted by the sentence, not its grammaticality) and a traditional verification judgment task (i.e., post-sentence comprehension/verification questions) on Mandarin RCs using a slightly irregular Mandarin RC type containing two proper names as the RC noun and head noun. The plausibility task was added to determine if any result obtained was influenced by task artefacts. According to Caplan, Chen, and Waters (2008), the use of comprehension or verification questions may be more cognitively demanding than what is required to process and understand the sentence. They attribute this to participants attempting to rehearse the sentence while reading it for the purpose of answering the post-sentence question. To demonstrate this, they conducted a series of tasks using functional magnetic resonance imaging (fMRI): A verification task, a plausibility task, and a non-word detection task. In comparison between the plausibility task and verification task, the plausibility task was shown to activate fewer brain regions (as indicated by the blood-oxygen-level-dependent or BOLD observed in each brain region) than the verification task while still having activation in brain regions responsible for syntactic processing similar to their verification task. In other words, plausibility tasks were shown to be representative of sentence processing effects and may even be less susceptible to extra-cognitive effects (i.e., processing beyond the bounds of understanding the sentence). Considering that the majority of the studies investigating Mandarin RC processing have used traditional comprehension questions, I investigate the effect of task on RC processing as a secondary, minor objective of Experiment 1. In other words, I would like to determine how the ORC (dis)advantage is influenced by what the task participants must attend to during the reading of Mandarin RCs. At the very least, I expect to find increased reading times in the verification task in comparison to the plausibility task in support of Caplan et al. (2008).

## 2.3.1. Materials and Methods

### 2.3.1.1. Participants

Thirty-two native speakers of Mandarin Chinese, all originating from Mainland China, were recruited from Nagoya University, Japan, but five were removed due to extensive calibration difficulties (N = 27; Female = 17). These participants were either graduate or research students at Nagoya University at the time of the study. The mean age of the participants was 24.5 years (range 22 - 30.5 years).

### 2.3.1.2. Materials

Thirty-two experimental items were created; see Appendix Chapter 2 (p. 265). Each item contained an ambiguous relative clause that only modified the matrix subject. Each RC had two variants: an ORC and its SRC counterpart. Items were counterbalanced to ensure that participants would only see one condition of each item per task session. Half of the participants first undertook the plausibility task before the verification task and vice versa.

All experimental items were plausible. The length of each noun, verb, and adverb was two simplified Chinese characters. All nouns were set as an animate proper name; for example “*Lǐ Fāng*” and “*Liáng Yuán*”. The majority of these names were taken from a list of common Chinese names from the National Citizen Identity Information Center [全国公民身份号码查询服务中心]. Furthermore, the gender of the nouns was controlled such that male and female names were distributed equally. Animacy has been a well-known issue for RC processing in Mandarin with ORCs having the preference of having an inanimate head and animate RC noun whereas SRCs are preferred to have an inanimate RC noun and animate head. Within animate-animate contexts, however, subject-modified SRCs appear to be more frequent in comparison to subject-modified ORCs (Wu, Kaiser, & Anderson, 2011, 2012). Therefore, it is possible that by using only animate nouns this may create a slight ORCs disadvantage. However, RCs with two proper nouns should be relatively rare for both RC types, so I believe animacy effects should not be problematic for ORCs. While the frequency of the verbs was also controlled, stroke count was not controlled for the nouns, adverbs and verbs. However, this is not problematic as the number of strokes per RC condition would be the same for ORCs and SRCs.

As seen below in (2.2), each word, besides the particle "*Le*", has been coded: N1 stands for the RC noun, V1 is the RC verb, DE is the relativizer, N2 is the head noun, ADV is an adverb, and V2 identifies the matrix clause verb with the aspect marker "*Le*". In the plausibility task, an equal number of implausible RC distractors were also shown, see (2.3) below. In the verification task, half of the questions were true or correct probes and the other half were false or incorrect probes.

(2.2) Experiment 1 Stimuli Regions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | V1 | N1 / N1 | V1 | DE | N2 | ADV | V2 |
| [$t_i$ | *Yāoqǐng* | *LǐFāng* / *LǐFāng* | *Yāoqǐng* $t_i$ | *De*] | *LiángYuán*$_i$ | *Gāngcái* | *Chídào Le* |
| [$t_i$ | invited | Li Fang / Li Fang | invited $t_i$ | REL] | Liang Yuan | just.now | late ASP |

'Liang Yuan [who invited Li Fang / Li Fang invited] was late just now.'

(2.3) Example of Implausible RC Distractor
[*Zhāng Wěi Chī Le De*] *Li Qiáng Yǐjīng Huí Jiā Le*
[Zhang Wei ate REL] Li Qiang already returned
'Li Qiang who Zhang Wei ate already went home.'

## 2.3.1.3. Procedure

Experiment 1 involved exposing participants to two different tasks. Each task was done in a separate session and half of the participants first took one task before the other. In both tasks, items were counterbalanced such that no participant would see the same item twice within a single task, nor would they see an identical item between tasks. Stimulus sentences were displayed horizontally on the centre left of a 17-inch Mitsubishi LCD monitor at a distance of 70 cm from the head and chin rest mount. The resolution of the monitor was 1024 by 768. All characters were displayed on a white screen in Chinese MingLiU 30pt in black font. At this distance, each character subtended a visual angle of 0.87˚. Eye-movements were recorded using an EyeLink 1000 Core System.

Prior to the experiment, participants were instructed in Mandarin (by both the proctor and instruction screen) that they would be reading Mandarin sentences displayed one at a time on a computer monitor, and were given the opportunity to ask questions about the procedure. Prior to each session, the camera was calibrated by a 9-point calibration method and subsequent validation. Calibration was periodically repeated throughout each session after block sessions (eight items).

For the plausibility task, participants were instructed in Mandarin to read each sentence naturally and judge if the sentence meaning was plausible, that is, if the actions or ideas depicted would be able to exist in a real world, everyday setting. If the sentence meaning was plausible, they were instructed to press a button on a gamepad labelled "True"; conversely, if the sentence meaning was not plausible, they were instructed to press a button labelled "False". Participants were instructed to read and judge each sentence within eight seconds. After pressing either button, the stimulus was immediately removed from the screen. Reading times were measured from the onset of the stimulus to the button press event. Eight practice trials were given to ensure participants understood the task.

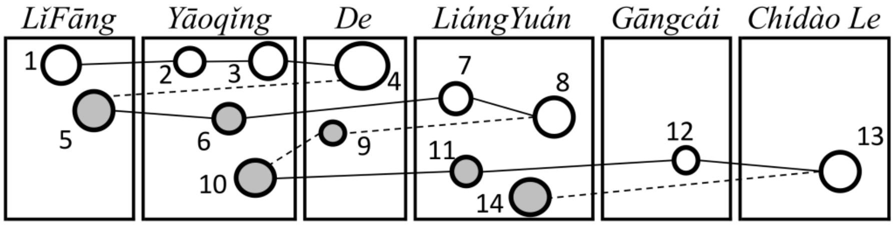
For the verification task, only minor changes were made to the procedure. Participants were instructed in Mandarin to read each sentence naturally and told that after reading the sentence a comprehension question would appear. Again, participants were asked to read each sentence within eight seconds. When they had finished reading the sentence, participants were instructed to press a button that would replace the sentence with a comprehension/verification question (e.g., did *Li* invite *Liang*?). Reading times were measured from the onset of the stimuli to this button press event. For the question, participants had up to eight seconds to answer. When answering, participants were instructed in Mandarin to press the "True" button for correct or true probes or the "False" button for incorrect or false probes. Eight practice trials were given to ensure participants understood the task. For both tasks, since reading times were measured from the onset of stimuli until the button response events (i.e., judging the plausibility of the sentence or proceeding onto the question) reading times and eye-movements are comparable between the two tasks.

#### 2.3.1.4. Eye-tracking Measures

The earliest reading time measure reported here is *first-pass* time, all fixations made within a region from when it is first entered until it is exited. The late measures reported are *re-reading* time, the sum of all fixations in a region after first-pass (total time minus first-pass), and *go-past* time, the combined RT for an interest region (e.g., DE) before it is exited to the right (e.g., N2) for the first time including any regressive readings out of the region to the left (e.g., N1, V1). Go-past times are thus greater than or equal to first-pass times for a region. Regression-in and regression–out (i.e., first-pass regression-out) proportion measures, the total reading time of the sentence and accuracy (for the verification questions and plausibility judgements) are also reported. While accuracy for the plausibility task denoted whether the participant accurately judged the experimental RCs as plausible, accuracy for the verification task indicated whether the participant accurately judged the probe to be true/correct or false/incorrect. The interest regions for analyses were the sentence, the RC structure (N1, V1), the relativizer (DE), the head noun (N2), the adverb (ADV), and the matrix verb (V2). Prior to the analyses, eye-fixations were first treated to remove data not representative of reading (e.g., blinks, pauses, tracker-loss, etc.). Fixations below 80 ms were merged into a neighbouring fixation, and the remaining fixations under 80 ms and those exceeding 1000 ms were removed (523 fixations or 2.91%). Refer to Figure 2.2 for an illustration of these measures (see also Clifton, Staub, & Rayner, 2007).

### 2.3.2. Results

A series of linear mixed effect (LME) model analyses (Baayen, Davidson, & Bates, 2008) were conducted using the *lme4* package (Bates, Mächler, Bolker & Walker, 2014a, 2014b) within R (R Core Team, 2014); the RC condition (ORC = -0.5 & SRC = 0.5) and Task type (Plausibility = -0.5 & Verification = 0.5) comprised the fixed effects, and random effects were the subjects and items. If the interaction of condition:type was significant, a pairwise analysis was conducted. RTs were transformed using natural logarithms for improved normality of the residuals. LME models (a cross-section of random subjects and items with full variance-covariance random effect matrices to




| Measurement | N1 | V1 | DE | N2 | ADV | V2 |
|---|---|---|---|---|---|---|
| Early Measurements | | | | | | |
| First-fixation | 1 | 2 | 4 | 7 | 12 | 13 |
| First-pass | 1 | 2+3 | 4 | 7+8 | 12 | 13 |
| Late Measurements | | | | | | |
| Go-past | 1 | 2+3 | 4+5+6 | 7+8+9+10+11 | 12 | 13 |
| Re-reading | 5 | 6+10 | 9 | 11+14 | NA | NA |
| Reg-out | NA | NA | 4-to-5 | 8-to-9 | NA | 13-to-14 |
| Reg-in | 4-to-5 | 9-to-10 | 8-to-9 | 13-to-14 | NA | NA |

**Figure 2.2. Example of eye-tracking measurements**
In this figure, an illustration of eye-fixations and saccadic movements are given for an ORC item from Experiment 1. However, this does not represent actual data collected from Experiment 1. White circles (e.g., 2 and 3) represent fixations that were made during the first-pass through a given region and grey coloured circles (e.g., 6 and 10) represent any fixation that was made after the first-pass (i.e., re-reading) in a given region. Solid lines (e.g., the line between fixations 7 and 8) represent left-to-right saccades (i.e., eye-movements) and dashed lines (e.g., the dashed lines between fixations points 8 and 9) represent backwards right-to-left regressive saccades.

those with only varying intercepts (Barr, Levy, Scheepers, & Tily, 2013)) were compared to determine the best fit model using the maximum likelihood technique. This revealed that the simplest model (i.e., random intercepts for both subjects and items) did not differ significantly from (i.e., did not show a lesser fit between) more complex models (i.e., inclusion of random slopes) for all the analyses. Accordingly, I opted to use the simpler model. Analyses of RTs and regression data only included items with correct responses. RT measures with zero RT or regions which were skipped were treated as missing values and were not included in the RT analyses. The *lmerTest* package (Kuznetsova, Brockhoff, & Christensen, 2014) in R was used to provide RT models with *p*-values using Satterthwaite's approximation for the degrees of freedom. For accuracy and regression proportions, *glmer* (binomial family) within lme4 was used to calculate the *z* distribution using Laplace approximations. Data outliers (RTs only) were trimmed upon ± 2.5 standard deviations of each model (1.65%). Refer to

Tables 2.1-2.4 for means, standard errors, and LME results (pp. 99-101). The trimmed reading times and regression proportions are shown for the RC conditions per task in Figure 2.3 (only the significance for the fixed effect of RC condition is shown).

#### 2.3.2.1. Sentence

*Accuracy*. While both RC condition ($p$ = .131) and task type ($p$ = .09) were not significant, their interaction ($p$ < .01) was significant. This interaction revealed that while within the plausibility task, accuracy between ORCs and SRCs was not significantly different ($p$ = .295), ORCs in the verification task had a significantly higher accuracy compared to SRCs ($p$ < .001).

*Total reading time*. For the total reading time of the sentence, only task type ($p$ < .001) was significant, revealing that the verification task had significantly longer overall reading times compared with the sentences found in the plausibility task. Both RC condition ($p$ = .069) and the interaction of RC condition and task type ($p$ = .219) did not reveal any significant differences.

#### 2.3.2.2. RC (N1, V1 / V1, N1)

*First-pass RT*. For the first reading of the RC phrase, RC condition ($p$ = .388) was not significant. In contrast, task type ($p$ < .001) was significant, showing longer reading times for the verification task sentences. Interaction ($p$ < .01) of RC condition and task type was significant. This demonstrated that in addition to verification types being significantly longer than the plausibility type counterparts, ORC:Verification ($p$ < .05) had significantly longer reading times than SRC:Verification. While the reading times for ORC:Plausibility was numerically less than SRC:Plausibility, this difference was shown to be not significant ($p$ = .198).

*Re-reading Time*. For the re-reading of the RC phrase, only task type ($p$ < .001) was significant, again showing longer RTs for the verification task items in comparison to the plausibility task. Both RC condition ($p$ = .700) and interaction were not significant ($p$ = .051) despite RTs for ORC:Verification being numerically less than SRC:Verification.

*Regression-in*. Similar to re-reading time, while RC condition ($p$ = .376) and interaction were not significant ($p$ = .376), task type ($p$ < .001) was significant which

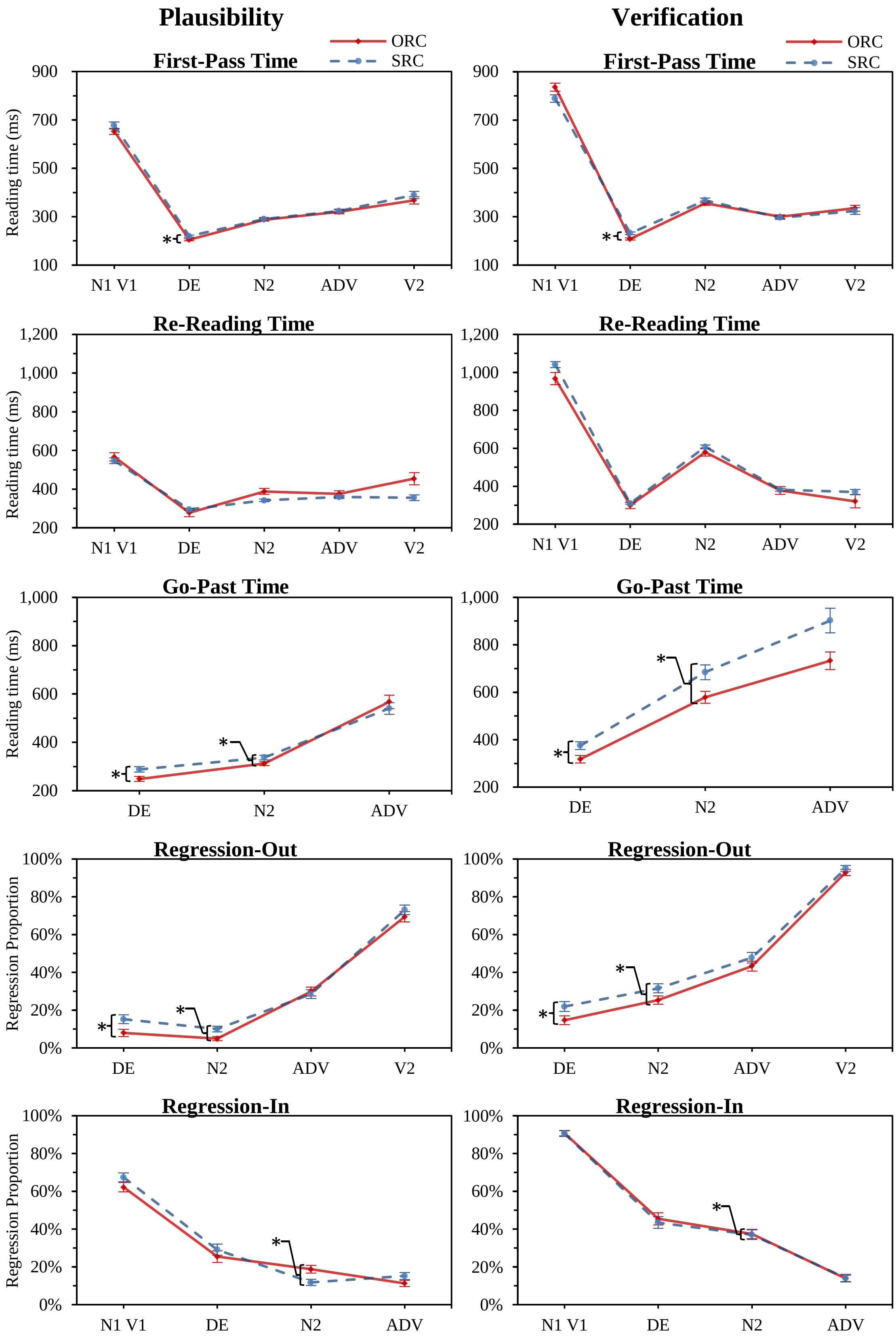



**Figure 2.3. Experiment 1: the trimmed reading times and regression proportions.**

revealed a higher probability for the verification task to regress back into the RC compared with the plausibility task.

#### 2.3.2.3. Relativizer (DE)

*First-pass RT*. For the first reading of the relativizer, it was found that RC condition ($p < .001$) revealed a significant difference between RCs with the SRC condition having longer RTs in comparison with the ORC condition. Neither task type ($p = .165$) nor interaction ($p = .336$) were significant.

*Re-reading Time*. No significant effects were found for RC condition ($p = .541$), task type ($p = .388$) and interaction ($p = .821$) during re-reading time.

*Go-past Time*. Prior to moving on to the head noun, go-past RT for RC condition was significant ($p < .001$); it was found that SRCs required longer RTs before moving on. Task type ($p < .001$) was also significant which revealed that the items within the verification task had longer go-past RTs than items in the plausibility task. Interaction ($p = .386$) was not significant.

*Regression-out*. Similar to go-past, both the RC condition ($p < .01$) and task type ($p < .001$) were significant revealing a comparable pattern. SRCs had a higher probability to regress out, and sentences within the verification task also had a higher chance of regressing out of the relativizer. Again, interaction ($p = .663$) of RC condition and task type was not significant.

*Regression-in*. The probability of regressing back into the relativizer was only significant for task type ($p < .001$); it was revealed that there was a higher chance of moving back into the relativizer for items within the verification task. Neither RC condition ($p = .691$) nor interaction were significant ($p = .295$).

#### 2.3.2.4. Head noun (N2)

*First-pass RT*. Upon first entering the head noun, the only significant RT difference was observed for task type ($p < .001$) which revealed significantly longer RTs for the items of the verification task. Neither RC condition ($p = .608$) nor interaction ($p = .678$) had significant results.

*Re-reading Time*. Similar to first-pass, the re-reading of the head only revealed longer RTs for the verification task in comparison with the plausibility task (task type:

$p < .001$). Neither RC condition ($p = .563$) nor interaction had significant results ($p = .066$).

*Go-past Time*. Go-past time, however, did reveal a significant difference for RC condition ($p < .01$) which resulted in SRCs having longer go-past times compared to ORCs. Again, task type ($p < .001$) was significant, showing the same pattern of the items of the verification task having longer RTs than those of plausibility. Interaction was not significant ($p = .099$).

*Regression-out*. Similar with go-past RT, the RC condition ($p < .001$) revealed that SRCs had a significantly higher chance of regressing out, and task condition ($p < .001$) showed that the verification task items also had a significantly higher chance. Interaction of the two was not significant ($p = .205$)

*Regression-in*. In contrast to the above, the significant difference between RC conditions ($p < .05$) revealed an opposite pattern. That is, ORCs were more likely to have a regression back into the head noun. However, task type ($p < .001$) demonstrated once more that verification items were more likely to have regressions back into the region than the plausibility items. The interaction of RC condition and task type was significant ($p < .05$); this result demonstrated that it was only within the plausibility task ($p < .001$) that ORCs had a higher probability of having a regression in, while ORCs in the verification task ($p = .880$) did not have a significant difference with their SRC counterparts.

#### 2.3.2.5. Adverb (ADV)

*First-pass RT*. At the adverb, only task type ($p < .001$) was significant. However, at this position, plausibility items had longer RTs compared to verification items. RC condition ($p = .919$) and interaction ($p = .672$) were not significant.

*Re-reading Time*. No significance was found for RC condition ($p = .554$), task type ($p = .917$) and interaction ($p = .944$) during re-reading time at the adverb.

*Go-past Time*. In contrast with first-pass RT, while task type ($p < .001$) was significant, verification sentences had longer go-past RTs compared to plausibility sentences. Once again, RC condition ($p = .246$) and interaction ($p = .065$) were not significant.

*Regression-out*. Regression-out revealed the same findings as go-past. Task type ($p < .001$) demonstrated that within the verification task there was a higher likelihood of regressing back. Neither RC condition ($p$ = .704) nor interaction ($p$ = .316) were significant.

*Regression-in*. RC condition ($p$ = .184), task type ($p$ = .696) and interaction ($p$ = .347) were not significant.

### 2.3.2.6. Matrix Verb (V2)

*First-pass RT*. It was shown that for task type ($p < .01$), plausibility sentences initially had significantly longer first-pass RTs than verification sentences. Neither RC condition ($p$ = .450) nor interaction ($p$ = .083) were significant.

*Re-reading Time*. Similar with first-pass, task type ($p < .05$) revealed longer re-reading times for the plausibility task. Once more, RC condition ($p$ = .678) and interaction ($p$ = .115) were not significant.

*Regression-out*. While task type ($p < .001$) was significant, it was found that opposite to first-pass and re-reading, within the verification task there was a higher chance of a regression occurring out of the verb. RC condition ($p$ = .206) and interaction ($p$ = .621) were not significant.

In the following sections I include additional analyses separate from the main findings to give further insight on how these sentences were processed. As discussed above, the word/thematic order is a confounding factor in temporarily ambiguous contexts. ORCs are facilitated by the surface canonical SVO word and agent-to-patient order in Mandarin while VOS word and patient-to-agent ordered SRCs deviate from it. Accordingly, the RC structure (N1, V1, DE) would be predicted to be easier to process on the basis that canonicity would support ORCs before the head noun since the relativizer satisfies the categorical selectional restriction of the RC verb. Additionally, I included the matrix clause (N2, ADV, V2) to widen the scope to include associated effects of the matrix subject and matrix verb together.

### 2.3.2.7. Full RC Structure (N1, V1, DE)

*First-pass RT*. For the first reading of this region, RC condition ($p < .01$) demonstrated that SRCs had significantly longer first-pass RTs compared to ORCs. Also, task type ($p < .001$) showed that within the verification task, first-pass RT was significantly longer than within the plausibility task. Interaction ($p$ = .085), however, was not significant.

*Re-reading Time*. For the re-reading of this expanded RC region, RC condition ($p$ = .354) was not significant. Task type ($p$ < .001) showed that significantly longer RTs were required for the verification task. The interaction of RC condition and task type, however, was significant ($p$ < .05). This interaction revealed that within the plausibility task ($p$ = .365), ORC:Plausibility did not have significantly different RTs compared with SRC:Plausibility. On the other hand, in the verification task ($p$ < .05) SRC:Verification had significantly longer re-reading times compared with ORC:Plausibility.

*Regression-in*. For regression-in proportion, task type ($p$ < .001) demonstrated that verification sentences had a higher probability of having a regression back into the RC compared with plausibility task sentences. RC condition ($p$ = .758) and interaction ($p$ = .096) were not significant.

#### 2.3.2.8. Matrix Clause (N2, ADV, V2)

*First-pass RT*. For the first reading of the matrix clause region, RC condition ($p$ < .01) revealed that ORCs had significantly longer first-pass RTs compared to SRCs. Also, task type ($p$ < .001) demonstrated that the plausibility task had longer RTs than the verification task. Interaction ($p$ = .575) was not significant.

*Re-reading Time*. There was no effect of RC condition ($p$ = .179) during re-reading. Task type ($p$ < .001), on the other hand, now revealed that the verification task required longer re-reading times for the matrix clause as a whole. Interaction ($p$ = .477) was not significant.

*Regression-out*. Only task type ($p$ < .001) was significant, revealing a greater probability of regressing back into the RC for the verification task. Neither RC condition ($p$ = .896) nor interaction was significant ($p$ = .142).

### 2.3.3. Discussion

The results of Experiment 1 for both tasks revealed a general pattern of SRC difficulty within the relative clause and ORC difficulty at the main clause. SRC difficulty was indicated by the increased go-past time and regression-out proportion at the relativizer and head noun, as well as the increased first-pass RTs for the expanded RC structure. In contrast, ORC difficulty was seen primarily during the first-pass reading of the matrix clause and for the regression-in proportion at the head noun.

Despite the fact that both tasks produced relatively similar results, RTs differed between the two tasks; specifically, RTs increased within the verification task for the large majority of the measures. Also, the initial reading of the RC phrase (N1, V1) during first-pass RT was significantly longer for ORC:Verification in comparison to SRC:Verification while ORC:Plausibility was faster, yet not significantly so, compared to SRC:Plausibility. This discrepancy between tasks may possibly be attributed to the participants reading more slowly initially within the verification task at this region. I suspect two possibilities for this: (1) a pro-drop interpretation may have been initially considered and appeared more natural for participants, or (2) the longer reading times at this region allowed participants to reject the matrix clause interpretation prior to reading the relativizer thus initially supporting expectation-based processing. Caplan et al. (2008) argued that for verification judgments the differences between tasks may be due to a strategy involving the repeated rehearsal of the sentence, during its display, in order to answer the post-sentence question. As such, I believe the increased reading times for the verification task compared to the plausibility task likely reflected a task strategy where participants slowed down their reading of the sentence for this purpose. Despite the difference in overall RTs, the general pattern of results (e.g., an ORC advantage within the RC structure and a disadvantage within the matrix clause) was seen in both tasks with only minor differences. Accordingly, I believe that the main findings are not task artefacts and that both tasks tapped into RC processing in a similar fashion.

The overall findings provided clear evidence of SRC difficulty at the relativizer, head noun, and relative clause structure (i.e., N1, V1, DE). These results appear consistent with previous eye-tracking and ERP studies showing difficultly for SRCs at the relativizer and head noun within ambiguous RCs. Furthermore, the results for the RC structure as a whole are compatible with the combined response times for a similar combined RC region found in Qiao et al.'s (2012) maze task. In general, these results are compatible with models that support an ORC advantage: (i) they generate fewer predicted syntactic heads in storage, (ii) the expectations made on the incorrect matrix clause interpretation can facilitate the reading within the ORC, and (iii) ORC heads are easier to integrate with the gap due to linear/temporal-based integration locality. Packard et al.'s (2011) assertion that the relativizer can serve as a potential filler during integration was found to be supported by the increased first-pass RT, go-past RT and increased likelihood of regressing out at the relativizer for the SRC condition.

From the observations of RTs at individual regions, there was little evidence (e.g., regression-in at the head for the plausibility task) to suggest a similarity-based interference. However, when viewing the entire matrix clause, ORC processing difficulty was observed in both tasks, as indicated by the significantly faster first-pass RTs for SRCs. Considering that this difficulty for ORCs seems associated with the processing of the matrix verb, I feel that these results could hint at a similarity-based interference.

Additionally, these results at the matrix clause may also provide some support for accounts on animacy preferences in Mandarin. In short, since ORCs are less frequently found to be animate-animate compared to SRCs, this preference could manifest itself in a slowdown in reading within the matrix clause. While I did not test for animacy in this study, I cannot rule out completely that animacy had some effect making ORCs more difficult at these loci since animacy effects during parsing have been well documented (Mak, Vonk, & Schriefers, 2002; Traxler, Morris, & Seely, 2002).

The results of Experiment 1, however, are not compatible with proposals supporting ORC difficulty based on expectation-based processing for the RC itself, save the initial first-pass reading of the RC for the verification task. The differences between past studies and my own possibly originate from the fact that Experiment 1 used both ambiguous RCs and eye-tracking. Previous studies finding ORC difficulty either used unambiguous RCs and eye-tracking or used ambiguous RCs in a moving window design. Considering that eye-tracking allows for "normal" reading, while moving-window paradigms do not, there may be differences in the degree of sensitivity for each method.

As previously mentioned, ambiguous items are highly confounded by Mandarin's canonical order. Considering this, items in Experiment 2 were based on Jäger et al. (2015) in order to test for the effect of the initial ambiguity on RC processing. Accordingly, Experiment 2 was designed to test if the above findings are indicative of a simple garden path effect or if the results reflect a more intricate pattern of processing involving multiple processing factors. It is my opinion that it is the latter and that multiple factors may be playing a role: canonicity, memory-based constraints, and expectation effects.

## 2.4. Experiment 2

The purpose of Experiment 2 is to determine whether the ambiguity of the RC alters the processing of Mandarin RCs. More specifically, I question whether the above results of Experiment 1 reflect a simple garden path effect due to the canonical word order of ORCs within ambiguous contexts or if canonicity and linear/temporal locality are also applicable under a less ambiguous context. I also investigate if expectation-based processing is the dominant factor guiding processing of unambiguous RCs. Lastly, I aim to verify my claim that similarity-based interference may be responsible for increasing ORC reading times within the matrix clause region.

### 2.4.1. Materials and Methods

#### 2.4.1.1. Participants

Forty-one native speakers of Mandarin Chinese, all from Mainland China, were recruited from Nagoya University in Japan. Four participants were removed due to calibration errors (leaving N = 37; Female = 27). These participants were either graduate or research students at the time of the study. The mean age of the participants was 25.2 years (range 22 - 33 years). None of these participants took part in Experiment 1.

#### 2.4.1.2. Materials

The items for Experiment 2 (see Appendix Chapter 2, p. 268) were analogous to the eye-tracking items and questions of Jäger et al. (2015), which, in turn, originated from Gibson and Wu (2013). Considering these items were designed for Taiwanese speakers of Mandarin and not Mainland Chinese speakers of Mandarin, minor modifications to the texts were required to better suit the intended participants of this study. These modifications involved converting the script from traditional to simplified Chinese since only mainland Mandarin speakers were recruited. Also, several words and phrases were changed to make them more appropriate and natural for mainland Mandarin speakers. Specifically, 13 of the 32 items contained modifications; out of those 13, six items had their frequency phrase (see below) replaced with another frequency phrase found in other stimuli items. While Jäger et al. (2015) used both subject- and object-modified relative clauses, only subject-modified relative clauses were used in the current study. This allowed us to keep the number of items the same per condition between studies. In addition, object-modified RCs were also not included since in situ object-modified RCs are not preferred in Mandarin. In situ object-modified RCs are instead preferred to be topicalized to the front of the sentence (Matthews & Yip, 2016); see below for the item conditions.

The items from Jäger et al. (2015) were designed to have two syntactic cues which would be able to help attenuate the initial ambiguity: (i) a sentence initial determiner and classifier (henceforth "Det+Cl") for increased head noun anticipation at the start of the RC, and (ii) a frequency phrase adjacent to the relativizer to provide an increased chance for an RC interpretation prior to the relativizer. The initial Det+Cl phrase inserted prior to the RC was followed directly by a temporal adverb which could not be modified by the Det+Cl phrase. In a sentence completion task, they (Jäger et al., 2015) found that interpretations of a missing pronominal intervening between the two phrases was only taken 10% of the time for SRCs and never for ORCs. Accordingly, the combination of the two phrases keeps Det+Cl open for modifying another noun in the sentence. Furthermore, the temporal adverb prevents modification of the Det+Cl with anything within the RC therefore leaving it open for the head noun. Consequently, Det+Cl acts as a syntactic cue to help eliminate the matrix clause interpretation for the RC as well as increasing anticipation for the noun modified by it. In the current experiment, I manipulated the subject-modified RCs to either have the initial Det+Cl present (i.e., reducing the level of ambiguity, henceforth "DCL") or omitted (i.e., ambiguous, henceforth "Empty"). The frequency phrase was present in all items. It is important to note that the position of the frequency phrase for ORCs is not natural and would appear ungrammatical within a matrix clause. For both ORCs and SRCs, the frequency phrase was implemented to prevent the relativizer from being interpreted as a genitive marker. Thus, its inclusion enhances an RC interpretation at the relativizer locus.

I used a 2 (RC condition: ORC vs. SRC) x 2 (determiner type: Empty vs. DCL) design for the 32 experimental items. In the example below, Det+Cl stands for the Det+Cl modifying the head noun, ADV is a temporal adverb for the RC, V1 is the embedded RC verb, N1 is the RC noun, Freq is the frequency phrase, DE is the relativizer, N2 is the head noun, V2 is the first matrix verb, and N3 is the first matrix object. The remainder of the sentence is not denoted. Since the verification task was repeated in Experiment 2, an equal number of true and false verification/comprehension probes were given per counterbalanced list.

(4) Experiment 2 Stimuli Regions

| (Det+Cl) | ADV | | V1 | N1 | / | N1 | V1 | | Freq | DE |
|---|---|---|---|---|---|---|---|---|---|---|
| (*Nàgè*) | [*Zuówǎn* | $t_i$ | *Zòule* | *Fúwùshēng* | / | *Fúwùshēng* | *Zòule* | $t_i$ | *Yīdùn* | *De*] |
| that.one | [last.night | $t_i$ | beat | waiter | / | waiter | beat | $t_i$ | more.than.once | REL] |

| N2 | V2 | N3 | | | |
|---|---|---|---|---|---|
| *Gùkè*$_i$ | *Tīngshuōguò* | *Lǎobǎn* | *Bìngqiě* | *Jìdé* | *Tā* |
| *customer*$_i$ | heard.of | boss | and | remember | him |

'(The) customer [who beat up the waiter / the waiter beat up last night] has heard of the boss and remembers him.'

#### 2.4.1.3. Procedure

The procedure was similar to Experiment 1. All characters were displayed in simplified Chinese SimSun 22pt font, with a visual angle of 0.64˚. The font and size were changed to better fit the longer stimuli used in Experiment 2. Again, the screen colour was white, and the font colour was black. Here, participants now had a maximum of 12 seconds to read the sentence and press any button when they were finished reading to replace the sentence with the question. Participants still had a maximum time of eight seconds to answer the verification/comprehension probe. The increase in allotted time also accommodated for the increased length of the items.

### 2.4.2. Results

Eye-fixations were treated following the same procedure as Experiment 1 which resulted in the removal of 1,963 fixations or 7.34%. The same LME methods were used as in Experiment 1. RC condition (ORC vs. SRC) and determiner type (Empty vs. DCL) were considered as fixed effects, and subject and item composed the random effects. If interaction of condition:type was significant, a pairwise analysis was conducted. Data trimming for each model resulted in the removal of 1.68% of the data. Refer to Tables 2.4-to-2.8 (pp. 102-106) for means, standard errors and LME results. Following Jäger et al. (2015), I analysed N1/V1 (RC), Freq (frequency phrase), DE (relativizer), N2 (head noun), V2 (matrix verb) and N3 (matrix object). I also analysed the sentence as a whole (accuracy and total reading time), the RC structure (N1, V1, Freq, DE) and matrix clause (N2, V2, N3) as in Experiment 1. The trimmed reading times, regression proportions and fixed effect significance for RC condition per determiner type (Empty and DCL share RC condition fixed effect significance), individual region and eye-tracking measure are shown in Figure 2.4.

#### 2.4.2.1. Sentence

*Accuracy*. The analysis on the accuracy for the verification probes revealed no significant differences for RC condition ($p$ = .516), determiner type ($p$ = .920) or condition:type interaction ($p$ = .531). The mean scores were rather close between items.

*Total reading time of the sentence*. For the reading of the sentence, while both RC condition ($p$ < .001) and determiner type ($p$ < .01) were significant, interaction was not ($p$ = .800). The general pattern of results revealed that the ORC condition had longer RTs than the SRC condition and that the DCL type had longer RTs compared to the Empty type.

#### 2.4.2.2. RC (N1, V1 / V1, N1)

*First-pass RT*. For the RC condition ($p$ = .068), even though ORCs were read quicker than SRCs, the result was not significant. For determiner type ($p$ < .001), the Empty type had significantly longer RTs than the DCL type. Interaction was not significant ($p$ = .428).

*Re-reading Time*. In contrast to first-pass RT, ORC re-reading time was significantly longer than SRC re-reading time at this later stage of processing ($p$ < .001). For determiner type, while the Empty type had longer RTs in comparison to the DCL type, the difference did not reach significance ($p$ = .063). There was still no effect of interaction ($p$ = .504).

*Go-past Time*. While there was no significant difference between RC conditions ($p$ = .129), there was a significant difference in determiner type ($p$ < .05) showing unsurprisingly that the DCL type had longer RTs than the Empty type since the DCL type items had one additional region compared with the Empty type items. During this stage, there was a significant effect of interaction ($p$ < .001). The pairwise comparison revealed that ORC:DCL had significantly longer RTs than SRC:DCL ($p$ < .001). While

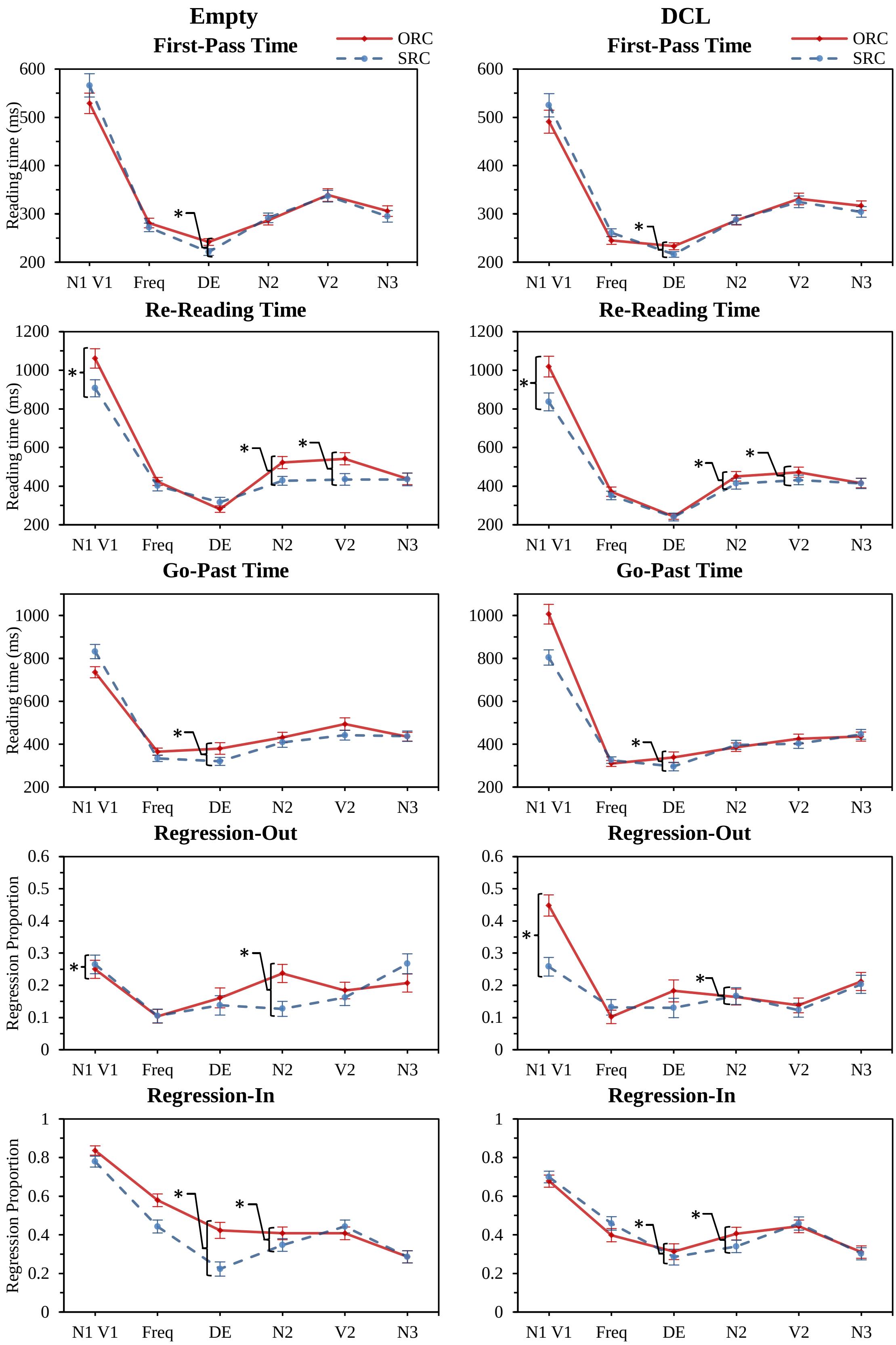



**Figure 2.4. Experiment 2: The trimmed reading times and regression proportions.**

ORC:Empty had the lowest RTs, it was not significantly faster than SRC:Empty in the pairwise analysis.

*Regression-out*. The RC condition ($p < .01$) and determiner type ($p < .01$) revealed that ORCs were more likely to have a regression out than SRCs, and the DCL type was more likely than the Empty type. Again, there was a significant effect of interaction showing that ORC:DCL was more likely to regress out than SRC:DCL ($p < .001$). Consequently, it appears that ORC:DCL was driving the effects for this measure.

*Regression-in*. While RC condition ($p = .299$) was not significant, determiner type ($p < .001$) demonstrated that the Empty type was more likely to have a regression made back into the RC in comparison to the DCL type. Interaction was not significant ($p = .141$).

#### 2.4.2.3. Frequency phrase (Freq)

*First-pass RT*. At the first-pass reading of the frequency phrase, there were no differences between RC conditions ($p = .179$), but determiner type ($p < .05$) demonstrated that the Empty type had longer RTs compared to the DCL type. Interaction was not significant ($p = .075$).

*Re-reading Time*. RC condition ($p = .146$) and interaction ($p = .368$) did not show significant differences during re-reading. Again, determiner type ($p < .05$) revealed that the Empty type had significantly longer RTs compared to the DCL type sentences.

*Go-past Time*. RC condition ($p = .844$) was still not significant during go-past time, while determiner type ($p < .05$) still demonstrated that the Empty type had longer RTs compared to the DCL type. Interaction of condition:type was significant ($p < .05$). However, this only demonstrated that ORC:Empty had significantly longer go-past RTs than ORC:DCL ($p < .01$).

*Regression-out*. RC condition ($p = .514$), determiner type ($p = .680$) and interaction ($p = .540$) revealed no significant differences.

*Regression-in*. RC condition ($p = .131$) was not significant, but determiner type ($p < .05$) revealed that the Empty type was more likely to have a regression back into the frequency phrase than the DCL type. There was a significant effect for interaction

($p < .01$), demonstrating that ORC:DCL was less likely to have a regression back into the phrase than SRC:DCL ($p < .05$).

#### 2.4.2.4. Relativizer (DE)

*First-pass RT*. For the RC condition ($p < .05$), it was shown that ORCs had significantly longer RTs than SRCs. Neither determiner type ($p = .554$) nor interaction ($p = .415$) at the relativizer were significant.

*Re-reading Time*. In later re-reading times, the RC condition ($p = .543$) was no longer significant. However, determiner type ($p < .01$) indicated that the Empty type had longer RTs than the DCL type. Interaction was not significant ($p = .311$).

*Go-past Time*. Only the RC condition ($p < .05$) revealed a significant difference in RTs, showing that ORCs as a whole had longer RTs in comparison to SRCs. There was no significance for determiner type ($p = .103$) and interaction ($p = .640$).

*Regression-out*. The RC condition ($p = .230$), determiner type ($p = .791$) and interaction ($p = .617$) did not reveal any significant differences.

*Regression-in*. For the RC condition ($p < .01$), ORCs were significantly more likely to have a regression back into the relativizer than SRCs ($p < .01$). However, determiner type ($p = .670$) was not significant. While there was a significant interaction effect found ($p < .05$), it only indicated that ORC:Empty was more likely to have a regression back into the relativizer than SRC:Empty ($p < .01$), despite both ORCs having higher regression-in means than their SRC counterparts.

#### 2.4.2.5. Head noun (N2)

*First-pass RT*. RC condition ($p = .497$), determiner type ($p = .578$) and interaction ($p = .778$) revealed no significant differences during first-pass reading.

*Re-reading Time*. For fixations made after first-pass, RC condition ($p < .05$) demonstrated that ORCs had longer RTs than SRCs, and determiner type ($p < .05$) revealed that the Empty type had longer RTs compared to DCL type items. Interaction did not show significant differences ($p = .806$).

*Go-past Time*. While the RC condition ($p = .692$) and interaction ($p = .340$) were not significant, the determiner type ($p < .05$) showed that the Empty type items required longer RTs before moving on to the matrix clause verb.

*Regression-out*. The RC condition ($p < .05$) revealed that the ORC condition was significantly more likely to make a regression out of the head noun back into previous parts of the sentence in comparison to SRCs. Determiner type ($p = .624$) was not significant. However, interaction ($p < .05$) was significant and demonstrated that ORC:Empty was significantly more likely to make a regression out of the head than SRC:Empty ($p < .05$).

*Regression-in*. Only the RC condition ($p < .05$) was significant showing that ORCs were more likely to have a regression back into the head from later parts of the matrix clause. Determiner type ($p = .911$) and interaction ($p = .938$) were not significant.

#### 2.4.2.6. Matrix Verb (V2)

*First-pass RT*. RC condition ($p = .955$), determiner type ($p = .302$) and interaction ($p = .728$) revealed no significant differences during first-pass reading.

*Re-reading Time*. For the RC condition ($p < .01$), ORCs had significantly longer RTs than SRCs, whereas determiner type ($p = .440$) was not significant. While interaction ($p < .05$) was significant, the pairwise analysis revealed that ORC:Empty only had significantly longer RTs than SRC:Empty ($p < .01$).

*Go-past Time*. While RC condition ($p = .209$) and interaction ($p = .967$) were not significant, determiner type ($p < .01$) indicated that the Empty type sentences had significantly longer RTs in comparison to DCL sentences.

*Regression-out*. RC condition ($p = .414$) and interaction ($p = .921$) were not significant; determiner type ($p = .061$) also revealed no significance even though the Empty sentences had a higher likelihood to regress out than DCL sentences.

*Regression-in*. RC condition ($p = .567$), determiner type ($p = .377$) and interaction ($p = .748$) revealed no significant effects.

#### 2.4.2.7. Matrix Object (N3)

*First-pass RT*. For the RC condition ($p = .058$), no significant differences were found. Also, neither determiner type ($p = .136$) nor interaction ($p = .417$) indicated significant differences during first-pass reading.

*Re-reading Time*. RC condition ($p = .643$), determiner type ($p = .997$) and interaction ($p = .863$) revealed no significant effects.

*Go-past Time*. RC condition ($p$ = .562), determiner type ($p$ = .921) and interaction ($p$ = .377) revealed no significant effects.

*Regression-out*. RC condition ($p$ = .405), determiner type ($p$ = .264) and interaction ($p$ = .295) revealed no significant effects.

*Regression-in*. RC condition ($p$ = .912), determiner type ($p$ = .537) and interaction ($p$ = .886) revealed no significant effects.

Next, I present the additional analyses as described above. Refer to Tables 2.7 and 2.8 (pp. 105-106) for means, standard errors and LME results.

#### 2.4.2.8. Full RC Structure (N1, V1, Freq, DE)

*First-pass RT*. There was a significant effect for the RC condition ($p$ < .01) showing that ORCs were read faster than SRCs. Determiner type ($p$ < .001) was also significant and revealed that the Empty type sentences had longer RTs during first-pass reading compared to DCL sentences. Interaction ($p$ = .069), however, did not reach the significance threshold.

*Re-reading Time*. The RC condition ($p$ < .001) and determiner type ($p$ < .05) were both significant which demonstrated that ORC conditions had significantly longer RTs than SRCs and the Empty type items had significantly longer RTs compared to DCL items. Interaction ($p$ = .993) was not significant.

*Go-past Time*. The RC condition ($p$ = .069) did not reveal a significant difference between ORCs and SRCs. Determiner type ($p$ = .151) was also not significant. Interaction ($p$ < .001) of condition:type was significant and demonstrated contrasting effects for the ORC types. This interaction showed that the ORC:DCL condition had significantly longer RTs than SRC:DCL ($p$ < .001). On the other hand, it was revealed that the ORC:Empty condition had significantly faster RTs than the SRC:Empty ($p$ < .05) condition.

*Regression-out*. The RC condition ($p$ < .001), determiner type ($p$ < .001) and interaction ($p$ < .001) were all significant. It was shown that the ORCs conditions and DCL types were significantly more likely to regress out than their counterparts. However, the pairwise analysis indicated that it was only the ORC:DCL condition which was significantly more likely to regress out of the RC structure than SRC:DCL ($p$ < .001).

*Regression-in*. While the RC condition ($p$ = .097) was unable to reveal significant differences between conditions, determiner type ($p$ < .001) and interaction ($p$ < .01) were both significant. While the Empty type was significantly more likely to have a regression back into the RC structure, the pairwise analysis revealed that, opposite to regression-out, it was only ORC:Empty which was more likely to have a regression made back into the RC structure in comparison to SRC:Empty ($p$ < .01).

#### 2.4.2.9. Matrix Clause (N2, V2, N3)

*First-pass RT*. While the RC condition ($p$ = .640) and determiner type ($p$ = .216) were not significant, interaction ($p$ < .01) was significant. However, from the pairwise analysis, it was only revealed that ORC:Empty was significantly faster than SRC:Empty ($p$ < .05).

*Re-reading Time*. The RC condition ($p$ < .001) revealed that ORCs had significantly longer re-reading times than SRCs, and determiner type ($p$ < .01) showed that the Empty sentences had significantly longer RTs compared to DCL sentences. Interaction ($p$ = .271) was not significant.

*Go-past Time*. The RC condition ($p$ < .01), determiner type ($p$ < .001) and interaction ($p$ < .01) were all significant. As with re-reading time, ORCs had significantly longer RTs compared to SRCs, and the Empty sentences had significantly longer RTs in comparison to their DCL counterparts. In contrast to first-pass time, the pairwise analysis showed that ORC:Empty now had significantly longer go-past times in comparison to SRC:Empty ($p$ < .001).

*Regression-out*. For the RC condition ($p$ = .087), ORCs only had a trending likelihood of regressing out of the matrix clause in comparison with SRCs. However, determiner type ($p$ < .01) revealed that the Empty type items were significantly more likely to regress out than DCL type items. Interaction ($p$ < .01) was significant, and similar to go-past time, the pairwise analysis indicated that ORC:Empty was significantly more likely to have a regression out of the matrix clause in comparison to SRC:Empty ($p$ < .001).

*Regression-in*. RC condition ($p$ = .661), determiner type ($p$ = .088) and interaction ($p$ = .942) revealed no significant differences between conditions and types.

### 2.4.3. Discussion

In contrast to Experiment 1, Experiment 2 clearly showed that ORCs were more difficult to process than SRCs. Nonetheless, the results also indicated that multiple processing factors were involved in the processing of Mandarin RCs revealing both ORC advantages and disadvantages: Canonicity (ORC facilitation), expectation (ORC disadvantage), and perhaps similarity interference (ORC disadvantage) as well.

While integration resources were not directly supported in Experiment 2, evidence of canonicity was nevertheless present for both unambiguous and ambiguous ORC items during early RTs within both RC regions. Additionally, Jäger et al. (refer to Table 13 in Jäger et al., (2015)) also appeared to have initial, albeit non-significant, ORC facilitation at the RC (N1,V1) during first-pass reading time. In the current study, however, it was later revealed during go-past RTs at these regions that while ORC:DCL became more difficult in comparison to its SRC:DCL counterpart, ORC:Empty remained easier than its SRC:Empty counterpart. Accordingly, the presence of the determiner increased RTs for ORC:DCL in comparison to SRC:DCL, but just not initially. This initial facilitation for the unambiguous ORC happens to conflict with expectation, canonicity (i.e., that is canonicity models incorporating both frequency and regularity, see MacDonald & Christiansen, (2002)) and storage-based models of processing. Expectation-based processing was not supported because ORCs are less frequent and thus should be initially more difficult. While canonicity (i.e., frequency and regularity) appeared to be supported, it is likely the case that it was not since the Det+Cl phrase should have attenuated the simple matrix clause interpretation. In other words, the garden path argument seems no longer valid since there should not have been an initial misparse confusing the RC as a matrix clause. For the ambiguous items lacking the Det+Cl, however, a garden path effect may still have been present which allowed the ORC:Empty items to remain easier to process than SRC:Empty items at the RC structure. This likely suggests that canonicity was influencing processing in a different manner for the unambiguous RCs. Simply put, if an argument is closer to the canonical order, be it grammatical word order or thematic order, facilitation can be predicted regardless of the structure's actual statistical frequency (here, ORCs are less frequent than SRCs). That is not to say that frequency effects are not important for canonical facilitation, but to instead suggest that in rare contexts where the matrix clause interpretation is no longer attainable, regularity alone may provide facilitation in reading. It may be the case that while a matrix clause interpretation was attenuated, the RC interpretation was only formed after reading the relativizer which allowed the regularities of a simple matrix clause structure to facilitate reading inside the embedded relative clause.

In addition to canonicity effects, the initial benefit for ORCs may also loosely provide indirect support for linear/temporal metrics of integration. However, integration was not directly supported at the relativizer or head noun which I attribute to antilocality effects. In other words, with the introduction of syntactic cues (e.g., the Det+Cl phrase and the frequency phrase for both sets of items), there would be greater expectation or anticipation (Konienczny, 2000) for the SRC relativizer and the head in comparison to the items used in Experiment 1 since both syntactic cues favour SRCs.

For expectation-based effects, the general pattern of results observed in Jäger et al. (2015) was replicated such that ORC difficulty was not initially seen at the RC until later reading times. In addition to these results, there was also an influence of ambiguity. ORC:DCL became more difficult to process than its SRC counterpart earlier compared to ORC:Empty in respect with its SRC counterpart. Despite this, surprisal effects were largely supported at the relativizer where both ORCs had increased RTs in respect to their SRC counterparts. Jäger et al. (2015), however, did not reveal an effect of surprisal at the relativizer. While Experiment 1 and other studies revealed an opposite trend at the relativizer, the observation of late ORC difficulty within the RC can be partially attributed to the presence of the frequency phrase (Freq), which helps provide the RC with its correct interpretation. In turn, the cue likely increased expectation for the relativizer within the RC conceivably causing an antilocality effect at both loci of integration (i.e., the relativizer and head noun). What is more, the position of the frequency phrase is not in a natural position for ORCs which may make the phrase appear initially ungrammatical without Det+Cl. However, no significant differences were seen between determiner types during early measures. At the very least, the frequency phrase may have partially contributed to the ORC difficulty found at the relativizer and head noun.

Similarity-based interference was again hinted at by the indication of ORC difficulty at the matrix clause. Since Jäger et al. (2015) also found significantly longer total reading time at the matrix verb for subject-modified ORCs using eye-tracking, I suspect the similarity interference effect here is relatively minor, but nevertheless present. In Experiment 2, the Empty conditions had increased RTs compared to DCL counterparts during later measures. As such, the presence of Det+Cl may have made the DCL items less susceptible to interference from the RC noun. Considering these points, I believe that this finding is more representative of similarity interference rather than the influence of animacy. Animacy, however, still cannot be completely ruled out as a contributing factor.

In summary, while canonicity facilitated ORCs early on with indirect support for linear/temporal integration, the influences of expectation-based processing later reversed this within the RC. At the matrix clause, similarity-based interference was also observed to be a potential factor responsible for increasing ORC difficulty. In all, the reading of these sentences was seen to be influenced by multiple factors of processing.

## 2.5. General Discussion

In this study, I sought out to determine which Mandarin relative clause structures are more demanding to process. I investigated the reading of ambiguous RCs as well as unambiguous RCs using eye-tracking. More specifically, I aimed to determine how the initial clause type ambiguity and processing factors such as canonicity, expectation, integration and similarity-based interference influence the reading of Mandarin sentences containing RCs. The results of Experiment 1 revealed that ambiguous ORCs were generally easier to process than SRCs, regardless of task design supporting canonicity, expectation, storage and integration-based effects. Yet, in the long run, ORCs became more difficult to process at the matrix clause, a result which may provide support for similarity-based interference as well as accounts on animacy preferences in Mandarin RC processing. The results of Experiment 2 revealed that canonicity and possibly locality facilitated the early readings of the ORC within the relative clause. Also, the initial advantage for ORCs persisted longer for ambiguous than unambiguous ORCs in respect to their SRC counterparts. ORCs were still more difficult during later RTs within the RC and matrix clause as explained by expectation-based processing and similarity interference. Experiment 2, however, did not provide direct evidence supporting linear/temporal integration-based models at the relativizer or head noun. This was possibly due to antilocality effects or due to the inclusion of the frequency phrase in items used in Experiment 2, given the irregular position of the phrase for ORCs.

One particular framework of processing and cognitive behaviour can support the findings of this study, that is, Lewis and Vasishth's (2005; Vasishth & Lewis, 2006) activation-based model within the scope of ACT-R. Vasishth and Lewis (2006) consider both bottom-up and top-down mechanisms to have corresponding interdependent influences on the activation level of a particular node in the sentence structure. Lewis and Vasishth (2005; Vasishth & Lewis, 2006) note three constraints for activation levels: (1) locality, (2) anticipation, and (3) similarity interference. Here, I would like to add an additional and interactive constraint, (4) canonicity, which has often been shown to support processing and comprehension across languages such as Basque (Erdocia, Laka, Mestres-Missé, & Rodriguez-Fornells, 2009), German (Weyerts, Penke, Münte, Heinze, & Clahsen, 2002), and Japanese (Tamaoka, Asano, Miyaoka, & Yokosawa, 2014; Tamaoka, Sakai, Kawahara, Miyaoka, Lim, & Koizumi, 2005). As Love and Swinney (1998) suggested, however, languages may differ in how (and if) they benefit from canonicity. Put another way, the influence of canonicity may fall along a continuum across different languages.

I view canonicity as a top-down mechanism based upon a coarsely-tuned account of a language's structural or thematic regularities. While expectation and anticipatory effects may be more dependent on fine-tuned structural and collocational frequencies, canonicity can influence processing even for less frequent structures based solely on regularities of the language. This interpretation would therefore differ from and supplement previous notions of canonicity which have been based upon both statistical frequency and regularity (MacDonald & Christiansen, 2002). I find that this additional interpretation of canonicity, separate from storage-based and expectation-based processing, provides the best interpretation as to why unambiguous ORCs were initially read more quickly. In other words, despite ORCs being less frequent not only in overall structure but also after a Det+Cl phrase, ORCs nevertheless received some benefit from their relationship to the canonical word or thematic order of Mandarin. In contrast, a storage-based or an expectation-based account would predict initial ORC difficulty instead of SRC difficulty for these items if a matrix clause interpretation was attenuated. Considering that Experiment 1 used ambiguous RCs and did not contain any syntactic cues to hint at an RC interpretation, the combined influences of canonicity, locality and possibly storage-based resources likely impacted the processing of the ORC phrase much more than the expectation for the SRCs at the relativizer.

Recall that Mandarin Chinese is rather unique in being a right-branching language that displays left-branching prenominal RCs, and that the less frequent ORC structure follows the canonical SVO and agent-to-patient word and thematic orders. Following this, the effect of canonicity against expectation effects may be exclusive to languages such as Mandarin Chinese displaying this infrequent language pattern. Specifically for Mandarin RC processing, I believe this influence of canonicity is best observed globally for the RC structure as a whole whereas expectation-based processing, such as surprisal, is more localized at individual regions.

In contrast with canonicity, as syntactic cues which helped give an RC interpretation were introduced into the sentence (e.g., the ambiguous Empty types and unambiguous DCL types in Experiment 2), anticipatory processes greatly influenced the processing for the more frequent SRC structure. This caused SRCs to be processed more easily than ORCs at the relativizer and during later reading times for the RC (N1, V1) and RC structure (N1, V1, Freq, DE) in Experiment 2. However, I understand this greater expectation or anticipation for the SRC structure to be an antilocality effect. I believe this effect could have possibly prevented the observation of a linear or temporally defined integration metric at the relativizer and head noun. As mentioned above, locality is a constraint on the reactivation of an item from memory. In general, after the initial activation of an item, the activation level will begin to decay, and the more distant a gap is to its filler, the greater the decay will be. Since ORCs would have less activation decay due to the gap and filler being more local defined by either a linear or temporal metric, ORCs should be easier to process when integrating filler-gap dependencies. This was clearly supported by the results of Experiment 1. Experiment 2, on the other hand, only was able to support effects of locality beyond the scope of the specific loci of integration in Mandarin Chinese. If I consider that locality does influence processing, then the fact that the results of Experiment 2 conflict with ORC locality is best explained by antilocality effects, rather than a structural-phrase integration metric. Lastly, there was partial evidence supporting a similarity-based interference when the mental parser needed to retrieve the subject of the matrix verb (i.e., the head noun) from memory. This was indicated by the ORC difficulty found at the matrix clause for both experiments and all ORC types. I believe that similarity-based interference provides the most suitable explanation for the ORC difficulty here. The difficulty for ORCs at the matrix clause verb can be explained by the proactive interference of the ORC relative clause subject on the activation level of the matrix clause subject. On the other hand, the SRC relative clause object should not lower the activation level of the matrix clause subject. Thus, during the retrieval of the subject at the matrix verb, ORCs should have greater processing difficulty compared to SRCs.

In summary, the results seem to be compatible with activation-based constraints on processing showing multiple influences on sentence processing. In the current study, I limited these to more global interpretations on sentence processing; as such, see Vasishth and Lewis (2006; Lewis & Vasishth, 2005) and citations within for a more detailed account for these activation constraints.

### 2.5.1. Issues to Address

The current study is not without limitation and there are several issues left to be addressed. Both experiments potentially involved issues since animacy, passivation and object-modification were not addressed as independent factors. Consequently, the current study is somewhat limited in its overall interpretability. One issue, for example, is that the current study cannot dissociate semantics and syntax for canonical order effects. Yet, considering that ORCs are preferred to be in passive voice, the thematic canonicity of agent-to-patient may admittedly have a greater influence on processing compared to grammatical SVO word order.

In the current study, while subject/object asymmetry was only investigated for RC processing in Mandarin, subject biases have also been observed within other structures as well. For instance, Simpson, Wu, and Li (2016) using a sentence completion task revealed that for pronoun anaphora resolution in Mandarin there was a general preference to form an antecedent relationship with the subject of a preceding sentence. This result was also supported by corpus data which revealed that subjects are predominately found to be the antecedent of a pronoun. Seeing that there is a general tendency to form an antecedent relationship with the subject of a clause, be it embedded or matrix, it may be worthwhile for future studies to also investigate pronoun anaphora in Mandarin to further detail the interrelationship of memory-based and expectation-based models of processing. Furthermore, Simpson et al. (2016) found that by altering the coherence relation of the prompt used for the sentence completion task, the number of subject antecedents was increased or reduced. Considering the influence of discourse semantics on pronoun anaphora in Mandarin, future studies can adopt similar experimental methods as Simpson et al. (2016) for RCs in Mandarin to tease apart the effects of syntax and semantics on RC processing.

Concerning canonical order facilitation, while the current study found clear benefits of canonicity at the RC structure for both experiments, it is still unclear how and when statistical frequencies are used for the items with attenuated clause type ambiguity. In the current study, it appeared that the statistical frequencies are not retrieved until a cue can assign RC features to the clause. This cue was the relativizer in this study. Hsiao and MacDonald (2013) found that for the statistical regularity of ambiguous RCs and competitor interpretations in Mandarin, numerous interacting factors (e.g., animacy, RC type and modification position) are highly involved in areas of ambiguity. Yet, in the case where the clause type ambiguity is attenuated by the Det+Cl phrase, it is uncertain if competitor interpretations based on simple matrix clauses are permissible; it is my belief that they are likely not. Instead, I assert that while rejecting the matrix clause interpretation, it is conceivable that a RC interpretation was not yet committed. Therefore, the regularities of the word or thematic order could facilitate the clause despite not being garden pathed. As Hsiao and MacDonald (2013) argue, with whom I certainly agree, ORC advantages and disadvantages are highly dependent on the context in which they are found. Consequently, further investigation may be needed to clarify which statistical regularities are being utilized for the initial processing of unambiguous relative clauses and if these regularities are counter or congruent with the interpretations made upon the structure.

A notable issue of this study was that the frequency phrase in Experiment 2 still acted as a syntactic cue to help attenuate ambiguity. Thus, the items lacking the Det+Cl were still less ambiguous than the items of Experiment 1. Furthermore, the position of the frequency phrase is unnatural for the ORC condition. Consequently, the difficulty found at the relative clause or head noun for ORCs during later RTs may be attributed in some part to the unnaturalness of the frequency phrase for ORCs. Since the phrase is not in a canonical position for ORCs, it may also be the case that semantics rather than word order may have been facilitating ORCs during early RTs at the full RC region. Future studies using eye-tracking should further address the issue of semantics and also address the frequency phrase as experimental factors to determine its influence inside the RC and at head noun.

In a similar vein, since the Det+Cl can either appear prior or after the RC, it may be best to compare such a design to determine the influence of modification position on the processing of the head noun using eye-tracking. In fact, previous research (Wu, Kaiser, & Andersen, 2009) has already shown that pre-RC classifiers occur predominately in both subject- and object-modified expressions for SRCs whereas ORCs prefer to have post-RC classifiers. It was shown (Wu et al., 2009) that for pre-RC classifiers, SRCs received a greater benefit from the cue. Accordingly, it was not surprising SRCs were ultimately easier than ORCs in the current study, considering these past findings. In conjunction with the frequency phrase, I believe that these combined disadvantages for ORCs in the item design attributed to the antilocality effect at the relativizer and head noun.

An additional issue was that object-modified RCs were not addressed in this study. Considering that in situ object-modified RCs are not preferred, I believe future studies should follow Lin and Garnsey (2011) and investigate object-modified RCs in a topicalized position instead of placing RCs at the in situ position where they would be prone to garden path (Lin & Bever, 2011) and clause boundary effects.

There are several other possible issues in the items used as well. Since 13 items were slightly modified, a post-hoc naturalness decision task was carried out on all the RC items to ensure that the 13 modified items did not differ in naturalness from the 19 unmodified items. For this, ten native speakers of Mandarin (female = 10; age range: 22-33 years) volunteered to rate the stimuli on a 1-5 Likert scale at Nagoya University in Japan. All volunteers originated from Mainland China and none participated in either eye-tracking experiment. An LME model was used to investigate this difference. RC condition (ORC vs. SRC) and item modification (modified vs. unmodified) were the fixed effects (each coded as -.5 and .5 respectively), and items and subjects were included as random intercepts and slopes as determined by model comparisons. The naturalness rating was coded from -2 (unnatural) to +2 (natural). The result of the analysis revealed that while there was a significant effect of RC condition [coef. = 0.89, SE = 0.17, $t$ = 5.14, $p$ < .001], neither item modification [coef. = 0.17, SE = 0.20, $t$ = 0.87, $p$ = .389] nor the interaction of the two [coef. = -0.03, SE = 0.24, $t$ = -0.11, $p$ =.911] were significantly different. It was found for both the modified and unmodified items, SRCs (Mean = 0.84, SE = .05) were rated significantly higher than ORCs (Mean = -0.05, SE = .06). In Jäger et al. (2015), it was found that there was also a numerical difference showing higher acceptability for SRCs, but it was found to be not significant. The prospective difference between the current study and theirs (Jäger et al., 2015) could likely reflect random variability from participant judgements. As such, I assert that the modified items used in Experiment 2 of the current study should not be considered any less or more natural than the items from Jäger et al. (2015). Another possible issue in the items used is that one particular item may have given an undesired interpretation. The RC noun of item 19 from Experiment 2 (see Appendix Chapter 2) is *zuòjiā* 'foreign ministry'. This particular noun may possibly be considered as a location rather than an agent for the ORC condition. However, since this item was not modified from the previous study (Jäger et al., 2015) and the overall of pattern of results did not change with its exclusion, I decided to not remove the item from the analyses.

The last limitation addressed here is that relatively few participants were recruited in both experiments. With the high number of analyses conducted in the study, the possibility remains that Type S and M errors were obtained leading to results favouring both ORCs and SRCs within both experiments (Gelman & Carlin, 2014). However, considering that the overall results of Experiment 1 and 2 replicated previous findings, I do not believe my findings to be overly spurious or misrepresentative, if such errors exist within my analyses.

#### 2.5.1.1. Random Variability

Another interpretation besides fluctuations in activation is that expectation or memory effects are not always visible in reading time data. Consequently, self-paced reading studies, complemented with eye-tracking and ERP studies, seem to produce opposing results between studies. Though Vasishth et al. (2013, pp. 10-12) argued for an overall SRC advantage, they allowed that random variability may possibly contribute to this appropriate inconsistency to some extent. If there is random variability, then the possible contributing factors should be determined. It is possible that differences in experimental items, the method or the number of cues to attenuate temporary ambiguity, the experimental methodology (i.e., self-paced reading, maze task, eye-tracking, & ERP), and participant-pools (e.g., dialect and exposure to other languages) may all contribute to the random variability. For instance, there have been many studies using Gibson and Wu's (2013) items and unambiguous design (Jäger et al., 2015, Lin, 2014, Vasishth et al., 2013), but even among them and the current study, there are inconsistencies in the findings between studies. Specifically, the current study and Jäger et al. (2015) have diverging results at the relativizer region for subject-modified RCs.

Although the previous studies and the current study used native Mandarin speakers (with the majority recruiting participants originating from either Mainland China or Taiwan), there is still variability among regional dialects of Mandarin. For instance, even among similar Pǔtōnghuà and Guóyǔ standard dialects of Mandarin (i.e., Standard Mainland China Mandarin and Taiwanese Mandarin), there are differences in grammar, phonology, and vocabulary. As such, it may be of empirical interest for future studies to assess the influence of dialect.

## 2.6. Conclusion

In an effort to further previous eye-tracking studies that used either ambiguous relative clauses in Mandarin or syntactic cues to attenuate ambiguity, the current study has shown that canonicity and linear/ temporal-based integrations metrics support an ORC advantage. However, these effects are more prominent when the structure of the RC is initially ambiguous. As such, I also have shown that as additional syntactic cues are given, the more likely, quickly and severely the expectations generated from the structural frequency will impact the processing of object-relative clauses. I view this as an antilocality effect. In addition, I have also shown evidence for a similarity-based interference within the matrix clause regardless of ambiguity. I argue along the lines of Vasishth and Lewis (2006; Lewis & Vasishth, 2005) that multiple processing factors (e.g., locality, anticipation, expectation, similarity interference and canonicity) constrain the activation level of items. However, more work is needed to detail their relationships within sentence processing. Consequently, I assert that for Mandarin Chinese, relative clause processing should not be viewed under the scope of a single model or context but rather under an interdependent model.

## 2.7. Compliance with Ethics Standards

At Nagoya University ethics committees are operated separately from the main institution within each graduate school; however, not all graduate schools have a committee. Since the Graduate School of Languages and Cultures at Nagoya University, Japan did not have an ethics committee at the time of the study, approval from such a committee could not be obtained. Instead, this research was approved by the faculty of the Graduate School of Languages and Cultures at Nagoya University, Japan which adheres to the Declaration of Helsinki for research using human subjects.

### 2.7.1. Conflict of Interest

No authors had a conflict of interest.

### 2.7.2. Human and Animal Rights Statement

All personal information collected from participants was stored in a secured location, and participants were given pseudonyms for data analysis purposes. Participants were not subject to harm and could only experience mild discomfort from prolonged seating or eye discomfort from prolonged reading.

### 2.7.3. Informed Consent

In the current study, all participants first gave written, informed consent prior to starting the experiments. After the completion of the experimental session, participants then received monetary compensation.

## 2.8. Acknowledgements and Funding

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## 2.9. Supplementary Tables and Figures

In the following pages, the supplementary Tables listed above are provided.

**Table 2.1. Experiment 1: RC condition and Task type means**

| | RC Condition | | | | Task Type | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | Plausibility | | Verification | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 2,819 | 40 | 2,860 | 42 | 2,372 | 31 | 3,324 | 43 |
| ACC | 92.01% | 0.92% | 89.58% | 1.04% | 92.13% | 0.92% | 89.47% | 1.04% |
| N1V1(RC) | | | | | | | | |
| FP | 744 | 11 | 731 | 11 | 665 | 10 | 814 | 12 |
| RR | 805 | 23 | 820 | 25 | 556 | 16 | 1002 | 24 |
| RI | 76.57% | 1.50% | 78.55% | 1.48% | 64.82% | 1.69% | 90.67% | 1.05% |
| DE (Relativizer) | | | | | | | | |
| FP | 206 | 3 | 226 | 4 | 213 | 3 | 220 | 4 |
| RR | 292 | 14 | 305 | 13 | 287 | 16 | 306 | 12 |
| GP | 286 | 10 | 334 | 10 | 270 | 8 | 348 | 12 |
| RO | 11.60% | 1.54% | 18.70% | 1.76% | 11.90% | 1.55% | 18.52% | 1.76% |
| RI | 36.19% | 2.32% | 36.59% | 2.17% | 27.46% | 2.14% | 44.44% | 2.26% |
| N2 (Head Noun) | | | | | | | | |
| FP | 322 | 5 | 327 | 6 | 289 | 4 | 362 | 6 |
| RR | 515 | 16 | 512 | 18 | 364 | 13 | 593 | 16 |
| GP | 446 | 14 | 504 | 17 | 325 | 7 | 630 | 20 |
| RO | 15.36% | 1.29% | 20.48% | 1.47% | 7.50% | 0.95% | 28.37% | 1.63% |
| RI | 28.30% | 1.61% | 24.04% | 1.55% | 15.27% | 1.29% | 37.25% | 1.75% |
| ADV (Adverb) | | | | | | | | |
| FP | 311 | 6 | 311 | 5 | 322 | 6 | 299 | 5 |
| RR | 377 | 14 | 369 | 14 | 367 | 13 | 380 | 15 |
| GP | 646 | 23 | 703 | 28 | 554 | 18 | 813 | 31 |
| RO | 36.38% | 1.78% | 37.29% | 1.83% | 29.23% | 1.65% | 45.45% | 1.92% |
| RI | 12.53% | 1.22% | 14.71% | 1.34% | 13.24% | 1.23% | 14.01% | 1.34% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 352 | 10 | 363 | 11 | 379 | 11 | 330 | 9 |
| RR | 385 | 28 | 361 | 25 | 404 | 26 | 341 | 26 |
| RO | 80.37% | 1.71% | 81.84% | 1.72% | 71.31% | 1.87% | 93.81% | 1.14% |
| N1 V1 DE (Full RC) | | | | | | | | |
| FP | 829 | 12 | 874 | 12 | 770 | 10 | 936 | 12 |
| RR | 852 | 23 | 885 | 27 | 594 | 16 | 1,083 | 26 |
| RI | 79.97% | 1.42% | 80.23% | 1.43% | 69.22% | 1.64% | 91.32% | 1.01% |
| N2 ADV V2 (Matrix Clause) | | | | | | | | |
| FP | 915 | 16 | 874 | 17 | 910 | 16 | 879 | 17 |
| RR | 812 | 27 | 832 | 28 | 721 | 25 | 889 | 28 |
| RO | 79.97% | 1.42% | 80.44% | 1.43% | 69.22% | 1.64% | 91.56% | 1.00% |

Note. Means and standard errors of reading times are displayed in milliseconds.

**Table 2.2. Experiment 1: RC condition : Task type interaction means**

| | Plausibility | | | | Verification | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | ORC | | SRC | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 2,320 | 44 | 2,422 | 44 | 3,309 | 57 | 3,341 | 64 |
| ACC | 91.20% | 1.36% | 93.06% | 1.22% | 92.82% | 1.24% | 86.11% | 1.67% |
| N1V1 (RC) | | | | | | | | |
| FP | 653 | 13 | 678 | 15 | 836 | 17 | 789 | 16 |
| RR | 566 | 24 | 547 | 21 | 967 | 32 | 1,041 | 37 |
| RI | 62.18% | 2.45% | 67.41% | 2.34% | 90.75% | 1.45% | 90.59% | 1.52% |
| DE (Relativizer) | | | | | | | | |
| FP | 205 | 4 | 220 | 5 | 208 | 5 | 232 | 5 |
| RR | 278 | 25 | 295 | 21 | 300 | 17 | 310 | 17 |
| GP | 249 | 10 | 288 | 11 | 318 | 16 | 375 | 16 |
| RO | 8.00% | 1.92% | 15.19% | 2.34% | 14.72% | 2.34% | 21.96% | 2.60% |
| RI | 25.50% | 3.09% | 29.11% | 2.96% | 45.45% | 3.28% | 43.53% | 3.11% |
| N2 (Head Noun) | | | | | | | | |
| FP | 288 | 6 | 290 | 6 | 356 | 8 | 368 | 10 |
| RR | 388 | 20 | 342 | 16 | 580 | 21 | 608 | 24 |
| GP | 312 | 8 | 337 | 10 | 579 | 25 | 684 | 31 |
| RO | 4.96% | 1.11% | 10.00% | 1.52% | 25.38% | 2.18% | 31.61% | 2.43% |
| RI | 18.80% | 2.00% | 11.79% | 1.64% | 37.44% | 2.43% | 37.06% | 2.52% |
| ADV (Adverb) | | | | | | | | |
| FP | 320 | 8 | 323 | 8 | 301 | 8 | 296 | 7 |
| RR | 375 | 20 | 359 | 16 | 378 | 20 | 381 | 23 |
| GP | 567 | 27 | 540 | 24 | 733 | 37 | 902 | 52 |
| RO | 29.92% | 2.35% | 28.53% | 2.31% | 43.34% | 2.64% | 47.80% | 2.81% |
| RI | 11.29% | 1.62% | 15.18% | 1.84% | 13.88% | 1.84% | 14.15% | 1.96% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 368 | 15 | 390 | 15 | 335 | 12 | 324 | 14 |
| RR | 454 | 41 | 355 | 31 | 321 | 35 | 370 | 40 |
| RO | 69.44% | 2.72% | 73.09% | 2.56% | 92.86% | 1.63% | 95.00% | 1.54% |
| N1 V1 DE (Full RC) | | | | | | | | |
| FP | 733 | 14 | 806 | 16 | 923 | 18 | 949 | 17 |
| RR | 603 | 24 | 585 | 22 | 1,031 | 33 | 1,141 | 41 |
| RI | 67.26% | 2.37% | 71.14% | 2.26% | 92.50% | 1.32% | 90.05% | 1.55% |
| N2 ADV V2 (Matrix Clause) | | | | | | | | |
| FP | 926 | 22 | 894 | 22 | 903 | 24 | 853 | 25 |
| RR | 700 | 37 | 740 | 34 | 880 | 37 | 898 | 41 |
| RO | 67.26% | 2.37% | 71.14% | 2.26% | 92.50% | 1.32% | 90.54% | 1.52% |

Note. Means and standard errors of reading times are displayed in milliseconds.

**Table 2.3. Experiment 1: linear mixed effect models**

| | RC Condition | | | Task Type | | | Interaction | | |
|---|---|---|---|---|---|---|---|---|---|
| | coef. | SE | *t/z* value | coef. | SE | *t/z* value | coef. | SE | *t/z* value |
| Sentence | | | | | | | | | |
| TT | 0.03 | 0.01 | 1.82 † | 0.34 | 0.01 | 23.47*** | -0.04 | 0.03 | -1.23 |
| ACC | -0.26 | 0.17 | -1.51 | -0.29 | 0.17 | -1.70 † | -1.05 | 0.35 | -3.05** |
| N1 V1 (RC) | | | | | | | | | |
| FP | -0.01 | 0.02 | -0.86 | 0.20 | 0.02 | 12.26*** | -0.09 | 0.03 | -2.67** |
| RR | 0.01 | 0.03 | 0.39 | 0.60 | 0.03 | 17.90*** | 0.13 | 0.07 | 1.95 † |
| RI | 0.13 | 0.15 | 0.89 | 1.78 | 0.15 | 11.85*** | -0.26 | 0.30 | -0.89 |
| DE (Relativizer) | | | | | | | | | |
| FP | 0.09 | 0.02 | 4.20*** | 0.03 | 0.02 | 1.39 | 0.04 | 0.04 | 0.96 |
| RR | 0.04 | 0.06 | 0.61 | 0.05 | 0.06 | 0.87 | -0.03 | 0.12 | -0.23 |
| GP | 0.15 | 0.04 | 4.41*** | 0.19 | 0.04 | 5.38*** | 0.06 | 0.07 | 0.87 |
| RO | 0.61 | 0.20 | 3.03** | 0.61 | 0.20 | 3.01** | -0.18 | 0.40 | -0.44 |
| RI | 0.06 | 0.14 | 0.40 | 0.80 | 0.15 | 5.49*** | -0.30 | 0.29 | -1.05 |
| N2 (Head Noun) | | | | | | | | | |
| FP | 0.01 | 0.02 | 0.51 | 0.19 | 0.02 | 9.75*** | 0.02 | 0.04 | 0.42 |
| RR | -0.02 | 0.04 | -0.58 | 0.47 | 0.04 | 11.61*** | 0.15 | 0.08 | 1.84 † |
| GP | 0.09 | 0.03 | 3.23** | 0.49 | 0.03 | 17.55*** | 0.09 | 0.06 | 1.65 † |
| RO | 0.59 | 0.17 | 3.40*** | 1.89 | 0.18 | 10.59*** | -0.44 | 0.34 | -1.27 |
| RI | -0.30 | 0.13 | -2.34* | 1.29 | 0.13 | 9.77*** | 0.56 | 0.26 | 2.16* |
| ADV (Adverb) | | | | | | | | | |
| FP | 0.002 | 0.02 | 0.10 | -0.07 | 0.02 | -3.32*** | -0.02 | 0.04 | -0.42 |
| RR | -0.03 | 0.05 | -0.59 | -0.01 | 0.05 | -0.10 | 0.01 | 0.10 | 0.07 |
| GP | 0.05 | 0.04 | 1.16 | 0.27 | 0.04 | 6.59*** | 0.15 | 0.08 | 1.85 † |
| RO | 0.05 | 0.12 | 0.38 | 0.82 | 0.12 | 6.77*** | 0.24 | 0.24 | 1.00 |
| RI | 0.21 | 0.16 | 1.33 | 0.06 | 0.16 | 0.39 | -0.30 | 0.32 | -0.94 |
| V2 (Matrix Verb) | | | | | | | | | |
| FP | 0.03 | 0.03 | 0.76 | -0.10 | 0.03 | -2.89** | -0.12 | 0.07 | -1.73 † |
| RR | -0.04 | 0.09 | -0.42 | -0.20 | 0.09 | -2.13* | -0.05 | 0.07 | -0.70 |
| RO | 0.28 | 0.23 | 1.26 | 1.92 | 0.23 | 8.42*** | 0.22 | 0.45 | 0.49 |
| N1 V1 DE (Full RC) | | | | | | | | | |
| FP | 0.06 | 0.01 | 4.29*** | 0.19 | 0.01 | 13.03*** | -0.05 | 0.03 | -1.73 |
| RR | 0.03 | 0.03 | 0.93 | 0.61 | 0.03 | 18.90*** | 0.15 | 0.06 | 2.29* |
| RI | -0.05 | 0.15 | -0.31 | 1.65 | 0.15 | 10.67*** | -0.51 | 0.31 | -1.67 |
| N2 ADV V2 (Matrix Clause) | | | | | | | | | |
| FP | -0.06 | 0.02 | -2.64** | -0.10 | 0.02 | -3.91*** | -0.03 | 0.05 | -0.56 |
| RR | 0.06 | 0.04 | 1.35 | 0.18 | 0.05 | 4.07*** | -0.06 | 0.09 | -0.71 |
| RO | -0.02 | 0.15 | -0.13 | 1.68 | 0.16 | 10.75*** | -0.45 | 0.31 | -1.47 |

Note. $p < .1$ †, $p < .05$*, $p < .01$**, $p < .001$***. A positive coefficient indicates an increase in reading time, accuracy or regression for the SRC condition or Verification task.

**Table 2.4. Experiment 2: RC condition and Determiner type means**

| | RC Condition | | | | Determiner Type | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | Empty | | DCL | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 5,571 | 111 | 4,993 | 103 | 5,152 | 107 | 5,413 | 109 |
| ACC | 79.3% | 1.7% | 77.9% | 1.7% | 78.5% | 1.7% | 78.8% | 1.7% |
| N1V1(RC) | | | | | | | | |
| FP | 510 | 16 | 545 | 17 | 548 | 16 | 508 | 17 |
| RR | 1,040 | 36 | 873 | 32 | 985 | 34 | 931 | 35 |
| GP | 869 | 27 | 818 | 24 | 783 | 21 | 905 | 29 |
| RO | 34.8% | 2.2% | 26.2% | 2.1% | 25.8% | 2.0% | 35.3% | 2.2% |
| RI | 75.8% | 2.0% | 73.8% | 2.1% | 80.8% | 1.8% | 68.8% | 2.2% |
| Freq (Frequency Phrase) | | | | | | | | |
| FP | 264 | 7 | 267 | 6 | 277 | 7 | 253 | 6 |
| RR | 402 | 16 | 377 | 17 | 414 | 16 | 361 | 16 |
| GP | 338 | 11 | 330 | 11 | 350 | 11 | 318 | 10 |
| RO | 10.3% | 1.5% | 11.8% | 1.6% | 10.4% | 1.5% | 11.7% | 1.6% |
| RI | 49.2% | 2.4% | 45.1% | 2.4% | 51.3% | 2.4% | 42.8% | 2.4% |
| DE (Relativizer) | | | | | | | | |
| FP | 238 | 5 | 218 | 5 | 232 | 5 | 225 | 5 |
| RR | 264 | 12 | 282 | 17 | 294 | 14 | 242 | 12 |
| GP | 360 | 18 | 308 | 14 | 351 | 17 | 318 | 16 |
| RO | 17.2% | 2.3% | 13.4% | 2.1% | 15.0% | 2.2% | 15.7% | 2.3% |
| RI | 36.9% | 3.0% | 25.3% | 2.7% | 32.6% | 2.9% | 29.9% | 2.9% |
| N2 (Head Noun) | | | | | | | | |
| FP | 287 | 7 | 290 | 7 | 289 | 7 | 288 | 7 |
| RR | 488 | 20 | 421 | 18 | 477 | 20 | 433 | 19 |
| GP | 409 | 16 | 403 | 16 | 420 | 17 | 391 | 15 |
| RO | 20.1% | 1.9% | 14.7% | 1.7% | 18.4% | 1.8% | 16.6% | 1.8% |
| RI | 40.7% | 2.3% | 34.3% | 2.3% | 37.9% | 2.3% | 37.3% | 2.3% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 335 | 9 | 331 | 9 | 338 | 9 | 328 | 8 |
| RR | 506 | 20 | 433 | 19 | 490 | 22 | 453 | 18 |
| GP | 459 | 18 | 422 | 16 | 469 | 19 | 414 | 16 |
| RO | 16.1% | 1.7% | 14.2% | 1.7% | 17.4% | 1.8% | 13.0% | 1.6% |
| RI | 42.6% | 2.3% | 45.1% | 2.4% | 42.5% | 2.4% | 45.2% | 2.4% |
| N3 (Matrix Object) | | | | | | | | |
| FP | 312 | 8 | 299 | 8 | 301 | 8 | 310 | 8 |
| RR | 427 | 19 | 425 | 21 | 437 | 22 | 415 | 18 |
| GP | 435 | 15 | 442 | 16 | 436 | 16 | 441 | 15 |
| RO | 21.0% | 2.0% | 23.5% | 2.1% | 23.7% | 2.1% | 20.8% | 2.0% |
| RI | 29.8% | 2.2% | 29.4% | 2.2% | 28.6% | 2.2% | 30.7% | 2.2% |

Note. Means and standard errors of reading times are displayed in milliseconds.

**Table 2.5. Experiment 2: RC condition : Determiner type means**

| | Empty | | | | DCL | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | ORC | | SRC | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 5,424 | 155 | 4,872 | 143 | 5,719 | 159 | 5,111 | 149 |
| ACC | 79.8% | 2.4% | 77.1% | 2.5% | 78.8% | 2.4% | 78.8% | 2.4% |
| N1V1 (RC) | | | | | | | | |
| FP | 529 | 21 | 566 | 24 | 491 | 24 | 525 | 24 |
| RR | 1,061 | 50 | 907 | 44 | 1,019 | 53 | 836 | 46 |
| GP | 735 | 26 | 832 | 33 | 1,006 | 46 | 804 | 36 |
| RO | 25.0% | 2.8% | 26.5% | 2.9% | 44.8% | 3.3% | 25.8% | 2.9% |
| RI | 83.6% | 2.4% | 77.9% | 2.8% | 67.8% | 3.1% | 69.9% | 3.0% |
| Freq (Frequency Phrase) | | | | | | | | |
| FP | 281 | 10 | 272 | 9 | 245 | 8 | 261 | 8 |
| RR | 424 | 21 | 401 | 26 | 371 | 24 | 352 | 22 |
| GP | 365 | 17 | 334 | 15 | 310 | 14 | 326 | 15 |
| RO | 10.4% | 2.1% | 10.5% | 2.1% | 10.2% | 2.1% | 13.2% | 2.4% |
| RI | 57.9% | 3.3% | 44.3% | 3.4% | 39.8% | 3.4% | 45.9% | 3.5% |
| DE (Relativizer) | | | | | | | | |
| FP | 242 | 7 | 221 | 7 | 233 | 7 | 216 | 6 |
| RR | 281 | 17 | 316 | 26 | 243 | 15 | 240 | 20 |
| GP | 380 | 27 | 320 | 19 | 339 | 25 | 296 | 20 |
| RO | 16.1% | 3.1% | 13.8% | 3.0% | 18.3% | 3.4% | 13.0% | 3.0% |
| RI | 42.3% | 4.2% | 22.3% | 3.7% | 31.3% | 4.1% | 28.5% | 4.1% |
| N2 (Head Noun) | | | | | | | | |
| FP | 287 | 10 | 292 | 10 | 287 | 10 | 288 | 10 |
| RR | 522 | 31 | 428 | 23 | 451 | 25 | 413 | 28 |
| GP | 431 | 24 | 409 | 23 | 386 | 20 | 397 | 21 |
| RO | 23.7% | 2.8% | 12.7% | 2.3% | 16.4% | 2.5% | 16.7% | 2.6% |
| RI | 40.8% | 3.3% | 34.7% | 3.3% | 40.6% | 3.3% | 34.0% | 3.2% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 339 | 13 | 337 | 12 | 331 | 12 | 325 | 12 |
| RR | 542 | 31 | 435 | 30 | 472 | 26 | 432 | 25 |
| GP | 494 | 29 | 442 | 23 | 425 | 22 | 403 | 22 |
| RO | 18.4% | 2.6% | 16.2% | 2.5% | 13.8% | 2.3% | 12.3% | 2.2% |
| RI | 40.8% | 3.3% | 44.3% | 3.4% | 44.4% | 3.3% | 45.9% | 3.4% |
| N3 (Matrix Object) | | | | | | | | |
| FP | 306 | 11 | 295 | 12 | 317 | 10 | 304 | 11 |
| RR | 438 | 30 | 435 | 33 | 416 | 25 | 414 | 27 |
| GP | 435 | 21 | 437 | 24 | 436 | 21 | 446 | 23 |
| RO | 20.7% | 2.8% | 26.7% | 3.1% | 21.2% | 2.8% | 20.3% | 2.8% |
| RI | 28.6% | 3.1% | 28.6% | 3.1% | 31.1% | 3.2% | 30.2% | 3.2% |

Note. Means and standard errors of reading times are displayed in milliseconds.

**Table 2.6. Experiment 2: linear mixed effect models**

| | RC Condition | | | Determiner Type | | | Interaction | | |
|---|---|---|---|---|---|---|---|---|---|
| | coef. | SE | *t/z* value | coef. | SE | *t/z* value | coef. | SE | *t/z* value |
| Sentence | | | | | | | | | |
| TT | -0.11 | 0.02 | -6.23*** | 0.02 | 0.01 | 3.13** | 0 | 0.01 | 0.37 |
| ACC | -0.1 | 0.15 | -0.65 | 0.01 | 0.05 | 0.1 | 0.06 | 0.1 | 0.63 |
| N1 V1 (RC) | | | | | | | | | |
| FP | 0.07 | 0.04 | 1.83 † | -0.04 | 0.01 | -2.90** | 0.02 | 0.03 | 0.79 |
| RR | -0.19 | 0.05 | -4.32*** | -0.03 | 0.02 | -1.87 † | -0.02 | 0.03 | -0.67 |
| GP | -0.05 | 0.03 | -1.52 | 0.03 | 0.01 | 2.35* | -0.1 | 0.02 | -4.46*** |
| RO | -0.42 | 0.15 | -2.73** | 0.15 | 0.05 | 2.97** | -0.34 | 0.1 | -3.35*** |
| RI | -0.18 | 0.17 | -1.04 | -0.27 | 0.06 | -4.62*** | 0.17 | 0.11 | 1.47 |
| Freq (Frequency Phrase) | | | | | | | | | |
| FP | 0.04 | 0.03 | 1.34 | -0.02 | 0.01 | -2.41* | 0.03 | 0.02 | 1.79 † |
| RR | -0.07 | 0.05 | -1.46 | -0.04 | 0.02 | -2.40* | 0.03 | 0.03 | 0.9 |
| GP | -0.01 | 0.04 | -0.2 | -0.03 | 0.01 | -2.43* | 0.05 | 0.02 | 2.00* |
| RO | 0.15 | 0.23 | 0.65 | 0.03 | 0.08 | 0.41 | 0.09 | 0.15 | 0.61 |
| RI | -0.23 | 0.15 | -1.51 | -0.12 | 0.05 | -2.43* | 0.31 | 0.1 | 3.05** |
| DE (Relativizer) | | | | | | | | | |
| FP | -0.06 | 0.03 | -2.36* | -0.01 | 0.01 | -0.59 | 0.01 | 0.02 | 0.82 |
| RR | 0.04 | 0.07 | 0.61 | -0.07 | 0.02 | -3.10** | -0.04 | 0.04 | -1.02 |
| GP | -0.11 | 0.05 | -2.27* | -0.03 | 0.02 | -1.64 | 0.01 | 0.03 | 0.47 |
| RO | -0.3 | 0.25 | -1.2 | 0.02 | 0.08 | 0.26 | -0.08 | 0.17 | -0.5 |
| RI | -0.54 | 0.2 | -2.79** | -0.03 | 0.07 | -0.43 | 0.27 | 0.13 | 2.10* |
| N2 (Head Noun) | | | | | | | | | |
| FP | 0.02 | 0.03 | 0.68 | 0 | 0.01 | -0.56 | 0 | 0.02 | 0.28 |
| RR | -0.12 | 0.05 | -2.51* | -0.04 | 0.02 | -2.22* | 0.01 | 0.03 | 0.25 |
| GP | -0.01 | 0.04 | -0.4 | -0.02 | 0.01 | -1.99* | 0.02 | 0.02 | 0.96 |
| RO | -0.39 | 0.19 | -2.09* | -0.03 | 0.06 | -0.49 | 0.27 | 0.12 | 2.21* |
| RI | -0.35 | 0.15 | -2.31* | -0.01 | 0.05 | -0.11 | -0.01 | 0.1 | -0.08 |
| V2 (Matrix Verb) | | | | | | | | | |
| FP | 0.00 | 0.03 | -0.06 | -0.01 | 0.01 | -1.03 | -0.01 | 0.02 | -0.35 |
| RR | -0.14 | 0.05 | -2.79** | -0.01 | 0.02 | -0.77 | 0.07 | 0.03 | 2.07* |
| GP | -0.05 | 0.04 | -1.26 | -0.04 | 0.01 | -2.86** | 0 | 0.03 | 0.04 |
| RO | -0.16 | 0.19 | -0.82 | -0.12 | 0.06 | -1.88 † | 0.01 | 0.13 | 0.1 |
| RI | 0.09 | 0.15 | 0.57 | 0.04 | 0.05 | 0.88 | -0.03 | 0.1 | -0.32 |
| N3 (Matrix Object) | | | | | | | | | |
| FP | -0.05 | 0.03 | -1.90 † | 0.01 | 0.01 | 1.49 | 0.01 | 0.02 | 0.81 |
| RR | -0.03 | 0.06 | -0.46 | 0 | 0.02 | 0 | -0.01 | 0.04 | -0.17 |
| GP | -0.02 | 0.04 | -0.58 | 0 | 0.01 | 0.1 | 0.02 | 0.03 | 0.88 |
| RO | 0.14 | 0.17 | 0.83 | -0.06 | 0.06 | -1.12 | -0.12 | 0.11 | -1.05 |
| RI | -0.02 | 0.16 | -0.11 | 0.03 | 0.05 | 0.62 | -0.02 | 0.11 | -0.14 |

Note. A positive coefficient indicates an increase in reading time for SRCs or for the DCL type. p < .1 † , p < .05*, p < .01**, p < .001***

**Table 2.7. Experiment 2: means for the additional analyses**

| | RC Condition | | | | Determiner Type | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | Empty | | DCL | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| N1 V1 Freq DE (Full RC) | | | | | | | | |
| FP | 754 | 20 | 798 | 20 | 807 | 17 | 713 | 25 |
| RR | 1,533 | 42 | 1,312 | 37 | 1,460 | 34 | 1,357 | 50 |
| GP | 1,211 | 27 | 1,174 | 23 | 1,165 | 20 | 1,251 | 35 |
| RO | 33.2% | 1.8% | 27.3% | 1.7% | 27.0% | 1.5% | 36.7% | 2.3% |
| RI | 83.3% | 1.4% | 79.6% | 1.5% | 84.5% | 1.2% | 75.4% | 2.0% |
| N2 V2 N3 (Matrix Clause) | | | | | | | | |
| FP | 808 | 19 | 831 | 19 | 806 | 17 | 846 | 24 |
| RR | 1,190 | 36 | 988 | 33 | 1,142 | 32 | 994 | 39 |
| GP | 1,260 | 31 | 1,139 | 26 | 1,236 | 26 | 1,129 | 32 |
| RO | 29.3% | 1.7% | 22.6% | 1.6% | 28.5% | 1.5% | 20.9% | 1.9% |
| RI | 53.4% | 1.9% | 52.9% | 1.9% | 51.6% | 1.7% | 56.3% | 2.3% |
| | Empty | | | | DCL | | | |
| | ORC | | SRC | | ORC | | SRC | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| N1 V1 Freq DE (Full RC) | | | | | | | | |
| FP | 795 | 25 | 820 | 25 | 673 | 35 | 754 | 35 |
| RR | 1,562 | 51 | 1,350 | 46 | 1,474 | 76 | 1,231 | 64 |
| GP | 1,138 | 30 | 1,192 | 27 | 1,363 | 55 | 1,139 | 42 |
| RO | 26.2% | 2.0% | 27.9% | 2.1% | 47.4% | 3.3% | 26.1% | 2.9% |
| RI | 88.0% | 1.5% | 81.0% | 1.8% | 73.9% | 2.9% | 77.0% | 2.8% |
| N2 V2 N3 (Matrix Clause) | | | | | | | | |
| FP | 771 | 23 | 842 | 24 | 883 | 35 | 810 | 33 |
| RR | 1,254 | 46 | 1,017 | 42 | 1,053 | 55 | 934 | 54 |
| GP | 1,321 | 41 | 1,148 | 32 | 1,137 | 45 | 1,121 | 44 |
| RO | 33.9% | 2.2% | 23.0% | 2.0% | 20.0% | 2.6% | 21.7% | 2.7% |
| RI | 51.9% | 2.3% | 51.3% | 2.4% | 56.5% | 3.3% | 56.1% | 3.3% |

**Table 2.8. Experiment 2: linear mixed effect models for the additional analyses**

| | RC Condition | | | Determiner Type | | | Interaction | | |
|---|---|---|---|---|---|---|---|---|---|
| | coef. | SE | *t/z* value | coef. | SE | *t/z* value | coef. | SE | *t/z* value |
| N1 V1 Freq DE (Full RC) | | | | | | | | | |
| FP | 0.12 | 0.04 | 2.98** | -0.06 | 0.01 | -4.29*** | 0.05 | 0.03 | 1.82 † |
| RR | -0.19 | 0.04 | -4.98*** | -0.03 | 0.01 | -2.43* | 0.00 | 0.02 | 0.009 |
| GP | -0.04 | 0.02 | -1.821 † | 0.01 | 0.01 | 1.437 | -0.07 | 0.01 | -5.02*** |
| RO | -0.51 | 0.13 | -3.78*** | 0.16 | 0.04 | 3.53*** | -0.39 | 0.09 | -4.38*** |
| RI | -0.26 | 0.16 | -1.66 † | -0.25 | 0.05 | -4.76*** | 0.28 | 0.10 | 2.74** |
| N2 V2 N3 (Matrix Clause) | | | | | | | | | |
| FP | 0.01 | 0.03 | 0.468 | 0.01 | 0.01 | 1.238 | -0.06 | 0.02 | -2.70** |
| RR | -0.18 | 0.04 | -4.46*** | -0.04 | 0.01 | -3.15** | 0.03 | 0.03 | 1.102 |
| GP | -0.08 | 0.03 | -2.96** | -0.03 | 0.01 | -3.41*** | 0.04 | 0.02 | 2.57* |
| RO | -0.25 | 0.15 | -1.71 † | -0.16 | 0.05 | -3.26** | 0.25 | 0.10 | 2.59** |
| RI | -0.06 | 0.13 | -0.439 | 0.07 | 0.04 | 1.71 † | 0.01 | 0.08 | 0.073 |

Note. A positive coefficient indicates an increase in reading time for the SRC condition or an increase in reading time for the DCL type.

# CHAPTER 3

# Ambiguity in Korean Relative Clause Processing

This chapter is modified from the study:

Mansbridge, M., Park, S., & Tamaoka, K. (2017). Disambiguation and integration in Korean relative clause processing. *Journal of Psycholinguistic Research*, *46*(4), 827-845. doi:10.1007/s10936-016-9461-z

This published work is a collaborative project designed by myself, Michael Patrick Mansbridge. The paper and its arguments were written primarily by me. Professor Katsuo Tamaoka supervised the project, and both co-authors provided feedback during the writing process. Professor Sunju Park was responsible for stimuli development for Experiment 1. She also helped by providing a native speaker's interpretation. For the eye-tracking experiments, I designed and built both experiments. Both Professor Sunju Park and I proctored Experiment 1, and I along with a research assistant, proctored Experiment 2. For all the results of this Chapter, I did all the analyses.

## 3.1. Abstract

Previous studies on Korean relative clauses (RC) show that, with respect to processing, object-extracted relative clauses (ORC) are more difficult to process at the head noun than subject-extracted relative clauses (SRC) within temporarily ambiguous contexts. ORCs, however, are predicted by expectation-based processing models of surprisal to incur a greater processing cost during early processing stages at the RC verb, since it is a likely locus of disambiguation for RCs in Korean, and because ORCs are a less frequent structure compared to SRCs. Consequently, the current study investigates whether processing difficulty for ORCs manifests itself at the RC verb using eye-tracking methods, both ambiguous and unambiguous RCs, and both a sentential-decision task and comprehension task. The results revealed significantly increased go-past reading times for ORCs at the RC verb and head noun for both ambiguous and unambiguous RCs. I believe this is a result of a less frequent structure being more difficult to parse during disambiguation. Additionally, the findings at the head noun support an integration metric based on structural-phrase integration rather than linear/temporal metrics. Ambiguity, however, had little effect on the overall processing pattern for Korean RCs. The lack of influence from ambiguity may be attributed to Korean having distinct loci for disambiguation and integration. Consequently, expectation-based models of processing accurately predicted difficulty for ORCs at the locus of disambiguation in Korean.



**Keywords** Korean, relative clauses, eye-tracking, expectation, ambiguity


## 3.2. Introduction

Relative clauses (RC) are a prominently discussed topic in the field of experimental linguistics. Crosslinguistic research has shown that among the large majority of languages which allow both subject-extracted relative clauses (SRC) and object-extracted relative clauses (ORCs), ORCs are both less frequent in corpora and more difficult to process and comprehend. Korean is an example of a language with this footprint. This has been demonstrated by Kwon and colleagues (Kwon, 2008; Kwon, Gordon, Lee, Kluender, & Polinsky, 2010; Kwon, Kluender, Kutas, & Polinsky, 2013; Kwon, Polinsky, & Kluender, 2006) using self-paced reading (SPR), eye-tracking and event related potentials (ERP). However, even within Korean, there have been numerous explanations to account for the difficulty of ORC processing, and the influence of the initial clause-type ambiguity apparent in Korean relative clauses is still debatable. Consequently, the aim of the current study is to, after replicating the previous findings (i.e., ORC difficulty), use eye-tracking experiments to tease apart the factors that contribute to the ORC processing difficulty found in Korean as well as determining what influence, if any, the initial clause-type ambiguity found in Korean relative clauses has on relative clause processing in Korean.

### 3.2.1. Korean Relative Clauses

In Korean, the RC precedes the head noun it modifies (i.e., RCs are head-final or prenominal). According to the *World Atlas of Language Structures* (Dryer, 2013), languages with prenominal RCs are the second most frequent RC-ordering type (17%) after languages where the RC follows the head noun (i.e., head-initial or post-nominal languages, such as English; 70%). Examples of Korean head-final relative clauses are given below:

(3.1a) Subject exracted relative clause (SRC)

| | | | | | |
|---|---|---|---|---|---|
| [GAP$_i$ | *Uywon-ul* | *Kongyekha-n*] | *Gijaneun*$_i$*-i* | *Jinju-lul* | *Boass-ta* |
| [*gap* | senator-ACC | criticize-ADN] | reporter-NOM | Jinju-ACC | saw |

English: The reporter$_i$ [who$_i$ GAP$_i$ criticized the senator] saw Jinju.

(3.1b) Object-extracted relative clause (ORC)

| | | | | | |
|---|---|---|---|---|---|
| [*Uywon-i* | GAP$_i$ | *Kongyekha-n*] | *Gijaneun*$_i$*-i* | *Jinju-lul* | *Boass-ta* |
| [senator-NOM | *gap* | criticize-ADN] | reporter-NOM | Jinju-ACC | saw |

English: The reporter$_i$ [who$_i$ the senator criticized GAP$_i$] saw Jinju.

Korean is a canonically SOV (i.e., Subject-Object-Verb) ordered language. As seen above, Korean RCs also demonstrate a canonical SOV word order. Similar to other languages, Korean is argued to have gaps within the relative clause where the head noun would need to link back in order to receive its grammatical role specific to that clause (Kaplan & Whitman, 1995). There has, however, been some debate about the nature of gapped RC interpretations for prenominal RC languages such as Korean, Japanese and Mandarin. Some researchers (e.g., Comrie, 1996, 2003; Murasagi, 2000) believe that instead of a gapped relative clause interpretation, these languages utilize argument ellipsis, zero anaphora or pronominal drop (i.e., pro-drop: Subject pro-drop and object pro-drop) to account for the missing argument within the RC. In these arguments, the general principal is that the pro within the RC and the head noun are both base generated at their respective positions in the structure. Comrie's motivation for this is that Japanese and Korean allow for zero anaphora and each has other clauses similar in structure in which no gap exists. From this argument, Comrie instead argued that relative clauses in these languages should instead be classified as attributive clauses. However, I follow along the lines of Bugaeva and Whitman (2016) and Cha (1999) who also demonstrated that typical Korean RCs likely have gaps as well as Lee (2006) who provided a convincing argument for why movement (specifically, *wh*-operator movement) provides the most suitable explanation for the Korean RC structure. Thus, I hereafter consider that RCs in Korean have gaps. As such, my position on this issue should not be considered controversial.

For this study, whether the clause has a gapped argument or a pro-drop argument is not so critical, as in both cases, the head noun must co-index with either the gap position or the pro. However, what may be critical is how movement is defined. Specifically, the issue would be if the RC undergoes head-raising movement from the gap to the situated position of the head, or if the RC involves covert *wh*-movement of a *wh*-operator from the gapped position to [Spec, CP]. For example, in English even when the relative pronoun is dropped, RCs are formed by the existence of a null or covert *wh*-operator (Browning, 1987). This operator, while not manifested on the surface form, covertly moves from the gap position to [Spec, CP] to assign RC features to the embedded clause, thus allowing the clause to be understood as an RC. The issue between operator movement and head-raising is, in terms of filler-gap parsing, whether or not the head needs to interact with the operator or the operator's trace (i.e., gap).

For Korean, while each RC structure is inherently different, the only surface difference between the RC structures is the case marker suffixed to the RC noun (e.g., senator-ACC & senator-NOM), and in both types of RCs, the RC is only overtly marked as a general embedded clause by the adnominal marker (*–n*/*–un*/*–nun*) affixed to the embedded RC verb (e.g., criticize-ADN) (see Kim, 2016; Lee, Madigan, & Park, 2016; Martin 1992; O'Grady, 1991; Sohn, 2001). The use of this adnominal marker is not exclusive to RCs as it can also appear in other embedded clause contexts which have distinct structures from RCs. While the adnominal marker is sometimes referred to as a relativizer marker in Korean (e.g., Shin, 2003), I will henceforth refer to it only as an adnominal marker.

These Korean features potentially make the RCs temporarily ambiguous during processing, since they lack an overt RC marker at the left boundary (i.e., left edge) of the clause. This is particularly true since Korean also allows both pro-dropping and scrambling. In other words, without any facilitating discourse that could signal an initial RC interpretation, the parser might misconstrue an RC as a matrix clause until disambiguating information arrives. The phenomenon of clause-type ambiguity is also present in other prenominal languages and is addressed prominently in RC studies dealing with Japanese (Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008) and Mandarin Chinese (Hsiao & Gibson, 2003). See examples in Appendix Chapter 3 (p. 274) for a small subset of other possible clause types bearing similarity to the initial NP-ACC/NOM VP surface structure found in Korean RCs.

Korean also allows for the marker –*kes* to appear after the adnominal marker for not only relative clauses but other structures such as cleft and pseudo-cleft structures as well (e.g., Cha, 1999; Chung & Kim, 2003; Jhang, 1994). The marker –*kes* is similar to the -*no*-*ha* (nominalizer-topic) marked internally-headed and headless constructions in Japanese (Simpson & Wu, 2001) as well as the internally-headed clauses in Cantonese (Chan, Matthews & Yip, 2011) and headless constructions in Mandarin marked only with the relativizer –*de* (Simpson & Wu, 1999). This is because –*kes* typically occurs within internally-headed and headless constructions in Korean as well. However, there is some controversy surrounding the exact role of –*kes* in Korean. While some researchers considered it as a pronominal (e.g., carrying the meaning of he, she, it, etc.); others considered it as a complementizer for embedded clause structures (Simpson & Wu, 1999). Considering that the marker can appear in both externally-headed and internally-headed relative clauses, the complementizer function may be more appropriate for Korean RCs. Yet, it is important to note that –*kes* infrequently appears in colloquial externally-headed RCs (see Jhang, 2004), which are the main point of interest in the current study. As such, –*kes* is not used in any form in the current study.

In terms of sentence processing, Kwon and colleagues (Kwon, 2008; Kwon et al., 2010; Kwon et al., 2013; Kwon et al., 2006) have revealed much about the processing of Korean, and chiefly attributed the processing difficulty associated with

ORCs to expectation-based (i.e., experience-based) effects (Hale, 2001, 2006; Levy, 2008; MacDonald & Christiansen, 2002; Mitchell, Cuetos, Corley, & Brysbaert, 1995) and structural-phrase integration (O'Grady, 1997) at the head noun. While Kwon et al. (2010) illustrates that the locus of disambiguation for each clause may vary in temporarily ambiguous contexts and that the head noun will guarantee a correct RC interpretation, the adnominal marker can at the very least disambiguate RCs from matrix clauses since matrix verbs lack adnominal markers. A brief review of both processing accounts is given below, followed by a review of Kwon and colleagues' findings.

## 3.2.2. Relative Clause Processing

### 3.2.2.1. Expectation-Based Processing Models

*Expectation-based processing* models (Hale, 2001, 2006; Levy, 2008; MacDonald & Christiansen, 2002; Mitchell et al., 1995), regard processing to be guided by our prior experience with a given language. Accordingly, a more frequent structure in a language will be easier to parse than a less frequent structure (see Demberg & Keller, 2008; Husain, Vasishth, & Srinivasan, 2014; Levy, Fedorenko, & Gibson, 2013; Reali & Christiansen, 2007). Since Korean ORCs occur significantly less frequently in corpora than their SRC counterparts (see Kwon, 2008), expectation-based processing models (Hale, 2001; Levy, 2008) predict that there should be greater difficulty when reading a Korean sentence containing an ORC compared to an SRC. For temporarily ambiguous structures, such effects based on the frequency of RC structures should not begin until the structure has been disambiguated. At this point the expectation that the RC is a more frequent SRC would be met, or there would be a dashed expectation (i.e., high surprisal cost) if it is instead the less frequent ORC (Hale, 2001; Levy, 2008). See below for an example of dashed-expectations in both post-nominal English and prenominal Korean. A key difference between these languages is that expectations are predicted prior to reading the RC in English and after reading the RC in Korean (for ambiguous contexts).

(3.2) Postnominal English Example

The reporter who…

[At the relative pronoun ‘who’, the parser is aware of the RC structure and would predict an SRC. Thus, following ‘who’, a verb/predicate would be expected. For the ORC condition, an article (e.g., ‘a’ or ‘the’) following the relative pronoun would be less expected.]

SRC: The reporter who… criticized

[Expected. No increase in processing difficulty]

ORC: The reporter who… the

[Dashed-expectation or surprising. Increase in processing difficulty]

(3.3) Prenominal Korean Examples

SRC: *uywon-ul kongyekha-n*…

senator-ACC criticized-ADN

[Here, the parser is aware of the embedded structure, and the SRC structure is expected. No increase in processing difficulty.]

ORC: *uywon-i kongyekha-n*…

senator-NOM criticized-ADN

[Here, the parser is aware of the embedded structure, and the ORC structure has a dashed-expectation since the nominative case marker disagrees with an RC expectation. Increase in processing difficulty.]

Evidence supporting an expectation-based account for RC processing has already been revealed for Mandarin Chinese. Mandarin is another language which has prenominal, temporarily ambiguous RC structures, and in which ORCs occur less frequently than SRCs. What is more, Mandarin, similar to Korean, has a relativizer marker adjacent to the head noun. In an ambiguous context, this relativizer would be the locus of disambiguation for clause type. Studies by Lin and Bever (2006) and Qiao, Shen, and Forster (2010) found an increased processing cost at the relativizer position for ORCs within ambiguous contexts supporting expectation-based processing predictions. Furthermore, Jäger, Chen, Li, Lin, and Vasishth (2015) demonstrated that if the initial ambiguity is removed by creating a clause boundary for an embedded clause, SRCs become easier to process compared to ORCs prior to the relativizer in Mandarin. However, such clear and concrete evidence for an expectation-based processing account has yet to be observed in Korean or other prenominal languages such as Japanese.

According to the *Entropy Reduction Hypothesis* (Hale, 2006; Yun, Chen, Hunter, Whitman, & Hale, 2015), there is greater processing difficulty due to the uncertainty in the sentence. More specifically, when the entropy level is reduced, the case that has the largest reduction in entropy (i.e., moving from a more uncertain to certain structure) is an indication of processing work. Thus, I would expect an increase in reading times for these cases. In terms of Korean relative clauses, ORCs have greater entropy reduction than SRCs at the processing of the case marker at the critical RC noun (e.g., nominative case for ORCs and accusative case for SRCs) and at the head noun as well. In particular, when processing the RC noun for both RC conditions, there is high level of uncertainty in each structure. However, when the case marker is parsed, there is a greater drop in entropy for ORCs since the nominative case marker narrows down the number of possible structures in comparison to the accusative case marker for SRCs. This should consequently increase reading times for ORCs at this position. Similarly, since there is greater reduction in entropy moving from the RC verb to the head noun for ORCs, ORCs are also predicted to be more difficult to process at the head noun. However, entropy reduction makes no prediction for ORC difficulty at the RC verb which contains the disambiguating adnominal marker. On the other hand, for truly unambiguous relative clauses (i.e., 100% certainty), Yun et al. (2015, p. 127) state that entropy reduction may not be able to explain differences in processing since the structure would be certain from the start; thus, no uncertainty. For a more detailed account on entropy reduction predictions in Korean, refer to Yun et al. (2015).

#### 3.2.2.2. Integration-Based Models

For filler-gap dependencies (Chomsky, 1965, 1981; Clifton & Frazier, 1989; Fodor, 1989; Hawkins, 1999), the head noun is required to be integrated with the gap to assume its grammatical role within the RC; however, the mechanism for integration is not yet fully understood, and there are several competing models within the literature (c.f., Gibson, 2000; Lewis & Vasishth, 2005; O'Grady, 1997). A basic principle for integration is that as the distance increases between the filler and the gap, integration becomes more difficult. Distance metrics, however, have been defined differently by different researchers. Specifically, these distance metrics have been defined as: (1) Linear-distance (Gibson, 1998, 2000) based on the number of intervening syntactic dependencies on a linear plane, (2) temporal distance (Lewis & Vasishth, 2005) based on the amount of time between the processing of the filler and gap, and (3) structural-phrase distance (O'Grady, 1997) based on the number of intervening structural-phrase nodes in syntactic structure. For a language such as Korean, linear- and temporal-distance both would predict that integration for ORCs should be easier than SRC integration. This is because there are less discourse referents between the filler and gap. Meanwhile, the structural-phrase definition of distance predicts that ORCs should be more difficult than SRCs, as there are more intervening structural phrases between the gap and the object head than between the gap and the subject head. See Figure 3.1 for an illustration of this.

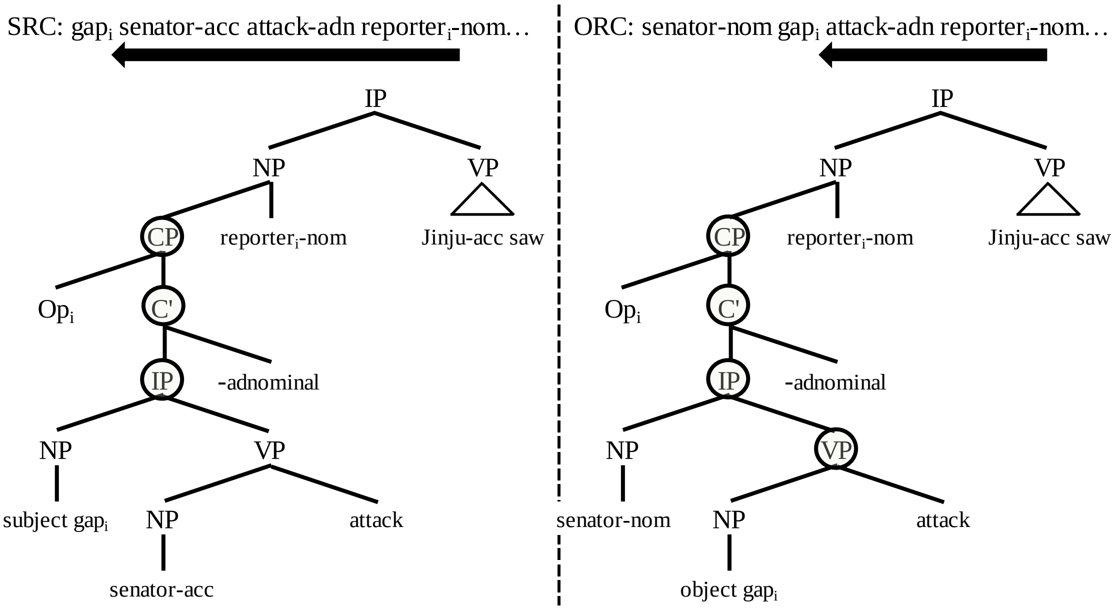


**Figure 3.1. Basic syntactic structure for Korean relative clauses**
The circles represent the syntactic phrases intervening between the filler and gap for each RC. The black arrows represent the general linear/temporal distance between the filler and gap for each RC.

### 3.2.2.3. Similarity-Based Interference and Successive Case

According to Gordon et al.'s (2001) *Similarity-Based Interference* model, while reading sentences, I store and maintain noun dependents with their assigned syntactic and semantic features in working memory for later reactivation and integration with their respective verbs. Accordingly, if two or more similar nouns are stored in memory, they may interfere with each other during the retrieval of one of them. This would also be modulated by how similar these nouns are to one another. As they become more similar in gender, number, noun type, semantic or grammatical role, the larger the impact of the interference will become. Consequently, this model would predict ORC difficulty at the matrix verb for the retrieval of the matrix subject since an ORC head would be more similar to the RC subject NP in comparison to an SRC head which as an RC object NP.

It is important, however, to note that this model differs from Lewis and Vasishth's (2005) similarity-interference model. Their model is based within the framework of cue-based retrieval. In relation to *ACT-R* (Anderson, 1996), it is described that the activation level of a given word or structure is also influenced by the number of other items sharing overlapping features (e.g., animacy, syntactic position, gender, number) surrounding it within a sentence. Dissimilar to Gordon and colleagues, Lewis and Vasishth's claim that similarity-interference is an issue only related to retrieval processes and not encoding processes. That is to say storing similar nouns with matching features does not increase processing difficulty but instead only lowers the activation level of these nouns. The difficulty occurs only when a retrieval cue for one of these nouns is initiated. In Gordon's model, difficulty occurs while storing and retrieving these nouns.

In Lee, Lee, and Gordon (2007), similarity-based interference was observed for similar centre embedded structures in Korean. In cases where two nouns, one within the embedded structure and the other the matrix clause, were marked with nominative case and had matching noun-type features, processing difficulty was seen at the matrix clause predicate as predicted by Gordon's similarity-based interference model. This finding is also compatible with Nakayama, Lee, and Lewis (2005) who found similar effects in Japanese as well as greater difficulty understanding two NPs marked with nominative case in Korean.

While Lee et al. (2007) also tested similarity-based interference within relative clause constructions, this was done exclusively for in situ object-modified ORCs. In such a construction, the RC subject directly follows the matrix clause subject, and the matrix object assumes the role as the RC head (i.e., [$_{\text{matrix clause}}$ NP-NOM [$_{\text{RC}}$ NP-NOM VP-ADN] NP-ACC VP]. Furthermore, they did not compare ORCs with SRCs; instead, they exclusively tested ORC sentences. Like before, they observed that when the matrix subject and the ORC subject matched in features, there were greater processing demands compared to when the noun types were different, albeit during later re-reading time. The key difference between Lee et al.'s (2007) design and using subject-modified materials would be that the two nouns would not follow directly after one another. Instead, there would at least be an intervening verb to process prior to the reading of the second noun bearing similar features (i.e., $[_{\text{matrix clause}}$ $[_{\text{RC}}$ NP-NOM VP-ADN] NP-NOM NP-ACC VP]. Even though Lee et al. (2007) did not compare ORCs to SRCs for similarity-based interference, the same principles may be applied to such a comparison. The critical difference would not compare noun types as in previous studies, but instead compare the matching or mismatching conditions of case or grammatical function between nouns. In other words, ORCs would have matching features of nominative case and subject role while SRCs would not since the RC noun would have accusative case and object role features.

#### 3.2.2.4. The Object-Before-Subject-Bias

The *Object-Before-Subject-Bias* (Nakamura & Miyamoto, 2013) is another processing account predicting ORC difficulty in Korean. This theory relies less on expectation and integration processing resources and is instead formulated around the difficulties surrounding thematic (i.e., theta role) assignment for the subject and object arguments of the relative clause. For example, there is difficulty assigning <agent> and <patient> roles to the subject and object respectively for ORCs. Nakamura and Miyamoto (2013) base their theory off of Tomlin’s (1986) *Verb-Object Bonding Principle* which states that while a transitive verb assigns the theta role of the direct object, however, the object is responsible in assigning the theta role to the subject. This phenomenon is due to some degree of ambiguity in the theta grid of a transitive verb (i.e., what theta roles can be assigned by a transitive verb). Take the verb ‘caught’ for example. For such a predicate there are multiple theta roles available for the subject, and it is only after integrating the object into the sentence that the subject’s role is determined. See below for an example of how the object determines the theta role of the subject.

(3.4) English Example
Prefix String: The man caught…
Theta Role Option 1: a ball [‘the man’ becomes <agent>]
Theta Role Option 2: a cold [‘the man’ becomes <experiencer>]

For both Korean and Japanese, the object-before-subject-bias states that ORCs are inherently more difficult due to ordering of assignment for thematic roles and also for ORCs the object head appears after the relative clause. In other words, the subject’s role for ORCs has to wait until the head noun is parsed for theta role assignment while the subject’s role in SRCs is immediately assigned at the head noun; see below.

(3.5) Ordering of Thematic Arguments: Korean Examples

SRC: *Uywon-ul Kongyekha-n Gijaneun-i*

senator-ACC criticize-ADN reporter-NOM

[Theta role assignment: (1) the object 'senator' and then (2) the subject 'reporter'. In other words, the RC theta role for 'reporter' is immediately assigned.]

ORC: *Uywon-i Kongyekha-n Gijaneun-i*

senator-NOM criticize-ADN reporter-NOM

[Theta role assignment: (1) the object 'reporter' and then (2) the subject 'senator'. The RC theta role for 'senator' is assigned after reading 'reporter'.]

According to Nakamura and Miyamoto (2013), processing difficulty for ORCs is predicted to occur at both the head noun and the RC verb. However, it is important to note that the difficulty at the RC verb would occur after processing the head noun since the RC direct object would be required to interface with it to assign the theta role of the RC subject. Recently, Kwon (2016) herself speculated that for Korean RC processing, ORC difficulty may be attributed to thematically related issues rather than integration. Considering how she and Miyamato (2016) agree on this matter, thematic assignment could very well be a source of processing difficulty for ORCs at the head noun for both Japanese and Korean.

However, as Nakamura and Miyamoto note (2013, p. 324), the assignment of the thematic role for the subject can appear prior to the integration of an object, due to anticipatory resources. This is a probable scenario for unambiguous clauses, which would allow the assignment of thematic roles to occur earlier out of greater anticipation for a head noun at the embedded RC verb. There is one additional problem for the object-before-subject-bias theory. That is pronominal drop interpretation. Considering that both Japanese and Korean allows for subjects and objects to be dropped from the sentence on the surface structure, thematic role assignment for the subject and object in both ORCs and SRCs can occur prior to the reading of the head noun.

#### 3.2.2.5. Previous Findings in Korean

While Kwon and colleagues have effectively shown that ORCs are more difficult to process than SRCs in Korean, a general issue with these studies is that there are far too many accounts for this difficulty. In Kwon et al. (2010), expectation, integration, similarity-based interference (Gordon, Hendrick, & Johnson, 2001) and successive NP marking (Lee, Lee, & Gordon, 2007; Nakayama, Lee, & Lewis, 2005) were all shown to contribute to ORC difficulty in eye-tracking studies. In temporarily ambiguous structures, Kwon et al. (2010) claimed that this processing difficulty starts with the introduction of the head noun. These findings, combined with Kwon et al. (2006) and Kwon et al. (2013), which both revealed no reliable observation of ORC difficulty prior to the head noun, would suggest that ORC difficulty in Korean begins at the head noun. As such, Kwon and colleagues claim that the locus of disambiguation for Korean RCs is the head noun. However, the following paragraphs describe how this point is debatable, given that adnominal markers likely correspond with an RC interpretation. This is supported by corpora findings and expectation-based models, both of which explain the ORC difficulty found at the adnominal marker and how difficulties at the head noun most likely represent effects of integration as defined by a structural-phrase metric.

As mentioned previously, the adnominal marker in Korean at the very least allows the parser to eliminate an incorrect matrix clause interpretation for the RC structure. Kwon and colleagues hold the belief that the parser will wait until reading the head noun to construct a new interpretation for the RC, as the adnominal marker does not guarantee an RC reading. This is because other embedded clauses can also be marked with the same adnominal marker, and the surface structure of these clauses can appear nearly identical to an RC's until the adnominal marker. For instance, a *fact*-clause (see Kwon, 2008, pp. 17-18) would appear identical to an RC except that instead of a subject or object gap, there would be a null pronominal (i.e., subject or object drop) in the underlying structure. The two clauses would differentiate at the head noun which would either be a RC noun (e.g., *gijaneun* 'reporter') or a de facto expression (e.g., *sasil* 'fact'). Kwon (2008) reported that the average frequency of RC headed clauses (12,154 per million) is higher than fact-clauses (10,732 per million) within the Sejong corpus (see Kang & Kim, 2004). A log-likelihood test revealed this difference to be significant ($\chi^2(1) = 88.41$, $p < .001$). Despite the two clause types being indistinguishable in ambiguous contexts at the embedded verb (e.g., criticize-ADN), under the expectation-based processing framework and the assumption that parsing is incremental and predictive (Kamide, 2008; Kamide, Altmann, & Haywood, 2003; Kamide & Mitchell, 1999) the parser would have a greater expectation of encountering the comparatively more frequent RC structure, compared to the less frequent fact-clause. This expectation would be either met or refuted when the parser encounters the head noun (Hale, 2001; Levy, 2008). Nevertheless, RCs would still be more difficult to parse at the head noun, compared to a fact-clause. This is because RCs would have to undergo the integration of the filler and gap, whereas the fact-clause would not.

According to expectation-based models of processing, if the parser is interpreting each clause as an RC at the embedded RC verb, then the ORC condition will begin to experience greater processing difficulty since it is the less frequent structure compared to SRCs. In fact, Kwon et al. (2010) was able to show marginal processing difficulty at the RC verb using temporarily ambiguous contexts and a significant difference with unambiguous RCs, both via regressive *go-past* measures (i.e., regression-path duration). Kwon and colleagues characterize this go-past measure as a later stage of processing and believe that it represents general comprehension difficulty. Accordingly, they did not attribute the difficulty found at the RC verb during go-past exclusively to expectation-based processing. However, go-past has the potential of being interpreted as an early stage effect (c.f., Clifton, Staub, & Rayner, 2007) and it has been shown to be a valuable measure within other RC studies (Gordon, Hendrick, Johnson, & Lee, 2006; Staub, 2010; Traxler, Morris & Seely, 2002). Considering that the head noun is not yet integrated into the sentence when the RC verb and the adnominal marker are read, there is nothing that could occupy the RC gap until the head noun is encountered. As such, the increased distance of filler-gap dependencies seems to be poorly suited to describe ORC difficulty at the RC verb before the reading of the head noun within ambiguous contexts. Accordingly, I interpret their results at the RC verb in both ambiguous and unambiguous contexts to be representative of expectation-based processing which first appear due to the adnominal marker allowing for the disambiguation of clause type.

While I hold the view that the adnominal marker would serve as a clause type disambiguation point and therefore would incur a surprisal cost for ORCs during disambiguation (Hale, 2001; Levy, 2008), I also maintain that ORC difficulty at the head noun is better explained by structural-phrase integration. Specifically since RC clause type would likely be established at the adnominal marker, the head noun should not be a locus of high surprisal for either RC type.

In summary, I assert that the processing of Korean RCs within a temporarily ambiguous context should be reinvestigated to validate an expectation-based processing account of ORC processing difficulty prior to the reading of the head noun.

### 3.2.3. Current Study

The present study will further investigate Korean RCs using eye-tracking. For Experiment 1, the main focus is to confirm that the processing difficulty for temporarily ambiguous Korean ORCs begins at the embedded RC verb, as predicted by expectation-based accounts of processing. A lesser aim of this study is to replicate the previous findings of Kwon and colleagues: I expect to find ORC difficulty at the head noun as predicted by the structural-phrase integration metric. In other words, I aim to show that both expectation-based processing and the structural-phrase integration model are accurate for Korean RC processing, and also that these effects appear at different loci, the adnominal marker suffixed to the RC verb and the head noun respectively. Accordingly, I presented participants with Korean sentences containing either an initially ambiguous SRC or ORC and used eye-tracking to monitor reading. Unlike previous studies, I included a sentential-decision task about the overall plausibility of the target sentence (i.e., whether the sentence can be acceptable/said in the language without resorting to paranormal interpretations) for Experiment 1. I chose this approach over the typical post-sentence comprehension probe because there has been some indication that comprehension probes may be more task-demanding than is required to parse and comprehend the sentence (Caplan, Chen, & Waters, 2008). For Experiment 2, the initial clause-type ambiguity was introduced as an experimental variable. Similar to Kwon et al. (2010), the purpose is to determine if RC processing is influenced as a factor of the level of ambiguity at the start of the RC. However, while Kwon et al. (2010) used discourse priming to attenuate ambiguity, a syntactic cue was given to create a clause boundary between the RC and matrix clause at the start of the relative clause structure.

## 3.3. Experiment 1

The aim of Experiment 1 was to investigate whether Korean ORCs are more difficult to process at the embedded RC verb than SRCs before the head noun is read within ambiguous contexts (i.e., the RC is initially interpreted as a simple matrix clause). If this is so, this experiment can be understood as an indication of support for expectation-based models of processing. A sentential judgment task and eye-tracking methods were used to capture eye-movements and reading times to reveal which RC type was more difficult to process.

### 3.3.1. Methods

#### 3.3.1.1. Participants

Thirty-two native speakers of Korean were recruited from Nagoya University, Japan. Due to calibration errors, one participant was removed from the study (N = 31, female = 17). These participants were undergraduate, graduate or research students of Nagoya University at the time of the study. The mean age of the participants was 24 years and 7 months (range: 19 years and five months to 35 years and 10 months). Participants gave written, informed consent and received monetary compensation after the experimental session.

#### 3.3.1.2. Materials

Thirty-two experimental items containing RCs were created for this study (see Appendix Chapter 3, p. 272). All RCs modified the matrix subject of the sentence. Items were counterbalanced to ensure that a participant would only view either the SRC or ORC variant for a given target. A SRC and its ORC counterpart only differed in the case marking suffix at the end of the RC noun (SRC is N-ACC & ORC is N-NOM). The head noun was always marked with nominative case.

All experimental items were designed to have a relatively simple structure. The RC only contained the RC noun and verb, and the matrix clause consisted of the head noun, an adverb and an intransitive verb. In Kwon et al.'s (2010) items, there was an additional argument in both the RC and matrix clause. I used a simpler structure than their previous experiments because I wished to eliminate any processing difficulty related to parsing additional arguments.

All nouns were proper first names (e.g., Jinju and Minji). The basic structure for the experimental stimuli was as follows: [$_{\text{matrix clause}}$ [$_{\text{RC}}$ NP-ACC/NOM VP-ADN] NP-NOM ADV VP]. The example below transliterates the target sentence into the Roman alphabet. However, Korean speaking participants were shown sentences written in Hangul. Since the secondary task was a sentential-correctness decision and all experimental items were semantically correct (e.g., plausible) utterances in Korean, 32 additional RC items (SRC = 16) were created that contained a semantically incorrect (implausible) verb at either the RC verb or matrix verb. See (3.6) below for an example of an item used in the study.

(3.6) Korean RC Stimuli Regions

| RC Noun | RC Verb | Head Noun | Adverb | Matrix Verb |
| --- | --- | --- | --- | --- |
| [*jinju-lul/ka* | *seoldeugha-n*] | *minji-ka* | *gyeolgug* | *nawassda* |
| Jinju-ACC/NOM | persuaded-ADN | Minji-NOM | eventually | came.out |

'Minji who persuaded Jinju (Jinju persuaded) eventually left.'

#### 3.3.1.3. Apparatus

Stimulus sentences were displayed horizontally on the centre left of a 17-inch Mitsubishi LCD monitor at a distance of 70 cm from the head and chin rest mount. All characters were displayed in Korean (Gulim 25pt; visual angle of 0.72˚). The colour of the screen was white, and the colour of the font was black. The resolution of the monitor was 1024 by 768. Eye movements were recorded using an EyeLink 1000 Core System (desktop EyeLink 1000 SR Research Ltd., Ontario, Canada). The resolution of the eye-tracker was 0.01˚ RMS, and the sampling rate was 1,000 Hz (i.e., measured every 1 ms). Only right eye-fixation data was collected. An attached gamepad was used for button-responses.

#### 3.3.1.4. Procedure

Participants were instructed in Korean (by the proctor and the experimental program) to read Korean sentences displayed one at a time on a computer monitor, and told that they would be asked to judge whether the sentence was semantically correct (that is, able to be said or make sense in a real world setting without resorting to a paranormal interpretation) by pressing either "True" or "False" marked buttons on the gamepad. If the item was semantically correct, they were instructed to press the "True" button and "False" for semantically incorrect. It is important to note that "True" and "False" were only labels that oriented participants to press either a left or right button. This means participants were not instructed to judge the sentence using logic. They were instead asked to read and judge the sentence as quickly and accurately as possible while still maintaining accuracy and were given a maximum of eight seconds to complete each item in the task. Eight practice items were given prior to the experiment proper to ensure that the participants understood the task.

Prior to each experimental session, the camera was calibrated for each participant. This was accomplished by a 9-point calibration method and subsequent validation. Calibration was periodically repeated throughout each experimental session after block sessions (blocks of eight items) or when a participant was unable to accurately fixate on the mask (within a block session). Prior to each trial, a drift-checking fixation mask was presented at the centre left of the screen, the point at which the sentence would begin. Once the participant accurately fixated on the mask, the proctor would remove the mask and display the trial sentence. The participants then read each sentence and made their judgment using the gamepad (within eight seconds). After the button response, the stimulus item was immediately removed and no feedback was given. Reading times were measured from the onset of the stimuli to the button press response.

#### 3.3.1.5. Eye-Tracking Measures

Reading time measures for the various processing stages (i.e., early and late) were collected for each word of the sentence. For eye-tracking measures, I follow Clifton et al.'s (2007) descriptions of eye-tracking. The earliest processing stage reported is *first-fixation duration* which refers to the first fixation made in an interest region consisting of only a singular fixation point. Next is *first-pass* reading time (RT) which is composed of all fixations made within an interest region from when the region is first entered (from the left) until the region is exited in either direction (left or right). This measure can be a collection of one or more fixation points; thus, it is equal to or greater than first-fixation duration. A key regression measure reported in this study is *go-past* RT, the total reading of an interest region (e.g., RC Verb) before the region is exited to the right (e.g., Head Noun) for the first time. This also includes any regressive readings out of the region to the left (e.g., RC Noun) before going right. Therefore, go-past RTs are greater than or equal to first-pass RTs. The late processing measure reported in this study is *re-reading* time, the sum of all fixations after first-pass RT for an interest region (total time in the region minus first-pass RT). Additionally, *regression–out* (i.e., first-pass regression-out) *proportion* and *regression–in proportion* are reported where applicable. The total reading time of the sentence and accuracy ratings are also reported.

### 3.3.2. Results

Prior to the analyses, five trials were removed due to participants failing to make a judgment within the eight second trial period. For the remaining trials, all fixations below 80 ms were merged into a neighbouring fixation within a one-radian degree distance (72 fixations). This was then followed by the removal of all remaining fixations under 80 ms and also fixations that exceeded 1,000 ms resulting in the removal of 824 fixation points (7.17% of all fixations). This treatment was done to remove data not representative of reading (e.g., blinks).

The collected reading times and binomial data (i.e., accuracy and regression-out) were analysed using linear mixed effect modelling (Baayen, Davidson, & Bates, 2008) and the *lme4* package (Bates, Mächler, Bolker, & Walker, 2014) within R (R Core Team, 2014). For every analysis, the fixed effect was RC type (ORC = -.5 & SRC = +.5) and the random effects were subjects and items (random intercept and slopes). Besides accuracy, all other analyses were done only on trials with correct judgments. Reading times were transformed using their natural logarithm (for improved normality of the residuals) and analysed with the *lmer* function with maximum likelihoods. Satterthwaite's approximations were used via the *lmerTest* package to generate *p* values for each model (Kuznetsova, Brockhoff, & Christensen, 2014). For binomial data, the *glmer* function (binomial link function) was used to calculate the *z* distribution using maximum likelihoods and Laplace approximations (Harding & Hausman, 2007; Jaeger, 2008). Data outliers (RT data only) were trimmed based upon ± 2.5 standard deviations of the predicted model which resulted in the elimination of 1.58% of the data. In the sections below, the results of each region of the sentence is reported separately. Refer to Table 3.1 (p. 156) for means and standard errors (natural log transformation for RTs) and Table 3.2 (p. 157) for the detailed results of the linear mixed effect modelling. See Figure 3.2 for individual plots.

#### 3.3.2.1. Sentence

The overall processing of sentences did not differ between RC conditions. While the total reading time of all sentences revealed that the ORC condition was read more slowly than the SRC condition, this effect was only marginal ($p = .077$). In addition, the difference in plausibility judgment accuracy between ORC (83%) and SRC (87%)

types was not significant ($p$ = .281). Consequently, the overall processing data of the sentences alone could not reveal which condition was more difficult to parse.

### 3.3.2.2. RC Noun (Jinju-ACC/NOM)

At the reading of the first region of the sentence, there were no significant differences between conditions during first-fixation duration ($p$ = .247) or first-pass RT ($p$ = .388). As such, no difficulty was found for either condition during early measures of processing at the RC noun. Re-reading time, however, revealed a marginal difference ($p$ = .082) between conditions, indicating that ORCs were read more slowly than SRCs during this later processing stage. Yet, regression-in probability ($p$ = .879) did not

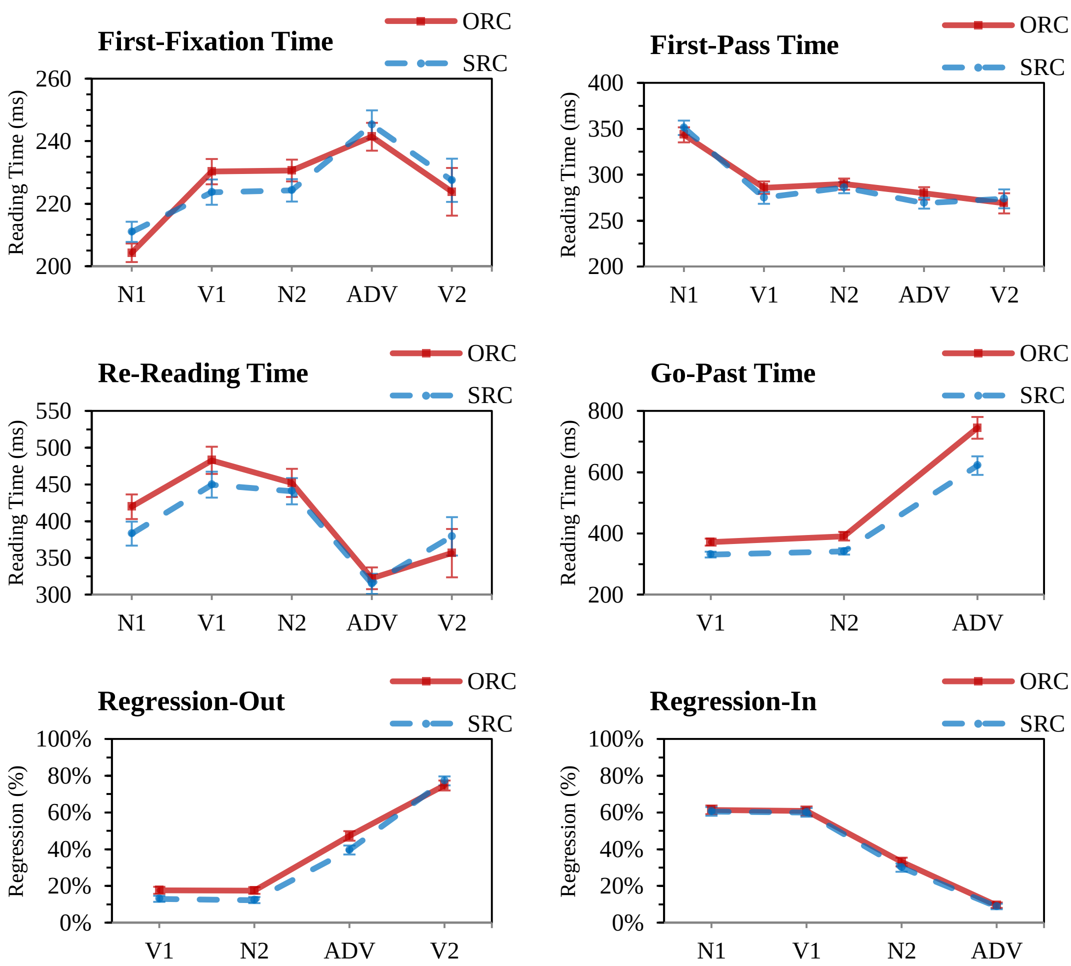


**Figure 3.2. Experiment 1 individual plots**
N1 stands for the RC noun, V1 stands for the RC verb, N2 stands for the head noun, ADV stands for the adverb, and V2 stands for the matrix verb.

reveal any differences between RC conditions. So, despite the marginal trend for longer re-reading times for ORCs, there was no difference in the likelihood of moving back into the RC noun.

#### 3.3.2.3. Embedded RC Verb (Persuaded-ADN)

For the RC verb, while first-past RT only displayed a marginal increase in RTs for the ORC condition ($p$ = .077), go-past RT did reveal a significant difference between conditions ($p$ < .01), demonstrating that participants spent more time reading ORCs before moving on to the head noun. However, despite the significant difference in go-past RT, the regression-out proportion ($p$ = .378) was not significantly different between conditions. Additionally, neither first-fixation duration ($p$ = .152) nor re-reading time ($p$ = .266) revealed any significant differences in RTs between conditions, and regression-in proportion ($p$ = .504) was also not significant. This suggests that ORC difficulty begins during the early stages of processing, but that this difficulty does not persist on to later stages. This difficulty likely subsides after the adnominal marker (e.g., criticize-ADN) was read, since first-fixation was not significant.

#### 3.3.2.4. Head noun (Minji-NOM)

At the head noun, only go-past RT revealed a significant difference between conditions ($p$ < .05). It was found that ORCs required more regressive readings back into the RC structure before moving into the adverb, compared with SRCs. First-fixation duration ($p$ = .153), first-pass RT ($p$ = .387), re-reading RT ($p$ = .846), regression-out proportion ($p$ = .169) and regression-in proportion ($p$ = .325) were not found to be significantly different between conditions.

#### 3.3.2.5. Adverb (Eventually) (N+1)

At the adverb, ORCs were read significantly more slowly than SRCs during go-past RT ($p$ < .05) and were significantly more likely to regress-out back to a prior region ($p$ < .05). First-fixation duration ($p$ = .492), first-pass reading ($p$ = .658), re-reading ($p$ = .797), and regression-in proportion ($p$ = .649), however, did not reveal any differences between conditions.

#### 3.3.2.6. Matrix verb (Came.out)

There were no significant differences between conditions during any reading time measure at the matrix verb (first-fixation duration ($p$ = .782), first-pass reading ($p$ = .849) and re-reading ($p$ = .265) and regression-out proportion ($p$ = .901).

### 3.3.3. Discussion

The results of Experiment 1 clearly indicated processing difficulty for object-extracted relative clauses in Korean. This was effectively shown at RC verb and head noun. Similar to Kwon and colleagues, this difficulty can be explained by several different processing accounts for the processing of ambiguous RCs in Korean. Despite multiple accounts being supported, the best explanations for the ORC processing difficulty at the embedded RC verb and the head noun are expectation-based processing effects at the RC verb and integration processing effects at the head noun. Below, I will note each account separately.

#### 3.3.3.1. Expectation-based processing

Considering that the first indication of ORC difficulty began at the RC verb during go-past reading times, this provides strong support for expectation-based processing models based on surprisal metrics (Hale, 2001 & Levy, 2008). As mentioned above, go-past should be considered as an earlier-than-late processing measure here since this measure is composed of both the first-pass reading times at the RC verb and any regressive readings to the left prior to the moving on to and reading the head noun. Since the adnominal marker acts as a locus of disambiguation and at the very least eliminates the simple matrix clause interpretation for the RC, ORC difficulty at this locus can be explained by the relative frequency of RCs in Korean. Owing to the fact that ORCs are less common, upon reading the adnominal marker suffixed to the RC verb, ORCs should incur a processing cost of surprisal because an SRC structure would have higher expectation than the less predicted ORC structure. While no significant effects were seen during first-fixation duration or first-pass reading time, first-fixation duration should not incur costs of surprisal since multiple fixations are, in all probability, required to read and process the verb and its morphology because of the length of the word. First-pass reading time at the RC verb, however, had a marginal trend showing longer RTs for ORCs which may have not reached significance due to the low number of participants recruited in Experiment 1.

One particular aspect of predictions based on structural frequency was not supported. This was the entropy reduction hypothesis at the RC noun (Hale, 2006). According to Yun et al. (2015), ORCs should be more difficult to process at the case marker of the RC noun due to the greater reduction of entropy when compared to SRCs. However, no processing difficulty was observed during early or late measures. While entropy-reduction can be supported at the head noun (the critical region is the noun itself), the RC noun may have not revealed any difference since the critical region is the case marker suffixed to the RC noun and not the noun itself. Consequently, I may have been looking at an unsuitable eye-tracking measurement for entropy at this region. For example, first-fixation duration is likely not sufficient to capture the processing of the case marker and first-pass reading time may have been a too coarse measurement for capturing the processes occurring which are related to integrating the case marker into the structure. Instead, second fixation duration may be more suitable to investigate entropy reduction models here. While second fixation duration is an available measurement for the apparatus, I nevertheless opted not to investigate it since it is not a common measurement for sentence processing. Thus, I do not refute the predictions made by entropy reduction at the RC noun, but simply assert that the typical eye-tracking measurements reported in sentence processing literature may have trouble revealing processing differences in such a case.

#### 3.3.3.2. Integration-Metrics

The difficulty at the head noun, however, should not be considered as spillover from the RC verb since, were that the case, spillover effects would be apparent during first-fixation or first-pass reading time at the head but this did not occur. Instead, the go-past reading time at the head noun should be instead viewed as support for an integration metric based on structural-phrase distance in Korean (linear/temporal metrics would predict an ORC advantage instead). Despite the RC being disambiguated at the RC verb, the head noun still needs to reactivate the gap for filler-gap processing. Since ORC difficulty was found here, integration appears to be defined by the structural-phrase metric and not the linear or temporal metrics which instead predict SRC difficulty. Since there are more intervening structural phrases between the head noun and gap in structure for ORCs compared to SRCs, ORCs have a greater processing demand here to integrate the two. Overall, the findings at the head noun are consistent with Kwon et al. (2010) who also revealed ORC difficulty at the head noun during the same reading measurement.

#### 3.3.3.3. Similarity-Based Interference

According to the similarity-based interference model as defined by Gordon et al. (2001), but not Lewis and Vasishth's (2005) model, there is difficulty in storing multiple nouns bearing similar features in working memory. Not only this, but there should also be greater difficulty in retrieving one of these particular nouns from working memory. Since ORC have two nouns bearing similar case and grammatical function, storing and retrieving these nouns should be more demanding than for SRCs which do not have these overlapping features. Thus, similarity-based interference may explain some of the processing difficulty at the head noun. However, a better indication of similarity-based interference would have been at the matrix clause verb since the predicate would have to retrieve the matrix subject which would have the RC subject as a competitor in memory.

#### 3.3.3.4. The Object-Before-Subject-Bias

Another possible interpretation for the ORC difficulty found at the RC verb and head noun could be the object-before-subject-bias (Nakamura & Miyamoto, 2013), which predicts greater processing difficulty for ORCs at both positions. The ORC processing difficulty, according to this theory, is attributed to the order of thematic assignment for the RC. Specifically, since thematic assignment of the subject is dependent on the object, ORCs would be more difficult since the head noun is the object of the RC. In other words, the RC subject would have to wait for its assignment until the processing of the head noun. This theory also predicts increased difficulty at the embedded RC verb after the parsing of the head noun since the object would likely be required to interface with the predicate when assigning the thematic role of the RC subject. However, late processing difficulty was not observed at the RC verb. Seeing as ORC difficulty was not observed at the RC noun as well, the object-before-subject-bias is perhaps not the best explanation for the increased go-past reading times at the head. As argued above, the more conceivable explanation for the ORC processing difficulty at the head noun is the structural-phrase integration metric.

#### 3.3.3.5. The Issue with Ambiguity and Discourse Priming

While Experiment 1 only investigated RCs with a temporarily ambiguous structure, Kwon et al. (2010) conducted a second eye-tracking experiment using facilitating contexts (i.e., discourse priming) that would help disambiguate the RC initially. However, no processing difficulty based on RC type was observed before the embedded RC verb in their study. This is peculiar, as ORCs should be initially more difficult to process at the RC noun if the parser correctly took an initial RC interpretation according to surprisal, expectation-based processing models. Here, the case marker would disambiguate for RC type. This means that ORCs should have a higher processing cost due to greater surprisal for the structure (Hale, 2001; Levy, 2008). While it was shown that including a facilitating context did indeed speed up the reading of the clause, no difference between RC types was shown prior to the RC Verb.

Considering that the results of Experiment 1 and both of Kwon et al.'s (2010) experiments are similar (i.e., marginally or significantly longer go-past times for ORCs at the RC verb), it is not clear whether participants took an initial RC interpretation in Kwon's study. In other words, the question remains whether discourse priming attenuated the expected difficulty for ORCs at the RC noun or whether the discourse did not prime for an RC interpretation. If the latter is accurate, then the results of Experiment 1 and Kwon et al. (2010) both can support the same claim that expectation-based processing effects are first predicted at the embedded RC verb for ORCs prior to the reading of the head noun under ambiguous contexts. Experiment 1 cannot support either possibility, but evidence from another prenominal RC language may shed light on this issue.

Recently, there has been some criticism against discourse priming methods for prenominal RCs. Gibson and Wu (2013), using this technique, found an ORC advantage for Mandarin Chinese RCs, which they claimed supported a linear-based integration mechanism and conflicted with expectation-based processing models (i.e., SRC advantage). However, Lin (2014) and Vasishth, Chen, Li, and Guo (2013) both provide arguments that Gibson and Wu's (2013) observation is better explained by thematic priming from the preceding discourse. Furthermore, findings in Japanese using discourse priming which supported an ORC advantage were actually retracted due to issues with the priming method, see Kwon et al. (2010) for their for retraction. As mentioned in the introduction, Jäger et al. (2015), using the target sentences from Gibson and Wu (2013), revealed that if the initial ambiguity is reduced or eliminated by creating a clause boundary for an embedded clause rather than using the priming technique, SRCs would become easier to process in Mandarin as explained by expectation-based processing. For Mandarin Chinese at the very least, attenuating the initial clause type ambiguity can influence whether expectation-based processing models correctly predicted the data or not.

Since methodology may be a confounding factor, I believe that more studies are needed, using both ambiguous and unambiguous structures, to reveal a better account of processing for Korean RCs prior to the head. Additionally, I believe that other methods may be needed to attenuate the clause type ambiguity found in Korean RCs as well as RCs in other prenominal RC languages (e.g., Japanese and Mandarin Chinese). Therefore, in Experiment 2, ambiguity was introduced as a possible processing factor using a method other than discourse priming. As a substitute for discourse priming, I adopted the overall strategy Jäger et al. (2015) used in Mandarin for Korean.

## 3.4. Experiment 2

In Experiment 2, clause-type ambiguity will be introduced as a factor in relative clause processing for Korean. Dissimilar to Kwon et al. (2010), discourse priming will not be the method used to attenuate the initial-clause type ambiguity since prior studies in Japanese and Mandarin have had issues with the interpretability of the results from such a design. This is not to speculate on any potential wrong-doing by Kwon or that her results are spurious. Instead I intend to use a separate design to validate the previous findings and investigate any differences in the reading behaviour from Experiment 1. The method to attenuate the ambiguity in Korean relative clauses for Experiment 2 is similar to that of Jäger et al. (2015). Instead of priming, a clause boundary will be created at the start of RC. This will be done by inserting a pre-relative clause demonstrative at the start of the sentence. In other words, the relative clause will be centre embedded inside a determiner phrase (DP). While demonstratives typically occur after the RC, pre-RC demonstratives are grammatical, albeit slightly unnatural, in Korean.

## 3.4.1. Methods

### 3.4.1.1. Participants

Forty (N= 40, female =18) native speakers of Korean were recruited from Nagoya University, Japan. All participants were either students or research students of Nagoya University at the time of the study. The mean age was 24 years and 4 months (range: 18 years and six months to 36 years and 9 months). Participants first signed written consent and were compensated for their participation after completing the experiment.

### 3.4.1.2. Materials

For Experiment 2, a 2 (ambiguity type: ambiguous vs. unambiguous) x2 (RC condition: ORC vs. SRC) design was created. 32 experimental items were created and put into four counterbalanced lists (see Appendix Chapter 3, p. 273). In order to attenuate the initial clause-type ambiguity, a pre-RC demonstrative was inserted at the start of the sentence. While Korean has been thought to only allow post-RC demonstratives (e.g., de Vries, 2001), it in fact allows demonstratives to precede the RC. According to Kim (1993; see also Sohn, 2001), when the demonstrative precedes the RC, the RC becomes strictly restrictive similar to that of Japanese (Ishizuka, 2008). Thus, there should not be any issue using pre-RC demonstratives as cues in terms of Korean grammar.

To prevent this demonstrative from modifying anything within the RC, a temporal adverb was placed at the start of the RC which also could not be modified by the demonstrative. This adverb would block any grammatical interpretation that the demonstrative would modify the RC noun. Consequently, the only grammatical interpretation for this demonstrative would be that it is instead modifying another noun (i.e., the RC head noun) yet to come. While for Mandarin Chinese this design is not unnatural per se, for Korean it is quite uncommon to have the demonstrative prior to the RC. However, I assert that if participants process the sentence in a grammatical manner, the unnaturalness of this design will not be a confounding factor. As such, this design would force participants to create a clause boundary after processing the temporal adverb and begin to interpret the clause as embedded and not as a simple, matrix clause. See below for examples of possible (un)grammatical interpretations for the modification of the demonstrative (written DET below).

(3.7) Grammaticality of pre-RC demonstratives

*[$_{\text{matrix}}$ [$_{\text{DP}}$ DET Temp.ADV]…]

*[$_{\text{matrix}}$ [$_{\text{DP}}$ DET Temp.ADV NP-ACC]…]

*[$_{\text{matrix}}$ [$_{\text{DP}}$ DET Temp.ADV NP-ACC VP-ADN]…

[$_{\text{matrix}}$ [$_{\text{DP}}$ DET [$_{\text{RC}}$ Temp.ADV NP-ACC VP-ADN] NP-TOP]…

Unlike Experiment 1, an adverb was also inserted directly prior to the RC verb and an additional argument (i.e., matrix object with accusative case) was inserted in the matrix clause (i.e., a transitive argument for the matrix clause). Additionally, to control for the effect of successive case between the RC noun and head noun, the head noun was marked with the Korean topic case marker for Experiment 2. See below for the underlying structure for both ORCs and SRCs in Experiment 2.

(3.8a) Subject-extracted relative clause (SRC) structure
[$_{\text{matrix}}$ [$_{\text{DP}}$ DET [$_{\text{RC}}$ Temp.ADV NP-ACC ADV VP-ADN] NP-TOP] NP-ACC VP]

(3.8b) Object-extracted relative clause (ORC) structure
[$_{\text{matrix}}$ [$_{\text{DP}}$ DET [$_{\text{RC}}$ Temp.ADV NP-NOM ADV VP-ADN] NP-TOP] NP-ACC VP]

Below, I provide an example of an RC item, both SRC and ORC, used in Experiment 2. Above each word in example (9) below, the interest regions are labelled. DET in parentheses stands for the demonstrative only used within unambiguous types. Temp.ADV stands for the temporal adverb within the RC. RC Noun represents the critical noun within the RC which either had accusative case for SRCs or nominative case for ORCs. ADV stands for the adverb that modified the relative verb. RC verb represents the relative clause verb and its morphology. The Head Noun stands for the noun being modified by the relative clause; as mentioned, this noun always contained the topic marker and was always the subject of the matrix clause. The Matrix Object represents the direct object of the matrix clause phrase and was typically suffixed with accusative case. Lastly, the Matrix Verb stands for the matrix clause verb. The Head Noun, Matrix Object and Matrix Verb regions are the arguments for the matrix clause or simple clause and could be a sentence by itself.

(3.9) Korean Relative Clause stimuli regions
<u>(DET)</u> <u>Temp.ADV</u> <u>RC Noun</u> <u>ADV</u> <u>RC Verb</u> <u>Head Noun</u>
(*i*) [*eojesbam* *teleoliseuteu-leul/ga* *hodoege* *gomunha-n*] *gun-in-eun*
That [last.night terrorist-ACC/NOM severely tortured-ADN ] soldier-TOP
<u>Matrix Object</u> <u>Matrix Verb</u>
*mogsum-eul kkeunh-eossda*
his.life-ACC ended
'The soldier who severely tortured the terrorist (the terrorist severely tortured) last night ended his life.'

### 3.4.1.3. Procedure

Similar to Experiment 1, the same apparatus was used for Experiment 2. However, this time, the font was set slightly smaller at size 23 in order to fit longer stimulus items on the screen. According, the visual angle was now 0.66˚. Participants were seated in a quiet room and were told (in Korean) that they would be reading single Korean sentences written in Hangul one at a time on a computer monitor. Participants were instructed to read the sentence naturally as they would in a normal environment. In contrast to Experiment 1, Experiment 2 utilized traditional comprehension / verification probes as the secondary task. In other words, I gave participants 'yes' or 'no' questions after each sentence. Half of the questions were positive probes, answers requiring correct 'yes' responses, and the other half were negative probes, answers requiring correct 'no' responses.

Participants now had up to 16 seconds to read the target sentence for Experiment 2. The increased reading time was given to accommodate the increased length of the sentence. Once they finished reading and understanding the sentence, they were instructed to press any button to replace the sentence with the comprehension question. Reading times were recorded from the onset of the stimuli up to the button press response. Items lacking corresponding button responses (i.e., time outs) were eliminated from the subsequent analyses. For answering the question / probe, participants were instructed to press the left button marked TRUE for 'yes' responses and the right button marked FALSE for 'no' responses (maximum display of 12 seconds for the question). After responding, the question was removed from the screen and feedback was subsequently provided. The feedback was automatically displayed in the middle of the screen and indicated whether or not the participant's response was correct or incorrect in Korean.

(3.10) Comprehension Probe/Question Example

*gunineul teleoliseuteuga hodoege gomunhaessseubnikka*?

'Did the terrorist torture the soldier?'

Correct response: ORC = "yes" & SRC = "no"

## 3.4.2. Results

Similar to Experiment 1, the same treatment was first done on eye-fixations to remove any data point that may be representative of tracker loss or non-reading; this resulted in the removal of 2,736 fixations (10.76%). Like Experiment 1, LME modelling was used. The fixed effects were set as ambiguity type (ambiguous = -.5, unambiguous = +.5) and RC condition (ORC = -.5, SRC = +.5). Since these factors were crossed, fixed effects and their interaction were obtainable. Subjects and items were again set as the random effects. To provide better normalization of residuals, reading times were first log transformed and data trimming was done within R on the reading times for each model which resulted in the removal of 1.46% of the data.

Only the sentence as a whole, the RC noun, the RC adverb, RC verb, head noun, matrix object and matrix verb will be analysed below. The same eye-tracking measures as Experiment 1 were analysed for Experiment 2. Refer to Tables 3.3-3.5 (pp.158-160) for means and LME models; refer to Figure 3.3 for plots.

### 3.4.2.1. Sentence

*Total Reading Time*. For the total reading time of the sentence, it was seen that both ambiguity type ($p < .001$) and RC condition ($p < .001$) revealed significant differences. Since the unambiguous condition has an additional region, it is unsurprising that the unambiguous condition had longer reading times compared to the ambiguous condition. For RC condition, it was observed that the ORC condition had significantly longer reading times compared with SRCs. The interaction of these two variables was not significant ($p = .748$). This indicates that regardless of the initial ambiguity of the RC, ORCs were more difficult to read overall.

*Accuracy*. For the accuracy ratio on the comprehension questions, it was revealed that only RC condition ($p < .01$) had a significant difference between ORCs and SRCs. In line with previous literature on subject/object asymmetry, ORC accuracy was significantly lower compared to SRC accuracy. Ambiguity type ($p = .909$) and interaction ($p = .757$) were not significant. Unlike total reading time, unambiguous RCs

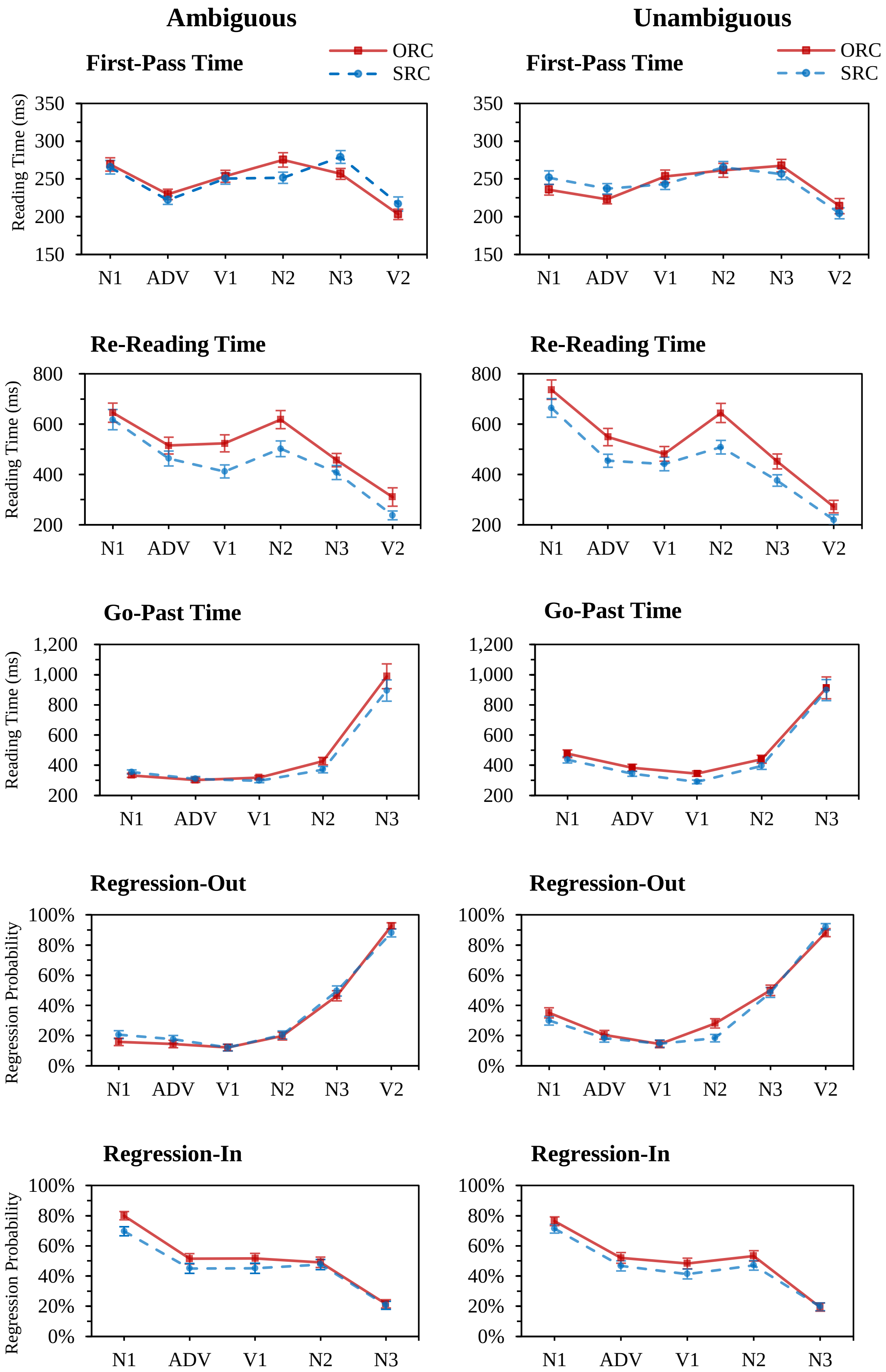


**Figure 3.3. Experiment 2 individual plots**

N1 stands for the RC noun, ADV stands for the adverb, V1 stands for the RC verb, N2 stands for the head noun, N3 stands for the matrix object, V2 stands for the matrix verb.

were not more difficult to comprehend in comparison to ambiguous RCs. In conjunction with the total reading time, it is apparent that sentences with ORCs are more difficult to process and comprehend overall compared to sentences containing SRCs.

#### 3.4.2.2. RC Noun (Terrorist-NOM/ACC)

*First-pass.* Only ambiguity Type ($p < .01$) revealed a significant difference between conditions for the first-pass reading of the RC noun. It was shown that the unambiguous condition had shorter first-pass reading times than the ambiguous type. RC condition ($p = .934$) and interaction ($p = .406$) were not significant.

*Re-Reading.* The variables ambiguity type ($p < .001$) and RC condition ($p < .01$) were significant which revealed that for later re-reading of the RC noun, unambiguous items and ORC items now had longer reading times compared to their counterparts. Interaction of these two variables, however, was not significant ($p = .614$). This reveals that after reading the other parts of the sentence, sentences with ORCs required longer re-readings of the RC noun. For the ambiguity type, however, there was a reversal effect during re-reading. It appears that having attenuated ambiguity increased the later processing of RCs.

*Go-past.* Only ambiguity Type ($p < .001$) was significant. However, since the unambiguous type had an additional region that could be looked back at, this condition should have increased RTs compared to its counterpart. RC condition ($p = .638$) and interaction ($p = .299$) were not significant.

*Regression-Out.* Again, only ambiguity Type ($p < .001$) was significant showing the same pattern as the above go-past measure; i.e., unambiguous items had higher probability to regress out, likely attributed to the additional region. RC condition ($p = .791$) and interaction ($p = .138$) were not significant.

*Regression-In.* For regression-in proportion, it was found that only RC condition ($p < .01$) was significant which supports the finding for re-reading time at this region. In effect, ORCs had a higher likelihood to have a regression made back into the RC noun, and once a participant returned to the region, they had longer re-reading times for ORCs.. Ambiguity type ($p = .829$) and interaction ($p = .271$) were not significant.

#### 3.4.2.3. RC Adverb (Severely)

*First-pass.* No significant effects were observed: RC condition ($p$ = .688), ambiguity type ($p$ = .861), and interaction ($p$ = .331). Considering this region served more as a spillover region, it is not too surprising that significance between RC condition and ambiguity type was not observed here.

*Re-reading.* Unlike first-pass reading time, the re-reading of the adverb phrase revealed that for RC condition ($p$ < .01), ORC had significantly longer re-reading times at the adverb when compared with SRC conditions. Ambiguity type ($p$ = .430) and interaction ($p$ = .398) were not significant.

*Go-past.* For go-past time at the adverb, within the ambiguity type items ($p$ < .001), unambiguous had increased go-past reading times prior to moving on to the RC verb. However, again, this should be expected since there is an additional region for the unambiguous to revisit. RC condition ($p$ = .778) and interaction ($p$ = .489) were not significant.

*Regression-Out.* No significant effects were observed: RC condition ($p$ = .701), ambiguity type ($p$ = .153), and interaction ($p$ = .309).

*Regression-In.* No significant effects were observed: RC condition ($p$ = .134), ambiguity type ($p$ = .579), and interaction ($p$ = .800).

#### 3.4.2.4. RC Verb (Torture-PST-ADN)

*First-pass.* For the first-pass reading of the embedded RC verb, no significant effects were observed: RC condition ($p$ = .286), ambiguity type ($p$ = .414), and interaction ($p$ = .538).

*Re-reading.* Unlike first-pass reading, within RC condition ($p$ < .01), ORCs were seen to have significantly longer re-reading times compared to SRCs. Ambiguity type ($p$ = .987), and interaction ($p$ = .073) were not significant. This shows that after leaving and coming back to the RC verb, ORCs started to become more difficult to process.

*Go-past.* Prior to the reading of the head noun, go-past time at the RC verb revealed significant differences only for RC condition ($p$ < .05), showing longer reading times for ORCs compared with SRCs. This finding is compatible with the result found at the same region in Experiment 1. Again, ambiguity type ($p$ = .890), and interaction ($p$ = .223) were not significant. It is particular that ambiguity type was not significant here as previous regions had reached significance. Considering that the unambiguous condition has an additional region to read prior to moving to the next region (i.e., the head noun), I would expect longer reading times. This may indicate that there is some extra difficulty for processing ambiguous RCs here at this region.

*Regression-Out.* No significant effects were observed: RC condition ($p$ = .982), ambiguity type ($p$ = .278), and interaction ($p$ = .950).

*Regression-In.* In congruence with re-reading time, the RC condition ($p$ < .05) revealed a significantly higher regression-in probability for ORCs compared to SRCs. Ambiguity type ($p$ = .402), and interaction ($p$ = .814) were not significant.

#### 3.4.2.5. Head Noun (Soldier-TOP)

*First-pass.* At the first-pass reading of the head noun, no significant effects were observed: RC condition ($p$ = .270), ambiguity type ($p$ = .982), and interaction ($p$ = .094).

*Re-reading.* The re-reading of the head noun was significant only for the RC condition ($p$ < .001). This indicated that ORCs required longer re-reading times in comparison to SRCs. Ambiguity type ($p$ = .162), and interaction ($p$ = .466)

*Go-past.* Go-past time at the head noun revealed significant effects for the RC condition ($p$ < .05) which as predicted demonstrated longer reading times for ORCs. Ambiguity type ($p$ = .355), and interaction ($p$ = .651)

*Regression-Out.* While RC condition $p$ = .208) and ambiguity type ($p$ = .227) were not significant, Interaction ($p$ < .05) was, which showed a higher probability of regressing out for unambiguous ORCs.

*Regression-In.* No significant effects were observed: RC condition ($p$ = .154), ambiguity type ($p$ = .366), and interaction ($p$ = .658).

#### 3.4.2.6. Head +1 (Matrix Object) ($3^{rd}$ pronoun)

*First-pass.* No significant effects were observed: RC condition ($p$ = .615), ambiguity type ($p$ = .273), and interaction ($p$ = .067).

*Re-reading.* Here, only RC condition ($p$ < .01) was significant, showing longer re-reading times for ORCs. Ambiguity type ($p$ = .376) and interaction ($p$ = .767) were not significant.

*Go-past.* No significant effects were observed: RC condition ($p$ = .942), Ambiguity type ($p$ = .512), and interaction ($p$ = .813).

*Regression-Out.* No significant effects were observed: RC condition ($p$ = .633), ambiguity type ($p$ = .710), and interaction ($p$ = .529).

*Regression-In.* No significant effects were observed: RC condition ($p$ = .517), Ambiguity type ($p$ = .585), and interaction ($p$ = .730).

#### 3.4.2.7. Head+2 (Matrix Verb) (ended.life)

*First-pass.* No significant effects were observed: RC condition ($p$ = .800), ambiguity type ($p$ = .911), and interaction ($p$ = .185).

*Re-reading.* Only RC condition ($p$ < .05) revealed a significant effect. It was found that ORCs required longer re-reading at the matrix verb. Ambiguity type ($p$ = .366) and interaction ($p$ = .516) were not significant.

*Go-past.* Here, only ambiguity type ($p$ < .01) revealed a significant difference. The unambiguous type items required longer reading times prior to pressing the button to end the sentence than the ambiguous items. No other significant effects were observed: RC condition ($p$ = .472) and interaction ($p$ = .213) were not significant.

*Regression-Out.* While RC condition ($p$ = .862) and ambiguity type ($p$ = .918) were not significant, Interaction ($p$ < .05) was significant. Within ambiguous items, ORCs had a numerically higher regression-out probability compared to its counterpart and vice versa for the unambiguous ORCs.

### 3.4.3. Discussion

The results of Experiment 2 revealed that ORCs were more difficult to process and comprehend in comparison to SRCs and this was not influenced by the initial clause-type ambiguity.

Similar to Experiment 1, the first indication of difficulty due to RC condition was observed at the embedded RC-verb, which has the adnominal marker. Furthermore, this was seen during the same go-past measure. This was then followed by difficulty at the head noun. Late processing difficulty was also observed at the RC noun, the RC verb and head noun during re-reading time. While these findings may appear to suggest that the method to attenuate ambiguity did not work as intended, this is unlikely case. In fact, Kwon et al. (2010) also revealed the exact same pattern of results in their Experiment 2 using eye-tracking and priming discourse to attenuate the clause-type ambiguity. Furthermore, the lack of significance at the embedded RC verb for their Experiment 1 could likely be attributed to them using ANOVA rather than LME for statistical analysis since LME models are more flexible and generalizable (Baayen et al., 2008). In other words LME does not assume independence for the observations as random effects must be included that can have varying intercepts and slopes. This allow for a more generalized model rather than a model reliant only on the observations of the data. Consequently, the results of the current study and Kwon et al. (2010) seem to indicate a similar processing pattern for Korean RCs regardless of ambiguity condition.

#### 3.4.3.1. Expectation-Based Processing

Like Experiment 1, the difficulty at the RC verb should be viewed as support for expectation-based processing since the adnominal marker acts as the locus of disambiguation for Korean RCs. While the clause had attenuated ambiguity, it is probable that that an RC interpretation is not guaranteed until this spot in the sentence where a participant can confirm the RC structure. In other words, despite there being attenuated ambiguity in the unambiguous type sentences, the benefit of the top-down expectation-based processing does not occur until the entire structure has been parsed. Owing to that, since the adnominal marker is required to complete the RC, both ambiguous and unambiguous conditions begin to experience processing difficulty for ORCs at the RC verb during go-past reading time.

#### 3.4.3.2. Integration-Metrics

The difficulty at the head noun supports integration metrics based on structure rather than linear or temporal distance as in Experiment 1. In other words, since the distance between the filler and gap is greater as defined by the structural-phrase metric, the ORC gap filling process is more demanding than the SRC process. Furthermore, this finding was the same for both ambiguous and unambiguous RCs.

#### 3.4.3.3. Similarity-Based Interference and Successive Case

In Experiment 1, there was an issue of successive nominative case for the ORC condition. In order to eliminate this as a potential confound, the topic case particle was used to replace the nominative case marking for the head noun. Despite this change in stimuli design, the same overall pattern was observed as in Experiment 1. Consequently, this may be interpreted in two possible ways in terms of successive case. First, the findings of Experiment 1 may be less attributed to case effects and similarity-based interference than previously supposed. Another possibility is that similarity interference has more to do with grammatical assignment rather than case. The latter possibility is more in line with general similarity-based interference effects as described by Gordon et al. (2001). In other words, even if the case is different on the second noun, if the grammatical role for the noun is similar or matching to the first noun, additional difficulty with storing and retrieving this noun may be predicted.

#### 3.4.3.4. The Object-Before-Subject-Bias

An additional interpretation for the difficulty found at the head noun may be attributed to the object-before-subject-bias. In other words, the ORC processing difficulty may be due to the assignment of thematic role, instead of or in addition to integration of the filler and gap. Since the object of the ORC must be processed after the embedded predicate, there is difficulty in assigning thematic role back to the subject of the ORC, and moreover, this interpretation also explains the late re-reading difficulty at the RC verb and RC noun. As it happened, the object-before-subject-bias was better supported in Experiment 2. Thus, there is a possibility that thematic assignment is partially responsible for difficulties found in prenominal relative clause processing after the head noun is integrated into the structure. The fact that the head noun must be read for this account to take hold is paramount because it is dissociated with what occurred at the embedded-RC verb during go-past reading. Object-before-subject bias is still not satisfactory for explaining the ORC at that locus.

#### 3.4.3.5. The Influence of Ambiguity

There was seemingly little to no effect of the initial clause-type ambiguity. The general result indicated that the unambiguous condition required longer processing time. However, the initial processing of the RC noun during first-pass reading was easier for unambiguous RCs, a similar finding to that of Kwon et al. (2010). Also, while not significant, the re-reading time at the RC verb had marginal interaction. Looking at the numerical differences between the four conditions, unambiguous ORCs required less re-reading than its ambiguous counterpart. While this may not reveal concrete evidence for ambiguity effects, at the very least it hints that the later difficulty at the RC verb can be attenuated if the clause-type ambiguity is eliminated. For example, prior to the RC verb, go-past time had also indicated that unambiguous types required longer reading times than the ambiguous types, which can be attributed to the extra demonstrative starting off the sentence. However, for the RC verb, head noun, and matrix object, there was no longer any difficulty during go-past for unambiguous sentence types. The importance of this is that at the RC verb, the ambiguous items required a structural reanalysis from an incorrect simple, matrix clause interpretation to a correct relative clause interpretation. Admittedly, while null findings are only speculative at best, it appears that after the disambiguation of the clause-type for ambiguous items, ambiguity was no longer a factor. Thus, I can conclude that ambiguity may have been a factor prior to the locus of disambiguation; however, in terms of processing behaviour, ambiguity did not alter the overall reading pattern.

Besides these points, there was no indication that the initial clause-type ambiguity altered Korean RC processing. However, this could indicate that ambiguity does not change the reading behaviour for Korean as previously assumed. This was precisely the case of Kwon et al. (2010) who also did not reveal critical differences between ambiguous and unambiguous RCs in Experiment 2. According to surprisal models (Hale, 2001; Levy, 2008), there should be greater expectation for SRCs compared to ORCs. If the clause-type ambiguity is attenuated, then the case marker at the RC noun may potentially act as a locus of disambiguation for subject/object asymmetry. However, neither Kwon et al. (2010) nor the current study revealed differences at this critical region. This may indicate that despite ambiguity being attenuated, there is still uncertainty or ambiguity left in the structure which requires a more concrete locus of disambiguation for the RC interpretation. This would explain why in both ambiguous and unambiguous cases in the current study and Kwon et al. (2010), processing difficulty for ORCs only started to begin during go-past reading time at the RC verb which contains adnominal morphology.

According to entropy-based reduction (Yun et al., 2015), at the RC noun for an unambiguous context, the case marker should not reveal any differences in processing, since there is no uncertainty in the structure. Specifically, with a concrete embedded RC interpretation, there is no drop in entropy after the processing of the case marker suffixed to the RC noun between conditions. Admittedly, the unambiguous RC items used in Experiment may be better described as having attenuated ambiguity. In other words, despite a clause-boundary being formed and the mental parser treating the clause as an embedded variety, there is no actual guarantee that the clause is being processed as an RC. Consequently, entropy-reduction models seem to be better supported for the lack of effects found at the RC noun in comparison to surprisal (Levy, 2008) expectation-based processing models. Yet, entropy-reduction should predict difficulty at this locus for ambiguous RCs in Experiment 2. Since this was not observed, the influenced of entropy-reduction is left unclear.

Similar to Mandarin which has a free relativizer marker, Korean has an adnominal marker at the embedded RC verb. For both languages, these markers act as the locus of disambiguation. Yet, for Mandarin the relativizer may also be a locus of integration (c.f., Packard et al., 2011) whereas in Korean the adnominal marker cannot fulfil the role of the filler. This may explain why previous studies in Mandarin (Mansbridge et al., 2017) revealed altered processing behaviour between ambiguous and unambiguous RCs and why Korean did not. According to Levy (2008), expectation-based processing may be difficult to observe when other factors, such as integration filler-gap processing, are simultaneously co-occurring at the same locus. Since Mandarin is a language for which both integration and disambiguation can occur at the same locus, having reduced ambiguity allows the parser to more strongly tap into the expectations of the frequency of the language which could then overturn the processing difficulty associated with integration. In Korean, on the other hand, since these points are always dissociated with each other, the same pattern of reading behaviour will occur regardless of ambiguity.

## 3.5. General Discussion

The purpose of this study was to replicate the previous findings which showed that Korean ORCs are more difficult to process, compared to SRCs, and to provide a more detailed account of how and why this processing difficulty occurs. More specifically, the chief aim of this study was to demonstrate that ORC processing difficulty first arises after the disambiguation of the temporarily ambiguous RC, as explained by expectation-based models.

The overall results of this study clearly demonstrated that the ORC condition was more difficult to process (i.e., required longer reading times) compared to its SRC counterpart. This was clear at multiple positions, including the RC noun, embedded RC verb, the head noun and the adverb regions. This data strongly supports the general aim of the study. Similar to Kwon et al. (2010), there were several explanations for the higher processing costs of ORCs: expectation-based processing (Hale, 2001, 2006; Levy, 2008; MacDonald & Christiansen, 2002; Mitchell et al., 1995), memory-based effects defined by structural-phrase integration (O'Grady, 1997) and similarity-based interference (Gordon et al, 2001). However, unlike Kwon et al (2010), I am able to attribute these processing effects to different regions within the sentence.

### 3.5.1. Integration

At the parsing of the head noun, the integration of the co-indexed filler and gap dependencies occurs. However, as mentioned before, if this backwards anaphoric search for the gap utilizes a linear-based (Gibson, 1998, 2000) or a temporal-based (Lewis & Vasishth, 2005) mechanism, then ORCs should actually be easier to process at the head noun since there is less intervening discourse separating the filler and gap at the surface structure. However, according to the structural-phrase integration model (O'Grady, 1997), ORCs are more difficult to process since there are more syntactic-phrases intervening between the filler and gap in ORCs than in SRCs (refer to Figure 3.1). Nearly identical to Kwon et al. (2010), go-past RTs in the current study provide evidence for a structural-phrase integration model and cannot currently support either the linear- or temporal-based models regardless of the ambiguity context. Considering that Kwon et al. (2013) revealed that the difficulty at the head noun is similar to integration effects in English (Gouvea, Phillips, Kazanina, & Poeppel, 2007) and Japanese (Ueno & Garnsey, 2008), it is likely that integration-based effects are at least partially inducing longer reading times for ORCs at the head noun. However, integration-effects cannot account for the processing difficulty during go-past RT at the RC verb since it is not the locus of integration in Korean RCs.

In the discussion below, I will eventually argue for an expectation-based processing account at the embedded RC verb. However, it is not likely that expectation-based processing effects are driving the difficulty at the head. For instance, as revealed by Kwon (2008), RCs as a whole are more difficult to process at the head than fact-clauses due to integration, despite the fact that RCs are a more frequent structure than fact-clauses. In the current study, if expectation-based processing effects were originating from the RC verb, I would expect these effects at the head noun to be seen immediately. However, difficulty at the head noun did not begin until go-past reading for both Experiment 1 and Experiment 2. While I argue that go-past should be considered an early measure of processing, go-past at the head noun should be viewed differently than the significant difference during go-past at the RC verb. This is because first-fixation and first-pass reading at the head noun failed to show longer reading times for the ORC condition. Consequently, expectation-based processing effects and integration-based effects appear to be disassociated from each other at different loci within the sentence. Because of this, I believe that both models are valid for Korean RC processing. While the locus of integration appears at the head noun, the locus of expectation-based processing effects in Korean is found at the embedded-RC verb due to the adnominal marker prior to the head noun.

There is one case where integration may occur prior to the head noun. This would be relative clauses in Korean marked with the *–kes* complementizer. As previously mentioned, the complementizer can occur in colloquial Korean within the EHRC structure (Lee, 2006). If it is the case that the complementizer is grammatical in such a context, then integration may occur prior to the head at the marker. However, to my knowledge, no online experimental study (i.e., real-time behaviour is recorded) has investigated processing in cases where both the complementizer and head noun are presented, so it is left unseen whether Korean would result in a similar processing pattern as in Mandarin where processing difficulty is seldom seen at the head noun due to the relativizer assuming the role of the filler.

While I argued for a structural-based integration metric above, there is a possibility that the counter hypothesis (i.e., a linear/temporal integration metric) is still valid. In the above argument, it was assumed that the head noun directly retrieves the gap position. However, if I instead interpret the RC as containing a *wh*-operator which is co-indexed with the head noun, then there is a possibility that the head integrates/retrieves the operator instead of the gap itself, and the operator carries the case and grammatical role features vital for understanding the role of the head noun. Consequently, this proposal would have the distance between the operator and its trace predicting ORC difficulty regardless of the operational metric since all metrics would predict greater decay for ORCs. While this interpretation of RCs in Korean would help resolve the issue of the dichotomy in the predictions of these models, there is not enough evidence in the current study to validate it. As such, future research needs to further explore the underlying syntax of Korean RCs and the relationship the head noun has with the gap position.

### 3.5.2. The Object-Before-Subject-Bias

According to Miyamoto (2016; Nakamura & Miyamoto, 2013), and also brought up by Kwon (2016) herself, the assignment of thematic roles can possibly be an explanatory factor for subject/object processing asymmetry for Korean and Japanese as well. Under this proposition, grammatical objects are required to be processed prior to the assignment of the thematic role of the subject. Considering that ORCs in both of these languages have the grammatical object as the head noun, there should be greater difficulty going back and assigning the thematic role of the RC subject. Miyamoto (2016) also argued that due to clause closure effects (i.e., purging a current string from working memory when the clause is closed), effects such as integration may not be feasible in Korean and Japanese since the clause is likely closed at the reading of the embedded predicate, especially when the clause is ambiguous. However, there are several flaws with this proposal. First, in Korean it is extremely unlikely that the clause would be closed at the embedded predicate (i.e., the right edge of the embedded clause) since the suffixed adnominal marker should prevent clause closure from occurring since it signals an upcoming head. Second, while clause closure may be a satisfactory explanation for moving window designs (e.g., self-paced reading, maze task, EEG) or listening, it is poorly suited to explain reading in eye-tracking. Simply, even if the clause is closed and the contents of it are purged from working memory, eye-tracking allows regressive readings which would allow participants to reparse the clause if needed by re-reading the clause. Consequently, while the object-before-subject bias seems to be supported here, its effect in all likelihood is minimal in comparison to integration and expectation.

### 3.5.3. Similarity-Based Interference

Under the framework of similarity-based effects (Gordon et al., 2001; Gordon et al., 2006; Lee et al., 2007), storing multiple nouns with similar features into working memory creates a difficulty during the retrieval of a noun. Since the RC noun in Experiment 1 shared many of the same features as the head noun for ORCs (i.e., case-marking, animacy and proper name), under this theory, these two nouns compete with each other in working memory at predicate positions. This competition could increase the processing cost. This can be supported by the increased go-past RTs at the head noun and adverb. As Kwon et al. (2010) notes, having two successive nouns marked with nominative case could also have increased RTs for ORCs at the head noun and prior regions during later stages of processing. This would partially explain the longer re-reading RTs at the RC noun. However, similar to integration-resources, similarity-based interference cannot explain the difficulty for ORCs before the head noun was parsed (i.e., the go-past RT at the embedded RC verb).

### 3.5.4. Expectation-Based Processing Effects

According to expectation-based models of processing, less frequently occurring structures in a language will be more difficult to process than more frequently occurring structures (Hale, 2001; Levy, 2008; MacDonald & Christiansen, 2002; Mitchell et al., 1995). However, as mentioned before, in temporarily ambiguous structures, RC frequency effects will not be observable until the structure is disambiguated. Accordingly, a lack of significant effects during the early stages of processing at the RC noun and during first-fixation duration at the RC verb (since multiple fixations are likely needed to read the verb and its morphology) are not in conflict with expectation-based models. This is because, at these early stages of processing, the structure would likely still be ambiguous. All the effects found in this study are potentially compatible with frequency-based effects. However, as previously mentioned, the effects at the head noun and adverb region (Experiment 1) are better explained by structural-phrase integration-effects and similarity-based interference effects.

In order to observe expectation-based effects of processing alone (i.e., without other contributing factors such as integration or similarity-based interference), it is necessary for reading times in the ORC condition to be longer, prior to the reading of the head noun. Since Experiment 1 used temporarily ambiguous RC structures, processing difficulty due to expectation-based effects of RC structure type should not occur until the parser has disambiguated the (correct) RC structure from a (more frequently seen, but incorrect) matrix clause interpretation. While there may be different loci of disambiguation for each clause type, it was likely that readers could correctly predict the RC structure at the full reading of the embedded RC verb (i.e., verb-adnominal) for both the RC types. Thus, because ORCs are less frequent in Korean, they were more difficult to parse after disambiguation. This was indicated by the significant difference during go-past RT and the marginal difference in first-pass RT at the RC verb. In addition, the difficulty found at the head noun, adverb and the re-reading at the RC noun indicate greater processing difficulty for the less frequent ORC structure. Accordingly, these results provide general support for expectation-based models of processing.

For unambiguous RCs, however, this pattern of results did not differ from ambiguous RCs. Previously I suspected that if the clause-type ambiguity was attenuated, then expectation-based processing effects should be observed earlier than for ambiguous RCs. For example, the case marker on the RC noun could potentially be a locus of disambiguation since RC types only differ between the case markers suffixed to the RC noun. Here, ORCs should incur longer reading times since the structure would be less expected than an SRC. To my surprise, this was not the case for Experiment 2 and Kwon et al.'s (2010) Experiment 2, both using unambiguous RCs. The data from both studies instead suggest that a clear locus of disambiguation is still needed to form a concrete RC interpretation. In other words, even though both studies may have attenuated the clause-type ambiguity and effectively eliminated a matrix clause interpretation, the parser still nevertheless requires the adnominal marker to form an RC.

Following the framework of cue-based retrieval models (see Levy, 2013; Lewis & Vasishth, 2005; Van Dyke & Lewis, 2003; Vasishth & Lewis, 2006), the similarity between ambiguous and unambiguous RCs may be quite easily understood. While post-nominal languages with relativizers, such as English, mark the clause as an RC at typically at the left edge of the RC, this is not the case in prenominal Korean which does it at the right edge instead. In other words, the cue for the RC feature comes late in Korean. Whether this feature is provided by the adnominal marker or whether the adnominal marker is responsible for probing the operator which assigns RC feature is not so critical. What is important here is that there is a principal cue responsible in Korean RCs to provide the clause with the RC interpretation. Therefore, until this cue is integrated into the structure, the clause is not parsed as an RC or even a matrix clause in the case of the unambiguous clause. After this, the parser then draws from the frequencies which are subject to surprisal effects (Hale, 2001; Levy, 2008). As such, unambiguous RCs not immediately providing an RC interpretation or allowing expectations to be made upon statistical probabilities can be explained by expectation-based processing in relation to cue-based parsing.

In the subsections below, I discuss disambiguation and evidence for expectation-based models.

#### 3.5.4.1. The Locus of Disambiguation and Evidence for an Expectation-Based Processing Account

As mentioned above, RCs in Korean have the potential to be initially ambiguous, meaning that the parser would be unaware that the structure was a RC until a locus of disambiguation. For ambiguous contexts, the first possible locus would be the adnominal marker suffixed to the embedded verb (e.g., criticize-ADN). While this locus would eliminate the matrix clause interpretation, the embedded clause would still be ambiguous, as there are other possible embedded clauses in Korean, such as fact-clauses (e.g., subject-pro senator-ACC criticize-ADN) or pseudo-relative (gapless) relative clauses. As such, Kwon and colleagues claim that the parser needs to wait until the head noun, allowing it to distinguish a fact-clause (e.g., *sasil* ‘fact’) from a RC (e.g., *gijaneun* ‘reporter’). Admittedly, it is possible that since the two structures are too similar, the subject/object asymmetry at the embedded verb can be explained by the general frequency of Korean embedded clauses (which lack either an overt subject or object). This would, nevertheless, still support an expectation-based account for the ORC difficulty at the embedded verb (e.g., criticize-ADN). In other words, regardless of the initial interpretation made at the adnominal marker, the processing difficulty for ORCs at this locus would still appear. However, I hold the view that the structure would likely be interpreted as an RC. As previously mentioned, Kwon had reported that the head of an embedded clause affixed with the adnominal marker was more frequently an RC. Taking a more fine-grained approach, the parser would prefer an RC interpretation here. Future studies focusing on the differences in processing between fact-clauses and RCs prior to the head in Korean may be needed to clarify this.

Taking a look at *because*-clause structures in Korean (which are marked with –*se* 'because'), at the reading of the because-marker (e.g., criticize-because), there is no longer an ambiguity of clause type at the marker. In fact, Kwon (2008) was able to show a significant difference between subject/object null pronominals. This can be attributed to the extreme rarity of Korean null objects. Accordingly, expectation-based models (Hale, 2001; Levy, 2008) seem to be an accurate predictor of processing difficulty for embedded clause structures at the locus of the embedded verb and suffixed marker in the Korean language. However, it stands to the question if there are any other possibilities that might explain the difficulty for ORCs prior to the head noun.

At the first reading of the RC noun, both the accusative and nominative marker can elicit difficulty for SRCs and ORCs respectively. As Kwon and colleagues (Kwon, 2008; Kwon et al., 2010; Kwon et al., 2013; Kwon et al., 2006) discuss, while a sentential initial, accusative-marked NP may be more difficult to process (since it would indicate either scrambling or a null subject), a nominative-marked NP could also be difficult, since there is less predictability for a transitive verb than an accusative NP. For the ORC condition, there could be some difficulty at a transitive verb (prior to the reading of the adnominal marker) since the parser would have to posit a null object pronominal. In summary, early SRC difficulty would be seen at the RC noun, and ORC difficulty would be seen at either or both the RC noun and verb. However, Kwon and colleagues (Kwon, 2008; Kwon et al., 2010; Kwon et al., 2013; Kwon et al., 2006) and the current study did not observe any initial difficulty for accusative- or nominative-marked NPs in the embedded clause, either by self-paced reading, eye-tracking or ERP methods. As such, verb transitivity and a single nominative marked NP may not be that difficult for the parser to handle. Though this has already been argued by Kwon et al. (2013, p. 29), more studies on either Korean or Mandarin are likely needed to clarify the strength, reliability and time-course duration what effects on processing case marking would have during reading.

The current study reports slightly, but still critically, different results from previous studies on Korean RCs. Because of this the following section will explain possible sources for these differences.

### 3.5.5. Comparison to Previous Studies

In Kwon et al. (2006) and Kwon et al. (2013), there was no processing difficulty associated with the embedded RC verb when using both SPR and ERP for ambiguous RCs. Furthermore, Kwon et al. (2010) only revealed marginal effects for temporarily ambiguous structures at this position using eye-tracking. From these results, Kwon and colleagues claim that disambiguation in Korean does not occur until the head noun, a position where each study revealed significant findings. There are four explanations as to why my findings may conflict with the previous studies: differences in (1) experimental technique, (2) task methodology, (3) materials and (4) the analysis and interpretation of the results.

In the previous SPR and ERP studies, participants were only allowed to view a sentence one word at a time. In other words, participants were incapable of re-reading previous regions. For eye-tracking in general, go-past measurements have often been an important measure of processing difficulty in RCs (Gordon et al., 2006; Kwon et al., 2010; Staub 2010; Traxler et al., 2002). Considering that Korean RCs are both prenominal and ambiguous, go-past may be considered as an early processing stage for Korean RCs. At the very least, go-past should be considered a highly indicative measure of RC processing difficulty, as both the current study and Kwon et al. (2010) largely reveal ORC difficulty via go-past measures. Since SPR and ERP techniques lack such a measure, it could be that it is more difficult to view a processing cost at the RC verb within a moving-window paradigm.

Another difference between experiments was the secondary task method. Experiment 1 admittedly used a method not frequently used in eye-tracking studies. However, I do not believe the use of a sentential judgment task has skewed my results in a way that would make them misrepresentative. This is because the current study replicated the general findings of Kwon and colleagues. As previously mentioned, the motivation for using this task in place of comprehension probes was that comprehension probes may be a more demanding task, as they require participants to store target items in memory for the purpose of answering a question (Caplan et al., 2008); thus, if that were the case, then participants would be expending cognitive resources beyond the normal reading function. However, more studies are needed to show the detailed relationship between task methodology and sentence processing.

Additionally, the current study used materials of a simpler structure than Kwon et al. (2010) for Experiment 1. The motivation for using simpler structures was that Kwon et al.'s items may have been unnecessarily difficult for participants to process, given that they contained more information than was required to show the differences between RC types. Thus, I decided to remove extra arguments in both the RC and matrix clause. Since a simpler structure may be easier to process than a more complex structure, the simpler items used here may account for some of the differences between studies.

Lastly, the current study and Kwon et al. (2010) may not differ entirely. In Kwon et al. (2010), difficulty for ORCs was seen at the RC verb for ambiguous contexts, albeit marginally, during go-past measures. Considering that Kwon et al. (2010) used classical ANOVA measures, it remains unseen whether or not their results would have reached significance if they had adopted to use LME models. Consequently, a main difference between the current study and their results could simply boil down to the statistical methods used. While Kwon et al. (2010) do not fully commit to an expectation-based processing account at the RC verb, I assert that this account best explains the ORC difficulty encountered during both studies. Also, it is possible that my results are also compatible with Kwon et al.'s second experiment, which also featured unambiguous RCs.

### 3.5.6. Expectation-Based Effects in Other Prenominal Languages

Overall, expectation-based processing costs for a less frequent structure at the locus of disambiguation within a temporarily ambiguous RC structure are common for prenominal languages. As previously mentioned, several studies on Mandarin Chinese (Jäger et al., 2015; Lin & Bever, 2006; Qiao et al., 2010) show ORC difficulty at the disambiguating relativizer morpheme or prior if the initial clause type ambiguity was attenuated, albeit during later re-reading time. Both these effects are predicted by expectation-based processing models. Therefore, the current results at the RC verb appear to be consistent with prior expectation-based processing effects found in Mandarin Chinese while adding support to the account for Korean.

However, there is at least one other prenominal language that shows an opposite trend. Carreiras, Duñabeitia, Vergara, de la Cruz-Pavía, and Laka (2010) report that in Basque (i.e., Euskara), ORCs are easier to process at the disambiguation region for their items, which happened to be the ultimate or penultimate word in the sentence, despite ORCs being less frequent. At first glance, this would appear to be strong evidence against expectation-based processing effects (Grodner & Gibson, 2005; Pickering, Traxler, & Crocker, 2000). However, unlike Korean, Mandarin Chinese and Japanese, RC type could not be distinguished easily in their study since an SRC or ORC interpretation was not possible until the matrix verb. Carreiras et al. (2010, p.83) themselves mention that the SRC difficulty may be likely due to a garden path effect for the SRC structure, which is caused by the ambiguity of the morphemes affixed to the RC noun, which assign number and indicate grammatical role. In other words, the morphemes on the RC noun for SRCs and ORCs appeared identical (e.g., *–ak* ‘plural’ for SRCs and *–a–k* ‘singular+subject’ for ORCs). What is more, this confound appears not to have been addressed in later experiments in their study. Because of this confound, it is difficult to interpret their results as being against expectation-based processing models. Thus, future studies are needed to resolve this confound before any claim for or against expectation-based processing can be made. It is my prediction that if this issue could be resolved, then ORC difficulty would appear at the complementizer marker, which sits at the right boundary of the RC. If this proves to be accurate, Basque would appear consistent with Mandarin Chinese and Korean under the framework of expectation-based processing models. For ambiguous RCs in Japanese, however, there is not a way to view expectation-based processing effects prior to the head, which is also the locus of integration, within ambiguous contexts. Consequently, it may be too difficult to tease apart expectation-based processing and integration-based resources at the head noun.

In summary, expectation-based processing effects may be limited to or best seen at a locus of disambiguation for RCs. However, they are nonetheless integral for the proper prediction of processing difficulty within ambiguous and unambiguous RCs. Considering that there is also evidence against frequency effects, I believe more studies are needed to investigate if there are underlying factors which could explain whether or not expectation-based models are more tightly connected to the processing of specific structures or contexts. Nevertheless, the current study adds empirical evidence within a prenominal RC language to the growing body of literature supporting expectation-based processing models for relative clause processing.

## 3.6. Conclusion

In this study, I sought out to support the claim that object-extracted relative clauses in Korean are more demanding than subject-extracted relative clauses with respect to processing. More specifically, I aimed to determine whether expectation-based processing accounts of processing can accurately predict greater difficulty for ORCs before the reading of the head noun. Overwhelmingly, the results of both experiments confirmed that RCs in Korean first experience ORC difficulty prior to the head noun at the RC verb regardless of the ambiguity context. The implication here is that expectation-based processing likely fits in the framework of cue-based parsing and that for RC frequencies to be obtained by the parser, a cue responsible for assigning RC features must be first integrated into the structure. This cue in Korean happens to be the adnominal marker. Consequently, even in the unambiguous RC case, until this cue was integrated, expectations on statistical probabilities were unlikely to be made.

Not only did the results support the main hypothesis, but also they replicated previous findings at the head noun, supporting the claim that integration in Korean likely uses a structural-phrase integration mechanism; however, as noted within, other metrics may also be supported if RCs in Korean utilize null operators. In other words, the current study adds to the previous literature by showing that the effects of integration and expectation are dissociated with each other and appear at separate loci within the sentence.

Accordingly, the current study adds support from the Korean language for an expectation-based processing account at the locus of disambiguation for RC processing similar to that of other prenominal languages such as Mandarin Chinese. In conclusion, temporarily ambiguous and unambiguous ORCs both first incur processing difficulty at the locus of disambiguation as a result of being the less frequent structure prior to the integration of the filler and gap dependencies.

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# 3.8. Compliance with Ethical Standards

## 3.8.1. Conflict of interest

No authors had a conflict of interest.

## 3.8.2. Human and Animal Rights Statement

All personal information collected from participants was stored in a secured location, and participants were given pseudonyms for data analysis purposes. Participants were not subject to harm and could only experience mild discomfort from prolonged seating or eye discomfort from prolonged reading.

## 3.8.3. Informed Consent

In the current study, all participants first gave written, informed consent prior to starting the experiments. After the completion of the experimental session, participants then received monetary compensation.

## 3.9. Chapter 3 Supplementary Tables

In the following pages, the supplementary Tables of Chapter 3 are provided.

**Table 3.1. Experiment 1 means for RC condition**

| | ORC | | SRC | | |
|---|---|---|---|---|---|
| | Means | SE | Means | SE | *p* value |
| Sentence | | | | | |
| Total time | 7.71 | 0.02 | 7.66 | 0.02 | $p = .077$ |
| Accuracy | 0.83 | 0.02 | 0.87 | 0.02 | $p = .281$ |
| | | | | | |
| RC Noun | | | | | |
| First-fixation | 5.28 | 0.01 | 5.31 | 0.01 | $p = .247$ |
| First-pass | 5.74 | 0.02 | 5.77 | 0.02 | $p = .388$ |
| Re-reading | 5.88 | 0.04 | 5.77 | 0.04 | $p = .082$ |
| Regression-in | 0.61 | 0.02 | 0.61 | 0.02 | $p = .879$ |
| RC Verb | | | | | |
| First-fixation | 5.38 | 0.02 | 5.35 | 0.02 | $p = .152$ |
| First-pass | 5.56 | 0.02 | 5.51 | 0.02 | $p = .070$ |
| Re-reading | 5.97 | 0.04 | 5.91 | 0.04 | $p = .226$ |
| Go-pass | 5.76 | 0.03 | 5.66 | 0.03 | $p < .01$ |
| Regression-out | 0.18 | 0.02 | 0.13 | 0.02 | $p = .378$ |
| Regression-out | 0.61 | 0.02 | 0.60 | 0.01 | $p = .504$ |
| Head Noun | | | | | |
| First-fixation | 5.40 | 0.02 | 5.36 | 0.02 | $p = .153$ |
| First-pass | 5.59 | 0.02 | 5.59 | 0.02 | $p = .387$ |
| Re-reading | 5.90 | 0.04 | 5.90 | 0.04 | $p = .846$ |
| Go-pass | 5.78 | 0.03 | 5.68 | 0.03 | $p < .05$ |
| Regression-out | 0.18 | 0.02 | 0.12 | 0.02 | $p = .169$ |
| Regression-in | 0.33 | 0.02 | 0.30 | 0.02 | $p = .325$ |
| Adverb | | | | | |
| First-fixation | 5.43 | 0.02 | 5.44 | 0.02 | $p = .492$ |
| First-pass | 5.54 | 0.02 | 5.52 | 0.02 | $p = .658$ |
| Re-reading | 5.63 | 0.04 | 0.54 | 0.04 | $p = .797$ |
| Go-pass | 6.23 | 0.04 | 6.08 | 0.04 | $p < .05$ |
| Regression-out | 0.47 | 0.03 | 0.40 | 0.02 | $p < .05$ |
| Regression-in | 0.09 | 0.02 | 0.09 | 0.01 | $p = .649$ |
| Matrix Verb | | | | | |
| First-fixation | 5.29 | 0.03 | 5.32 | 0.03 | $p = .782$ |
| First-pass | 5.42 | 0.04 | 5.45 | 0.03 | $p = .849$ |
| Re-reading | 5.70 | 0.08 | 5.78 | 0.07 | $p = .265$ |
| Regression-out | 0.75 | 0.03 | 0.77 | 0.03 | $p = .901$ |

Note. Reading times in log transformations, accuracy and regression in frequency proportion

**Table 3.2. Experiment 1 LME estimates and *t/z* values**

| | Estimate | SE | DF | *t/z* value |
|---|---|---|---|---|
| Sentence | | | | |
| Total time | -.04708 | .02526 | 20.58 | -1.86† |
| Accuracy | .6559 | .6084 | 979.00 | 1.08 |
| | | | | |
| RC Noun | | | | |
| First-fixation | .02548 | .02 | 53.25 | 1.17 |
| First-pass | .02308 | .03 | 28.26 | 0.88 |
| Re-reading | -.10003 | .06 | 29.78 | -1.803† |
| Regression-in | 0.03514 | .23 | 833 | 0.15 |
| RC Verb | | | | |
| First-fixation | -.03513 | .02 | 30.32 | -1.47 |
| First-pass | -.05225 | .03 | 160.34 | -1.822† |
| Re-reading | -.07711 | .06 | 29.92 | -1.24 |
| Go-pass | -.09438 | .04 | 193.51 | -2.696** |
| Regression-out | -.2064 | .23 | 823.00 | -0.88 |
| Regression-in | -0.1329 | .20 | 831 | -0.67 |
| Head Noun | | | | |
| First-fixation | -.03352 | .02 | 20.46 | -1.48 |
| First-pass | -.02489 | .03 | 29.61 | -0.88 |
| Re-reading | .01188 | .06 | 32.01 | 0.20 |
| Go-pass | -.10758 | .04 | 45.47 | -2.475* |
| Regression-out | -.4583 | .33 | 820.00 | -1.38 |
| Regression-in | -0.2049 | .21 | 828 | -0.99 |
| Adverb | | | | |
| First-fixation | .02048 | .03 | 31.15 | 0.70 |
| First-pass | -.01521 | .03 | 28.01 | -0.45 |
| Re-reading | -.0157 | .06 | 36.71 | -0.26 |
| Go-pass | -.15575 | .06 | 66.00 | -2.532* |
| Regression-out | -.4716 | .20 | 776 | -2.393* |
| Regression-in | 0.2041 | .45 | 776 | 0.65 |
| Matrix Verb | | | | |
| First-fixation | .01 | .05 | 22.12 | 0.28 |
| First-pass | .01 | .0 | 26.41 | 0.19 |
| Re-reading | .12 | .10 | 17.05 | 1.15 |
| Regression-out | .04 | .33 | 534.00 | 0.12 |

Note. For reading time measures, a negative estimate indicates an increase in reading time in log transformed milliseconds for the ORC condition. For accuracy and regression measures, a positive estimate indicates an increase of accuracy or probability of regression. † < .1 p < .05*, p < .01**, p < .001***

**Table 3.3. Experiment 2: RC condition and determiner type means**

| | RC Condition | | | | Ambiguity Type | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | Ambiguous | | Unambiguous | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 3,986 | 95 | 3,591 | 79 | 3,472 | 79 | 4,083 | 93 |
| ACC | 67.9% | 1.8% | 74.8% | 1.7% | 71.6% | 1.8% | 71.2% | 1.8% |
| N1 (RC Noun) | | | | | | | | |
| FP | 253 | 6 | 258 | 6 | 267 | 6 | 244 | 6 |
| RR | 691 | 27 | 643 | 27 | 632 | 27 | 699 | 27 |
| GP | 402 | 15 | 395 | 13 | 344 | 10 | 455 | 17 |
| RO | 25.3% | 2.1% | 25.3% | 2.0% | 18.3% | 1.8% | 32.3% | 2.2% |
| RI | 78.2% | 2.0% | 70.5% | 2.1% | 74.7% | 2.0% | 73.7% | 2.1% |
| ADV2 | | | | | | | | |
| FP | 226 | 5 | 229 | 4 | 226 | 4 | 230 | 5 |
| RR | 532 | 24 | 459 | 19 | 491 | 22 | 499 | 21 |
| GP | 341 | 14 | 326 | 11 | 306 | 11 | 362 | 14 |
| RO | 17.4% | 1.9% | 17.9% | 1.8% | 16.0% | 1.8% | 19.3% | 1.9% |
| RI | 51.7% | 2.5% | 45.9% | 2.4% | 48.1% | 2.4% | 49.2% | 2.4% |
| V1 (RC Verb) | | | | | | | | |
| FP | 254 | 6 | 247 | 5 | 252 | 5 | 248 | 5 |
| RR | 503 | 22 | 427 | 19 | 468 | 21 | 462 | 20 |
| GP | 331 | 11 | 293 | 9 | 307 | 9 | 316 | 11 |
| RO | 13.2% | 1.7% | 13.4% | 1.6% | 12.1% | 1.6% | 14.6% | 1.7% |
| RI | 50.0% | 2.5% | 43.2% | 2.3% | 48.3% | 2.4% | 44.6% | 2.4% |
| N2 (Head noun) | | | | | | | | |
| FP | 269 | 7 | 259 | 5 | 263 | 6 | 264 | 6 |
| RR | 631 | 26 | 505 | 20 | 561 | 24 | 575 | 23 |
| GP | 433 | 18 | 383 | 16 | 398 | 16 | 416 | 18 |
| RO | 23.8% | 2.1% | 19.3% | 1.8% | 20.0% | 1.9% | 22.9% | 2.0% |
| RI | 51.2% | 2.4% | 47.3% | 2.3% | 48.3% | 2.4% | 50.0% | 2.4% |
| N3 (Matrix Object) | | | | | | | | |
| FP | 262 | 5 | 268 | 6 | 268 | 6 | 262 | 6 |
| RR | 454 | 20 | 391 | 18 | 433 | 19 | 411 | 19 |
| GP | 952 | 55 | 896 | 49 | 941 | 54 | 904 | 50 |
| RO | 48.1% | 2.4% | 49.0% | 2.3% | 48.0% | 2.4% | 49.2% | 2.4% |
| RI | 20.5% | 2.0% | 20.1% | 1.9% | 21.1% | 1.9% | 19.6% | 1.9% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 208 | 6 | 211 | 6 | 210 | 6 | 209 | 6 |
| RR | 292 | 22 | 228 | 14 | 274 | 21 | 242 | 16 |
| GP | 1,894 | 105 | 1,716 | 87 | 1,643 | 83 | 1,972 | 108 |
| RO | 90.6% | 1.7% | 90.1% | 1.7% | 90.4% | 1.6% | 90.3% | 1.7% |

Note. Means and errors of reading times are displayed in milliseconds.

**Table 3.4. Experiment 2: interaction means**

| | ORC: Ambiguous | | SRC: Ambiguous | | ORC: Unambiguous | | SRC: Unambiguous | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 3,650 | 121 | 3,307 | 101 | 4,329 | 144 | 3,867 | 120 |
| ACC | 69.4% | 2.6% | 73.8% | 2.5% | 66.5% | 2.6% | 75.9% | 2.4% |
| N1 (RC Noun) | | | | | | | | |
| FP | 269 | 9 | 265 | 9 | 236 | 7 | 252 | 9 |
| RR | 645 | 38 | 618 | 40 | 737 | 39 | 665 | 37 |
| GP | 333 | 13 | 355 | 14 | 476 | 26 | 436 | 22 |
| RO | 15.9% | 2.5% | 20.5% | 2.6% | 35.1% | 3.3% | 29.9% | 3.0% |
| RI | 80.0% | 2.7% | 69.7% | 3.0% | 76.3% | 2.9% | 71.4% | 2.9% |
| ADV2 | | | | | | | | |
| FP | 230 | 7 | 222 | 6 | 223 | 6 | 237 | 7 |
| RR | 515 | 33 | 464 | 30 | 549 | 34 | 455 | 26 |
| GP | 302 | 15 | 309 | 15 | 383 | 24 | 343 | 17 |
| RO | 14.4% | 2.4% | 17.6% | 2.6% | 20.5% | 2.9% | 18.2% | 2.6% |
| RI | 51.4% | 3.5% | 45.0% | 3.3% | 52.0% | 3.5% | 46.7% | 3.3% |
| V1 (RC Verb) | | | | | | | | |
| FP | 254 | 8 | 250 | 7 | 253 | 8 | 243 | 7 |
| RR | 524 | 34 | 412 | 26 | 482 | 30 | 441 | 27 |
| GP | 318 | 15 | 297 | 12 | 344 | 18 | 290 | 12 |
| RO | 12.1% | 2.2% | 12.1% | 2.2% | 14.4% | 2.5% | 14.7% | 2.4% |
| RI | 51.6% | 3.4% | 45.1% | 3.3% | 48.3% | 3.5% | 41.3% | 3.3% |
| N2 (Head noun) | | | | | | | | |
| FP | 275 | 10 | 252 | 8 | 262 | 9 | 265 | 8 |
| RR | 619 | 36 | 502 | 31 | 644 | 38 | 508 | 27 |
| GP | 427 | 24 | 371 | 21 | 440 | 26 | 396 | 23 |
| RO | 19.7% | 2.7% | 20.3% | 2.7% | 28.1% | 3.1% | 18.3% | 2.5% |
| RI | 49.1% | 3.4% | 47.6% | 3.3% | 53.3% | 3.5% | 47.1% | 3.2% |
| N3 (Matrix Object) | | | | | | | | |
| FP | 257 | 7 | 279 | 9 | 268 | 8 | 257 | 8 |
| RR | 457 | 26 | 408 | 28 | 452 | 30 | 376 | 23 |
| GP | 989 | 82 | 895 | 70 | 913 | 72 | 897 | 70 |
| RO | 46.3% | 3.4% | 49.6% | 3.3% | 50.0% | 3.5% | 48.5% | 3.2% |
| RI | 21.6% | 2.8% | 20.6% | 2.7% | 19.4% | 2.8% | 19.7% | 2.6% |
| V2 (Matrix Verb) | | | | | | | | |
| FP | 203 | 7 | 217 | 9 | 214 | 10 | 205 | 7 |
| RR | 310 | 37 | 237 | 18 | 272 | 24 | 220 | 21 |
| GP | 1,740 | 126 | 1,544 | 107 | 2,070 | 173 | 1,886 | 135 |
| RO | 92.7% | 2.0% | 88.1% | 2.6% | 88.2% | 2.7% | 92.1% | 2.1% |

Note. Means and errors of reading times are displayed in milliseconds.

**Table 3.5. Experiment 2: LME estimates and *t/z* values**

| | RC Condition | | | Ambiguity Type | | | Interaction | | |
|---|---|---|---|---|---|---|---|---|---|
| | coef. | SE | *t/z* value | coef. | SE | *t/z* value | coef. | SE | *t/z* value |
| Sentence | | | | | | | | | |
| TT | -0.10 | 0.02 | -5.38 *** | 0.17 | 0.02 | 8.89 *** | -0.01 | 0.04 | -0.32 |
| ACC | 0.45 | 0.14 | 3.17 ** | -0.02 | 0.14 | -0.11 | 0.34 | 0.28 | 1.21 |
| N1 (RC Noun) | | | | | | | | | |
| FP | 0.00 | 0.03 | 0.08 | -0.09 | 0.03 | -3.22 ** | 0.05 | 0.06 | 0.83 |
| RR | -0.12 | 0.04 | -2.77 ** | 0.16 | 0.04 | 3.54 *** | -0.04 | 0.09 | -0.51 |
| GP | -0.02 | 0.04 | -0.47 | 0.19 | 0.04 | 5.06*** | -0.08 | 0.07 | -1.04 |
| RO | 0.04 | 0.17 | 0.27 | 0.86 | 0.17 | 5.14*** | -0.49 | 0.33 | -1.48 |
| RI | -0.47 | 0.17 | -2.77** | -0.04 | 0.17 | -0.22 | 0.37 | 0.34 | 1.10 |
| ADV2 | | | | | | | | | |
| FP | 0.01 | 0.02 | 0.40 | 0.00 | 0.02 | 0.18 | 0.05 | 0.05 | 0.97 |
| RR | -0.15 | 0.05 | -3.00** | 0.04 | 0.05 | 0.79 | -0.08 | 0.10 | -0.85 |
| GP | -0.01 | 0.04 | -0.28 | 0.12 | 0.04 | 3.08** | -0.05 | 0.08 | -0.69 |
| RO | 0.07 | 0.19 | 0.38 | 0.27 | 0.19 | 1.43 | -0.38 | 0.37 | -1.02 |
| RI | -0.23 | 0.15 | -1.50 | 0.08 | 0.15 | 0.56 | 0.08 | 0.30 | 0.25 |
| V1 (RC Verb) | | | | | | | | | |
| FP | -0.03 | 0.03 | -1.07 | -0.02 | 0.03 | -0.82 | -0.03 | 0.05 | -0.62 |
| RR | -0.15 | 0.05 | -3.00** | 0.00 | 0.05 | -0.02 | 0.18 | 0.10 | 1.80 † |
| GP | -0.08 | 0.04 | -2.20* | 0.00 | 0.04 | 0.14 | -0.09 | 0.07 | -1.22 |
| RO | 0.00 | 0.20 | 0.02 | 0.22 | 0.20 | 1.08 | 0.03 | 0.40 | 0.06 |
| RI | -0.31 | 0.15 | -2.10* | -0.12 | 0.15 | -0.84 | 0.07 | 0.30 | 0.24 |
| N2 (Head noun) | | | | | | | | | |
| FP | -0.03 | 0.03 | -1.11 | 0.00 | 0.03 | -0.02 | 0.09 | 0.05 | 1.68 † |
| RR | -0.21 | 0.05 | -4.42*** | 0.07 | 0.05 | 1.40 | 0.07 | 0.10 | 0.73 |
| GP | -0.10 | 0.04 | -2.31* | 0.04 | 0.04 | 0.93 | 0.04 | 0.09 | 0.45 |
| RO | -0.22 | 0.17 | -1.26 | 0.21 | 0.17 | 1.21 | -0.69 | 0.34 | -2.01* |
| RI | -0.21 | 0.15 | -1.43 | 0.13 | 0.15 | 0.90 | -0.13 | 0.29 | -0.44 |
| N3 (Matrix Object) | | | | | | | | | |
| FP | 0.01 | 0.03 | 0.50 | -0.03 | 0.03 | -1.10 | -0.09 | 0.05 | -1.83 † |
| RR | -0.17 | 0.05 | -3.20 | -0.05 | 0.05 | -0.89 | 0.03 | 0.10 | 0.30 |
| GP | 0.00 | 0.06 | -0.07 | -0.04 | 0.06 | -0.66 | 0.03 | 0.12 | 0.24 |
| RO | 0.07 | 0.16 | 0.48 | 0.06 | 0.16 | 0.37 | -0.20 | 0.31 | -0.63 |
| RI | -0.12 | 0.18 | -0.65 | -0.10 | 0.18 | -0.55 | 0.13 | 0.37 | 0.35 |
| V2 (Matrix Verb) | | | | | | | | | |
| FP | -0.01 | 0.03 | -0.25 | 0.00 | 0.03 | 0.11 | -0.08 | 0.06 | -1.33 |
| RR | -0.17 | 0.08 | -2.06* | -0.07 | 0.08 | -0.91 | -0.10 | 0.16 | -0.65 |
| GP | -0.04 | 0.06 | -0.72 | 0.18 | 0.06 | 3.17** | 0.14 | 0.11 | 1.25 |
| RO | 0.05 | 0.31 | 0.17 | 0.03 | 0.31 | 0.10 | 1.45 | 0.63 | 2.30* |

Note. A positive estimate indicates an increase in reading time for SRCs or for the Unambiguous type. $p < .1$ †, $p < .05$*, $p < .01$**, $p < .001$***

# CHAPTER 4

# Ambiguity in Japanese Relative Clause Processing

This chapter is a collaborative project designed by myself, Michael Patrick Mansbridge. The paper and its arguments were written primarily by me. Professor Katsuo Tamaoka supervised the project. Both Professor Tamaoka and I developed stimuli, but he also helped by providing a native speaker's interpretation. For the eye-tracking experiments, I designed and built both experiments. I along with a research assistant proctored both Experiments. For all the results of this Chapter, I did all the analyses.

# 4.1. Abstract

In Japanese, relative clauses typically have initial clause-type ambiguity. Since embedded noun-modifying structures lack overt marking at the left boundary or edge of the clause, it can be initially difficult to distinguish matrix clauses from RCs and complement clauses (e.g., *-koto, -to iu, -jijitsu*). Accordingly, the parser only becomes aware of the RC structure at a locus of disambiguation which happens to be the head noun. While there are previous studies which have eliminated this ambiguity resulting in an attenuated difficulty at the head noun, these studies, however, have not effectively investigated the classical processing asymmetry between subject- and object-relatives during reading comprehension. In the current study, eye-tracking was employed on native Japanese speakers to determine how RC processing is influenced by ambiguity. The results revealed different processing patterns for each ambiguity context. Specifically, for the ambiguous RC context, ORC difficulties were observed during overall measures of processing at the head noun and RC verb which can be attributed to a variety of processing factors such as structural-integration, similarity-interference, expectation and the object-before-subject-bias. In contrast, when the clause structure was unambiguous, ORC difficulty was mainly observed during early processing measures at the head noun. This shift in processing behaviour is indicative of effects of expectation-based processing, i.e., since ORCs are less frequent than SRCs, they are more difficult to process. Thus, when the clause becomes less ambiguous, expectations become a more salient processing feature. Overall, RC processing in Japanese is influenced by the level of ambiguity.

**Keywords** Japanese, relative clauses, ambiguity, expectation, object-before-subject-bias

# 4.2. Introduction

The current study aims to reveal the influence ambiguity has on Japanese relative clause processing by comparing the classical subject/object relative clause asymmetry (i.e., for the majority of the world languages, object-extracted relative clauses have been found to be more difficult to process and comprehend than their subject-extracted counterparts) within both ambiguous and unambiguous relative clauses in Japanese. While previous studies have time and again shown that object-extracted relative clauses are more difficult to process in Japanese, there are far too many accounts which accurately predict this difficulty. Therefore, more work is needed in Japanese to tease apart these factors to determine which factors are truly bottlenecks of processing. In the Japanese language, RCs are often ambiguous in terms of clause structure which has been a contentious issue since the ambiguity allows for a garden path effect to occur up to the head noun. Thus, recent studies have begun to investigate RCs in Japanese within an unambiguous context using a variety of methods. However, these studies have often not included an ambiguous baseline context and this makes it difficult to ascertain if ambiguity had an influence in the processing of RCs. Therefore, the current study aims to investigate RCs in Japanese within both ambiguous and unambiguous contexts to determine how ambiguity influences RC processing in Japanese. In line with previous studies arguing for hybrid or interconnected models of sentence processing containing both expectation-based processing effects as well as effects of working memory, I argue that this should also be the case for Japanese RC processing. Considering that previous studies have shown that with attenuated ambiguity, expectation-based processing becomes more salient during reading, I aim to demonstrate this in Japanese. I suspect that changes in processing behaviour will be limited to the locus of the sentence which acts as the cue for the RC interpretation as well as serving as the locus of integration/retrieval between the filler-gap dependencies. In other words, I predict that the head noun should be subject to changes of processing as an influence of ambiguity. Specifically, as the level of ambiguity decreases, indications that processing is guided by our expectations for the language become stronger and more salient over other processing mechanisms such as working memory.

### 4.2.1. Relative Clauses

A relative clause (RC) in Japanese is a noun-modifying expression in which the head noun (i.e., the noun being modified by the clause) is required to be a grammatical argument within the clause itself. According to Na and Huck's (1993, p. 197) *Argument Condition*: "A RC must contain an element E that the clause predicates something of, where E is either (A) a gap co-indexed with the clause head or (B) a nominal whose denotation is thematically subordinate to that of the head noun". Accordingly, RCs would differ from other similar structures in which the head does not satisfy one or the other above conditions. For instance, while complement clauses (e.g., *-koto* ‘thing/about that’, *-no* ‘event’, *-to iu* ‘said that’, *-jijitsu* ‘fact that') and pseudo-relative clauses (i.e., gapless relative clauses) bear a similar structure to that of RCs, their heads have no co-reference at any grammatical position within the clause and there is no part-denoting element within the clause subordinate to that of the head. Thus, they should not be considered to fall under the specific category of RC. While there are many types of relative clauses, this study will focus on only two types, that is, subject-extracted relative clauses (SRCs) and object-extracted relative clauses (ORCs) for subject-modified RCs (i.e., the subject of the matrix clause is modified). See (4.1a) and (4.1b) below for examples of RCs in English.

(4.1a) Subject-extracted relative clause (SRC)
The reporter$_i$ [$_{RC}$ who$_i$ GAP$_i$ criticized the mayor] interviewed the doctor.

(4.1b) Object-extracted relative clause (ORC)
The reporter$_i$ [$_{RC}$ who$_i$ the mayor criticized GAP$_i$] interviewed the doctor.

When discussing the processing of RCs, the term filler-gap parsing is often brought forward. The *filler* is the co-indexed element that fills the *gap* created at the trace of a *wh*-movement. In the above examples for English, it can be easily seen that the head noun is co-indexed with the relative pronoun which originated from a deeper syntactic position within the RC where the grammatical assignment and case is received. Afterwards the relative pronoun undergoes *wh*-movement to the left edge of the clause where it can assign *wh*-features to the clause.

Considering that there are no overt RC markers in Japanese, this interpretation of RCs may be problematic. Admittedly, the underlying structure for RCs in Japanese is still being debated. Some researchers (e.g., Bugaeva & Whitman, 2016; Kaplan & Whitman, 1995) consider there to be a gap within the RC and that there is covert w*h*-movement of a *wh*-operator just as in English when there is not an overt relativizer. In contrast, others (e.g., Comrie, 2008; Davis, 2006; Matsumoto, 1988, 1997; Murasagi, 2000) disagree with the movement claim and instead argue that there is a pronominal element which is co-indexed with the head. One of the main purposes of the latter group has been to classify RCs and other similar structures under one unified structure proposal. Since it is not the purpose of this study to make a definite claim for the Japanese RC structure, I will henceforth assume a gapped interpretation with the stipulation that there is some missing element within Japanese RCs which is co-indexed with the head noun. See (4.2a) and (4.2b) below for examples of RCs in Japanese.

(4.2a) Subject-extracted relative clause (SRC)
市長を非難したレポーターは医師を面接した。
[$_{RC}$ GAP$_i$ *shichō-o hinanshita*] *repōtā*$_i$*-ha ishi-o mensetsushita*.
[$_{RC}$ GAP$_i$ mayor-ACC criticized] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who criticized the mayor interviewed the doctor.'

(4.2b) Object-extracted relative clause (ORC)
市長が非難したレポーターは医師を面接した。
[$_{RC}$ *shichō-ga* GAP$_i$ *hinanshita*] *repōtā*$_i$*-ha ishi-o mensetsushita*.
[$_{RC}$ mayor-NOM GAP$_i$ criticized] reporter$_i$-TOP doctor-ACC interviewed
'The reporter who the mayor criticized interviewed the doctor.'

## 4.2.2. Ambiguity in Japanese Relative Clauses

Temporary ambiguity can lead the mental parser to a classic garden path effect, i.e., an initial misinterpretation of word meaning or sentence structure which requires a reanalysis at a point of disambiguation within the sentence. However, garden path effects can be attenuated using a variety of methods such as discourse priming, prosodic reading, punctuation or syntactic cues. Like Mandarin Chinese and Korean, Japanese is an East Asian language which has prenominal (i.e., head-final) RCs. All of these languages exhibit a temporary clause-type ambiguity. In Japanese, externally headed relative clauses typically lack overt marking, and furthermore, the language also permits pronominal dropping and syntactic scrambling. These features allow Japanese RCs to appear temporarily ambiguous. For example, out-of-the-blue RC-initial expressions, such as examples (4.2a) and (4.2b) above, lack both RC-specific discourse and syntactic markers. When these clauses are encountered, the mental parser is likely to incorrectly assign a matrix-clause interpretation to the RC structure, until a viable cue signals otherwise. This viable clue can be considered as the locus of disambiguation. In Japanese, this point is regularly the head noun of the RC. Yet, even if an initial cue is given to disregard a matrix clause interpretation, other embedded clause interpretations may still be available. For example, complement clause (e.g., because-clauses or fact-expressions) and pseudo-relative clauses (i.e., gapless RCs) may still look identical to an RC up to the embedded verb. Therefore, an RC interpretation is difficult to form until the head noun is parsed. As illustrated in RC fragments (4.3a) and (4.3b) and (4.4a) and (4.4b) below, the initial word order between these fragments are identical on the surface up to the head of the structure. Therefore, the head of the clause acts as the cue to disambiguate the structure.

(4.3a) Subject-extracted relative clause
市長を非難したレポーター…
[$_{RC}$ GAP$_i$ *shichō-o hinanshita*] *repōtā*$_i$…
[$_{RC}$ GAP$_i$ mayor-ACC criticized] reporter$_i$ …
'The reporter [(who) criticized the mayor]…'

(4.3b) Object-extracted relative clause
市長が非難したレポーター…
[$_{RC}$ *shichō-ga* GAP$_i$ *hinanshita*] *repōtā*$_i$…
[$_{RC}$ mayor-NOM GAP$_i$ criticized] reporter$_i$ …
'The reporter [(who) the mayor criticized]…'

(4.4a) Subject-drop fact clause
市長を非難した事実
[$_{CC}$ pro *shichō-o hinanshita*] *jijitsu…*
[pro mayor-ACC criticized] fact…
'The fact [(that) someone criticized the mayor]…'

(4.4b) Object-drop fact clause
市長が非難した事実…
[$_{CC}$ *shichō-ga* pro *hinanshita*] *jijitsu…*
[mayor-NOM pro criticized] fact…
'The fact [(that) the mayor criticized someone]…'

Japanese is a *mixed* relative clause language which allows for both externally-headed relative clauses (EHRC) and internally-headed relative clauses (IHRC) (Dryer, 2013; Kuroda, 1992; Shibatani, 1990); though, EHRCs are the more dominant variety. The above RC examples are EHRCs since the head noun is juxtaposed outside the RC structure. In contrast, IHRCs contain the head noun within the RC. While for EHRCs there is no overt marking to denote the RC structure, internally-headed clauses are marked with the nominalizer *–no* (Simpson & Wu, 2001). This *–no* differs in function from the genitive *–no* and a pronominal since while it is understood to be the head noun, the head noun cannot actually replace it and be present at both positions (Ohara, 1992). After the nominalizer, case marking follows. This case marking is typically nominative, accusative or topic case. Similar to externally-headed relative clauses, there is also clause-type ambiguity for these clauses as well (e.g., Ohara, 1992): First of all, it is possible to initially parse the clause as a sentence and secondly, these clauses may sometimes be confused with event-clauses in Japanese which are also modified by the –*no*-case (nominative, accusative, topic) pattern. In some cases, both interpretations of an internally-headed clause and event-type clause may be possible. See below for examples of internally-headed clauses (provided by Ohara, 1992) and event-clauses.

(4.5a) Externally-headed relative clause
太郎は走って来た花子を捕まえた。
*Taro-ha hashittekita Hanako-o tsukameata*.
Taro-TOP [GAP$_i$ came.running] Hanako$_i$-ACC caught.
'Taro caught Hanako who came running.'

(4.6a) Internally-headed relative clause
太郎は花子が走って来たのを捕まえた。
*Taro-ha Hanako-ga hashittekita no-o tsukameata*.
Taro-TOP [Hanako-NOM came.running] NO-ACC caught.
'Taro caught Hanako who came running.'

(4.6b) Internally-headed relative clause
太郎は花子が走って来たのを見た。
*Taro-ha Hanako-ga hashittekita no-o mita*.
Taro-TOP [Hanako$_i$-NOM came.running] NO$_i$-ACC saw.
'Taro saw Hanako who came running.'

(4.7a) Event-clause
太郎は花子が走って来たのを見た。
*Taro-ha Hanako-ga hashittekita no-o mita*.
Taro-TOP [Hanako-NOM came.running] NO-ACC saw.
'Taro saw that Hanako came running.'

The importance of IHRCs to the discussion of EHRCs (i.e., the focus of this paper), is that even in cases where the clause is marked, the locus in the sentence where clause-type ambiguity would be disambiguated is also the point in the sentence where the integration/retrieval occurs, or the extraction of semantic meaning in the case of IHRCs (Shimoyama, 1999). Accordingly, in order to attenuate ambiguity, cues outside of regular RC morphology must be used.

#### 4.2.2.1. Attenuating Ambiguity

As mentioned before, garden path effects can be eliminated. Previous research in Japanese has shown this using discourse-priming (Miyamoto, 2016; Miyamoto & Tsujino, 2016) punctuation (Niikuni & Muramoto, 2014), prosodic effects (Hirose, 2003), clause-type plausibility (Nakamura & Arai, 2015), successive case marking (Miyamoto, 2002), and pre-RC cues (Kahraman, Tanigawa & Hirose, 2014).

Furthermore, more recent research (Arai & Kahraman, 2016; Arai, 2017) has used post-RC cues to help increase an RC interpretation. The bulk of these studies observed that the processing burden for RC processing at the head noun can be attenuated when the RC becomes unambiguous. These methods were effective at eliminating or reducing ambiguity by creating clause boundaries, which typically indicate movement into an embedded clause. For example, there is an increased probability of an embedded clause when the clause contains successive case marking (e.g., Miyamoto, 2002). Both the sentences in (4.8a) and (4.9b) below, are ambiguous; the verb "interrogated" may appear to be a matrix predicate until the head noun "policeman" is encountered. On the other hand, since in (4.8b) and (4.9a) "Tanaka" and "reporter" have the same case marking, it becomes likely that the second noun is contained within an embedded clause. This creates a clause boundary between the two nouns (Miyamoto, 2002; Yamashita, 1996). Consequently, the head noun would be easier to parse since it (i) lacks structural reanalysis and (ii) has higher anticipation. In contrast, sentences (4.8a) and (4.9b) would have a garden path effect at the head noun causing a reading slowdown.

(4.8a) in situ object-modified SRC
田中がレポーターを尋問したお巡りさんを見た。
*Tanaka-ga* [*repota-o jinmonshita*] *omawarisan-o mita*.
Tanaka-NOM [reporter-ACC interrogate] policeman-ACC saw.
'Tanaka saw the policeman who interrogated the reporter.'

(4.8b) in situ object-modified ORC
田中がレポーターが尋問したお巡りさんを見た。
*Tanaka-ga* [*repota-ga jinmonshita*] *omawarisan-o mita*.
Tanaka-NOM [reporter-NOM interrogate] policeman-ACC saw.
'Tanaka saw the policeman who the reporter interrogated.'

(4.9a) scrambled subject-modified SRC
田中をレポーターを尋問したお巡りさんが見た。
*Tanaka-o* [*repota-o jinmonshita*] *omawarisan-ga mita*.
Tanaka-ACC [reporter-ACC interrogate] policeman-NOM saw.
'The policeman who interrogated the reporter saw Tanaka.'

(4.9b) scrambled subject-modified ORC
田中をレポーターが尋問したお巡りさんが見た。
*Tanaka-o* [*repota-ga jinmonshita*] *omawarisan-ga mita*.
Tanaka-ACC [reporter-NOM interrogate] policeman-NOM saw.
'The policeman who the reporter interrogated saw Tanaka.'

This design, however, may not be suitable to compare the processing between SRCs and ORCs since it does not allow for equal comparisons. This is because in two conditions successive case effects create a clause boundary while the other two do not, so it would only show that, in the other two conditions, a garden path effect is present. Also, if I were to compare the processing of (4.8b) and (4.9a), it still would not allow for a fair comparison since (4.9a) involves scrambling. Therefore, other methods should be used to create a clause-boundary at the start of the RC.

Another notable method of attenuating ambiguity is using pre-RC cues (i.e., not successive case cues) to enhance the RC interpretation. Such a method was implemented by Kahraman et al. (2014). In their study on Japanese processing, they inserted numerical classifiers in the pre-RC position which either matched or mismatched with the RC noun. See below for examples provided by Kahraman et al. (2014).

(4.10a) Match-SRC

一人の快活なおじさんを真似した黄色い鸚鵡は
*hitori-no kaikatsuna ojisan-o maneshita kiiroi oumu-wa*
1 person-GEN cheerful mister-ACC imitated yellow parrot-TOP
箱の中で煩く泣き始めた。
*hakononaka-de urusaku nakihajimeta.*
in box-LOC loudly start crying
'The yellow parrot that imitated one cheerful mister started to squawk loudly in the box.'

(4.10b) Match-ORC

一人の快活なおじさんが真似した黄色い鸚鵡は
*hitori-no kaikatsuna ojisan-ga maneshita kiiroi oumu-wa*
1 person-GEN cheerful mister-NOM imitated yellow parrot-TOP
*hakononaka-de urusaku nakihajimeta.*
in box-LOC loudly start crying
'The yellow parrot that one cheerful mister imitated started to squawk loudly in the box.'

(4.10c) Mismatch-SRC

一羽の快活なおじさんを真似した黄色い鸚鵡は
*ichiwa-no kaikatsuna ojisan-o maneshita kiiroi oumu-wa*
1 bird-GEN cheerful mister-ACC imitated yellow parrot-TOP
箱の中で煩く泣き始めた。
*hakononaka-de urusaku nakihajimeta.*
in box-LOC loudly start crying
'One yellow parrot that imitated the cheerful mister started to squawk loudly in the box.'

(4.10d) Mismatch-ORC

一羽の快活なおじさんが真似した黄色い鸚鵡は
*ichiwa-no kaikatsuna ojisan-ga maneshita kiiroi oumu-wa*
1 bird-GEN cheerful mister-NOM imitated yellow parrot-top
箱の中で煩く泣き始めた。
*hakononaka-de urusaku nakihajimeta.*
in box-LOC loudly start crying
'One yellow parrot that the cheerful mister imitated started to squawk loudly in the box.'

The results of their study revealed that when the numerical classifier matched with the RC noun, ORC difficulty was observed at spillover regions of the head noun. In contrast, when the classifier mismatched with the RC noun, ORC difficulties were not observed. They therefore concluded that with an increased expectation for an RC structure, processing difficulties can be attenuated and that the numerical classifier mismatch cue is an effective tool for eliminating the clause-type ambiguity. However, there is one issue with this paradigm which may have allowed for ORCs to become just as easy/difficult to parse than SRCs. Specifically, the animacy values for the RC noun and head noun could be somewhat problematic for their account. It is well known that animacy contrast is a major factor for RC processing. For example, it is often found in corpora of various languages that SRCs are preferred to have an animate head and inanimate RC noun with ORCs preferring the opposite (e.g., Mak et al., 2012; Traxler et al., 2002; Traxler et al., 2005; Wu et al., 2011). Considering this, it is likely that similar distributions occur in Japanese. Accordingly, in the sense that many classifiers are for inanimate objects or for animals which are lower on the animacy hierarchy scale than humans (c.f., Aissen 1998; Ransom, 1977) there should be higher expectations for ORCs when said classifiers are provided, thus attenuating some ORC difficulty. This by no means diminishes the value of the findings by Kahraman et al. (2014) but instead implies that their findings may relate more to the particular expectations attributed to the distributions of frequency for animacy contrast rather than the frequency of RCs as a whole. Bearing in mind that the distributions of RCs are more equal when both nouns are animate even though SRCs are nevertheless more frequent, it may be better to test subject/object asymmetry in this more neutral environment. Thus, pre-RC classifiers could not be utilized since in most cases, the classifier for humans would likely match with both the RC noun and head noun.

As mentioned previously, post-RC cues can be used as well to help eliminate the clause-type ambiguity. As the name suggests, post-RC cues occur after the RC but before the head noun. Accordingly, the clause-type ambiguity is not attenuated until after processing the RC structure. Instead of the head noun being the locus of disambiguation, the garden path effect would only occur up to the cue instead of the head noun. See examples (4.11a-c) below provided by Arai & Kahraman (2016) and Arai (2017).

(4.11a) SRC + Adjective
理系の大学院生を国際学会で厳しく非難した意地悪な研究者は足早に去った。
*rikei-no daigakuinse-o kokusaigakkai-de kibishiku hinanshita ijiwaruna kenkyusha-ha ashibaya-ni satta*
science.major graduate.student-ACC international.conference-LOC harshly critized mean researcher-TOP quickly left
'The mean researcher who the science graduate student criticized harshly at an international conference quickly left.'

(4.11b) SRC + Adjective
理系の大学院生を国際学会で厳しく非難した風力発電の研究者は足早に去った。
*rikei-no daigakuinse-o kokusaigakkai-de kibishiku hinanshita huuryokuhatsuden-no kenkyusha-ha ashibaya-ni satta*
science.major graduate.student-ACC international.conference-LOC harshly critized wind.energy-GEN researcher-TOP quickly left
'The wind-energy researcher who the science graduate student criticized harshly at an international conference quickly left.'

(4.11c) SRC + Demonstrative
理系の大学院生を国際学会で厳しく非難したその研究者は足早に去った。
*rikei-no daigakuinse-o kokusaigakkai-de kibishiku hinanshita sono kenkyusha-ha ashibaya-ni satta*
science.major graduate.student-ACC international.conference-LOC that critized wind.energy-GEN researcher-TOP quickly left
'That researcher who the science graduate student criticized harshly at an international conference quickly left.'

Such cues can be demonstratives, adjectives, or genitive phrases. Recently, Arai has been investigating Japanese RC processing using such cues and has found that asymmetry between RCs can be explained by the structural frequencies of the language (i.e., expectation-based processing). Yet, as mentioned, the said design still allows for a garden path effect during the initial parsing of the RC. Therefore, in order to view the processing of RCs without a garden path effect involved, pre-RC cues may be more appropriate in this regard. Consequently, for this research, I will use pre-RC cues.

### 4.2.3. Processing Theories

In the following subsections, several processing theories are described and their relation to Japanese RC processing is spelled out. The following processing accounts are by no means an exhaustive list for RC processing. Instead, I have limited the discussion of these points since they are prominently focused on for RC research. In this research memory-mechanisms and expectation-based processing will be addressed. Memory and expectation together compose the hybrid model of processing, and they operate in the framework of cue-based retrieval models. Additionally, the *Object-Before-Subject-Bias* theory is included as a counter-hypothesis to both expectation and memory.

#### 4.2.3.1. Integration-Based Resources

For filler-gap dependencies (Chomsky, 1981; Clifton & Frazier, 1989; Fodor, 1989), the head noun is required to be integrated with the gap to assume its grammatical role within the RC. Otherwise, the RC would not able to be properly understood. For integration/retrieval processes (Chomsky, 1965; Gibson, 2000; Lewis & Vasishth, 2005; O'Grady, 1997), they are generally understood as a function of working memory and that the activation level of a referent in working memory will decay (i.e., decrease). While there are three main metrics to measure this decay (or distance as it is commonly known), the general principle is that as more meaningful dependencies intervene between filler and gap, the activation level will continue to decay. And, as the activation level decreases, the processing work associated with the integration/retrieval of the referent will increase.

##### 4.2.3.1.1. Linear-Distance Metric

According to Gibson's (2000) *Dependency Locality Theory* (DLT), each meaningful syntactic dependency or discourse referent intervening between two co-indexed elements carries a mental unit in working memory which makes integration more difficult as the distance between the two dependents (the filler and the gap) increases, resulting in an increased memory load. Gibson's DLT for integration/retrieval is often described as the *linear* metric since intervening material is counted on the surface structure not the syntactic. This implies that even if an adjunct phrase intervened between two referents, there would be a cost in working memory to carry the co-indexed referent over this intervening material. For Japanese, the distance between the head noun and gap is greater in SRCs in comparison to ORCs thus indicating that the integration process should be more demanding in SRCs. In contrast, the predictions made in English call for greater ORC difficulty since the gap is more distant when the gap is in the object position. The differences with English are not limited to Japanese. In fact, many prenominal languages make predictions for SRC difficulty (e.g., Basque).

#### 4.2.3.1.2. Temporal-Distance Metric

In a similar vein to the DLT, Lewis and Vasishth's (2005; Vasishth & Lewis, 2006) *Activation-Based Model*, based within the scope of the *Adaptive Control of Thought–Rational* (ACT-R) model (Anderson, 1996), proposes that the decay of the initial activation increases as a function of time (i.e., temporal locality). However, they contend there is no processing cost associated with maintaining dependencies in working memory contrasting Gibson's DLT and that integration/retrieval does not invoke a reactivation of the co-indexed dependency. This metric of integration again predicts greater SRC difficulty in Japanese. This again would contrast with other languages such as English in which the prediction is for ORC difficulty. Since this metric makes the same prediction as DLT (i.e., greater SRC difficulty in Japanese), these two accounts will henceforth be collapsed into a single metric.

#### 4.2.3.1.3. Structural-Distance Metric

Lastly, the *Structural-Phrase Hierarchy* model (O'Grady, 1997) instead proposes that the decay in memory is attributed to the number of intervening phrases in syntactic hierarchy. This model directly contrasts with the above since intervening material on the surface level, which does not intervene between two co-indexed dependencies in structure, does not impact on the level of decay. In Japanese, since there are more intervening syntactic phrases in hierarchy between the filler and gap for ORCs, there is greater difficulty for ORC processing than SRC processing during integration.

For Japanese, there are contrastive predictions based upon the metric used to define the distance between the filler and gap. When defining distance by either the linear or temporal metric, SRCs are predicted to be more difficult since the gap has more intervening dependencies on a linear plane in comparison to ORCs. This would contrast with a language like English which would instead have a prediction for greater

ORC difficulty. On the other hand, when distance is defined by the number of syntactic phrases intervening between the filler and gap, ORCs are proposed to be more difficult since there would always be an additional intervening phrase in comparison to SRCs (i.e., a language universal). Refer to Figure 4.1 for an illustration of integration metrics.

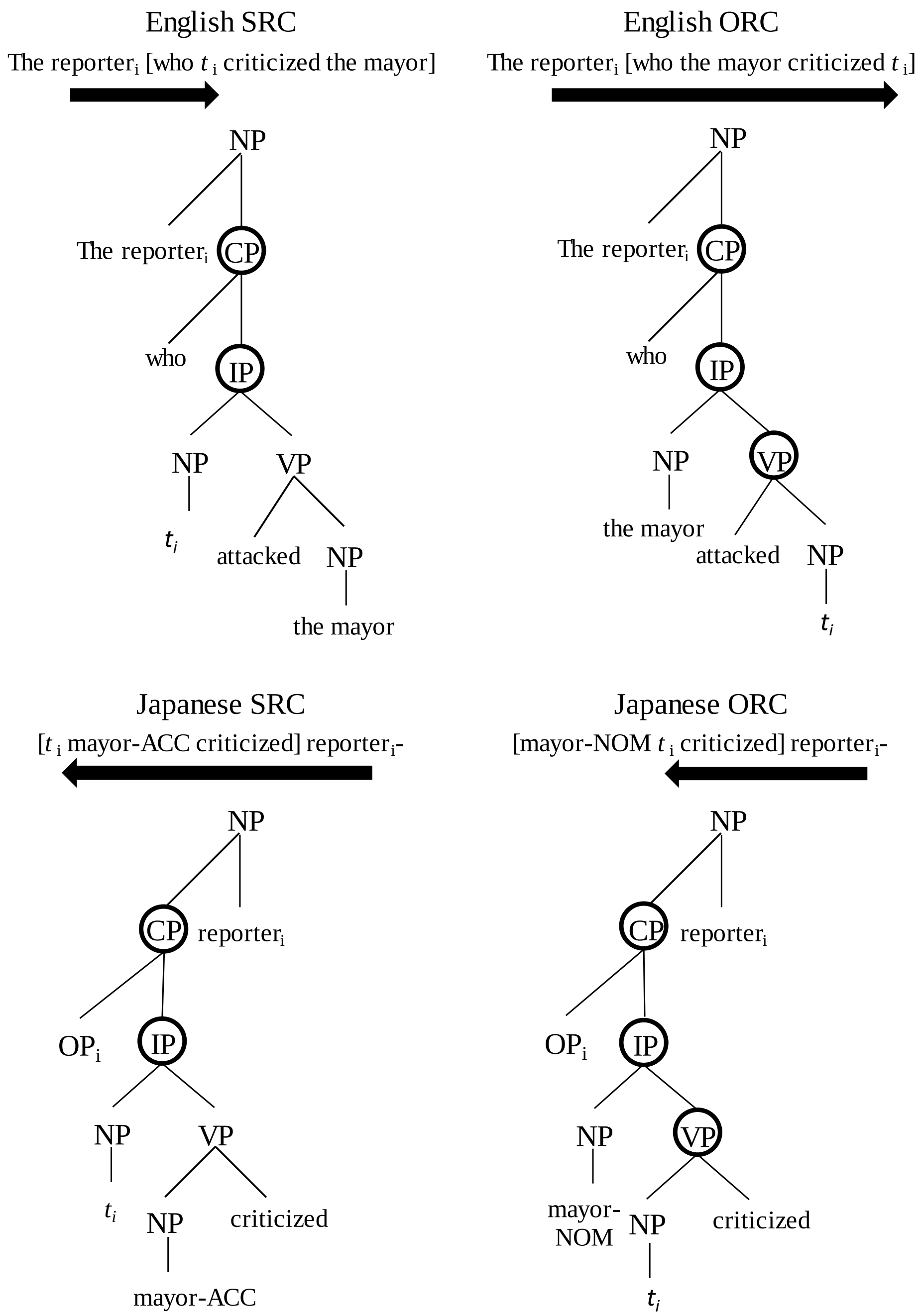



**Figure 4.1. Integration metric predictions for English and Japanese RCs**
The linear/temporal metric distance is indicated by the horizontal arrow, and the longer the arrow, the greater the decay in memory. The structural-phrase metric distance is indicated by the circles around the phrases, and the more phrases circled intervening between the filler and the gap, the greater the decay.

#### 4.2.3.2. Expectation-Based Processing

*Expectation-based Processing* (Hale, 2001; Levy, 2008) is a probabilistic model of processing which assumes processing is incremental (e.g., Altmann & Kamide, 1999) and is constantly drawing from prior language exposure to make predictions for the upcoming structure. As described by Levy (2008), at each individual word, the parser is making ranked-parallel expectations based upon the structural frequencies for the possible structures which can complete the string, and when processing difficulty is observed at a word for a less frequent structure, it generally reflects the difficulty in revising the expectations for the structure. This may be understood as a less frequent structure being more difficult to process than a more frequent structure at a point where two structures diverge. In this probabilistic theory, the calculations made at any individual word are referred to as *Surprisal* (see Levy, 2008 or Yun et al., 2015). After encountering ambiguity (e.g., a garden path) at a locus of disambiguation where the structural representation becomes clear, expectation-based processing becomes a critical factor. If the structure turns out to be the more frequent one, then the expectation is met and processing demands are kept to a minimum. In contrast, if the less frequent structure is encountered, then the parser's expectation is dashed and more processing work is required to reallocate the structural predictions.

For other languages such as English (Staub, 2010), Russian (Price & Witzel, in press), Korean (Kwon et al., 2010) and Mandarin (Jäger, Chen, Li, Lin, & Vasishth, 2015), expectation-based processing has been well supported. However, while there have been some claims against probabilistic models of processing (e.g., Roland et al., 2012), Levy (2008) has considered that expectation-based processing effects may not always be observable and other factors of processing which bottleneck the parser to a greater degree can mask observances of expectation. This point may have serious implications for Japanese RC processing.

For Japanese, in terms of the structural frequencies for RCs, it has already been shown that ORCs do in fact occur less often in corpora than their SRC counterparts. Both Collier-Sanuki (1993) and Yun et al. (2015) found that SRCs occur more frequently than ORCs. While Collier-Sanuki (1993) used translated novel corpora to reveal RC frequencies, Yun et al. (2015) used the Kyoto Corpus 4.0 (Kurohashi & Nagao, 2003). From their investigation it was revealed that SRCs (537 token counts) are overwhelmingly more frequent than their ORC counterparts (116 token counts) in

Japanese, which is significant by a chi-square goodness of fit test, $\chi^2(1, N = 653) = 271.43$, $p < .001$. Thus, despite arguments that ORCs occur just as often than SRCs as revealed by child acquisition studies (Ozeki & Shirai, 2007) and sentence completion tasks producing varied results (c.f., Kahraman et al., 2014; Nakamura & Miyamoto, 2012 Miyamoto & Tsujino, 2016), corpora evidence tells otherwise. Furthermore, there is a simple explanation as to why sentence completion tasks reveal mixed findings. Simply, the ORC fragments are more constrained to RC interpretations due to the rarity of object pro-drop while SRC fragments can also be interpreted as other types of embedded clauses with subject pro-drop. This premise, however, does not imply that ORC fragments should have a higher expectation for RCs since both SRCs and subject pro-drop embedded clauses still have higher frequencies. Thus, within a ranked-parallel parser, SRCs and their other embedded clause counterparts would be ranked higher than ORCs. Expectation-based processing, therefore, would predict greater difficulty for ORCs in comparison to SRCs. Considering the initial-clause type ambiguity, however, these effects should not be observed until the correct RC interpretation is realized. This occurs at the head noun (i.e., locus of disambiguation) since in ambiguous contexts it is the first cue to give an RC interpretation. This would imply that a garden path effect exists up to this locus for a simple clause structure. For unambiguous RCs, on the other hand, the first cue in the sentence that may potentially indicate the RC type (e.g., ORC or SRC) would be the case marking on the RC noun. If only an accusative noun is given, then the structure should be interpreted as being an SRC. In contrast, if a noun marked with nominative is provided, then an ORC should be understood. Thus, ORC difficulty should be observed prior to the head noun if the parser understands that it has entered an RC. But even then, considering that other embedded complement clause structures are more likely to contain a subject pro-drop in comparison to object pro-drop, a general subject/object asymmetry may be observed prior to the head. Refer to Yun et al. (2015) for the frequencies of complement clauses in Japanese.

Another frequency-based account is the *Entropy Reduction Hypothesis* (Hale, 2006; Yun et al., 2015). While Hale claims that the underlying calculations of frequency are similar to that of surprisal (Levy, 2008), Hale interprets processing difficulty to be the result of reductions in the structural entropy between words. According to Hale, there is a degree of uncertainty left in the structure at each word, and when this level of uncertainty is lowered at the subsequent word, processing work has occurred. In Yun et al. (2015), the entropy levels for the remaining structure was calculated at each word of the RC, and according to this model, ORCs should be more difficult to process since its structure has multiple greater drops in entropy compared to the SRC structure. For instance, at the RC noun, the case morphology between ORCs (i.e., nominative case) and SRCs (i.e., accusative case) should reveal a greater reduction in entropy for ORCs since the nominative case would likely constrain the noun's interpretation as being a matrix subject. Following this difficulty, ORCs are again predicted by Yun et al. (2015) to be more difficult at the head noun since the ORC structure is more ambiguous at the RC verb in regards to the missing object being considered as a pro-drop or gap, whereas the missing subject in SRCs are more likely to be considered as a subject pro-drop. According to Yun et al.'s (2015) calculations, there is a minimal drop in entropy moving from the embedded verb to the head noun for SRCs while there is a greater drop in entropy for ORCs after eliminating the pro-drop interpretation. It is important to specify that this model predicts ORC difficulty at the RC noun and head noun for ambiguous Japanese RCs. For unambiguous RCs, Yun et al. (2015) speculate that no difficulty may be observed since the structural representation should be clear at the start of the clause.

#### 4.2.3.3. Similarity-Based Interferences

Similarity-interference is another working memory account for processing difficulty. Generally speaking, when two referents are stored into working memory with similar features, there is greater difficulty in selecting a specific referent from memory due to the interference from the other. However, the particularities of similarity-interference are not agreed upon. While some see it as difficulty in storage, encoding and retrieval (e.g., Gordon et al., 2001), others consider difficulty to occur primarily during retrieval (e.g., Lewis & Vasishth, 2005). For an overview on these points, refer to Lewis, Vasishth, and Van Dyke (2006).

According to Lewis and Vasishth's (2005; Vasishth & Lewis, 2006) *Activation Constraint or Cue-based Retrieval* model, there are fluctuations in activation for particular referents in memory. When a particular referent has a high activation level, its retrieval should be easier in comparison to when it has a low activation level. More specifically, when there are other referents within the sentence with overlapping features (e.g., animacy, syntactic position, gender, or number), the activation level for each referent will lower. This could be both proactive and retroactive in nature. Unlike Gordon's model described below, the lowering of activation does not increase the difficulty in storing and encoding these dependencies. Instead, difficulty occurs during the retrieval stage at the locus which initiates a retrieval process (e.g., a pronoun, reflexive or verb).

The other proposal relies less on activation-based constraints. According to Gordon and colleagues (Gordon et al., 2001; Gordon et al., 2006), there is difficulty with storing, encoding and retrieving two or more nouns when they share overlapping/matching features. Simply put, while reading sentences, we store and maintain noun dependents with their assigned syntactic and semantic features in working memory for later reactivation and integration with their respective verbs. Accordingly, if two or more similar nouns are stored in memory, they may interfere with each other during the retrieval of one of them. This would also be modulated by how similar these nouns are. As they become more similar in gender, number, noun type, semantic or grammatical role, the larger the impact of the interference will become. Under Gordon's model, difficulty can occur both at the encoding and retrieval stages of processing.

For Japanese subject-modified RCs, ORCs should incur a greater processing cost due to similarity-interference in comparison to SRCs since both the ORC noun and head noun share overlapping features in grammatical role (e.g., subject role). Specifically, the RC noun would proactively interfere with the head noun for ORCs during the retrieval of the matrix subject at the matrix verb. Also considering Gordon's account for similarity-interference, later stage difficulty may also be observed at the head noun or even within the RC if the head noun retroactively interferes with the RC noun.

#### 4.2.3.4. The Object-Before-Subject-Bias

Nakamura and Miyamoto (2013), claim that ORC difficulty may be better explained by other processing accounts rather than expectation and working memory. Within the framework of their *Object-Before-Subject-Bias* model, ORC difficulty in Japanese can be explained by difficulties in thematic assignment. Drawing upon the *Verb-Object Bonding Principle* for transitive arguments (Tomlin, 1986), the claim that thematic role of the direct object is assigned by the transitive verb and the subject's role by the direct object, Nakamura and Miyamoto (2013) argue that when each argument is stated (i.e., overt or not dropped; see Nakamura and Miyamoto, 2013 for understated, dropped arguments in Japanese) there is inherently greater difficulty for ORC constructions. See below for an example of how the object determines the theta role of the subject.

(4.12) English Example
    Prefix String: The man caught…
        Theta Role Option 1: a ball ['the man' becomes <agent>]
        Theta Role Option 2: a cold ['the man' becomes <experiencer>]

Generally speaking, not only is there greater difficulty for ORCs because the object argument is juxtaposed outside the clause as a head in comparison to when it is within the clause, there is also greater difficulty with ORCs because of how thematic roles are first assigned for the object head and then back to the RC subject. In comparison with SRCs, the assignment of the subject head's theta role occurs during one step at the head noun. This difficulty in assignment, they claim, would manifest itself at the head noun and the RC verb as well. See below for an example of the ordering of thematic roles in Japanese.

(4.13) Ordering of Thematic Arguments: Japanese Examples
    SRC: 市長を非難したレポーター
        *shichō-o hinanshita repōtā*
        mayor-ACC criticized reporter-NOM
        [Theta role assignment: (1) the object 'mayor and then (2) the subject 'reporter'. In other words, the RC theta role for 'reporter' is immediately assigned.]
    ORC: 市長が非難したレポーター
        *shichō-ga hinanshita repōtā*
        mayor-NOM criticize-ADN reporter-NOM
        [Theta role assignment: (1) the object 'reporter' and then (2) the subject 'mayor. The RC theta role for 'senator' is assigned after reading 'reporter'.]

However, as Nakamura and Miyamoto (2013, p. 324) note, the assignment of the thematic role for the subject can appear prior to the integration of an object, due to anticipatory resources. This is a probable scenario for unambiguous Japanese clauses, which would allow the assignment of thematic roles to occur earlier out of greater anticipation for a head noun. As such, I believe that this would remove some of processing difficulty related to thematic role assignment at the head noun and RC verb. However, if the subject/object asymmetry still persists at the head noun, then other processing accounts may be indicative of the difference when the clause is unambiguous, especially since the clause would no longer require a structural reanalysis. Considering evidence for expectation-based resources in other prenominal RC languages such Mandarin (Jäger, Chen, Li, Lin, & Vasishth, 2015) and Korean (Kwon, Gordon, Lee, Kluender, & Polinsky, 2010) when the RC is unambiguous, I predict to find evidence of expectation-based resources in Japanese. However, to better understand the role of ambiguity in relation to these processing accounts, it is of empirical interest to investigate RC processing asymmetry under various levels of ambiguity.

### 4.2.4. Current Issues

Most of the current literature surrounding East Asian languages with prenominal RCs had been investigating the classical processing asymmetry between SRCs and ORCs using unambiguous RCs. This is because RC ambiguity is viewed as an undesired confound. However, many of the above Japanese studies, which used unambiguous RCs, either did not account for RC asymmetry or did not offer ideal circumstances for investigating the differences in processing. For past studies using ambiguous RCs in Japanese (Ishizuka, 2005; Kahraman et al., 2011; Kahraman & Sakai, 2015; Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008), it was clearly observed that ORCs, as in many other languages, were more difficult to process and comprehend compared to SRCs. These studies explained ORC processing difficulty in Japanese from the perspectives of the *Accessibility Hierarchy* (Keenan & Comrie, 1977), which posits that the subject position is in a more accessible position within the RC compared to the object position, and the syntactic-phrase hierarchy integration metric (O'Grady, 1997). However, ambiguous RCs may not be an ideal context to properly compare these conditions since both require structural reanalysis at the head noun. In fact, Nakamura and Miyamoto (2012) and Miyamoto (2016), drawing upon the aspect of *closure* (Frazier & Fodor, 1978) and the fact that Japanese is head-final and typically an early closure language, argues that at the embedded RC verb, the clause would close and the contents would be purged from working memory prior to integration of the head noun. Therefore, the processing of ambiguous RCs in Japanese is unlikely to use memory-based resources related to the integration/retrieval of filler-gap dependencies. Additionally, these studies also contend that expectation-based processing (Hale, 2001; Levy, 2008) may not be an principal factor for Japanese RC processing as well (see Kahraman et al., 2014; Nakamura & Miyamoto, 2012; Miyamoto & Tsujino, 2016 for conflicting evidence for expectation in Japanese). Yet, as Levy (2008, p. 1,116) puts it, observations of expectation are likely to be masked by other operations such as integration. In Japanese, structural reanalysis at the head may be preventing genuine measures of expectation from being seen.

In summary, for relative clause processing in Japanese, it is well known that ORCs are more difficult; yet, there are currently far too many competing accounts which support the general finding that ORCs are more difficult to process than SRCs. What is more, these investigations, while addressing ambiguity as a potential factor causing a garden-path effect, have not fully addressed ambiguity as a factor since comparisons were chiefly made within ambiguous or unambiguous RCs without a proper comparison of effects between the two contexts without a garden path effect or other confounds. Consequently, an investigation is needed to compare the processing of both ambiguous and unambiguous RCs which are attenuated by a method which can be used equally for both RC types.

### 4.2.5. Current Study

The current study investigates RC processing in Japanese via two eye-tracking experiments. Each experiment differs with respect to the level of the initial clause type ambiguity. The experiments demonstrate how processing patterns change under different ambiguity contexts at the head noun. Specifically, this study explores the detailed patterns of reading behaviour within a normal reading design by using eye-tracking. Experiment 1 compares the processing of strictly ambiguous RCs in Japanese, while Experiment 2 compares both ambiguous and unambiguous RCs by inserting a potential syntactic cue to help attenuate clause-type ambiguity. I predict that ambiguous and unambiguous contexts each have distinct patterns of processing. Particularly, I predict that the object-before-subject-bias will account for the processing asymmetry when the clause is ambiguous, and once the clause-type ambiguity has been attended to, expectation-based resources will explain any processing difference.

## 4.3. Experiment 1

The main purpose of Experiment 1 was to replicate the results from previous studies which used ambiguous RCs in Japanese. Specifically, I wished to replicate the results of Ueno and Garnsey (2008) using eye-tracking. As previously mentioned, their results revealed that within ambiguous RCs in Japanese, ORCs were found to be more difficult to process at the head noun. Accordingly, when using eye-tracking it was predicted that ambiguous Japanese ORCs would be more difficult to process at the head noun compared to SRCs. And if this effect was replicated, I also aimed to determine whether the structural-phrase hierarchy, expectation-based processing or the object before subject-bias would account for the ORC difficulty.

### 4.3.1. Methods

#### 4.3.1.1. Participants

Thirty-three (Female = 16) native Japanese speakers were recruited from Nagoya University in Japan. These participants were undergraduate, graduate or research students at the time of the study. The mean age of the participants was 22 years and 3 months; ranging from 18 years and 8 months to 46 years and 2 months.

#### 4.3.1.2. Materials

All 40 relative clause (SRC vs. ORC) experimental items were borrowed from Ueno and Garnsey (2008) (see Appendix Chapter 4, p. 277). These items were put into counterbalanced lists to ensure that participants would only see one RC variant for each item. An additional ten practice and 50 distractor items were included in each list. SRC and ORC conditions only varied by the case marking attached to the RC noun (i.e., accusative or nominative case). The head noun was an oblique adjunct marked with a dative and topic marker to reduce the chance of *Perspective Shift* effects (MacWhinney, 1977, 1982), which is the difficulty of maintaining and shifting perspectives within a sentence, and similarity-based interference effects (Gordon, Hendrick, & Johnson, 2001), which is the difficulty in memory to select a given noun when two or more nouns are stored in memory with similar attributes.

(4.14a) Subject-extracted relative clause (SRC)
せこい議員を非難した記者には長年の相棒がいた。
[$_{RC}$ GAP$_i$ *sekoi giin-o hinanshita*] *kisha*$_i$*-ni-wa naganenno aibou-ga ita*.
[$_{RC}$ GAP$_i$ stingy senator-ACC criticized] reporter$_i$-DAT-TOP long.term colleague-NOM existed
'The reporter who criticized the stingy senator had a long term colleague.'

(4.14b) Object-extracted relative clause (ORC)
せこい議員が非難した記者には長年の相棒がいた。
[$_{RC}$ *sekoi giin-ga* GAP$_i$ *hinanshita*] *kisha*$_i$*-ni-wa naganenno aibou-ga ita*.
[$_{RC}$ stingy senator-NOM GAP$_i$ criticized] reporter$_i$-DAT-TOP long.term colleague-NOM existed
'The reporter who the stingy senator criticized had a long term colleague.'

#### 4.3.1.3. Apparatus & Procedure

Stimulus sentences were displayed horizontally on the centre left of a 17 inch Mitsubishi LCD computer monitor at a distance of 70 cm from the head and chin rest mount. All characters were displayed in Japanese MS P Gothic 22pt which subtended a visual angle of 0.64˚. The font colour was black and the screen background colour was white. The resolution of the monitor was 1024 by 768. Eye-movements were recorded using an EyeLink 1000 Core System (desktop Eyelink 1000 SR Research Ltd., Ontario, Canada). The resolution of the eye-tracker was 0.01˚ RMS, and the sampling rate was 1000 Hz. An attached gamepad was used for button-responses.

Participants were instructed in Japanese that they would be reading Japanese sentences one at a time on the computer monitor. Instructions were given by the proctor aurally and by the experimental program via an instruction's screen which appeared prior to each block session. Prior to each stimulus, a drift-checking mask was presented at the centre left of the screen, the point at which the sentence would begin. Once the participant accurately fixated on the mask, the proctor would remove the mask and display the sentence. Participants were given a maximum time of 12 seconds to read the sentence and were instructed to press a button on an interfaced gamepad when they had finished reading and comprehending the sentence. When the participants pressed the button, the sentence was replaced with a comprehension probe (e.g., *Did the reporter hit the senator?*). Participants were given a maximum of eight seconds to answer the question as "TRUE" or "FALSE" using marked buttons on the gamepad. Reading times were collected from the onset of a stimulus item to the button response. Prior to each session and periodically throughout the session, participants' eyes were calibrated using a 9-point calibration and validation technique. See Figure 4.2.

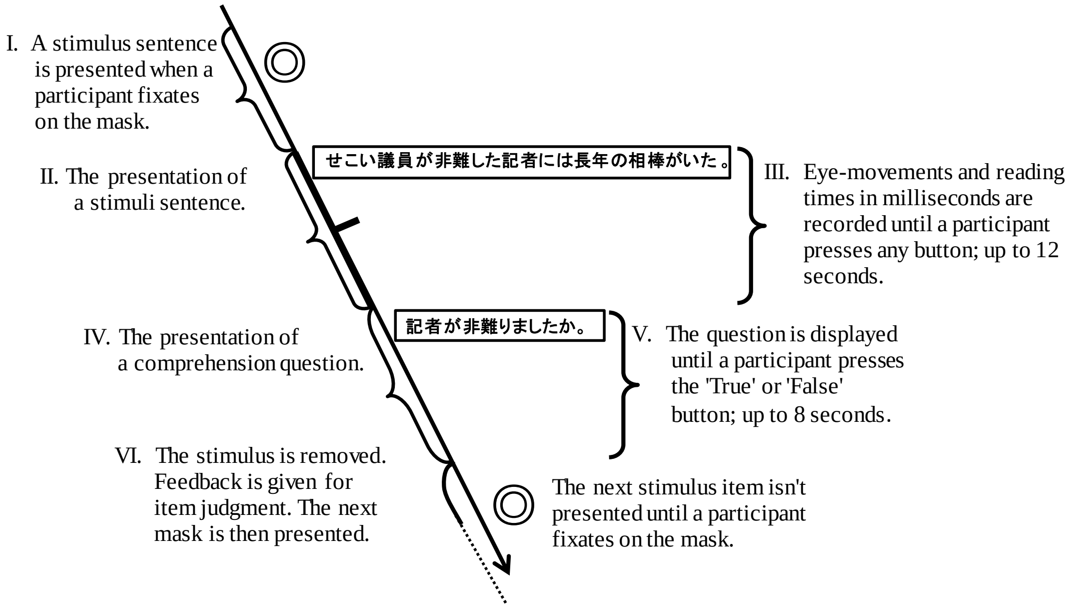
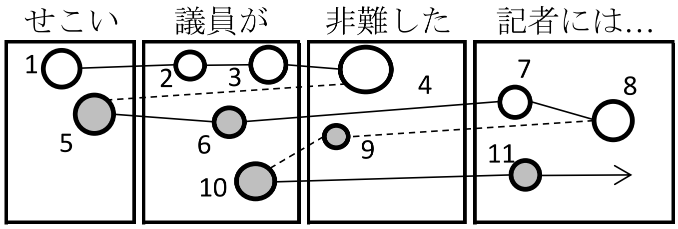



**Figure 4.2. Eye-tracking Procedure**

### 4.3.1.4. Eye-Tracking Measures

Reading time measures were collected for each word of the sentence. The earliest processing measure reported here is *first-fixation duration* which refers to only the first fixation made in an interest region. Next is *first-pass* time which is composed of all fixations made within an interest region from when it is first entered until it is exited in either direction. This measure can be a collection of one or more fixation points; thus, it is equal to or greater than first-fixation duration. Next is *go-past* time which is the total reading of an interest region before it is exited to the right for the first time. Go-pass time also includes any regressive readings out of the region to the left before going right. Therefore, go-past time is greater than or equal to first-pass time. For eye-tracking studies, go-past has been observed to be an indication of early or late stages of processing, depending on the context in which it is found. For RC processing in particular, the phenomenon of integration is often observed during go-past time at the given locus for both post-nominal and prenominal RC languages. The late reading time measures reported in this study are *re-reading* time which is the sum of all fixations after first-pass RT for an interest region (dwell time in the region minus first-pass RT) and *dwell time* which is the sum of all fixations in an interest region. Dwell-time, however, is also representative of early effects. Additionally, regression–out (i.e., first-pass regression-out) and regression-in proportion measures are reported. In this study, I only report on the sentence as a whole and all regions except the initial adjective: RC noun, RC verb, head noun, adjective, matrix object and matrix verb. For more on eye-tracking measures, see Clifton, Staub and Rayner (2007). See Figure 4.3.




| Measurement | N1 | V1 | DE | N2 |
|---|---|---|---|---|
| Early Measurements | | | | |
| First-fixation | 1 | 2 | 4 | 7 |
| First-pass | 1 | 2+3 | 4 | 7+8 |
| Late Measurements | | | | |
| Go-past | 1 | 2+3 | 4+5+6 | 7+8+9+10+11 |
| Re-reading | 5 | 6+10 | 9 | 11+14 |
| Reg-out | NA | NA | 4-to-5 | 8-to-9 |
| Reg-in | 4-to-5 | 9-to-10 | 8-to-9 | NA |
| Total Measurments | | | | |
| Dwell-Time | 1+5 | 2+3+6+10 | 4+9 | 7+8+11 |

**Figure 4.3. Eye-tracking data example**
The above figure is an illustration of eye-tracking data and the possible measurements representing reading behaviour. The number next to each fixation represents the chronological order of the fixations. White circle fixations represent fixations made during early measures of processing (i.e., first-fixation & first-pass). Grey circle fixations represent fixations made during late measurements. While go-past is listed as a late measurement, it is sometimes referred as an earlier-than-late measurement.

## 4.3.2. Results

A series of linear mixed effect (LME) model analyses (Baayen, Davidson, & Bates, 2008) were conducted on the collected reading times and binomial data (i.e., regression-in and regression-out proportion) using the lme4 package (Bates, Mächler, Bolker, & Walker, 2014a, 2014b) within R (R Core Team, 2014); the RC condition (ORC = -0.5 & SRC = 0.5) comprised the fixed effects, and random effects were the subjects and items. Analyses of RTs and regression data only included items with correct responses. RT measures with zero RT or regions which were skipped were treated as missing values and were not included in the RT analyses. The lmerTest package (Kuznetsova & Brockhoff, 2014) in R was used to provide RT models with *p*-values using Satterthwaite's approximation for the degrees of freedom. For accuracy and regression proportions, glmer (binomial family) within lme4 was used to calculate the *z* distribution using Laplace approximations. Data outliers (RTs only) were trimmed upon ± 2.5 standard deviations of each model (1.62%) to provide better normality of residuals. Refer to Table 4.1 (p. 212) for means and standard errors and Table 4.2 (p. 213) for LMEs. Refer to Figure 4.4 for plots of each measure and region.

#### 4.3.2.1. Sentence

At the sentence level, there was a significant difference between RC conditions for accuracy ($p < .001$) and the total reading time of the sentence ($p < .05$). It was revealed that the questions for SRCs were easier to comprehend, and the sentences overall were more quickly read compared to their ORC counterparts.

#### 4.3.2.2. RC Noun

No eye-tracking index revealed a significant difference between RC conditions at the RC noun: first-fixation ($p = .447$), first-pass ($p = .531$), go-past ($p = .197$), re-reading ($p = .14$), dwell-time ($p = .134$), regression-out ($p = .247$) and regression-in ($p = .579$).

#### 4.3.2.3. RC Verb

While first-fixation ($p = .108$), first-pass ($p = .943$), go-past ($p =.97$), regression-out ($p = .883$) and regression-in ($p = .343$) measures did not reveal significant differences between conditions, re-reading time ($p < .05$) and dwell-time ($p < .01$) revealed that ORCs had significantly longer reading times during later eye-tracking measures.

#### 4.3.2.4. Head Noun

Only re-reading time ($p < .05$) revealed a significant difference between conditions: ORCs had longer re-reading times at the head noun. All other measures were not significant: first-fixation ($p = .476$), first-pass ($p = .069$), go-past ($p = .636$), dwell-time ($p = .080$), regression-out ($p = .075$) and regression-in ($p = .511$).

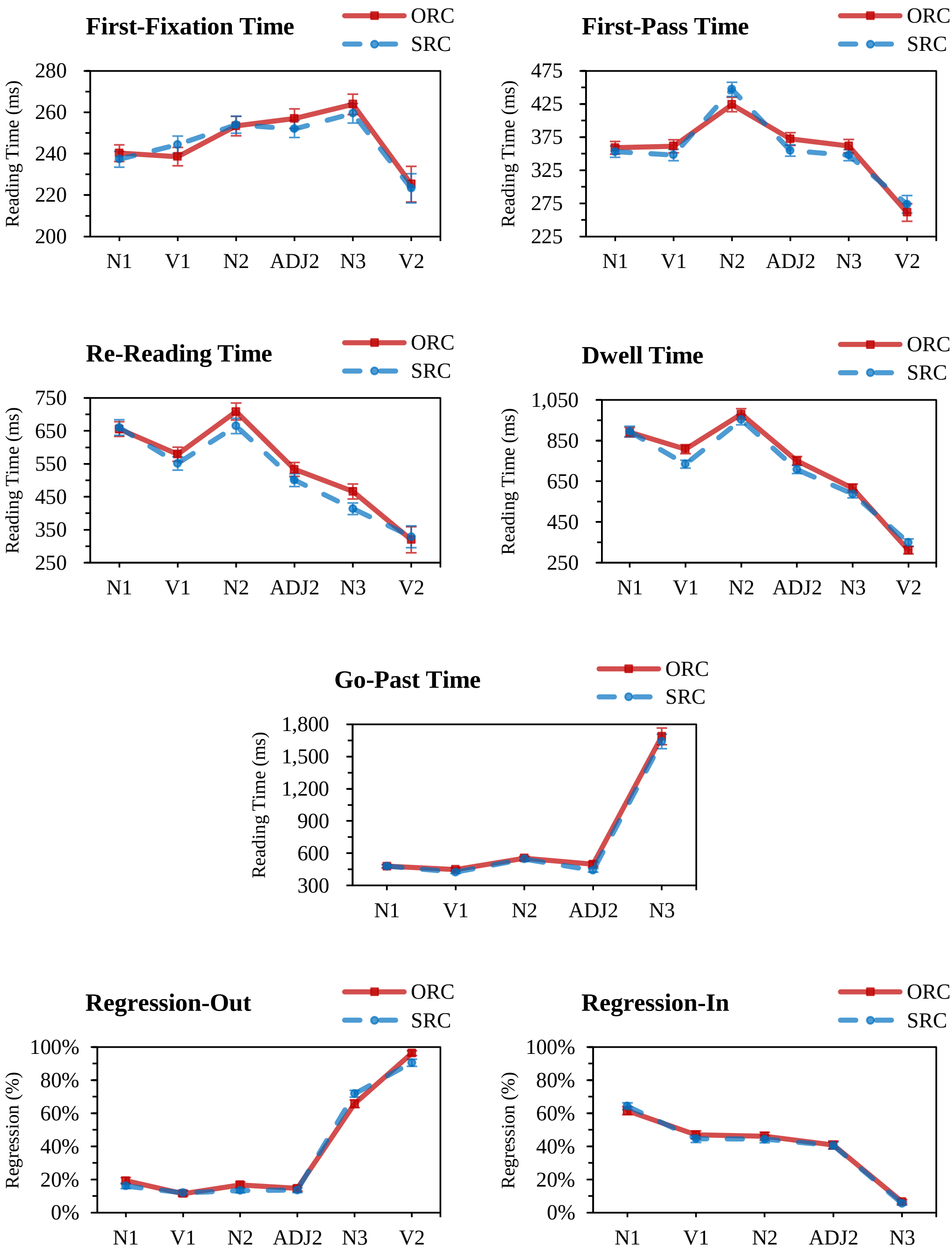



**Figure 4.4. Experiment 1 individual plots**

N1 stands for the RC noun, V1 stands for the RC verb, N2 stands for the head noun, ADJ2 stands for the second adjective found in the matrix clause, N3 stands for the nominative matrix object, V2 stands for the matrix verb. ADJ1 prior to N1 is not shown.

#### 4.3.2.5. Adjective

At the adjective which exists at the Head+1 region (i.e., a spillover region), the only significant difference between RC conditions was observed during re-reading time ($p$ <.05) with ORCs necessitating longer re-reading times than SRCs. No other measure was significant. First-fixation duration ($p$ = .815), first-pass RT ($p$ = .482), dwell-time ($p$ = .095), go-past time ($p$ = .172), regression-in proportion ($p$ = .745) and regression-out proportion ($p$ = .745) were all not significant.

#### 4.3.2.6. Matrix NP-NOM Object

Interestingly, regression-out proportion ($p$ <.05) revealed that there was a higher probability for SRCs to make a regression out of the matrix object. Yet, there were no other observations of SRC or ORC difficulty in any other measure. First-fixation duration ($p$ = .280), first-pass RT ($p$ = .547), re-reading time ($p$ = .084), dwell-time ($p$ = .276), go-past time ($p$ = .516), and regression-in proportion ($p$ = .508) were all not significant.

#### 4.3.2.7. Matrix Verb

Similar yet contrasting with the matrix object region, regression-out proportion ($p$ <.05) was the only measure revealing a significant difference between conditions. However, at the matrix verb, ORCs had a higher probability of regressing out to other regions of the sentence. Again, no other measure was significant. First-fixation duration ($p$ = .845), first-pass RT ($p$ = .414), re-reading time ($p$ = .801), dwell-time ($p$ = .129), and go-past time ($p$ = .490) were all not significant.

### 4.3.3. Discussion

The results of Experiment 1 demonstrated greater ORC processing difficulty for strictly ambiguous RCs, replicating the general findings from previous studies. However, this difficulty was only shown during later stages of processing (i.e., re-reading time & dwell-time) at the RC verb, head noun and the sentence as a whole. In the following sub-sections, ORC difficulty will be explained in terms of each processing account.

#### 4.3.3.1. Similarity-Based Interference

Ueno and Garnsey (2008) claimed that by using dative-topic case marking for the head noun, the effects of similarity-based interference should be controlled. As such, they argued that these effects are unlikely to contribute to the overall difficulties with RC processing. However, that may not have been the case. Despite the case markings being different between the RC noun and head noun, the head noun is still understood as the sentential subject with the other matrix NP marked with nominative case understood as the object. In other words, the head noun is a dative-subject while the other NP is a nominative-object. Thus, grammatical roles rather than case morphology may have a more important role in causing similarity-interference. This explanation would serve to explain why re-reading times and dwell-times in particular were longer for ORC conditions. Also, the increased regression-out ratio of the matrix verb for ORCs fits into this interpretation. Accordingly, similarity-interference should not be completely ruled out as a potential factor for ORC difficulty, especially since it is compatible within the framework of Gordon's similarity-interference account (Gordon et al., 2001).

#### 4.3.3.2. Integration-Based Resources

The linear (Gibson, 2000) and temporal distance (Lewis & Vasishth, 2005) metrics both predict SRC difficulty in Japanese, assuming the head noun integrates directly with the gap. The structural-phrase hierarchy metric, on the other hand, predicts ORC difficulty. Since ORC difficulty was found at the head noun, as in the previous studies, the only conclusion which could be made is that decay increases as a function of structural-distance. Thus, the distance between the head noun and gap is more local in terms of structural-distance. However, late measure effects such as re-reading are most likely not indications of an integration/retrieval process. Typically, difficulties with these processes are demonstrated by early-measures or regressive measures, yet none revealed any difference between RC conditions. Accordingly, difficulties in integration may only be prospective rather than confirmed. Nevertheless, since the bulk of the previous literature has revealed ORC processing at this locus, it is safe to assume that there is some inherent difficulty with integrating the filler-gap dependencies with ORCs.

#### 4.3.3.3. Expectation-Based Processing

Similar to integration, expectation-based processing (Hale, 2001; Levy, 2008) predicts ORC difficulty at the head noun since ORCs are less frequent in Japanese corpora as explained above. Considering that these clauses were ambiguous up to the point of the head noun (i.e., a garden path effect), expectation-based processing should not be observed until this locus. However, there was no immediate difficulty for ORCs at the head noun and only late ORC difficulty was observed at both the head noun and RC verb. Thus, even though expectation-based processing predicts ORC difficulty, it does not seem to be the case that the ORC difficulty here is an indication of expectation.

For the entropy reduction hypothesis (Hale, 2006; Yun et al., 2015), though ORC difficulty is predicted at the head noun as well, ORC difficulty should first be observed at the case morphology on the RC noun. However, ORC difficulty was not shown at this region. Thus, entropy-based reduction is unlikely to account for the ORC difficulty here. Yet, it could be the case that since only case morphology acts as the cue to lower the entropy, the measures of processing here were too coarse to reveal any difference.

#### 4.3.3.4. The Object-Before-Subject-Bias

Considering that the head noun and RC verb both became more difficult for ORCs during later measures of processing, this may reflect the greater difficulty in thematic assignment for ORCs in comparison to SRCs as Nakamura and Miyamoto (2013) claim. In other words, after restructuring the clause at the head noun, there is greater difficulty to assign the thematic role of the object head and then the role for the RC subject. This thus increases re-reading at the head noun and RC verb for ORCs. But then again, it is still possible that working memory, expectation and OBSB all contributed to the ORC difficulties in some fashion. Since only late-stage overall difficulties were found, it is hard to attribute the difficulties to any single processing account or determine their interrelations.

#### 4.3.3.5. Ambiguity

Altogether, ambiguous RCs may not be the most suitable context to investigate expectation- or memory-based processing models in Japanese. This is because each RC condition involves a reanalysis of clause type. This may explain why ORCs only become more difficult during later measures. Furthermore, it seems that the use of a topic-dative marker may have not alleviated similarity-based interference. In Experiment 2, I aim to demonstrate using eye-tracking that the disambiguation of clause type is a chief source of processing difficulty at the head noun.

Considering that discourse-priming, successive case, clause-type plausibility, and numerical classifiers may all be slightly problematic methods to disambiguate the RC from a matrix clause interpretation initially, another method of disambiguation should be used. In Japanese, there is one pre-RC cue which has yet to be explored. That is pre-RC demonstratives. In Japanese, the demonstrative can either follow or precede the RC while still grammatically modifying the same head noun (c.f., Ishizuka, 2008). Following Kamio (1977; as reported by Ishizuka, 2008), if the demonstrative follows the RC, then the RC can have both a restrictive or non-restrictive RC interpretation while for pre-RC demonstratives only a restrictive RC interpretation is possible. See below for an example from Kamio (1977, pp. 153-154; as reported by Ishizuka, 2008).

(4.15a) Pre-RC demonstrative
その兄貴が買って来たりんご
*sono* [$_{\text{RC}}$ *aniki-ga katte-kita*] *ringo*
that brother-NOM buy-came apple
‘that apple that brother bought’

(4.15b) Post-RC demonstrative
皆が探しているその論文
[$_{\text{RC}}$ *minna-ga sagasi-teiru*] *sono ronbun*
everyone-NOM look.for-PROG that paper
‘that paper, which everyone is looking for’

Accordingly, by using this pre-RC syntactic cue, similar to that of Kahraman et al. (2014), the clause-type ambiguity may become disambiguated and a clause boundary may be formed. There is one issue with this design however. Since the demonstrative may also modify the RC noun, there is a good chance that this condition would still be ambiguous. Therefore, a word which cannot be modified by the demonstrative must intervene between the demonstrative and the RC noun. Jäger et al. (2015) used a similar task design with determiner and classifiers in Mandarin Chinese. To prevent the determiner and classifier from modifying the RC noun, they inserted a temporal adverb at the start of the RC which would intervene between the two thus preventing modification. Their findings revealed that this method was quite effective at creating a clause boundary and effective at having the determiner and classifier modify the head of the RC. Thus, by using pre-RC demonstratives and Jäger et al.'s (2015) design, RCs in Japanese may become unambiguous at the start of the RC. This will be explored in Experiment 2.

## 4.4. Experiment 2

The aim of the Experiment 2 was to compare RC processing under both ambiguous and unambiguous contexts. In Kahraman et al. (2014), they used pre-RC noun classifiers which mismatched with the RC noun to attenuate ambiguity. However, as mentioned, this may introduce animacy confounds. As such, I sought to use a cue for which neither the RC noun nor head noun had to agree. In Mandarin, Jäger et al. (2015) used a similar technique as Kahraman et al. (2014) to establish a clause boundary at the start of the RC. Specifically, after the pre-RC cue a temporal adverb adjunct followed within the RC structure. Adopting a similar approach, a demonstrative article modifying the head noun prior to the RC was inserted to act as syntactic cue for an RC interpretation. In order to prevent the demonstrative from modifying the RC noun, a temporal adverb at the start of the RC was also inserted. I predict that expectation resources will allow greater anticipation for the SRC head noun in such a context.

### 4.4.1. Methods

#### 4.4.1.1. Participants

Forty (Female = 6) native Japanese speakers were recruited from Nagoya University, Japan. These participants were either undergraduate or graduate students at the time of the study. The mean age was 19 years and 4 months; range 18 years and 2 months to 22 years and 11 months. None of the participants took part in Experiment 1.

#### 4.4.1.2. Materials

Thirty-two experimental items were created in a 2 (condition: SRC vs. ORC) by 2 (type: ambiguous vs. unambiguous) design (see Appendix Chapter 4, p. 279). The items were put into counterbalanced lists such that only eight items of each were shown per participant. For the unambiguous types, a demonstrative modifying the head noun appeared at the sentence initial position. To ensure that the demonstrative could not modify the noun in the RC, the demonstrative was followed by a temporal adverb which blocked other interpretations, see below for an example

(4.16) Basic Syntactic Structure using the pre-RC cue

*[$_{\text{matrix clause}}$ [$_{\text{DP}}$ DET Temp.ADV]…]
*[$_{\text{matrix clause}}$ [$_{\text{DP}}$ DET Temp.ADV NP-ACC]…]
*[$_{\text{matrix clause}}$ [$_{\text{DP}}$ DET Temp.ADV NP-ACC VP]…
[$_{\text{matrix clause}}$ [$_{\text{DP}}$ DET [$_{\text{RC}}$ Temp.ADV NP-ACC VP] NP-TOP]…

Additionally, an adverb also now intervened between the RC noun and RC verb, and the matrix clause was expanded so that the first matrix predicate could include regressive measures. For the ambiguous condition, the pre-RC demonstrative was simply not included. See below for an example of each RC type. An additional eight practice and 72 distractor items were included in each list.

(4.17a) Subject-extracted relative clause (SRC)
その昨夜給仕さんを激しく襲った顧客は上司から聞いて、事件を伝えた。
*sono sakuya kyūji-san-o hageshiku osotta kokyaku-wa jōshi-kara kiite, jiken-o tsutaeta.*
(that)[last.night customer-ACC fiercely hit]waiter-TOP boss-DAT heard incident-ACC reported
'That waiter who fiercely hit the customer last night heard the boss and reported the incident.'

(4.17b) Object-extracted relative clause (ORC)
その昨夜給仕さんが激しく襲った顧客は上司から聞いて、事件を伝えた。
*sono sakuya kyūji-san-o hageshiku osotta kokyaku-wa jōshi-kara kiite, jiken-o tsutaeta.*
(that)[last.night customer-NOM fiercely hit]waiter-TOP boss-DAT heard incident-ACC reported
'That waiter who the customer fiercely hit last night heard the boss and reported the incident.'

#### 4.4.1.3. Apparatus & Procedure

The same apparatus of Experiment 1 was used in Experiment 2. The overall procedure remained the same; however, feedback was provided after each question as an attempt to improve accuracy scores. After a participant responded to the verification question, feedback was automatically displayed in the middle of the display which replaced the question with the feedback message. The feedback displayed respective correct and incorrect messages in Japanese. By giving the participants feedback, I had hoped that participants would become more involved in the task.

## 4.4.2. Results

The same LME procedures were repeated for Experiment 1. For the eye-tracking data cleaning treatment, 8.44% of eye-tracking fixations were trimmed during the cleaning procedure. Ambiguous and unambiguous RC types were analysed separately. RC condition composed the fixed effect and subject and items were treated as random effects. RTs were log transformed and 1.51% of the data was trimmed. The following regions were analysed: the sentence as a whole, RC noun, RC adverb, RC verb, head noun, matrix object, and matrix verb. Refer to Table 4.2 (p. 216) for means and standard errors and Table 4.3 (p. 218) for LMEs. See Figure 4.5 for plots.

### 4.4.2.1. Sentence

Ambiguous: Accuracy ratings were not significant ($p$ = .275), but the total reading time of the sentence was significant ($p$ < .05). ORCs had significantly longer reading times compared to SRCs.

Unambiguous: Again, accuracy ratings were not significant ($p$ = .513). Additionally, total reading time was not significant as well ($p$ = .780).

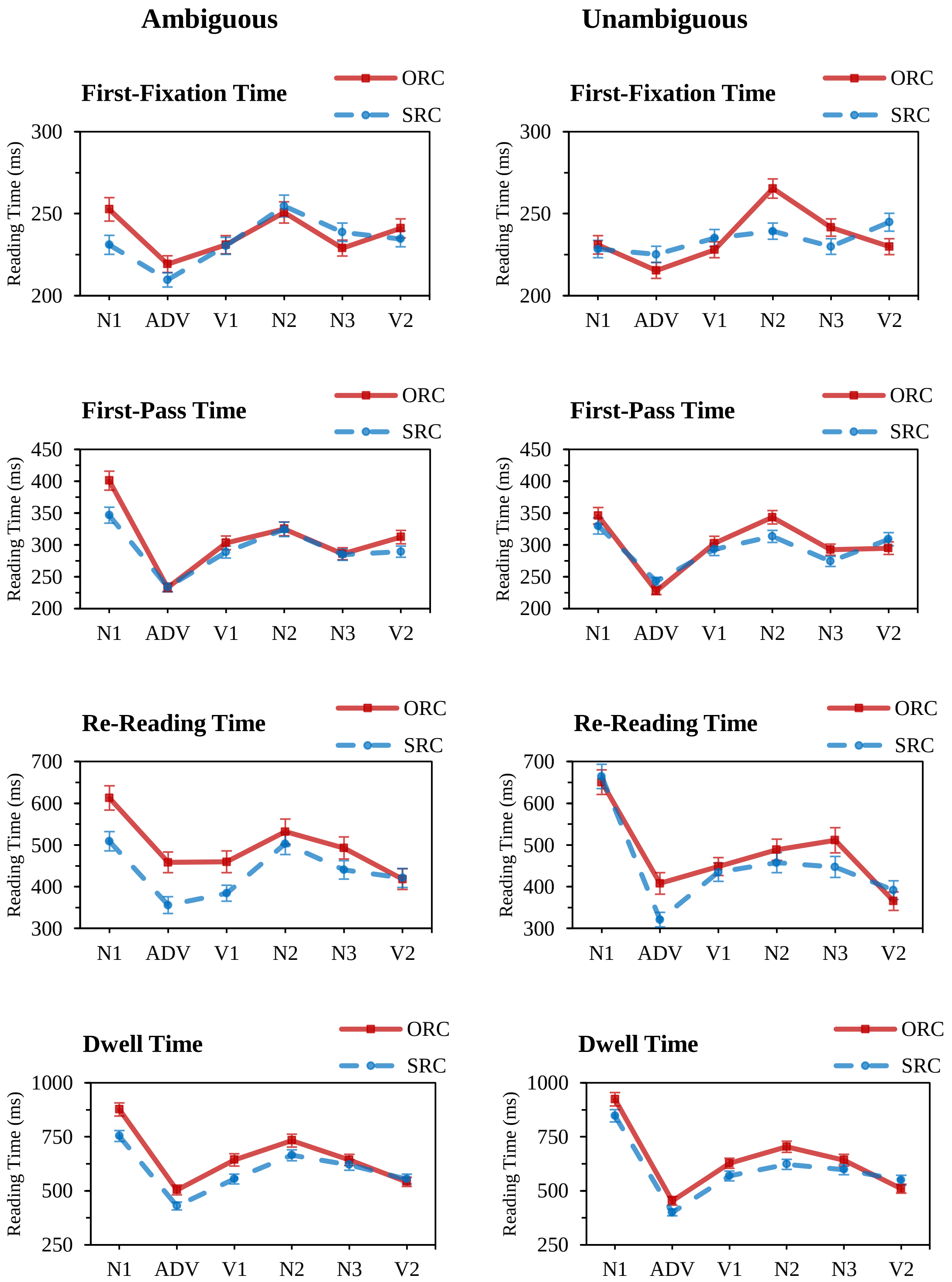
### 4.4.2.2. RC Noun

Ambiguous: During first-fixation ($p$ < .01), first-pass ($p$ < .01), re-reading ($p$ < .01) and dwell time ($p$ < .001) measures, it was revealed that ORCs required longer RTs compared to SRCs. Go-past ($p$ = .214) and regression-in ($p$ = .929) were not significant. Regression-out ($p$ < .05) on the other hand, revealed that SRCs were significantly more likely to regress out.

Unambiguous: Only dwell-time ($p$ < .05) revealed a significant difference between RCs revealing that ORCs required overall longer RTs. The remaining indexes were not significant: First-fixation ($p$ = .766), first-pass ($p$ = .267), go-past ($p$ = .373), re-reading ($p$ = .414), regression-out ($p$ = .376) and regression-in ($p$ = .405) all showed non-significant results.

### 4.4.2.3. RC Adverb

Ambiguous: Both re-reading time ($p$ < .001) and dwell time ($p$ < .01) revealed that ORCs required significantly longer reading times during later measures of processing.


Ambiguous
Unambiguous
First-Fixation Time
First-Pass Time
Re-Reading Time
Dwell Time
ORC
SRC
Reading Time (ms)
N1
ADV
V1
N2
N3
V2
200
250
300
350
400
450
500
600
700
750
1000

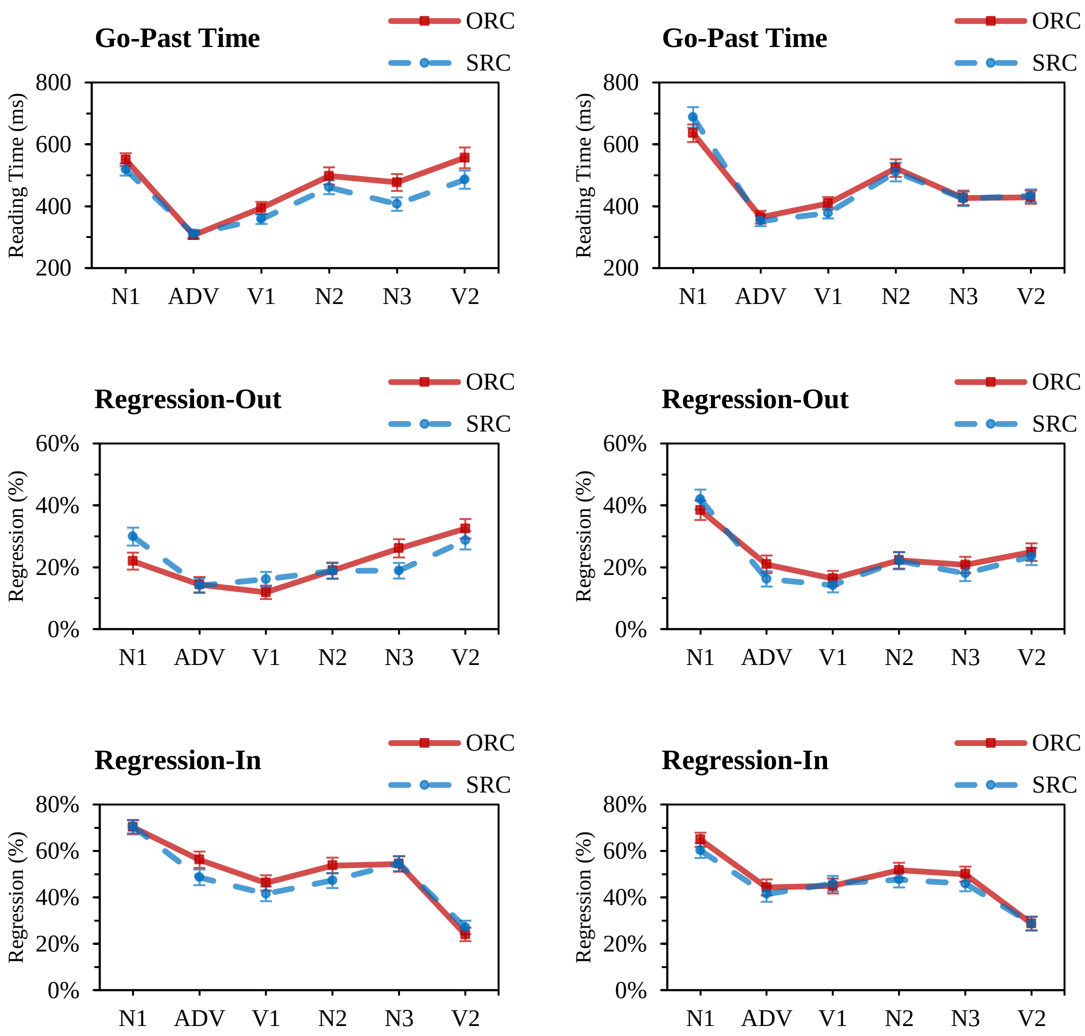



**Figure 4.5. Chapter 4 Experiment 2 individual plots**
N1 stands for the RC noun, ADV stands for the adverb, V1 stands for the RC verb, N2 stands for the head noun, N3 stands for the matrix object, V2 stands for the matrix verb. The pre-RC demonstrative and temporal adverb are not shown prior to N1. The remaining content after V2 is also not shown.

However, dwell-time here should only be considered to reflect the difference in re-reading since early measures revealed no significant differences: First-fixation ($p$ = .193), first-pass ($p$ = .877), go-past ($p$ = .829), regression-out ($p$ = .829), and regression-in ($p$ = .090).

Unambiguous: Both first-pass reading time ($p$ < .05) and re-reading time ($p$ < .05) were shown to reveal significant differences in reading times between RC conditions. However, while first-pass demonstrated longer reading times for SRCs, this was reversed for re-reading time. First-fixation duration ($p$ = .067), dwell-time ($p$ = .061), go-past ($p$ = .916), regression-out ($p$ = .170), and regression-in ($p$ = .778) did not show significant differences between RC conditions at the RC adverb when the clause was unambiguous.

#### 4.4.2.4. RC Verb

Ambiguous: It was revealed that during re-reading ($p$ < .05) and dwell time ($p$ < .05) the ORC condition had significantly longer RTs. However, during first-fixation ($p$ = .797), first-pass ($p$ = .497), go-past ($p$ = .460), regression-out ($p$ = .158) and regression-in ($p$ = .289) no significant differences were observed between conditions.

Unambiguous: No index revealed a significant difference between RC conditions. First-fixation ($p$ = .356), first-pass ($p$ = .962), go-past ($p$ = .309), re-reading ($p$ = .775), dwell-time ($p$ = .116), regression-out ($p$ = .478) and regression-in ($p$ = .835) all showed no significant results.

#### 4.4.2.5. Head Noun

Ambiguous: Only dwell-time ($p$ < .05) revealed a significant difference between conditions revealing that ORCs required longer overall RTs. First-fixation ($p$ = .792), first-pass ($p$ = .712), go-past ($p$ = .447), re-reading ($p$ = .498), regression-out ($p$ = .974) and regression-in ($p$ = .127) were not significant.

Unambiguous: First-fixation ($p$ < .01), first-pass ($p$ < .05) and dwell time ($p$ < .05) measures demonstrated that ORCs were read more slowly than SRCs at the head. The remaining measures were not significant: Go-past ($p$ = .422), re-reading ($p$ = .388), regression-out ($p$ = .96) and regression-in ($p$ = .450) were all not significant.

#### 4.4.2.6. Matrix Object

Ambiguous: Only regression-out proportion ($p < .05$) revealed a significant difference between RC conditions. It was revealed that ORCs had a higher likelihood to regress out of the matrix object to previous regions. While all other measures were not significant, notably, go-past time ($p = .059$) had a marginal trend showing that ORCs had longer regressive reading times before moving on to the matrix verb. First-fixation ($p = .231$), first-past ($p = .923$), re-reading time ($p = .071$), dwell-time ($p = .206$), and regression-in ($p = .852$) were not significant.

Unambiguous: No measure displayed a significant difference between RC conditions: First-fixation ($p = .180$), first-pass ($p = .124$), re-reading time ($p = .108$), dwell-time ($p = .347$), go-past time ($p = .641$), regression-out ($p = .413$), and regression-in ($p = .336$).

#### 4.4.2.7. Matrix Verb

Ambiguous: No measure displayed a significant difference between RC conditions: First-fixation ($p = .676$), first-past ($p = .173$), re-reading time ($p = .662$), dwell-time ($p = .736$), go-past time ($p = .057$), regression-out ($p = .353$), and regression-in ($p = .436$).

Unambiguous: Surprisingly, first-fixation duration ($p < .05$) revealed that SRCs required significantly longer reading times than ORCs during the earliest measure of processing at the matrix verb. However, this effect quickly diminished since no other measure of processing was significant. First-past ($p = .253$), re-reading time ($p = .296$), dwell-time ($p = .170$), go-past time ($p = .873$), regression-out ($p = .627$), and regression-in ($p = .865$) all were not significant.

#### 4.4.2.8. Post-Hoc Sentence Completion Task

To determine whether or not these particular items would have elicited a particular RC interpretation (e.g., ORC or SRC), a sentence completion task was also carried out on a group of native Japanese speakers who did not participate in the main experiment. Sentence completion tasks have often been considered as a technique that can tap into production preferences of native speakers, but as aforementioned for Japanese RC processing studies, these investigations have often yielded conflicting results. This may, however, not be too surprising when considering the overall frequency distributions for the language. Specifically, while SRCs are more frequent than ORCs, subject pro-drop is much more frequent than object pro-drop as well (see Yun et al., 2015). Thus, this creates a conflict in predictions when a provided NP contains accusative case since both an RC interpretation and a pro-drop interpretation are favoured. In contrast, since object pro-drop is so infrequent, it should be easier for participants to consider the clause as an RC. Therefore, the data collected from this task has a high probability of being incongruent with the statistical properties of the language in this regard. Since many previous studies on Japanese RC processing included the task, I include it here as well.

Fifty native Japanese speakers were recruited to participate in this task. All participants were undergraduate students at Nagoya University at the time of their participation. Six participants were removed from the data set since they did not follow directions thus leaving 44 participants (N = 44, female = 20).

For the task, the items for Experiment 2 were made into fragments such that the string of words ended at the RC verb. However, in order to not prime participants for an RC interpretation, the pre-RC demonstrative cue was not included. Two counterbalanced lists were created, each containing 32 fragments. Half of the fragments contained an overt accusative marked NP and the other half contained an overt nominative marked NP. The ordering of fragments was also controlled so that the NP case marking would not repeat more than twice in a row.

(4.18a) Subject-extracted relative clause fragment
昨夜給仕さんを激しく襲った
*sakuya kyūji-san-o hageshiku osotta*
[last.night waiter-ACC fiercely hit]
'(gap/pro) fiercely hit the waiter last night'

(4.18b) Object-extracted relative clause fragment
昨夜給仕さんが激しく襲った
*sakuya kyūji-san-o hageshiku osotta*
[last.night waiter-NOM fiercely hit]
'The waiter fiercely hit (gap/pro) last night'

For this task, participants were instructed that for the 32 items they must complete the fragment provided to make into a grammatical sentence. They were also instructed that they must provide at least one additional word and not end the sentence with a noun. For data collection purposes, I only recorded whether or not participants created an externally headed RC out of the fragment upon completing the sentence. See below for examples.

(4.19a) Relative Clause – 1 (an RC)
昨夜給仕さんを激しく襲った顧客は逮捕された。
*sakuya kyūji-san-o hageshiku osotta kokyaku-ha taihosareta*
[$_{RC}$ last.night waiter-ACC twice hit] customer-TOP was.arrested
'The customer who fiercely hit the waiter last night was arrested'

(4.19b) Relative Clause – 0 (not an RC)
昨夜給仕さんを激しく襲ったと聞いた。
*sakuya kyūji-san-o hageshiku osotta to kiita*
[$_{CC}$ last.night customer-ACC twice hit] COMP heard
'(I) heard that (pro) fiercely hit the customer last night'

The results of the sentence completion task was analysed using LME methods. For this data set, if it was determined that the participant made the fragment into an RC upon finishing the sentence, the item was given a value of 1, and if another structure was created, the item was given a 0 value (i.e., a binomial). For the analysis, the glmer function within lme4 was used in R. RC condition comprised the fixed effect and both subject and items were treated as random effects with both intercepts and slopes.

The results revealed that when participants completed the fragments, the likelihood of the fragment being made into an ORC (Mean = 0.766, SE = 0.016) was much more probable than the fragment becoming an SRC (Mean = 0.604, SE = 0.018); coefficient = -1.42, SE = 0.33, $z$ = -4.31, $p$ < .001). However, the question remains whether or not this finding should be indicative of participants' expectations. It is my opinion that it should not. As mentioned above, since object pro-drop would be considered unnatural for these fragments, participants were more likely to make the fragments into RCs. On the other hand, it is more natural to interpret a subject pro-drop within the fragment, so other clause structures are possible. Consequently, this is not indicative of higher expectations for ORCs but instead representative that ORC structures are more constrained, a point addressed by Yun et al. (2015).

#### 4.4.2.9. Post-Hoc Naturalness Decision Task

It is common that naturalness decisions tasks are done on the experimental stimuli. As such, to determine whether a particular condition was more natural than the other, a post-hoc naturalness decision task was carried out on the above stimuli.

Twenty (N = 20, female =12) native Japanese speakers were recruited from Nagoya University. All participants were undergraduate students and none took part in the above eye-tracking experiments or sentence completion task.

The experimental stimuli were separated into four counterbalanced lists with each containing eight items for each RC and ambiguity condition. A seven point Likert scale was used for this task with -3 being rated as most unnatural and +3 being rated as most natural. Participants were instructed to rate the items on the naturalness of each sentence, not grammaticality or plausibility. Each response was recorded as -3 to +3 respectively. LME models were used to analyse the data. RC condition and ambiguity type composed the fixed effects with subject and items as random factors.

The results revealed that there was a significant difference between RC condition (coefficient = 0.341, SE = 0.110, $t = 3.09$, $p < .01$) which demonstrated that SRCs (Mean = 0.27, SE = 0.10) were rated more natural than ORCs (Mean = -0.72, SE = 0.10). Similarly, there was a difference between ambiguity contexts (coefficient = 1.295, SE = 0.111, $t = 11.67$, $p < .001$) revealing that ambiguous context (Mean = 0.74, SE = 0.10) was more natural than the unambiguous context (Mean = -0.54, SE = 0.09). There was no effect of interaction.

Interestingly, this result is in direct conflict with the sentence completion task. If ORCs were produced more often, they should be considered more natural, but they were not. Consequently, my above claim that the sentence completion task does not tap into expectations seems exceptionally probable. As previously mentioned, using pre-RC demonstratives should be quite unnatural. However, it was the point of the design to use an unnatural context which would enhance the RC interpretation. Since there was no interaction effect, I do not consider the use of the pre-RC demonstrative to be problematic.

### 4.4.3. Discussion

Overall, Experiment 2 revealed greater ORC difficulties in the processing of RCs by native Japanese speakers. Similar to the case in Experiment 1, ambiguous RCs revealed ORC difficulties at the RC noun, RC verb and head noun. For unambiguous RCs, on the other hand, ORC difficulty was reserved at the head noun. In the following sections, each processing account will be addressed in relation to this data. Moreover, the influence of ambiguity will also be explored.

#### 4.4.3.1. Similarity-based Interference

For ambiguous RCs, similarity-based interference models (Gordon et al., 2001) were supported at the RC noun, RC verb and head noun. This would imply that there was similarity-interference within the RC argument. Since ORC heads and RC nouns have matching features, the ORC head may retroactively interfere with the RC noun. Drawing on aspects of the object-before-subject-bias (OBSB) account (Nakamura & Miyamoto, 2013), the prenominal RC structure may demand that the head of the ORC be integrated into the structure before the assignment of theta to the subject. As such, similarity-interference occurring after the first reading of the RC agrees with OBSB. Moreover, since a garden path effect exists up to the head noun, the entire structure would need to be reanalysed which would thus make the RC structure subject to similarity interference again. Taking the later point into consideration, similarity-interference according to cue-based retrieval models (Lewis & Vasishth, 2005) are also supported here.

For unambiguous RCs, on the other hand, there were less indications of similarity-based interference since difficulties were no longer shown at the RC verb. However, it would be hasty to rule out interference altogether. The explanation for the attenuated interference effects may be broken down into a simple premise. Essentially, having a head noun modified by a demonstrative makes it more distinct in working memory. If this reasoning is accurate, there should be less proactive and retroactive interference between the NPs which would attenuate the interference, but may not eliminate it all together. As such, similarity-based interference for unambiguous RCs is also supported.

#### 4.4.3.2. Integration-Based Resources

According to linear/temporal distance metrics (Gibson, 2000; Lewis & Vasishth, 2005), SRCs should be more difficult since the distance between the filler and gap is more local than ORCs. In contrast, the structural distance metric predicts the opposite. Since both ambiguous and unambiguous RCs produced ORC difficulty at the head noun, the structural metric (O'Grady, 1997) is better supported. Yet, I claim that neither case provides the crucial evidence for integration processes using eye-tracking. In the ambiguous context ORCs were more difficult during late measures while for unambiguous RCs this difficulty was seen during early measures of processing. Even though some may suggest that both support a structural distance metric of integration, I claim that regressive eye-tracking measures of processing, such as go-past time and regression-out proportion, would better indicate integration effects. Consequently, despite that the structural-phrase hierarchy (O'Grady, 1997) being supported here, I do not believe that it is the best account for ORC difficulty in Experiment 2.

### 4.4.3.3. Expectation-Based Processing

For ambiguous RCs, the first indication of greater ORC difficulty was found at the RC noun as early as first-fixation duration. Considering that these clauses were ambiguous and thus should be initially parsed as a simple matrix clause sentence, this finding goes against surprisal theory (Levy, 2008). Difficulties at the RC noun during early measures of processing, however, are predicted by the entropy-based reduction model (Hale, 2006; Yun et al., 2015). Notably, this finding conflicts with that of Experiment 1 which did not reveal any significant results at the RC noun, let alone early measurements for ORC difficulty. Nevertheless, similar to Experiment 1, ORC difficulty was again observed at the RC verb and head noun during late measures of processing such as re-reading and dwell-time. While expectation based models (e.g., surprisal and entropy-reduction) predict ORC difficulty at the head noun, these models would be better supported if ORC difficulties occurred during early-stage processing.

For unambiguous RCs, the first indication of early ORC difficulty was observed at the head noun which is a drastic shift in processing compared to the ambiguous items of Experiment 1 and 2. I believe this change in processing to reflect the higher activation level of the SRC structure due to the additional cues to disambiguate the clause-type ambiguity. However, these cues did not allow direct access to RC frequencies immediately since for unambiguous RCs there were no differences between RC conditions at the RC NP which would serve as a potential cue for RC type due to the case morphology. Instead, ORC difficulty first occurred at the head noun (i.e., the locus of disambiguation) which suggests that the parser must wait for a viable cue to assign RC features to the clause, and after this, RC frequencies can be accessed. Nonetheless, the additional cues were able to enhance the expectation of the RC structure and likely increased the activation level for each structure. But since SRCs are more frequent in Japanese, these cues had a greater benefit for them over ORCs. Moving on to the entropy-reduction model (Hale, 2006), Yun et al. (2015) claim that there may be no change in entropies for an unambiguous RC since the structure should be certain. This may explain why no difficulty was observed early at the RC noun. However, following their rational, it is suspicious that there was still lingering difficulty at the head noun.

The results of the naturalness decision task revealed that SRCs were regarded by the participants as more natural than ORCs and that pre-RC demonstrative was less natural than items without it included. However, neither result is surprising as the more frequent SRC structure should more often than not be more natural and pre-RC demonstratives can appear somewhat awkward for native speakers despite them being grammatically permissible, giving a limited restrictive RC reading. Thus, the naturalness decision task fits in well with probabilistic accounts of language processing.

For the sentence-completion task, ORC fragments were shown to have a higher probability of having an RC structure formed than SRC fragments. As argued above, this is also expected. Owing to the fact that object pro-drop is rare for matrix clauses and embedded clauses, these fragments should produce RC fragments over other possible structures. For the SRC fragments, on the other hand, since subject pro-drop occurs more often, other structures are more tolerable which explains why SRCs were formed less often. This, however, does not imply that ORCs have higher expectation. Expectation-based processing is an incremental, ranked-parallel probabilistic processing account and as such, both SRCs and embedded clauses with subject pro-drop would have higher ranks than their counterparts. In Yun et al., (2015) it was clearly shown that their attestation counts for each structure demonstrated that both SRCs and embedded complement clauses with subject pro-drop are more frequent than ORCs. This finding in relation to the eye-tracking results, however, better fits with surprisal theory (Levy, 2008) since ORCs will be more difficult to process at the head noun regardless of the initial interpretation made for the embedded clause.

In summary, expectation-based processing models, particularly surprisal theory, were shown to be satisfactory predictors of ORC processing for both ambiguous and unambiguous RCs. Yet, when the RC structure became less ambiguous, expectation-based processing observations became clearer and more robust.

### 4.4.3.4. The Object-Before-Subject-Bias

The results of Experiment 2 revealed that the general pattern for ambiguous items was replicated when the items were strictly ambiguous. In other words, the late processing difficulty was still observed for ORCs. This result again provides support for the object-before-subject-bias. Specifically, for ORCs after reading the head noun, there were inherent difficulties involved in thematic assignment to the arguments of the RC predicate. This resulted in increased re-reading at the RC noun, RC verb and head noun.

For unambiguous RCs, however, ORC difficulty was no longer observed at the RC verb and the late difficulty for ORCs at the head noun was shifted to earlier measures of processing. While Nakamura and Miyamoto (2013) suggested that for unambiguous RCs OBSB may not induce ORC processing difficulty since the head noun would be more anticipated, Miyamoto (2016), however, argued counter to this point. Yet, considering if the RC structure is anticipated, then the collocations between a predicate and its direct object should also anticipate the class of head noun. As such, I argue along the lines of the earlier claim that OBSB should not reflect the ORC difficulties of unambiguous RCs. What is more, seeing that there was attenuated ORC difficulty at the RC verb gives the impression that after reading the head noun, there was less need to interface back with the predicate to assign the theta role of the subject.

In summary, my impression is that OBSB is a better predictor for ORC difficulty when the clause is ambiguous.

### 4.4.3.5. Ambiguity

Comparing the effects of ambiguous and unambiguous RCs, there was a clear change in processing behaviour. Importantly, processing changed at the head noun. For the ambiguous the previous results of Experiment 1 were replicated (i.e., general late ORC difficulties); however, for unambiguous RCs, ORC difficulty was observed much earlier. As mentioned above, I consider this change between conditions as an indication of expectation-based processing becoming more prominent. In all, the expectation-based processing account provides the most suitable explanation for the results found in Experiment 2. Since cues were introduced to eliminate the matrix clause interpretation and likely generated an RC interpretation, upon reaching the locus of disambiguation, the activation level for SRCs would have been much higher than ORCs due to their higher frequency in corpora, and also, the parser would be less bottlenecked by other processing factors such as OBSB and similarity-interference.

## 4.5. General Discussion

The purpose of this study was to investigate how relative clause processing in Japanese unfolds as a factor of ambiguity. Particularly, I wished to investigate the validity of the object-before-subject-bias, working memory (i.e., integration and similarity-interference) and expectation-based processing as factors of ambiguity. Overall, the results revealed that different patterns of processing were associated with the different levels of ambiguity found in each context: (1) ambiguous items had general ORC difficulty during later reading times and (2), when the head noun was modified by a demonstrative article preceding the RC, ORCs had longer reading times during early-stages at the head noun. In general, processing was altered when there was greater anticipation for a head noun. In other words, when RCs were ambiguous, the object-before-subject-bias provided the best account for the ORC difficulty, and when they were unambiguous, expectation-based processing was better at predicting ORC difficulty. Below, I provide a summary of the findings for each RC processing account.

### 4.5.1. Similarity-Based Interference

Indications of similarity-based interference (Gordon et al., 2001; Lewis & Vasishth, 2005) were observed in both Experiment 1 and 2. This is particularly interesting because Ueno and Garnsey (2008) had attempted to control for the effect in their items by making the head noun have dative-topic case rather than nominative case. Despite this change in case morphology, the head noun was still the sentential subject thus still allowing the RC noun and head noun to have overlapping features within ORCs. To better control for the influence of similarity-based interference, I suggest that RCs modifying an indirect object may attenuate this effect, for instance, ‘The mailman delivered the letter to the reporter who criticized the mayor.’ Overall, similarity-based interference should be considered as an interactive factor in RC processing in Japanese.

### 4.5.2. Integration-Based Resources

In both Experiment 1 and 2, only the structural-phase hierarchy (O'Grady, 1997) was supported. This would suggest that the distance-based decay metric in Japanese follows a strictly structural pathway. However, this proposition assumes that the head noun integrates directly with the gap. As previously mentioned, the structure of Japanese is still being debated. While some believe that there is no gap within the RC, others insist that there is covert *wh*-movement involved. If the later point is valid, then there is a possibility that the structural metric (O'Grady, 1997), the linear metric (Gibson, 2000) and temporal (Lewis & Vasishth, 2005) metric may all be valid predictors of ORC difficulty in Japanese. Specifically, if the head noun first needs to retrieve the null *wh*-operator and if that the operator moves to the left edge of the clause rather than the right, then distance-based metrics no longer make dichotomous predictions.

Admittedly, this point is only speculative at best as more research is required to validate such a structure. Yet, nevertheless, the results of the study would imply that the structure is more or less similar to the one proposed here if integration/retrieval metrics are not subject to decay as defined by structural-distance.

Future research can explore integration/retrieval processes in Japanese by investigating processing in other contexts where retrieval of a co-indexed dependent or semantically bound referent occurs, such as anaphora and internally-headed RCs in Japanese. Additionally, further research is needed in externally-headed RCs to determine if linear/temporal decay is a factor for retrieval and integration. This can be done by simply increasing the number of dependencies on the linear structure and controlling the structural distance to be the same.

### 4.5.3. Expectation-Based Resources

For ambiguous RCs in Japanese, only late-stage difficulty was observed at the head noun. While the surprisal model of expectation-based processing (Levy, 2008) predicts difficulty at the head noun in Japanese, this model would be better supported if early-stage difficulty was observed instead. Since many other effects are also predicted at the locus of disambiguation which also happens to be the locus of integration, the effects of expectation could have been masked (see Levy, 2008). Accordingly, in order to obtain a better observance of expectation, additional cues for the RC interpretation may be needed. Following the framework of cue-based retrieval models (e.g., Lewis &

Vasishth, 2005; Vasishth & Lewis, 2006), inserting additional cues would increase the activation level for the clause structure. Moreover, increasing the length of the clause would also increase its activation level as more successive activations on the structure would be made. As such, the results of Experiment 2 would greatly support this account. In Experiment 2, not only did I insert a pre-RC demonstrative to help prime the RC interpretation, but also the length of the RC was increased by an additional adverb phrase. However, difficulty was also localized at the head noun rather than the RC NP which contains case morphology cues. This implies that the parser still had to wait for a viable cue at the head noun, even though the clause was disambiguated earlier. This alludes to there to being a crucial cue which can assign RC features to the embedded clause, and before this cue is parsed, RC frequencies cannot be extracted from top-down resources. As it happened, this cue appeared at the head noun which was also the locus of disambiguation for ambiguous RCs. Considering that the current study and previous studies (e.g., Miyamoto & Tsujino, 2016) did not find ORC difficulty prior to the head noun within unambiguous contexts, this proposal for a cue-based retrieval for access to frequencies is consistent with the findings. In order to further validate surprisal models of processing, future studies may explore other embedded clause structures in Japanese. As reported in Yun et al., (2015), complement clauses in Japanese also have an asymmetry in distribution between subject-drop and object-drop. Thus, at the head of each structure, the object-drop case should induce longer reading times.

For entropy-reduction models (Hale, 2006; Yun et al., 2015), the results supporting the model are mixed. Particularly, in Experiment 1, no ORC difficulty was observed at the RC NP while ORCs were more difficult to process in Experiment 2 at the RC NP. This may suggest that entropy-reduction may not always be observable in reading studies. Accordingly, future research is needed to determine which methods may better capture these effects if they are present during reading.

### 4.5.4. The Object-Before-Subject-Bias

The object-before-subject-bias (Nakamura & Miyamoto, 2013) appears well suited to correctly predict the ORC difficulty for ambiguous RCs in Japanese. Within ambiguous RCs, processing difficulty was chiefly observed at the head noun and RC verb during later stages of processing which is consistent with the predictions made by OBSB. As such, the ordering of theta roles for the RC argument allows SRCs to be easier to process since the object is integrated first with the RC verb prior to the head noun. Conversely, ORCs are more difficult since the parser is required to wait until the head noun to go back and assign the theta role to the RC subject.

Interpreting OBSB for unambiguous RCs may be problematic since Nakamura & Miyamoto (2013) first claimed that OBSB may not account for ORC difficulty if the clause is unambiguous while Miyamoto (2016) claimed that the model still applies for unambiguous clauses. Thus, there seems to be disagreement. Yet, considering that the unambiguous RCs in Experiment 2 did not reveal ORC difficulty at the RC verb, it appears that OBSB was no longer a factor. If it was, the parser would have to go back and interface with the RC predicate to assign the theta role, but no evidence for this was shown. Furthermore, OBSB may ultimately be broken down to issues of collocations. Considering that it is widely believed that processing is incremental, even if the object had not been integrated yet, at the RC verb, there would be some anticipation for an object which has a high collocation with it. Thus, difficulty may be reserved to cases in which an object was not highly collocated with the RC predicate. I argue that future studies exploring the role of OBSB in RC processing should investigate it in terms of collocations.

# 4.6. Conclusion

I conclude that clause type ambiguity is an integral factor in Japanese relative clause processing. Furthermore, eliminating this ambiguity had great impact on the processing of the sentence, particularly at the head noun as predicted. When the RC was ambiguous, ORCs were more difficult to process after disambiguation, possibly due to the inherent difficulty of assigning thematic roles when the object appears outside the clause as object-before-subject-bias predicts. Yet, at the same time, other processing factors such as expectation, structural-integration and similarity interference were also supported since all predict ORC difficulty. Thus, for ambiguous RCs it is challenging to attribute ORC difficulties to any individual account listed above or to other accounts not listed in this study. In contrast, when the RC were unambiguous, ORCs became more difficult early on at the head noun. I attribute this primarily as a factor of expectation-based processing and cue-based retrieval accounts of processing. Specifically, with attenuated difficulty and increased cues for the RC interpretation, expectation-based processing effects became more observable. Not only did this study provide support for hybrid models of processing, it also replicated findings in other languages such that expectation-based processing is the chief processing factor when the clause structure is unambiguous. Future research on this issue can explore these processing accounts inside additional contexts or modulate the contexts here, for instance, using punctuation or prosodic effects. Furthermore, future research should also investigate the role of memory-based resources as a factor of ambiguity. However, as seen here, reading times studies may not be the best method to explore these relationships. Instead, methods tapping deeper into the neurophysiological aspects of processing may be better suited to explore memory-based accounts in Japanese.

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## 4.8. Compliance with Ethical Standards

### 4.8.1. Conflict of interest

No authors had a conflict of interest.

### 4.8.2. Human and Animal Rights Statement

All personal information collected from participants was stored in a secured location, and participants were given numerical pseudonyms for data analysis purposes to ensure privacy. Participants were not subject to harm and could have only experienced mild discomfort from prolonged seating or reading. Participants were allowed to take short breaks to prevent discomfort.

### 4.8.3. Informed Consent

In the current study, all participants first gave informed consent prior to the experimental sessions. After the completion of the eye-tracking sessions and the sentence completion task, all participants received monetary compensation. For the naturalness decision task, participants partook in the survey on a voluntary basis, thus they did not receive monetary compensation.

## 4.9. Chapter 4 Supplementary Tables

In the following pages, the supplementary Tables of Chapter 4 are provided.

**Table 4.1. Experiment 1: RC condition means**

| | ORC | | SRC | |
|---|---|---|---|---|
| | Mean | SE | Mean | SE |
| Sentence | | | | |
| TT | 4,956 | 93 | 4,807 | 90 |
| ACC | 65.2% | 1.9% | 79.5% | 1.6% |
| N1 (RC Noun) | | | | |
| FF | 240 | 4 | 237 | 4 |
| FP | 359 | 10 | 353 | 9 |
| RR | 655 | 23 | 660 | 24 |
| DT | 891 | 24 | 895 | 25 |
| GP | 479 | 15 | 479 | 16 |
| RO | 19.2% | 1.9% | 16.1% | 1.6% |
| RI | 61.5% | 2.4% | 64.2% | 2.1% |
| V1 (RC Verb) | | | | |
| FF | 239 | 4 | 244 | 4 |
| FP | 361 | 10 | 348 | 9 |
| RR | 579 | 22 | 551 | 20 |
| DT | 808 | 22 | 734 | 20 |
| GP | 449 | 16 | 424 | 12 |
| RO | 11.4% | 1.5% | 12.0% | 1.4% |
| RI | 47.0% | 2.4% | 44.6% | 2.2% |
| N2 (Head Noun) | | | | |
| FF | 253 | 5 | 254 | 4 |
| FP | 424 | 11 | 447 | 11 |
| RR | 708 | 26 | 665 | 23 |
| DT | 980 | 26 | 953 | 25 |
| GP | 554 | 19 | 547 | 18 |
| RO | 16.8% | 1.8% | 13.3% | 1.5% |
| RI | 46.2% | 2.4% | 44.4% | 2.2% |
| ADJ (Adjective) | | | | |
| FF | 257 | 5 | 252 | 4 |
| FP | 372 | 10 | 355 | 9 |
| RR | 533 | 21 | 500 | 19 |
| DT | 750 | 21 | 708 | 20 |
| GP | 498 | 22 | 441 | 17 |
| RO | 14.6% | 1.7% | 13.6% | 1.5% |
| RI | 40.8% | 2.4% | 40.5% | 2.2% |
| N3 (Matrix Object) | | | | |
| FF | 264 | 5 | 260 | 5 |
| FP | 362 | 10 | 348 | 8 |
| RR | 466 | 22 | 414 | 18 |
| DT | 616 | 21 | 588 | 19 |
| GP | 1,687 | 77 | 1,640 | 66 |

| | | | | |
|---|---|---|---|---|
| RO | 65.7% | 2.3% | 71.8% | 2.0% |
| RI | 6.6% | 1.2% | 5.5% | 1.0% |
| V2 (Matrix Verb) | | | | |
| FF | 225 | 9 | 223 | 7 |
| FP | 261 | 13 | 274 | 13 |
| RR | 320 | 40 | 329 | 33 |
| DT | 312 | 18 | 349 | 18 |
| GP | 2,111 | 119 | 2,298 | 131 |
| RO | 96.3% | 1.4% | 90.5% | 2.1% |

Note. Means and errors of reading times are displayed in milliseconds.

**Table 4.2. Experiment 1: LME estimates and *t/z* values**

| | RC condition | | | |
|---|---|---|---|---|
| | coef. | SE | *t/z* value | |
| Sentence | | | | |
| TT | -0.04 | 0.02 | -2.53 | *** |
| ACC | 1.03 | 0.15 | 6.86 | * |
| N1 (RC Noun) | | | | |
| FF | -0.02 | 0.02 | -0.76 | |
| FP | -0.02 | 0.03 | -0.63 | |
| RR | -0.06 | 0.04 | -1.48 | |
| DT | -0.05 | 0.03 | -1.65 | † |
| GP | -0.04 | 0.03 | -1.21 | |
| RO | -0.21 | 0.18 | -1.16 | |
| RI | 0.08 | 0.15 | 0.56 | |
| V1 (RC Verb) | | | | |
| FF | 0.03 | 0.02 | 1.61 | |
| FP | 0.00 | 0.03 | -0.07 | |
| RR | -0.10 | 0.05 | -2.11 | * |
| DT | -0.10 | 0.03 | -3.23 | ** |
| GP | 0.00 | 0.03 | -0.04 | |
| RO | 0.03 | 0.20 | 0.15 | |
| RI | -0.13 | 0.14 | -0.95 | |
| N2 (Head Noun) | | | | |
| FF | 0.01 | 0.02 | 0.71 | |
| FP | 0.05 | 0.03 | 1.82 | † |
| RR | -0.11 | 0.05 | -2.34 | * |
| DT | -0.05 | 0.03 | -1.75 | † |
| GP | -0.02 | 0.03 | -0.47 | |
| RO | -0.34 | 0.19 | -1.78 | † |
| RI | -0.09 | 0.14 | -0.66 | |
| ADJ (Adjective) | | | | |
| FF | 0.00 | 0.02 | -0.23 | |
| FP | -0.02 | 0.03 | -0.70 | |
| RR | -0.10 | 0.05 | -2.11 | * |
| DT | -0.05 | 0.03 | -1.67 | † |
| GP | -0.05 | 0.04 | -1.37 | |
| RO | -0.06 | 0.20 | -0.33 | |
| RI | -0.05 | 0.15 | -0.33 | |
| N3 (Matrix Object) | | | | |
| FF | -0.02 | 0.02 | -1.08 | |
| FP | -0.02 | 0.03 | -0.60 | |
| RR | -0.10 | 0.06 | -1.73 | † |
| DT | -0.04 | 0.03 | -1.09 | |
| GP | 0.04 | 0.05 | 0.65 | |

| | | | | |
|---|---|---|---|---|
| RO | 0.42 | 0.17 | 2.44 | * |
| RI | -0.19 | 0.29 | -0.66 | |
| V2 (Matrix Verb) | | | | |
| FF | 0.01 | 0.04 | 0.20 | |
| FP | 0.04 | 0.05 | 0.82 | |
| RR | 0.03 | 0.13 | 0.25 | |
| DT | 0.08 | 0.06 | 1.52 | |
| GP | 0.04 | 0.06 | 0.69 | |
| RO | -1.09 | 0.50 | -2.18 | * |

Note. A positive estimate indicates an increase in reading time for SRCs. p < .1 †, p < .05*, p < .01**, p < .001***

**Table 4.3. Experiment 2: RC condition and determiner type means**

| | Ambiguous | | | | Unambiguous | | | |
|---|---|---|---|---|---|---|---|---|
| | ORC | | SRC | | ORC | | SRC | |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Sentence | | | | | | | | |
| TT | 4,623 | 99 | 4,459 | 93 | 4,930 | 102 | 74.9% | 2.4% |
| ACC | 73.4% | 2.5% | 76.8% | 2.4% | 76.7% | 2.4% | 4,814 | 93 |
| N1 (RC Noun) | | | | | | | | |
| FF | 253 | 7 | 231 | 6 | 231 | 6 | 228 | 5 |
| FP | 401 | 15 | 347 | 13 | 346 | 13 | 330 | 13 |
| RR | 613 | 29 | 509 | 23 | 650 | 30 | 664 | 29 |
| DT | 877 | 30 | 754 | 25 | 924 | 31 | 847 | 28 |
| GP | 551 | 21 | 519 | 20 | 636 | 28 | 687 | 33 |
| RO | 22.0% | 2.7% | 29.9% | 2.9% | 38.4% | 3.1% | 41.9% | 3.2% |
| RI | 70.3% | 3.0% | 70.5% | 2.9% | 64.9% | 3.1% | 60.2% | 3.2% |
| ADV2 | | | | | | | | |
| FF | 219 | 5 | 210 | 4 | 215 | 5 | 225 | 5 |
| FP | 233 | 6 | 234 | 7 | 228 | 6 | 243 | 6 |
| RR | 458 | 25 | 356 | 20 | 408 | 26 | 321 | 17 |
| DT | 504 | 23 | 430 | 18 | 453 | 20 | 400 | 15 |
| GP | 307 | 13 | 311 | 13 | 365 | 21 | 352 | 17 |
| RO | 14.4% | 2.5% | 14.1% | 2.4% | 21.0% | 2.8% | 16.2% | 2.5% |
| RI | 56.2% | 3.5% | 48.6% | 3.4% | 44.3% | 3.4% | 41.4% | 3.3% |
| V1 (RC Verb) | | | | | | | | |
| FF | 231 | 6 | 230 | 5 | 228 | 5 | 235 | 5 |
| FP | 303 | 11 | 289 | 9 | 303 | 11 | 293 | 10 |
| RR | 460 | 26 | 384 | 19 | 448 | 22 | 435 | 22 |
| DT | 644 | 29 | 555 | 23 | 627 | 23 | 569 | 23 |
| GP | 395 | 20 | 359 | 15 | 409 | 20 | 378 | 18 |
| RO | 11.9% | 2.2% | 16.1% | 2.4% | 16.4% | 2.4% | 14.2% | 2.3% |
| RI | 46.3% | 3.3% | 41.5% | 3.2% | 45.0% | 3.2% | 45.9% | 3.3% |
| N2 (Head Noun) | | | | | | | | |
| FF | 251 | 6 | 255 | 7 | 265 | 6 | 239 | 5 |
| FP | 325 | 11 | 324 | 11 | 343 | 10 | 313 | 9 |
| RR | 532 | 31 | 503 | 26 | 489 | 26 | 458 | 24 |
| DT | 733 | 30 | 665 | 25 | 704 | 26 | 623 | 24 |
| GP | 498 | 28 | 461 | 22 | 523 | 29 | 511 | 30 |
| RO | 18.9% | 2.6% | 18.8% | 2.5% | 22.3% | 2.7% | 22.1% | 2.7% |
| RI | 53.7% | 3.3% | 47.3% | 3.2% | 51.7% | 3.2% | 47.6% | 3.3% |
| N3 (Matrix Object) | | | | | | | | |
| FF | 229 | 5 | 239 | 6 | 242 | 5 | 230 | 5 |
| FP | 286 | 10 | 285 | 9 | 292 | 9 | 274 | 8 |
| RR | 493 | 26 | 440 | 22 | 511 | 30 | 447 | 25 |
| DT | 643 | 26 | 620 | 24 | 642 | 28 | 598 | 24 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GP | 477 | 28 | 407 | 22 | 427 | 23 | 424 | 23 |
| RO | 26.1% | 2.9% | 18.9% | 2.5% | 20.8% | 2.6% | 18.0% | 2.5% |
| RI | 54.4% | 3.3% | 54.6% | 3.2% | 50.0% | 3.3% | 45.9% | 3.3% |
| V2 (Matrix Verb) | | | | | | | | |
| FF | 241 | 6 | 235 | 5 | 230 | 5 | 245 | 5 |
| FP | 312 | 11 | 289 | 9 | 295 | 10 | 309 | 10 |
| RR | 418 | 25 | 421 | 23 | 365 | 22 | 392 | 23 |
| DT | 541 | 22 | 554 | 23 | 510 | 21 | 550 | 22 |
| GP | 557 | 33 | 486 | 29 | 429 | 22 | 434 | 21 |
| RO | 32.4% | 3.1% | 28.7% | 2.9% | 24.9% | 2.8% | 23.5% | 2.8% |
| RI | 24.0% | 2.9% | 27.0% | 2.9% | 28.7% | 2.9% | 28.7% | 3.0% |

Note. Means and errors of reading times are displayed in milliseconds.

**Table 4.4. Experiment 2: LME estimates and *t/z* values**

| | Ambiguous | | | | Unambiguous | | | |
|---|---|---|---|---|---|---|---|---|
| | coef. | SE | *t/z* value | | coef. | SE | *t/z* value | |
| Sentence | | | | | | | | |
| TT | 0.10 | 0.10 | 1.09 | | 0.00 | 0.01 | -0.28 | |
| ACC | -0.02 | 0.01 | -2.08 | * | -0.06 | 0.10 | -0.65 | |
| N1 (RC Noun) | | | | | | | | |
| FF | -0.04 | 0.02 | -2.61 | ** | 0.00 | 0.02 | -0.30 | |
| FP | -0.07 | 0.02 | -3.12 | ** | -0.03 | 0.02 | -1.11 | |
| RR | -0.09 | 0.03 | -3.20 | ** | 0.02 | 0.03 | 0.82 | |
| DT | -0.07 | 0.02 | -3.36 | *** | -0.05 | 0.02 | -1.97 | * |
| GP | -0.03 | 0.02 | -1.25 | | 0.03 | 0.03 | 0.89 | |
| RO | 0.27 | 0.12 | 2.34 | * | 0.09 | 0.10 | 0.89 | |
| RI | -0.01 | 0.11 | -0.09 | | -0.08 | 0.10 | -0.83 | |
| ADV2 | | | | | | | | |
| FF | -0.02 | 0.01 | -1.31 | | 0.03 | 0.01 | 1.84 | † |
| FP | 0.00 | 0.02 | -0.16 | | 0.03 | 0.02 | 2.05 | * |
| RR | -0.13 | 0.03 | -3.87 | *** | -0.09 | 0.04 | -2.26 | * |
| DT | -0.07 | 0.03 | -2.66 | ** | -0.05 | 0.03 | -1.88 | † |
| GP | 0.00 | 0.02 | -0.22 | | 0.00 | 0.03 | 0.11 | |
| RO | -0.03 | 0.15 | -0.22 | | -0.18 | 0.13 | -1.37 | |
| RI | -0.17 | 0.10 | -1.70 | † | -0.03 | 0.11 | -0.28 | |
| V1 (RC Verb) | | | | | | | | |
| FF | 0.00 | 0.01 | 0.26 | | 0.01 | 0.01 | 0.92 | |
| FP | -0.01 | 0.02 | -0.68 | | 0.00 | 0.02 | -0.05 | |
| RR | -0.07 | 0.03 | -1.98 | * | -0.01 | 0.04 | -0.29 | |
| DT | -0.06 | 0.02 | -2.44 | * | -0.04 | 0.03 | -1.58 | |
| GP | -0.02 | 0.03 | -0.74 | | -0.03 | 0.03 | -1.02 | |
| RO | 0.20 | 0.14 | 1.41 | | -0.09 | 0.13 | -0.71 | |
| RI | -0.11 | 0.10 | -1.06 | | 0.02 | 0.10 | 0.21 | |
| N2 (Head noun) | | | | | | | | |
| FF | 0.00 | 0.02 | 0.26 | | -0.04 | 0.01 | -3.252 | ** |
| FP | -0.01 | 0.02 | -0.37 | | -0.04 | 0.02 | -2.059 | * |
| RR | -0.02 | 0.03 | -0.68 | | -0.03 | 0.03 | -0.865 | |
| DT | -0.05 | 0.02 | -2.15 | * | -0.05 | 0.02 | -2.309 | * |
| GP | -0.02 | 0.03 | -0.76 | | -0.02 | 0.03 | -0.803 | |
| RO | 0.00 | 0.12 | -0.03 | | -0.01 | 0.12 | -0.05 | |
| RI | -0.15 | 0.10 | -1.53 | | -0.07 | 0.10 | -0.756 | |
| N3 (Matrix Object) | | | | | | | | |
| FF | 0.02 | 0.01 | 1.20 | | -0.02 | 0.01 | -1.34 | |
| FP | 0.00 | 0.02 | 0.10 | | -0.03 | 0.02 | -1.54 | |
| RR | -0.06 | 0.03 | -1.81 | † | -0.06 | 0.04 | -1.61 | |
| DT | -0.03 | 0.02 | -1.27 | | -0.02 | 0.03 | -0.94 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GP | -0.05 | 0.03 | -1.89 | † | -0.01 | 0.03 | -0.47 | |
| RO | -0.28 | 0.13 | -2.16 | * | -0.10 | 0.13 | -0.82 | |
| RI | -0.02 | 0.10 | -0.19 | | -0.10 | 0.10 | -0.96 | |
| V2 (Matrix Verb) | | | | | | | | |
| FF | -0.01 | 0.01 | -0.42 | | 0.03 | 0.01 | 2.12 | * |
| FP | -0.03 | 0.02 | -1.37 | | 0.02 | 0.02 | 1.15 | |
| RR | 0.02 | 0.04 | 0.44 | | 0.04 | 0.04 | 1.05 | |
| DT | 0.01 | 0.02 | 0.34 | | 0.04 | 0.03 | 1.37 | |
| GP | -0.06 | 0.03 | -1.91 | † | 0.00 | 0.03 | 0.16 | |
| RO | -0.10 | 0.10 | -0.93 | | -0.06 | 0.12 | -0.49 | |
| RI | 0.09 | 0.11 | 0.78 | | 0.02 | 0.11 | 0.17 | |

Note. A positive estimate indicates an increase in reading time for SRCs. $p < .1$ †, $p < .05$*, $p < .01$**, $p < .001$***

# CHAPTER 5

# General Discussion

## 5.1. Overview

In the previous chapters (i.e., Chapters 2-4), relative clause (RC) processing was investigated in the Mandarin Chinese, Korean and Japanese languages. In Chapter 1, three overlaying research questions were proposed: (i) are ORCs more difficult to process than SRCs for each language, (ii) does (i) change as a factor of ambiguity, and (iii) which processing models are supported and how are they interrelated? Briefly put, while ORCs were more difficult to process in Japanese and Korean, in Mandarin, they were actually easier to process in some contexts. For both Japanese and Mandarin, RC processing was influenced by the level of ambiguity in the clause structure. In Mandarin, as ambiguity was attenuated, SRCs became easier to process, and in Japanese, ORC difficulty appeared earlier as the ambiguity was attenuated. For all three languages, both expectation-based processing and working memory resources were seen to be influential factors in processing. Moreover, as ambiguity was attenuated in Japanese and Mandarin, expectation-based processing became a more salient processing factor. Consequently, the interconnectedness of these factors appeared limited at specific positions in the sentence at which both factors were operational. These findings suggest that both expectation and memory are mechanisms within the framework of cue-based parsing. Specifically, not only are cues needed to initiate integration/retrieval processes within memory, but also they are responsible for assigning specific features (e.g., + RC, + interrogative, etc.). In certain cases, if a clause, such as an RC, does not have its feature assigned to it, the clause will not be interpreted correctly. Furthermore, without this feature, specific information about the clause, such as its frequency situated in the language, will not be accessible. Thus, cues are responsible to allow access to language frequencies. Importantly, this influences expectation-based processing as this processing mechanism is reliant on lexical and structural frequencies.

As cues are manipulated in the sentence context, the activation levels of specific co-referents and structures fluctuate in memory. In summary, the data collected from these languages support an interconnected expectation-memory approach of processing.

## 5.2. Summary for Each Language

Even though all three of these East Asian languages contain prenominal RCs, there are still typological differences between them. Thus, it is quite obvious that there would be several notable differences in the overall processing behaviour for each language. Particularly, the major differences were that Mandarin was the only language to show a clear ORC processing advantage and that both Mandarin and Japanese had clear effects of ambiguity while Korean processing did not change drastically. Despite these differences, there was one clear processing effect observed for all three languages. That is, expectation-based processing was observed to be a clear processing factor for each language at the locus of disambiguation resulting in increased difficulty for ORCs. Since ORCs are less frequent than SRCs in each language, upon reaching the locus of disambiguation, ORCs became more difficult to process. However, for both Mandarin and Japanese, this effect was more pronounced when the RC context was unambiguous. Refer to Table 5.1 for a summary of the theories supported in each language.

**Table 5.1. Summary of theories supported in each language**

| Theory | Japanese | Korean | Mandarin |
|---|---|---|---|
| Expectation | | | |
| RC | Yes (head) | Yes (ADN) | Yes (REL, EXP 2) |
| Simple Clause | Yes (head) | Yes (ADN) | Yes (RC) |
| Integration | | | |
| Head-Gap | | | |
| Linear/Temporal | No | No | Yes (REL & head, EXP 1) |
| Structural | Yes (head) | Yes (ADN) | No |
| Operator-Gap | | | |
| Linear/Temporal | Yes (head) | Yes (ADN) | Yes (REL, EXP2) |
| Structural | Yes (head) | Yes (ADN) | Yes (REL & Head, EXP 1) |
| Similarity Interference | Partial (head) | Partial (RC & head) | Partial (head & matrix) |
| OBSB | Yes | No | NA |

Note. OBSB stands for the Object-Before-Subject-Bias, NA stands for Not Applicable. For expectation, RC stands for the expectations based on RC frequencies while Simple Clause stands for expectations based on a simple matrix clause. Within parentheses below each response, specific loci or experimental context may also be listed.

### 5.2.1. Mandarin Chinese Findings

In Experiment 1, which only included ambiguous RCs, SRC difficulty was primarily observed. In previous studies on Mandarin RC processing, while there have been mixed findings for ORC advantages and disadvantages within ambiguous contexts, studies also using eye-tracking (Sun et al., 2015) have revealed the ORC advantage as well. Accordingly, the finding of Experiment 1 is consistent with the previous research using this design and context scheme. Thus, this data would appear to be consistent with the linear/temporal distance integration account predicting SRC difficulty. While the data is consistent with linear/temporal integration, at this stage it was still unclear whether a garden path effect contributed to the overall difficulty for SRCs since its structure deviates from canonical order. Considering that when the RC was ambiguous, a simple matrix clause interpretation would likely be taken, a garden path effect seems to be a reasonable explanation for the SRC difficulty, maybe even the appropriate explanation.

In Experiment 2, which included both ambiguous and unambiguous RCs, it was found that the findings of Experiment 1 should not be attributed to a simple garden path effect. The reasoning for this is that for both ambiguous and unambiguous RCs, there were indications of early SRC difficulty at the RC structure. Since SRC difficulty for unambiguous RCs cannot be attributed to a garden path effect, it brings into question if the findings for ambiguous RCs are indications of a canonical word order, garden path effect or if SRC difficulty is attributable to another processing effect. It is my claim that it is the latter with two factors contributing to the SRC difficulty. In accordance with Packard et al. (2011), since the relativizer can satisfy the selectional restriction of the RC predicate, it has the capability of integrating with it and with the co-indexed gap. Because of this, the basic thematic consistency between the ORC argument and the canonical word/semantic order makes the ORC structure easier to parse out initially in comparison to the SRC structure which deviates from canonical order. However, this is not a garden path effect since it is known that the structure cannot be a simple clause sentence. Instead of relying on specific frequencies for either the simple clause structure or for RCs, the underlying regularities of the language were able to support the initial parsing of the RC. Also, since the distance between the filler and gap was much more local in comparison to the linear/temporal distance found in the SRC structure, the integration/retrieval process was less taxing. Consequently, ORC advantages in Mandarin are attributable to canonical word order (but it is not always a garden path effect) and a linear/temporal integration metric.

As mentioned above, only early SRC difficulty for the clause as a whole was observed within unambiguous RCs. In fact, in contrast to the above, the main findings for Experiment 2 revealed ORC difficulty. Similar to Jäger et al. (2015), the later re-reading times at the RC demonstrated overall ORC processing difficulty. While Jäger et al. (2015) claimed that this is direct support for expectation-based processing, it is in actuality not. For expectation-based processing to be directly supported at this locus, early ORC difficulty must have been shown; yet, it was not for both studies, and both studies actually showed trending ORC advantages for this combined region. However, the current study was able to reveal direct evidence for expectation-based processing (Hale, 2001; Levy, 2008), since at the relativizer ORC difficulty was seen during early measurements of processing for both ambiguous and unambiguous RCs. This was also influenced by the level of ambiguity since unambiguous ORCs became more difficult to process quicker than ambiguous ORCs (which were actually less ambiguous than the RCs in Experiment 1) in comparison with both of their counterparts. The implication of this finding is that regardless of the initial interpretation, the first true indication of surprisal is found at the locus of disambiguation. Accordingly, despite the surprisal calculations of Chen et al. (2012) predicting ORC difficulty earlier on in the sentence, the frequency information of the RC structure does not seem obtainable until the clause has been completely parsed. Thus, after the reading of the relativizer, ORCs became more difficult than SRCs as a factor of expectation-based processing (Hale, 2001; Levy, 2008), since the fined-tuned structural frequencies then became available for the RC. This would differ from languages such as English (e.g., Staub, 2010) and Russian (Price & Witzel, in press) which has been shown to tap into expectation-based processing at the first available cue to determine RC type (i.e., ORC or SRC type). This may be a difference between prenominal and post-nominal languages or it could suggest that for prenominal languages, a certain level of ambiguity still exists, which necessitates the clause to be parsed out fully. Another possibility is that Mandarin is actually similar to languages like English and Russian. In English and Russian, the *wh*-operator (i.e., relative pronoun and relativizer) comes early, but it comes late for Mandarin. It could be that the operator is responsible for the access to the structural frequencies of the clause since it is necessary to check the *wh*-features of the clause

(Aoun & Li, 1993; Chomsky, 1977; May, 1985; c.f., Watanabe, 1992, 2003 in reference to Japanese). Thus, without it integrated into the structure, frequencies cannot be fully accessed. This account would better explain the data for Mandarin as RC frequency effects were not observed until the relativizer, and effects opposite to those predicted by RC statistical frequencies were observed prior to it regardless of the ambiguity the clause had. In addition, this basic premise fits within the framework of cue-based parsing (e.g., Lewis & Vasishth, 2005): (i) A principal cue is required to assign RC features and (ii) additional cues either enhance or decay the activation level of the structure once the principal cue is integrated into the structure. In Mandarin, this cue is the relativizer free morpheme (i.e., the locus of disambiguation).

For both experiments, there were also indications of late ORC processing difficulty found at the head noun and general ORC difficulty at the matrix clause. This likely demonstrated processing influences from similarity-based interference. Specifically, since there was proactive interference for the head noun via the RC noun in ORCs, upon reading the matrix clause verb, there is greater difficulty in retrieving the subject of the matrix clause (i.e., the head noun). This effect was also influenced by ambiguity because when the head noun was modified by the determiner and classifier, the effects of similarity interference was less detrimental to the retrieval process which likely demonstrated that being modified by an additional structure made the two nouns more specific in working memory.

In summary from these two experiments on Mandarin RC processing, there was a shift of observance from working memory factors towards expectation-based processing factors as the clause became less ambiguous at the locus of disambiguation in Mandarin (i.e., the relativizer). Overall, ambiguity was in fact a confounding factor for Mandarin RC processing, and should be taken into consideration when investigating RCs in Mandarin. The processing factors supported in Mandarin RC processing included expectation-based processing, a linear/temporal integration metric, similarity-based interference, and canonical word order. These particular processing accounts are chief factors for Lewis and Vasishth's (2005) cue-based retrieval model, except canonical word order which was added to account for the data. This would suggest that there are fluctuations in activation for a given structure or string, that are influenced by both bottom-up and top-down parsing factors. The last implication from Mandarin is that it appears that the *wh*-operator is responsible for accessing RC frequencies.

However, it is not yet clear if the relativizer itself or a covert operator, which moves to [Spec, CP], is responsible for assigning RC features to the clause. This will have to be addressed in future research.

### 5.2.2. Korean findings

In Experiment 1, which only included ambiguous RCs, ORC difficulty was observed first at the embedded RC verb. At this position in the sentence, the adnominal marker suffixed to the verb acts as a disambiguating cue for the initial clause-type ambiguity. Accordingly, ORC difficulty at the locus of disambiguation supported expectation-based processing (Hale, 2001; Levy, 2008) since frequency information for the RC structure becomes available at the locus. Because no other factors are predicted to be involved for subject-modified RCs at the RC verb, the only factor which can account for this difficulty was expectation-based processing. In essence, since ORCs are less frequent, they had increased processing difficulty at this locus. In addition, since an RC interpretation may have the highest interpretation ranking at the adnominal marker, frequencies should be drawn for RCs instead of other similar structures (e.g., complement clauses such as fact-clauses and pseudo-relatives). However, even if other structures are predicted and the expectations were based on them, ORCs would be more difficult regardless since transitive argument clauses lacking overt objects are less frequent in corpora. Additionally, after the RC verb at the head noun, ORC difficulty was also observed as well. Yet, this should not be considered as an indicator of expectation-based processing, as Kwon et al. (2010) argued, since (i) the clause has already been disambiguated and (ii) no spillover effects were seen there. Instead, this finding should be interpreted as supporting the structural-phrase hierarchy integration metric (O'Grady, 1997). While the interpretations of the results differ between studies, the results are actually quite consistent since Kwon et al. (2010) would have likely revealed significance at the RC verb if they had used LME methods for analysing their results rather than analysis of variance (ANOVA) which is becoming less popular as researchers have begun adopting LME methods.

In Experiment 2, which included both ambiguous and unambiguous RCs, the same pattern of results was observed and was consistent with Experiment 2 of Kwon et al. (2010). Consequently, ambiguity was not seen an interactive factor for Korean RC processing at the RC verb or head noun, which is similar to the findings of Kwon et al.

(2010). Since the same pattern of results was observed, it would appear that attenuating the ambiguity does not shift the locus of disambiguation from the RC verb to the RC noun as predicted. While both Kwon et al. (2010) and the current study likely succeeded in attenuating the ambiguity (e.g., unambiguous RCs were initially quicker to read), it appears that RC structural frequencies were not obtainable until the clause was fully parsed. As such, while the mental parser is aware of the embedded clause structure early on, the parser probably does not commit to the RC interpretation and makes word by word expectations for it until the adnominal marker is met by the parser. Thus, this would fall into the framework of cue-based retrieval models of parsing. In other words, at the adnominal marker, the *wh*-operator is likely activated to assign RC features to the clause, and only after this, RC frequencies are obtainable by the parser. Accordingly, the adnominal marker (i.e., the locus of disambiguation) serves as the principal cue for the RC interpretation regardless of whether the matrix clause interpretation is eliminated within the contexts of these experiments. Also, since expectation and integration effects are found at different loci in Korean RCs, attenuating the ambiguity did not alter the overall reading behaviour even if the underlying processes were different. Specifically, these processes do not interfere with each other when increasing or decaying the activation level of the structure and its dependents. As mentioned before, regardless of the clause predicted at the start of the RC, ORC difficulty will always be more difficult at the RC verb due to any specific frequency account. Additionally, subsequently at the head noun, ORCs then again become more difficult due to the integration process which is non-local via a structural distance metric.

The difficulty at the head noun may also support a similarity-based interference account; however, such an account was supported partially at best since little difficulty was observed at the matrix predicate. This could have revealed some evidence for interference at the encoding stage.

Overall, for Korean RC processing, the specific processing theories supported were expectation-based processing, a structural-phrase hierarchy integration metric and possibly similarity-based interference, all of which are factors in cue-based retrieval models of processing. Moreover, due to the typological features of Korean, ambiguity did not alter reading behaviour in a meaningful way for surface level observations save the faster reading times during early measures at the RC for unambiguous RCs.

### 5.2.3. Japanese Findings

In Experiment 1, which only included ambiguous RCs, ORC difficulty was observed at both the embedded RC verb and head noun. The ORC difficulties, however, were only observed during dwell-time reading, which is an overall processing measure. Accordingly, it was hard to attribute these difficulties to any specific processing theory. However, since the object-before-subject-bias predicts general difficulty at these loci, this account may be better supported than expectation-based processing and integration since neither early difficulty nor regressive measures revealed ORC difficulty. Another possibility is that similarity-interference after reading the head noun was retroactive in nature causing general comprehension difficulty for the RC argument. Yet, no account above was fully supported.

Moving on to Experiment 2 which included both ambiguous and unambiguous RCs, while the two clause types were analysed separately, there were still key differences in reading behaviour between the two nonetheless. For ambiguous RCs, similar to Experiment 1, only overall ORC difficulties were observed again. In contrast for unambiguous RCs, ORC difficulty was observed at the head noun during early-measures of processing. Ambiguity, therefore, had an influence on the processing of RCs in Japanese. Considering OBSB predicted difficulty at both the head noun and RC verb, it does not appear to be supported for unambiguous RCs since ORC difficulty was no longer observed at the RC verb. Integration effects also seem to not fit the data since in both Korean and Mandarin, go-past reading time appeared to reflect integration processes. While first-past reading time may also reflect integration, since neither go-past nor regression-out revealed ORC difficulty, it seems unlikely that an integration process took place or was that costly in terms of processing demands. Since early difficulty was not observed in Korean, Mandarin and for ambiguous Japanese RC contexts, similarity-based interference during the encoding/storage stages was not well supported. Consequently, expectation-based processing was the only factor left which did not have serious issues in accounting for the data. Once the RC structure was completely parsed out and realized at the head noun, ORCs became more difficult since it generated greater surprisal (i.e., it is a less frequent structure). While the attenuated clause-type ambiguity likely eliminated the simple matrix clause interpretation, the expectations for the RC structure were not readable at the RC noun at which the RC condition is determined on the surface level. Instead, frequencies were obtained at the locus of disambiguation, i.e., the head noun.

For Japanese RC processing, the particular processing theories supported here were numerous. For ambiguous RCs, general ORC difficulty supports too many theories. For instance, object-before-subject-bias, similarity-based interference, a structural-phrase hierarchy integration metric, and expectation-based processing were all supported. On the other hand, for unambiguous RCs, expectation-based processing was found to best account for the ORC difficulty observed. Consequently, ambiguity was observed to be a crucial factor which altered reading behaviour.

### 5.2.4. Language Independent Findings

The common finding shared between languages was that processing difficulty was chiefly centred on the locus of disambiguation for each language within both ambiguous and unambiguous contexts. Since at this locus the structural frequencies of RCs are available, these shared findings support expectation-based processing accounts, chiefly, surprisal (Levy, 2008).

There were also common patterns found between two of the three languages as well. For instance, both in Japanese and Korean, there were no indications of early processing difficulty at the RC noun for unambiguous RCs. Accordingly, for both languages, the locus of disambiguation was not shifted to a potential cue occurring earlier in the sentence. In a similar vein, this also may be consistent with the findings in Mandarin since the initial region was not seen to be subject to expectation-based processing during early measurements of processing. Thus, these languages differ in regards to expectation-based processing effects found in post-nominal languages such as English (e.g., Staub, 2010) and Russian (e.g., Price & Witzel, in press) which revealed effects prior to completing the parse of the RC structure. One explanation for this is that for prenominal RCs in general, there is a general ambiguity of the specific embedded clause type which necessitates the clause-type to be confirmed, regardless if the RC interpretation was favoured. Another possibility is that these cues are not informative enough by themselves to project a CP structure to inherit the RC frequencies. Instead, the entire clause first needs to be integrated into working memory or possibly the *wh*-operator first needs to be parsed prior to the access of RC frequencies. To confirm either possibility, further experiments are needed.

For both Japanese and Mandarin, reading behaviour was observed to be a factor of processing while it was not in Korean. While typologically different, Japanese and Mandarin are similar in regards to both the locus of disambiguation and the locus of integration potentially occurring at the same locus within each language. As Levy (2008) mentioned, expectation-based processing may be a low level effect that could be masked by other processing effects which are more taxing to the parser such as integration. Thus, by attenuating the ambiguity and increasing the RC interpretation, expectation-based processing became a stronger processing factor.

While there were similarities between languages, there were also differences between them as well. See the next section for language dependent results.

### 5.2.5. Language Dependent Findings

The most salient language specific finding was that for Mandarin RC processing. Specifically, there were indications of greater SRC difficulty. This result directly contrasts with both Japanese and Korean. Unlike those two languages, the surface word order is important for Mandarin RCs since it is the surface cue responsible for determining RC type. Considering that Mandarin is a relatively rare language which has its ORC matching the canonical word order of the language, such an ORC advantage may be limited to these types of languages with rare typological features. This finding, though, is not entirely attributable to canonical word order facilitation. There was evidence for a linear/temporal-based integration metric (Gibson, 2000; Lewis & Vasishth, 2005). This directly conflicts with the findings in both Japanese and Korean which supported a structural-based integration metric (O'Grady, 1997). Accordingly, it appears that these languages seemingly used different integration metrics for processing. The explanations for this are numerous. For example, languages may have parametric processing behaviours dependent on key universal grammar (UG) parameters. In other words, the differences in UG parameters may also result in different parsing parameters to be used, or, because of the typological features for a language a specific parsing parameter becomes more dominant for parsing economy. Either way, considering that Mandarin RCs are typologically rare, it could just be pure coincidence that Mandarin developed a more dominant integration/retrieval metric which makes ORCs easier. This line of reasoning resonates with Gibson, Pearlmutter, and Canseco-Gonzalez (1996) who also argued this to explain the differences in attachment preferences (as well as early/late closure effects) in languages as a function of recency and predicate proximity. Considering that both English and Mandarin are SVO languages, the overall distance between the subject and the predicate is considerably local, and according to Gibson's *predicate proximity theory*, the arguments and the predicate only require a low level of activation. Thus, for these languages, *recency* and *locality* are more subject to linear/temporal based constraints. In contrast, both Korean and Japanese are SOV languages which require strong activation for their arguments since the distance between the subject and predicate is greater. Gibson et al. (1996) speculate that when arguments and predicates are strongly activated, there is a greater chance to violate recency effects allowing for high attachment preferences. Following this framework, the differences between integration parameters may be broken down into simple word order effects between languages. While this claim may be partially true, it is probably more likely that all parsing metrics are available for any specific structure, and one metric is more dominant than the other due to statistical frequencies; something which Gibson et al. (1996) also speculated.

In the below example, it is seen that there is some ambiguity in the attachment of the RC. While both 'the son' and 'the banker' are grammatically correct interpretations, only one can be modified by the RC. In English, the attachment preference prefers a more recent local noun (i.e., 'the banker'). But in other languages such as Japanese, this preference may be reversed. For that reason, it is not implausible to consider that languages may also have preferred parsing mechanisms as well.

(5.1) Attachment preferences

Ambiguous Attachment
The son of the banker who the receptionist gave the letter to flew to Denmark.

High Attachment
The son to whom the receptionist gave the letter

Low Attachment
The banker to whom the receptionist gave the letter

Another example to show that parsing mechanisms may be parametric or that one metric is stronger than the other comes from English reflexives. When an anaphoric reflexive initiates an antecedent recall (i.e., the reading of herself triggers a search in memory for a female antecedent), the search in memory has primarily been observed to be influenced by grammatical constraints (i.e., Binding Parameter A) and is not influenced by local ungrammatical antecedents which have matching features to the grammatical antecedent (e.g., Dillon et al., 2013). However, there is some evidence that local ungrammatical antecedents may in fact interfere at some level for L1 English speakers (e.g., Badecker & Straub, 2002; Mansbridge & Witzel, 2012) and L2 English learners (Felser, Sato, & Bertenshaw, 2009). Considering this in relation with attachment preference, it does appear possible that the parser in each language can utilize different metrics of parsing and that even multiple parsing operations may occur simultaneously, with one being more dominant than the other. See below for examples of anaphoric reflexives in English.

(5.2) Anaphoric Reflexives

ORC Matching
The policeman who the butler suspected drove himself to the airport.

SRC Matching
The policeman who suspected the butler drove himself to the airport.

ORC MisMatching
The policeman who the maid suspected drove himself to the airport.

SRC MisMatching:
The policeman who suspected the maid drove himself to the airport.

As seen in the example above, since the gender stereotype for ‘the policeman’ and ‘the butler’ are both male while ‘the maid’ is female, there should be a greater level of interference in the case where the nouns are both male and are subjects of their clauses (e.g., ORC Matching). However, Binding Principle A (Chomsky, 1981; Chomsky & Lasnik, 1993) states that the reflexive anaphor must be bound by its antecedent in its local binding domain, which means that the reflexive must be c-commanded and governed by the antecedent (i.e., the antecedent must be in a dominant position that is in an adjacent node which both it and the reflexive share). In all cases above, the noun of the RC is in a non c-commanding position and thus would be an ungrammatical antecedent to the anaphor. While this has been generally shown to be true, for the above example with centred embedded RCs, Mansbridge and Witzel (2012) revealed that there is some level of interference. This revealed that even ungrammatical local antecedents have the potential to interfere in working memory.

Considering that this would be viewed as a violation to Principle A to some degree (i.e., a violation of a syntactic constraint when searching through memory), it could be that multiple searches occur through memory simultaneously. In the case above, one could immediately consider grammatical antecedents by searching through syntactic hierarchy while the other search looks for matching features via a linear/temporal metric. However, the latter in this case seems to be a weaker retrieval metric. This would also explain why non-native speakers of English often prefer the local, ungrammatical antecedent since L2 speakers are often assumed to have shallow parsers and are more constrained by linearly local factors rather than structural ones (Clahsen & Felser, 2006). Under this proposition, integration/retrieval mechanisms in general may have multiple operational modes for a retrieval process, but for a given retrieval cue, one mode will be more dominant.

Another important finding limited to a specific language was that Korean had little influence from the clause-type ambiguity while the results in both Mandarin and Japanese were seen to alter as an influence of ambiguity. Specifically, in Korean, ORC difficulties were found to occur at the same loci and time-course duration regardless of the ambiguity condition. As I have mentioned above, this finding may be attributed to the fact that the locus of disambiguation and integration occur at separate loci in Korean while they may appear at the same locus in the other languages. Accordingly, without any other interfering factors at the locus of disambiguation, Korean RC processing would typically display ORC difficulty at this position at around the same time course duration of processing (i.e., the initial reading of the RC verb with its morphology prior to the reading of the head noun). While the current study only found effects of ORC difficulty during go-past measures of processing at the RC verb in Korean, it is possible that such effects could occur as early as first-pass reading time. For the other two languages, since multiple processing effects occurred at the same locus, decreasing the level of ambiguity gave stronger anticipation for an RC structure thus allowing for clearer observations of expectation-based processing at this critical region. This is not to say that the other factors became obsolete in such cases, but instead suggests that expectation became a more principal factor.

## 5.3. Processing Models

### 5.3.1. Expectation-Based Processing

For surprisal expectation-based processing models (Hale, 2001; Levy, 2008), fined-tuned frequencies are used to predict the upcoming words. When we encounter the expected word, there is no processing difficulty. When we encountered a word we did not expect (i.e., dashed expectation), processing difficulty is induced. In terms of RC processing, since ORCs are less frequent, they are less expected than SRCs. For both ambiguous and unambiguous RCs, expectation-based processing was likely a contributing factor for ORC difficulties in these languages.

In the case of Mandarin, the reason why expectation-based processing based upon RC frequencies was not seen for ambiguous RCs in Experiment 1 was likely attributed to the strong influence of integration and canonical word order facilitation which likely masked the effects of expectation. Levy (2008) even speculates that this often could be the reason surprisal effects are not observed at predicted loci. However, when cues were used to enhance the RC interpretation, the influence of expectation became stronger as the cues likely increased the activation level more drastically for the more frequent SRC structure.

For each language, the first influence of expectation-based processing was observed at the locus of disambiguation in each language for either ambiguous or unambiguous RCs. This could be viewed as problematic since for unambiguous RCs, there are cues in each language which would reveal the RC type (i.e., ORC or SRC), and at this potential cue, ORCs should incur greater processing difficulties owing to their lower frequency. However, this was not observed. One may make a hasty conclusion that the ambiguity for these clauses was not attenuated or that the ambiguity was not attenuated enough, but these accounts are not likely the case. Instead, this finding may implicate that there is some cue necessary for the extraction of RC frequencies.

In English (Forster et al., 2009; Staub, 2010) for example, the relative pronoun acts as the necessary cue to tap into the structural frequencies for each RC type thus making expectation-based processing effects observable prior to finishing the clause. Also, in Russian (Levy et al., 2013; Price & Witzel, in press), the relativizer itself is enough to allow for observations of RC frequencies since the relativizer contains the case morphology the head noun would assume within the RC (e.g., [N [$_{RC}$ REL-NOM

V NP-ACC]] or [N [$_{RC}$ REL-ACC NP-NOM V]]). In comparison, Mandarin Chinese, Japanese and Korean have their critical cues at the right boundary of the RC. This may also even suggest that there are covert (i.e., null) *wh*-operators in Japanese and Korean which are necessary for the interpretation of the RC and the extraction of frequencies. If these operators exists (i.e., it is still debated), then in order to realize and probe for them, another cue in the sentence or clause is required since these operators do not exist on the surface representation. This would also explain why ORC difficulty was not found until the RC verb in Turkish (e.g., Kahraman et al., 2010), which also has prenominal RCs. In Turkish, since the word order is SOV and the RC verb contains the RC marker, the relative marker comes at the right edge or boundary of the RC. Accordingly, expectation-based processing correctly predicts ORC difficulty in Turkish based upon their frequencies being lower than SRCs. Kahraman et al. (2010), however, chiefly argued that a structural-distance integration metric (O'Grady, 1997) could explain why ORCs were more difficult at the RC verb since they claimed that the RC markers can project an upcoming filler, which is actually reasonable since RCs can be headless in Turkish (Ketrez, 2012). I believe that Turkish would be consistent with the languages investigated here. Specifically, if Turkish RCs were given cues to attenuate the ambiguity, I predict that ORC difficulty would still be found first at the RC verb where the *wh*-operator can access the structural frequencies despite the case marking on the RC noun potentially acting as a cue to distinguish between ORCs and SRCs like Korean and Japanese.

If this line of reasoning proves to be valid, then this would not only reveal that movement exists in Japanese and Korean RCs but also reveal that it is necessary to process the *wh*-operator to extract structural frequencies from top-down resources. This would implicate that top-down and bottom-up factors are interconnected as they are both reliant on each other. In this case, the frequencies from top-down resources are not utilized until a specific cue is parsed in working memory.

### 5.3.2. Integration

As mentioned in the Introduction, Chapter 1, there are three general integration/retrieval metrics. First, there is the linear metric (Gibson, 1998, 2000) which measures distance by the number of intervening meaningful dependencies separating two referents. Second, there is the temporal metric (Lewis & Vasishth, 2005) which measures distance in terms of the time between processing the two referents. Third, there is the structural metric (O'Grady, 1997) which measures distance in terms of the number of intervening syntactic phrases within structural hierarchy (e.g., a syntactic tree).

In a post-nominal language, such as English, these metrics would make the same prediction that since ORCs have a greater distance between the filler and gap the integration process will be more difficult compared to SRCs. However, for prenominal RC languages, these predictions are diametrically opposed. Specifically, linear and temporal metrics predict that SRCs should be more difficult while the structural metric predicts ORC difficulty.

While the results of this study suggested that expectation-based processing was a chief processing factor for prenominal RC processing in East Asian languages, there was, nonetheless, strong evidence that integration/retrieval of filler-gap dependencies took place in Mandarin and Korean. While the results were less convincing in Japanese, previous research using ERP (Ueno & Garnsey, 2008) has revealed similar processes at the head noun in Japanese to that of the locus of integration in English. Thus, it is assumed that Japanese does integrate the head noun with the gap at the head noun. For Korean and Japanese, the integration metric supported was the structural-phrase hierarchy metric (O'Grady, 1997) since ORC difficulty was observed. For Mandarin, on the other hand, a linear/temporal metric was supported since SRC difficulty was found. As previously mentioned, this would suggest that integration metrics may be parametric between languages, i.e., while some languages follow structural pathways, others follow a linear/temporal path when retrieving referents. Other possible interpretations are that these processes could even be parametric within a given language or both metrics are active at the same time but specific language features will make one more dominant than the other for specific structures. The current study, however, cannot support any proposal at this time. Yet, if I consider that all languages utilize linear or temporal metrics, then how do I resolve the issues in Japanese and Korean revealing effects counter to these metrics? As mentioned in Chapter 1, the underlying syntactic structures for RCs in these languages are still being debated. If the Japanese and Korean structures involve covert *wh*-movement from the gap position to the [Spec, CP], as to assign *wh* and RC features to the embedded clause, then there may be no issue with the linear or temporal metrics for these languages. Instead of predicting SRC difficulty, these metrics would then correctly predict the ORC difficulty since the distance between the null operator and the gap would be greater for ORCs irrespective if the distance was linear, structural or temporal. In Mandarin, however, it is more difficult to resolve the different predictions of these distance-based metrics since interpreting the underlying structure in different ways, introduces new issues for the RC structure. Consequently, the underlying structures for each of these languages still need to be verified in order to better validate models of processing.

### 5.3.3. Similarity-Interference

Similarity-based interference was only partially supported in this study for each language as defined by Gordon et al.'s (2001) and Lewis and Vasishth's (2005) similarity-interference accounts.

Difficulties of interference were primarily seen during later processing measures at the head noun. This would suggest that similarity-interference for the RC argument is not a factor which can explain ORC difficulty. Yet, this should not come as a surprise for prenominal subject-modifying RCs. Since the subject of the matrix clause is not integrated into the subject prior to the first reading of the RC, there is nothing to interfere with or lower the activation level of the RC noun when it is a subject in the ORC condition. For the matrix clause, however, a similarity-based interference account seems more probable. Since the ORC subject is stored prior to the reading of the subject of the head noun which is the subject of the matrix clause sentence, there is interference or a lowering of activation (i.e., proactive interference) for the head noun which makes it more difficult once the matrix clause verb is parsed. Yet, stronger evidence for a similarity-based interference account was not observed. According to Lewis and Vasishth (2005), interference should largely be seen at the locus which initiates the retrieval, which would be the matrix verb in this case. There are three possibilities to explain why the matrix verb did not show ORC difficulty. First and foremost, the ORC difficulty at the head noun was not a result of similarity-interference. This would suggest that similarity-based interference was not an explanatory factor at all; thus, no difficulty should be observed at the predicate in the first place. The second possibility is that similarity-interference, when agreement cues are relatively low, does not induce great difficulty at a predicate. In other words, since the verb only needed to retrieve a grammatical subject, which in most cases also needed to be animate, there is simply not enough interference for difficulties to be observed. The third possibility is that Lewis and Vasishth (2005) were too hasty in rejecting later difficulties for the referent which needs to be retrieved, especially when eye-tracking methods are involved. Since in these experiments, the matrix verb often appeared in ultimate or penultimate locus of the sentence, sentence wrap-up effects may have been masking the observance of similarity-interference. However, the later re-readings of the sentence which primarily focused on the head noun may be reflective of interference effects from the RC noun. In other words, after both the RC noun and head noun were processed and stored into memory, this likely caused comprehension difficulty between these similar NP arguments for the RC predicate argument. As such, Gordon and colleagues' (Gordon et al., 2001; Gordon et al., 2006) account for similarity-interference would seem to be better supported in this regard. Yet, for Gordon's aspect of encoding and storage difficulty, since there was little evidence for early difficulty at the head noun in ORCs, this aspect of similarity-interference was not well supported.

### 5.3.4. The Object-Before-Subject-Bias

Clear effects of the object-before-subject-bias (OBSB) in Japanese and Korean were not observed. While ambiguous RCs in Japanese seemed to support the predicted ORC difficulty at the head noun and RC verb, support for Korean was found in unambiguous RCs which would not likely be subject to OBSB effects. Specifically, while in Japanese late ORC difficulty was found at the RC verb and head noun for ambiguous clauses, this was not the case in Korean. Furthermore, the claim Miyamoto (2016) made about Mandarin not being subject to OBSB effects appears to be accurate. Critically, the results in Mandarin were in direct conflict with this account since early SRC difficulty was observed. Because the results appear inconsistent for all three languages, I argue that while OBSB may contribute some level of difficulty for Japanese and Korean, it does represent the major processing difficulties for ORCs in these languages. Since I strongly believe OBSB to be linked with expectation-based processing, it would be better to test the influence of OBSB in contexts where the subject's thematic role would alter due to the type of object. Yet, such an experiment would not prove the influence of OBSB but rather show the influence of collocation frequencies and the expectations made upon them.

## 5.4. Implications

The major implication from these combined experiments would suggest that expectation and working memory are interconnected processing factors. Moreover, expectation-based processing can be considered as a chief processing factor involved in relative clause processing for prenominal RC, East Asian languages such as Mandarin Chinese, Korean and Japanese, especially when the RC has attenuated ambiguity. For unambiguous RCs, the influence from expectations became stronger and more observable over other effects such as integration. Previously, Levy (2008) had argued that in cases where both expectation and memory should be observable, expectation may not since he considered integration to possibly be a stronger effect. Yet, this appears to be reversible when the RC becomes less ambiguous for these languages. The reasoning for this is that with the expectation for an RC structure, each word in the structure increases the level of activation for it. As such, at a critical region which taps into the frequencies of the language, the more frequent structure would have a higher activation level.

Yet, since expectation-based processing was largely observed at the locus of disambiguation for each language, this would suggest that neither a strictly top-down or bottom-up parsing mechanism were at work initially. There are three possibilities for why RC frequency information was not utilized initially for each language despite other cues, such as case marking or word order, revealing the RC type (e.g., ORC and SRC types). First, ambiguity may not have been attenuated to a level where frequencies could be extracted. Second, for prenominal RC languages, the entire RC may need to be integrated into the structure first. And third, *wh*-operators in the RC need to be integrated with the structure in order to access RC frequencies. The latter account would explain why a language such as English (e.g., Staub, 2010) and Russian (e.g., Levy et al., 2013; Price & Witzel, in press) can be influenced by structural frequencies prior to finishing the RC since the relative pronoun and relativizer comes early. In contrast, for prenominal languages with right-boundary markers, frequencies are not obtainable until these cues are realized and are integrated into the structure which explains why frequencies did not influence the reading of the RC prior to the locus of disambiguation.

The second major implication from this study is that integration metrics may be parametric between languages or that specific metrics are more predominant in a given language due to specific typological features of the language. Following the lines that attachment preferences may be a parametric parsing feature between languages, retrieval processes may be as well. This would explain why Mandarin, an SVO language, supported a linear/temporal metric while Japanese and Korean, SOV languages, supported a structural one. In order to confirm this, other languages which bear the same typological features as Mandarin are needed to be examined.

There is still, however, the possibility that integration/retrieval is not parametric and that only a linear/temporal metric is used. In the previous discussions, it was argued that integration metrics may be parametric between languages. Here, I will speculate that this only appears to be the case. As mentioned in Chapter 1, since the underlying syntactic structure for these languages is debated, it has not proven if a covert *wh*-operator exists in these languages and where in the structure they would appear after moving from the gap position. In terms of the linear/temporal metric, if retrieval of the *wh*-operator is required, this could suggest the existence of the *wh*-operator at a left [Spec, CP] in syntactic hierarchy for Japanese and Korean. Consequently, for the RC argument to be understood correctly, the operator needs to be retrieved to check the *wh*-feature for the CP structure (Chomsky, 1977, 1981, 2015). This would be similar to recent findings which argued for the linking of covert operators for in situ *wh*-operators in Mandarin interrogatives (Xiang et al., 2014; Xiang et al., 2015). If the underlying structure for RCs in Japanese and Korean is approximately (i.e., shown without internal subject movement) $[_{NP} [_{CP} [OP_i [_{IP}\ \mathit{GAP}_i\ [_{VP}\ N\ V]]]]\ N_i]$ and $[_{NP} [_{CP} [OP_i [_{IP}\ N\ [_{VP}\ \mathit{GAP}_i\ V]]]]\ N_i]$ for SRCs and ORCs respectively, then a linear/temporal distance metric would actually predict ORC difficulty. To clarify, this means that the distance critical for retrieval is between the *wh*-operator and the gap and not between the head and the gap. This results in greater distance (i.e., decay) between the operator (i.e., OP) and the gap for ORCs compared to SRCs. Thus, similar to English, both a linear/temporal and structural distance metric predict ORC difficulty. Such an interpretation for a structure like that above would thus solve the issue of the dichotomy in predictions each metric makes for RC processing for those two languages. For Mandarin, in contrast, the relativizer acts as the *wh*-operator without being a relative pronoun, and because of this, the metrics still make diverging predictions for RC difficulties. Since Mandarin appears to support the linear/temporal distance account, Japanese and Korean could likely utilize the same mechanism. The current study cannot prove either account however, and future studies on RC processing and syntax are needed to first clarify the true syntactic representation of RCs in these languages. Consequently, as it stands now, the better interpretation calls for differences in parameters until the syntax is known.

## 5.5. Issues to Address

The current study was not without limitation and of course did not exhaust all possible research on the topic of relative clause processing in prenominal, East Asian languages. In the following sections, several limitations and possible future research topics are addressed.

### 5.5.1. Context and Cues

As argued throughout this dissertation, RC processing behaviour may only be considered as an indication of the context in which it is found. Thus, one notable limitation as defined by this study is that the experiments used highly contextualized RCs. Consequently, the processing outcomes for these RCs may be limited to these specific contexts using ambiguous and unambiguous RCs.

In English, for instance, it was found that if RCs were situated in natural discourse, ORCs became no more difficult to process than SRCs (Roland et al., 2012). Yet, in terms of providing discourse for prenominal RCs, it was already discussed that it introduced new confounds in Mandarin RC processing (e.g., Lin, 2014) such that the ORC advantage could be interpreted as a thematic priming effect, rather than an indication of a linear integration/retrieval metric as Gibson and Wu (2013) argued. A recent example of discourse used in Japanese comes from Miyamoto (2016; Miyamoto & Tsujino, 2016). In this experiment, both self-paced reading and discourse were used to investigate RC processing in Japanese by L1 speakers. It was found that there was marked ORC difficulty at the spillover region to the head noun which happened to be the matrix predicate (specifically, a Japanese copula). Since ORCs were found to be more difficult in unambiguous contexts, Miyamoto (2016; Miyamoto & Tsujino, 2016) claimed that this finding supports his OBSB account. While I do not discredit the use of discourse priming as it more than likely allowed for a correct RC interpretation, I am not convinced that the effects were purely attributable to OBSB. Instead, expectation-based processing could still explain ORC difficulty following the framework above that frequencies are not accessed until a viable cue for RCs is processed. Or, if the effect was not spillover and truly occurred at the matrix verb, then this would support Gordon's similarity-based interference (Gordon et al., 2001) and Lewis and Vasishth's (2005) cue-based retrieval account since both would predict greater difficulty for ORCs in this context at that position. Consequently, the approach used in that study, while being able to show ORC difficulty, appeared to have minor design flaws that too allowed for multiple valid interpretations. In all, I do not believe that discourse methods should be avoided, but importantly, careful consideration is required for techniques using discourse priming to attenuate the ambiguity and make ORCs more natural in context just like any other method. Certainly, future studies should investigate RC processing using RCs within a larger, more natural discourse to discover if ORCs are typically more difficult due to the less than natural experimental contexts in which participants read or listen to RCs.

An additional context issue of this study was that the clause-type ambiguity effect was primarily addressed as an issue for relative clauses in each of these languages. However, clause-type ambiguity exists for the other clause-types which bear a similar surface structure to RCs (i.e., complement clauses). The issue here is that subject/object asymmetry may not be limited just to RCs and likely applies to the other clause-types as well. In Mandarin, Korean and Japanese, subject and object dropping is permitted, but subject-drop is much more frequent. In these cases, instead of a gapped interpretation, which resulted from a syntactic movement, the NP drop would instead leave a null pronominal interpretation within the complement clause. Owing to this, these structures can appear identical on the surface to RCs. Thus, it should be questioned if embedded clauses with object drop (i.e., similar to ORCs) are more difficult to process and comprehend than clauses with subject drop (i.e., similar to SRCs). Actually, Kwon (2008) has already revealed that in Korean, other embedded clauses which lack an overt object are more difficult to parse at the head noun in comparison to those which lack an overt subject. This finding would suggest that in the case of Korean, expectation-based processing is chiefly responsible for the subject/object asymmetry since there is (1) nothing to integrate with at the head for non-RC clauses (e.g., fact, thing, time), (2) there are no issues with thematic assignment since the head would not be responsible for the thematic assignment of the NPs contained within the embedded clause, and (3) there is no issue with similarity-interference since the head is distinctively dissimilar to an NP. While there is some evidence for this in Korean, there is a current poverty in empirical research in Japanese exploring the processing of complement clauses in contexts which make them appear initially identical to RCs, and certainly, more research can be done in Mandarin on this topic as well. Since the frequencies for all three of these languages show that clauses with non-overt objects (i.e., pro-drop objects or gaps) are less frequent, then expectation-based processing would support a general subject/object asymmetry in processing regardless of clause structure.

### 5.5.2. Working Memory in Japanese

While there was concrete evidence for the integration/retrieval mechanism having an effect on reading behaviour in Mandarin and Korean (despite being opposite), there was still a lack of critical evidence in Japanese since too many processing factors would correctly predict ORC difficulty at the head noun (Chapter 4).

Though Ueno and Garnsey (2008) have shown detailed evidence for a structural-phrase hierarchy integration metric in Japanese using ERP which was consistent with previous English findings (e.g., Kaan, Harris, Gibson, & Holcomb, 2000), their increased P600 finding in ORCs could have still represented other processing factors rather than integration. For instance, P600 effects have also been observed in instances of structural ambiguity (Frisch, Schlesewsky, Saddy, Alpermann, 2002). Since Ueno and Garnsey (2008) used an ambiguous context design and a moving-window task design, there is a possibility that the P600 was more representative of a garden path effect rather than integration. Furthermore, in a window-moving task, Miyamoto's (2016) claim that early-closure occurs at the RC verb seems more applicable since participants would not be able to re-read the clause. Thus, when reading the head noun, a garden path effect will be present rather than retrieving a gap from working memory as there is a chance the RC was purged. For Japanese RC processing, the garden path effect, expectation-based processing, similarity-based interference, object-before-subject-bias, and integration may all be contributing to the ORC difficulty found at the head noun, but it is simply too difficult to ascertain each factor's validity. Though Ueno and Garnsey's (2008) pattern of results were more or less consistent with English and Korean (Kwon et al., 2013), there is still the chance that their P600 was entirely or partially reflective of another processing account as mentioned previously. To show that filler-gap parsing occurred at the head noun, other methods or contexts may be needed.

In the current study, when using ambiguous RCs, only a general, overall ORC difficulty was found at the head noun in Japanese. It was claimed that by attenuating ambiguity, expectation-based processing observations could be better observed at the head noun. Even then, however, filler-gap processing still could have had some effect on the overall processing difficulties at the head noun. Consequently, investigations are needed to determine if working memory is involved at the head noun in Japanese for both ambiguous and unambiguous cases.

The simplest way to test this would to be to measure participants' working memory capacity (WMC) and access whether or not WMC is an explanatory factor of processing at the head noun. Simply, participants could partake in an *n-back* test (Kirchner, 1958) or a *digit-span* test (e.g., de Beni, Palladino, Pazzaglia, & Cornoldi, 1998) for example, both of which would measure participants' WMC. Participants could either be classified into groups of high and low WMC, as it is commonly done, or WMC can be classified as a continuous variable.

Another possible way to test whether or not integration accounts for ORC difficulty at the head noun is to use post-RC cues which would separate the head noun and RC. For example, Arai (2017) used post-RC cues to eliminate the simple clause interpretation for the RC. See below for examples used by Arai (2017, p.131).

(5.3) Adjective-HEAD
理系の大学院生を国際学会で厳しく非難した意地悪な研究者は足早に去った。
*rikei-no daigakuinsei-o kokusaigakkai-de kibshiku hinanshita ijiwaruna kenkusha-ha ashibaya-ni satta*
science-GEN graduate.student-ACC/NOM international.conference severely criticized mean researcher quickly left
'The mean researcher who harshly criticized the science graduate student at the international conference quickly left.'

(5.4) Genitive-HEAD
理系の大学院生を国際学会で厳しく非難した風力発電の研究者は足早に去った。
*rikei-no daigakuinsei-o kokusaigakkai-de kibshiku hinanshita huuryokuhatsuden-no kenkusha-ha ashibaya-ni satta*
science-GEN graduate.student-ACC/NOM international.conference severely criticized wind.energy-GEN researcher quickly left
'The wind energy researcher who harshly criticized the science graduate student at the international conference quickly left.'

Using the adjective and genitive cues, Arai (2017) argued that between SRCs the genitive cue condition would be unnatural and difficult to interpret as a head whereas in the adjective cue condition, it would be easier to interpret some sort of head being modified by the RC at the adjective. Arai's (2017) results revealed that at the cue locus, there was a difference between RCs for the adjective condition but not for the genitive cue condition while ORC difficulty was found at the head noun for both cue conditions. My interpretation of his findings is that in the adjective cue condition, an RC interpretation can be made thus causing a surprisal effect (Levy, 2008) for the less frequent ORCs. In the genitive case, while difficult overall, an RC interpretation was not readable at the cue thus leaving some uncertainty in the overall structure or how the clause should be interpreted. Accordingly, when the context includes an adjective, the locus of disambiguation was shifted to the cue rather than the head noun. Interestingly, this introduces other important implications for the processing at the head noun. This would make the structure similar to Korean in regards to the locus of disambiguation and integration no longer occurring at the same locus. In Arai's (2017) research, he revealed ORC difficulty at both loci. While his claimed that expectation-based processing accounted for the data at both loci, something I do not disagree with, I assert that the effects at the head noun better represent integration effects. Since the clause would be disambiguated at the adjective, there should no longer be any surprisal at the head noun for the ORC structure. Thus, the difficulty at the head noun would be attributed to the integration of the filler with its gap. Arai, however, has not yet explored integration as an account for processing difficulty at the head noun in the above contexts. In order to determine whether integration was the chief factor at the head noun in Arai's investigation (2017), further research is needed on the comparison in processing at the head noun between contexts with pre-RC cues (i.e., the current study) with post-RC cues (Arai, 2017). It is my prediction that pre-RC cues would enhance the expectation-based account at the head noun as I argued for the experiment dealing with Japanese. For post-RC cues, on the other hand, integration will be shown as the chief processing factor at the head noun while the effects of expectation will be found at the new locus of disambiguation. The measure to investigate this will again be WMC. Working memory capacity, while a factor at the head in both cases, should be a stronger predictor for processing when post-RC cues are used since other effects such as expectation should no longer present at the head noun.

### 5.5.3. Internally-Headed Relative Clauses

In this study, while internally-headed relative clauses (IHRC) were briefly mentioned for Korean and Japanese (IHRCs do not exist in Mandarin but do exist in Cantonese), they were excluded from the study. The main reasons why IHRCs were excluded was that their overall structure is still controversial and that they do not exist in Mandarin; thus, a comparison between the three languages would not have been feasible. While it is more or less agreed upon that the nominalizer (-*kes* in Korean & -*no* in Japanese) relates to the head back within the RC, it is unclear whether the nominalizer is only linked by semantics or if there is syntactic binding (the more controversial proposal). Since it is not the aim of the study to solve the structure of IHRCs, I will assume that the nominalizer is semantically related to the head noun. Such an account usually assumes that the nominalizer is an E-type pronoun anaphora (Shimoyama, 1999), e.g., "donkey sentences": [Every farmer [$_{RC}$ who buys a donkey] beats it.]. See below for an example of the typical EHRC and its IRHC counterpart.

(5) Externally-Headed Relative Clause in Japanese (EHRC)
太郎は走って来た花子を捕まえた。
[*Taro-ha* [*gap*$_i$ *hashittekita*] *Hanako*$_i$*-o tsukamaeta*.]
Taro-TOP came.running Hanako-ACC caught
'Taro caught Hanako who came running.'

(6) Internally-headed Relative Clause in Japanese (IHRC)
太郎は花子が走って来たのを捕まえた。
[*Taro-ha* [*Hanako-ga hashittekita*] *no-o tsukamaeta*.]
Taro-TOP Hanako-NOM came.running NO-ACC caught
'Taro caught Hanako who came running.'

For Japanese and Korean RCs, only a metric based upon a search through syntactic-hierarchy (O'Grady, 1997) has been supported since the underlying syntactic structure has not been confirmed, and metrics based on linear- (Gibson, 2000) and temporal-distance (Lewis & Vasishth, 2005) were not supported as they would have resulted in SRC difficulty instead. As such, investigating IHRCs will allow for a better understanding of the overall integration mechanism used by Japanese speakers and if it differs between structures. In other words, despite the nominalizer and the internal-head not being linked by syntactic means in IHRCs, it is still unclear whether or not if the integration/retrieval search follows a structural or linear/temporal path. The former would implicate that Japanese has a singular integration/retrieval mechanism which differs from other languages which follow the linear/temporal metric (e.g., Mandarin Chinese). The latter, however, would suggest that for syntactically bound referents in Japanese, a structural search is required, but when only the overall semantics of a referent is needed, the search metric will change to a linear/temporal metric. Such a result would support the above inclinations that although the parser for any language can utilize both retrieval metrics, the usage of these parsing metrics are largely dependent on the overall frequency of the applied interpretation in a specific context or structure in order for the parser to become more economical.

### 5.5.4. Issues in Syntactic Structure

As previously mentioned, the underlying structure for RCs in each language is still being debated (e.g., Bugaeva & Whitman, 2016). However, if I consider that integration does only follow a linear/temporal metric (Gibson, 2000; Lewis & Vasishth, 2005) and disregard the structural-phrase metric (O'Grady, 1997), then there seems to be an issue with integration/retrieval models not supporting the data for Japanese and Korean RC processing. This is due to the linear/temporal metric predicting SRC difficulty which was clearly not observed for Japanese and Korean RC processing at the head noun. Yet, if I assume that the structure does involve A-bar movement of a *wh*-operator, even if it is covert movement, then the data would actually be consistent with the predictions made by all the distance-based decay metrics. Importantly, the syntactic movement of the covert *wh-operator* would involve A-bar movement to the left edge of the RC boundary in Spec-CP to assign *wh*-features for the embedded clause (Chomsky, 1977, 1981, 2015). Thus, when processing the head noun, the *wh*-operator first needs to be retrieved from memory to link back with its gap where the co-indexed head noun would receive its grammatical role for the RC. Interpreting Korean and Japanese in this fashion would help forward our understanding of the overall structure of RCs and would help forward the understanding of integration/retrieval metrics. Nonetheless, at the given time it is difficult to claim with any degree of certainty that this account is valid though. Future studies on RC processing in Japanese may help clarify this issue of uncertainty in syntax. For example, if there is truly no movement in syntax, then the distance between the left edge of the RC and the head noun should not result in greater processing demands at the head noun. In other words, adding an adjunct phrase intervening between the left edge of the RC and the gap position would not increase difficulty. This is because if there is no movement to left [Spec, CP], then increasing the distance at this position would not matter since the head noun would have to integrate directly with the gap position. On the other hand, if intervening adjunct phrases between the RC subject and left edge does increase processing difficulty at the head noun, then this would suggest that there was greater decay in the activation of the operator residing at left [Spec, CP]. It is important to note that for the linear/temporal metric to be supported, the operator does not move to right [Spec, CP] since the distance would be the same in such a case. For other accounts which argue against movement, processing difficulty would not change at the head noun since the distance would also be the same.

The existence of null *wh*-operators in Japanese and Korean would further explain why frequencies were underutilized prior to the reading of the locus of disambiguation. Considering that these operators would be covert and not exist on the surface structure, the parser would have to wait for another cue which could probe and activate it. In this study, the cues for Japanese and Korean were the head noun and RC verb with the adnominal marker respectively which happened to be the locus of disambiguation for ambiguous contexts. Similarly in Mandarin, the relativizer appears at the right edge of the clause, so frequencies are also unable to be extracted until then.

Moving to Mandarin, if the relativizer acts as the *wh*-operator and exists in deep structure at the gap position, then this would provide strong evidence for linear (Gibson, 2000) and temporal (Lewis & Vasishth, 2005) metrics of integration. While the data appears to be consistent with this interpretation of Mandarin's syntax within the framework of anti-symmetry and head-raising/promotion (Kayne, 1994), researchers still have not agreed on a singular structure for RCs in Mandarin (c.f., Huang et al., 2009; Lin, 2006; Wu, 2000). If the structure differs from the one assumed here, then the results would become inconsistent again. For instance, if I consider that Mandarin has covert *wh*-operator movement as well, then the linear/temporal metric no longer predicts SRC difficulty as laid out by the propositions listed above for Japanese and Korean.

Consequently, studies in both syntax and processing are needed to identify and validate RC structures in these prenominal, East Asian languages before any resolution on the issues of sentence processing becomes possible.

# CHAPTER 6

# Conclusion

## 6.1. Concluding Remarks

The current study addressed the issue of ambiguity for relative clause (RC) processing in Mandarin Chinese, Korean and Japanese. Particularly, the study investigated whether the processing of the initial clause-type ambiguity found within ambiguous RCs (i.e., initial garden path effect for a simple sentence) was an influential factor for the processing in these prenominal RC, East Asian languages. The comparison between ambiguous and unambiguous RCs for each language was intended to reveal which processing mechanisms are chiefly responsible for the difficulties associated with the processing and comprehension of object-extracted relative clauses (ORC) in comparison to subject-extracted relative clauses (SRC). Additionally, this design also investigated how major processing factors interacted at specific loci in the sentence as an influence of ambiguity. The overall finding, common between languages, was that expectation-based processing chiefly accounted for ORC difficulties. In addition to this finding, it was observed that expectation-based processing first came to influence processing once the structure had been completely parsed. The implications of this finding suggests that even for clause contexts with attenuated ambiguity (or even possibly, completely unambiguous), the structural frequencies for RCs in each language are not tapped into until the clause has been completed. Accordingly, even within attenuated ambiguity, in order to receive the particular frequency information, the complete clause structure or a certain RC cue is needed for prenominal languages. This would explain why earlier points in the sentence which could disambiguate clause-type did not reveal effects of surprisal, i.e., the initial NP-VP/VP-NP order in Mandarin and the case morphology of the RC noun for both Korean and Japanese. Thus, this information which does distinguish between ORCs and SRCs is not enough for the parser to extract structural frequencies. Instead, that is reserved for the locus of disambiguation for each language. While unambiguous RCs supported expectation-based processing at the disambiguating point similar to ambiguous RCs, there was still nevertheless an effect of ambiguity in Mandarin and Japanese; less so for Korean. For both Mandarin and Japanese, unambiguous RCs allowed for stronger effects of expectation-based processing earlier on than for ambiguous RCs. In Korean, on the other hand, little change in processing was observed between ambiguity contexts. The probable explanation here is that Mandarin and Japanese share a particular typological feature which would be subject to ambiguity. Specifically for these languages, the locus of disambiguation can also be a locus of integration. In Korean, however, these two processes occur at different loci in the sentence. Thus, for Korean in this subject-modifying context, attenuating the clause-type ambiguity would not alter the reading behaviour in a meaningful way since the only effect possible at the locus of disambiguation is expectation-based processing. In contrast, Mandarin and Japanese have altered reading behaviour since increased expectation for an RC structure would allow for expectation-based processing effects to give a clearer effect at the locus which is also subject to other factors such as integration. In conclusion, RC processing in general should be considered as a highly interactive network of top-down and bottom-up processes. For East Asian languages in particular (i.e., Mandarin Chinese, Korean, and Japanese), ambiguity is also an interactive factor for a given locus responsible for multiple processing mechanisms.

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# List of Appendixes

# Appendix Chapter 2

## Experimental Stimuli

### Experiment 1

The following sentences are all the ORC experimental items from Experiment 1. The SRC sentence condition is given only for the first item. The interest regions are designated between asterisk marks: N1 V1 (the RC noun and RC verb), DE (the relativizer), N2 (the head noun), ADV (the adverb), V2 (the matrix verb).

1. ORC: *李芳邀请*的*梁媛*刚才*迟到了*
*Li Fāng yāoqǐng de Liáng Yuán gāngcái chídàole*
Li Fang invited REL Liang Yuan just late
'LiangYuan who LiFang invited was late just now.'

1. SRC: *邀请李芳*的*梁媛*刚才*迟到了*
*yāoqǐng Li Fāng de Liáng Yuán gāngcái chídàole*
invited Li Fang REL Liang Yuan just late
'LiangYuan who invited LiFang was late just now.'

2. *王磊联系*的*张艳*刚才*进门了*
*WángLěi liánxì de Zhāng Yàn gāngcái jìnménle*
Wang Lei contact REL Zhang Yan just entered
'Zhang Yan who Wang Lei contacted just entered the door.'

3. *王艳走访*的*王伟*前天*参赛了*
*Wáng Yàn zǒufǎng de Wáng Wěi qiántiān cānsàile*
Wang Yan visited REL Wang Wei day.before.yesterday entered.competition
'Wang Wei who Wang Yan visited entered the competition the day before yesterday.'

4. *张伟勾结*的*李强*去年*入狱了*
*Zhāng Wěi gōujié de Lǐ Qiáng qùnián rùyùle*
Zhang Wei conspired REL Li Qiang last.year jailed
'LiQiang who ZhangWei conspired with went to jail last year.'

5. *杨敏辅导*的*杨昊*今天*就任了*
*Yáng Mǐn fǔdǎo de Yáng Hào jīntiān jiùrènle*
Yang Min mentor REL Yang Hao today inducted
'Yang Hao who Yang Min mentored was inducted today.'

6. *王强关注*的*王洁*上周*获胜了*
*Wáng Qiáng guānzhù de Wáng Jié shàngzhōu huòshèngle*
Wang Qiang follow.with.interest REL Wang Jie last.week won
'Wang Jie who Wang Qiang follows with interest won last week.'

7. *王霞拥护*的*马超*今天*下台了*
*Wáng Xiá yōnghù de Mǎ Chāo jīntiān xiàtáile*
Wang Xia supports REL Ma Chao today resigned
'Ma Chao who Wang Xia supports resigned today.'

8. *李丽抢救*的*罗英*前天*牺牲了*
*Lǐ Lì qiǎngjiù de Luó Yīng qiántiān xīshēngle*
Li Li saved REL Luo Ying day.before.yesterday sacrificed
'Luo Ying who Li Li saved sacrificed his life the day before yesterday.'

9. *李昊寻找*的*王刚*已经*逝世了*
*Lǐ Hào xúnzhǎo de Wáng Gāng yǐjīng shìshìle*
Li Hao search REL Wang Gang already passed.away
'Wang Gang who Li Hao is searching for has passed away already.'

10. *王军关心*的*李婧*去年*结婚了*
*Wáng Jūn guānxīn de Lǐ Jìng qùnián jiéhūnle*
Wang Jun cares.about REL Li Jing last year married
'Li Jing who Wang Jun cares about married last year.'

11. *王芳推荐*的*张强*刚才*上台了*
*Wáng Fāng tuījiàn de Zhāng Qiáng gāngcái shàngtáile*
Wang Fang recommended REL Zhang Qiang just.now appear.on.stage
'Zhang Qiang who Wang Fang recommended appeared on the stage just now.'

12. *李明聘请*的*刘梦*去年*转行了*
*Lǐ Míng pìnqǐng de Liú Mèng qùnián zhuǎnhángle*
Li Ming hired REL Liu Meng last.year switched.profession
'Liu Meng who Li Ming hired switched to another profession last year.'

13. *王茜提及*的*李明*去年*搬家了*
*Wáng Qiàn tíjí de Lǐ Míng qùnián bānjiāle*
Wang Qian mentioned REL Li Ming last.year moved
'Li Ming who Wang Qian mentioned moved last year.'

14. *李艳采访*的*王丽*昨天*自杀了*
*Lǐ Yàn cǎifǎng de Wáng Lì zuótiān zìshāle*
Li Yan interviewed REL Wang Li yesterday committed.suicide
'Wang Li who Li Yan interviewed committed suicide yesterday.'

15. *李明资助*的*刘洋*去年*破产了*
*Lǐ Míng zīzhù de Liú Yáng qùnián pòchǎnle*
Li Ming funded REL Liu Yang last.year bankrupted
'Liu Yang who Li Ming funded went bankrupt last year.'

16. *周婕提拔*的*张梦*上周*违纪了*
Zhōu Jié tíbá de Zhāng Mèng shàngzhōu wéijìle
Zhou Jie promoted REL Zhang Meng last.week broke.rules
'Zhang Meng who Zhou Jie promoted broke the rules last week.'

17. *张杰负责*的*刘鹏*去年*辞职了*
*Zhāng Jié fùzé de Liú Péng qùnián cízhíle*
Zhang Jie in.charge.of REL Liu Peng last.year resigned
'Liu Peng who Zhang Jie was in charge of resigned last year.'

18. *王静录用*的*李莲*今天*加班了*
*Wáng Jìng lùyòng de Lǐ Lián jīntiān jiābānle*
Wang Jing employed REL Li Lian today worked.overtime
'Li Lian who Wang Jing employed worked overtime today.'

19. *王静信任*的*李涛*今天*缺席了*
*Wáng Jìng xìnrèn de Lǐ Tāo jīntiān quēxíle*
Wang Jing trust REL Li Tao today absent
'Li Tao who Wang Jing trusts is absent today.'

20. *王阳培养*的*周洁*去年*掌权了*
*Wáng Yáng péiyǎng de Zhōu Jié qùnián zhǎngquánle*
Wang Yang mentored REL Zhou Jie last.year in.power
'Zhou Jie who Wang Yang mentored came into power last year.'

21. *刘刚思念*的*高军*昨天*生病了*
*Liú Gāng sīniàn de Gāo Jūn zuótiān shēngbìngle*
Liu Gang missed REL Gao Jun yesterday sick
'Gao Jun who Liu Gang missed was sick yesterday.'

22. *张涛招待*的*李艳*去年*退休了*
*Zhāng Tāo zhāodài de Li Yàn qùnián tuìxiūle*
Zhang Tao entertained REL Li Yan last.year retired
'Li Yan who Zhang Tao entertained retired last year.'

23. *周超指导*的*李勇*刚才*出事了*
*Zhōu Chāo zhǐdǎo de Lǐ Yǒng gāngcái chūshìle*
Zhou Chao tutored REL Li Yong just.now accident
'Li Yong who Zhou Chao tutored had an accident just now.'
'Something bad happened to Li Yong who Zhou Chao tutored just now.'

24. *王芳栽培*的*张静*上周*去世了*
*Wáng Fāng zāipéi de Zhāng Jìng shàngzhōu qùshìle*
Wang Fang mentored REL Zhang Jing last.week died.
'Zhang Jing who Wang Fang mentored died last week.'

25. *王娟支持*的*李勇*昨天*获奖了*
*Wáng Juān zhīchí de Lǐ Yǒng zuótiān huòjiǎngle*
Wang Juan support REL Li Yong yesterday won.award
'Li Yong who Wang Juan supports won an award yesterday.'

26. *张超宴请*的*王婕*刚才*道歉了*
*Zhāng Chāo yànqǐng de Wáng Jié gāngcái dàoqiànle*
Zhang Chao entertained REL Wang Jie just.now apologized
'Wang Jie who Zhang Chao entertained apologized just now.'

27. *张静逮捕*的*李鹏*那天*受伤了*
*Zhāng Jìng dàibǔ de Lǐ Péng nàtiān shòushāngle*
Zhang Jing arrested REL Li Peng that.day injured
'Li Peng who Zhang Jing arrested was injured that day.'

28. *刘杰赏识*的*高燕*最终*受骗了*
*Liú Jié shǎngshí de Gāo Yàn zuìzhōng shòupiànle*
Liu Jie admire REL Gao Yan eventually deceived.
'Gao Yan who Liu Jie admires was deceived eventually.'

29. *王强培育*的*张勇*今年*创业了*
*Wáng Qiáng péiyù de Zhāng Yǒng jīnnián chuàngyèle*
Wang Qiang mentored REL Zhang Yong this.year started.business
'Zhang Yong who Wang Qiang mentored started a business this year.'

30. *王静照顾*的*李娜*上周*捐款了*
*Wáng Jìng zhàogù de Lǐ Nà shàngzhōu juānkuǎnle*
Wang Jing take.care REL Li Na last.week made.donation
'Li Na who Wang Jing takes care of made a donation last week.'

31. *王猛服务*的*李刚*今年*入选了*
*Wáng Měng fúwù de Lǐ Gāng jīnnián rùxuǎnle*
Wang Meng served REL LI Gang this.year selected
'Li Gang who Wang Meng served was selected this year.'

32. *李茜担心*的*陈倩*今天*住院了*
*Lǐ Qiàn dānxīn de Chén Qiàn jīntiān zhùyuànle*
Li Qian worried.about REL Chen Qian today hospitalized
'Chen Qian who Li Qian worried about is in the hospital today.'

## Experiment 2

The following sentences are all the ORC experimental items from Experiment 2. The SRC sentence condition is given only for the first item. For the unambiguous condition, the determiner + classifier region which is the first region for all of the sentences was removed. The interest regions are designated between asterisk marks: Det+Cl (the pre-RC determiner and classifier), ADV (the temporal adverb), N1 V1 (the RC noun and RC verb), Freq (the frequency phrase), DE (the relativizer), N2 (the head noun), V2 (the matrix verb), N3 (the matrix object), and the remainder of the sentence.

1. ORC: *那个*昨晚*服务生揍了*一顿*的*顾客*听说过*老板*并且记得他。*
*nàgè zuówǎn fúwùshēng zòule yī dùn de gùkè tīngshuōguò lǎobǎn bìngqiě jìde tā*
that.one last.night waiter beat more.than.once REL customer have heard of boss and remember him
'The customer who the waiter beat up last night has heard of the boss and remembers him.'
1. SRC: *那个*昨晚*揍了服务生*一顿*的*顾客*听说过*老板*并且记得他。*
*nàgè zuówǎn zòule fúwùshēng yī dùn de gùkè tīngshuōguò lǎobǎn bìngqiě jìde tā*
that.one last.night beat waiter more.than.once REL customer have.heard.of boss and remember him
'The customer who beat up the waiter last night has heard of the boss and remembers him.'
2. *那辆*下午*摩托车追了*很久*的*轿车*发现了*记者*所以停了下来。*
*nàliàng xiàwǔ mótuōchē zhuīle hěnjiǔ de jiàochē fāxiànle jìzhě suǒyǐ tíngle xiàlái*
that.car afternoon motorcycle chased long.time REL car found reporter so stopped
'The car that the motorcycle chased for a long time in the afternoon found the reporter so it stopped.'
3. *那个*今天*男孩打了*几次*的*女孩*看到了*校长*所以假装读书。*
*nàgè jīntiān nánhái dǎle jǐcì de nǚhái kàndàole xiàozhǎng suǒyǐ jiǎzhuāng dúshū*
that.one today boy hit several.times REL girl saw principal so pretended to read
'The girl who the boy hit several times today saw the principal and thus pretended to read.'
4. *那辆*当时*自行车撞了*两次*的*吉普车*拦住了*警察*并且要求调查清楚。*
*nàliàng dāngshí zìxíngchē zhuàngle liǎngcì de jípǔchē lánzhùle jǐngchá bìngqiě yāoqiú diàochá qīngchu*
that.car then bike hit twice REL jeep stopped police and asked investigation clear
'The jeep that the bike hit twice then stopped the police and asked for a clear investigation.'
5. *那个*刚才*男孩推了*一下*的*妇女*偷了*店员*并且打伤了她。*
*nàgè gāngcái nánhái tuīle yīxià de fùnǚ tōule diànyuán bìngqiě dǎshāngle tā*
that.one just.now boy pushed a.bit REL woman stole clerk and wounded her
'The woman who the boy pushed just now stole from the clerk and wounded her.'
6. *那个*上个月*男孩邀请了*几次*的*女孩*认识*王老师*因为上过她的课。*
*nàgè shànggèyuè nánhái yāoqǐngle jǐcì de nǚhái rènshi wánglǎoshī yīnwèi shàngguò tā de kè*
that.one last.month boy invited several.times REL girl knows teacher.WANG because went to her class
'That girl who the boy invited several times last month knows teacher Wong because she went to her class.'
7. *那条*去年*主人救了*好几次*的*狗*喜欢*小男孩*所以很兴奋。*
*nàtiáo qùnián zhǔrén jiùle hǎojǐcì de gǒu xǐhuan xiǎonánhái suǒyǐ hěn xīngfèn*
that.animal last.year master saved several.times REL dog like little.boy so it be very excited
'The dog that the master saved several times last year likes the little boy so it was very excited.'

8. *那个*刚才*职业选手推了*一下*的*业余选手*骂了*裁判*而且威胁了他。*
*nàgè gāngcái zhíyè xuǎnshǒu tuīle yīxià de yèyú xuǎnshǒu màle cáipàn érqiě wēixiéle tā*
that.one just.now professional.player pushed a.bit REL amateur scolded referee and threatened him
'The amateur who the professional player pushed a bit just now scolded the referee and threatened him.'
9. *这个*上个月*杀手监视了*一段时间*的*侦探*讨厌*当地人*所以没有寻求帮助。*
*zhège shànggèyuè shāshǒu jiānshìle yīduàn shíjiān de zhēntàn tǎoyàn dāngdìrén suǒyǐ méiyǒu xúnqiú bāngzhù*
this.one last.month killer watched a.while REL detective hated local so did.not ask for help
'The detective who the killer watched for a while last month hated the locals so he did not ask for help.'
10. *那位*最近*房东抱怨了*好多次*的*住户*找了*律师*而且打算*起诉。*
*nàwèi zuìjìn fángdōng bàoyuànle hǎoduōcì de zhùhù zhǎole lǜshī érqiě dǎsuàn qǐsù*
that.person recently landlord complained many.times REL tenant found lawyer and intended sue
'The tenant who the landlord complained about many times recently found a lawyer and intends to sue.'
11. *那个*上个月*教练骂了*一顿*的*球员*爱上了*女歌星*还送她礼物。*
*nàgè shànggèyuè jiàoliàn màle yīdùn de qiúyuán àishàngle nǚ gēxīng hái sòng tā lǐwù*
that.one last.month coach scolded more.than.once REL player fell.love.with female singer and sent her gift
'The player who the coach scolded last month fell in love with a female singer and sent her a gift.'
12. *那位*以前*指挥家崇拜了*很久*的*作曲家*结识了*小提琴手*并且两人常见面。*
*nàwèi yǐqián zhǐhuījiā chóngbàile hěnjiǔ de zuòqǔjiā jiéshìle xiǎotíqínshǒu bìngqiě liǎng rén cháng jiànmiàn*
that.person before conductor respected long.time REL composer met violinist and both meet often
'The composer who the conductor respected for a long time in the past met a violinist and they meet often.'
13. *这个*去年*电视台批评了*几次*的*女演员*很欣赏*金城武*因为他个性坦率。*
*zhège qùnián diànshìtái pīpíngle jǐcì de nǚ yǎnyuán hěn xīnshǎng jīnchéngwǔ yīnwèi tā gèxìng tǎnshuài*
this.one last.year TV.station criticized several.times REL actress very.appreciate Jincheng Wu because his frank personality
'This actress who the TV station criticized several times last year appreciates Jincheng Wu very much because of his frank personality.'
14. *那位*上个月*飞行员约了*两次*的*空姐*惹怒了*经理*因为她常迟到。*
*nàwèi shànggèyuè fēixíngyuán yuēle liǎngcì de kōngjiě rěnùle jīnglǐ yīnwèi tā cháng chídào*
that.person last.month pilot ask out twice REL stewardess angered manager because she often late
'The stewardess who the pilot asked out twice last month angered the manger because she was often late.'
15. *这位*今天*导演称赞了*多次*的*男明星*批评了*影评家*并且表示很难过。*
*zhèwèi jīntiān dǎoyǎn chēngzànle duōcì de nán míngxīng pīpíngle yǐngpíngjiā bìngqiě biǎoshì hěn nánguò*
this.one today director praised many.times REL male star criticized critics and said he was very sad
'The male star who the director praised many times today criticized the critics and said he was very sad.'
16. *那位*昨天*作家采访了*两个小时*的*记者*质疑了*县长候选人*而且扬言报复。*

*nàwèi zuótiān zuòjiā cǎifǎngle liǎng gè xiǎoshí de jìzhě zhíyíle xiàn zhǎng hòuxuǎnrén érqiě yángyán bàofù*
that.person yesterday writer interviewed two.hours REL reporter questioned county.magistrate candidate and threatened revenge
'The reporter who the writer interviewed for two hours yesterday questioned the county magistrate candidate and threatened revenge'
17. *那个*今早*犯人追了*一阵*的*小狗*嗅出*主人*并且停了下来。*
*nàgè jīnzǎo fànrén zhuīle yīzhèn de xiǎo gǒu xiùchū zhǔrén bìngqiě tíngle xiàlái*
that.one this.morning criminal chased a.while REL puppy sniffed.recognize the master and stopped
'The puppy who the prisoner chased a while this morning sniffed and recognized the mater and stopped.'
18. *那位*昨天*邻居教训了*一番*的*大妈*通知*管理员*然后诉了苦。*
*nàwèi zuótiān línjū jiàoxunle yī fān de dàmā tōngzhī guǎnlǐ yuán ránhòu sule kǔ*
that.person yesterday neighbor taught for.a.while REL aunt noticed administrator and complained
'The aunt who the neighbor taught a lesson yesterday noticed the administrator and complained.'
19. *这位*去年*外交部访问了*一次*的*政治家*支持*外交官*并且相信他。*
*zhèwèi qùnián wàijiāobù fǎngwènle yīcì de zhèngzhì jiā zhīchí wàijiāoguān bìngqiě xiāngxìn tā*
this.person last.year ministry.foreign.affairs visited once REL politician support diplomat and believed him.
'This politician who the Ministry of Foreign Affairs visited once last year supports the diplomat and believes him.'
20. *那个*今年*作家批评了*一番*的*评论家*洽询了*出版商*而且建议了出版内容。*
*nàgè jīnnián zuòjiā pīpíngle yīfān de pínglùnjiā qiàxúnle chūbǎnshāng érqiě jiànyìle chūbǎn nèiróng*
that.one this.year writer criticized for.a.while REL critic consulted publisher and suggested publication.content
'The critic who the writer criticized for a while this year consulted the publisher and suggested the content for publication.'
21. *那位*下午*学生称赞了*多次*的*老师*认出*家长*然后打招呼。*
*nàwèi xiàwǔ xuéshēng chēngzànle duōcì de lǎoshī rènchū jiāzhǎng ránhòu dǎzhāohū*
that.person afternoon student praised several.times REL teacher recognized parents and.then greeted
'The teacher who the student praised several times this afternoon recognized the parents and greeted them.'
22. *那位*上周*护士请教了*一次*的*营养师*看了*医生*而且确定病征。*
*nàwèi shàngzhōu hùshì qǐngjiàole yīcì de yíngyǎngshī kànle yīshēng érqiě quèdìng bìngzhēng*
that.person last.week nurse consulted once REL nutritionist went.to.see doctor and identified symptoms
'That nutritionist who the nurse consulted once last week went to see a doctor and identified symptoms.'
23.*这位*上个月*新同事介绍了*几次*的*员工*说服过*上司*然后转了部门。*
*zhèwèi shànggèyuè xīn tóngshì jièshàole jǐcì de yuángōng shuōfúguò shàngsi ránhòu zhuǎnle bùmén*
this.person last.month new.colleague introduced several.times REL employee persuaded boss and.then transferred department
'This employee who the new colleague introduced several times last month persuaded the boss and then transferred to another department.'
24. *这位*上午*妻子陪了*许久*的*丈夫*问了*旅行社*然后决定规划旅行。*
*zhèwèi shàngwǔ qīzi péile xǔjiǔ de zhàngfū wènle lǚxíngshè ránhòu juédìng guīhuà lǚxíng*

this.person morning wife accompany long.time REL husband inquire travel.agency and.then decide plan trip
'The husband who his wife accompanied a long time this morning inquired the travel agency and then decided to plan a trip.'
25. *那个*上午*店员询问了*一番*的*女孩*找到*妈妈*然后回了家。*
*nàgè shàngwǔ diànyuán xúnwènle yī fān de nǚhái zhǎodào māmā ránhòu huíle jiā*
that.one morning clerk asked for.a.while REL girl found mom and.then returned home
'The girl who the clerk asked about in the morning found the mom and then returned home.'
26. *这个*去年*新娘恭喜了*几次*的*商人*吻了*女儿*并且举办喜宴。*
*zhège qùnián xīnniáng gōngxǐle jǐcì de shāngrén wěnle nǚ'ér bìngqiě jǔbàn xǐyàn*
this.one last.year bride congratulated several.times REL businessman kissed daughter and held wedding banquet
'This businessman who the bride congratulated several times last year kissed the daughter and held a wedding banquet.'
27. *这位*昨晚*科学家相信了*一时*的*播报员*联系*物理专家*并且调查了真相。*
*zhèwèi zuówǎn kēxuéjiā xiāngxìnle yīshí de bōbàoyuán liánxì wùlǐ zhuānjiā bìngqiě diàochále zhēnxiàng*
this.person last.night scientist believed momentarily REL announcer contacted physician and investigated truth
'This announcer who the scientist believed momentarily last night contacted a physician and investigated the truth.'
28. *那个*前天*小说家取悦了*许久*的*歌剧家*想到*大学教授*所以联络了。*
*nàgè qiántiān xiǎoshuōjiā qǔyuèle xǔjiǔ de gējùjiā xiǎngdào dàxué jiàoshòu suǒyǐ liánluòle*
that.one day.before.yesterday novelist flatter long.time REL opera.singer thought.of university.professor so contacted
'The opera singer who the novelist flattered for a long time the day before yesterday thought of the university professor so she contacted him.'
29. *这个*刚才*姑姑接了*一次*的*叔叔*送了*伯伯*并且一起坐车去。*
*zhège gāngcái gūgū jiēle yīcì de shūshu sòngle bóbo bìngqiě yīqǐ zuòchē qù*
this.one just.now aunt picked up once REL the.younger.uncle sent the.older.uncle and went by car
'The younger uncle who the aunt picked up once just now sent off the older uncle and went by car together.'
30. *这个*今晚*客人迎接了*多次*的*男生*遇见*一位女孩*然后要了电话号码。*
*zhège jīnwǎn kèrén yíngjiēle duōcì de nánshēng yùjiàn yīwèi nǚhái ránhòu yàole diànhuà hàomǎ*
this.one tonight guest greeted many.times REL boy met one.girl and.then asked for phone.number
'This boy who the guest greeted many times tonight met a girl and then asked for her phone number.'
31. *那个*刚刚*女同学邀请了*一次*的*男生*拒绝*好朋友*并且离开了教室。*
*nàgè gānggāng nǚ tóngxué yāoqǐngle yīcì de nánshēng jùjué hǎopéngyǒu bìngqiě líkāile jiàoshì*
that.one just.now female.classmate invited once REL boy refused good.friend and left classroom
'The boy who the female classmate invited once just now refused a good friend and left the classroom.'
32. *那位*昨天*亲戚拜访了*两次*的*生意人*撞到*青梅竹马*并且感到讶异。*
*nàwèi zuótiān qīnqi bàifǎngle liǎngcì de shēngyìrén zhuàngdào qīngméizhúmǎ bìngqiě gǎndào yà yì*
that.person yesterday relatives visited twice REL businessman hit childhood friend and felt surprised
'The businessman who the relatives visited twice yesterday hit the childhood friend and felt surprised.'

# Appendix Chapter 3

## Experimental Stimuli

### Experiment 1

The experimental items for Experiment 1 are provided below. For each item, besides item 1 only the object-extracted relative clause condition is given. Each region is separated by an asterisk: N1 (the RC noun), V1 (the RC verb), N2 (the head noun), ADV (the adverb), V2 (the matrix verb).

| | |
|---|---|
| 1 | SRC: 영수를 *방문한 *정훈이가 *크게 *당황했다. |
| 1 | ORC: 영수가 *방문한 *정훈이가 *크게 *당황했다. |
| 2 | 성호가 *기다리는 *진주가 *내일 *돌아온다. |
| 3 | 경주가 *가르친 *민호가 *다시 *우승했다. |
| 4 | 은경이가 *기억한 *명미가 *먼저 *웃었다. |
| 5 | 도현이가 *감싸는 *영일이가 *정말 *부러웠다. |
| 6 | 민혁이가 *초대한 *미경이가 *방금 *도착했다. |
| 7 | 서현이가 *걱정한 *도현이가 *먼저 *합격했다. |
| 8 | 지원이가 *깨운 *은미가 *먼저 *식사했다. |
| 9 | 승헌이가 *무시하는 *광진이가 *단연 *우수했다. |
| 10 | 지훈이가*괴롭힌 *현지가*오히려 *당했다. |
| 11 | 미진이가 *미워하는 *광수가 *많이 *도왔다. |
| 12 | 진미가 *설득한 *지영이가 *결국 *나왔다. |
| 13 | 혁재가 *공격한 *정남이가 *재빨리 *피했다. |
| 14 | 준영이가 *그리워한 *혜수가 *다시 *나타났다. |
| 15 | 현지가 *넘어뜨린 *상훈이가 *크게 *다쳤다. |
| 16 | 선미가 *지지한 *지연이가 *이번에 *출전한다. |
| 17 | 승혁이가 *대신한 *성훈이가 *월등히* 뛰어났다. |
| 18 | 진혁이가 *담당한 *은주가 *일찍 *돌아갔다. |
| 19 | 진미가 *아끼는 *준호가 *멀리 *이민갔다. |
| 20 | 민지가 *신뢰하는 *수미가 *끝내 *배신했다. |
| 21 | 민재가 *부러워한 *정호가 *곤경에 *빠졌다. |
| 22 | 준영이가 *존경하는 *지수가 *갑자기 *떠났다. |
| 23 | 지은이가 *상담한 *현준이가 *급히 *나갔다. |
| 24 | 은정이가 *뽑은 *지민이가 *상을 *받았다. |
| 25 | 성훈이가 *싫어하는 *현수가 *매일 *인사한다. |
| 26 | 소진이가 *지도한 *유정이가 *훌륭히 *통과했다. |
| 27 | 수혜가 *추천한 *현우가 *최고로 *뽑혔다. |
| 29 | 수혁이가 *소개한 *성민이가 *직접 *조사한다. |
| 30 | 민석이가 *보호하는 *지선이가 *갑자기 *위험해졌다. |
| 31 | 민희가 *의심하는 *용준이가 *바로 *신고했다. |
| 32 | 정희가 *초청한 *혜순이가 *단호히 *거절했다. |

## Experiment 2

The experimental items for Experiment 2 are provided below. For each item, besides item 1 only the object-extracted relative clause condition is given. Each region is separated by an asterisk: DET (the pre-RC demonstrative), ADV1 (the temporal adverb), N1 (the RC noun), ADV2 (the adverb), V1 (the RC verb), N2 (the head noun), N3 (the matrix object), V2 (the matrix verb).

1 SRC: *이 *어젯밤 *테러리스트를 *호되게 *고문한 *군인은 *목숨을 *끊었다.*
1 ORC: *이 *어젯밤 *테러리스트가 *호되게 *고문한 *군인은 *목숨을 *끊었다.*
2 *이 *오늘 *오토바이가 *몰래 *쫓은 *자동차는 *접촉사고를 *냈다.*
3 *이 *작년 *소년이 *수차례 *때린 *여자아이는 *면담을 *하게 되었다.*
4 *이 *이전에 *자전거가 *두 번 *격돌한 *지프차는 *수리를 *받았다.*
5 *이 *지난주 *남자가 *세게 *민 *여성은 *다리를 *다쳤다.*
6 *이 *지난달 *동생이 *세 번 *초대한 *선생님은 *정년을 *맞이했다.*
7 *이 *작년 *주인이 *몇차례 *도운 *개는 *세상을 *떠났다.*
8 *이 *올해 *선수가 *급히 *추천한 *주장은 *첫 경기를 *시작했다.*
9 *이 *지난달 *야쿠자가 *매우 *경계한 *경찰은 *치안을 *강화했다.*
10 *이 *최근 *집주인이 *신랄하게 *욕한 *세입자는 *변호사를 *찾아갔다.*
11 *그 *지난달 *코치가 *심하게 *모욕한 *선수는 *비난을 *받았다.*
12 *그 *어젯밤 *지휘자가 *깊이 *존경한 *작곡가는 *신곡을 *발매했다.*
13 *그 *작년 *비평가가 *엄격하게 *비판한 *여배우는 *새 드라마를 *찍었다.*
14 *그 *지난달 *회사가 *매우 *신뢰한 *승무원은 *계약을 *연장했다.*
15 *그 *최근 *배우가 *서둘러 *섭외한 *감독은 *연기를 *지도했다.*
16 *그 *어제 *작가가 *몰래 *찾아간 *기자는 *특종 기사를 *보도했다.*
17 *그 *오늘 아침 *고양이가 *5 분간 *뒤쫓아간 *강아지는 *다리를 *절었다.*
18 *그 *어제 *배우가 *몹시 *부러워한 *모델은 *화보를 *찍었다.*
19 *그 *작년 *총리가 *한 번 *초빙한 *정치인은 *선거 운동을 *지원했다.*
20 *그 *올해 *저자가 *굉장히 *좋아한 *비평가는 *서평을 *출간했다.*
21 *저 *어제 *학생이 *끊임없이 *칭찬한 *교사는 *상을 *받았다.*
22 *저 *지난주 *환자가 *한 번 *만난 *의사는 *진료 기록을 *읽었다.*
23 *저 *지난달 *동료가 *잘 *알고있는 *직원은 *사장을 *설득했다.*
24 *저 *오늘 아침 *아내가 *장시간 *설득한 *남편은 *회사를 *찾아갔다.*
25 *저 *오늘 아침 *그녀가 *오래 *지켜봐온 *남자친구는 *결혼을 *계획했다.*
26 *저 *작년 *거래처가 *힘들게 *유치한 *회사는 *사업을 *성공시켰다.*
27 *저 *어젯밤 *과학자가 *굳게 *믿은 *회장은 *연구비를 *기부했다.*
28 *저 *어제 *총장이 *강력하게 *추천한 *교수는 *논문을 *발표했다.*
29 *저 *오늘 아침 *이모가 *심하게 *원망한 *삼촌은 *이혼 서류를 *작성했다.*
30 *저 *오늘 *손님이 *정중하게 *맞이한 *남자는 *식사를 *대접했다.*
31 *그 *지난주 *여학생이 *두 번 *미행한 *학생은 *퇴학을 *당했다.*
32 *그 *어제 *친척이 *오랜만에 *방문한 *지인은 *오빠를 *찔렀다.*

## Additional Example Sentences

The following set of sentences each bears a similar initial surface structure to that of relative clauses in Korean. Below, relative clause examples are first given as a baseline for the initial surface NP VP string. Following the RCs are a series of clauses containing pronominal drop (or argument ellipsis) which means that either the subject or object of the clause is omitted: Simple matrix clause sentences, de facto clauses, resultative-clauses, when-clauses, and because-clauses. After these examples a new RC example is given and is compared with a pseudo-relative clause (i.e., a gapless relative clause).

### Relative Clause

Subject-extracted relative clause (SRC)
SRC: 간호사를 좋아한 의사는 새 병원을 열었다.
*kanhosalul cohahan uysanun say pyengwenul yelessta*.
nurse-ACC loved-ADN doctor-TOP new hospital-ACC opened
'The doctor who loved the nurse opened a new hospital.'

Object-extracted relative clause (ORC)
ORC: 간호사가 좋아한 의사는 새 병원을 열었다.
*kanhosaka cohahan uysanun say pyengwenul yelessta*.
nurse-NOM loved-ADN doctor-TOP new hospital-ACC opened
'The doctor who the nurse loved opened a new hospital.'

### Simple Matrix Clause with Pronominal Drop

Subject-drop, simple matrix clause sentence
간호사를 좋아했다.
*kanhosalul cohahayssta*.
nurse-ACC loved
'(someone) loved the nurse.'

Object-drop, simple matrix clause sentence
간호사가 좋아했다.
kanhosaka cohahayssta.
nurse-NOM loved
'The nurse loved (someone).'

## Pronominal Drop De Facto Clause

Subject-drop, de facto clause
간호사를 좋아한 사실은 의사에게 전해졌다.
*kanhosalul cohahan sasilun uysaeykey cenhaycyessta.*
nurse-ACC loved-ADN fact-TOP doctor-DAT informed
'The fact that (someone) loved the nurse, was informed to the doctor.'

Object-drop, de facto clause
간호사가 좋아한 사실은 의사에게 전해졌다.
*kanhosaka cohahan sasilun uysaeykey cenhaycyessta.*
nurse-NOM loved-ADN fact-TOP doctor-DAT informed
'The fact that the nurse loved (someone), was informed to the doctor.'

## Pronominal Drop Resultative Clause

Subject-drop, resultative clause
간호사를 좋아한 결과는 매우 끔찍했다.
*kanhosalul cohahan kyelkwanun maywu kkumccikhayssta*.
nurse-ACC loved-ADN result-TOP terrible was.terrible
'The result that (someone) loved the nurse extremely was terrible'

Object-drop, resultative clause
간호사가 좋아한 결과는 매우 끔찍했다.
*kanhosaka cohahan kyelkwanun maywu kkumccikhayssta*.
nurse-NOM loved-ADN result-TOP extremely was.terrible
'The result that the nurse loved (someone) was terrible'

## Pronominal Drop When Clause

Subject drop when clause (Japanese toki):
간호사를 좋아할 때, 그는 질투했다.
*kanhosalul cohahal ttay, kunun cilthwuhayssta*.
nurse-ACC loved TIME he-TOP became.jealous
'When (someone) loved the nurse, he became jealous.'

Object drop when clause (Japanese toki):
간호사가 좋아할 때, 그는 질투했다.
*kanhosaka cohahal ttay, kunun cilthwuhayssta*.
nurse-NOM loved TIME he-TOP became.jealous
'When the nursed loved (someone), he became jealous.'

## Pronominal Drop Because Clause

Subject drop because clause:
간호사를 좋아해서 고백했다.
*kanhosalul cohahay-se kopaykhayssta*.
nurse-ACC loved-Because confessed
'Because (someone) loved the nurse, (he) confessed.'

Object drop because clause:
간호사가 좋아해서 고백했다.
*kanhosaka cohahay-se kopaykhayssta*.
nurse-NOM loved-Because confessed
'Because the nurse loved (someone), (he) confessed.'

## Pseudo-Relative Clause

The following examples are set apart from the others due to the nature and implications of the clause. The reasoning for this is that pseudo-relatives or gapless relative clauses do not contain any gapped or dropped-pronominal interpretation where the missing argument occurs (e.g., Cha, 1999).

Relative clause (SRC)
생선 굽는 요리사…
*saengseon gubneun yolisa*…
fish-ACC burn-ADN chef
'The chef who burned the fish…'

Pseudo-relative clause
생선 굽는 냄새…
*saengseon gubneun naemsae*…
fish-ACC burn-ADN smell
'The smell of the burning the …'
*'The fish burning smell…'

# Appendix Chapter 4

## Experimental Stimuli

### Experiment 1

The experimental items for Experiment 1 are provided below. For each item, besides item 1 only the object-extracted relative clause condition is given. Each region is separated by an asterisk. The regions are as follows: ADJ1 (the adjective Phrase), N1 (the RC noun), V1 (the RC verb), N2 (the head noun), ADJ2 (the adjective), N3 (matrix nominative object), and V2 (matrix verb).

1. SRC: *新任の*議員を*非難した*記者には*長年の*相棒が*いた。*
1. ORC: *新任の*議員が*非難した*記者には*長年の*相棒が*いた。*
2. *人気者の*先生が*疎んじた*生徒たちには*根暗な*人が*多かった。*
3. *年寄りの*母が*褒め称えた*看護士には*臨機応変な*者が*多かった。*
4. *中年の*女性社員が*助けた*同僚には*誠実な*人物が*多かった。*
5. *保守派の*教頭先生が*嫌がった*母親達には*高学歴の*インテリが*多かった。*
6. *几帳面な*書記が*ほめた*委員長には*高校生の*娘が*いた。*
7. *照れ屋な*寮母さんが*ほめた*女子学生には*同郷の*友人が*少なかった。*
8. *聡明な*国王が*騙した*貴族には*ずる賢い*悪党が*ついていた。*
9. *賢明な*店長が*信頼した*コックには*たくさんの*知り合いが*いた。*
10. *排他的な*政治家が*排除した*運動家には*熱狂的な*支持者が*いた。*
11. *近所の*囲碁仲間が*愛した*曾祖父には*長生きな*連れ合いが*いた。*
12. *隣人の*亭主が*追い返した*舅には*意中の*女性が*いた。*
13. *アルバイトの*若者が*指導した*婦人には*手強い*敵が*いた。*
14. *陽気な*嫁が*うるさがった*曾祖母には*ベテランの*家政婦さんが*ついていた。*
15. *偉大な*指導者が*接待した*貴婦人には*年若い*恋人が*いた。*
16. *お屋敷の*坊ちゃんが*敬愛した*婆やには*愛らしい*孫娘が*いた。*
17. *太っ腹な*スポンサーが*探し出した*監督には*有能な*マネージャーが*ついていた。*
18. *若い*係長が*批判した*秘書には*酒好きな*女友達が*いた。*
19. *売れっ子の*芸能人が*使った*カメラマンには*金持ちの*スポンサーが*ついていた。*
20. *エレガントな*ウグイス嬢が*引き止めた*立候補者には*有力な*政治家が*ついていた。*
21. *新人の*役者が*賞賛した*演出家には*元女優の*愛妻が*いた。*
22. *夜勤明けの*医者が*呼び止めた*入院患者には*献身的な*女房が*ついていた。*
23. *アメリカ人の*選手が*選んだ*コーチには*ヨーロッパ人の*奥さんが*いた。*
24. *昔の*アイドルが*けなした*マネージャーには*長年の*悪友が*いた。*
25. *地元の*名士が*からかった*芸者には*大富豪の*旦那が*ついていた。*
26. *男勝りな*姉が*どなり付けた*課長には*社内の*支持者が*少なかった。*
27. *ずうずうしい*大家が*どなった*借主には*無責任な*親が*いた。*
28. *赤毛の*少女が*ナンパした*高校生には*幼なじみの*彼女が*いた。*
29. *気短な*板前が*非難した*板長には*有望な*後継者が*いた。*
30. *非情な*借金取りが*追いまわした*ライターには*貧乏な*親戚が*いた。*
31. *怒りっぽい*夫が*殴った*息子には*同い年の*彼女が*いた。*
32. *喧嘩早い*男子が*挑発した*教師には*意地悪な*悪友が*いた。*
33. *無口な*旦那が*追い払った*おかみさんには*うわさ好きな*おしゃべり仲間が*いた。*
34. *内気な*姉が*はげました*妹には*大好きな*アイドル歌手が*いた。*

35. *有名な*スター女優が*好んだ*監督には*青年層の*ファンが*多かった。*
36. *手強い*敵が*殺した*兵士には*老齢の*母親が*いた。*
37. *直属の*部下が*裏切った*上司には*親しい*仲間が*少なかった。*
38. *せこい*小役人が*ののしった*市民には*幼い*娘が*いた。*
39. *元気な*お袋が*追いかけた*配達人には*意地悪な*雇い主が*いた。*
40. *同室の*入院患者が*起こした*少女には*憧れの*医師が*いた。*

**Experiment 2**

The experimental items for Experiment 2 are provided below. For each item, besides item 1 only the object-extracted relative clause condition is given. Each region is separated by an asterisk. The regions are as follows: DET (the pre-RC demonstrative), ADV1 (the temporal Adverb), N1 (the RC noun), ADV2 (the RC adverb), V1 (the RC verb), N2 (the head noun, N3 (the matrix object), V2 (the matrix verb), N4 (the 2nd Matrix Object), V3 (the 2nd Matrix Verb). For analysis purposes, the only regions analysed were from the N1 to V2.

1. SRC: *その*昨夜*給仕さんを*激しく*襲った*顧客は*上司から*聞いて、*事件を*伝えた。*
1. ORC: *その*昨夜*給仕さんが*激しく*襲った*顧客は*上司から*聞いて、*事件を*伝えた。*
2. *その*今日*単車が*密かに*追った*車は*駐車場を*見つけ、*直ちに*駐車した。*
3. *その*昨年*男の子が*数回*殴った*女の子は*校長を*見て、*目を*逸らした。*
4. *その*以前*バイクが*2回*激突した*ジープは*交番で*止まって、*事件を*伝えた。*
5. *その*先週*男性が*そっと*押した*女性は*バス停で*転んで、*左手を*負傷した。*
6. *その*先月*弟さんが*3回*招待した*妹さんは*教師に*挨拶して、*教室へ*行った。*
7. *その*昨年*主人が*数回*助けた*犬は*少年が*好きで、*元気に*なった。*
8. *その*今年*選手が*急に*雇った*監督は*審判を*侮辱して、*彼を*脅かした。*
9. *この*先月*ヤクザが*とても*警戒した*警察は*平和を*愛して、*街を*守った。*
10. *この*最近*家主が*３度*ののしった*住人は*弁護士を*見つけて、*すぐに*訴えた。*
11. *この*先月*コーチが*ひどく*侮辱した*選手は*ファンを*愛して、*帽子を*あげた。*
12. *この*昨夜*指揮者が*深く*尊敬した*作曲家は*奏者に*電話して、*長時間*話した。*
13. *この*昨年*評論家が*厳しく*批判した*女優は*俳優に*感謝して、*急に*泣いた。*
14. *この*先月*機長が*とても*信頼した*乗務員は*社長を*案内して、*部屋に*帰った。*
15. *この*最近*監督が*一度*表彰した*役者は*歌手と*結婚して、*子供を*授かった。*
16. *この*昨日*作家が*密かに*訪ねた*記者は*仲間に*お願いして、*報復を*計画した。*
17. *あの*今朝*子猫が*5分*追いかけた*子犬は*清掃員を*嗅いで、*しっぽを*振った。*
18. *あの*昨日*隣人が*不快に*思った*母親は*管理者に*通知して、*不満を*報告した。*
19. *あの*昨年*首相が*一度*招聘した*政治家は*議員を*集めて、*法案を*書いた。*
20. *あの*今年*著者が*大層*好んだ*評論家は*出版社に*連絡して、*執筆を*勧めた。*
21. *あの*昨日*学生が*しきりに*褒めた*教師は*両親を*見かけて、*軽く*挨拶した。*
22. *あの*先週*看護師が*一回*注意した*医者は*カルテを*読んで、*症状を*決定した。*
23. *あの*先月*同僚が*よく*知った*職員は*上司を*説得して、*計画を*変えた。*
24. *あの*今朝*妻が*長時間*説得した*夫は*旅行会社を*訪ねて、*ツアーを*決めた。*
25. *ある*今朝*店員が*ちょっと*馬鹿にした*女子は*母親を*見つけて、*家に*帰った。*
26. *ある*昨年*花嫁が*盛大に*祝福した*事業家は*娘に*キスして、*宴会へ*行った。*
27. *ある*昨夜*科学者が*固く*信じた*放送局は*医師に*連絡して、*真実を*調査した。*
28. *ある*昨日*警察官が*見事に*騙した*泥棒は*裁判官を*偽って、*刑務所へ*行った。*
29. *ある*今朝*叔母が*ひどく*憎んだ*叔父は*友達に*愚痴って、*ビールを*飲んだ。*
30. *ある*今夜*来客が*丁寧に*迎えた*男性は*女性に*会って、*電話番号を*聞いた。*
31. *ある*先週*女学生が*２回*誘惑した*生徒は*親友に*怒って、*教室を*去った。*
32. *ある*昨日*親戚が*久々に*訪問した*実業家は*兄さんを*刺して、*証拠を*隠した。