

The Processing Foundation of Head-Final Relative Clauses^{*}

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This article examines the special processing characteristics of head-final relative clauses. As head-final relative clauses superficially resemble other prenominal modifiers such as adjectivals, stative verbs, and adjunctive/complement clauses, their status as a distinct kind has constantly been challenged. We present existing processing evidence to show that head-final relative clauses should be distinguished from other prenominal modifiers as they do involve structure-based filler-gap integrations (like those of head-initial relative clauses) and observe universal extraction effects. The evidence includes: (a) processing differences between possessive relative clauses and adverbial relative clauses in Mandarin; (b) processing differences between gapped relative clauses and adjunct clauses with null pronouns in Korean; and (c) subject-extracted relative clauses being easier to process than object-extracted relative clauses in head-final relativization.

Key words: relative clauses, sentence comprehension, head-final structures, Chinese

1. Background: head-initial and head-final relative clauses

Relative clauses (RCs) are subordinate clauses embedded within nominal phrases. Semantically, this embedded clause modifies the dominating nominal head. Syntactically, the nominal head is associated with an empty element within the subordinate clause.¹

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¹ At this point of the discussion, we do not distinguish between an NP and a DP analysis. Refer to Aoun & Li (2003) for an analysis that focuses on the NP/DP distinction within head-initial and head-final relative clauses. Note also that in this article, we are not committed to specific syntactic analyses of the empty element. Suffice it to assume that an unpronounced element at the gap position has to be associated with the head noun. The discussion is neutral as to whether this unpronounced element is a trace or a pronoun.

RCs have received great attention from language researchers as they demonstrate crucial properties of the human language. They display clausal recursions—the possibility of one clause being infinitely embedded in another. They show that linguistic expressions can appear unpronounced and be associated with other expressions within the same sentence.² The dependency between the expressed and the unpronounced elements (in this case between a relativized gap and a nominal head) need not be adjacent, which demonstrates the importance of phrase-structure grammar in establishing discontinuous dependent relationships.

Across languages, relative constructions vary regarding whether the head noun precedes or follows the RC. Languages with head-initial RCs, such as English, appear with the head nouns preceding the RCs. Languages with head-final RCs (e.g., Chinese, Japanese, and Korean) appear with the head nouns following the RCs. With such typological diversity regarding head positions, a natural question is whether head-initial and head-final relativizations observe similar structural representations and derivations.³ From the perspective of sentence processing, the crucial question lies in whether head-initial and head-final RCs share similar structural representations and whether these structures are processed in a similar fashion.

Various proposals have been made regarding the structure of head-initial and head-final RCs. The most salient issues concern whether the empty noun phrase in the RC should be analyzed as a trace (thus involving displacement and observing island constraints) or as an unpronounced pronoun (thus involving coreference and observing pronominal properties in terms of binding).⁴ A relevant issue is whether the RC itself is a complement or an adjunct to the head noun. The formalist analysis proposed by Aoun & Li (2003) provides distinct representations for head-initial and head-final RCs, adopting complementation and adjunction as the structures of head-initial and head-final RCs

² The empty positions inside the RCs can also be filled by resumptive pronouns. The distribution and acceptability of resumptive pronouns are more restricted, and the occurrences usually involve solving processing difficulties and saving grammaticality violations (see Dickey 1996, McDaniel & Cowart 1999, McKee & McDaniel 2001, Ning & Lin 2007, 2008).

³ In the formal analyses of RCs, two types of proposals have been made. The unified approach (Grosu & Landman 1998) adopts a universal analysis for all RC constructions. The diversified approach (e.g., Aoun & Li 2003) suggests that different structures (e.g., complementation versus adjunction) are at work within and across languages.

⁴ For movement analyses involving traces, see Huang (1982), Aoun & Li (2003), and Hsu (2008) on Chinese, Sakai (1994) on Japanese, Han & Kim (2004) on Korean. For non-movement analyses involving null pronouns, see Li (2002) and Tsai (1997) on Chinese, Han (1992) on Korean, and Murasugi (1991) on Japanese.

respectively.⁵ More extreme conjectures focus on the fundamental differences between head-initial and head-final RCs. For instance, head-final RCs are taken to be attributive and no dependent relations are assumed to exist between the head noun and a particular element in the RC (Comrie 1996, 1998, Huang 2007, Matsumoto 1997). An extension of this view is that RCs do not exist in head-final languages—a claim of great consequence as it implies that RCs are language-specific constructs and cannot be found in all languages.

It is thus important to investigate whether head-final RCs involve filler-gap dependencies like head-initial RCs.⁶ That is, is there a dependency between the head noun and a specific position inside the RC in head-final relativization? If filler-gap dependencies can be observed in head-final RCs, it then provides evidence for not treating head-final RCs as mere noun-modifying clauses (e.g., complement clauses) but rather as RCs that contain relativized positions. In this article, we provide processing evidence that such dependencies do exist. We show that when the parser processes head-final RCs, it attempts to construct a dependent relationship between the head and the gap in the RC. In processing, head-final RCs share similar gap-head relations as head-initial RCs.

The rest of this article is organized as the following. Section 2 introduces the processing basis for comparing head-initial and head-final relative clauses. Section 3 discusses the different forms of prenominal modifiers. Section 4 reviews the issue of garden path in processing head-final RCs. Section 5 presents evidence for the distinct processing of RCs, including the processing differences between gapped and adjunct clauses in Korean and Chinese, and universal extraction effects observed in head-final relative clauses. Section 6 concludes this article.

2. Processing relative clauses

In the past three decades, much psycholinguistic research has been focused on the processing of head-initial RCs. It has been demonstrated that the head nouns in head-initial relative constructions function as fillers that search for gaps in sentence comprehension. Since the filler appears prior to the gap in these head-initial RCs, it is reasonably

⁵ It is important to clarify that even though Aoun & Li (2003) did not adopt the same analyses for head-initial and head-final RCs, the internal structures involving an empty category is assumed to exist in both head-initial and head-final RCs. This characteristic (of adopting syntactic structures and empty categories in the representation and derivation) distinguishes their analysis from those that altogether refute the existence of head-final RCs as a distinct kind.

⁶ Following the convention in the sentence comprehension literature, we use the terms fillers and gaps to refer to the head noun and the relativized position in the RC. Again, this choice of terminology is neutral to whether the gap should be treated as a trace or a pronoun.

argued that once the head noun is encountered, the parser initiates a search for the gap, following the Active Filler Strategy (Frazier & Clifton 1989).

Over the years, important findings were made regarding the comprehension of head-initial RCs. It has been demonstrated that, in sentence comprehension, shorter distances between the filler and the gap are preferred to longer ones. Essentially, this has to do with the limited cognitive resources consumed in processing (in terms of the amount of working memory used for the storage and integration of linguistic materials, cf. Gibson 1998). Since the linear distance between the head noun and the gap is shorter in subject-extracted RCs than in object-extracted RCs (see (1)-(2)), RCs involving subject extractions are comprehended with greater ease than those involving object extractions (King & Just 1991, Gibson et al. 2005, Traxler, Morris & Seely 2002, see Lin 2006 for a typological overview); this prediction follows directly from the principle of locality in processing. However, the fact that subject positions are structurally closer to the head noun than object positions can be an alternative explanation (see Hsiao & Gibson 2003, and Lin 2006 for reviews of different theoretical accounts and their predictions).⁷

- (1) Subject RC: The linguist that Ø talked to me yesterday works on relative clauses.
- (2) Object RC: The linguist that I talked to Ø yesterday works on relative clauses.

The processing of head-final RCs has received increasing attention in the past decade, particularly regarding the comprehension of RCs in Chinese (Hsiao & Gibson 2003, Hsu et al. 2005, Hsu & Chen 2007, Lin & Bever 2006, 2007), Japanese (Miyamoto & Nakamura 2003, Ishizuka 2005, Ishizuka et al. 2006), and Korean (Kwon et al. 2006). A crucial difference between head-initial and head-final RCs has to do with the opposite positions of the filler and the gap and therefore the opposite patterns of filler-gap distances in subject and object extractions. In languages with head-final RCs, the gap precedes the filler. Due to the filler following the gap, languages with the same basic word orders but opposite head positions (such as English and Chinese both being SVO languages) turn out to demonstrate opposite distance patterns. In Chinese, RCs with subject extractions appear with longer distances between the filler and the head (see (3)-(4)).

⁷ Note that the analysis that a gap and the head noun hold a dependency is corroborated by Gorrell (1993) and Gibson & Hickok (1993). The direct association hypothesis by Pickering & Barry (1991), on the other hand, holds that no trace or empty categories have to be postulated. The head noun is simply associated with the verb in the subordinate clause owing to subcategorizational requirements.

(3) Chinese Subject RC:

Ø zuotian pengdao wo de yuyanxuezhe yanjiu guanxi ziju
 GAP yesterday met I REL⁸ linguist investigate relative clauses
 ‘The linguist that Ø met me yesterday works on relative clauses.’

(4) Chinese Object RC:

wo zuotian pengdao Ø de yuyanxuezhe yanjiu guanxi ziju
 I yesterday met GAP REL linguist investigate relative clauses
 ‘The linguist that I met Ø yesterday works on relative clauses.’

The typological differences between head-initial and head-final relative clauses discussed so far provide foundation for further exploration regarding whether the same processing effects and strategies observed on head-initial RCs can also be found on head-final RCs. This issue is important especially with respect to whether relative clauses that appear before a noun and those that follow a noun are of the same kind. The following questions regarding the processing of head-final RCs are, therefore, explored. First, as the gap precedes the filler in head-final RCs, does the parser adopt a similar gap-searching strategy like that of head-initial RCs? Or rather, does the gap search for a filler (i.e. a potential Active Gap Strategy)? Also important is the question whether the subject versus object asymmetry in head-initial RCs can be replicated in head-final RCs. If yes, what motivates such an asymmetry? These questions bear implications for a fundamental issue regarding the status of head-final RCs: do relativized gaps exist in head-final RCs? Are head-final RCs true relative clauses or are they to be treated as noun-modifying attributive constructs?

3. Head-final relative clauses and noun modification

In this section, we consider noun modification in head-final languages, and specifically why relative clauses in these languages are problematic. An important reason why head-final relative clauses are difficult to define is because of the diverse forms of prenominal modification in these languages. If relative clauses are to be taken as a special kind, they ought to be distinguishable from other kinds of prenominal modifiers. In Chinese, prenominal modifiers are of diverse forms—bare adjectives and a wide range of DE-phrases which bear diverse internal structures (e.g., (6)-(12)).⁹ Among the examples of

⁸ Abbreviations in the transliteration: ACC: accusative case; CL: classifier; DE: *de*; GAP: relativized gap; GEN: genitive case; NOM: nominative case; PERF: perfective aspect; REL: relativizer.

⁹ See den Dikken (2006) for treating DE as a “linker,” and Cheng (1986) and Simpson (2002) on relevant treatments of various DE phrases. In particular, den Dikken (2006) adopted the following structure for all instances involving *de* in Chinese: [_{DP} D (...) [_{FP} [_{XP} ...]_i] [_{LINKER}=*de*

DE-phrases in (6)-(12), only (12) is the standard gapped RC. The DE-phrase in (6) indicates a possessive (genitive) relationship. (7) is a noun complement, also known as apposition. (8)-(9) are adverbial relative clauses involving adjunctions. (10) contains a stative predicate and can be taken as an adjectival phrase or as relativization involving subject extraction. (11) is a particularly difficult case (nevertheless quite common in the language) where the prenominal clause is argument-complete (like that of an adverbial relative clause) while the head noun is not a common adverbial (such as place, time, reason, or instrument). Only (12) appears with an apparent missing argument, which can be reconstructed by restoring the head noun at the gapped argument position.

- (5) hong hua
red flower
'red flower'
- (6) taiwan de zongtong
Taiwan DE president
'president of Taiwan'
- (7) taiwan duli de zhuzhang
Taiwan independent DE claim
'the claim that Taiwan is independent'
- (8) tamen chufa de shijian
they leave DE time
'the time they left'
- (9) xiayu de yewan
rain (v.) DE night
'the night when it rained'
- (10) wanpi de haizi
naughty DE kids
'naughty kids'
- (11) yi ge ren zhu de kongju
one CL person live DE fear
'the fear of living alone'

[_{RP} [head noun] [RELATOR *t_i*]]]. However, he did not detail on how the gap in the relative clause is reconstructed and how the dependency between the gap and the head noun is constructed. Following the spirit of Kayne's (1994) antisymmetry, Simpson (2002) provided an analysis of Chinese DE phrases, adopting large-scale leftward movements inside the DP (with base generations similar to those of head-initial RCs).

- (12) taiwan zhizao Ø de chanpin
 Taiwan make GAP DE product
 ‘the products that Taiwan made’

Such diversity of prenominal DE-phrases led researchers to treating *de* as a linker (den Dikken 2006) or as a functional head that “introduces some kind of predication on a nominal (Simpson 2001).” It is noteworthy that these approaches analyze all cases of *de* as syntactically undifferentiated. As the different relating functions of *de* are not specified, the special syntactic status of relativization is also understated.

A relevant approach by Matsumoto (1988, 1997) emphasizes the diversity of prenominal constructions and suggests that instead of distinguishing the different structures in these prenominal modifiers, one can focus on how the meaning of prenominal modifiers and the nouns they modify should be composed. A crucial datapoint that Matsumoto provides as a challenge to syntactic analyses is the difficulty in deriving different meanings in the following examples.¹⁰

- (13) feiji shishi de yuanyin hai bu qingchu
 airplane crash DE reason still not clear
 ‘The reason why the airplane crashed is still not clear.’
 (14) feiji shishi de yuanyin, gongsi pochan le
 airplane crash DE reason, company bankrupt PERFECT
 ‘For the reason that the airplane crashed, the company went bankrupt.’

In (13), the relation between *reason* and the prenominal clause is adjunctive, while in (14), it seems appositive. The challenge lies in how to provide a satisfactory account that can derive the different meanings for (13) and (14) when both involve an identical head noun (i.e. *the reason*) and the same prenominal clause. The solution proposed by Matsumoto (ibid.) was inherently semantic—an account that is based on “construal” in frame semantics. We do not further elaborate on the details of Matsumoto’s proposal; suffice it to say that this approach places the burden of semantic interpretation on semantics and pragmatics, but not on syntax. Prenominal clauses are simply linked to the head nouns (without differentiation on their internal syntactic structures). It is the semantic frame that dictates how the meaning is to be construed. Following the same line of reasoning, Comrie (1996, 1998, 2007) proposes that noun phrases in Asian languages are typologically distinct from those of European languages and Indo-Aryan languages in that

¹⁰ The original examples provided by Matsumoto (1997) were in Japanese. The examples we offer in (13)–(14) are their counterparts in Chinese.

the prenominal noun-modifying constructions are attributive in nature, not involving gaps or movements.¹¹

The position we hereby undertake is to show that such a treatment of prenominal modification is insufficient as it understates the different kinds of syntactic (and consequently semantic) compositions among the different kinds of prenominal modifiers. We show that prenominal structures involving relativization should, in fact, be distinguished from those that are simply attributive. Relevant processing data are provided in §5.

4. The issue of garden path in head-final relative clauses

Before moving onto the processing evidence, we need to consider factors that are specific to the comprehension of head-final relative clauses for a fair comparison between the processing of head-initial and head-final relativizations.

In addition to the fact that prenominal RCs look like many other prenominal modifiers, the most problematic issue relevant to the processing of head-final RCs is the temporal ambiguity involved (Lin & Bever 2007). In head-final RCs, the relativizer, if it exists, follows the RC. Prior to the relativizer and the head noun, no specific marking is provided to indicate the left boundary of the RC. Temporary structural ambiguity thus exists before the head noun is reached. Since a head-final RC may be taken as a main clause initially, misanalysis is likely to occur, inducing reanalysis subsequently and affecting the natural filler-gap integrations.

Temporary ambiguity has been regarded as an issue of crucial importance in the processing of head-final RCs (Hsu et al. 2005, 2006, Ishizuka et al. 2006, Lin & Bever 2007). In fact, the same issue has long been at the center of investigation of head-initial RCs.¹² The point of interest concerns whether the RCs are initially misread as main clauses and whether such misreading can be rescued. Research on this issue has increased our knowledge about the factors that contribute to constructing syntactic structures and semantic interpretations.

¹¹ Crucial evidence for Comrie relies on the prevalence of zero anaphora—the dropping of nominal arguments due to discourse prominence—in Asian languages. For acquisition data arguing for distinctions between head-initial and head-final relative clauses, see Yip & Matthews (2007) on Cantonese, and Comrie (2007).

¹² In English, the classic garden-path sentence that has been extensively studied involved reduced relatives (e.g., *the horse raced past the barn fell*, Bever 1970). The misreading of these sentences and the difficulty in reanalyzing them have sparked decades of research, shedding light on the factors leading to misanalysis and reanalysis (Crain & Steedman 1985, MacDonald et al. 1994). In fact, not all issues have been settled and debates continue till the present day (e.g., McKoon & Ratcliff 2003, 2007).

Unlike English, in which the misreading of RCs as main clauses occurs primarily in carefully designed reduced relative clauses, head-final RCs regularly involve garden path readings. If we assume the minimal attachment strategy advanced by Frazier (1987) that the parser does not postulate additional syntactic nodes unless necessary, then the main-clause reading will most likely be adopted in the initial parsing of head-final RCs, where the RCs, without specific markings on the left edge, can be read as main clauses with missing nominal entities (e.g., pro dropping of the subject or the object). This is illustrated in (15)-(16):

- (15) a. correct analysis of a head-final subject RC:
 $[\emptyset \ V \ O]_{RC} \text{ relativizer head_noun}$
b. misanalysis of a head-final subject RC:
 $\text{pro} \ V \ O$ (main clause with a zero subject)
- (16) a. correct analysis of a head-final object RC:
 $[S \ V \ \emptyset]_{RC} \text{ relativizer head_noun}$
b. misanalysis of a head-final object RC:
 $S \ V$ (main clause)

Such misanalysis is due to the relativizer and head noun appearing only after the subordinate clauses. Without markings on the left edge or the gap, the parser adopts main-clause analyses initially. Misanalysis can also occur when an object RC appears at the object position of a main clause (that is, when the RC modifies the object of the matrix clause as in (17)-(18)). The subject inside the RC may be mistaken as the object of the matrix clause.

- (17) Correct analysis of a head-final object RC modifying the object of the main clause:
 $S_{\text{main_clause}} \ V_{\text{main_clause}} [S \ V \ \emptyset \text{ relativizer}]_{RC} \text{ head_noun} = O_{\text{main_clause}}$
- (18) Misanalysis of a head-final object RC modifying the object of a main clause:
 $S_{\text{main_clause}} \ V_{\text{main_clause}} \ O_{\text{main_clause}}$

Likewise, if the verb of the main clause can select for another verb, a subject RC that appears in the object position of a main clause can also be misread (19)-(20).

- (19) Correct analysis of a head-final subject RC modifying the object of a main clause:
 $S_{\text{main_clause}} \ V_{\text{main_clause}} [\emptyset \ V \ O \text{ relativizer}]_{RC} \text{ head_noun} = O_{\text{main_clause}}$
- (20) Misanalysis of a head-final subject RC modifying the object of a main clause:
 $S_{\text{main_clause}} \ V_{\text{main_clause}} \ V_{\text{main_clause}}$
e.g., John enjoys sing \Rightarrow John enjoys singing.

To sum up, there are multiple ways to misread head-final RCs as part of a main clause. This poses a serious challenge to parsing. Is the parser immediately committed to an analysis following the principle of structural economy (e.g., minimal attachment) and incremental processing? Does it wait until the disambiguating region (e.g., the head) is reached at the risk of being burdened with greater storage costs? These questions correspond to the debates in sentence comprehension regarding whether the parser commits itself to incremental structure-building or holds decisions until the head is reached in processing head-final structures (incremental processing: Bader & Lasser 1994, Miyamoto 2002; head-driven processing: Abney 1989, Pritchett 1991, 1992). Processing evidence that I review below demonstrates that the parser does commit itself to an initial main-clause analysis in reading head-final RCs.

To show that the garden-path effect does exist in the comprehension of head-final RCs, we need to compare the comprehension of head-final RCs that may be garden-pathed and those that are clearly not. Four approaches (with various degrees of success) have been adopted in the literature to indicate the existence of an RC, including using an RC-internal marker, classifier-noun mismatches, contexts, and overt instructions about RCs. We briefly review each of them with an attempt to evaluate whether a garden-path effect does exist and whether this garden path can be successfully removed in the comprehension of head-final RCs.

In Mandarin, object RCs can be optionally marked with *suo* appearing right before the VP inside the RC (Ting 2003):

- (21) zhangsan (suo) zunjing de laoshi
 Zhangsan SUO respect DE teacher
 ‘the teacher that Zhangsan respected’

Hsu et al. (2005) compared online comprehension of object RCs in Mandarin that are marked with *suo* and those that are not. The parser slowed down upon reaching *suo*, but when it reached the relativizer and the head noun, the reading time was shorter in sentences with *suo* than those without it. Their results suggested that *suo* did provide useful information for disambiguation so that when the parser reached the relativizer and the head noun, it was ready to adopt an RC analysis.¹³

The second method that has been adopted to indicate a potential RC boundary was classifier-noun mismatch. In languages like Chinese and Japanese where there are classifiers in the nominal phrases, the selectional restriction between the classifier and the noun can

¹³ In an offline sentence completion task, Hsu et al. (2005) showed that a sentence starting with a subject nominal and *suo* (e.g., *laoshi xiang xuesheng suo*—‘teacher to students SUO’) induces more completion using RCs than a sentence that does not contain *suo*.

indicate whether a classifier and the adjacent noun phrase are one constituent. For instance, the classifier *tiao* selects for a nominal object that is long in shape (22). When it is adjacent to a noun that is not semantically congruent, it appears ill-formed as in (23). Yoshida et al. (2004) and Hsu et al. (2005) used this classifier mismatch to indicate an RC boundary in sentence processing. In (24), for instance, the fact that *tiao* and the policeman do not form a classifier phrase indicates that policeman should be part of a separate noun phrase.

- (22) na tiao she
 that CL snake
 ‘that snake’
- (23) *na tiao jingcha
 that CL policeman
 ‘that policeman’
- (24) na tiao [jingcha zhuazou Ø de] she
 that CL policeman caught GAP DE snake
 ‘the snake that the policeman caught’

Yoshida et al. (2004) did find reduced reading times on the head nouns in the classifier-noun mismatching condition in Japanese. Hsu et al. (2006) only found a similar effect when the classifier-noun mismatch was used with a felicitous context (which provided a narrowed set of referents consistent with the mismatched classifier). Classifier-noun mismatch alone was not sufficient to suggest an RC parse in Mandarin. These results suggest that when appropriately contextualized, sentences with classifier-noun mismatches were indeed read faster on the critical disambiguating regions. Without such a contextual motivation, head-final RCs can be garden-pathed.

A third method that has been adopted is the use of RC-inducing contexts. RCs serve discourse functions (Fox & Thompson 1990, 2007). Researchers thus created contexts to motivate an upcoming RC (Ishizuka et al. 2006, Hsu et al. 2006, Hsu & Chen 2007).¹⁴ However, even though a context can be felicitous for RCs, it is still not guaranteed that an RC will be the *only* way to continue that context.

To illustrate the effect of contexts on the processing of RCs, let us consider studies of Hsu et al. (2006), Hsu & Chen (2007), and Gibson and colleagues. Hsu et al. (2006) contrasted contexts that provided referents of the same kind (e.g., two motorcycles) with contexts containing referents of different kinds (e.g., a computer and a television set). Only referents of the same kind called for further specification and thus created a felicitous context for RCs. Referents of different kinds did not create a context that

¹⁴ Crain & Steedman (1985) were the first to show the effect of contextual information in inducing RCs. Much of the subsequent studies using contexts adopt the same paradigm.

induces RCs. Interestingly, different contexts can cast different processing impacts over the target materials. Hsu & Chen (2007), for instance, showed that the use of different contexts induced opposite results in sentence comprehension. The series of experiments done by Gibson and colleagues (e.g., Ishizuka et al. 2006, and Wu & Gibson 2008) created contexts to induce RCs. However, the linguistic materials inside the contexts (in terms of syntactic structures, word orders, or semantic contents) need to be examined to evaluate their potential impact on the target sentences.

My own recent experiments reexamined this issue by taking the extreme. In Lin & Bever (2007), we instructed the participants explicitly that they were reading sentences containing RCs. The positions of the RCs were also stated in the instructions so that the participants knew exactly where to expect the RCs in the sentences (e.g., whether the RC modified the subject or the object of the matrix clause). In another experiment (Lin & Bever 2006), we presented the sentences in isolation without special instructions about RCs (and thus the garden-path effect may have been present). By comparing the reading patterns of the two experiments, we are able to see the effect of overt instructions about RCs and whether a garden-path effect exists without these instructions. In (25), the reading times of the RC regions are contrasted. An apparent increase in reading time was found on the head noun of the object RCs when they were presented without specific instructions.

- (25) Reading times (msec) of the relative clauses in two experiments (Lin & Bever 2006, 2007):

SRC Regions	V	N	de (REL)	N (head)
Experiment 1 (Lin & Bever 2007)	685	709	607	907
Experiment 2 (Lin & Bever 2006)	643	697	592	877
Difference (Exp2-Exp1)	-42	-8	-15	-30
ORC Regions	N	V	de (REL)	N (head)
Experiment 1 (Lin & Bever 2007)	659	713	613	948
Experiment 2 (Lin & Bever 2006)	651	742	677	1143
Difference (Exp2-Exp1)	-8	+29	+64	+195*

This comparison suggested that the garden-path effect did exist on object-extracted RCs when these sentences with RCs were presented without specific instructions (as in Lin & Bever 2006). With specific instructions on the existence and locations of the RCs, the reading times on the critical regions (i.e. the relativizer and the head noun but not the pre-head RC regions) of object-extracted RCs were reduced. As discussed earlier

through examples in (16)-(18), object-extracted RCs create various possibilities of main-clause misanalyses and are, therefore, more susceptible to garden path.¹⁵

The review in this section demonstrated that in processing head-final RCs, the pre-head regions (especially of an object-extracted RC) tend to be analyzed as a main clause initially. When the experimental conditions provided information for early disambiguation, the garden-path effect is reduced or removed. Markers (such as *suo* in Mandarin) and classifier-noun mismatches can indicate the left edge of an RC, thus facilitating an RC analysis. Experiments explicitly specifying the existence of RCs can also remove the potential garden-path effect in reading head-final RCs. Contexts can be felicitous; however, they may also induce different biasing effects and have to be used with caution.

5. The processing of a relativized gap in head-final RCs

As discussed in §3, prenominal modifiers in head-final languages have diverse internal structures (demonstrated in (5)-(11)). This led some researchers to treating all prenominal modifiers (including RCs) as attributive modifiers and not focusing on the distinct internal structures. An extreme version of this position is to claim that the kind of relative construction found in head-initial languages does not exist in head-final languages (e.g., Comrie 1996, 1998, Huang 2007).

One reasonable way to test this hypothesis is to examine if the relativized gap hypothesized to exist in a prenominal RC casts any influence on sentence processing, and, if it does, how it is integrated with the head noun. In this section, I cite three sets of evidence demonstrating that relativized gaps are processed as a distinct kind; that is, the parser does attempt to construct a dependency between the head noun and the relativized gap in a prenominal RC. In addition, the universal structure inside the RCs produces similar integration effects in head-initial and head-final RCs.

¹⁵ As one reviewer correctly pointed out, the lack of differences between the two experiments in the subject RC condition implies that a misanalysis like (15b) may not exist. An object RC seems to involve more misanalysis (i.e. garden path) than a subject RC. When the RCs modifying the subject positions and those modifying the object positions were statistically examined separately, Lin & Bever (2007) found that the effect of garden path was primarily on the object-extracted RCs that modified the object positions of the main clauses (e.g., the misanalysis illustrated in (18)). The fact that a garden-path effect was found on (18), not on (15b), (16b), or (20), suggested that an apparent NVN order was the primary source of a main-clause misanalysis in Mandarin sentences with RCs. This also suggested that when Mandarin RCs were located at sentence-initial positions, misanalyses were actually not apparent.

5.1 Gapped versus adjunctive relative clauses in head-final RCs

If we assume that all noun-modifying clauses are adjuncts directly adjoined to the head nouns they modify for semantic integration, there seems to be no need to elaborate on the internal syntactic structure of the subordinate clauses. Such is the position of frame semantics (Matsumoto 1997), which places the burden of explanation exclusively on semantics. According to this approach, there would be no distinction between a prenominal RC that is gapped and one that is adjunctive in terms of structural processing. On the other hand, if the parser does position a gap in the internal structure of prenominal clauses, then we should observe distinct reading patterns resulting from the different structural properties of the prenominal clauses. A subordinate clause involving a relativized gap would then be distinguishable from one that does not involve gaps (such as an adjunctive clause).¹⁶

In Lin, Fong & Bever (2005), we contrasted the processing of possessive RCs with that of adjunctive RCs and found distinctive reading patterns between the two.¹⁷ Specifically, we were concerned with the position of the relativized gap inside the possessive RCs in predicting different processing difficulties. With possessive relativization (in which the head noun has to be associated with a relativized possessor in the RC as shown in (26b-d)), the reading time is contingent on the position of the possessee (i.e. where the relativized possessor is located).

(26) Possessive RCs:

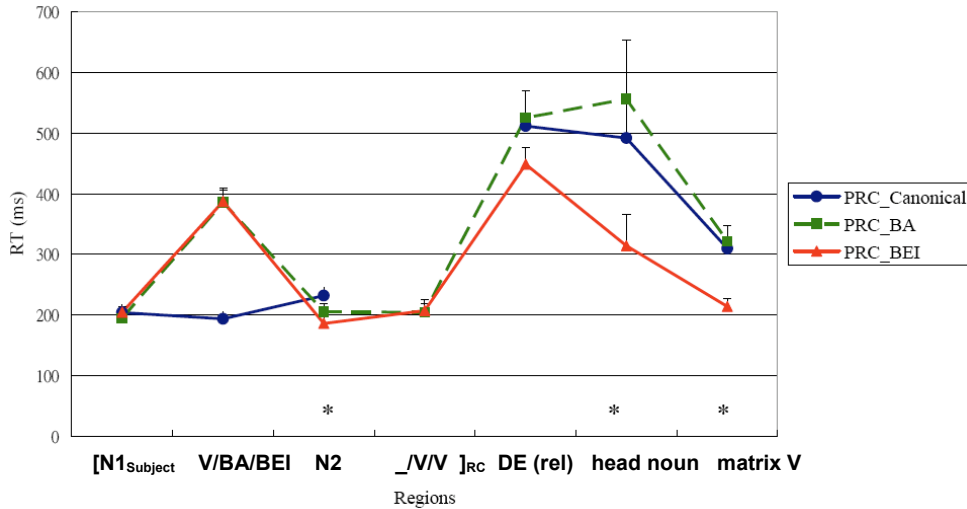
- a. the guy whose house the typhoon destroyed
- b. Ø_fangzi bei taifeng chuikua de na wei xiansheng
GAP_house PASSIVE typhoon destroy DE that CL guy
'the guy whose house was destroyed by the typhoon'
- c. taifeng ba Ø_fangzi chuikua de na wei xiansheng
typhoon BA GAP_house destroy DE that CL guy
'the guy whose house the typhoon destroyed'
- d. taifeng chuikua Ø_fangzi de na wei xiansheng
typhoon destroy GAP_house DE that CL guy
'the guy whose house the typhoon destroyed'

¹⁶ In these adjunctive RCs, depending on the syntactic analysis adopted, the head nouns can also be analyzed as being associated with an empty adverbial gap position inside the RC (e.g., at the preverbal positions in Mandarin Chinese). However, such an analysis does not account for the processing differences in the adjunctive RCs in (29). We therefore maintain that the head nouns in the adjunctive RCs do not need to be associated with specific positions inside the RC.

¹⁷ Similar results were obtained in Japanese (Fong, Hirose & Lin 2006).

Reading time on the head noun was shorter when the gap was located at the sentence-initial subject position (i.e. passive *bei* condition, the bottom line in (27)), getting longer as the gap position is located toward the end of the clause (e.g., at the object position—the dotted line in (27)).

(27) Reading times in Mandarin possessive RCs from Lin, Fong & Bever (2005):



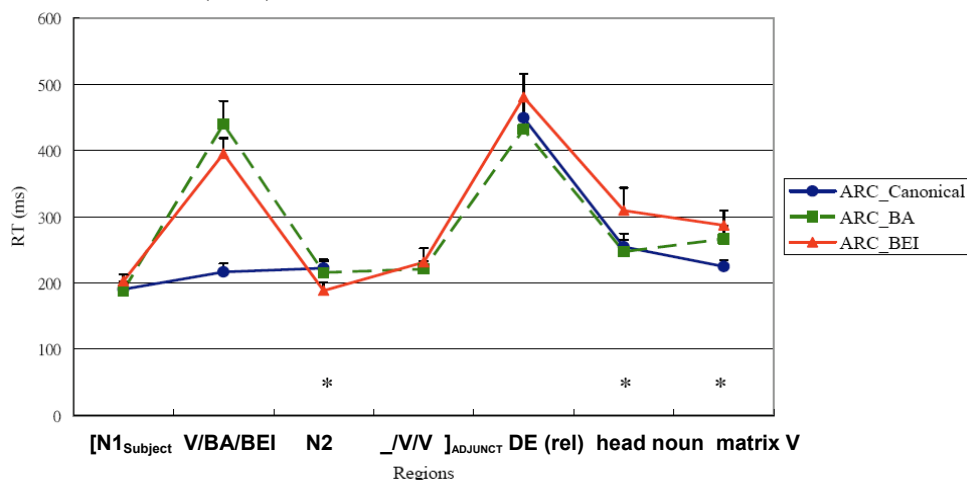
With adjunctive clauses, we replaced the head nouns with adverbial nominals such as *place*, *time*, *instrument*, etc.; these head nouns were traditionally treated as adverbial heads as they do not point to a specific gap position in the prenominal RC (see examples in (28)).

(28) Adjunctive RCs:

- a. the reason why the house was destroyed by the typhoon
- b. fangzi bei taifeng chuikua de yuanyin
house PASSIVE typhoon destroy DE reason
'the reason why the house was destroyed by the typhoon'
- c. taifeng ba fangzi chuikua de yuanyin
typhoon BA house destroy DE reason
'the reason why the typhoon destroyed the house'
- d. taifeng chuikua fangzi de yuanyin
typhoon destroy house DE reason
'the reason why the typhoon destroyed the house'

Different reading patterns were obtained. The passive adjunctive clause (with *bei*, now the top line in (29)) was read the longest. This is consistent with the baseline condition that showed passives in Mandarin were generally harder to process than canonical SVO sentences.¹⁸ The different patterns found in possessive RCs and adjunct clauses demonstrated that the parser is sensitive to the gap positions inside the RCs. Since there are no specific gap positions in adjunctive clauses, the reading difficulties reflect the overall structural complexity of the adjunctive clauses. Thus, we showed that a relativized position does exist in prenominal RCs, and that filler-gap integration is sensitive to the location of the gap in the prenominal clause.

(29) Reading times in Mandarin adjunctive relative clauses from Lin, Fong & Bever (2005):



5.2 Relativized gap versus pro in head-final clauses

Parallel to the distinction between possessive RCs and adjunct RCs in Chinese discussed in §5.1, Kwon et al. (2006:6) compared the processing of prenominal RCs (clauses with relativized gaps in (30)) and adjunctive clauses (clauses with pro-drops in (31)) in Korean. The apparent parallel structures in gapped RCs and adjunct clauses in Korean (being minimally distinguished only by a suffix on the embedded verb) offer a

¹⁸ In the baseline condition, we compared the comprehension of passive sentences (the *bei* construction in Mandarin), sentences with a preposed object phrase (the *ba* construction in Mandarin), and the canonical SVO clauses. Passives were read the longest, then the *ba* sentences. Canonical sentences were the easiest. These baseline reading patterns were replicated in the adjunctive condition, but not in the possessive RC condition.

good comparison for the distinction between prenominal clauses that involve a gap and those that contain an unpronounced pronoun.

(30) Gapped RC in Korean:

a. Subject RC:

t_i ku tulama-uy kukcakka-lul pangsongk wuk inkun
 that soap_opera-GEN writer-ACC broadcast station vicinity
 swulcip-eyse phokhaynggha-n paywu_i-ka
 bar-at hit-REL actor-NOM
 ‘the actor who GAP hit the writer of the soap opera at a bar close to the radio station’

b. Object RC:

ku tulama-uy kukcakka-i t_i pangsongk wuk inkun
 that soap_opera-GEN writer-NOM broadcast station vicinity
 swulcip-eyse phokhaynggha-n paywu_i-ka
 bar-at hit-REL actor-NOM
 ‘the actor who the writer of the soap opera hit GAP at a bar close to the radio station’

(31) Adjunct clause in Korean:

a. Subject pro-drop:

PRO_i ku tulama-uy kukcakka-lul pangsongk wuk inkun
 PRO that soap_opera-GEN writer-ACC broadcast_station vicinity
 swulcip-eyse phokhaynggha-se paywu_i-ka
 bar-at hit-BECAUSE actor-NOM
 ‘because PRO_i(=he) hit the writer of the soap opera at a bar close to the radio station, the actor_i ...’

b. Object RC:

ku tulama-uy kukcakka-i PRO_i pangsongk wuk inkun
 that soap_opera-GEN writer-NOM PRO broadcast_station vicinity
 swulcip-eyse phokhaynggha-se paywu_i-ka
 bar-at hit-BECAUSE actor-NOM
 ‘because the writer of the soap opera hit PRO_i(=him) at a bar close to the radio station, the actor_i ...’

In a self-paced reading study, they found that sentences with relativized gaps and those with dropped pros showed different reading patterns across three positions at the critical regions (32)-(34):

- (32) At the embedded verb where the suffixes *-n* or *-se* indicated if the subordinate clause was an RC or an adjunct clause, clauses with a subject pro was read faster than those with an object pro. No difference was found regarding subject versus object gaps.
- (33) At the head-noun position (namely, the matrix subject position for pro sentences), sentences involving missing subjects (whether it was a gap or a pro) were read faster than those involving missing objects. A main effect of grammatical functions was established.
- (34) At the matrix-verb region (i.e. right after the head-noun position), adjunct clauses were read faster than relative clauses.

These diverging patterns are enlightening as they demonstrated that relative clauses ought to be distinguished from adjunct clauses and that subordinate clauses involving subject gaps and those involving object gaps differ in processing. The overall pattern is that co-indexations involving subjects in the embedded clauses (both the RC traces and the pros) are easier than those involving objects (found in (32)-(33)). In addition, RCs and adjunct clauses can be distinguished around the head-noun region in (32) and (34).

To sum up, Kwon et al. showed that, in Korean, subordinate clauses involving relativization and those involving pro-drops can be distinguished. Relativization is established as involving dependencies between the head noun and the trace—a process that is distinct from co-referencing involving pronouns and a referent in the discourse. In addition, the different structural positions of the relativized gaps inside the subordinate clauses induce distinct processing difficulties. Subject RCs are generally processed faster than object RCs. This leads to our discussion of subject/object asymmetry in RC processing in §5.3.

5.3 Differential extraction effects of subject and object RCs

In addition to the distinction between RCs and adjunctive clauses as discussed in previous sections, RCs involving different levels of extractions also produced different degrees of processing difficulties. In languages with head-initial RCs, there has been general consensus that subject-extracted RCs are processed with greater ease than object-extracted RCs (see Lin 2006 for a typological review). In languages with head-final RCs, the results have been somewhat mixed. Advantage for subject RCs was reported in most studies (Chinese: Lin & Bever 2006, 2007; Korean: Kwon et al. 2006; Japanese: Ishizuka 2005, Miyamoto & Nakamura 2003, Ueno & Garnsey 2008), while easier comprehension with object RCs was reported by some others (Chinese: Hsiao & Gibson

2003, Wu & Gibson 2008; Japanese: Ishizuka et al. 2006).¹⁹ The different degrees of processing difficulty in relation to the extraction of NPs at different positions (e.g., subject versus object positions) are of great significance, as they would demonstrate whether the parser is sensitive to the positions of the gaps in the internal syntactic structure of the prenominal clauses. Of equal importance are the parsing mechanisms that caused the asymmetry in processing.

The mixed results in head-final RC processing can be attributed to several different sources of influence. Most of the studies that found an advantage for subject extractions supported a structural account for RC processing. Subject positions are universally higher than object positions in terms of the syntactic structure of a clause. When processing prenominal as well as postnominal RCs, a gap located at the subject position should be easier to get at than one located at a lower position. This argument is in line with a universalist view on the structure of RCs. However, a potential competing account for the more laborious comprehension of object RCs has to do with the garden-path effect found on head-final object RCs (as discussed in §4).

The existent studies that claimed to have found an advantage for object RCs all have issues that are unresolved. While Gibson and colleagues argued for an account based on the linear distance between the head noun and the gap in the prenominal clauses (and therefore predicting easier comprehension for object RCs), there has yet been no clear processing evidence for easier comprehension with object RCs. Hsiao & Gibson's (2003) study was confounded by the types of embeddings involved. Their primary finding for an advantage of the object RCs was based on doubly embedded object RCs being easier than the doubly embedded subject RCs. I have pointed out elsewhere that this difference was due to the filler-gap relations in the former being in a serial relationship while those in the subject RCs being in a nested relationship (Lin & Bever 2006).

To tackle the issue of garden-path effects, follow-up experiments with contexts preceding the RCs were designed so that an RC can be appropriately induced (Ishizuka et al. 2006, Wu & Gibson 2008). However, the context they created biased towards easier processing of object RCs than subject RCs (due to the priming of word orders, see Lin & Bever 2007 for detailed discussions). There is, therefore, no clear support for a processing advantage for object RCs.

On the other hand, my recent experiments reexamined this issue taking into account the garden-path effect discussed in §4. Lin & Bever (2007) reduced the possibility of the main-clause garden path by instructing the participants on the existence and position of the RCs. With reduced reading time (due to the removal of the garden path), we still

¹⁹ Note, however, that according to Su et al. (2007), no aphasic data has showed better comprehension of subject RC in Mandarin or Cantonese.

found a processing advantage for subject-extracted RCs.²⁰ We concluded that subject gaps are easier to integrate than object gaps. The fact that the same effect (preference for processing subject RCs) was observed in both head-initial and head-final RCs supported a universal structure-based strategy for filler-gap integration. As subject gaps are located higher syntactically, they are easier to integrate than object gaps.²¹ Therefore, we have processing evidence showing that both head-initial and head-final RCs involve structure-based integration strategies. Even though head-final RCs appear prenominal like other prenominal modifiers, they should be distinguished from prenominal modifiers that are attributive and adjunctive in nature.

6. Conclusion

Even though head-final RCs are prenominal and superficially look like prenominal adjectivals, they contain gaps that are located at specific structural positions. This finding is validated by first removing a main-clause garden-path effect in head-final RCs and then showing that prenominal RCs containing a gap and prenominal adjunctive (relative) clauses are indeed processed differently. The parser is sensitive to the position of the gap in the prenominal RC.

We further provided evidence that the position of a relativized gap produces different processing difficulties. Gaps at subject positions are processed with greater ease than gaps at object positions. These various aspects of RC processing can be accounted for by treating RCs as distinct from noun-modifying adjuncts. Prenominal RCs contain gap positions. They are clauses with internal structures, based on which a dependency between the gap and the filler (i.e. the head noun) is constructed. The evidence provided in this article demonstrated that prenominal RCs have unique processing characteristics and should not be taken as mere adjectivals or attributive clauses.

²⁰ The effect was found on the relativizer of the RC embedded in another RC in a nested filler-gap relationship. We concluded that extraction effects regarding subject and object RCs are most likely to be found when the sentences are demanding on working memory (as in the nested condition).

²¹ The gap that is postulated high in structure can be integrated with the head more easily than a gap that is low. From this perspective, head-final relativization involves gap-to-filler integration, while head-initial relativization involves filler-to-gap integration.

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詞頭在尾關係子句之語句處理基礎

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由於詞頭在尾之關係子句表面上看似其他名詞前的修飾語，許多分析只將此類關係子句當作如同形容詞或狀語等名詞前修飾語，而將之認定為不同於詞頭在首的關係子句。本文旨在檢視詞頭在尾關係子句之語句處理特性，欲證明詞頭在尾的關係子句仍具有內在句法結構及空詞類，而應被視為獨立於其他名詞前修飾語。主要證據來自三方面：首先，在語句理解中，漢語所有格關係子句受所有者在關係句中句法位置所影響，不同於副詞性關係子句；其次，韓文關係子句的理解研究中亦發現涉及位移的關係子句不同於含有零代名詞的副詞子句；第三，漢語中主語提出的關係子句較賓語提出者容易理解，顯示關係子句含有內在句法結構，且空詞類在結構上所佔的位置影響其理解之難易。因此，本文認為詞頭在尾之關係子句具有內在句法結構及空詞類，在語句理解上顯示他們不同於其他的名前修飾語。

關鍵詞：關係子句，語句理解，詞頭在尾結構，漢語