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Garden path and the comprehension of head-final relative clauses

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Abstract This chapter explores the issue of garden path in the comprehension of head-final relative clauses (particularly in Chinese and Japanese). Experimental data from two self-paced reading studies in Chinese were compared, showing the existence of a main-clause garden-path effect on the object-extracted relative clause modifying the object of the matrix clause. Different approaches adopted to indicate an upcoming relative clause (and thus to avoid a potential garden-path effect) are evaluated, including using internal relative-clause markers, classifier-noun mismatches, relativization-inducing contexts, and providing specific instructions on the existence and position of relative clauses in the matrix clauses. The garden-path effect associated with a relative clause can be avoided by using a classifier-noun mismatch along with a carefully constructed referential context. Experiments giving specific instructions on the existence of relative clauses can also diminish the garden-path effect.

Keywords: relative clauses; garden path; sentence comprehension; head-final structures; context.

1. Headedness and the Comprehension of Relative Clauses

Constructing dependent relations between linguistic units has been a central issue in sentence processing research. In order to establish a dependency, the parser needs to detect the dependent elements and to formulate syntactic and semantic relations between these elements. The head plays an important role in sentence comprehension as it specifies subcategorizing and adjunctive relations with other elements within the same phrase and gets integrated with linguistic units outside of the phrase. Two main proposals in sentence processing have been made about the integration process involving the head. One takes an incremental position to argument integrations, positing that arguments are assigned their thematic roles as soon as they come into presence in a sentence (Bader & Lesser, 1994; Miyamoto, 2002). The other argues for a head-driven approach to thematic assign-

ments (Abney, 1989; Pritchett, 1991, 1992), maintaining that thematic roles are not assigned until the head is reached.

In this chapter, we focus on the comprehension of head-final relative clauses. A critical issue in the processing of these relative clauses is when the parser realizes it has encountered a relative clause and whether reanalysis after the temporary ambiguity successfully takes place. Incremental processing and head-driven parsing each have distinct predictions about the comprehension of head-final relative clauses. According to incremental processing, pre-head sequences are analyzed based on top-down heuristics (e.g., Canonical Form Constraints of Bever, 1970 and Townsend & Bever, 2001) and processing strategies such as minimal attachment (Frazier, 1987a). Thus a head-final relative clause creates a garden path for the parser since prior to the head noun, a relative clause is preferably analyzed as a main clause. Based on the head-driven approach, however, the temporary ambiguity prior to the head makes processing laborious since multiple possibilities need to be maintained before the head is reached. In this chapter, the data support an incremental garden-path analysis. We further discuss how such a garden path should be dealt with so that an unbiased comparison between the processing of head-final relative clauses and that of head-initial relative clauses can be made.

In the following sections, we first introduce the structural properties of head-final relative clauses and demonstrate the existence of garden path in Section 2. Section 3 then reviews different approaches to resolve this garden path, and evaluates the degrees of success of each approach. Section 4 discusses the significance of the garden-path effect in studying head-final relative clauses.

2. Structural Properties of Head-Final Relative Clauses and the Issue of Garden Path

Head-final relative clauses present a word order mirroring that of head-initial relative clauses (1-2). Such a typological difference produces distinct filler-gap relations. In a head-initial language like English, the head (i.e., the filler) precedes the relativized gap. When the filler is encountered, the parser initiates a gap-searching process, actively postulating a gap at the earliest possible position in the upcoming string of words (i.e., the Active Filler Strategy, Frazier and d'Arcais, 1989). With head-final relative clauses, however, the head and the relativizer are both linearized to the right of the relative clause. As a result, the gap precedes the filler. Without overt marking, detecting the gap prior to the head noun becomes a challenge for the parser.

(1) head-initial relative clauses
head noun – relativizer – relative clause
filler >>>>>>>>>>>>>>>>> gap
e.g., the guy$_{\text{FILLER}}$ that you bumped into __$_{\text{GAP}}$ yesterday [English]

(2) head-final relative clauses
relative clause – relativizer – head noun
gap >>>>>>>>>>>>>>>>>>>> filler
e.g., ni zuotian pengjian $\_\_{}_{GAP}$ de nage ren_{FILLER} [Chinese]
you yesterday bumped into $\_\_{}_{GAP}$ relativizer that guy_{FILLER}
'the guy that you bumped into yesterday'

A crucial difference in the comprehension of head-initial and head-final relative clauses lies in the relative ordering between the filler and the gap. When the filler precedes the gap as in a head-initial relative clause, the left edge of a relative clause is unambiguously marked by the relativizer. When the filler follows the gap as in a head-final relative clause, however, the parser is additionally challenged by the structural ambiguity prior to the head noun. Since the left edge of the relative clause is not overtly indicated, both a main-clause analysis and a relative-clause analysis are initially possible.

Before presenting processing evidence for this potential misanalysis, let us first consider how relative clauses appear in sentences. In the following, we take Chinese relative clauses as an example. In (3), relative clauses with subject and object extractions appear at sentence-initial positions to modify the subjects of the sentences; in (4), they appear in medial positions to modify the objects of the sentences.

(3) a. Subject-extracted relative clause modifying the subject
dashang shangren de daitu jiandaole jizhe
hurt businessman REL[1] gangster saw reporter
[V N de HN]
'The gangster who hurt the businessman saw the reporter.'
b. Object-extracted relative clause modifying the subject
shangren dashang de daitu jiandaole jizhe
businessman hurt REL gangster saw reporter
[N V de HN]
'The gangster who the businessman hurt saw the reporter.'

(4) a. Subject-extracted relative clause modifying the object
jizhe jiandaole dashang shangren de daitu
reporter saw hurt businessman REL gangster
[V N de HN]
'The reporter saw the gangster who hurt the businessman.'
b. Object-extracted relative clause modifying the object
jizhe jiandaole shangren dashang de daitu
reporter saw businessman hurt REL gangster
[N V de HN]
'The reporter saw the gangster who the businessman hurt.'

[1] REL stands for "relativizer." HN stands for "head noun." CL stands for "classifier." Relative clauses involving subject extractions are abbreviated as SRCs; those involving object extractions as ORCs.

The sentences in (3) begin with relative clauses. A subject relative clause as in (3a) contains a sentence-initial gap, which can be mistaken as a null subject in a main clause (i.e., a subject that is pro-dropped). In Chinese, this sequence can be analyzed as a sentence containing a pro (as in 5a), a PRO (as in 5b), or correctly as a gapped relative clause (as in 5c). Both (5a-b) are main-clause misanalyses; only (5c) is the correct subordinate relative-clause analysis.

(5) a. pro dashang shangren
hurt businessman
'(Somebody) hurt the businessman.'
b. PRO dashang shangren hui dailai gengduo mafan
hurt businessman will bring more trouble
'Hurting businessmen will bring more trouble.'
c. t_i dashang shangren de $daitu_i$ jiandaole jizhe
GAP hurt businessman REL gangster saw reporter
'The gangster who hurt the businessman saw the reporter.'

Object relative clauses like (3b) are also ambiguous prior to the relativizers. These fragments can be misread as part of a main clause (as in 6a) because of its apparent NV order (conveniently mapped onto an agent-action-(patient) template). The correct gap analysis of a relative clause (in 6b) requires postulating more layers of syntactic nodes and is more consuming to construct.[2]

(6) a. shangren dashang yige daitu
businessman hurt one gangster
'The businessman hurt a gangster.'
b. shangren dashang t_i de $daitu_i$ jiandaole jizhe
businessman hurt GAP REL gangster saw reporter
'The gangster who the businessman hurt saw the reporter.'

The discussion so far showed that both subject and object relative clauses can be misread as main clauses before the relativizer and the head nouns. Object relative clauses are especially susceptible to the main-clause misanalysis because of the initial NV sequence following the canonical main-clause order—NVN—in Mandarin Chinese.

When relative clauses modify the object of a sentence, they appear in the medial position of a sentence. Due to the lack of overt marking on the left edge, the leftmost element of a relative clause can be mistaken as part of the ongoing main clause. In the case of a subject relative clause, a PRO analysis in (7a) is still possible, in contrast to a relative-clause parse (like 7b).

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[2] In a sentence completion task, Hsu et al. (2005) found NV fragments predominantly solicited main-clause completions. See also Chapter 14 (Ng & Fodor) of this volume on the interpretation of empty categories in Chinese in relation to the left-edge ambiguity in head-final structures and its interplay with the exitence of a plausible referent in the contexts.

(7) a. jizhe xihuan PRO dashang shangren
reporter like hurt businessman
'The reporter enjoys hurting businessmen.'
b. jizhe xihuan t_i dashang shangren de $daitu_i$
reporter like hurt businessman REL gangster
'The reporter likes the gangster who hurt the businessman.'

An object relative clause is also susceptible to misanalysis. The embedded subject can be mistaken as the object of the main clause, following an apparent NVN order as in 8a, thus calling for subsequent reanalysis at the embedded verb or the relativizer regions. Similar problems of garden path can be found in Japanese and Korean relative clauses.

(8) a. jizhe jiandaole shangren …
reporter saw businessman …
'The reporter saw the businessman ….'
b. jizhe jiandaole shangren dashang t_i de $daitu_i$
reporter saw businessman hurt REL gangster
'The reporter saw the gangster who the businessman hurt.'

The Chinese examples presented above show that in isolated sentence comprehension, garden-path readings are likely to take place. Crucially, since there is no overt marking on the left edge of a relative clause, the parser is constantly challenged by the uncertainty of main-clause versus subordinate-clause analyses.[3]

In the following, we compare two self-paced reading experiments of Chinese relative clauses. In one experiment (hereafter cited as Experiment 1), participants were given specific instructions about the existence and the position of a relative clause in each experimental sentence. The purpose of Experiment 1 was to reduce the possibility of garden path by indicating exactly where in the sentence the relative clause is located so that participants knew where to expect an upcoming relative clause in a sentence. In another (cited as Experiment 2 below), the sentences containing relative clauses were presented along with filler sentences of various syntactic types; no specific instructions about the existence and position of relative clauses were given. In Experiment 2, therefore, there is possibility of garden path described in (5-8), while in experiment 1, the possibility of misreading is greatly

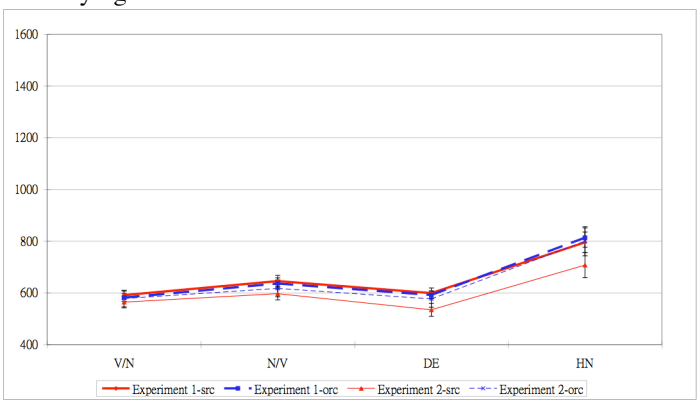
[3] In this chapter, we focus on garden path associated with canonical relative clauses, namely simple relative clauses that involve subject or object extractions. Lin (2006, Experiment 5) investigated "movement-induced" garden path in head-final relative clauses, where topicalization inside a subject relative clause produces an apparent NVN sequence and an unrecoverable garden-path effect:

[$nanyou_i$ fangqiguo haoji wei t_i] de nyuyanyuan conglai bu juede houhui
boyfriend abandoned many CL REL actress always not feel regretful
N V N
'The actress who has abandoned many boyfriends never felt regretful.'

reduced. Comparing the reading patterns in these two experiments will shed light on whether the comprehension of head-final relative clauses without specific cues would involve main-clause garden-path misanalyses.[4]

These two experiments each recruited as participants 48 college students in Taiwan, who were native speakers of Mandarin Chinese. Two factors were investigated in a factorial design--whether the relative clauses modified the subject or the object positions of the main clauses, and whether the relative clauses involved subject or object extractions. Figures 1a-b present the average reading times of the relative-clause regions in these two experiments. In Figure 1a, the relative clauses modified the subjects of the main clauses (as exemplified by 3a-b); in Figure 1b, they modified the objects (exemplified by 4a-b).

a. subject-modifying relative clauses



b. object-modifying relative clauses

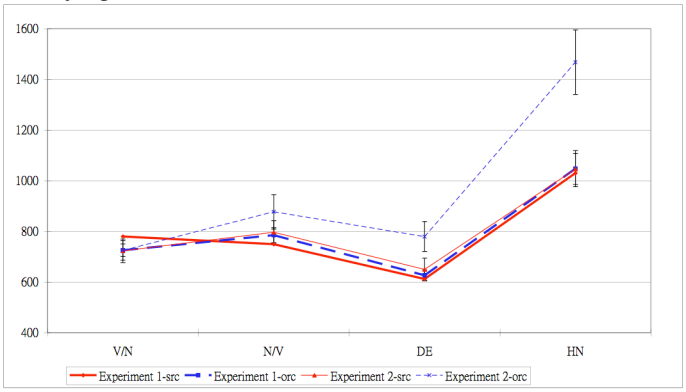


Fig. 1. Reading times (msec) of the relative clauses modifying (a) the subject and (b) the object positions of the main clauses in Experiments 1 & 2.

[4] Experiment 2 cited in this article was first reported in Lin and Bever (2006).

Comparison of these two experiments demonstrated a reading-time increase on the relativizer and the head-noun regions of the object relative clauses in the object-modifying condition when the sentences were read without special instructions about where the relative clauses were located (i.e., in Experiment 2). It is important to note that the increase of reading time was significant only at the relativizer ($F_2(1, 23) = 17.85$, $p < .001$) and the head noun ($F_2(1, 23) = 4.13$, $p < .05$) of the object-modifying object-extracted relative clause, not at the pre-head relative-clause regions, and not on the subject-extracted relative clauses. This reading-time increase demonstrated that object relative clauses that modified the objects of the main clauses are especially susceptible to garden-path readings. When the participants were provided with information about where the relative clause was located as in Experiment 1, the garden-path reading (with increased reading times) was not observed.[5]

In summary, head-final relative clauses are susceptible to garden-path readings due to the lack of markings on the left edge. According to the self-paced reading data, such a garden path was not obvious when the relative clauses appeared at the subject-modifying position (e.g., 5-6). However, when the relative clauses appeared at the object-modifying position and when they involved object extractions, the superficial NVN sequence engenders a main-clause illusion and induces a garden-path parse (e.g., 8). When the participants were expecting a relative clause (as instructed in Experiment 1), however, this garden-path effect was not observed.

This comparison has two important implications. First, head-final relative clauses that appear at sentence-initial positions are not severely garden-pathed. That is, multiple parses may be maintained for superficial NV and VN sequences. However, when the superficial sequence appears to be argument-complete (e.g., NVN) as in the object-modifying object relative clauses, the parser is committed to a main-clause misanalysis. Second, this comparison demonstrated that overt instructions about the existence of relative clauses are able to reduce the garden-path effect on head-final relative clauses. This latter methodological implication is further discussed in 3.4.

3. Attempts to Avoid the Garden Path

If one attempts to compare the processing of head-final relative clauses with that of head-initial relative clauses, the issue of garden path discussed in Section 2

[5] Even though the reading time on the head noun in the object-modifying object relatives was long (over 1400 ms), the comprehension accuracies were over 95% and did not differ across conditions (e.g., Experiment 2: SRC-S modification 97%, ORC-S modification 95%, SRC-O modification 97%, ORC-O modification 96%), suggesting that after reanalysis, the parser was able to reach similar comprehension accuracies regardless of the garden path. Note also the possibility that the long reading time on this position was partly due to the end-of-sentence wrap-up effect, thus enlarging the differences.

has to be considered. Much previous sentence processing research has focused on the processing differences between subject and object extractions in head-initial languages (Brazilian Portuguese: Gouvea, 2003; Dutch: Frazier, 1987b; Mak, Vonk, & Schriefers, 2002; English: Ford, 1983; King & Just, 1991; Gibson, Desmet, Grodner, Watson, & Ko, 2005; Traxler, Morris, & Seely, 2002; King & Kutas, 1995; French: Frauenfelder, Segui, & Mehler, 1980; Cohen & Mehler, 1996; Holmes & O'Regan, 1981; German: Schriefers, Friederici, & Kuhn, 1995; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995). So far, there is little dispute that subject extractions are easier to comprehend in head-initial relative clauses. In English, for example, (9) is easier than (10) according to self-paced reading studies (King & Just, 1991), eye-movement studies (Traxler et al., 2002), and ERP studies (King & Kutas, 1995).

(9) The gangster who hurt the businessman saw the reporter.
(10) The gangster who the businessman hurt saw the reporter.

There are various plausible explanations for this advantage on subject extractions. A locality-based working-memory account (Gibson, 1998), a structural account (Lin, 2006; O'Grady, 1997), and a canonical templatic account (Bever, 1970) are all compatible with this subject advantage in head-initial languages (see Hsiao & Gibson, 2003 and Lin, 2006 for reviews of these accounts). Head-final languages, on the other hand, distinguish among the predictions of these theories, making it possible to test the validity of these accounts.

Much research has recently been conducted regarding subject versus object extractions in head-final relative clauses (Chinese: Hsiao & Gibson, 2003; Lin & Bever, 2006, 2007; Lin & Garnsey, this volume; Packard, Zhang, & Zhou, this volume; Qiao & Forster, 2008; Wu & Gibson, 2008; Korean: Kwon, Polinsky, & Kluender, 2004, 2006; Japanese: Ishizuka, 2005; Ishizuka, Nakatani, & Gibson, 2006; Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008). Given that the issue is about extractions out of subject and object positions, the additional problem induced by garden path in head-final relative clauses need to be controlled for. As discussed in Section 2, there is potentially more garden path on object relative clauses than subject relative clauses in object-modifying relative clauses. Therefore, research investigating extraction effects of head-final relative clauses needs to consider the issue of garden path (especially when they appear in the medial positions of the main clauses) so that a fair comparison between extraction effects in head-initial and head-final relative clauses can be made.

In this section, we review previous attempts to tackle the garden-path issue in head-final relative-clause processing. In particular, we examine whether and how garden path could be successfully avoided. We restrict this review to sentence comprehension in Chinese, Japanese, and Korean. Japanese and Korean are both strictly head-final. The basic word orders in Japanese and Korean are SOV. In both languages, the pre-head nominal entities are case-marked. The primary difference between these two languages is the existence of the suffix *-n* on the em-

bedded verb functioning as a relative-clause marker in Korean. Examples of relative clauses in Japanese and Korean are provided in (11) and (12) respectively.

(11) a. Japanese SRC (Miyamoto & Nakamura, 2003, p. 343)
[__ tosiyorino obaasan-o basutei-made miokutta] onnanoko
elderly woman-acc bus stop-to accompanied girl
'the girl that accompanied the elderly woman to the bus stop'

b. Japanese ORC (Miyamoto & Nakamura, 2003, p. 343)
[tosiyorino obaasan-ga __ basutei-made miokutta] onnanoko
elderly woman-nom bus stop-to accompanied girl
'the girl that the elderly woman accompanied to the bus stop'

(12) a. Korean SRC (Kwon, p.c.)
[__ naitun pwuin-ul bes cenkecang-kkaci tonghayngha]-n sonye
elderly woman-acc bus stop-to accompany-REL girl
'the girl that accompanied the elderly woman to the bus stop'

b. Korean ORC (Kwon, p.c.)
[naitu-n pwuin-i __ bes cenkecang-kkaci tonghayngha]-n sonye
elderly woman-nom bus stop-to accompany-REL girl
'the girl that the elderly woman accompanied to the bus stop'

In Chinese, however, the head positions are mixed. In the verbal domain, Chinese is head-initial. The object follows the verb, resulting in the same canonical order SVO as in English. In the nominal domain, however, it is head-final, with the nominal modifiers appearing prior to the nominal heads.

The challenge posed by a head-final relative clause is that no overt marking indicates its left edge. In order to adopt a relative-clause parse in left-to-right incremental processing, the relative clause needs to be motivated before it appears. So far, researchers have adopted both covert and overt cues to indicate the existence of a head-final relative clause. Overt cues included grammatical markings inside the relative clauses, and special instructions about the existence of relative clauses in the experimental design. Covert cues included referential contexts that motivate relative clauses and semantic clashes that indicate syntactic discontinuity. We evaluate each of these in turn.[6]

3.1. Markings Inside the Relative Clauses

In Chinese, object relative clauses can be optionally marked by the preverbal marker *suo* as in (13).[7] *Suo* does not appear in main clauses; therefore, when it ap-

[6] See research by Kang & Speer (2003) and Kang, Speer, & Nakayama (2004) on how prosody facilitates the identification of clausal boundaries in head-final languages, such as Korean and Japanese.

[7] See Chiu (1995) and Ting (2003) for relevant syntactic analyses of *suo*.

pears, it indicates the existence of an object relative clause. In an offline sentence completion experiment, Hsu, Phillips, and Yoshida (2005) used sentence fragments containing *suo* (e.g., *laoshi xiang xuesheng <u>suo</u>* … —'teacher to students SUO …') and was able to induce more completions of relative clauses than when they used sentence fragments without *suo*.

(13) shangren (suo) dashang de daitu jiandaole jizhe
businessman (SUO) hurt REL gangster saw reporter
'The gangster who the businessman hurt saw the reporter.'

In an on-line self-paced reading experiment, Hsu et al. (ibid.) compared the processing of object relative clauses with and without the marking of *suo*. They found that the parser slowed down upon reaching *suo* due to its general lower frequency of occurrence. When the parser reached the relativizer and the head noun, however, the reading time was shorter in sentences with *suo* than in those without it. The results suggested that *suo* did successfully indicate the existence of an object relative clause in the sentence. Without it, an object relative clause was more difficult to process due to the temporary ambiguity.

The sentence-completion and self-paced reading results showed that *suo* can indeed indicate an object relative clause before the head-noun regions. Nevertheless, there are critical insufficiencies about using *suo* markings to indicate Chinese relative clauses. First, *suo* appears before the embedded verb inside an object relative clause. The embedded subject is not marked and can still be incorrectly treated as part of a main clause (i.e., the kinds of garden path described in (6) and (8)). Even though these sentences are disambiguated relatively early, the possibility of a garden path is still not removed. Second, *suo* only marks relative clauses with object extractions in Chinese. Since there is no equivalent marker in subject-extracted relative clauses, it is not possible to compare subject and object relative clauses by using *suo*.

3.2. Classifier-Noun Mismatch

In East-Asian languages, such as Chinese, Japanese, and Korean, nominal classifiers appear before count nouns under constraints on semantic consistency. Different classifiers selectively co-occur with nouns that share semantic properties in terms of shape and other physical dimensions. In Chinese, for instance, the classifier *tiao* denotes nominal entities that are thin, long and flexible in shape. Nouns such as *shengzi* 'rope', *she* 'snake', *malu* 'road', but not *gunzi* 'rod' or *xiang* 'elephant,' co-occur with the classifier *tiao* as in (14).

(14) a. yi tiao she
one CL snake
'a snake'

b. *yi tiao xiang
one CL elephant
'an elephant'
c. yi tiao [xiang caibian de] she
one CL elephant step-flat REL snake
'a snake that an elephant stepped on (and became flat)'

The agreement between the classifier and the noun phrase following it has therefore been used to indicate potential constituent boundaries. In (14c), for instance, the fact that *tiao* and *xiang* cannot compose one constituent implies that *xiang* should be part of a different phrase. Thus a relative-clause boundary may be postulated between *tiao* and *xiang*.

Yoshida, Aoshima, & Phillips (2004), Hsu, et al. (2005), and Hsu, Hurewitz, & Phillips (2006) used this classifier-noun mismatch to indicate a relative-clause boundary. Yoshida et al. (2004) found that, in Japanese, the reading time at the disambiguating region (i.e., the embedded verb *yonda* in 15) was shorter in the classifier-noun mismatch condition. Classifier-noun mismatch was picked up as an indicator of an embedded relative clause in Japanese.

(15) [san-satu-no [sensee-ga yonda] hon]…
three-Classifier(book)-Gen teacher-Nom read book
'three books that the teacher read' (Yoshida et al. 2004)

In Chinese, however, Hsu et al. (2005) did not find similar patterns when using classifier-noun mismatch as the only cue for relative clauses. Instead, they found longer reading times on the mismatching condition (16) than the matching condition (17) starting from the mismatching noun phrase till the head noun region.

(16) laoshi caixiang na-si-pian yonggong-de xuesheng zaoshang
teacher guess that-four-CL(article) diligent student morning
jingchang yu tongxue taolun de wenzhang …
often with classmate discuss REL article
'The teachers thinks that the four articles that the diligent students often discussed with a classmate in the morning …' (Hsu et al., 2007)

(17) laoshi caixiang na-si-wei yonggong-de xuesheng zaoshang
teacher guess that-four-CL(human) diligent student morning
jingchang yu tongxue taolun de wenzhang …
often with classmate discuss REL article
'The teachers thinks that the four articles that the diligent students often discussed with a classmate in the morning …' (Hsu et al., 2007)

Classifier-noun mismatch alone was not adequately suggestive of a relative-clause parse in Chinese. Comparing the Chinese and Japanese materials in (15) and (16), it seems plausible that when the mismatching noun phrase follows the

classifier in Chinese, the parser is still inclined to treat the classifier and the adjacent noun phrase as one classifier phrase. Such a misconstrued classifier-NP constituent is taken as syntactically well-formed but semantically incongruent. In such cases, the classifier-noun mismatch induced a surprisal effect but not a correct syntactic reanalysis; therefore, an embedded relative clause was not successfully postulated. With incongruity as such, it is likely that the parser never arrived at the correct parse (Ferreira, 2003; Lin, 2008).[8] In Japanese, however, the genitive marker *no* makes a potential phrasal boundary salient, thus possibly increasing the likelihood of a relative-clause analysis.

In a follow-up experiment, Hsu et al. (2006) tested the disambiguating power of classifier-noun mismatch with the help of a felicitous context (which provided a narrowed set of referents consistent with the mismatched classifier and the head noun). Sentences with classifier-noun mismatches were then indeed read faster on the head-noun region. With appropriately designed contexts, the parser can then treat classifier-noun mismatch as an indicator of a relative-clause boundary. This leads to our discussion on the role of context in the processing of head-final relative clauses.

3.3. Context That Induces Relative Clauses

Crain and Steedman (1985, p.342) showed that an appropriate referential context facilitates a relative-clause parse in the target sentence following the context. They contrasted two kinds of contexts, one with and one without contrasting referents. When they presented a context without contrasting referents as in (18), a complement clause like (20) was preferred. When the context provided referents that need to be further specified as in (19), then a reduced relative clause like (21) became the preferred parse.

(18) Context that induces a complement clause
A psychologist was counseling a married couple. One member of the pair was fighting with him but the other one was nice to him.

(19) Context that induces a relative clause
A psychologist was counseling two married couples. One of the couples was fighting with him but the other one was nice to him.

(20) Complement target sentence
The psychologist told the wife that he was having trouble with her husband.

[8] Hsu et al. surmised that the longer reading times on the true head nouns in the mismatching condition may be due to the larger integration cost between a distant classifier and the real matching head noun in (16).

(21) Relative target sentence
The psychologist told the wife that he was having trouble with to leave her husband.

Relative clauses, as discussed, serve particular pragmatic functions within context. They increase "referential coherence" in texts, and tend to appear "when the speaker assumes that the referent's identity is accessible to the hearer—but not easily accessible (Givon, 1993, p.108)."[9] The propositional content inside a relative clause usually refers to the knowledge about the referent that is already familiar to the hearer.[10]

A reasonable way to induce a relative clause is therefore to provide a context such as the sort constructed by Crain and Steedman (1985). Since a relative clause can help select a referent from a set of referents previously mentioned, an appropriate context constructs a situation in which a small set of referents compete to be selected as the topic of the text that follows.

As mentioned in 3.2, Hsu et al. (2006) used contexts in addition to classifier-noun mismatches to induce relative clauses. Following Crain and Steedman (1985), they contrasted two kinds of contexts. The first context provided two referents of the same kind (as illustrated by 22) followed by a target relative clause selecting one of the referents. The second context provided two different kinds of referents (as illustrated by 23). Self-paced reading results showed that when the relative clause served to select between referents of the same kind as in (22), a sentence in which the left edge of the relative clause was indicated by a classifier-noun mismatch was read with greater ease. That is, the classifier-noun mismatch works with a felicitous context to foreshadow a relative clause. In (23), where the

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[9] Givon (1993, p.108) summarizes the referential properties of Restrictive Relative Clauses (RRCs) in terms of "referent tracking strategies" as the following:

a. The speaker assumes that a certain state or event is known, familiar or mentally accessible to the hearer.
b. The proposition corresponding to that familiar state/event is thus pragmatically presupposed.
c. The referent to be identified is a participant—subject, direct object, indirect object, etc.—in the state or event coded in the proposition.
d. The familiar proposition thus helps guide the hearer toward identifying the referent in his/her mentally stored knowledge. It grounds the referent in the hearer's knowledge-base.
e. The proposition used for such grounding is coded syntactically as a RRC.

Chinese relative clauses are not overtly marked regarding restrictiveness. Most relative clauses are restrictive. It remains controversial whether non-restrictive relative clauses exist in Chinese. See Lin (2003) for a review of this controversy.

[10] The information status inside sentences with relative clauses also matters. Gibson et al. (2005) compared relative clauses that appeared early (e.g., modifying the subject of the matrix clause) and those that appeared late (e.g., modifying the object of the matrix clause) in a sentence. They showed that relative clauses are read with greater ease when they appear early in the sentence. The propositional content inside the relative clause serves as grounding information within the sentence, referring to knowledge already present in text or new information that is not likely to be challenged (i.e., Givon's pragmatic definition of a restrictive relative clause). As relative clauses serve to ground the referent as old information in the sentence, they tend to appear early, e.g., in the subject position.

context did not provide a need for further specification, the grounding information provided by a relative clause was redundant, and the classifier-noun mismatch was insufficient to indicate a relative-clause parse.

(22) Context with two same kinds of referents: The college student upstairs has two motorcycles. He does not maintain one of the motorcycles, but he maintains the other motorcycle very carefully.
Target sentence: This semester, the motorcycle that the college student maintained carefully was stolen.

(23) Context with different referents: The college student upstairs has one motorcycle and one computer. He does not carefully maintain his computer, but he maintains his motorcycle very carefully.
Target sentence: This semester, the motorcycle that the college student maintained carefully was stolen.

Ishizuka et al. (2006) and Wu and Gibson (2008) also adopted referential contexts prior to their target relative clauses (as in 24). The goal was to motivate a relative clause to avoid potential garden-path effects.[11]

(24) A reporter interviewed a writer on a TV program. Then the writer interviewed another reporter for his new novel.
Taro: "Which reporter stands as a candidate for the election?"
Hanako: "It seems to be the reporter who {the writer interviewed / interviewed the writer}." (Ishizuka et al., 2006)

Again, to evaluate whether a garden-path effect was successfully avoided, one needs to compare the reading patterns in the experiments with and without a context. With contexts, Ishizuka et al. (2006) and Wu and Gibson (2008) both reported easier comprehension on object extractions. Ishizuka et al.'s (2006) findings in Japanese contrasted with findings by Ishizuka (2005), Miyamoto and Nakamura (2003), and Ueno and Garnsey (2008), who presented relative clauses without contexts and found comprehension advantages for subject extractions. Wu and Gibson's results in Chinese also contrasted with the subject-extraction advantage reported by Lin and Bever (2006).[12] It was suggested that when relative clauses are presented in isolation, the advantage for a subject extraction may be

[11] Hsu and Chen (2007) adopted similar contexts and are subject to similar problems as those discussed below.

[12] See Lin & Bever (2006) for critiques on the object-extraction advantage reported by Hsiao & Gibson (2003), which was, in fact, an effect resulting from nested dependencies being more difficult than serial dependencies. In a self-paced reading experiment focusing on doubly-embedded relative clauses (Lin & Bever, 2007), it was shown that the effect of dependency types (nested dependencies being harder than serial dependencies) contributed to the advantage of object extractions reported by Hsiao and Gibson.

due to the garden-path effect on object extractions. When relative clauses are presented in context, an advantage for object relative clauses is actually obtained.

Several crucial aspects about these experiments need to be considered to evaluate the significance of their results. While a context potentially motivates the occurrence of a relative clause, it also brings forth irrelevant effects. In both studies, the context was about three referents (two were of the same kind and one was of a different kind). The head of the target relative clause was one of the two referents of the same kind. The format of the context was the following:

(25) Context of Ishizuka et al. (2006) and Wu and Gibson (2008):
   a. A verbed B, and
   b. B verbed another A.

(26) Target sentence of Wu and Gibson (2008):
   a. Subject relative clause:
      [__ verbed B] relativizer A (meaning 'the A that verbed B')
   b. Object relative clause:
      [B verbed __] relativizer A (meaning 'the A that B verbed')

When the target relative clause (in the form of (26a-b)) was read after the context in (25), (26b) was found to be comprehended faster than (26a). It is crucial to note that thematic priming effects may exist between the context and the target sentence to facilitate the comprehension of the object relative but not the subject relative. That is, the context itself highlights the canonical thematic order (NVN mapping onto Agent-Action-Patient in Chinese, and N-nominative N-accusative V mapping onto Agent-Patient-Verb in Japanese), which appears in the object relative, but not the subject relative. The fact that (26b) maps directly onto the context (25b) maintaining an NVN order in Chinese, while (26a) does not, potentially makes (26b) easier than (26a). This processing asymmetry, therefore, had nothing to do with subject versus object extractions per se. This was indeed confirmed by Lin's (2009b) self-paced reading experiments manipulating the thematic orders in the contexts. It was found that when (25b) was passivized, with the thematic roles repositioned as Patient-Agent-Verb, the advantage for the object relative could no longer be obtained.

To sum up, an appropriately constructed referential context does facilitate the processing of relative clauses. However, it is crucial to attend to the potential thematic priming effects introduced by the context.

3.4. Overt Instructions on the Existence of a Relative Clause

Even though providing a context is a natural way to induce relative clauses, the fact that there is no context that ensures the appearance of a relative clause and that the context itself may affect the comprehension of the target sentences calls

for a more controlled experimental methodology. An extreme version to ensure the participants know they are reading head-final relative clauses is to simply tell them they are doing so in the experimental instructions. Lin and Bever (2007) explicitly instructed the participants that all the experimental sentences contained relative clauses. In addition, we specified the exact position of the relative clause inside the sentence—whether it appeared early in the sentence, modifying the subject position, or late modifying the object of the sentence.[13] The goal was to ensure that there is no ambiguity in the reading of these head-final relative clauses since the participants knew exactly where to expect relative clauses in the experimental sentences.

As discussed earlier in Section 2 (summarized in Figure 1), reading times collected in this way (Experiment 1) were reduced on the relativizer and head-noun regions (but not at the pre-relativizer regions). We concluded that with instructions like those of Lin and Bever (2007), the parser was indeed expecting the coming of a relative clause, and thus no garden-path effect or reanalysis took place on the relativizer and head-noun regions. This methodology makes it possible to evaluate the processing differences between subject and object extractions in head-final relative clauses. We found an advantage for subject extractions at the relativizer and the head-noun regions of doubly embedded (nested) relative clauses. No advantage was found on object extractions. This finding was consistent with the greater number of subject relatives found in the Chinese Treebank corpus (Wu, Kaiser, & Anderson, this volume; Lin, 2009a)

4. Implications

In this chapter, we demonstrated the garden-path effect in the processing of head-final relative clauses and evaluated the different methods that have been adopted to deal with it. Our discussions on this garden-path effect have the following implications.

In terms of headedness and sentence processing, it was demonstrated that a head-final relative clause is susceptible to garden-path readings due to the lack of markings on the left edge. The parser constructs syntactic structures incrementally before the head is reached, preferably following the canonical word orders in the language (Bever, 1970). The comparison between subject-modifying relative clauses and object-modifying relative clauses reveals a garden-path analysis when the sequence follows an apparent canonical NVN order. Unless otherwise motivated, a relative-clause analysis is only postulated as a last resort—when the disambiguating regions, including the relativizer and the head noun, are reached. This

[13] The participants were provided with examples of relative clauses in the instructions. All the sentences with subject-modifying relative clauses were presented in one block. All sentences with object-modifying relative clauses were presented in a separate block. Sentences with single layers of relative clauses and those with double layers of relative clauses were tested separately.

garden-path effect was found on object-extracted relative clauses modifying the object of the main clause due to the superficial NVN main-clause illusion. However, relative clauses that modify subjects did not show the same garden-path effects, suggesting the possibility that when a sentence-initial NV sequence and a VN sequence are encountered, multiple parses (e.g. main clauses and relative clauses) may have been maintained.

In terms of a general processing theory for relative clauses in both head-initial and head-final languages, one needs to consider both the similar and the different factors that are involved. A head-initial relative clause is unambiguously marked on its left edge with a relativizer (with the exception of a reduced relative clause like *the horse (which was) raced past the barn*); therefore, the cost of processing is primarily associated with filler-gap integrations. In head-final relative clauses, however, the gap precedes the filler, creating temporary ambiguity. Hence, in addition to costs on filler-gap integrations, there is cost on ambiguity resolution. Research focusing on issues of locality, filler-gap integration, and relativization effects in head-final relative clauses should therefore attend to the issue of temporary ambiguity and the garden-path effect.

Last but not least, relativization-inducing contexts should be used with caution. Even though a context provides a natural condition for the comprehension of certain structures, they also serve as a primary source of influence on the processing of the target sentences. As relative clauses serve to increase referential coherence by choosing from a set of plausible candidates, an infelicitous context (such as a context that provides two distinct kinds of referents) does not motivate a relative clause. The thematic ordering inside the context also affects the reading patterns in the target sentences. These specific properties within contexts should all be controlled for to better understand the filler-gap effects and to ultimately theorize filler-gap integrations based on the processing of both head-initial and head-final relative clauses.

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