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Processing Chinese relative clauses in context

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This paper presents a self-paced reading experiment comparing the processing of subject-extracted relative clauses (SRCs) and object-extracted relative clauses (ORCs) in supportive contexts in Chinese. It is argued that lack of a consistent pattern in the literature for the comparison between Chinese SRCs and ORCs is due to potential temporary ambiguity in these constructions in null contexts. By placing the materials in contexts biased towards a relative clause (RC) interpretation, we limit the effects of temporary ambiguity. The results of the experiment demonstrate that SRCs are read more slowly than ORCs in supportive contexts. These results provide evidence for working memory-based sentence processing theories whereby processing difficulty increases for connecting sentence elements that are further apart. Some convergent evidence that strengthens these conclusions comes from recent research on aphasic populations where a dissociation between English and Chinese RC processing has been revealed: whereas English aphasic patients have more difficulty with ORCs and Chinese aphasic patients have more difficulty with SRCs (Su, Lee, & Chung, 2007). Taken together, these results support the idea that sentence processing is constrained by working memory limitations.

Keywords: Sentence processing; Syntactic complexity; Relative clause; Working memory.

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1. INTRODUCTION

Relative clause (RC) structures have proven useful in evaluating theories of sentence comprehension, because they allow researchers to examine how different clausal word orders affect processing difficulty within and across languages. Researchers have most often compared the processing of subject-extracted relative clauses (SRCs) with object-extracted relative clauses (ORCs) – the two most common types of RCs cross-linguistically (Keenan & Comrie, 1977) – using animate noun phrases (NPs) in both subject and object positions, so that the meanings of the two clauses can be as similar as possible. For example, consider the English RCs modifying the subject NP “the reporter” in (1):¹

- (1) a. SRC
 The reporter who attacked the senator admitted the error.
 b. ORC
 The reporter who the senator attacked admitted the error.

In (1a), the *wh*-element “who” is the subject and agent of the embedded verb “attacked”. In (1b), on the other hand, “who” is interpreted as the object and patient of “attacked”. There are two ways to control for potential meaning differences across the two structures: (i) match the two events (a reporter attacking a senator and a senator attacking a reporter) for their likelihood in the world (in this particular example, the two events are equally likely: a reporter is just as likely to attack a senator as vice versa); or (ii) include two further versions of the structure in which the NPs switch positions, as in (2) (e.g., Fedorenko, Gibson, & Rohde, 2006):

- (2) a. SRC
 The senator who attacked the reporter admitted the error.
 b. ORC
 The senator who the reporter attacked admitted the error.

The SRCs in (1a) and (2a) have identical thematic content as the ORCs in (2b) and (1b), respectively, so averaging responses across these two pairs of conditions controls for any effects of the plausibility of the events while preserving the ability to compare across identical lexical items across conditions. In addition to comparing RCs modifying the main clause subject position of a sentence as in (1) and (2), researchers also sometimes compare

¹ Following standard conventions in the sentence processing and linguistics literature, we will indicate the grammatical position in the embedded clause which the relativiser is co-indexed with (e.g., subject or object position) as an underscore (), indicating that it is a phonologically empty position. The existence of the empty element is not critical to the accounts that are discussed here.

SRCs and ORCs modifying other syntactic positions, such as the object position of a main clause (e.g., for English, Gibson, Desmet, Grodner, Watson, & Ko, 2005). The extraction effect is typically the same independent of the syntactic position of the RC.²

Cross-linguistically, SRCs with animate subjects and objects have generally been found to be easier to comprehend than ORCs of the same type (English: Gibson, 1998; Grodner & Gibson, 2005; King & Just, 1991; Wanner & Maratsos, 1978; French: Holmes & O'Regan, 1981; German: Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Schriefers, Friederici, & Kuhn, 1995; Dutch: Frazier, 1987; Mak, Vonk, & Schriefers, 2002, 2006; Japanese: Ishizuka, Nakatani, & Gibson, 2003; Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008; Korean: Kwon, Polinsky, & Kluender, 2006). For example, in a subject-verb-object language like English, ORCs with animate subjects and objects have been found to be more difficult to process than corresponding SRCs according to a number of measures, including on-line lexical decision for a word presented during the RC, reading times (RTs) and response accuracy to probe questions (King & Just, 1991; among others; see Gibson, 1998, for a review). In English reading time experiments, RTs are typically slower in the ORC condition when processing the embedded verb "attacked" often spilling over onto the following word(s) as compared with the same regions in the SRC condition.

There are two general classes of theories explaining this kind of result: (1) *experience- and surprisal-based theories*; and (2) *working memory-based theories*, which include two general subclasses, each of which has several variants. We discuss each in detail below.³

² To the extent that there are complexity differences across positions, these differences may be due to differences in temporary ambiguity across positions, which may be especially relevant to languages without relative pronouns, to be discussed below.

³ According to a third class of explanations of RC complexity, the difficulty in understanding an embedded clause depends on whether or not the same *perspective* is used in the embedded clause as in the main clause. The perspective of a clause is defined to be its subject (MacWhinney, 1982; MacWhinney & Pleh, 1988). According to this hypothesis, ORCs modifying subject NPs are more complex than SRCs modifying subject NPs, because it is necessary to switch the perspective from the subject of the main clause to the subject of the embedded clause in the case of ORCs. In contrast, no switch is needed for an SRC modifying a subject NP.

Although this hypothesis can account for some aspects of the pattern of results for RCs modifying subject NPs, it does not account for results in which RCs modify other positions in sentences. For example, the perspective theory predicts that SRCs and ORCs modifying object NPs should not differ in complexity, because both involve a similar perspective shift away from the subject of the main clause, and should both be more complex than SRCs modifying subject NPs. But this pattern of data is not observed. In fact, the complexity difference that is observed for RCs modifying subject NPs is also present for RCs modifying object NPs (Gibson et al., 2005), contrary to the predictions of the perspective account. Consequently, the perspective account has not recently been promoted as a viable alternative to experience-based and working-memory-based theories.

1. *Experience- and surprisal-based theories.* According to these accounts, people's ease or difficulty in sentence comprehension is predicted by their experience in encountering similar words and structures in the past: the more common a construction is, the less difficulty it will cause in comprehension (Gennari & MacDonald, 2008; Hale, 2001, 2003; Keenan & Comrie, 1977; Levy, 2008). These accounts hypothesise that because ORC structures with animate subjects and objects are less frequent than corresponding SRC structures in sentence production (for relevant English corpus statistics, see Roland, Dick, & Elman, 2007), an SRC like (1a) is more expected than an ORC like (1b) following the word "who". Experience-based theories therefore predict complexity when the embedded subject NP (e.g., "the senator" in 1b and "the reporter" in 2b) is encountered in the ORC version, because it is the less expected continuation.

The earliest version of an experience-based account of RC complexity differences is due to Keenan and Comrie (1977), who observed that there is a subset relationship among languages with respect to whether a language allows RC extraction from a particular grammatical position. All languages allow extraction from subject position, but only a subset of languages allow extraction from direct object position, and only a subset of those languages allow extraction from indirect object position, etc. Keenan and Comrie proposed that a syntactic position is more or less "accessible" based on its position in this subset ordering (with subject position being the most accessible). Furthermore, they proposed that there is a greater processing cost associated with extracting elements from less accessible positions. The most plausible potential explanation for the accessibility-based idea is in terms of experience: extractions from less accessible positions are less frequent in the input than extractions from more accessible positions, leading to greater difficulty in processing the former. Later experience-based proposals have formalised the idea of experience in terms of notions like surprisal (Hale, 2001; Levy, 2008) or entropy (Hale, 2003).

2. *Memory-based theories.* According to memory-based theories, ORCs are more difficult to process than SRCs because they require more working memory resources. Two kinds of processes involved in sentence comprehension have been argued to require working memory, leading to two subclasses of memory-based accounts: (1) maintaining predictions about upcoming syntactic elements ("storage costs"); and (2) retrieving earlier encountered representations from memory when assembling the structures ("retrieval/integration costs"; both terms are commonly used, but we will use retrieval costs here).

- a. *Storage cost accounts.* Under the storage cost proposal, there is a cost associated with maintaining incomplete dependencies (e.g., Chomsky & Miller, 1963; Gibson, 1991, 1998, 2000; Lewis, 1996; Nakatani & Gibson, 2010; Stabler, 1994). This factor can potentially provide an explanation for the greater difficulty of ORCs relative to SRCs. For example, after processing the embedded subject “the senator” in (1b), there are three incomplete dependencies: one between the main clause subject “the reporter” and its predicted main verb; a second between the embedded subject “the senator” and its predicted verb; and a third between the wh-element “who” and its predicted object position at the embedded verb. In contrast, there are at most two incomplete dependencies when processing the SRC version in (1a). For example, when processing the word “who” in (1a), there is an incomplete dependency between the main clause subject “the reporter” and its predicted main verb, and there is an incomplete dependency between the wh-element “who” and the embedded verb.
- b. *Retrieval-cost accounts.* Under a retrieval cost proposal, there is a cost associated with retrieving elements from memory that need to be connected with incoming elements in order to form a structure for a sentence. ORCs are more complex than SRCs under this kind of proposal because the retrievals are more costly on average in ORCs compared to SRCs, often because the connections between dependencies are longer in ORCs than in SRCs. Two nonmutually exclusive general explanations of retrieval difficulty have been proposed (several concrete proposals have been advanced building on each of these explanations):
- i. According to the first explanation, the difficulty of retrieving the first element of the dependency at the time of processing the second element of the dependency is due to the *decay* in the activation of the representation of the first element as additional elements are being processed. Under such a decay-based framework, Gibson (1998, 2000) and Warren and Gibson (2002) have proposed that distance between syntactic dependents might be quantified in terms of the number of new discourse referents (nouns and verbs) intervening between the two relevant sentence elements. Warren and Gibson (2002) also consider a decay-based metric in terms of the surface type of intervening NPs (e.g., pronouns vs. names vs. definite descriptions), and Gibson (1998) considers a decay-based metric in terms of the number of intervening words (cf. Hawkins, 1994, for a word-based production difficulty metric). An important variant of a decay-based proposal comes from Lewis and Vasishth (2005), Lewis, Vasishth, and Van Dyke (2006), and Vasishth & Lewis (2006). According to

Lewis and colleagues, retrieval difficulty is determined not by some function of the linear distance between the syntactic dependents, but by the history of retrievals of the first element of the dependency (cf. Gibson, 1998, for a similar idea). In particular, if an item has been reactivated since it was first accessed, then its activation will increase. Thus, retrieval difficulty is affected by decay modulated by recent retrievals.⁴

ii. According to the second explanation, retrieval difficulty is due to *interference* of the elements intervening between the two ends of a dependency with the representation of the first (to-be-retrieved) element (Gordon, Hendrick, & Johnson, 2001, 2004; Lewis & Vasishth, 2005; Lewis et al., 2006; McElree, Foraker & Dyer (2003)). For example, under Lewis, Vasishth, and Van Dyke's model in an ORC, the difficulty of retrieving the head noun associated with the object position of the RC verb is affected by the match of the intervening element(s) to the constraints imposed by the retrieval cues at the verb. In particular, a better fit between an intervening element and the retrieval cues will lead to greater difficulty of retrieving the target element (e.g., Van Dyke & McElree, 2006).

The two main classes of accounts of RC processing – experience-based and working memory-based accounts – are not mutually exclusive. That is, aspects of both experience-based and working memory-based theories might be correct. Indeed, there is evidence for each class of theories that the other class of theories cannot easily explain. With respect to experience-based theories, several studies have shown that the relative difficulty of ORCs vs. SRCs depends on the types of NPs in the RCs and the head noun which the RC modifies (Gennari & MacDonald, 2008, 2009; Mak et al., 2002, 2006; Reali & Christiansen, 2007; Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005). For example, Traxler et al. (2002) demonstrated that ORCs modifying an inanimate patient are easy to process when the embedded

⁴ One additional retrieval-based account of RC complexity is the proposal by O'Grady (1997), who hypothesises that retrieval difficulty is affected by *the hierarchical distance between the empty element and its associated wh-element in the syntactic tree*. Under this proposal, an SRC is easier to process than an ORC because the wh-element to be retrieved from memory when processing the empty position in an RC is hierarchically closer to its corresponding wh-element for SRCs than for ORCs. Although this is an interesting hypothesis, to the best of our knowledge there is no independent evidence for it in the language processing literature, other than the SRC/ORC complexity difference. Furthermore, unlike linear distance-based memory theories which were motivated by a large body of literature on memory for sequences of elements, the hierarchical distance-based proposal lacks such a grounding in the cognitive psychology literature.

subject is animate (e.g., “the rock that the boy threw”), but ORCs modifying an animate patient when the embedded subject is inanimate (e.g., “the mountaineer that the boulder hit”) are hard to process (see Mak et al., 2002, 2006, for similar results in Dutch). Furthermore, Reali and Christiansen (2007) found that ORCs with pronominal subjects (e.g., “the barber that you admired”) are easier to process than SRCs with pronominal objects (e.g., “the barber that admired you”). This set of results can be explained by experience-based theories, because corpus frequencies match these complexity differences, but these results are not easily explained by current working memory-based theories.

On the other hand, there are data that are more easily explained by working memory-based theories than experience-based theories. For example, memory-based accounts explain the *locus* of difficulty in ORC structures. In particular, as mentioned above, experience-based theories predict difficulty to arise as soon as the comprehender realises that she/he has encountered a less frequent (ORC) structure, i.e., at the embedded subject (e.g., “the senator” in 1b). Furthermore, experience-based approaches predict little/no difficulty at the embedded verb because a verb is the most expected continuation following the embedded subject. In contrast, retrieval-cost memory-based accounts predict difficulty to arise at the point of dependency formation, i.e., at the embedded verb (“attacked” in 1b). Consistent with the predictions of these memory-based accounts, in reading paradigms such as self-paced reading (e.g., Gordon et al., 2001; Grodner & Gibson, 2005; King & Just, 1991) and eye-tracking (e.g., Gordon et al., 2004; Holmes & O’Regan, 1981; Traxler et al., 2002), difficulty has been shown to occur on the embedded verb with little/no difficulty observed at the embedded subject. One possibility is that the reading time slowdown at the embedded verb (and not at the embedded subject) in ORCs is due to spillover effects from the embedded subject. However, Grodner and Gibson (2005) have ruled out this possibility by showing that the slowdown occurs at the embedded verb even when the embedded subject is modified by a prepositional phrase (e.g., “the nurse at the clinic”).

Furthermore, memory-based, but not experience-based, accounts explain a set of findings from dual-task paradigms in which a sentence comprehension task is combined with a word-memory task. Such paradigms have (a) revealed an increase in the size of the extraction effect when the words to be remembered were similar to the words in the sentences (Fedorenko et al., 2006; Gordon, Hendrick, & Levine, 2002); (b) showed that the difficulty of retrieval increases when the nouns in memory are possible objects of the verb (Van Dyke & McElree, 2006); and (c) demonstrated that when the to-be-retrieved element is made highly accessible (eliminating the need to retrieve it from memory), the extraction effect is reduced or eliminated (Fedorenko, Woodbury, & Gibson, 2009). Memory-based accounts straightforwardly explain these results, but experience-based accounts do not, without making some additional assumptions or postulating additional mechanisms.

In summary, ORCs are more complex than SRCs in a head-initial language like English, when both NPs are animate as in (1) and (2). These results are explained by both experience-based and memory-based theories.

1.1. Cross-linguistic predictions: Head-final languages

One important way to evaluate experience- and working memory-based theories is to examine their predictions for languages with different word orders. An interesting test case for working memory-based theories in particular comes from head-final languages. Recall that in the head-initial word order in English in (1) and (2), the distance between the empty element in the RC and its head noun is greater in the ORC than in the SRC. This greater linear distance leads retrieval-cost memory-based theories to predict greater processing difficulty for ORCs compared to SRCs in a language like English. Consider now the RC word order in a head-final language such as Japanese or Korean:

(3) Head-final RC word order:

- a. Subject-extracted RC: $[_{RC} _ _ i \text{ NP-acc V}] \text{ NP}_i$.
- b. Object-extracted RC: $[_{RC} \text{ NP-nom} _ _ i \text{ V}] \text{ NP}_i$.

In contrast to a head-initial language like English, the distance between the empty element in the RC and its head noun in these structures is greater in the SRC than in the ORC. This has led some researchers to propose that retrieval-cost memory-based theories might predict that SRCs should be more complex than ORCs in a head-final language like Japanese (Ishizuka, Nakatani, & Gibson, 2006). However, as these and other researchers have later noted, the retrieval-cost memory-based account proposed by Lewis et al. (2006) – the account that is most strongly grounded in current memory theories because it incorporates the notion of repeated retrieval in an activation-based framework – predicts no complexity difference in processing SRCs and ORCs in Japanese and Korean. In particular, consider the predictions of this account for the RC structures in (3). In both SRCs and ORCs, both the empty NP and the full NP are integrated with the verb when the embedded verb is encountered, with the empty NP serving as a placeholder for the NP to come. There is therefore no difference in retrieval costs between the two structures. Next, the verb and the co-indexed empty element need to be integrated with the head noun which follows. The verb is immediately local in each case, and so there is no difference in retrieval costs here either. Hence, overall, there is no difference predicted between the two structures (Miyamoto & Nakamura, 2003).

Whereas retrieval-cost memory-based theories do not predict a difference for SRCs vs. ORCs in head-final languages like Japanese, storage-cost memory-based theories predict that ORCs should be harder to process than

SRCs, because of temporary ambiguity with a main clause interpretation for the initial component of the ORC.⁵ In particular, the initial NP in an ORC as in (3b) is marked with nominative case, which could therefore be the subject of a main clause to come. Given a choice between a main clause analysis and an RC analysis sentence initially, the main clause analysis will be preferred because this analysis requires fewer syntactic heads in order to be complete. The cue to reanalyse this structure as an RC occurs either on the following verb (if this verb is obligatorily transitive) or on the following NP (the head of the RC). In contrast to ORCs, the accusative NP which initiates an SRC does not have a likely main clause analysis in a null context, and thus is more likely to be correctly analysed as an SRC on the first interpretation. The storage-cost memory-based theories therefore predict greater complexity for ORC structures in head-final languages like Japanese.

Experience-based theories also predict that SRCs should be easier to process than ORCs in Japanese because SRCs with animate NPs are more frequent than ORCs with animate NPs (Ozeki & Shirai, 2007). It turns out that SRCs are easier to process than ORCs in Japanese and Korean (Ishizuka et al., 2003; Kwon et al., 2006; Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008). However, because this result is consistent with both the experience-based proposals and the storage-cost memory-based theories, such a result is not overly informative for deciding among the theories.

1.2. Processing relative clauses (RCs) in Chinese

Chinese provides a particularly interesting test case for experience- and memory-based proposals. As in other languages that have been investigated thus far, SRCs appear to be more frequent than ORCs in Chinese, overall and for RCs with animate NPs (Hsiao & Gibson, 2003; Kuo & Vasishth, 2006). Thus, according to the experience-based accounts, SRCs should be easier to process in Chinese, just as in a language like English. Critically though, whereas Chinese RCs are prenominal (like Japanese and Korean RCs), the basic word order in main clauses is subject–verb–object, as in English and in contrast to Japanese, Korean and other head-final languages. Consider (4) for example (from Hsiao & Gibson, 2003):

⁵ When a language has fewer morphological cues to the target structure as compared with another language, then there will sometimes be more temporary ambiguity in that language. Thus, languages like Japanese and Korean, which lack a relative clause marker (such as a complementiser or a relative pronoun), will sometimes contain temporarily ambiguous relative clauses which are difficult for comprehenders to resolve. Similarly, although Chinese contains a morphological relative clause marker, it lacks case-marking on its nouns. This lack of case-marking increases temporary ambiguity relative to other languages with head-final relative clauses, like Japanese and Korean.

(4) a. SRC

__ yaoqing fuhao de guanyuan xinhuaibugui
 __ invite tycoon REL official have bad intentions
 “The official who invited the tycoon had bad intentions”.

b. ORC

fuhao yaoqing __ de guanyuan xinhuaibugui
 tycoon invite __ REL official have bad intentions
 “The official who the tycoon invited had bad intentions”.

Because of the different position of RCs with respect to their head nouns and the word order within the RCs, retrieval-cost memory-based accounts predict that SRCs should be more complex than ORCs in Chinese. In particular, consider the processing steps during the RC, and at the marker “de”⁶ (roughly corresponding to English “that” or “who”) following the RC and the head noun for the RC. During the RC (“__ invite tycoon” or “tycoon invite __”), the integrations are local and matched across the two structures. Next, the RC marker “de” and the head noun for the RC are processed. The head noun for the RC needs to be linked with the empty NP position in the RC. This is a local integration in the ORC structure, because the object position and the verb are the most recent positions that have been processed. In contrast, this is a more distant integration in the SRC structure, because the object NP intervenes. Thus retrieval-cost memory-based theories predict that SRCs should be more complex than ORCs in Chinese.

Let us now consider the predictions of storage-cost working memory-based accounts with respect to these structures. Because of temporary ambiguity, the ORC materials – which are initiated by the sequence N V – are probably initially analysed as a main clause rather than an RC structure, because a main clause analysis has many fewer predicted syntactic heads. In contrast, a main clause analysis is much less likely initially for the SRC materials – which are initiated by the sequence V N – because a verb is an unlikely initial word in a main clause in a null context. Thus storage-cost memory-based accounts predict that the SRC structure may be read more slowly than the ORC structure initially, because there are more predicted syntactic heads in the

⁶ It is not clear what the syntactic category of the Chinese word “de” is. It may be a complementiser (corresponding roughly to the word “that” in English), as suggested by e.g., Cheng (1986, 1997) and Paul (2006), or it may be a more general linker of a modifier to a head, as suggested by e.g., Den Dikken (2006) and Den Dikken and Singhapreecha (2004) (see also Aoun & Li, 2003; Huang, Li, & Li, 2009). Evidence consistent with the second approach consists of the observation that the word “de” can mark modifiers other than clauses. No matter which approach turns out to be correct, the head noun for the RC needs to be interpreted as coindexed with the empty position within the RC: either the subject or the object of the RC in these examples. This is the critical integration that differs between head-first and head-final languages.

initial analysis of the first part of the SRC than in the initial part of the ORC. This account also predicts a corresponding reanalysis effect later in the ORC structure (in which the correct ORC analysis is obtained), but none in the SRC. Thus, these accounts predict an initial complexity difference favouring the ORC, followed by a reanalysis effect at the word “de” and during the head noun favouring the SRC, because of ambiguity resolution in the ORC structure.

Because of the temporary ambiguity in the ORC structure, the predictions of experience-based accounts are the same as those of storage-cost working memory-based accounts. In particular, experience-based accounts also predict that ORCs should be processed more easily than SRCs initially, because an initial N V sequence is very frequent in the language, as a main clause. This account also predicts a reanalysis effect later for the ORC structure (Kuo & Vasishth, 2006).

There have been several recent on-line reading studies of Chinese RCs, but the results of these studies have not been conclusive. Hsiao and Gibson (2003) initially observed that SRCs were slower to process than ORCs, and Chen, Ning, Bi, and Dunlap (2008) replicated this effect for readers with low memory spans (Daneman & Carpenter, 1980), but found no complexity difference for readers with high memory spans. Lin and Garnsey (2007) also demonstrated a similar complexity effect to that of Hsiao and Gibson, on a closely related structure pair. But in contrast to Hsiao and Gibson (2003), Kuo and Vasishth (2006), and Lin and Bever (2006) each argued to have found that SRCs are processed faster than ORCs in Chinese. Let us first consider Lin and Bever’s (2006) results. Although they found that ORCs were slower to read than SRCs overall, this was only when the results were collapsed across both subject-modifying RCs (as in (4) above) and object-modifying RCs as in (5) (examples from Lin & Bever, 2006):

(5) a. Subject-modifying ORC

N1 V1 [[V2 N2 REL] N3]

yiyuan zhuangdao le gouyin yuanzhang de shaonyu.

Congressman bumped into seduce dean REL young lady.

“The congressman bumped into the young lady that seduced the dean”.

b. Object-modifying ORC

N1 V1 [[N2 V2 REL] N3]

yiyuan zhuangdao le yuanzhang gouyin de shaonyu

Congressman bumped into dean seduce REL young lady.

“The congressman bumped into the young lady that the dean seduced”.

The initial sequence of words in an object-modifying ORC as in (5b) consists of a noun–verb–noun string (e.g., *yiyuan zhuangdao le yuanzhang* “congressman bumped into dean” in (5b)). Although the noun following the initial verb ends up being the subject of an RC, initially a reader will probably interpret this noun as the direct object of the verb, for several possible reasons: following the corpus statistics (Hale, 2001; Kuo and Vasishth, 2006;

Levy, 2008); minimising storage costs (Gibson, 1998, 2000); or perhaps minimising syntactic structure according to the Minimal Attachment heuristic (Frazier, 1978). However, when the following word – another verb (gouyin “seduce” in (5b)) – is encountered, the direct object analysis must be abandoned in favour of the target ORC structure. In contrast, there is no such temporary ambiguity in the object-modifying SRC structure as in (5a). In particular, the initial sequence of words in the object-modifying SRC structure is noun–verb–verb. The second verb is most likely the beginning of an RC modifying the direct object of the main verb, which is the target interpretation. Thus, a plausible cause for the relative ease of processing SRC structures as compared to ORC structures when they modify NPs in the object position of a verb is a difference in temporary ambiguity across these two structures: ORC structures in this position are temporarily ambiguous, leading to a need for reanalysis, whereas SRC structures in this position have less temporary ambiguity. Indeed, like Lin and Bever (2006), Hsiao (2003) also demonstrated a behavioural effect favouring SRCs over ORCs in object-modifying positions. She argued that temporary ambiguity differences between the subject- and object-modifying structures caused different preferences between SRC and ORC structures. Although Lin and Bever do not analyse the results for subject- and object-modifying RCs separately, it appears from their graphs that the SRC preference that they observed is carried by the object-modifying conditions. There appears to be no difference between the two subject-modifying conditions. In summary, the results do not demonstrate a conclusive SRC advantage, in contrast to Lin and Bever’s claim. But the results do not replicate the ORC advantage that Hsiao and Gibson (2003) observed either.

Like Lin and Bever (2006), Kuo and Vasishth (2006) also reported that ORCs were processed slower than SRCs. But unlike Lin and Bever (2006), Kuo and Vasishth (2006) reported such a difference for the ORCs and SRCs modifying subjects, thus avoiding the temporary ambiguity confound in object-modifying RCs. These results do neither replicate the ORC advantage that Hsiao and Gibson (2003) observed, but nor are they very similar to those of Lin and Bever.

In summary, although some studies demonstrate that SRCs are more complex than ORCs in Chinese, the effect is not robust thus far. Moreover, to the extent that SRCs are harder to process than ORCs in Chinese null contexts, this effect appears to be due to temporary ambiguity, such that the initial fragment of an ORC is misanalysed as a main clause. Such an effect of temporary ambiguity does not distinguish working memory-based theories from experience-based theories: both kinds of theories are compatible with such a result.

In order to better compare the predictions of retrieval-cost working memory-based accounts to the predictions of experience-based accounts, we

sought to exclude the potential confound of temporary ambiguity which is present in a null context (especially in RCs modifying NPs in object position), by examining Chinese SRC and ORC structures modifying NPs in subject position, in contexts that support both kinds of RCs. Our experimental design follows that of Gibson, Fedorenko, and Ishizuka (2007) and Ishizuka et al. (2006) who explored the processing of RCs in supportive contexts in Japanese and English, respectively. An example set of materials for the Chinese experiment is given in (6) (adapted from the English materials from one of Gibson et al.'s 2007 experiments):

- (6) zai kuaisudaolu yongsai de cheliu zhong, you yi-tai zhongxingjiche zhui-zhe yi-tai jiaochē.

“On a highway, a motorcycle chased a car through heavy traffic”.

Lingwai yi-tai jiaochē kandao zhihou, jiu zhui-zhe na-tai zhongxingjiche.

“Another car saw (the situation), and then chased the motorcycle”.

Xiaoming shuo: wo tingshuo shi yi-ge gaozhongsheng kai-zhe qizhong

yi-tai jiaochē, er lingwai yi-tai shi you yi-ge zhongnian funu kaizhe.

“Xiaoming said: I heard that a high school student was driving one of the cars and a middle-aged woman was driving the other”.

Na-ge gaozhongsheng shi kai-zhe na-yi-tai chē ne?

“Which car was the high-school student driving?”

a. Subject-extraction

Xiaomei shuo: zhui zhongxingjiche de chē shi gaozhongsheng kai de chē.

“Xiaomei said: The car which chased the motorcycle is the one that the student was driving”.

b. Object-extraction

Xiaomei shuo: zhongxingjiche zhui de chē shi gaozhongsheng kai de chē.

“Xiaomei said: The car which the motorcycle chased is the one that the student was driving”.

The design of this experiment licenses both the SRC and ORC structures by setting up a context with one individual of Type X (here, a motorcycle, x) and two individuals of Type Y (here, two cars, y_1 and y_2), where (1) y_1 is the agent of verb v (here, chasing) and x is the patient of v ; and (2) y_2 is the patient of verb v and x is the agent of v . Thus, both $y_1 v x$ and $x v y_2$ are true. In this example, one car chases a motorcycle and the motorcycle chases the other car. This context therefore licenses both the SRC “the car which chased the motorcycle” and the ORC “the car which the motorcycle chased”. Following this context, a dialogue ensues between two people, where one person states a property that she/he believes to be true of one of the individuals of Type Y (the cars), but she/he wants to know which of the two Ys it is (e.g., “Which car was the high-school student driving?”). In this context, the most felicitous response is an SRC or an ORC, to pick out the right Y (car). Importantly, the possibility of a main clause interpretation of a RC is infelicitous in this context, for both the ORC and SRC sequence of words. We can thus target the two structures in question, without the

confound of temporary ambiguity, which was a problem in all the previous studies investigating Chinese RCs. Retrieval-cost working memory-based accounts predict that the ORC should be less complex to process, whereas experience-based accounts predict that the SRC should be the less complex structure, because of its greater frequency in the language.

2. EXPERIMENT

2.1. Design and materials

Sixteen sets of sentences were constructed, typed in traditional Chinese characters, each with the two conditions as in (6) above. Each target item consisted of two context sentences, followed by a dialogue between Xiaoming and Xiaomei. The first part of the dialogue consisted of a statement and a question prefaced by “Xiaoming said:” to indicate that Xiaoming was the speaker of these utterances. The second part of the dialogue consisted of a single sentence response by Xiaomei. This sentence was the target region of each text, consisting of an initial SRC or ORC, followed by the head noun and then the main clause of the sentence. The four context sentences were presented sentence-by-sentence. In the last sentence (the target region), the first two words “Xiaomei shuo:” (“Xiaomei said:”) were presented together as a region, and the words of the utterance were presented word-by-word.

(7) Format of materials:

Context (sentence-by-sentence presentation):

Context sentence 1; Context sentence 2; Statement by Xiaoming; Question by Xiaoming.

Target sentence (word-by-word presentation):

Xiaomei said: (N1 V1) / (V1 N 1) de N2 main-clause.

The structure of the context sentences was varied with regard to whether the description of the events started with the unique referent or one of the two referents of the same kind: seven of the 16 items (items 1–5, 7, 8; see Appendix 1) started with the unique noun (as in (6), where the motorcycle is mentioned first, followed by one of the cars), and nine of the 16 items (items 6, 9–16; see Appendix 1) started with a nonunique noun.⁷

As discussed above, the context consisting of Xiaoming asking which of two referents with the same head noun (N2 in (7)) is associated with some

⁷ Item 6 was intended to be unique-referent first item, but an error was made in constructing this item. In any case, the items are still almost equally balanced with respect to the presentation order of the unique referent. In fact, as discussed in the results section, due to a script error, item 12 was not presented to the experimental participants. Consequently, the items were as well balanced as possible with respect to the order of presentation of the unique referent.

predicate P leads to the strong expectation that Xiaomei's response will be initiated by a RC modifying N2, and then to be continued with predicate P. Furthermore, the form of the RC is likely to be an SRC or an ORC with the same words in each, thus picking the relevant noun from the set of two nouns introduced in the context.

The question asked by Xiaoming was always a wh-question, asking which of two head nouns was associated with some predicate P. Across the items, half of these wh-questions were subject-extracted questions, and the other half were object-extracted questions. Appendix 1 provides a complete list of the target stimuli.

As mentioned above, the materials were translations of materials that were used in an English study conducted by Gibson et al. (2007), which were matched for plausibility. Furthermore, Gibson et al. (2007) found that ORCs were processed significantly more slowly than SRCs. Thus, in English, there was an on-line SRC preference for translations of the same materials, and this difference was not due to plausibility differences, because plausibility was controlled.

There were 48 filler items in the experiment. They all had the same general format as the target materials: two context sentences, a statement, and question by "Xiaoming", followed by a word-by-word response from "Xiaomei". An additional result from Gibson et al. (2007) suggested that increasing the overall predictability of the RC decreased the potential complexity difference between the two RC types. As a result, we included 16 fillers in which the format of the context material was identical to that of the target materials (i.e., one individual of Type X, two individuals of Type Y, etc.), and we varied the target region (Xiaomei's response) in these fillers in order to make the target RCs less predictable from the preceding context. For eight of these fillers, Xiaomei's response included passive structures, four of which were subject extracted, and four object extracted. An example of the passive continuation fillers is provided in (8).

- (8) you liang-zhi mao han yi-zhi gou zai houyuan li wan.
 "Two cats and a dog were playing in the yard".
 gou zhui-zhe qizhong yi-zhi mao pao, er ling yi-zhi mao ze zhui-zhe gou pao.
 "The dog chased one of the cats and then the other cat chased the dog".
 Xiaoming shuo: wo tingshuo qizhong yi-zhi mao shi liulang mao, lingwai yi-zhi ze shi linju yang de. Linju yang-le na-yi-zhi mao ne?
 "Xiaoming: I think that one of the cats was a stray, and a neighbor owned the other".
 "Which one did a neighbor own?"
 Xiaomei shuo: bei gou zhui de mao shi linju yang de.
 "Xiaomei: The cat that was chased by the dog was the cat that a neighbor owned".

The other eight of these fillers continued with a less predictable kind of response from Xiaomei, which varied across all eight items. An example of one of these fillers is provided in (9).

- (9) you yi-dui fufu juxingle yi-chang hen bang de hunli, qizhong yi-ge banniang hen xianmu xinniang.
 "A couple had a gorgeous wedding and one of the bridesmaids envied the bride a lot".

Lingyifangmian, xinniang ze hen xianmu lingwai yi-ge banniang, yinwei tade weihunfu shi yi-wei youmingde bangqiu xuanshou.

“On the other hand, the bride envied another bridesmaid since her fiancée was a famous baseball player”.

Xiaoming shuo: wo tingshuo qizhong yi-ge banniang shi jinfa, lingwai yi-ge shi hongfa.

“Xiaoming said: I heard one of the bridesmaids was a blonde, and another was a redhead”.

Shi na-yi-ge jinfa?

“Which one has blonde hair?”

Xiaomei shuo: wo jide meiyoun shi jinfa-de.

“Xiaomei said: I remember that none of the bridesmaids had blonde hair”.

Finally, we included 32 filler materials that had only the same general format as the target materials: two context sentences, a statement, and question by “Xiaoming”, followed by a word-by-word response from “Xiaomei”. An example of one of these filler items is provided in (10).

- (10) zai yi-ge dade gongyu zhuzhaiqu li, you yi-ge xiaofangyuan cong dahuo zhong jiule yiming furen.

“A firefighter saved a woman from a fire in a large apartment complex”.

Ta shi ge yisheng, erqie houlai faxian ta juran shi tade gaozhong tongxue.

“She was a doctor and she turned out to be his high-school classmate”.

Xiaoming shuo: wo tingshuo tamen shang-ge yue jiehun-le.

“Xiaoming said: I heard that they got married last month”.

Xiaomei shuo: na zhen shi langman a, ta jia gei le tade yingxiang le.

“Xiaomei said: That’s very romantic. She got married to her hero”.

2.2. Participants

Forty subjects participated in the experiment. All were undergraduate or graduate students, between 18 and 30 years of age, and were native speakers of Mandarin Chinese spoken in Taiwan. Thirty-five of the participants were run in New York City; these subjects came to the USA to study for no more than 2 years and Mandarin Chinese was the primary language they used in daily life. The remaining five were run in Taiwan. All participants were paid for their participation.

2.3. Procedure

The task was self-paced reading, using a moving window display (Just, Carpenter & Woolley, 1982). Linger 1.7 by Doug Rohde was the software used to run the experiment. Each trial began with a series of dashes marking the position and length of the words in the sentences, across several lines of text. Participants pressed the spacebar to reveal each fragment of the materials. The amount of time the participant spent reading each fragment was recorded as the time between key presses.

The first four sentences of each text were presented sentence-by-sentence. The final sentence of each text (Xiaomei's response, see (6)–(10)) was presented word-by-word.

To assure that the participants read the sentences for meaning, a comprehension question was presented at the end of each trial, asking about the propositional content of the sentence. Participants pressed one of two keys to respond “yes” or “no”. After an incorrect response, the Chinese version of “Oops, your answer was incorrect” flashed briefly on the screen. No feedback was given for correct responses. The comprehension questions asked about either the content of the context clauses or the final clause (containing the RC for the target materials). For instance, the comprehension question for the example in (6) was “Did the car chase take place through light traffic?”, and the answer was “no”. For the 16 target materials, eight asked about the context and eight asked about the RC.

Before the experiment started, a short list of practice items and questions was presented in order to familiarise the participants with the task. Participants took approximately 50 minutes to complete the experiment.

3. RESULTS

Due to a script error, one item (item 12) was not presented to the participants, leaving 15 items to be analysed. Three participants' results were omitted from analyses because of relatively poor comprehension question performance (< 70% accuracy; the mean for other participants' accuracies was 91.2%).

3.1. Comprehension question performance

The percentages of correct answers for the SRCs was the same as that for ORCs at 91.2% (standard error = 2.0). The high comprehension question performance indicates that the participants were paying attention in the task and processing the materials for meaning.

3.2. Reading times

We analysed all trials, regardless of whether the comprehension question was answered correctly. The statistical data patterns were very similar in the analysis of only the trials where the comprehension question was answered correctly. Figure 1 presents the mean word-by-word reading times in the target sentence.

An ANOVA conducted on each of the first four regions – the four context sentences (which were the same across conditions) – revealed no differences in any of these sentence RTs ($F_s < 1.2$; $p_s > .25$). There was also no difference at the first region of the target sentence, consisting of the words “Xiaomei said:”, marking the beginning of Xiaomei's response in both conditions ($F_s < 1$).

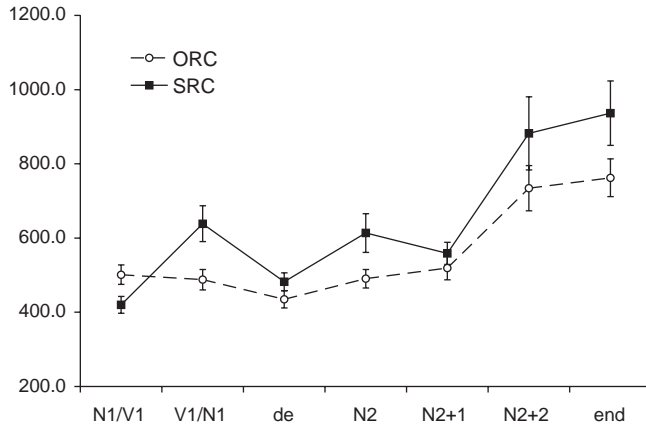


Figure 1. Reading times per word in the target sentence. Error bars indicate standard errors of the mean.

The next two words consisted of the RC: N1 V1 in the ORC condition and V1 N1 in the SRC condition. There was no difference between the two conditions during this region, although the SRC condition was numerically slower than the ORC [$F_1(1, 36) = 2.47$, $MS_{\text{within}} = 22,360$, $p = .13$; $F_2(1, 14) = 2.61$, $MS_{\text{within}} = 8,064$, $p = .13$]. The next word was the RC marker “de”. This region was read more slowly in the SRC condition, although this difference was not reliable in the items analysis [$F_1(1, 36) = 4.40$, $MS_{\text{within}} = 41,285$, $p < .05$; $F_2(1, 14) = 2.23$, $MS_{\text{within}} = 22,120$, $p = .16$]. The next word consisted of the head noun for the RC, N2. This region was read more slowly in the SRC condition [$F_1(1, 36) = 6.92$, $MS_{\text{within}} = 280,810$, $p = .01$; $F_2(1, 14) = 4.62$, $MS_{\text{within}} = 110,132$, $p < .05$]. When these two regions – the RC marker “de” and the head noun – were analysed together, the SRC condition was read more slowly [$F_1(1, 36) = 12.10$, $MS_{\text{within}} = 134,359$, $p < .001$; $F_2(1, 14) = 4.14$, $MS_{\text{within}} = 57,741$, $p < .05$]. There were no significant differences in reading times over the next two words of the sentence ($F_s < 2.2$; $p_s > .14$), although numerically the SRC was still the slower of the two in each region. At the final region of the sentence, the SRC condition was again read more slowly than the ORC condition, although the difference did not quite reach significance in the participants analysis [$F_1(1, 36) = 3.84$, $MS_{\text{within}} = 558,810$, $p < .06$; $F_2(1, 14) = 6.90$, $MS_{\text{within}} = 110,764$, $p < .05$].

4. DISCUSSION

The reading time evidence in this experiment clearly demonstrates that SRCs are more difficult to process than ORCs in Chinese, when the RCs appear in

a supportive context that eliminates the potential ambiguity confound present in all of the previous studies. This reading time difference occurred at the head noun following the RC, and persisted later in the sentence. These results offer support for retrieval-cost working memory-based accounts of language comprehension over experience-based accounts for this construction. In particular, despite the fact that SRCs are more common than ORCs in Chinese (Hsiao & Gibson, 2003; Kuo & Vasishth, 2006), SRCs are read more slowly, thus contradicting the prediction of experience-based accounts. In contrast, working memory-based theories of language processing predict the observed effect. According to these accounts, difficulty ensues when an earlier encountered sentence element needs to be retrieved from memory upon encountering its syntactic dependent. Because the head noun following an RC is closer to the verb that it integrates with in an ORC than in an SRC in Chinese, retrieval-cost memory-based theories predict that the ORC should be easier to process. Furthermore, the on-line location of the effect was as predicted by the retrieval-cost memory-based accounts: it occurred primarily at the RC marker “*de*” and the head-noun, where retrieval of the embedded verb takes place.

It is worth comparing the current results to the previously discussed results from the existing literature investigating SRC and ORC structures in Chinese. The current study found robust effects of SRC complexity compared to ORCs, resulting in a 630 ms reading time difference across the sentences on average per subject. No such robust effect has been observed in RC comparisons in Chinese before this study. For example, whereas there was an ORC preference in Hsiao and Gibson’s data, it was only 120 ms on average. Lin and Bever (2006) found no difference for the relevant conditions (in fact there was a numerical trend in the opposite direction), and Chen et al. (2008) found an effect which, from the graph of their results, looks to be about the same size as Hsiao and Gibson’s, but only for low-memory span participants. It is interesting to speculate about the factors that differentiate the current study from the previous ones. The obvious answer appears to be the presence of supportive contexts in the current study. The presence of supportive contexts critically removes the confound of temporary ambiguity, which was present in earlier Chinese RC studies. In addition, it is possible that supportive contexts decrease between-participant variance that is plausibly associated with lexical-level processing and world knowledge (i.e. differences in assessing the plausibility of various events described in the critical sentences), because the relevant lexical items and the relevant events are provided in full in the contexts. Consistent with this hypothesis, Gibson et al. (2007) found bigger extraction effects in supportive contexts in English than had been found in the literature comparing subject- and object-extractions in null contexts. In particular, whereas the null context effect is typically on the order of 100 ms or less, the supportive context effect that was observed by Gibson et al. was over 400 ms. Supportive contexts therefore seem to provide a useful paradigm for studying

syntactic complexity effects, as they appear to be amplified in supportive contexts.

5. CONCLUDING REMARKS

The results of the current experiment show that Chinese SRCs are more complex to process than ORCs in supportive contexts. This is the first language that has been observed with this pattern of results. As noted by Hsiao and Gibson (2003), such a pattern of results contradicts the predictions of Keenan and Comrie's (1977) accessibility hypothesis, which predicts a uniform complexity bias in favour of SRCs over ORCs cross-linguistically. Similarly, these results are inconsistent with O'Grady's (1997) working memory-based theory, which predicts that SRCs should always be less complex than ORCs cross-linguistically because the hierarchical distance between the *wh*-filler element and its empty position in the RC structure is always shorter in SRCs than in ORCs.

Most importantly, the current results add to the growing body of results that demonstrate the need for a working memory component in a complete model of language processing. Whereas there are many results which are best explained in terms of experience-based accounts (as summarised in the introduction), there are also many results that are not accounted for by such theories. Thus, it looks like both working memory and experience are important factors affecting on-line language processing complexity.

Finally, it is worth comparing the RC processing literature for normal adults to the relevant literature for patients with brain damage to language areas. It has long been observed that English aphasic patients typically exhibit exacerbated difficulty in processing object-extracted structures. In particular, English aphasic patients cannot reliably answer comprehension questions about ORCs, although they perform well on SRCs (Caplan & Futter, 1986; Caramazza & Zurif, 1976; Grodzinsky, 1989; Hickok, Zurif, & Canseco-Gonzalez, 1993). In contrast, it has recently been observed that there is a reverse pattern of difficulty in Chinese: some Chinese aphasic patients cannot reliably answer comprehension questions about SRCs, although they perform well on ORCs (Su, Lee, & Chung, 2007). These results from the neuropsychological studies are strikingly similar to the current literature on RC processing in healthy populations: English speakers have more difficulty with ORCs than SRCs, whereas Chinese speakers have more difficulty with SRCs than ORCs. The patient data therefore further strengthen the conclusion reached in the current study that a memory component is essential in order to explain the existing patterns of linguistic behaviour.

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APPENDIX 1: EXPERIMENT ITEMS

1.

有兩個人在朋友的單身派對結束之後到了東區的一間酒吧喝酒。

“Two men visited a bar in the East Area after a friend’s bachelor party”.

因為言語上的衝突，一名酒吧少爺揍了其中一個人，另外一個人就接著揍了酒吧少爺。

“Because of some verbal conflicts, a bouncer punched one of the men, and then another man punched the bouncer”.

小明說：我想這間酒吧的老闆曾經見過這兩個其中一個人，但沒見過另外一個人。
老闆是見過哪個人？

“Xiaoming said: I think that the bar owner had met one of the men before, but not the other. Which man had the bar owner met?”

Obj-Ext: 小美說：酒吧少爺揍的人是老闆見過的。
Xiaomei say: bouncer punch REL man be the owner met.

Subj-Ext: 小美說：揍酒吧少爺的人是老闆見過的。
Xiaomei say: punch bouncer REL man be the owner met.

“Xiaomei said: The man who {the bouncer punched/ punched the bouncer} was the one who the bar owner had met”.

2.

某天下午，在快速道路壅塞的車流中，有一台重型機車追著一台轎車。

“On an expressway, a motorcycle chased a car through heavy late-afternoon traffic”.

另外一台轎車看到之後，就追著那台重型機車。

“Another car watched them and then chased the motorcycle”.

小明說：我聽說是一個高中生開著其中一台轎車，而另外一台轎車是由一個中年婦女開著。
那個高中生是開著哪一台車呢？

“Xiaoming said: I heard that a high school boy was driving one of the cars and a middle-aged woman was driving the other. Which car was the high school boy driving?”

Obj-Ext: 小美說：重型機車追的車是高中生開的。
Xiaomei say: motorcycle chase REL car be high-school boy drive.

Subj-Ext: 小美說: 追重型機車的車是高中生開的。
Xiaomei say: chase motorcycle REL car be high-school boy drive.

“Xiaomei said: the car which {the motorcycle chased/chased the motorcycle} is the one that the boy was driving”.

3.

在一個大特賣的結帳隊伍中，一個高中女學生推了一個中年婦女一把。

“A high-school girl pushed a middle-aged woman in the line at a bargain sale”.

另外一個中年婦女也接著推了那個高中女學生一下。

“Then another middle-aged woman pushed the high school girl”.

小明說:我聽說有小偷偷了其中一個婦女的皮包，但是沒偷另一個婦女的。

小偷是偷了那個婦人的皮包?

“Xiaoming said: I heard that a thief stole a purse from one of the women but he failed to get the other’s purse. Which woman did the thief steal a purse from?”

Obj-Ext: 小美說: 高中女學生推的婦人是被小偷偷皮包的。
Xiaomei say: high-school girl push REL woman be thief steal purse.

Subj-Ext: 小美說: 推高中女學生的婦人是被小偷偷皮包的。
Xiaomei say: push high-school girl REL woman be thief steal purse.

“The woman who {the girl pushed/pushed the girl} was the one who the thief stole a purse from”.

4.

兩個小女孩和一個小男孩在公園裡玩耍時吵了起來。

“Two little girls and a little boy got into an argument when playing in a park”.

小男孩先打了其中一個女孩一巴掌，然後另一個女孩就接著打了男孩一巴掌。

“First, the boy slapped one of the girls, and then the other girl slapped the boy”.

小明說:我想幼稚園園長在三點的時候看到了其中一個女孩，在三點半的時候看到了另外一個。園長三點的時候是看到哪個女孩?

“Xiaoming said: I think that the school principal saw one of the girls at three o’clock and the other at 3:30. Which girl did the principal see at three o’clock?”

Obj-Ext: 小美說: 男孩打的女孩是園長在三點看到的。
Xiaomei say: boy slap REL girl be principal at 3 o’clock see.

Subj-Ext: 小美說: 打男孩的女孩是園長在三點看到的。
Xiaomei say: slap boy REL girl be principal at 3 o’clock see.

“The girl who {the boy slapped/slapped the boy} was the one that the principal saw at three o’clock.”

5.

兩台轎車和一台休旅車在高速公路上發生了激烈的口角。

“Two cars and a minivan got into an altercation on the highway”.

一開始，休旅車撞上了一台轎車，另一台轎車就接著撞上了這台休旅車。

“First, the minivan bumped one car, and then the other car bumped the minivan”.

小明說：我聽說其中一台轎車是福斯金龜車，另一台是喜美。哪一台是喜美？

“Xiaoming said: I heard that one car was a VW Beetle and the other was a Honda Civic. Which one was a Honda Civic?”

Obj-Ext: 小美說：休旅車撞的轎車是喜美。
Xiaomei say: mini-van bump REL car be Civic.

Subj-Ext: 小美說：撞休旅車的轎車是喜美。
Xiaomei say: bump mini-van REL car be Civic.

“The car that {the minivan bumped/bumped the minivan} was the Honda Civic”.

6.

有一個女孩邀請了一個男孩參加台北市政府辦的耶誕舞會。

“A girl asked a guy to a Christmas party held by the Taipei City Government”.

之後，那個男孩又邀了另一個女孩去舞會。

“Later, the guy asked another girl to the party”.

小明說：我記得其中一個女孩是台北人，另一個則是桃園人。哪一個是桃園人？

“Xiaoming said: I remember that one of the girls was from Taipei and the other was from Taoyuan. Which one was from Taoyuan?”

Obj-Ext: 小美說：男孩邀請的女孩是桃園人。
Xiaomei say: boy ask REL girl be Taoyuan person.

Subj-Ext: 小美說：邀請男孩的女孩是桃園人。
Xiaomei say: ask boy REL girl be Taoyuan person.

“The girl who {the guy asked/asked the guy} was from Taoyuan”.

7.

有一條狗掉入了河裡，就快要淹死了。一個男孩看到了就跳到河裡試圖救那條狗，

“A dog fell into a river and soon was in danger of drowning. A boy saw this and jumped into the river trying to save the dog”.

但是在他救那條狗的時候男孩也快溺水了，這時候，另外一隻狗也跳進河裡救了這個男孩。

“But later the boy was also in danger of drowning and then another dog saved the boy”.

小明說:我聽說其中一隻狗叫小黃, 另外一隻叫小白。哪一隻叫小白?

“Xiaoming said: I heard that one of the dogs was named Spot and the other was named Whitey. Which one was named Whitey?”

Obj-Ext: 小美說: 男孩救的狗叫小白。
Xiaomei say: boy save REL dog call Whitey.

Subj-Ext: 小美說: 救男孩的狗叫小白。
Xiaomei say: save boy REL dog call Whitey.

“The dog which {the boy saved/saved the boy} was the one that was named Spot”.

8.

在一場馬拉松賽事中, 有一位職業選手故意推了一位業餘選手一下。

“In a marathon race, a professional runner pushed an amateur runner on purpose”.

之後, 另一位業餘選手很生氣, 也接著推了那個職業選手一下。

“Then another amateur runner got mad and pushed the professional runner”.

小明說:我聽說其中一名業餘選手戴著藍色頭帶, 另一名則戴紅色頭帶。哪一個戴著紅色頭帶?

“Xiaoming said: I heard that one amateur runner was wearing a blue headband and the other was wearing a red headband. Which one was wearing a red headband?”

Obj-Ext: 小美說: 職業選手推的業餘選手戴著紅色頭帶。
Xiaomei say: professional runner push REL amateur runner wear red headband.

Subj-Ext: 小美說: 推職業選手的業餘選手戴著紅色頭帶。
Xiaomei say: push professional runner REL amateur runner wear red headband.

“The amateur runner who {the professional runner pushed/pushed the professional runner} was the one who was wearing the red headband”.

9.

有一個FBI雇用的探員正在監視一個職業殺手。

“A detective employed by the FBI was watching a hit-man”.

但其實這個職業殺手也正在監視另外一名探員。

“But actually the hit-man was watching another detective”.

小明說:我聽說地方人士很推崇其中一個探員, 但卻很輕視另外一個探員。地方人士是輕

視哪一個探員?

“Xiaoming said: I heard that the locals praise one of the detectives but criticise the other. Which one did the locals criticise?”

Obj-Ext: 小美說: 職業殺手監視的探員是被地方人士輕視的。
Xiaomei say: hit-man watch REL detective be locals criticise.

Subj-Ext: 小美說: 監視職業殺手的探員是被地方人士輕視的。
Xiaomei say: watch hit-man REL detective be locals criticise.

“The detective who {the hit-man watched/watched the hit-man} was the one who the locals criticised”.

10.

有一位公寓住戶抱怨房東噪音太大。

“An apartment resident blamed the landlord for making a lot of noise”.

另一方面, 房東則抱怨另一位住戶噪音太大。

“However, the landlord blamed another resident for the noise”.

小明說:我聽說IBM最近僱用了其中一名住戶, 微軟則僱用了另一位住戶。微軟是僱用哪一位?

“Xiaoming said: I heard that IBM recently hired one of the residents and Microsoft hired the other resident. Which one did Microsoft hire?”

Obj-Ext: 小美說: 房東抱怨的住戶是微軟僱用的。
Xiaomei say: landlord blame REL resident be Microsoft hire.

Subj-Ext: 小美說: 抱怨房東的住戶是微軟僱用的。
Xiaomei say: blame landlord REL resident be Microsoft hire.

“The resident who {the landlord blamed/blamed the landlord} was the one who Microsoft hired”.

11.

在某場棒球比賽中, 有一個球員突然發火, 揍了教練。

“During a baseball game, one player got angry and hit the coach”.

教練也因此很生氣, 揍了另外一個球員。

“Then the coach got angry and hit another player”.

小明說:我聽說蔡依林正在跟其中一個球員交往, 而蕭亞軒則和另外一個交往。蕭亞軒是跟哪一個交往呢?

“Xiaoming said: I heard that Jolin Tsai was dating one of the players, and Elva Hsiao was dating the other. Which one was Elva Hsiao dating?”

Obj-Ext: 小美說: 教練揍的球員和蕭亞軒交往。
Xiaomei say: coach hit REL player date Elva Hsiao.

Subj-Ext: 小美說: 揍教練的球員和蕭亞軒交往。
Xiaomei say: hit coach REL player date Elva Hsiao.

“The player who {the coach hit/hit the coach} was the one who Elva Hsiao was dating”.

12.

有一位指揮家和兩個作曲家正計畫辦場音樂會。

“A conductor and two composers were planning a concert”.

其中一個作曲家很尊敬那位指揮家，但那位指揮家則尊敬其中另一個作曲家。

“Only one of the composers respected the conductor, but the conductor respected only the other composer”.

小明說：我聽說某個鋼琴師嫁給了其中一個作曲家，而某個小提琴家嫁給了另一個作曲家。

小提琴家是嫁給了哪個作曲家？

“Xiaoming said: I heard that a pianist married one of the composers, and a cellist married the other. Which one did a cellist marry?”

Obj-Ext: 小美說：小提琴家嫁給了指揮家尊敬的作曲家。
Xiaomei say: violinist marry conductor respect REL composer.

Subj-Ext: 小美說：小提琴家嫁給了尊敬指揮家的作曲家。
Xiaomei say: violinist marry respect conductor REL composer.

“The composer who {the conductor respected/respected the conductor} was the one who the cellist married”.

13.

有兩個男人和一個女人在馬戲團裡表演空中飛人。

“Two men and one woman were performing on the trapeze at the circus”.

在表演過程中，其中的一個男人抓住那個女人的腳踝，然後那個女人抓住另外一個男人的手臂。

“During the performance, one of the men caught the woman by her ankles, and then the woman caught the other man by his arms”.

小明說：

我聽說其中一個男人以前是小丑，另外一個以前則是個會計師。哪一個以前是小丑呢？

“Xiaoming said: I heard that one of the men was a former clown, and the other was a former accountant. Which one was a former clown?”

Obj-Ext: 小美說：女人抓住的男人以前是小丑。
Xiaomei say: woman catch REL man before be clown.

Subj-Ext: 小美說：抓住女人的男人以前是小丑。
Xiaomei say: catch woman REL man before be clown.

“Xiaomei said: The one who {the woman caught/caught the woman} was a former clown”.

14.

等待登機時，有兩個空服員和一個英俊的機師在打情罵俏。

“Two flight attendants were flirting with a handsome pilot while waiting to board”.

隔天其中一個空服員打電話約了那個機師，但那個機師打電話約了另一位空服員。

“The next day, one flight attendant called the pilot, but afterwards, the pilot called the other flight attendant”.

小明說：我聽說其中一個空服員以前是護士，而另一位以前是老師。哪一個以前是護士？

“Xiaoming said: I heard that one of the flight attendants used to be a nurse, and the other used to be a teacher. Which one was a former nurse?”

Obj-Ext: 小美說：機師約的空服員以前是護士。
Xiaomei say: pilot call REL flight-attendant before be nurse.

Subj-Ext: 小美說：約機師的空服員以前是護士。
Xiaomei say: call pilot REL flight-attendant before be nurse.

“The flight attendant who {the pilot called/called the pilot} is the one who used to be a nurse”.

15.

在一場電影發表會中，有一位演員大力讚美了導演。

“At a press conference for a new movie, an actor praised the director”.

但是導演卻大力讚美了別的演員。

“However, the director praised a different actor”.

小明說：我聽說其中一個演員只吃魚不吃別的肉，而另外一位演員則只吃素。是哪個演員只吃魚？

“Xiaoming said: I heard that one of the actors eats fish but no red meat and the other is a vegetarian. Which one eats fish?”

Obj-Ext: 小美說：導演讚美的演員只吃魚。
Xiaomei say: director praise REL actor only eat fish.

Subj-Ext: 小美說：讚美導演的演員只吃魚。
Xiaomei say: praise director REL actor only eat fish.

“The actor who {the director praised/praised the director} is the one who eats fish”.

16.

有一位記者在某電視節目裡訪問了一位作家。

“A reporter interviewed a writer on a TV programme”.

之後那位作家訪問了另一位記者。

“Then the writer interviewed another reporter”.

小明說:我聽說其中一個記者是縣長參選人,另一個則是市長參選人。哪一個是縣長參選人?

“Xiaoming said: I heard that one of the reporters is a candidate for governor and the other is a candidate for mayor. Which one is a candidate for governor?”

Obj-Ext: 小美說: 作家訪問的記者是縣長參選人。
Xiaomei say: writer interview REL reporter be governor candidate.

Subj-Ext: 小美說: 訪問作家的記者是縣長參選人。
Xiaomei say: interview writer REL reporter be governor candidate.

“The reporter who {the writer interviewed/interviewed the writer} is the one who is a candidate for governor”.