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Chinese Relative Clauses Processing in Supportive Context Removing Ambiguity

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Abstract: There is a controversy about the difficulty in processing subject- and object-extraction relative clause. The current experiment examined the reading time of each relative clause in subject- and object-modifying conditions with a supportive context to remove the possible ambiguity. The results showed that at Head Noun position subject-extracted relative clauses were processed faster, yet no significant difference was found at other positions. Memory-based theories such as Dependency Locality Theory can not fully explain it, while high frequency of subject-extracted relative clause provides a better explanation.
Key Words: sentence comprehension; relative clause; Chinese; context

1. INTRODUCTION

Relative clause (RC) is an important case to study the processing difficulty in sentence comprehension. Depending on the function of head noun phrase, there is subject relative clause when the head noun is the subject of the verb in the relative clause while in object relative clause head noun phrase is the object of the embedded verb. Examples (1) are object relative sentence and subject relative sentence.

(1) a. Object-extraction in English relative clause:
The reporter [that the senator attacked] disliked the editor.
b. Subject-extraction in English relative clause:
The reporter [that attacked the senator] disliked the editor.

Unlike the head initial relative clause in languages such as English, Chinese relative clause is head final as shown in examples (2)

(2) a. Object-extraction in Chinese relative clause:
fuhao yaoching *(gap) de* guanyuan shinhuaibugui danshi shanyu yintsang
tycoon invite *(gap) gen* official have bad intentions but good at hiding
'The official who the tycoon invited has bad intentions but is good at hiding them.'

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b. Subject-extraction in Chinese relative clause:
(*gap)* yaoching fuhao *de* guanyuan shinhuaibugui danshi shanyu yintsang
(gap) invite tycoon *gen* official have bad intentions but good at hiding
'The official who invited the tycoon has bad intentions but is good at hiding them.'

Many studies have shown that subject preference is a universal pattern in many languages (Ford, 1983; King & Just, 1991; King & Kutas, 1995; Traxler, Morris, & Seely, 2002; Gibson, Desmet, Grodner, Watson, & Ko, 2005 in English; Gouvea, 2003 in Brazilian Portuguese; Frazier, 1987; Mak, Vonk, & Schriefers, 2002 in Dutch; Frauenfelder, Segui, & Mehler, 1980; Holmes & O'Regan, 1981;Cohen & Mehler, 1996 in French; Schriefers, Friederici, & Kuhn, 1995; Mecklinger, Schriefers, Steinhauer, & Friederici, 1995 in German). However, Hsiao and Gibson, in their Chinese relative-clause study in 2003, stated that subject-extracted structures are more complex than object-extracted structures. They explained that Chinese is different from other Subject-Verb-Object languages in its word order, whose relative clauses precede their head nouns, and storage cost is the main cause for this phenomenon.

Based on Hsiao and Gibson (2003), in processing (1a) more storage cost is needed than (1b) for there is a greater gap between "that", which is a relativizer representing "the reporter" as an object in the clause, and "attacked" which is a verb in the inner clause. After the first four words "The reporter that the", four syntactic heads are required: a noun for the determiner "the", a verb for the outer clause, a verb for the inner clause, and an empty noun element associated with the wh-filler "who". While in processing (1b) there are fewer heads needed between relativizer "that" and the inner-clause verb "attack", thus costing less storage. In Chinese as shown in examples (2), more storage cost is needed in (2b) than (2a) because three syntactic heads are needed in (2b) after a reader processes the first verb yaoching ("invite"), which are an NP object, the relative clause genitive marker, and a main clause verb. On the other hand, only one head is predicted after reading fuhao ("tycoon") in examples (2a), which is the verb for the clause or possibly for the main clause.

However, Lin and Bever (2006) found three problems in Hsiao and Gibson's (2003) research, namely, the invalidity of the claims, the invalid comparison between subject relative clauses embedded within subject relative clauses and object relative clauses embedded within object relative clauses in the double-embedding conditions, and the problem in the materials that syntactic ambiguity is not controlled. Also, Lin and Bever (2008) thought "the problem induced by garden path in head-final relative clauses need to be controlled for" since the issue is related to extractions out of subject and object positions. To make a fair comparison between extraction effects in head-initial and head-final relative clauses, it is necessary to consider garden path effect in extracting subject and object in head-final relative clauses such as those in Chinese. There are both covert and overt cues to motivate the relative clauses. "Covert cues included referential contexts that motivate relative clauses and semantic clashes that indicate syntactic discontinuity" while "overt cues included grammatical markings inside the relative clauses and special instructions about the existence of relative clauses in the experimental design." Meanwhile, Lin and Bever (2007) proved that subject-extractions are easier than object-extractions using context by telling participants that all sentences contained RCs and where the RCs are exactly located in the sentence.

However, in real time reading, no direct instruction will be given about the RCs contained in the sentences. A better context construction in the experiment removing the possible syntactic ambiguity or garden-path is needed to further examine the subject or object preference in processing Chinese relative clause. The current study will run the experiment with items in a controlled context prior to the Chinese target sentences containing subject- or object-extraction relative clauses. The results will answer which relative clause is more complex than the other with supportive context. Locality theories such as Dependency Locality Theory (Gibson, 1998) and experience-based theories such as frequency of relative-clause type (Kou and Vasishth, 2007) will be applied to analyze the results thus proving their validity.

2. EXPERIMENT

2.1 Participants

Sixty college students participated in the experiments voluntarily with Chinese Mandarin as their native language. None of them is bilingual yet with English or Japanese as their second language at primary or middle level. The average age is around 20. Other factors such as eye sight are also controlled.

2.2 Materials

Based on Lin and Bever's (2007) experiment items, twenty-four sets of Chinese sentences were constructed as target items. Each set consisted of one short context sentences less than 37 Chinese characters, two sentences with subject-extraction relative clause and object-extraction relative clause separately in subject modification condition (s-modifying), and two sentences with subject-extraction relative clause and object-extraction relative clause separately in object modification condition (o-modifying). For example:

Context:

The tycoon and the manager are acquaintance. When they attended a wedding ceremony, the tycoon was there earlier and he met the priest feeling happy.

富人和經理是舊相識，在去參加某人的婚禮時，富人先到了並遇見了牧師因而心裡很高興。

a. SRC in subject modification condition

shushi furen *de* jingli yujianle mushi suoyi xinli hen gaoxing.

knows tycoon *de* manager met priest so feeling very happy.

The manager who knows the tycoon met the priest so feeling very happy.

熟識富人的經理遇見了牧師所以心裡很高興。

b. ORC in subject modification condition

furen shushi *de* jingli yujianle mushi suoyi xinli hen gaoxing.

tycoon knows *de* manager met priest so feeling very happy.

The manager who the tycoon knows met the priest so feeling very happy.

富人熟識的經理遇見了牧師所以心裡很高興。

c. SRC in object modification condition

mushi yujian shushi furen *de* jingli suoyi xinli hen gaoxing.

priest met knows tycoon *de* manager so feeling very happy.

The priest met the manager who knows the tycoon so feeling very happy.

牧師遇見了熟識富人的經理所以心裡很高興。

d. ORC in object modification condition

mushi yujian furen shushi *de* jingli suoyi xinli hen gaoxing.

priest met tycoon knows *de* manager so feeling very happy.

The priest met the manager who the tycoon knows so feeling very happy.

牧師遇見了富人熟識的經理所以心裡很高興。

Also, to avoid sentence ending effect which usually takes longer time at the last word position in a sentence, all the target sentences in one set are arranged a same ending that is especially useful in object modification condition.

There are also eighty filler items in the experiment composed of one context sentence and one statement related to context sentence which has no special word order.

2.3 Procedure

The task was self-paced, word-by-word reading, using a moving window display. Linger 2.94 was the software applied to run the experiments.

Participants read the whole context sentence first. Then a series of dashes marking the length and position of the words in the sentences appeared. Participants needed to press the spacebar to reveal each word of the sentence. As each new word appeared, the previous word disappeared. The amount of reaction time (RT) the participant spent on each word was recorded as the time between key-presses. After the sentences, a true or false question was asked related to sentence comprehension based on context sentences. Participant pressed one of the two keys to respond "ture" or "false". If an incorrect answer was given, a message "Ooops, your answer was wrong!" stayed in the middle of the screen till next press. There was no feedback for the right answers. Participants were asked to read sentences at a natural rate and to be sure that they understood what they read. After each experiment, participants were also asked to give their comment in general, which was recorded, to exclude possible strategy formed in the experiment.

3. RESULTS

3.1 Comprehension question performance

The percentage of the correct answer based on each participant is 92% on average with standard deviation of 0.27. The statistics of correct answer by condition is shown in the following Table 1. Participants did better in subject-modifying conditions than in object-modifying conditions, as in t-test for SRC in two conditions, Ms-modifying=0.96, SEs-modifying=0.01; Mo-modifying=0.90, SEo-modifying=0.02; $t(718)=2.95$, $p<0.01$; and for ORC in two conditions, Ms-modifying=0.95, SEs-modifying=0.01; Mo-modifying=0.89, SEo-modifying=0.02; $t(718)=2.98$, $p<0.01$. In all, participants paid enough attention to the task.

Table 1: Mean (standard error) comprehension question performance by condition

SRC/s-modifying	ORC/s-modifying	SRC/o-modifying	ORC/o-modifying
0.96 (0.01)	0.95 (0.01)	0.90 (0.02)	0.89 (0.02)

3.2 Reaction times

As normally expected, SRCs and ORCs are processed faster in subject modification conditions than they are in object modification conditions due to their less structural and informational complexity as shown in Figure 1 with significant difference found at N(src) ($t(565)=-2.25$, $p<0.05$), and Figure 2 with significant differences found at V(orc) and DE ($t(571)=-5.87$, $p<0.01$; $t(571)=-3.66$, $p<0.01$).

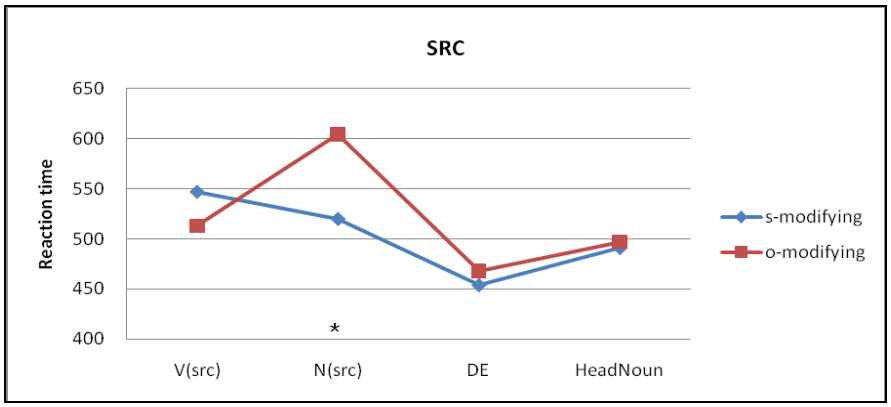


Figure 1: Reading time of each region within subject-extraction relative clause in s-modifying and o-modifying conditions

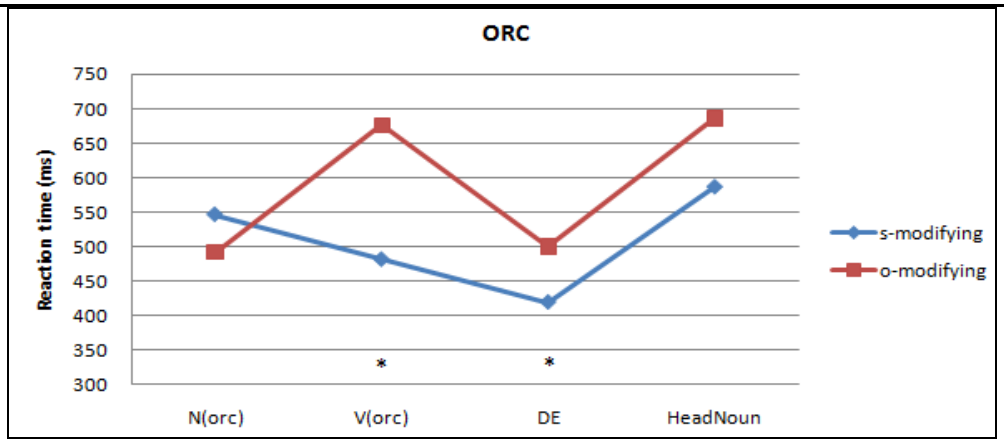
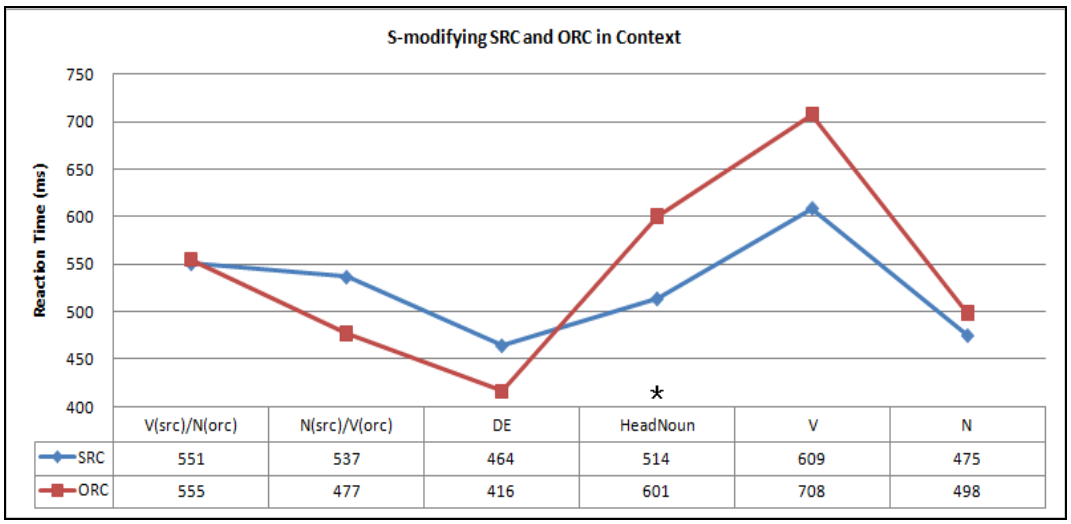


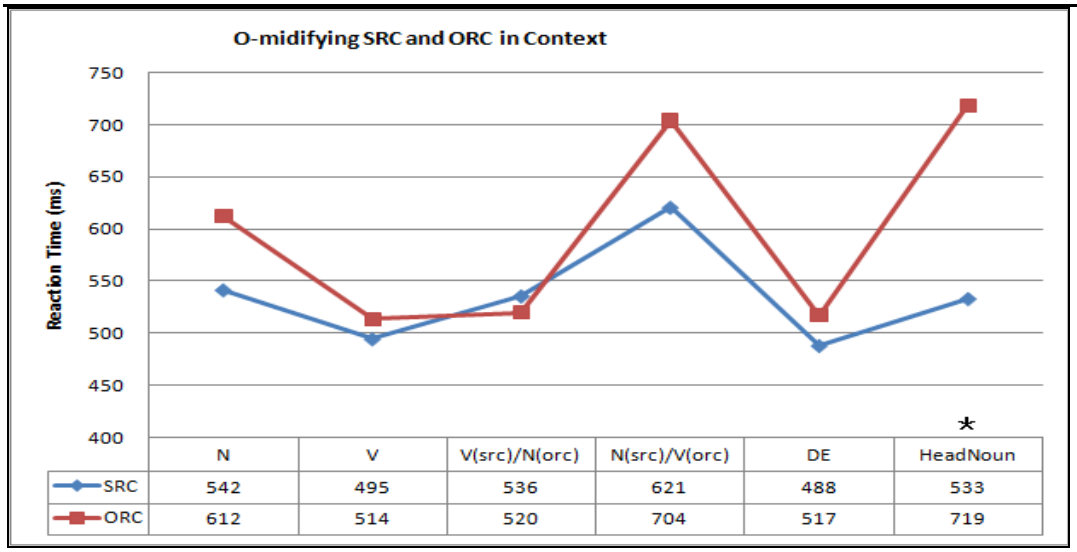
Figure 2: Reading time of each region within object-extraction relative clause in s-modifying and o-modifying condition

Comparing reading time of relative clause with genitive marker DE, head noun and two words after head noun for spillover between SRs and ORs, no significant differenc is found at the first and the second position (V(src)/N(orc) and N(src)/V(orc) in Figure 3 & 4) between subject relative clause and object relative clause. Same results are also found at position of genitive marker DE ($t(718)=1.66$, $p>0.05$; $t(718)=-1,24$, $p>0.05$) although in ORs it is processed numerically faster in subject-modifying condition while slower in object-modifying condtition. Yet significant differences are found in both conditions for the head noun ($t(718)=-2.55$, $p<0.05$; $t(718)=-3.62$, $p<0.05$). The head nouns are all processed faster in SR than in OR.



	V(src)/N(orc)	N(src)/V(orc)	DE	HeadNoun	V	N
SRC	551	537	464	514	609	475
ORC	555	477	416	601	708	498

Figure 3: Comparison of SRC and ORC in subject-modifying condition. Statistics at each position from left to right are: $t(718)=0.08$, $p>0.05$; $t(718)=1.53$, $p>0.05$; $t(718)=1.66$, $p>0.05$; $t(718)=-2.55$, $p<0.05$; $t(718)=-1.70$, $p>0.05$; $t(718)=0.21$, $p>0.05$



	N	V	V(src)/N(orc)	N(src)/V(orc)	DE	HeadNoun
SRC	542	495	536	621	488	533
ORC	612	514	520	704	517	719

Figure 4: Comparison of SRC and ORC in object-modifying condition. Statistics at each position from left to right are: t(718)=-1.23, p>0.05; t(718)=-0.74, p>0.05; t(718)=0.70, p>0.05; t(718)=-1.82, p>0.05; t(718)=-1.24, p>0.05; t(718)=-3.62, p<0.05

4. DISCUSSION

The current experiment result is contradictory to the results of Hsiao and Gibson's (2003). Locality theories such as Active Filler Strategy (Frazier and Flores d'Arcais, 1989), or Dependency Locality Theory (Gibson, 1998), cannot give a fully explanation. According to Dependency Locality Theory, the subject-extracted RC in (2b) should be more complex than the object-extracted RC in (2a). This theory assumes that after the first word yaoching in the subject-extracted RC (2b) is processed, the reader realizes that an RC is being processed for no subject for the verb appears. Thus, three syntactic heads are needed including a main clause verb, RC genitive marker DE and an NP object for the verb in the RC. When object noun fuhao is processed, two syntactic heads are still needed which are the main verb and the RC genitive marker. While in (2a) after the first word fuhao is processed, only one syntactic head is expected, a verb for the clause since this verb could also be the main verb for the main clause. After the second word yaoching is processed, there is still only one head needed which is a noun object for the verb. The genitive marker DE is processed for the same storage cost for each structure. However, it is hard to expect a relative clause when encountering a verb-initial Chinese sentence because Chinese sentences, though basically a SVO word order, have abundant subject-drop VOs.

Besides, the processing of the first and the second word in ORC is not significantly faster than in SRC as predicted. Chinese is often described as a "topic-prominent" language, making it difficult to define "subject" and "object" on the ground of grammatical relations due to its lack of case marking or subject-verb agreement. Chinese readers will most probably process sentences according to their language experience. This means the pragmatic or discourse-related criteria rather than structural or thematic role-related constraints play the role determining the argument for the initial word in a sentence. Shown in Wang et al. (2009), when comparing ERP responses at the position of the verb and the second NP in object-verb-subject (OVS) and subject-verb-object (SVO) structures, subject-preference is proved regardless of controversial view of grammatical relations. They found an N400 in the experiment for subject-initial control condition comparing with object-initial condition, which justified the lexical-semantic relatedness between NP and verb makes the difference.

Chinese holds the universal pattern of subject-preference. The pattern is well explained by experience-based theories. MacDonald and Christiansen (2002) argued that the unique word order of

object relatives makes their processing more difficult and more sensitive to the effects of previous experience than the processing of subject relatives. As a conclusion, they thought the variations in reading experience were the source of differences. Wells et al. (2009) tested the hypothesis in a large-scale study manipulating reading experiences of adults over several weeks. They found that comparing with a control experience group, the target group receiving relative clause experience increased reading speeds for object relatives more than for subject relatives. Meanwhile, the reading time data matched the performance of a computational model given different amounts of experience. These results showed the experience-based individual differences as well as the importance for statistical learning in sentence comprehension processes.Besides, Kou and Vasishth (2007) stated corpus evidences cross-linguistically for the subject preference as subject relatives occur more frequently than object relatives. Especially, in the Chinese Penn Treebank, there are 57.5% of subject relative clauses while 42.5% for the object relative clauses. (see also Desmet and Gibson, 2003) Even Gibson himself found that "online disambiguation preferences matched corpus frequencies when lexical variables were taken into account."(Reali & Christiansen 2007)

5. CONCLUSION

The experiment results in this paper find significantly faster processing speed at head noun in subject relative clauses than in object relative clauses but no significant difference at other positions with the supportive context. This matches the distribution of SRC and ORC in Chinese very well. The syntactic ambiguity is removed, and still subject preference is found in Chinese relative clauses, further proving the claims by Lin and Bever (2007) and Kou and Vasishth (2007) that Chinese as other languages follows the universal rule in relative clauses.

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