Arizona Working Papers in SLA & Teaching, 20, 20-39 (2013)

L2 PROCESSING OF RELATIVE CLAUSES IN MANDARIN

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Studies investigating native processing of relative clauses in Mandarin Chinese have shown a processing asymmetry in terms of subject-gapped (SRCs) or object-gapped (ORCs) relative clauses. Unlike research that has been done in English, which revealed a clear SRC advantage in relative clause processing, results from the studies in Chinese did not reach a unanimous agreement. In this study, a self-paced reading task and an off-line questionnaire were conducted to examine the native and non-native processing of Chinese relative clauses (RCs) containing either a subject-gap or an object-gap, either at the matrix subject or object position of the sentences. Twenty-four native speakers of Mandarin (L1) and thirty-two intermediate second language learners of Chinese (L2) participated in this study. The native languages of those L2 learners were either head-initial languages (e.g., English, Spanish, and French) or head-final languages (e.g., Korean and Japanese). Studies examining non-native processing of relative clauses in Mandarin Chinese have been limited, thus, research investigating how L2 learners of Chinese process relative clauses online can provide more information about whether L2 learners can construct abstract grammatical representations (e.g., filler-gap dependencies) as native speakers do in real-time processing. Results showed that, in answering the questionnaire, both L1 and L2 speakers found SRCs more difficult than ORCs. The reading time data showed that for native speakers, SRCs were read significantly more slowly than ORCs only when the RCs are modifying the matrix subject. Although the L2 data as a whole did not reveal a robust effect of gap site, dividing them into head-initial and head-final groups showed that learners from the head-initial group processed ORCs significantly more slowly than SRCs, irrespective of their positions in matrix sentences, which could be attributed to the result of L1 transfer. A main effect of the matrix position was also found for both the L1 and the L2 groups.

INTRODUCTION

L2 Processing of Relative Clauses in Mandarin

Three positions have been proposed in second language (L2) grammatical processing. One position is that L2 processing is qualitatively different from native processing, irrespective of L2 proficiency. Another position is that at lower proficiency level in L2, non-native processing is qualitatively different from that of native speakers; however, as learners' proficiency develops, L2 processing is only quantitatively different from L1 grammatical processing. The third position is that L2 grammatical processing is quantitatively different from native processing, regardless of L2 proficiency. To provide evidence for these accounts, studies investigating native and non-native processing of complex syntactic structures have been carried out in various languages.

Relative Clause (RC) is one of the structures that have gained much attention in processing literature. A relative clause is in nature an embedded sentence modifying a noun in a matrix sentence. One of the arguments of the embedded sentence consists of a "gap" that is co-referential with the head noun being modified. This characteristic of relative clauses offers us the possibility to investigate how people process filler-gap dependency in reading. In addition, a relative clause always contains the information "who is doing what to whom" (Packard, 2008 p. 108), which has made relative clauses fairly difficult for L2 learners to acquire.

A major goal in psycholinguistic research is to provide cross-linguistic evidence for human parsing mechanisms, especially for speakers of both head-initial and head-final languages, by comparing native and non-native processing. Regarding relative clause, in head-initial languages such as English and French, the head of relative clauses usually goes before the modifying phrase, while in head-final languages such as Chinese, Korean and Japanese, the head of relative clauses usually occurs after the modifying phrase. Although there are differences in the headedness of relative clauses, there are similarities in the basic structure of a relative clause across different languages. A relative clause can be either *subject-extracted* or *object-extracted*. A subject-extracted RC (SRC) means that the "gap" or the "logic trace" in the embedded phrase is co-referential with the head noun that is the subject of that embedded phrase, whereas an object-extracted RC (ORC) means that the "gap" is co-referential with the head noun that occupies the object position of the embedded phrase.

Table 1 shows examples representing SRCs and ORCs in English, Chinese and Korean, respectively. In these examples, ϕi represents the gap in relative clause that is co-referential with the head noun, with the filler indicated by "*i*" on the head. Sentences 1 and 2 are relative clauses in English, which is a head-initial SVO language, 3 and 4 are sentences in Chinese, which is a head-final SVO language, and sentences 5 and 6 are Korean sentences, which is a head-final SOV language. The underlined parts are relative clauses. Among the three languages, English has a relativizer "that" following the "filler", indicating the beginning of a relative clause, whereas both Chinese and Korean have a marker indicating the head noun (i.e., the filler), with DE for Chinese and –N for Korean, respectively.

Language	Type	Examples
English (head-initial)	SRCs	1. The dog$_i$ that ϕ_i likes Mary chased the cat.
	ORCs	2. The dog$_i$ that Mary likes ϕ_i chased the cat.
Chinese (head-final)	SRCs	3. ϕ_i喜欢 玛丽 的 狗$_i$ 追 猫。 xihuan Mali de gou zhui mao like Mary DE dog chase cat *The dog that likes Mary chased the cat.*
	ORCs	4. 玛丽 喜欢ϕ_i 的 狗$_i$ 追 猫。 Mali xihuan de gou zhui mao Mary like DE dog chase cat *The dog that Mary likes chased the cat.*
Korean (head-final)	SRCs	5. ϕ_i 마리 를 좋아하는 개$_i$ 가 고양이를 쫒았다. Mary-ACC like -N dog.NOM cat-ACC chased *The dog that likes Mary chased the cat.*
	ORCs	6. 마리 가 좋아하ϕ_i는 개$_i$ 가 고양이를 쫒았다. Mary-NOM like -N dog-NOM cat-ACC chased *The dog that Mary likes chased the cat.*

Table 1: Examples of Relative Clauses in English, Chinese and Korean[1]

The remaining parts of this paper will be organized as follows: first, previous studies on Chinese relative clause processing will be discussed; next, the current study will be described, followed by a general discussion and conclusion. Finally limitations and pedagogical implications will be discussed.

LITERATURE REVIEW

Studies investigating the processing of filler-gap dependencies in English have shown that ORCs are more difficult to process than SRCs. This subject-gap advantage has also been found in other head-initial languages, such as French (Cohen & Mehler, 1996; Cf. Lin & Bever, 2006), and Dutch (Mak, Vonk, & Schriefers, 2002; Cf. Lin & Bever, 2006). However, in the case of Mandarin Chinese, agreement has not been reached with respect to the asymmetric processing difficulty in reading SRCs and ORCs. Several theories and proposals have been provided to account for the gap-site effects observed in relative clause processing.

According to the linear distance account (King & Just, 1991; Hsiao & Gibson, 2003), the processing difficulty depends on the linear distance between the filler and the gap, with the longer filler-gap distance generating greater processing difficulty. In the case of Chinese, the linear distance between the gap and the head noun in SRCs are longer than that in ORCs, thus linear distance theory predicts that, in Chinese relative clauses, SRCs are harder to process than ORCs.

Corresponding to the structural distance theory (Lin & Bever, 2006), the processing difficulty is determined by the depth of the embedding of the filler and the gap, with the more deeply embedded relative clause being more difficult to process. In Chinese relative clauses, the filler and the gap are more deeply embedded in ORCs than in SRCs. Thus, the structural distance theory predicts the advantage of SRCs over ORCs during processing.

Canonical word order theory, proposed by MacDonald & Christiansen (2002), contends that a relative clause will be harder to process if the word order of the embedded clause is not the same as the canonical word order of the target language. In the case of Chinese, an SVO language, the word order of the embedded SRCs is VOS, whereas for ORCs, the word order of the embedded clause is SVO, which is consistent with the canonical word order of Chinese. Therefore, this theory predicts that greater processing difficulty will be induced in reading SRCs.

As claimed by the clause-initial agent theory (Diessel & Thomasello, 2005; Cf. Packard, 2008), there is a universal preference for the clause-initial noun phrase (NP). Since in the case of SRCs in Mandarin, the sentence-initial component is a verb, while it is an NP in ORCs, SRCs are thus harder to process than ORCs under this account.

Under the perspective shift theory (MacWhinney & Pleh, 1988), subject-modifying SRCs are universally predicted to be the easiest, followed by object-modifying SRCs and ORCs; the subject-modifying ORCs are predicted to be the most difficult to process (Lin & Garnsey, 2011). Thus, when modifying the matrix subject of the sentence, ORCs are considered to be more complex than SRCs.

However, as Lin and Garnsey (2011) point out, the accounts discussed above have not emphasized the importance of the processing demands on the online integration of upcoming words. Gibson (1998), on the other hand, proposed the Dependency Locality Theory, which distinguished two sources of processing cost, namely, storage cost and integration cost. According to the storage cost account, Chinese SRCs should be more complex than ORCs because SRCs require greater storage resources for holding the incomplete gap-head noun dependencies in working memory than ORCs. Along the same line, the integration-based resource theory also predicts greater difficulty in SRCs than ORCs because more efforts will be involved in integrating the incoming head noun with the gap in SRCs in Chinese.

Besides the working memory-based theories described above, there is another class of theories called experience-based theories (e.g., Tuning Hypothesis, Mitchell, Cuetos, Clorley, & Brysbaert, 1995), which suggest that people's ease or difficulty in sentence comprehension is largely predicted by their experience in encountering similar words or structures in the past (Gibson & Wu, 2011). Strictly speaking, the canonical word order theory and the clause-initial agent theory discussed above are all subcategories of the experience-based school, because these theories are all experience-driven. A corpus study of relative clauses in Chinese conducted by Wu et al. (2011) has shown that SRCs are more frequent in Mandarin, and that SRCs may therefore be predicted to be easier to process than ORCs.

Several studies have been conducted to investigate the asymmetry of difficulty in processing SRCs and ORCs among native speakers of Mandarin. Hsiao and Gibson (2003) was the first to employ an online self-paced reading paradigm to investigate this empirical question. Both singly- and doubly-embedded relative clauses modifying matrix subjects were included in their experiment, and they found that SRCs are more complex than ORCs in Chinese. Following the storage-based theory, they anticipated that the difficulty was because the storage cost associated with predicting syntactic heads in SRCs is greater than in ORCs. Such difficulty can also be explained by the canonical word order theory because the word order of the embedded SRCs is not consistent with the canonical SVO word order in Chinese.

Lin and Bever (2006) modified the stimuli used in Hsiao and Gibson (2003) by adding matrix object-modifying conditions to reevaluate the preference for the SRCs and ORCs by Chinese native speakers. In a self-paced reading paradigm, they found a robust subject preference irrespective of whether they modify the matrix subjects or the objects, as indicated by the shorter reading times in subject-extracted relative clauses. They attributed their findings to the structural distance theory.

Kuo and Vasishth (2006) also used Hsiao and Gibson's (2003) materials and added new stimuli using either determiners or BEI structure, however, they failed to replicate Hsiao and Gibson's (2003) results and found that subject-modifying ORCs are relatively more difficult to process than subject-modifying SRCs.

Using both self-paced reading and eye-tracking tasks, Yang, Johnson, and Gordon (2008) did not report a clear preference for SRCs or ORCs. They found that differences in reading time depended upon whether the relative clauses are modifying the matrix subject or the matrix object, with subject-modifying SRCs slower than ORCs, whereas the object-modifying ORCs were read more slowly than the SRCs.

Chen, Ning, Bi and Dunlap's (2008) study also indicated that for readers with low working memory spans, SRCs are found to be more difficult to process than ORCs, while for readers with high memory spans, no reliable difference was found regarding the processing difficulty in SRCs and ORCs.

Wu and Gibson (2011) included a supporting context in a self-paced reading study to examine the processing difficulty in Chinese relative clauses by arguing that adding contexts may reduce the temporary ambiguity of the experimental sentences, and also may decrease between-subject variance that is possibly associated with "lexical-level processing and world knowledge" (p. 19). It was found that SRCs are harder than ORCs when embedded in a supporting discourse context. What is more, the effect size of the gap site was found to be much larger than other experiments studying singly-embedded relative clauses.

Lin and Garnsey (2011) took advantage of the possibility of topicalizing the matrix object and the feature of allowing head dropping in

Chinese to examine the difficulty in processing SRCs and ORCs. Their results for both the head-present and head-absent conditions replicated the finding that SRCs are more difficult to process than ORCs when the relative clauses are modifying a topicalized matrix object. The relative difficulty of SRCs was attributed to the increased complexity caused by the topicalized object, as was the case in the doubly-embedded sentences in Hsiao and Gibson's (2003) study. Their findings are compatible with the canonical word order account, linear distance theory and Gibson's (1998) Dependency Locality Theory.

Using an Event-Related Potentials paradigm, Packard, Ye and Zhou's (2011) study examined the filler-gap processing in Chinese relative clauses by native speakers of Mandarin. They tested both the subject- and object-modifying SRCs and ORCs, and their results showed that the filler-gap integration is more costly for SRCs than ORCs, as suggested by a greater positivity for the subject-extracted over object-extracted relative clauses in the 600 milliseconds time window, which has been found to reflect the processing of long-distance syntactic dependencies in well-formed sentences.

Besides relative clause processing literature for normal individuals, a related study conducted by Su, Lee and Chung (2007), investigating the processing difficulty in Chinese aphasic patients, also found aphasic patients unable to reliably answer comprehension questions about SRCs, despite their high performance on ORCs. The results from this study further strengthened the significance of the role of memory in explaining relative clause processing.

Therefore, the results available so far seem to favor the claim that SRCs are more difficult to process than ORCs in Chinese, at least in L1 processing. Nevertheless, few studies have been conducted to assess L2 Chinese learners' processing of relative clauses. To the author's knowledge, the only published study investigating the processing difficulty of SRCs and ORCs in L2 learners of Mandarin was carried out by Packard (2008).

Packard (2008) examined nonnative processing of both subject-modifying and object-modifying SRCs and ORCs using a self-paced reading task. He found results consistent with the major findings for Chinese L1 speakers: that L2 Mandarin learners processed SRCs more slowly, compared to ORCs.

To conclude, the majority of the literature supports the relative advantage of ORCs over SRCs in Chinese in L1 relative clause processing both for normal individuals and aphasic patients. Among the various theories proposed, the canonical word order theory, the working memory-based Dependence Locality Theory (Gibson, 1998), and the linear distance theory seem to best account for the ORC advantage most frequently observed. However, some studies also suggested no clear processing difficulty of subject- or object-gap relative clauses in Mandarin. On the other hand, studies investigating L2 learners of Chinese are still limited, lacking enough evidence to draw a conclusion on the asymmetry of difficulty in processing SRCs and ORCs.

THE PRESENT STUDY

The present experiment was conducted with the aim of examining whether L2 learners of Mandarin Chinese process relative clauses the same way as native speakers do. This study follows Packard's (2008) experiment design, but adds two more words (a demonstrative pronoun "that" and an adjective) between the relative clause marker DE and the head noun. The purpose of adding two more words was to see whether increasing the distance between the "gap" and the "filler" would still replicate Packard's (2008) results that L2 learners of Chinese process subject-gapped relative clauses more slowly than object-gapped relative clauses.

Thus, the present study aims to investigate:

1. Whether the observed advantage of ORCs is replicable by native speakers (i.e., the L1 group) in this study;
2. Whether L2 learners process the relative clause the same way as native speakers do (i.e. slower in SRCs);
3. Whether the headedness of the native languages of L2 learners has an effect on their performance; and
4. Whether the different gap positions in the matrix sentence influence both L1 and L2 speakers' processing of Chinese RCs.

Participants

Fifty-seven participants took part in this experiment, with one participant failing to finish the on-line self-paced reading task due to technical problems. Among them, 24 participants (Female: 22, Male: 2) were native speakers of Chinese and college students in China. Seventeen of the 33 (Female: 13, Male: 20) Chinese L2 learners were from the head-initial L1 backgrounds (English: 15; Spanish: 1; French: 1), and sixteen were from the head-final language backgrounds (Korean: 12; Japanese: 4). The L2 speakers were recruited and tested in different locations. Fifteen of them were tested in the United States, while 18 were tested in Beijing, China.

The L2 group's average age was 24.5 (*SD*=6), and had studied Chinese for an average of 3 (*SD*=1.8) years. The pencil-and-paper-based Chinese Proficiency Test showed that the mean score for all the L2 speakers was 71.02 (*SD*=18.26) out of a 100-point scale.

Experimental Stimuli

There were 4 experimental conditions in this study, with the SRCs and ORCs modifying the matrix subject or object position of the sentences. Examples of each condition can be seen in Table 2.

Condition	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8
SS	帮助 help	邻居 neighbor	的 DE	**那个** That	**善良的** kind	***男孩*** boy	讨厌 hate	哥哥。 brother
	That kind boy that helped the neighbor hates the brother.							
SO	邻居 neighbor	帮助 help	的 DE	**那个** That	**善良的** kind	***男孩*** boy	讨厌 hate	哥哥。 brother
	That kind boy that the neighbor helped hates the brother.							
OS	哥哥 brother	讨厌 hate	帮助 help	邻居 neighbor	的 DE	**那个** that	**善良的** kind	***男孩*** boy
	The brother hates that kind boy that helped the neighbor.							
OO	哥哥 brother	讨厌 hate	邻居 neighbor	帮助 Help	的 DE	**那个** that	**善良的** kind	***男孩*** boy
	The brother hates that kind boy that the neighbor helped.							

Notes: SS- Subject-modifying subject-gapped relative clauses
SO- Subject-modifying object-gapped relative clauses
OS- Object-modifying subject-gapped relative clauses
OO- Object-modifying object-gapped relative clauses

Table 2: Experimental Conditions

Each stimulus sentence is segmented into eight regions, with the relative clause containing six regions. The relative clause is composed of a verb "*帮助*" (help), an argument "*邻居*" (neighbor), the relative clause marker "*的*" (DE), a demonstrative pronoun "*那个*" (that), an adjective "*善良的*" (kind), and the head noun "*男孩*" (boy). The pronoun "*那个*" (that) and the adjective "*善良的*" (kind) were added to increase the distance between the "gap" and the "filler" (i.e., the head noun). For the subject-modifying relative clauses, the relative clause occupies regions 1-6, whereas for the object-modifying sentences, the RC occupies regions 3-8.

Since most of the L2 participants had an average of three years of Chinese language instruction, the stimulus sentences were designed by using the vocabulary from the textbooks for the first- and second- year Chinese learners at the University of Illinois at Urbana-Champaign. All of the final selected experimental sentences were considered highly acceptable by a group (N=5) of native speakers of Chinese who were all graduate students at the University of Illinois.

Tasks

On-line Self-Paced Reading Task

For the self-paced reading task, all of the 40 stimulus sentences, with 10 sentences from each condition, were assigned into 4 experimental lists based on a Latin-square design. In each list, there were 10 stimulus sentences, 15 distracting relative clauses, and 40 filler sentences, yielding 65 sentences in total. In addition, to control for the plausibility effect, the two arguments of the relative clauses were also switched around, generating 8 experiment lists. Each participant was randomly assigned to one of the 8 lists. The items within each list were presented pseudo-randomly, with the sentences from the same condition never appearing consecutively.

Off-line Questionnaire

There were 20 items in the off-line questionnaire, with 3 items from each condition and 8 filler sentences. The 20 items were pseudo-randomly ordered, with no consecutive items coming from the same condition.

Procedure

The participants were tested individually on a laptop in a quiet environment.

Background Information Questionnaire

All participants were instructed to fill out a background information questionnaire, which included their age, native languages, other foreign languages learned, length of exposure to Chinese, years of Chinese instruction, years of immersion in a Chinese-speaking environment, and daily usage of Chinese.

Chinese Proficiency Test

After filling out the background information questionnaire, all L2 participants took a proficiency test, which was adapted from The Chinese Proficiency Test (HSK, *Hanyu Shuiping Kaoshi*) by the investigator in order to evaluate language competence.

On-line Self-Paced Reading Task

All participants then took part in an on-line noncumulative word-by-word reading task. The task was programmed on E-prime 2.0. The stimulus sentences were segmented into 8 regions. After participants finished reading one region, they pressed the space bar to elicit the next region, and the previous region disappeared from the screen. Reaction times were recorded in milliseconds for each press of the key. Once the participants finished reading the whole sentence, a comprehension question (in Chinese) regarding the sentence they had read appeared on the screen. The questions were True-or-False questions, not targeting the relative clauses.

To illustrate, participants pressed the space bar to read the whole sentence word-by-word until they reached the 8th region. The slashes between words represent the segmentation of the sentence.

帮助 |	邻居 |	的 |	那个 |	善良的 |	男孩 |	讨厌 |	哥哥。
help	neighbor	DE	that	kind	boy	hate	old brother

That kind boy that helped the neighbor hates the older brother.

After the presentation of the whole sentence, the comprehension question for this sentence appeared on the screen:

邻居讨厌哥哥。对不对？

The neighbor hates the brother. True or False?

Participants then pressed the "T" button on the keyboard if the statement was correct or the "F" button if the statement was wrong according to the information provided in the sentence. Upon answering the question, participants pressed the space bar to elicit the next sentence. Before the real experiment began, they underwent a brief practice session to ensure they fully understood the task.

Off-line Questionnaire

After finishing the on-line experiment, subjects who participated in the on-line task were asked to do an off-line questionnaire. Participants were guided to read the sentences and answer multiple-choice questions regarding the relative clauses about "who did what to whom."

A sample of the questionnaire is given as follows:

帮助邻居的那个善良的男孩讨厌哥哥。

That kind boy that helped the neighbor hates the brother.

Question: 谁帮助谁？*Who helped whom?*

a. 邻居帮助男孩。*The neighbor helped the boy*

b. 男孩帮助邻居。*The boy helped the neighbor*

The purpose of this questionnaire was to test whether readers have difficulty in comprehending relative clauses, either at the subject or object positions of the matrix sentences, and to determine which type of gap-site (SRC vs. ORC) was more difficult to comprehend.

English Proficiency Test

For native speakers of Mandarin and L2 learners from the head-final language backgrounds, an English proficiency test was given at the end of the experiment to examine whether the English proficiency of those participants would have an effect on their performance. There were 30 multiple-choice questions testing both English grammar and vocabulary, which was adopted by the investigator from the paper-based TOEFL (Test of English as a Foreign Language) questions.

For the native speakers, the whole session took approximately 20 minutes, whereas for the L2 speakers, the experimental process took 50 to 60 minutes in total.

DATA ANALYSIS

Since the online data sets were positively skewed, they were transformed by using a log transformation process. After the transformation, the data sets appeared to be a normal distribution, the assumption required by ANOVA. All statistical analyses were computed on the log-transformed values, but descriptive statistics were still reported using the raw data values.

Given the 2 (gap-site: SRCs vs. ORC) X 2 (matrix position: subject vs. object) mixed design of the on-line task, a repeated-measures ANOVA was conducted to analyze the data collected. The dependent variable was the reading time for the head noun of relative clauses; the gap site and matrix position factors were the within-subject independent variables, and the native languages and the Chinese proficiency scores served as the between-subject factors. The total reading times of the relative clauses were also calculated by summing up the reading times for each region of the RCs to test the effect of matrix position.

As for the off-line task, the error rate of each participant for each condition (i.e., SS, SO, OS, and OO) was collected, and compared between groups.

Results

Off-line Questionnaire

Out of the 288 stimulus sentences, native speakers answered 96.5% (278/288) of them correctly, while out of the 396 stimuli, L2 speakers responded to 70.96% (281/396) of them correctly. Among the 10 errors made by native speakers, 60% (6/10) of them were made in the SRCs, with a non-significant difference (X1=0.489, $p>0.4$). However, there was a main effect of matrix position, which was significant by subject (X1=5.308, $p<0.05$), with the relative clauses in the matrix object position answered less accurately than those in the matrix subject position. For L2 learners, among the 115 responses answered incorrectly, 33.84% (67/115) of them were in SRCs. The difference was significant (X1=3.94, $p<0.05$). There was also a significant effect for the matrix position both by subject (X1=6.695, $p<0.05$) and by item (X1=6.4, $p<0.05$), with the relative clauses in the matrix object position eliciting more errors than those in the matrix subject position.

Behavioral Data

Two participants from the L1 group and 6 from the L2 group were deleted from the final analysis due to their relatively low accuracy in answering the True-or-False questions, which led to an average accuracy of 88.6% (195/220) for the native group, and 65.77% (171/260) for the learners group. A chi-square test showed that the accuracy for the L2 group is significantly higher than the chance level (X1=6.4, $p<0.05$). Further analysis showed that, for the L1 group, 60% (15/25) of the questions answered incorrectly were attributed to SRCs; however, the difference between the SRCs and ORCs was found to be non-significant (X1=1.128, $p>0.2$). For the L2 group, 57.3% (51/89) of the wrong answers were in SRCs, but the difference between the sentences of the two types of gap sites was, again, not significant (X1=2.887, $p>0.08$).

Reading Times Data

The reading times for the SS and SO sentence types are plotted in Figure 1, and the OS and OO conditions are plotted in Figure 2. As seen in Figure 1, for native speakers, the reading time at the head noun "*男孩*" (boy) in the subject-modifying relative clauses was significantly longer in SRCs than in ORCs ($F_{1,21}=7.64$, $p<0.05$), suggesting that when modifying the matrix subject, SRCs are processed more slowly than ORCs. However, for the object-modifying relative clauses, as seen in Figure 2, the reading time for the head noun *boy* was not significantly different across the two gap sites ($F_{1,21}=0.025$, $p>0.5$), indicating that when modifying the matrix object position, there is no clear processing difficulty between SRCs and ORCs.

For the L2 learners as a whole group, in the subject-modifying relative clauses, the reading time for the head noun *boy* (Figure 1) is numerically longer in ORCs, but this difference was not statistically significant ($F_{1,25}=1.27$, $p>0.2$). Moreover, for the object-modifying relative clauses, as seen in Figure 2, the reading time for the head noun was also numerically longer in ORCs, but did not reach statistical significance ($F_{1,25}=0.5625$, $p>0.4$).

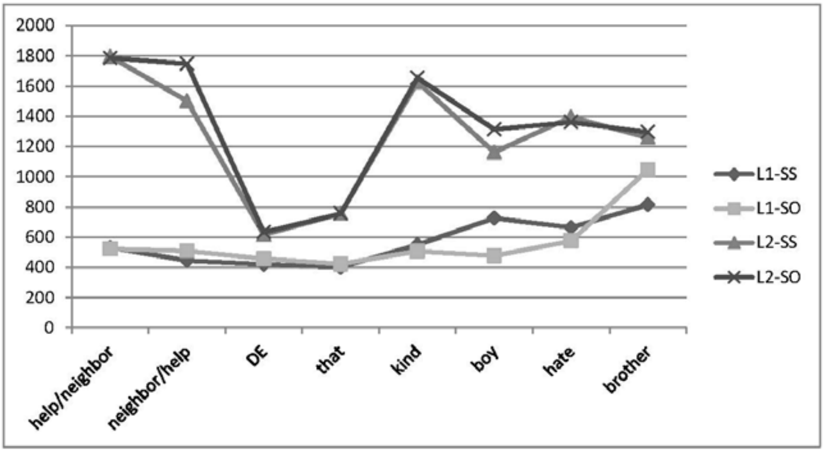

Figure 1: Mean Reading Time for SS and SO Sentences (in Milliseconds)

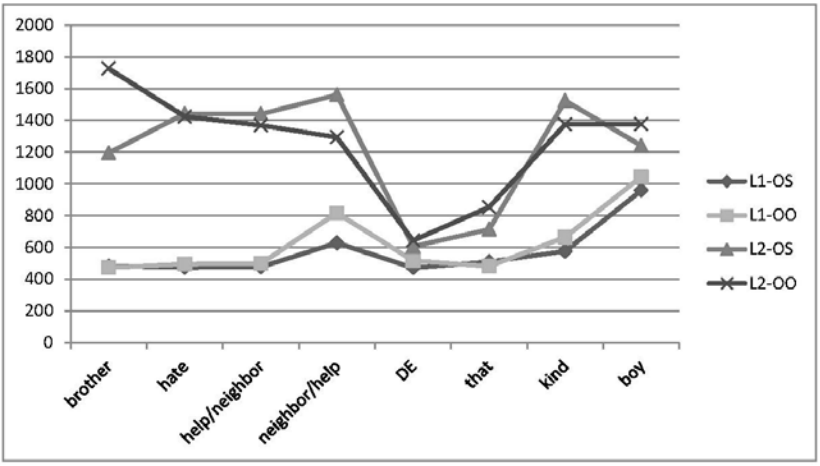

Figure 2: Mean Reading Time for OS and OO Sentences (in Milliseconds)

Since no clear gap site effect was found for the L2 learners, they were further divided into head-initial group (HI) and head-final group (HF) to see whether the native languages of L2 learners influenced their processing of relative clauses.

The mean reading times for the SS and SO sentence types are plotted in Figure 3, and the OS and OO conditions are plotted in Figure 4. As seen in Figure 3 and Figure 4, for learners whose native languages are head-initial languages, the reading time for the head noun was significantly longer in ORCs than in SRCs ($F1, 11=5.395$, $p<0.05$), regardless of whether they were in matrix subject or object position. This indicates that when processing relative clauses, learners from the head-initial L1 background show an SRC advantage, irrespective of its position in matrix sentences. However, for learners who are from head-final L1 background, no clear processing difficulty was observed in the current study ($F1, 13=0.16$, $p>0.05$).

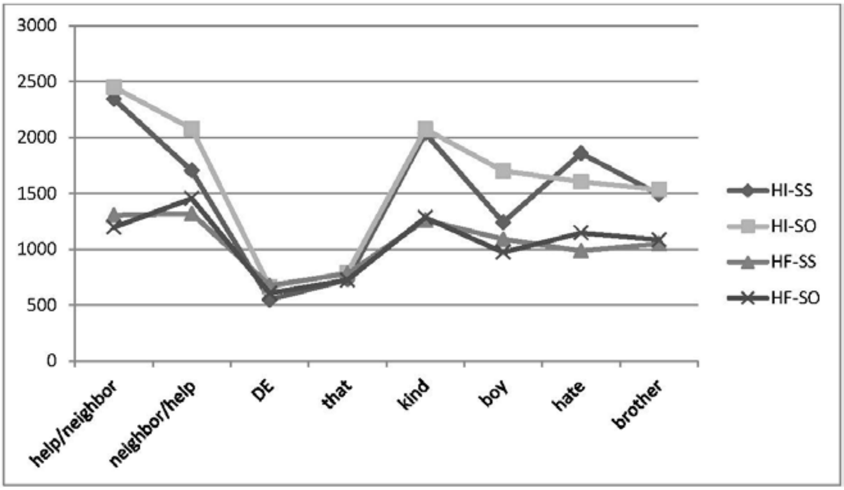

Figure 3: Mean Reading Time for SS and SO Sentences (in Milliseconds)

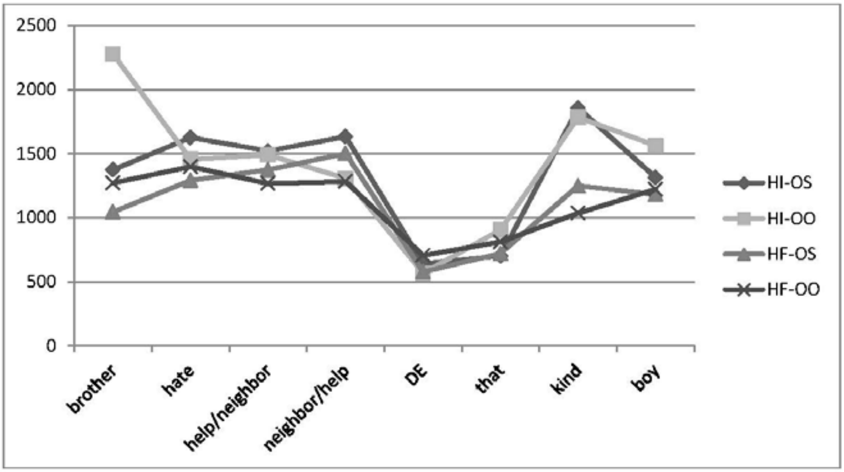

Figure 4: Mean Reading Time for OS and OO Sentences (in Milliseconds)

The total reading times for relative clauses are shown in Table 3. No main effect of gap site was found (F1, 21=0.073, p>0.7) for the L1 group. A main effect was found for the matrix position (F1, 21=10.347, p<0.05), with relative clauses in matrix object position being processed significantly more slowly. There was also a significant interaction effect between gap site and matrix position (F1, 21=5.646, p<0.05), suggesting the gap site effect was dependent upon whether the RCs are modifying matrix subject or matrix object of a sentence.

For the L2 group, ORCs were read numerically more slowly; however, the difference did not reach significance (F1, 25=0.051, p>0.5). The effect of the matrix position was also found to be statistically significant (F1, 25=4.708, p<0.05), with relative clauses in matrix subject position being read significantly more slowly. There was no interaction between gap site and matrix position (F1, 25=2.292, p>0.1).

		Subject Position	Object Position	**mean**
L1	SRC	3072.927	3624.6	3348.764
	ORC	2897.018	4024.704	3460.861
	mean	2984.973*	3824.652*	
L2	SRC	7458.691	7087.855	7273.273
	ORC	7895.061	6914.375	7404.718
	mean	7676.876*	7001.115*	

**p<.05*

Table 3: Mean Reading Times for Relative Clause by Gap Site and Matrix Position (in Milliseconds)

DISCUSSION

To summarize the findings from this study, both L1 and L2 speakers made more errors in SRCs and in object-modifying clauses in the offline questionnaire. As for the reaction time data, mixed results were found. Although both L1 and L2 groups responded to the comprehension questions more inaccurately in SRCs, the reading time data did not reveal consistent results. In terms of the reading time for the head nouns of the RCs, SRCs were read significantly more slowly only when the matrix subject position is modified in the L1 group. The L2 data as a whole did not reveal a robust ORC processing difficulty, but dividing the participants into head-initial and head-final groups showed that learners from head-initial native languages processed ORCs significantly more slowly, irrespective of their positions in matrix sentences. In terms of the total reading time for the relative clauses, there was a main effect for matrix position both for the L1 and the L2 groups, with relative clauses at matrix object position being processed more slowly by native speakers, and clauses at matrix subject position being read more slowly by L2 learners.

ORC Advantage in Off-Line Data

The off-line data revealed the expected ORC processing ease both for the L1 and L2 groups. Both L1 and L2 speakers' higher error rates on the SRCs indicated that readers may experience more difficulty when processing subject-extracted relative clauses. This finding supports the linear distance theory, the canonical word order theory, and the clause-initial agent theory in that all of those accounts predict the ORC advantage in processing relative clauses in Mandarin.

It was also indicated that object-modifying relative clauses elicited more errors than their subject-modifying counterparts. This tendency is probably due to the garden-path effect, which caused temporary ambiguity. For the subject-gapped sentences, the first word is the verb of the relative clause, which forms a di-verbal structure together with the main verb of the whole sentence occurring before it, a structure that is not very common in Mandarin. In addition, some of the verbs used in the experimental materials are such verbs as "*喜欢*" (like) and "*讨厌*" (hate), which allow action verbs to occur after them to form a phrase indicating "like doing" or "hate doing." For these reasons, readers might have misinterpreted the sentences, and could no longer recover from their initial readings. For the object-gapped relative clauses, the first word is the subject of the relative clause, which is easily parsed as the direct object of the main verb occurring immediately before it. However, considering the higher error rates for the OS condition than for the OO condition, it is highly possible that readers could recover from the garden-path effect more easily in the OO condition than in OS, indicating that readers may experience greater difficulty in processing subject-gapped sentences.

Main Effect of Gap Site

The reading time data revealed an ORC processing advantage for native speakers. According to Dependency Locality Theory (Gibson, 1998), Chinese SRCs should be more complex than ORCs because SRCs require greater storage resources for holding the incomplete gap-head noun dependencies in working memory than do ORCs. Similarly, the integration-based resource theory also predicts greater difficulty in SRCs than in ORCs, because more effort is involved in integrating the incoming head noun with the gap in SRCs in Chinese. The L1 data from this study supports this account.

As for the SRC advantage observed for L2 learners in this study, based on the experience-based Tuning Hypothesis (Mitchell et al., 1995), people's ease or difficulty in sentence comprehension is largely predicted by their experience in encountering similar words or structures in the past. The corpus study of Mandarin relative clauses conducted by Wu et al. (2011) also showed that SRCs are more frequent in Chinese. Since L2 learners in this study had limited exposure to Chinese, they might encounter the SRC structure relatively more frequently than the ORCs, which leads to easier processing for subject-gapped sentences. On the other hand, since both native speakers of English and Korean have been found to exhibit parsing difficulty in ORCs, there is probably an L1 transfer effect. The fact that learners from head-final group did not show a robust gap-site effect is possibly because they expected the head noun, and were less surprised when they encountered it.

Main Effect of Matrix Position

The online reading time data revealed a main effect of matrix position, with L1 speakers parsing relative clauses more slowly in matrix object position, whereas L2 speakers processed RCs more slowly in matrix subject position.

As discussed above, the slowdown in the matrix object position for native speakers is probably due to the garden-path effect, by which native speakers might have either misinterpreted the subject of the relative clause as the direct object of the main clause, or felt surprised to see an uncommon di-verbal structure when they encountered this region for the first time. After reaching for the next region, they realized that they had to reanalyze the preceding sentence structure. This process of reinterpretation might have caused the longer reading time when relative clauses were modifying matrix object position.

Nevertheless, the slower processing speed for the subject-modifying relative clauses observed for L2 learners can possibly be explained by the Late Closure account (Cuetos & Mitchell, 1988). According to this principle, L2 learners can better process and memorize the most recently processed information. Thus, for the purpose of comprehending the sentences, L2 learners had to pay more attention upfront to compensate for the poorer memory of the more distant information, which resulted in longer reading time for the information in the matrix subject position.

Another possible explanation for L2 speakers' spending more time in the matrix subject position is L1 transfer. Note that half of the L2 participants in this study are from head-initial L1 backgrounds where the upfront information is more important, and some of the subjects who are from head-final language backgrounds demonstrated high English proficiency on the English proficiency test. Thus, it is possible that the L2 group tended to pay more attention to the information upfront, as indicated by the longer reading time in the matrix subject position. Although their offline data showed that they have difficulty in comprehending relative clauses when they are in the matrix object position, the online data can better reflect their real-time processing.

L2 Relative Clause Processing

The results of this study have shown that L2 learners process relative clauses differently from native speakers, especially in real-time processing. Although L2 speakers showed processing difficulty in SRCs in the offline task, their online reading time data showed that the slowdowns occurred mainly at the verb, the argument, and the head noun of the relative clauses; whereas the native speakers mostly slowed down at the head noun where the integration occurs. This difference can possibly be explained by Clahsen and Felser's (2006) Shallow Structure Hypothesis (SSH). According to SSH, L2 processing is "shallower" and "less detailed" than L1 processing, which means L2 learners prefer to parse sentences using the lexical-semantic cues, word order, and contexts, whereas native speakers tend to process sentences by using both "shallow" lexical-semantic information and "deep" syntactic information (i.e., filler-gap dependency and decomposition, etc.). The fact that L2 speakers made significantly more errors in the offline questionnaire, together with their slowing down at the relative clause verb, argument, and the head noun, may indicate that L2 learners rely more on the lexical-semantic information and word order to parse Chinese sentences. Also, the results suggest that L2 learners are less likely to form a filler-gap dependency, which has been found to be largely used by native speakers of Chinese, especially when the distance between the filler and the gap is increased by adding two more words between them. However, since all of the L2 participants only had experience with Chinese for 3 years on average, and many of them had no or relatively little immersion experience with the Mandarin-speaking environment, their lexical and word order knowledge also seems to be inadequate. It might explain their substantially poorer performance in relative clause processing compared to native speakers.

CONCLUSION

This study has found that both L1 and L2 speakers made more errors in SRCs and in object-modifying clauses. For native speakers, SRCs were read significantly more slowly only when modifying the matrix subject position, which partially replicated Packard's (2008) results. However, the L2 parsing of relative clauses did not show the same pattern as that of native speakers, which provided evidence for the Shallow Structure Hypothesis (Clahsen & Felser, 2006) that L2 learners' processing of complex grammatical representations is qualitatively different from that of native speakers.

PEDAGOGICAL IMPLICATIONS

Although relative clauses are quite frequent in language input, they are difficult for L2 learners to acquire. Not only because relative clauses denote a dislocated constituent, but also indicate *who did what to whom*. The results from the current study suggest that it might be beneficial to teach learners to identify fillers and gaps, especially for L2 learners who are from head-initial language backgrounds where the head noun of a relative clause appears before the modifying phrase. It is necessary for learners to be able to identify the head noun (i.e., the filler) and the semantic relationship between the filler and the gap. Once learners learn how to identify the filler-gap relationship, they may experience less difficulty in acquiring relative clauses. By doing so, learners will also familiarize themselves with the prenominal feature and the use of DE of Chinese RCs. Another implication of this study is that it might be helpful to teach learners that main ideas often come later in Chinese. This is very important, not only at the phrase (e.g., relative clauses) and sentence levels (e.g., compound sentences), but also at the discourse level. Once learners are familiar with this 'style', they might expect great improvement in their reading skills in Chinese.

LIMITATIONS

As suggested by Lin & Garnsey (2011), more stimuli should be included in online experiments. There were only 10 experimental sentences for each participant, thus the number might not be large enough to yield robust results. Also, since two more words were added between the relative clause marker "DE" and the head noun, as compared to Packard's (2008) design, participants' individual working memory capacity measures should be included in future studies to examine whether increasing the distance between the "gap" and the "filler" would affect the performance of L2 learners with different working memory capacities. By doing so, as Packard (2008) also suggested, we can better understand whether the poor performance by language learners is due to their limited L2 working memory or to their reduced processing ability in general.

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Notes

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[1] Examples are adapted from Packard (2008).