J Psycholinguist Res (2016) 45:1089–1113
DOI 10.1007/s10936-015-9394-y

Investigating the Processing of Relative Clauses in Mandarin Chinese: Evidence from Eye-Movement Data

Yao-Ting Sung[1,2] · Jih-Ho Cha[2] · Jung-Yueh Tu[3] · Ming-Da Wu[2] · Wei-Chun Lin[2]

Published online: 18 September 2015

Abstract A number of previous studies on Chinese relative clauses (RC) have reported conflicting results on processing asymmetry. This study aims to revisit the prevalent debate on whether subject-extracted RCs (SRC) or object-extracted RCs (ORC) are easier to process by using the eye-movement technique. In the current study, the data are analyzed in terms of the gaze duration and regression of eye-movement in three critical areas: head noun, embedded verb, and RC-modifying noun phrase as subject. The results show an ORC preference for the processing of RC structures, which supports the word-order account and the Dependency Locality Theory, and a better cross-clausal integration for SRC, which supports the perspective-shift account. The processing asymmetry in Chinese RCs are discussed under relevant theoretical accounts, such as structure-based, memory-based, and perspective shift accounts. We argue that the findings are associated with the syntactic nature of Chinese (a head-initial language with pre-nominal RCs).

Keywords Mandarin Chinese · Relative clauses · Eye-movement · Processing asymmetry · Sentence complexity

Introduction

This study revisited a long-debated issue regarding processing asymmetry of relative clauses (RCs) in Chinese. An RC is a subordinate clause that modifies a noun and is embedded within a noun phrase. There are two types of RCs. One is the subject-extracted RC (SRC),

✉ Jung-Yueh Tu
jungyueh.tu@outlook.com

1 Department of Educational Psychology and Counseling, National Taiwan Normal University, 162, Sec. 1, Ho-Ping E. Rd., Taipei, Taiwan

2 Center of Learning Technology for Chinese, National Taiwan Normal University, 162, Sec. 1, Ho-Ping E. Rd., Taipei, Taiwan

3 International Chinese Education Center, School of Humanities, Shanghai Jiao Tong University, No. 1954, Hua Shan Rd., Shanghai 200030, China

in which the noun that the RC modifies is extracted from the subject position. The other is the object-extracted RC (ORC), in which the noun that the RC modifies is extracted from the object position. A considerable amount of previous research has demonstrated that an SRC is easier to process than an ORC in head-initial languages such as English (Gordon et al. 2006), Dutch (Frazier 1987; Mak et al. 2002), and French (Holmes and O'Regan 1981), as well as in head-final languages such as Japanese (Ueno and Garnsey 2008), Korean (Kwon et al. 2010), and German (Schriefers et al. 1995). However, the apparent universality of SRC preference has been challenged by Chinese RCs.

An SRC preference in Chinese has been found in some studies (Lin and Bever 2006a, b, 2007, 2011; Wu 2009; Vasishth et al. 2013) whereas others have found an ORC preference (Hsiao and Gibson 2003; Hsu and Chen 2007; Gibson and Wu 2013; Lin and Garnsey 2011). This discrepancy, which means there is no consensus about the processing preference of Chinese RCs, may be attributable to the nature of Chinese syntax. Chinese is a head-initial language with a dominant subject–verb–object (SVO) word order (Greenberg 1963), while the RC-modifying noun phrase is in a head-final structure where the RC precedes its head. In other words, Chinese is a head-initial language that exhibits a head-final pattern in RCs.

In order to approach the difficulty of processing Chinese RCs, we adopted an eye-movement-tracking technique to provide detailed online processing information, which can enrich what is already known from the offline data obtained in previous research on Chinese RCs, using methods such as self-paced reading tasks, corpus analysis, and computational modeling. Our aim was to obtain more data that would help to resolve this controversial issue.

Two Types of RCs in Chinese

There are two types of RCs in Chinese, SRC and ORC:

(1) SRC

Ø	介紹	老師	的	校長	說話	很	客氣
[e_i	jieshao	laoshi	de]	xiaozhang$_i$	shuohua	hen	keqi
GAP	introduce	teacher	DE	principle	talk	very	polite

'The principal who introduced the teacher talked in a very polite manner.'

(2) ORC

校長	介紹	Ø	的	老師	說話	很	客氣
[xiaozhang	jieshao	e_i	de]	laoshi$_i$	shuohua	hen	keqi
principle	introduce	GAP	DE	teacher	talk	very	polite

'The teacher whom the principal introduced talked in a very polite manner.'

In (1), the noun *xiaozhang*, extracted from the subject position of the embedded verb (EV) *jieshao*, serves as the head noun (HN) of the RC introduced by the relativizer *DE*. The noun *xiaozhang* leaves an empty position, called a "gap." The extracted noun *xiaozhang* is co-indexed with the gap and is called the "filler" because it should fill the gap. In (2), the noun *laoshi* is the extracted HN from the object position, forming an ORC. In both sentences, the RC-modifying noun phrase (including the RC and the HN) functions as the subject of the main clause. Comprehending and integrating RCs require the dependency between the filler and the gap to be developed in harmony.

Processing Preference in Chinese RCs

Several studies have investigated the processing of Chinese RCs. Some studies found an SRC preference while others showed an ORC preference. The finding of both preference types in Chinese indicates that there is not a universal SRC preference. The presence of processing asymmetry in Chinese RCs raises the issues of whether the processing patterns of Chinese RCs are language-specific, and whether the discordant findings are related to the syntactically mixed pattern in Chinese RCs.

Among those studies supporting the presence of a universal SRC preference, Lin and Bever (2006a, b, 2007, 2011) reported on a series of studies of RC processing preference that used self-paced reading tasks of singly embedded and doubly embedded RCs. They also compared the two conditions of RC modification: subject-modifying RC versus object-modifying RC. They found that participants spent significantly shorter reading times (RTs) on both the relativizer and the HN in SRCs than in ORCs irrespective of whether the RCs modified the subject or the object of the main clauses. Their results suggested an effect of an SRC preference, which is in line with findings across other languages.

That SRCs are universally easier to process, however, is challenged by the results of Hsiao and Gibson (2003). They conducted a self-paced task on singly embedded and doubly embedded RCs with an RC-modifying subject of main clauses. They found that in doubly embedded RCs, the participants showed slower RTs on the HN and the EV in SRCs than in ORCs. They demonstrated a preference for ORCs in Chinese, which is a head-initial language with prenominal RCs.

Theoretical Accounts for RC Processing

Previous research has shown that readers sometimes experience difficulty when processing either of the two types of RCs and that this difficulty can be attributed to various factors, resulting in many theories and processing models being proposed.

Structure-Based Accounts

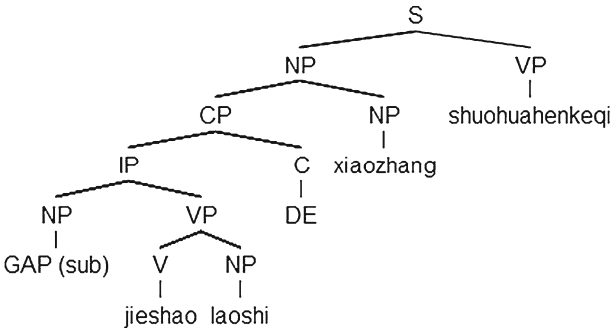
The structure-based account generally emphasizes the role of syntactic information in sentence comprehension, and invokes the syntactic position or syntactic knowledge as the prominent factor in sentence comprehension (see Lin et al. 2005; Lin and Bever 2006a). Keenan and Comrie (1977) proposed a universal tendency, called the Noun Phrase Accessibility Hierarchy (NPAH), which ranks the syntactic positions in a sentence as follows: subject, direct object, indirect object, oblique object, possessor, and object of comparison. Accordingly, a language that can relativize a given position in the hierarchy can also relativize all antecedent positions. Such a universal tendency implies that the use of SRCs makes sentence processing easier.

In addition, the word-order account (Bever 1970; MacDonald and Christiansen 2002) focuses on how readers analyze the structure as they read the sentence conveyed by the sequence of word order, from left to right. The underlying assumption is how canonical any given sequence of words is. The basic word order in Chinese is SVO, while the word order of SRCs is VO (*DE*) S and that of ORCs is SV (*DE*) O. The word-order account would therefore favor any given canonical structure.

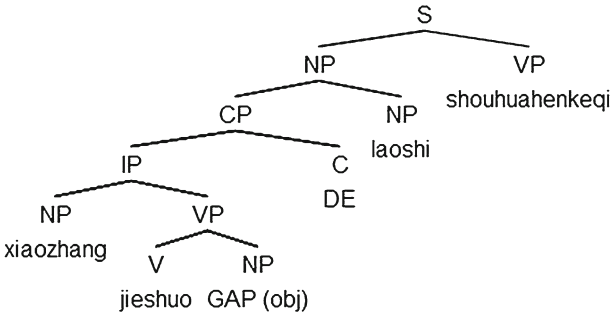
Another structure-based account, incremental minimalist parser (Lin and Bever 2006a), emphasizes the role of syntactic position in sentence processing. This account argues that a

gap located at a higher structural position is to be reached earlier than one located at a lower position. In the case of RCs, the gap in an SRC (i.e., the subject) is located higher than the gap in an ORC (i.e., the object). According to this account, Chinese SRCs are easier to process than ORCs because the gap in the SRC, which is the extracted subject, is located higher than the gap in the ORC, which is the extracted object. The gap positions for the SRC and the ORC in hierarchical representations are shown below.

(3) The hierarchical representation of SRC



(4) The hierarchical representation of ORC



Memory-Based Accounts

The memory-based account emphasizes that functional factors such as cognitive resources or working memory load will constrain sentence comprehension, and that the processing difficulty increases with the complexity of a given structure. The Dependency Locality Theory (DLT) (Gibson 1998, 2000) belongs to this account type. Its underlying assumption is based on sentence comprehension involving a series of words being input one at a time and readers using their available cognitive resources to integrate the current words into built structures, and storing these structures. The available computational resources that readers rely on for processing are the storage cost and the integration cost.

In particular, the integration-cost metric of the DLT is useful for explaining the ORC advantage in Chinese. In the case of RCs, this theory claims that the cognitive cost of integrating the HN extracted out of the RC and the gap it leaves is reflected by the number of discourse referents, introduced by NPs and VPs, appearing between them. The integration cost for the HN in an SRC is thus higher, as the number of referents between the extracted

HN and the gap in an SRC is greater than that in an ORC, indicating greater comprehension effort being required. The location of the intervening elements helps predict the degree of comprehension difficulty, with dependency over a long distance leading to both higher difficulty and higher cost for the integration. The gap-filler distances for SRC and ORC in linear representations are given below.

(5) The linear representation of SRC

[*GAP(sub)* jieshao laoshi de] xiaozhang shuohua hen keqi

(2 referents, 5 characters)

(6) The linear representation of ORC

[xiaozhang jieshao *GAP(obj)* de] laoshi shuohua hen keqi

(0 referent, 1 character)

Perspective-Shift Account

The perspective-shift account is associated with the conceptual or semantic information and the effect of discourse cues in processing (MacWhinney 1977, 1982; MacWhinney and Pleh 1988). MacWhinney (2005) proposed that examining the role of perspective shifting (usually the syntactic subject) in sentence comprehension may help in understanding how cognitive factors and syntax may work together to facilitate sentence comprehension. Considering the structure of RCs, the HN of either an SRC or an ORC could be the subject of the main clause. When processing a sentence with an RC, the HN, as the subject or object of RCs, needs to be integrated with the main clause.

This account argued that processing is easier when readers maintain a consistent perspective, as in SRC, than when they shift perspective, as in ORC (MacWhinney 1977, 1982; MacWhinney and Pleh 1988). For instance, in processing English SRC (e.g., 'The dog that chased the cat kicked the horse'), the subject of the main clause (*the dog*) is also the subject of the relative clause (*the dog*). Thus, a consistent perspective is maintained. However in processing English ORC (e.g., 'The dog that the cat chased kicked the horse'), readers need to move from the subject of the main clause (*the dog*) to the subject of the relative clause (*the cat*) when reading the EV *chased*, and move again back to the subject of the main clause (*the dog*) when reading the matrix verb *kicked*. Hence, the readers' perspective shifts. Following this, in the integration of RCs and the main clause, there may be perspective shift involved. The complexity of sentence processing may increase with the number and types of shifts in the perspective.

The Current Study

This study focused on three major questions related to the conflicting research findings about processing the two kinds of RCs: (a) which type of RC is more difficult to process; (b) which of the theoretical accounts better explains the results; and (c) how does an RC-modifying subject integrate with the main clause? We address the third of these questions for two reasons. First, the head dependency of RCs in Chinese is not consistent with head-initial patterns, and this question asks if the inconsistency makes the integration difficult. Second, most studies

of RCs focus on their structure. However, considering that a head-final RC structure exists in a head-initial language, we would like to know how an RC-modifying subject is integrated with the main clause.

Advantages of an Eye-Movement-Tracking Technique

The experiments performed in previous studies of the processing of Chinese RCs mostly involved self-paced reading tasks, in which reading times for each region were analyzed as the comprehension measures. People generally read more slowly than normal when performing such a task. Moreover, in such tasks the readers are not allowed to regress to ambiguous regions. In contrast, the reading is performed in a normal condition when using the eye-movement-tracking technique, and the researchers can record multidimensional data and better measures of initial interpretation processes (e.g., Garnsey et al. 1997; Traxler et al. 2002; Staub 2010). Thus, the eye-tracking paradigm reflects a combination of initial processing and later stage of processing, which can provide a direct measure of comprehension and reveal more subtle cognitive processes (Henderson and Ferreira 1990). It has been previously used to examine the processing difficulty of RCs in many languages (for Dutch, see Mak et al. (2002); for English, see Traxler et al. (2002); for French, see Holmes and O'Regan (1981); for Korean, see Kwon et al. 2010). In the present study we performed real-time eye-movement tracking and determined if eye-movement data would provide useful evidence about processing asymmetry.

Hypothesis and Interest Areas

The interest areas, based on previous research, included HN, EV, and RC-modifying subject noun phrase (S-NP, hereafter). These areas were examined in order to identify which type of RC is easier to process and where processing difficulties arise. We also examined the regression from the main clause to S-NP in order to determine if different types of S-NP influence how readers integrate the main clause.

The predictions of different theories about the RC, HN, EV and main clause vary according to the factors emphasized, as follows (summarized in "Appendix 1"):

(a) The NPAH would predict an SRC preference because the subject is easier to relativize than the object, and participants would spend less time on the HN of SRCs than on that of ORCs. That is, the processing time for HN in SRCs would be *shorter* than that in ORCs.
(b) The word-order account would predict ORCs to be easier to process because this account follows the canonical word order in Chinese. Since the word order in ORCs is the canonical word order (SV…O) in Chinese, the processing time for NP in SRCs would be expected to be *longer* than that in ORCs.
(c) The incremental minimalist parser would predict an SRC preference because the gap in SRCs is hierarchically located higher than the gap in ORCs. Thus, the gap in SRCs (i.e., the subject) is reached more easily. So, it is hypothesized that the processing time for HN and S-NP in SRCs would be *shorter* than that in ORCs.
(d) The DLT would also predict an ORC preference because the HN (e.g., *xiaozhang* in (1) above) is further from the gap in SRCs than in ORCs. In addition, two discourse referents (e.g., *jieshao* and *laoshi* in (1)) situated between the gap and the filler is present in SRCs, but does not exist on the same path in ORCs. This means that readers must retrieve the HN over the intervening discourse referent in the SRC. Readers therefore do not need to spend more resources integrating the gap and the filler, and they store a discourse

referent when processing ORCs. Hence, it is expected that the processing time for the HN and the S-NP in SRCs would be *longer* than that in ORCs.

(e) The perspective-shift account would predict that SRCs are easier to process because readers maintain the same perspective from the subject of the RC (e.g., *xiaozhang* in (1)) to the subject of the main clause. For instance, in processing (1), the subject of RC *xiaozhang* is the subject of both RC and the main clause, so the readers' perspective remains constant. However, in processing ORCs, readers need to rapidly move their perspective from the subject of RC *xiaozhang* to the subject of the main clause *laoshi*, thereby shifting their perspective. Thus, the processing time for SRCs is hypothesized to be *shorter* than that for ORCs.

Methods

Participants

Forty-one participants, who were all college students (18–22 years old) in Taiwan, were recruited in this experiment. All were native speakers of Mandarin Chinese and had normal or corrected-to-normal vision. The data from 40 participants were used (one was eliminated since the participant did not finish the experiment). The participants include 30 females and 10 males.

Apparatus

Stimuli were displayed on a 19-inch LCD monitor (CHIMEI CMV A902). Eye movements were recorded using an eye tracker (EyeLink 1000 Desktop, SR Research) at a sampling rate of 1000 Hz. The experiment was performed using two desktop computers with Intel Core i5 3.2-GHz CPUs: one was used to control experimental procedure and to display the stimuli, and the other monitored and recorded eye movements. Possible errors due to head movements were avoided by requiring the participants to lean on a chin rest. Viewing was binocular, but only the left eye was recorded.

The programming was performed using Experiment Builder 1.10.1, and data were analyzed using EyeLink Data Viewer 1.11.1 and SPSS.

Materials and Design

The experiment had a 2×2 within-subject design, with the independent variables being clause type and distance. The clause types were SRCs and ORCs. The distance independent variable referred to the distance between the gap and the filler. Distance was dichotomized into long distance (6–10 characters) and short distance (1–5 characters). The dependent variables were the accuracy in the reading comprehension test, gaze duration, regression-path duration, total viewing time, and regression rate.

Eye-Movement-Tracking Task

The eye-movement-tracking task involved 120 sentences, comprising 60 experimental sentences (sentences with RCs) and 60 fillers (sentences without RCs). Each of the sentences was presented in single line horizontally from left to right in traditional Chinese on the screen. The experimental sentences were made up of 30 SRCs and 30 ORCs, with 15 short-distance and

long-distance sentences, respectively. The distance was controlled by the variable lengths of the modifiers preceding the critical HN. The critical HNs were composed of two characters. The average number of strokes for HNs was 9.09. The average lexical frequency of HNs in SRCs was 549.73 and that in ORCs was 764.6,[1] difference between which did not reach statistically significance [$t(28) = .48$, $p = .638$]. Examples of the experimental sentences are as follows (the complete stimuli are upon request):

(5a) Short-distance SRC

介紹 老師 的 校長 說話 很 客氣
jieshao laoshi de xiaozhang shouhua hen Keqi
introduce teacher DE Principal talk very Politely
"The principal who introduced the teacher talked in a very polite manner"

(5b) Short-distance ORC

校長 介紹 的 老師 說話 很 客氣
xiaozhang jieshao de laoshi shouhua hen Keqi
principal introduce DE teacher talk very Politely
"The teacher who the principal introduced talked in a very polite manner"

(5c) Long-distance SRC

介紹 上課 認真 的 老師 的 校長 說話 很 客氣
jieshao shangke renzhen de laoshi de xiaozhang shouhua hen Keqi
introduceteach seriously DE teacher DE principal talk very politely
"The principal who introduced the hard-working teacher talked in a very polite manner"

(5d) Long-distance ORC

校長 介紹 的 上課 認真 的 老師 說話 很 客氣
xiaozhang Jieshao de shangke renzhen de laoshi shouhua hen Keqi
principal introduce DE teach seriously DE teacher talk very politely
"The hard-working teacher who the principal introduced talked in a very polite manner"

Sixty fillers were implemented in the study. All sentences were displayed as single lines in the middle of the LCD monitor. The lengths of the sentences ranged from 12 to 21 characters. The characters had a size of 36 pixels × 36 pixels and were separated by 10 pixels × 36 pixels. Participants were seated 70 cm from the computer monitor, which resulted in each character spanning a visual angle of 1.06 degrees.

Measurement Tools

For the eye-movement data, we employed four measures related to the structural processing of RCs: gaze duration, regression-path duration, total viewing time, and regression rate (which here refers to what is also called regressions in). The gaze duration is the total amount of time spent on all first-pass fixations on a region before the eyes move out of the region either right- or left-ward (Rayner 1998). This measure is generally regarded as a measure of initial sentence processing. The regression-path duration is the total time spent fixating on all of the target and pretarget regions, from the first fixation on a target region to fixation to the right of

[1] The lexical frequency was computed by word list with accumulated word frequency in Sinica Corpus http://elearning.ling.sinica.edu.tw/eng_teaching.html.

the target region (Rayner and Duffy 1986; Liversedge et al. 1998). This measure is considered to be sensitive for detecting the difficulty at later stages of processing. The total viewing time is the total time spent fixating on the target region. The regression rate in our study (which refers to regressions in) is corresponding to the probability of rereading the target (Yen et al. 2008), i.e., the probability of regressions back into the target region after it has already been read. Please note that for regression rate in the current study, 'regressions in' is analyzed instead of regressions out. We used two measures related to the integration of RCs and the main clause: total viewing time and regression rate. Regarding the comprehension test, the accuracy rate was measured.

Procedure

The eye-movement-tracking task was conducted for about 60 min. The participants were first asked to sign the consent form and provide background information. The participants were given the instruction by demonstration before the practice session and the experiment session. Before each session the experimenter calibrated the eye-tracker. During the experiment session, there was a short break after the first half of the session. The short break was designed to minimize fatigue possibly caused by the infrared rays illuminated on participants' eyes over a long period of time. The eye-movement-tracking task was then conducted for about 30 min.

The participants sat 70 cm from the monitor with their head leaning on the chin rest. The task started with a 13-point calibration, followed by 5 practice trials that were in the same format as the normal trials. Participants were instructed to fixate on a dot (to enable drift correction) located at the position where the first character of the sentence would be subsequently displayed. The participants were then instructed to read the sentence in their most natural way when the stimuli appeared on the monitor. When the participants had finished reading, they pressed the SPACE key to begin a true/false comprehension statement. True and false statements were equally distributed across conditions. Participants responded by pressing 'F' (with a circle sticker) for true and 'J' (with a cross sticker) for false. Each testing sentence was followed by a reading comprehension true/false question to ensure that the participants understood the sentence. For example, one of the comprehension statements for (5) was 老師說話很客氣 'The teacher talked in a very polite manner.' There were 120 trials in total, with a break at every 40 trials. A 13-point calibration was administered after each break.

Results

Accuracy of Comprehension Test

The overall accuracy rate for RCs was 95.7 %. The test results for participants (F_1) and items (F_2) were analyzed by two-way repeated-measures ANOVAs. As given in Fig. 1, the analysis showed a main effect of clause type only in the participants' analysis [$F_1(1, 39) = 15.86$, mean square error (MSE) $= .002$, $p < .001$, $\eta^2 = .29$; $F_2(1, 14) = 1.06$, $MSE = .011$, $p = .320$, $\eta^2 = .07$]. The main effect of distance was also significant only in the participants' analysis [$F_1(1, 39) = 7.33$, $MSE = .003$, $p < .05$, $\eta^2 = .16$; $F_2(1, 14) = 1.90$, $MSE = .004$, $p = .192$, $\eta^2 = .12$]. However, there was no significant interaction

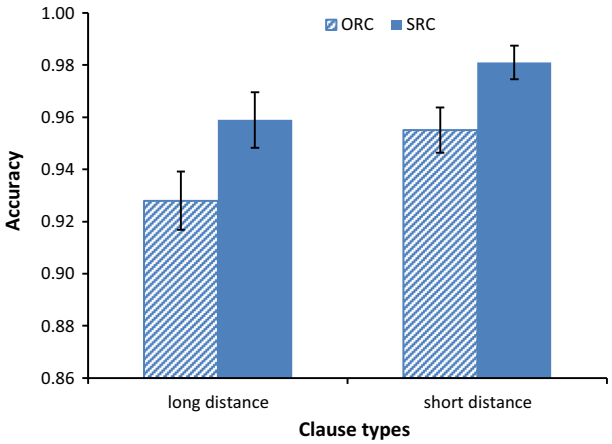


Fig. 1 Accuracy of the comprehension test

of clause type and distance (both $ps > .70$). These results indicate that the sentences with SRCs were easier to understand than those with ORCs.[2]

Eye-Movement Data

This study focused on the processing of RC itself and the integration between RC and the main clause. Eye-movement-tracking analyses were performed for HN, EV, and S-NP.

Two-way repeated-measures ANOVAs were conducted to analyze the eye-movement data for participants (F_1) and items (F_2). Fixations shorter than 80 ms or longer than 1200 ms (5.08 % of total fixations) were not included in the analyses (Drieghe et al. 2008; White 2008). Table 1 lists the descriptive statistics for the indices described below.

Head Noun

HNs were measured using gaze duration, regression-path duration, total viewing time, and regression rate; the analysis results are presented below.

Gaze Duration The main effect of clause type on gaze duration was significant [$F_1(1, 39) = 19.34, MSE = 1129, p < .001, \eta^2 = .33$; $F_2(1, 14) = 17.95, MSE = 416, p < .001, \eta^2 = .56$]. The gaze duration was significantly longer for HNs in SRCs ($M = 278$ms, $SD = 52$ ms) than for those in ORCs ($M = 254$ ms, $SD = 46$ ms). However, there was no significant main effect of distance or significant interaction of clause type and distance (all $ps > .10$) (see Fig. 2).

[2] One of the reviewers mentioned that lexical repetition might reduce effect size, and suggested the linear mixed effect model (LMM) with the trial sequence as a fixed factor for alternative analysis. The results of ANOVAs and LMM indicated that the main effects of clause type, distance, and clause type x distance remained the same overall pattern. As for sequence, its interactions with clause type showed that the difference between SRCs and ORCs became bigger over time only for the accuracy rate of comprehension test, gaze duration in S-NP, and regression rate in S-NP, which were noted here. Mainly, the LMM results conformed to the major findings in the current discussions.

Table 1 Mean (SD) values of eye-movement indices for each language component

	Head noun	Embedded verb	Subject noun phrase
Gaze duration			
ORC-L	249 (44)	262 (45)	1518 (446)
ORC-S	260 (47)	269 (53)	852 (232)
SRC-L	279 (49)	264 (70)	1813 (549)
SRC-S	276 (54)	261 (58)	1023 (284)
Regression path duration			
ORC-L	340 (87)	N/A	N/A
ORC-S	377 (103)	N/A	N/A
SRC-L	551 (154)	N/A	N/A
SRC-S	446 (102)	N/A	N/A
Total viewing time			
ORC-L	407 (110)	N/A	2299 (545)
ORC-S	453 (98)	N/A	1368 (296)
SRC-L	515 (118)	N/A	2694 (603)
SRC-S	480 (102)	N/A	1504 (280)
Regression rate			
ORC-L	.34 (.18)	.51 (.20)	.46 (.15)
ORC-S	.33 (.18)	.62 (.20)	.41 (.15)
SRC-L	.32 (.18)	.58 (.26)	.41 (.16)
SRC-S	.31 (.16)	.54 (.27)	.36 (.14)

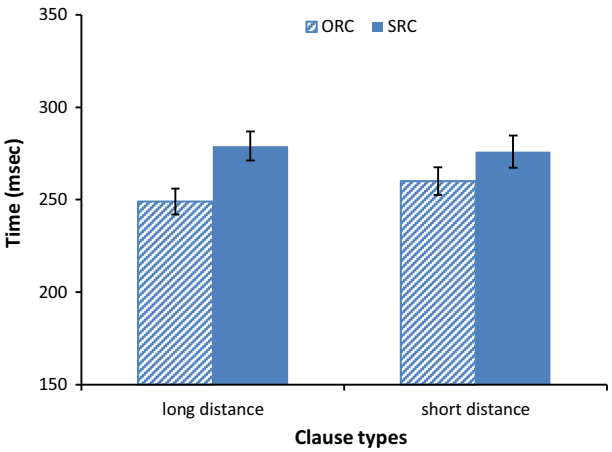


Fig. 2 Gaze duration for head nouns in RCs

Regression-Path Duration The main effect of clause type on regression-path duration was significant [$F_1(1, 39) = 78.00, MSE = 10056, p < .001, \eta^2 = .67$; $F_2(1, 14) = 71.05, MSE = 4189, p < .001, \eta^2 = .84$]. The regression-path duration was significantly longer for HNs in SRCs ($M = 498$ ms, $SD = 141$ ms) than for those in ORCs

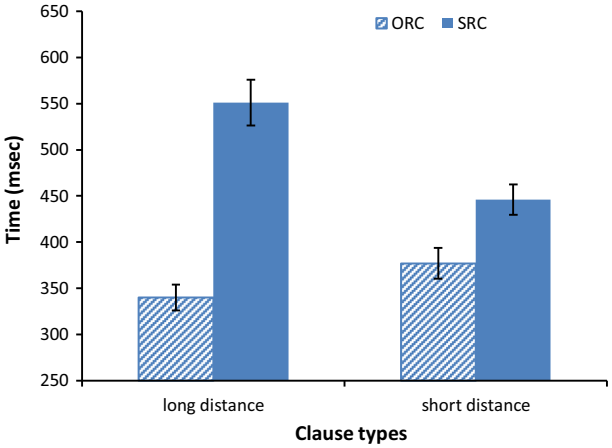


Fig. 3 Regression-path duration for head nouns in RCs

($M = 358$ ms, $SD = 97$ ms). The main effect of distance was significant only in the participants' analysis [$F_1(1, 39) = 4.33$, $MSE = 10645$, $p < .05$, $\eta^2 = .10$; $F_2(1, 14) = 4.05$, $MSE = 3397$, $p = .064$, $\eta^2 = .22$]. The interaction between clause type and distance was also significant [$F_1(1, 39) = 24.15$, $MSE = 8287$, $p < .001$, $\eta^2 = .38$; $F_2(1, 14) = 33.75$, $MSE = 2081$, $p < .001$, $\eta^2 = .71$]. A simple main effect test showed that in long-distance RCs, the regression-path duration was significantly longer for HNs in long-distance SRCs ($M = 551$ ms , $SD = 154$ ms) than for those in long-distance ORCs ($M = 340$ ms , $SD = 87$ ms) [$F_1(1, 78) = 96.87$, $MSE = 9172$, $p < .001$, $\eta^2 = .56$; $F_2(1, 28) = 104.79$, $MSE = 3135$, $p < .001$, $\eta^2 = .79$]. In short-distance RCs, the regression-path duration was significantly longer for HNs in short-distance SRCs ($M = 446$ ms , $SD = 102$ ms) than for those in short-distance ORCs ($M = 377$ ms , $SD = 103$ ms) [$F_1(1, 78) = 10.47$, $MSE = 9172$, $p < .01$, $\eta^2 = .12$; $F_2(1, 28) = 12.55$, $MSE = 3135$, $p < .01$, $\eta^2 = .31$] (see Fig. 3).

Total Viewing Time The main effect of clause type on total viewing time was significant [$F_1(1, 39) = 25.95$, $MSE = 7013$, $p < .001$, $\eta^2 = .40$; $F_2(1, 14) = 7.77$, $MSE = 8651$, $p < .05$, $\eta^2 = .36$]. The total viewing time was significantly longer for HNs in SRCs ($M = 498$ ms, $SD = 112$ ms) than for those in ORCs ($M = 430$ ms, $SD = 107$ ms). The main effect of distance was not significant (both $ps > .50$). The interaction between clause type and distance was also significant [$F_1(1, 39) = 15.57$, $MSE = 4178$, $p < .001$, $\eta^2 = .29$; $F_2(1, 14) = 7.84$, $MSE = 2881$, $p < .05$, $\eta^2 = .36$]. A simple main effect test showed that in long-distance RCs, the total viewing time was significantly longer for HNs in long-distance SRCs ($M = 515$ ms, $SD = 118$ ms) than for those in long-distance ORCs ($M = 407$ ms, $SD = 110$ ms) [$F_1(1, 78) = 41.52$, $MSE = 5595$, $p < .001$, $\eta^2 = .35$; $F_2(1, 28) = 14.54$, $MSE = 5766$, $p < .001$, $\eta^2 = .34$]. However, in short-distance RCs, the total viewing time was not significantly longer for HNs in short-distance SRCs than for those in short-distance ORCs (both $ps > .10$) (see Fig. 4).

Regression Rate The main effect of clause type on regression rate was not significant [$F_1(1, 39) = 2.10$, $MSE = .008$, $p = .161$, $\eta^2 = .05$; $F_2 < 1$], nor were the main effect of distance (both $ps > .60$) and the interaction of clause type and distance (both $ps > .90$).

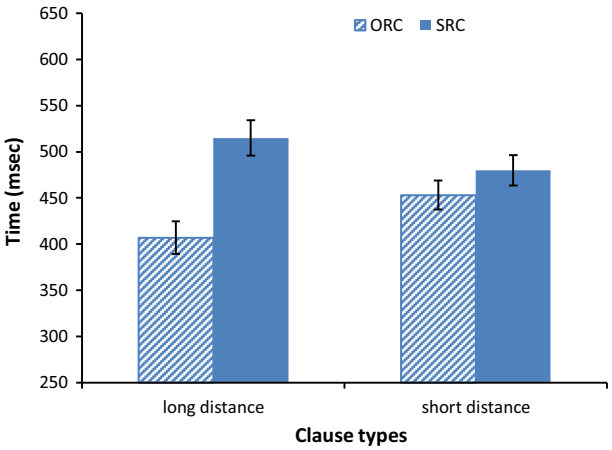


Fig. 4 Total viewing time for head nouns in RCs

The results for HNs showed that gaze duration, regression-path duration, and total viewing time on SRCs were all longer than ORCs. These results support the prediction of DLT that the processing time for SRCs would be longer than that for ORCs.

Embedded Verb

EVs were measured using gaze duration and regression rate; the analysis results are presented below. Note that the measures of regression-path duration and total viewing time were not used since the positions of the EVs in the two types of RCs are different. In particular, the EV of SRC is in sentence-initial position so that its regression time may be underestimated. Thus, the two measures involving regression time were excluded for the analysis of EV.

Gaze Duration The main effect of clause type was not significant (both $ps > .60$), as was the main effect of distance (both $ps > .70$) and the interaction of clause type and distance [$F_1 < 1$; $F_2(1, 14) = 1.32$, $MSE = 419$, $p = .270$, $\eta^2 = .09$].

Regression Rate The main effect of clause type was not significant (both $ps > .40$), as was the main effect of distance (both $ps > .06$). However, the interaction between clause type and distance was significant [$F_1(1, 39) = 9.43$, $MSE = .023$, $p < .01$, $\eta^2 = .20$; $F_2(1, 14) = 23.27$, $MSE = .003$, $p < .001$, $\eta^2 = .62$]. A simple main effect test showed that in short-distance RCs, the regression rate was significantly higher for EVs in short-distance ORCs ($M = .62$, $SD = .20$) than for those in short-distance SRCs ($M = .54$, $SD = .27$) only in the items' analysis [$F_1(1, 78) = 2.86$, $MSE = .041$, $p = .120$, $\eta^2 = .04$; $F_2(1, 28) = 9.06$, $MSE = .007$, $p < .01$, $\eta^2 = .24$]. However, in long-distance RCs, the regression rate was not significantly higher for EVs in long-distance SRCs than for those in long-distance ORCs (both $ps > .10$) (see Fig. 5).

The results from these two indicators cannot differentiate the processing difficulty between SRCs and ORCs. The interpretation for such findings will be discussed in the next section.

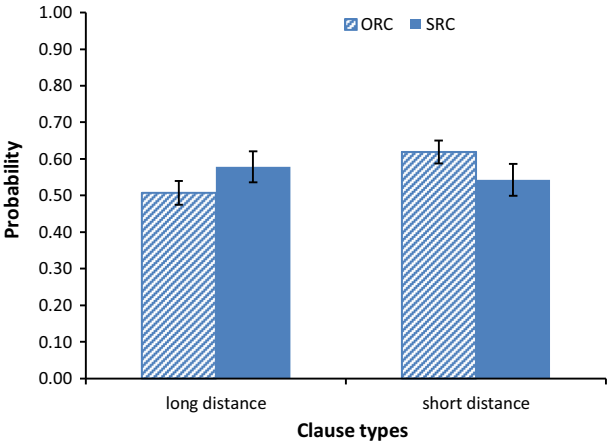


Fig. 5 Regression rate for embedded verbs in RCs

Subject Noun Phrase

S-NPs were measured using gaze duration, total viewing time and regression rate. Note that the measure of regression-path duration was not applicable to the analysis of S-NPs in that S-NPs in RCs are sentence-initial, which leaves nothing preceding to be calculated. The analysis results are presented below.

Gaze Duration The main effect of clause type on gaze duration was significant [$F_1(1, 39) = 84.10$, $MSE = 25844$, $p < .001$, $\eta^2 = .68$; $F_2(1, 14) = 173.29$, $MSE = 5088$, $p < .001$, $\eta^2 = .93$]. The gaze duration was significantly longer for S-NPs in SRCs ($M = 1418$ ms, $SD = 585$ ms) than for those in ORCs ($M = 1185$ ms, $SD = 484$ ms). The main effect of distance was significant [$F_1(1, 39) = 270.96$, $MSE = 78251$, $p < .001$, $\eta^2 = .87$; $F_2(1, 14) = 520.74$, $MSE = 14857$, $p < .001$, $\eta^2 = .97$]. The gaze duration of S-NPs was significantly longer for long-distance sentences ($M = 1665$ ms, $SD = 515$ ms) than for short-distance sentences ($M = 937$ ms, $SD = 270$ ms). The interaction between clause type and distance was also significant [$F_1(1, 39) = 5.23$, MSE $= 29195$, $p < .05$, $\eta^2 = .12$; $F_2(1, 14) = 9.74$, $MSE = 8867$, $p < .01$, $\eta^2 = .41$]. A simple main effect test showed that in long-distance RCs, the gaze duration was significantly longer for S-NPs in long-distance SRCs ($M = 1813$ ms, $SD = 542$ ms) than for those in long-distance ORCs ($M = 1518$ ms, $SD = 440$ ms) [$F_1(1, 78) = 63.20$, $MSE = 27520$, $p < .001$, $\eta^2 = .45$; $F_2(1, 28) = 108.92$, $MSE = 6978$, $p < .001$, $\eta^2 = .80$]. In short-distance RCs, the gaze duration was significantly longer for S-NPs in short-distance SRCs ($M = 1023$ ms, $SD = 281$ ms) than for those in short-distance ORCs ($M = 852$ ms, $SD = 229$ ms) [$F_1(1, 78) = 21.33$, $MSE = 27520$, $p < .001$, $\eta^2 = .22$; $F_2(1, 28) = 29.82$, $MSE = 6978$, $p < .001$, $\eta^2 = .52$] (see Fig. 6).

Total Viewing Time The main effect of clause type on total viewing time was significant [$F_1(1, 39) = 42.05$, $MSE = 66841$, $p < .001$, $\eta^2 = .52$; $F_2(1, 14) = 17.51$, $MSE = 54317$, $p < .001$, $\eta^2 = .56$]. The total viewing time was significantly longer for S-NPs in SRCs ($M = 2099$ ms, $SD = 758$ ms) than for those in ORCs ($M = 1834$ ms, $SD = 639$ ms). The main effect of distance was significant [$F_1(1, 39) = 376.43$, $MSE =$

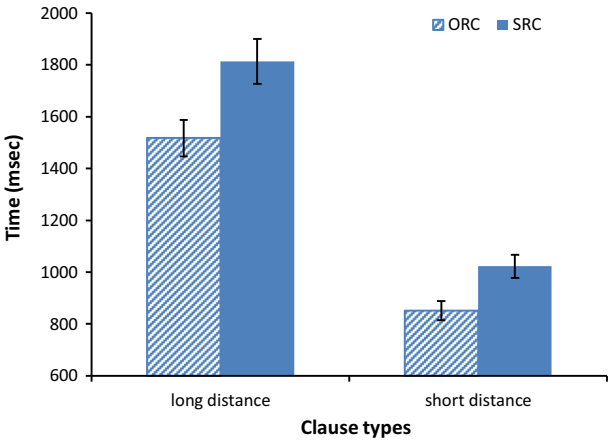


Fig. 6 Gaze duration for S-NPs

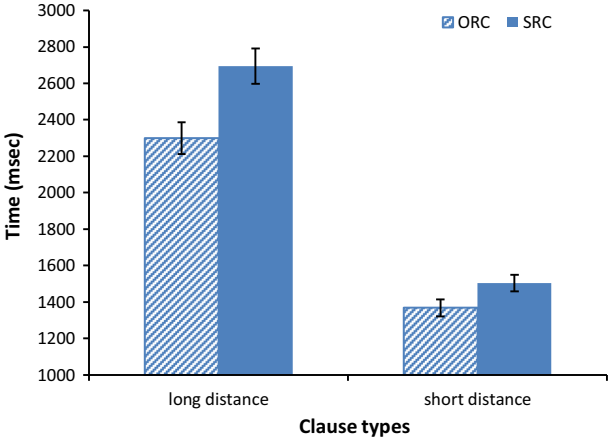


Fig. 7 Total viewing time for S-NPs

119521, $p < .001$, $\eta^2 = .91$; $F_2(1, 14) = 343.75$, $MSE = 50322$, $p < .001$, $\eta^2 = .96$]. The total viewing time of S-NPs was significantly longer for long-distance sentences ($M = 2497$ ms, $SD = 608$ ms) than for short-distance sentences ($M = 1436$ ms, $SD = 296$ ms). The interaction between clause type and distance was also significant [$F_1(1, 39) = 10.86$, $MSE = 61679$, $p < .01$, $\eta^2 = .22$; $F_2(1, 14) = 7.17$, $MSE = 36326$, $p < .05$, $\eta^2 = .34$]. A simple main effect test showed in long-distance RCs, the total viewing time was significantly longer for S-NPs in long-distance SRCs ($M = 2694$ ms, $SD = 603$ ms) than for those in long-distance ORCs ($M = 2299$ ms, $SD = 545$ ms) [$F_1(1, 78) = 48.44$, $MSE = 64260$, $p < .001$, $\eta^2 = .38$; $F_2(1, 28) = 24.34$, $MSE = 45322$, $p < .001$, $\eta^2 = .47$]. In short-distance RCs, the total viewing time was significantly longer for S-NPs in short-distance SRCs ($M = 1504$ ms, $SD = 280$ ms) than for those in short-distance ORCs ($M = 1368$ ms, $SD = 296$ ms) only in the participants' analysis [$F_1(1, 78) = 5.73$, $MSE = 64260$, $p < .02$, $\eta^2 = .07$; $F_2(1, 28) = 2.38$, $MSE = 45322$, $p = .143$, $\eta^2 = .09$] (see Fig. 7).

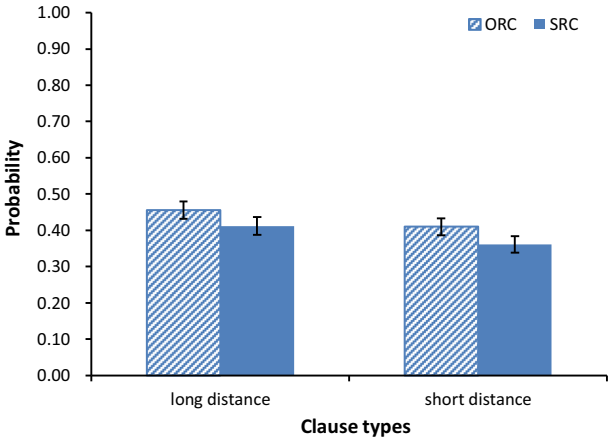


Fig. 8 Regression rate for S-NPs

Regression Rate There was a main effect of clause type on regression rate only in the participants' analysis [$F_1(1, 39) = 4.55, MSE = .019, p < .05, \eta^2 = .11$; $F_2(1, 14) = 3.33, MSE = .007, p = .089, \eta^2 = .19$]. The main effect of distance was also significant only in the participants' analysis [$F_1(1, 39) = 4.98, MSE = .019, p < .05, \eta^2 = .11$; $F_2(1, 14) = 2.15, MSE = .012, p = .168, \eta^2 = .13$]. The interaction between clause type and distance was not significant (both $ps > .80$) (see Fig. 8).

The results for S-NPs showed that gaze duration and total viewing time on SRCs were both longer than on ORCs, which support the predictions of the word-order account and DLT. On the other hand, the regression rate for S-NPs in SRCs was lower than in ORCs. This result implied that the S-NPs in SRCs were easier than ORCs to integrate with the main clauses, which supports the prediction of the perspective-shift account.[3]

Discussion

This study investigated the difficulty of processing RCs in Chinese, and the integration of the RC and the main clause. The results showed that ORCs were easier to process within RCs. However, the integration of the S-NP and the main clause was faster for SRCs. Our findings were consistent with the predictions of the DLT, word-order account, and perspective-shift account. Below we discuss our findings for theoretical accounts relative to the research questions that we were aiming to address.

ORC Processing Preference Within an RC-Modifying Noun Phrase

The preference for and easier processing of ORCs was evident from five results: (a) the gaze duration was shorter for HNs in ORCs than for those in SRCs; (b) the regression-path duration was shorter for HNs in ORCs than for those in SRCs; (c) the total viewing time was shorter for HNs in ORCs than for those in SRCs; (d) the gaze duration for S-NPs in ORCs is shorter than that in SRCs.; and (e) the total viewing time was shorter for S-NPs in ORCs than for those in SRCs. These results matched the predictions of the DLT and word-order account.

[3] See footnote 2.

According to the DLT (Gibson 1998), dependency requires greater cognitive resources when two dependent elements are further apart, and readers tend to prefer shorter local dependency and syntactic relationships. In SRCs, readers need greater cognitive resources to integrate the extracted HN and the gap because the HN is far from its gap and readers need to keep in memory the discourse referents (e.g.,*jieshao* and*laoshi* in (1)) in between while integrating the processed information and upcoming information (which corresponds to a storage cost according to the DLT). In other words, the gap filler in SRCs formed a longer dependency and there was an intervening discourse referent, so that SRCs had greater integration and storage costs. In ORCs, the gap and its HN form a shorter distance, reflecting local dependency. Thus, our findings suggest that ORCs are preferred in Chinese.

This result can also be explained by the word-order account (MacDonald and Christiansen 2002), which argues that sentences with noncanonical word orders may cause a greater processing load for readers. Recall that the dominant word order in Chinese is SVO. Comparing SRCs and ORCs, the clausal word order in SRCs (i.e., VO…S) is noncanonical, while that in ORCs (i.e., SV…O) is consistent with the dominant word order. Thus, SRCs should be structurally more difficult than ORCs.

The gaze duration of S-NPs in ORCs is shorter than that in SRCs, which also supports the aforementioned result that Chinese ORCs are easier to process than SRCs.

Integration Between RC and Main Clause

The integration of RC with the main clause can be observed by two indicators. The first is the accuracy of the comprehension test. The result from the comprehension test showed that the accuracy rate for SRCs was higher than that for ORCs in the participant's analysis, which may imply that readers understand the sentence with SRC as the subject better than its ORC counterpart because the comprehension questions focused on the interpretation of HN in RC as the subject of the main clause. The second is the regression rate in S-NP. The result of the regression rate in S-NP indicates that readers need less time to integrate the main clause and the S-NP in SRC sentence when they are interpreting the whole sentence. Those results above can be accounted for by the perspective shift, which hypothesizes that perspective changes consume processing resources and therefore posit the processing difficulty. In the SRC sentence, the HN (e.g., *xiaozhang* in (5a)) serves as the subject for the RC and also as the subject for the main clause. Thus, in SRCs there are no perspective shifts. However, in the ORC sentence, the HN serves both as the object for the RC and as the subject for the main clause. This means that the perspective switches from the object of the RC (e.g., *laoshi* in (5b)) to the subject of the main clause (e.g., *laoshi* in (5b)). When encountering the relativizer *DE*, readers realized that what they had read so far possibly formed an RC; when they encountered the matrix verb (e.g., *shouhua* in (5)) they started to consider the object of the RC as the subject of the main clause, and therefore the perspective shift occurred in ORCs but not in SRCs. The perspective in SRCs did not shift and therefore a sentence with SRC is easier to process than its ORC counterpart.

The results from the current study suggest that in Chinese the S-NP in SRC sentences is easier to integrate with the main clause, which can be explained by the perspective-shift account. Analyzing the regression data obtained from an eye-movement-tracking system made it possible to explore the integration between the S-NP and the main clause, which has not received sufficient attention in previous studies, except for Staub's (2010) study, which has already investigated to what extent different eye movement measures can dissociate processing patterns for RCs in English.

The Role of Modifiers in Chinese RCs

In addition to the main findings, it is worth mentioning that the modifiers of the HN in RCs may influence how readers process sentences. In the long-distance RCs, the modifiers of the HN in the ORCs convey information that allows readers to predict the upcoming head, whereas those in SRCs seemingly do not provide such information about the HN.

We found that the total viewing time of the HN was longer in SRCs than in ORCs for the long-distance RCs but not for the short-distance RCs. This difference may be due to the modifiers in the long-distance RCs. The information conveyed by the modifiers in ORCs directly modifies the HN and helps readers to predict the upcoming head. In contrast, the same modifiers in SRCs modify the object of the RCs instead of the HN. Therefore, the information from the modifiers does not help readers to predict the upcoming head. Furthermore, the long-distance SRCs in our stimuli are likely to form a nested dependency (where an RC appears within another RC) with a high structural complexity, which could result in incorrect initial parsing. On top of that, the marker DE has multiple functions, including those of a possessive marker, an adjective marker, a relativizer, and a nominalizer, which may cause readers to spend more time processing, since they may first parse DE as a possessive marker rather than as a relativizer. This is perhaps also the reason why readers spent more time on the long-distance SRCs than on the long-distance ORCs.

The result indicates that modifiers function as a prominent cue for the processing of long-distance ORCs.

Processing Chinese RCs as Language Specific

Many psycholinguistic studies have found an SRC preference in both head-initial and head-final languages. However, previous studies of the processing of RCs in Chinese produced discrepant results; for example, Lin and Bever (2006a) reported an SRC preference while Gibson and Hsiao (2003) reported an ORC preference. This might be due to Chinese presenting a mixed typological pattern, being a head-initial language with a head-final RC structure (Kwon et al. 2010).

The current study used an eye-movement-tracking technique to revisit this issue. Our results revealed an ORC preference within an RC and a better cross-clausal integration for the sentence with SRC. Building upon previous studies, from the present results we propose that the ORC preference in Chinese is language-specific. An ORC preference is found within RCs, which is probably due to the syntactic nature of Chinese. For example, the word order in ORCs is also the canonical word order in Chinese. Also, the modifiers in RCs help to predict the HN of ORCs but not that of SRCs. On the other hand, a better cross-clausal integration for the sentence with SRC was found when integrating the RC and the main clause due to no perspective shifts. The sentence with ORC, however, induces perspective shift from the object in the RC to the subject of the main clause. A perspective shift features general cognitive processing, rather than language-specific one. Dealing with perspective shifts requires cognitive loads beyond linguistic structures. The more perspective shifts occur in a sentence, the greater difficulties emerge in the sentence processing. Hence, one perspective shift occurring in the ORC sentence causes more cognitive loads and greater processing difficulty, whereas no perspective shift emerges in the SRC sentence, leading to a better cross-clausal integration.

The results of the present investigation of processing asymmetry between SRCs and ORCs suggest that ORCs are structurally preferred in Chinese and that SRCs are easier to integrate with the main clause. Our examination of the gaze duration and regression of eye movement

involving parsing and integration made it possible to obtain these results. We argue that those findings suggest an ORC preference within RC and a better SRC cross-clausal integration.

Conclusion

In this study we employed an eye-movement-tracking technique to investigate Chinese RC processing. Although this issue has been examined in previous studies, the methods they used were unable to reveal the re-reading patterns that occur when processing becomes difficult. Our approach made it possible to detect the difficulty encountered at later stages of processing, which has uncovered the regression patterns in sentence processing and provided a better understanding of how Chinese RCs are processed and integrated. While most of the previous studies focused on the processing of RC structures, we investigated the effects of RC structures on the integration of the RC and the main clause. The results of this study suggest that there is an ORC preference for the processing of RC structures, which supports the word-order account and the DLT, and a better cross-clausal integration for SRC, which supports the perspective-shift account. The reported findings may help to clarify the controversial issue of RC preference in Chinese.

Acknowledgments This research is partially supported by the "Aim for the Top University Project" and "Center of Learning Technology for Chinese" of National Taiwan Normal University (NTNU), sponsored by the Ministry of Education, Taiwan, R.O.C. and the "International Research-Intensive Center of Excellence Program" of NTNU and Ministry of Science and Technology, Taiwan, R.O.C. under Grant Nos. NSC 102-2511-S-003-001-MY3; 101-2511-S-003-047-MY3; 103-2911-I-003-301.

Appendix 1

See Table 2.

Appendix 2

There are 15 sets of stimuli in the experiment. Every set contains two pairs of RCs, with the first pair short-distance RCs and the second long-distance RCs. In each pair, the first sentence is SRC and the other is ORC.

Table 2 The predictions of processing preference in each interest area based on the accounts

Accounts	Predictions		
	HN	S-NP	Clausal integration
NPAH	SRC	N/A	N/A
Word-order account	N/A	ORC	N/A
IMP	SRC	SRC	N/A
DLT	ORC	ORC	N/A
Perspective-shift	N/A	N/A	SRC

1. 抱著兒子的媽媽開心地笑了。
   'The mother who was holding the son laughed happily.'
   媽媽抱著的兒子開心地笑了。
   'The son whom the mother was holding laughed happily'
   抱著剛滿一歲的兒子的媽媽開心地笑了。
   'The mother who was holding the son, who just turned 1 year old, laughed happily.'
   媽媽抱著的剛滿一歲的兒子開心地笑了。
   'The son, who just turned 1 year old, whom the mother was holding, laughed happily.'
2. 治療母貓的獸醫剛生小孩。
   'The veterinarian who cured the female cat just gave birth to a baby.'
   獸醫治療的母貓剛生小孩。
   'The female cat which the veterinarian cured just gave birth to a kitten.'
   治療有皮膚病的母貓的獸醫剛生小孩。
   'The veterinarian who cured the female cat, which had a skin disease, just gave birth to a baby.'
   獸醫治療的有皮膚病的母貓剛生小孩。
   'The female cat, which had a skin disease, which the veterinarian cured, just gave birth to a kitten. '
3. 批評教授的主任終於退休了。
   'The chair who criticized the professor finally retired.'
   主任批評的教授終於退休了。
   'The professor whom the chair criticized finally retired.'
   批評經常遲到的教授的主任終於退休了。
   'The chair who criticized the professor, who often came late, finally retired.'
   主任批評的經常遲到的教授終於退休了。
   'The professor, who often came late, whom the chair criticized, finally retired.'
4. 拜訪老師的家長為人謙虛。
   'The parents who visited the teacher are humble.'
   家長拜訪的老師為人謙虛。
   'The teacher whom the parents visited is humble.'
   拜訪剛剛出院的老師的家長為人謙虛。
   'The parents who visited the teacher, who just left hospital, are humble.'
   家長拜訪的剛剛出院的老師為人謙虛。
   'The teacher, who just left hospital, whom the parents visited, is humble.'

5. 關懷街友的社工歌喉很好。
   ‘The social worker who cares about the homeless is good at singing.’
   社工關懷的街友歌喉很好。
   ‘The homeless person whom the social worker cares about is good at singing.’
   關懷不便於行的街友的社工歌喉很好。
   ‘The social worker who cares about the homeless person, who uses a wheelchair, is good at singing.’
   社工關懷的不便於行的街友歌喉很好。
   ‘The homeless person, who uses a wheelchair, whom the social worker cares about, is good at singing.’
6. 讚美教友的牧師笑嘻嘻地走過來。
   ‘The priest who praised the church member came over with a smile.’
   牧師讚美的教友笑嘻嘻地走過來。
   ‘The church member whom the priest praised came over with a smile.’
   讚美剛剛受洗的教友的牧師笑嘻嘻地走過來。
   ‘The priest who praised the church member, who was just baptized, came over with a smile.’
   牧師讚美的剛剛受洗的教友笑嘻嘻地走過來。
   ‘The church member, who was just baptized, whom the priest praised, came over with a smile.’
7. 領養孤兒的老闆很有愛心。
   ‘The boss who adopted the orphan is good-hearted.’
   老闆領養的孤兒很有愛心。
   ‘The orphan whom the boss adopted is good-hearted.’
   領養體弱多病的孤兒的老闆很有愛心。
   ‘The boss who adopted the orphan, who was ill and weak, is good-hearted.’
   老闆領養的體弱多病的孤兒很有愛心。
   ‘The orphan, who was ill and weak, whom the boss adopted, is good-hearted.
8. 照顧孫子的外公昨天跌倒了。
   ‘The grandfather who took care of the grandson fell over yesterday.’
   外公照顧的孫子昨天跌倒了。
   ‘The grandson whom the grandfather took care of fell over yesterday.’
   照顧活潑好動的孫子的外公昨天跌倒了。
   ‘The grandfather who took care of the grandson, who was lively, fell over yesterday.’
   外公照顧的活潑好動的孫子昨天跌倒了。
   ‘The grandson, who was lively, whom the grandfather took care of, fell over

yesterday.'

9. 找來志工的鄉長安撫著鄉民。
   'The town mayor who recruited the volunteer comforted the town residents.'
   鄉長找來的志工安撫著鄉民。
   'The volunteer, whom the town mayor recruited, comforted the town residents.'
   找來熱心公益的志工的鄉長安撫著鄉民。
   'The town mayor who recruited the volunteer, who was zealous, comforted the town residents.'
   鄉長找來的熱心公益的志工安撫著鄉民。
   'The volunteer, who was zealous, whom the town mayor recruited, comforted the town residents.'
10. 懲罰學生的老師將參加公聽會。
    'The teacher who punished the student is going to attend the public hearing.'
    老師懲罰的學生將參加公聽會。
    'The student whom the teacher punished is going to attend the public hearing.'
    懲罰不守校規的學生的老師將參加公聽會。
    'The teacher who punished the student, who disobeyed school rules, is going to attend the public hearing.'
    老師懲罰的不守校規的學生將參加公聽會。
    'The student, who disobeyed school rules, whom the teacher punished, is going to attend the public hearing.'
11. 率領士兵的將軍接受表揚。
    'The general who led the soldiers received recognition.'
    將軍率領的士兵接受表揚。
    'The soldiers whom the general led received recognition.'
    率領常打勝仗的士兵的將軍接受表揚。
    'The general who led the soldiers, who often won battles, received recognition.'
    將軍率領的常打勝仗的士兵接受表揚。
    'The soldiers, who often won battles, whom the general led, received recognition.'
12. 採訪部長的記者突然辭職。
    'The journalist who interviewed the minister suddenly resigned.'
    記者採訪的部長突然辭職。
    'The minister whom the journalist interviewed suddenly resigned.'
    採訪傳出醜聞的部長的記者突然辭職。
    'The journalist who interviewed the minister, who was scandal-ridden, suddenly resigned.
    記者採訪的傳出醜聞的部長突然辭職。
    'The minister, who was scandal-ridden, whom the journalist interviewed,

suddenly resigned.'

13. 雇用秘書的廠長人緣很好。

'The factory manager who hired the secretary was popular.'

廠長雇用的秘書人緣很好。

'The secretary whom the factory manager hired was popular.'

雇用精通外語的秘書的廠長人緣很好。

'The factory manager who hired the secretary, who mastered foreign languages, was popular.'

廠長雇用的精通外語的秘書人緣很好。

'The secretary, who mastered foreign languages, whom the factory manager hired, was popular.'

14. 崇拜歌星的妹妹很有才華。

'My sister who admired the singer is talented.'

妹妹崇拜的歌星很有才華。

'The singer whom my sister admired is talented.'

崇拜會彈吉他的歌星的妹妹很有才華。

'My sister who admired the singer, who can play the guitar, is talented.'

妹妹崇拜的會彈吉他的歌星很有才華。

'The singer, who can play the guitar, whom my sister admired, is talented'

15. 威脅律師的黑道躲藏在國外。

'The Mafia member who threatened the lawyer is in exile overseas. '

黑道威脅的律師躲藏在國外。

'The lawyer whom the Mafia threatened is in exile overseas.'

威脅握有證據的律師的黑道躲藏在國外。

'The Mafia member who threatened the lawyer, who obtained the criminal evidence, is in exile overseas. '

黑道威脅的握有證據的律師躲藏在國外。

'The lawyer, who obtained the criminal evidence, whom the Mafia threatened, is in exile overseas.'

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