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Commemorative Essays for Yuen Ren Chao, Father of Modern Chinese Linguistics
現代漢語語言學之父：趙元任先生紀念論文集

"Nage" Before vs. After Relative Clauses in Chinese: A Processing View*

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Abstract　Chao (1968) proposes that the order of *Nage* before vs. after determines whether there are restrictive or descriptive uses of DE in Chinese relative clauses (RCs). *Nage* in post-RC is for restrictive use, whereas *Nage* in pre-RCs is for descriptive use. Recently Sheng and Wu (2012) have shown that *Nage* prefers to occur before subject-extracted relative clauses (SRCs) and after object-extracted relative clause (ORCs) in their spoken corpus and sentence production experiment. They attribute the distribution to pragmatic functions. This paper proposes that an effect of canonicity of thematic order-AGENT-ACTION-PATIENT may also affect real-time processing (Small et al. 2000, Lin 2012). Based on this effect, the structures of *Nage* in pre-SRCs and post-ORCs conform to the canonical thematic order, whereas the structures of *Nage* in post-SRCs and pre-ORCs do not. A self-paced reading experiment was conducted, and the result shows that *Nage* in pre-SRCs is easier to process than *Nage* in post-SRCs, whereas *Nage* in post-ORCs is easier to process than *Nage* in pre-ORCs. It suggests that when sentences conform to the canonical thematic order, it facilitates to process the regions of RC and head noun, and vice versa. The main processing difference for *Nage* position was interpreted as a processing demand for readers, and does not rely on the pragmatic functions only.

從語言處理觀點探討關係子句前後的「那個」

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摘要　趙元任（1968）提出，「那個」出現在關係子句前後的位置可判別漢語關係子句中「的」的用法是限定還是描述用法。「那個」在關係子句之後是限定用法，在關係子句之前則是描述用法。根據語料和造句實驗，盛亞南和吳芙芸（2012）指出「那個」傾向出現在主語關係子句之前和賓語關係子句之後。他們從語用功能角度解釋此傾向。本文則提出，一般語義角色語序，即「施事–動作–受事」也會在實時句子處理時產生作用 (Small et al. 2000, Lin 2012) ，使主語關係子句之前和賓語關係子句之後的「那個」符合一般的語義角色語序，相反，主語關係子句之後和賓語關係子句之前則沒有顯示相關作用。自訂速度的閱讀實驗結果顯示，跟主語關係子句之後的「那個」比較，主語關係子句之前的「那個」較容易理解，而比起賓語關係子句之前的「那個」，賓語關係子句之後的「那個」則較容易理解。實驗結果意味著當句子符合一般的語義角色語序時能促進大腦處理關係子句和其中心名詞，反之亦然。這些顯著差異可知「那個」的語序不僅是

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語用問題，也跟語言處理時的需求有關。

1. Introduction

In Chinese, the combination of demonstrative + (number) + classifier (DCL) can either precede or follow Chinese relative clauses (RCs), as in (1) and (2). In the context of discussing restrictive and descriptive uses of *de,* Chao (1968: 286) analyzed (1) as with descriptive use and (2) as with restrictive use.

(1) 那位 [戴 眼鏡 的] 先生 是 誰?
nawei dai yanjing de xiansheng shi shei
DCL wore glasses DE gentleman is who
"Who is that gentleman (who incidentally is) wearing glasses?"

(2) [戴 眼鏡 的] 那位 先生 是 誰?
dai yanjing de nawei xiansheng shi shei
wore glasses DE DCL gentleman is who
"Who is the gentleman who is wearing glasses?"

In (1), the DCL *nawei* precedes the relative clause, which is a descriptive use in that *nawei dai yanjing de* only describe the *xiansheng* rather than distinguish it from other *xiansheng*.[1] By contrast, in (2), the DCL *nawei* follows the relative clause, which has a restrictive use in that *xiansheng* is referring to *xiansheng* who is wearing glasses only rather than other *xiansheng*. At the same time, Chao (1968: 286) observed that if a stress is placed on the modifier *dai yanjing* in (1), the sentence will also have the restrictive sense as in (2). Later Hashimoto (1971) and Tang (1979) have analyzed this difference as equivalent to the distinction between restrictive and non-restrictive relative clauses (RCs) in English. Nevertheless, Teng (1987) and Lin (2003) and others show that Chinese doesn't have the distinction, all RCs being restrictive.

Recently, Huang, Li and Li (2009) observe that there are three positions that a Chinese RC may appear in a nominal phrase, as shown in (3).

(3) Huang, Li and Li (2009: 214)

Demonstrative + (Number) + Classifier + Noun
position I ***position II*** ***position III***

Chinese RCs in *position I* appear before the demonstrative, as in (4).

[1] In Chao's work, classifiers are individual measures. A measure, as a bound morpheme, forms a D-M compound with the demonstrative (p.584). Thus D-M is used in Chao (1968) rather than DCL (demonstrative + classifier). Also the English translations of (1) and (2) sentences are Chao's original translations to show the meaning contrast.

(4) Huang, Li and Li (2009: 214)

[[他 喜歡 的RC] 那 (一)個 孩子NP]
ta xihuan de na (yi)-ge haizi
he like DE that one-CL child
"the child that he likes"

Chinese RCs in *position II* appear between a demonstrative and a number, as in (5).

(5) Huang, Li and Li (2009: 215)

[這 [張三 說 出來 的RC] 一句 話NP] 比
zhe Zhangsan shuo chulai de] yiju hua bi
this Zhangsan speak out DE one-CL word compare

[那 [李四 寫 出來 的RC] 一百句 話NP] 還 有用
na Lisi xie chulai de yibaiju hua hai youyong
that Lisi write out DE one.hundred-CL word more useful
"This one sentence that Zhangsan uttered is even more useful than those hundred sentences that Lisi wrote."

Huang et al. (2009) suggest that the *position II* is the most unnatural position and most complex example for Chinese RCs. Chinese RCs in *position III* occur between a classifier and a noun as (6).

(6) Huang, Li and Li (2009: 215)

[那 (一) 個 [他 喜歡 的RC] 孩子NP]
na yi ge ta xihuan de haizi
that one-CL he like DE child
"the child that he likes"

For the purpose of this study, we focus on the distinction between position 1 and position III. Huang (1982) suggests that the two positions involve different scopes of modification, and function differently. In position I, the demonstrative is a deictic expression, referring to a designated entity ("that one"). In position III, the demonstrative is an anaphoric expression, identified by the preceding relative. A similar distinction between a descriptive versus identificational use of the two positions is also proposed by Lu (1998).

Incidentally, Zhang (2006) holds that there are two types of Chinese indefinite nominals: (i) the inner modifier nominal (IMN) and (ii) the outer modifier nominal (OMN) in accordance with the positions of a modifier of nominal such as a PP, AP, NP and RC modifier. IMN refers to the order of numeral-classifier-modifier-de-N that the modifier occurs internal position of the nominal (e.g., *san ge [dai yanjing de] xuesheng* "three students who wear glasses"). In contrast, OMN refers to the order of modifier-de-numeral-classifier-N that the modifier occurs the left-peripheral position

of the nominal (e.g., *[dai yanjing de] san ge xuesheng* "three students who wear glasses"). It should be noted here that the present study focuses on the position of *Nage* that can either precede or follow a RC (i.e. *position III* and *I*), and does not address Zhang's (2006) analysis of the positions of a modifier of nominal in general.

Previous corpus-based research (Wu 2009, Ming 2010) has shown that *Nage* in pre-SRCs (subject extracted relative clauses) outnumber *Nage* in post-SRCs, whereas *Nage* in post-ORCs (object extracted relative clauses) outnumber *Nage* in pre-ORCs. This asymmetric distribution was also reported by a combination of corpus-based and experimental study (Sheng and Wu 2012). They employed a spoken corpus and sentence-production experiment to examine the distribution of DCL *Nage* in SRCs and ORCs. They found an asymmetric distribution pattern according to 357 RCs investigated from a Chinese live TV-show: (i) *Nage* tended to occur before SRCs, and (ii) *Nage* tended to occur after ORCs. Furthermore, in their sentence-production experiment, sentences were chunked into 4 parts (DCL/ RC/ head noun/ matrix clause), and each randomly assigned to 4 boxes in a diamond layout on a visual display. The participants produced the utterance based on these four parts of the sentences. The results also show that the participants have preference to produce *Nage* in pre-SRC (Nage-SRCs), as compared to *Nage* in post-SRCs (SRCs-Nage), whereas they have preference to produce *Nage* in post-ORCs (ORCs-Nage), as compared to *Nage* in pre-ORCs (Nage-ORCs) ($p < .0001$). Their finding was interpreted within the Audience Design Model to the effect that speakers favor to use *Nage* before SRCs as an early cue for their listeners (or audience) to ease comprehension; but to use ORCs-Nage to avoid structural ambiguity with garden path in Nage-ORCs. The example (7) with structural ambiguity is extracted from Sheng and Wu (2012).

(7) Nage-ORCs:

那個	*星探*	遇見	的	*女孩*	長得	很	漂亮
nage	*xingtan*	yujian	de	*nuhai*	zhangde	hen	piaoliang
DCL	*star-hunter*	meet	DE	*girl*	look	very	beautiful

"The girl whom the star-hunter met looks very beautiful."

They suggested that *Nage* can be compatible with both the embedded noun *xingtan* "star-hunter" and head noun *nuehai* "girl" when *Nage* occurs in initial position of ORCs, and this structure is unable to clearly express whether speakers refer to either the embedded noun or head noun for their listeners. Hence, it resulted in reducing to use this type of RC sentences for speakers.

Lin (2012) observed an effect of thematic order in discourse context when processing Chinese SRCs and ORCs. Since Chinese is viewed as SVO word order with the canonical thematic order like AGENT-ACTION-PATIENT. The discourse with canonical condition is given in (8), and the target sentence either ORCs or SRCs is also given in (9).

(8) **Discourse Context with canonical condition** (Lin 2012: 45)

一棟 公寓 裡 住了 房東 以及 兩個 房客
yidong gongyu li zhule fangdong yiji liangge fangke
one apartment in lived landlord and two tenants
"A landlord and two tenants lived in an apartment."

一位 **住戶**AGENT 噪音 太 大 **吵醒了**ACTION **房東**PATIENT
yiwei zhuhu zaoyin tai da chaoxingle fangdong
one tenant noise too loud woke up landlord
"One of the tenants was too noisy and woke up the landlord."

這位 **房東**AGENT 噪音 也 不 小 **吵醒了**ACTION 另一位 **住戶** PATIENT
zhewei fangdong zaoyin ye bu xiao chaoxingle lingyiwei zhuhu
this landlord noise also not small woke.up the other tenant
"This landlord also made noises and woken up the other tenant."

小明: 我 聽說 其中 一名 住戶 被 微軟 雇用了
Xiaoming: wo tingshuo qizhong yiming zhuhu bei Weiruan guyongle
I heard among.them one tenant BEI Microsoft hired
"I heard one of the tenants was hired by Microsoft."
哪一位 住戶 被 微軟 雇用?
nayiwei zhuhu bei Weiruan guyong
which.one tenant BEI Microsoft hired
"Which tenant was hired by Microsoft?"

(9) **Target Sentences** (Lin 2012: 46)

a. **ORC**:
[**房東** AGENT **吵醒** ACTION 的] **住戶** PATIENT 被 微軟 雇用
Fangdong chaoxing de zhuhu bei Microsoft guyong
landlord woke.up DE tenant BEI Microsoft hire
"The tenant who the landlord woke up was hired by Microsoft."

b. **SRC**:
[**吵醒** ACTION **房東** PATIENT 的] **住戶** AGENT 被 微軟 雇用
chaoxing fangdong de zhuhu bei Microsoft guyong
woke.up landlord DE tenant BEI Microsoft hire
"The tenant who woke up the landlord was hired by IBM."

Lin (2012) emphasized that not only structural frequency information associated with lexical item but also the linear order of thematic roles play important roles. He conducted two self-paced reading experiments and successfully predicted that the target sentence (9a) for ORCs were read faster in the first and second regions after the head noun when the discourse context (8) given fully overlapped thematic orders-AGENT-ACTION-PATIENT (see the bold words).

Accordingly, we suggest that *Nage* constructions also imply the effect of the thematic order, as in (10) and (11). For SRCs, (10a) conforms to the canonical

thematic order (AGENT-ACTION-PATIENT), but (10b) does not. For ORCs, (11b) conforms to the canonical thematic order, but (11a) does not.

(10)a. **Nage-SRC with canonical thematic order:**

那個AGENT [上午 稱讚ACTION 讀者PATIENT 的] 作家
nage shangwu chengzan duzhe de zuojia
DCL morning praised readers DE writer
"the writer who praised the readers this morning"

b. **SRC-Nage with non-canonical thematic order:**

[上午 稱讚ACTION 讀者PATIENT 的] 那個 作家AGENT
shangwu chengzan duzhe de nage zuojia
morning praised readers DE DCL writer
"the writer who praised the readers this morning"

(11)a. **Nage-ORC with non-canonical thematic order**:

那個AGENT [上午 讀者AGENT 稱讚ACTION 的] 作家PATIENT
nage shangwu duzhe chengzan de zuojia
DCL morning readers praised DE writer
"the writer who the readers praised this morning"

b. **ORC-Nage with canonical thematic order:**
[上午 讀者AGENT 稱讚ACTION 的] 那個 作家PATIENT
shangwu duzhe chengzan de nage zuojia
morning readers praised DE DCL writer
"the writer who the readers praised this morning"

Hence, in addition to the discourse account from the production experiment (Sheng and Wu, 2012), we also propose that there is an effect of canonicity of thematic order in real-time processing.

While Sheng and Wu (2012) have analyzed the distribution and functions of Chinese *Nage* from the corpus-based studies as well as production experiment, real-time data from comprehension experiment are still needed to understand the role of *Nage* in processing of RC in Chinese. The goal of this study is to see if the asymmetric pattern observed in the production experiments and the effect of canonicity of thematic order also holds in comprehension experiments.

2. Self-paced reading experiment

For the comprehension experient, we employed a self-paced reading task to examine how the distribution of Chinese DCL *Nage* in SRCs and ORCs affects real-time processing. Beyond the frequency effect from the corpus analysis (Sheng and Wu 2012), we also want to know how the canonicity of thematic order (i.e. default semantic/syntactic linking in Chinese), affect on-line parsing. We predict that

the Chinese RCs which are compatible with the canonical thematic order (i.e. Nage-SRCs and ORCs-Nage) may facilitate sentence processing, particularly at the regions of RC and head noun, and vice versa.

2.1 Method

2.1.1 Participants

Twenty undergraduate and graduate students (11 males, 9 females) from National Chung Cheng University participated in this experiment. All participants were over the age of 18, and the age range was from 18 to 27 (M = 24.5, SD = 2.72). They had normal or corrected-to-normal vision by self-report. All participants were Taiwan Mandarin native speakers, while all were exposed to Taiwan Southern Min or Hakka since birth. They also reported no speech, hearing, language disorders, and brain injury. They each received a gift for participating in the experiment.

2.1.2 Materials

Twenty sets of target sentences were manipulated by two factors: (i) Extraction Types (SRCs vs. ORCs) and (ii) Position of *Nage,* before RC (Nage-RC) vs. after RC (RC-Nage), which denotes either *Nage* precedes or follows the RCs. A total of 80 (= 20 sets × 2 Extraction Types × 2 Positions of *Nage*) were designed, and one of the sets for target sentences is given in Table 1.

Table 1 Target sentences in self-paced reading experiment

Sentence types	**Example**
Nage-SRC	那個 [上午 __ 幫助 村民 的] 農夫 問候了 村長 DCL ADV RV RO DE MS MV MO Nage shangwu bangzhu cunmin de nongfu wenhoule cunzhang DCL morning help villager DE farmer greeted village head "The farmer who helped the villager greeted the village head this morning."
SRC-Nage	[上午 __ 幫助 村民 的] 那個 農夫 問候了 村長 ADV RV RO DE DCL MS MV MO Shangwu bangzhu cunmin de nage nongfu wenhoule cunzhang morning help villager DE DCL farmer greeted village head "The farmer who helped the villager greeted the village head this morning."
Nage-ORC	那個 [上午 村民 幫助 __ 的] 農夫 問候了 村長 DCL ADV RS RV DE MS MV MO Nage shangwu cunmin bangzhu de nongfu wenhoule cunzhang DCL morning villager help DE farmer greeted village head "The farmer who the villager helped greeted the village head this morning."
ORC-Nage	[上午 村民 幫助 __ 的] 那個 農夫 問候了 村長 ADV RS RV DE DCL MS MV MO Shangwu cunmin bangzhu de nage nongfu wenhoule cunzhang

	morning villager help DE DCL farmer greeted village head "The farmer who the villager helped greeted the village head this morning."

Note that in Table 1, an extra temporal adverbial such as *shangwu* "morning" was attached to the initial position of RCs to avoid the garden-path effect. Without a temporal adverbial in Nage-ORC, the sentence will be interpreted as *Nage cunmin* "that villager" in the initial stage of processing rather than the intended correct interpretation *Nage nongfu* "that farmer".

In order to prevent participants from noticing the patterns of experimental stimuli, forty filler sentences, which were not related to the intent of the experiment, were included. These filler sentences consist of diverse sentence types selected from Academia Sinica Balanced Corpus of Modern Chinese version 4.0 (Sinica Corpus) compiled by Academia Sinica in Taiwan (CKIP1995/1998). In addition, half of the filler items contain a possessive marker *DE* to distract participants' attention. The length of filler sentences was similar to the length of target sentences consisted of 7 to 9 words.

Overall, twenty sets of target sentences and forty filler sentences were counterbalanced across four conditions for twenty participants, and thus, each participant read a total of sixty (= 20+40) sentences for each version.

2.1.3 Procedure

A self-paced reading experiment was conducted with Linger version 2.94 software developed at MIT (Rohde 2003). This technique provides reliable online measures of processing difficulty or speed. Participants performed the experiment individually in a sound-proof cubicle room. At the beginning of the experiment, the written instruction was first given on the computer screen, and the experimenter gave the oral instruction to them later. Four practice trials were provided to familiarize the participants with the task before the formal test session. For each trial, a fixation symbol "+", which is an impending start of a sentence at the center of the computer screen. A word or phrase appeared in the center of computer screen when the participants pressed the spacebar to control the presentation of the successive chunks of the sentence. In this paradigm, while each word or phrase appears, the preceding word disappears. Hence, the times for each chunk of sentences that the participants read were recorded.

To ensure the participants were paying attention in this task, they were asked to give an answer to a comprehension question after reading each sentence. In a yes-no question, the participants were instructed to hit the key "F" for true and the key "J" for false. Feedback was immediately provided after they answer the comprehension questions. All sentences were presented randomly in order to control for the possible effects of the order of presentation, such as fatigue or habituation. Each experimental stimulus was presented one at a time in randomized order. In addition, participants were asked to read the sentence at their own and natural pace, so that there were no time constraints for participants to read sentences. The whole experiment took approximately twenty minutes to finish.

2.2 Results

2.2.1 Comprehension-question accuracy

The grand mean accuracy rate of comprehension questions for all target trials was 88.5%. The mean accuracy rates across two main effects are shown in Figure 1. The comparison of Extraction Type (i.e. SRCs and ORCs) shows that Nage-SRCs were comprehended more accurately than SRCs-Nage, whereas ORCs-Nage was comprehended more accurately than Nage-ORCs. In short, a ranking hierarchy of the grand mean accuracy for each sentence type was:

Nage-SRCs > ORCs-Nage > SRCs-Nage = Nage-ORCs

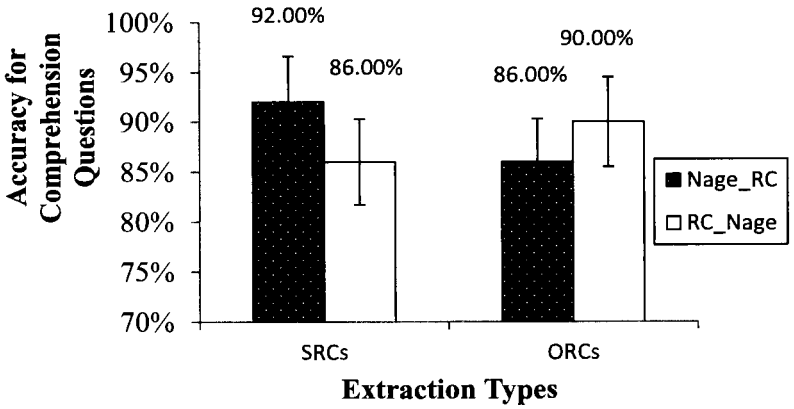


Figure 1 The comparison of mean accuracy rates between SRCs and ORCs

To obtain maximized power of statistical analysis, a mixed-effects logistic regression (Baayen 2008, Pinheiro and Bates 2000) in the free statistics program R (R Development Core Team 2011) was used to analyze two main effects (Extraction Types, and Position of *Nage*) for the binomial response of accuracy. The likelihood ratio test first carried out the comparison between the by-subject-and-item model and the by-subject-only model.

> acc.analysis.s = lmer (Accuracy ~ ExtractionType*PositionNage + (1|Subject), family = "binomial", data = acc)
> acc.analysis.si = lmer (Accuracy ~ ExtractionType*PositionNage + (1|Subject) + (1|Item), family = "binomial", data=acc)
> anova (acc.analysis.s, acc.analysis.si)

Table 2 illustrates that accuracy has no significant difference either on Extraction Types ($p > .05$) or Position of *Nage* ($p > .05$). In addition, no significant interaction was observed ($p > .05$).

Table 2 Linear mixed-effects logistic regression model of the predictors for Accuracy

Test Model	Predictors in mixed-effects logistic regression	*Estimate*	*Std. Error*	*z value*	*Pr (>|z|)*
Subject & Item	(Intercept)	2.30259	0.24823	9.276	0.000***
	Extraction Type	0.05352	0.22488	0.238	0.812
	NagePosition	0.07501	0.22488	0.334	0.739
	Extraction Type: NagePosition	0.25087	0.22488	1.116	0.265

Note: "***": $p < .001$

2.2.2 Reading time data

2.2.2.1 Interpretation of the measures

The main analysis for reading time was conducted by using a linear mixed-effects model in lme4 package (Bates, Maechler and Bolker 2011) in R (R Development Core Team 2012). Before analyzing the reading times data, the outliers for all reading time across different regions first were examined. The statistical outliers in this experiment were eliminated by using the method proposed by Hofmeister (2007) and Wu et al. (2012). Hofmeister (2007) proposes that the extremely high reading times reflect the less concentration on comprehending, parsing errors making, participants' physical problems, or even the irrelevant reasons to cause the slowdown of online parsing. To remove these statistical outliers, we used the trim methods by proposed Wu et al. (2012). They recommended that reading times which are longer than 4,000 ms for a double-syllable Chinese word should be excluded. Moreover, Hofmeister (2007) suggest that the number of the removal of extreme outliers for self-paced reading task typically should be less than 3% of the data. Accordingly, 5 extreme outliers for all reading times (3200 data) we analyzed were removed, and the result fitted the standard that was 0.16% (< 3%). After elimination of the statistical outliers, the remaining reading times were log transformed (i.e. logarithm) in this experiment because the previous studies suggest several advantages to analysis log-transformed reading times instead of raw reading times (Jaeger, Gillespie and Graff 2010, Wu et al. 2012). First, it has the advantages of log transformation to correct and remove skewness because individual RT varies with different participants' reading speeds as well as the difference of word length. Second, the data were analyzed using a LME predicted under a linear regression model, and hence, log transformation can reduce non-linear relations.

2.2.2.2 Analysis for each region

Four regions were analyzed across four sentence types, as shown Table 3. The gray parts in Table 3 stand for the regions in RCs: RV, RS, and RO. By contrast, the white parts stand for the regions in main clauses: DE and MS.

Table 3 Analysis of four regions across four sentence types

Sentence Type	**Region**			
Nage_SRCs	**RV**	**RO**	**DE**	**MS**
	幫助 bangzhu	村民 cunmin	的 DE	農夫 nongfu
SRCs_Nage	**RV**	**RO**	**DE**	**MS**
	幫助 bangzhu	村民 cunmin	的 DE	農夫 nongfu

Nage_ORCs	RS	RV	DE	MS
	村民 cunmin	幫助 bangzhu	的 DE	農夫 nongfu
ORCs_Nage	**RS**	**RV**	**DE**	**MS**
	村民 cunmin	幫助 bangzhu	的 DE	農夫 nongfu

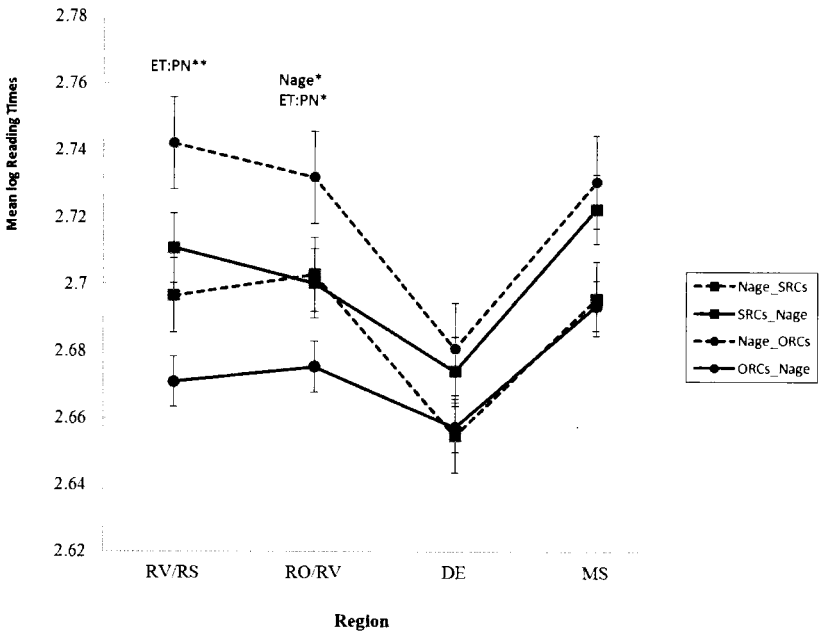
Note: "RV" = verbs in relative clauses; "RO" = objects in relative clauses; "RS" = subjects in relative clauses; "DE" = relativizers in matrix clause; "MS" = matrix subjects

Overall, a ranking hierarchy of the grand mean log reading times per region across four sentence types was:

Nage-ORCs > SRCs-Nage > **Nage-SRCs** > **ORCs-Nage**
2.723 > 2.706 > **2.702** > **2.690** (log reading times)

The result shows that ORCs-Nage were read faster than Nage-ORCs (2.690 vs. 2.723 log reading times); by contrast, Nage-SRCs were read faster than SRCs-Nage (2.702 vs. 2.706 log reading times).

Figure 2 illustrates the mean log reading times for four regions across four sentence types (i.e. Nage-SRCs, SRC-Nage, Nage-ORC and ORC-Nage).



Note: ***$p < .001$; *$p < .05$; "Nage Position*" stands for a significant effect of Position of *Nage*; "ET: PN*" stands for a significant interaction between Extraction Types (ET) and Position of *Nage* (PN).

Figure 2 Mean log reading times for four regions across four sentence types

Furthermore, two main effects (i.e. Extraction Types and Position of *Nage*) and their interaction were examined by using a linear mixed-effects model with the lme4

package in R. The likelihood ratio test first carried out the comparison between the by-subject-and-item model and the by-subject-only model for each region. The results showed that the by-subject-only model for each region fitted the data better than the by-subject-and-item model, as shown in Table 4. The overall statistical analysis for each region consists of *the test model*, *estimate*, *standard error*, *t value*, and *pMCMC* is reported in Table 4.

Table 4 Linear mixed-effects regression model of the predictors for four regions

Region	Test Model	Predictors in LME	*Estimate*	*Std. Error*	*t value*	*pMCMC*
RV/RS	Subject	(Intercept)	2.705062	0.031365	86.24	0.0001***
		Extraction Type	-0.001433	0.007648	-0.19	0.8658
		NagePosition	**0.014271**	**0.007648**	**1.87**	**0.068.**
		Extraction Type: NagePosition	**-0.02138**	**0.007648**	**-2.8**	**0.0046****
RO/RV	Subject	(Intercept)	2.702718	0.033332	81.08	0.0001***
		Extraction Type	-0.001193	0.006677	-0.18	0.8728
		NagePosition	**0.014957**	**0.006677**	**2.24**	**0.0306***
		Extraction Type: NagePosition	**-0.013648**	**0.006677**	**-2.04**	**0.0498***
DE	Subject	(Intercept)	2.666589	0.025815	103.29	0.0001***
		Extraction Type	-0.002326	0.006436	-0.36	0.732
		NagePosition	0.001038	0.006436	0.16	0.8666
		Extraction Type: NagePosition	-0.010696	0.006436	-1.66	0.1042
MS	Subject	(Intercept)	2.710626	0.03739	72.5	0.0001***
		Extraction Type	-0.001512	0.008025	-0.19	0.8538
		NagePosition	0.002577	0.008025	0.32	0.7458
		Extraction Type: NagePosition	**-0.015972**	**0.008025**	**-1.99**	**0.0554.**

Note: "***": $p < .001$; "**": $p < .01$; "*": $p < .05$; ".": $p < 1$

At the region of **RV/RS**, there was no significant effect of Extraction types ($p > .05$). However, there was a marginal effect of position of *Nage* ($p = .068$). Importantly, there was an interaction between Extraction Types and Position of *Nage* ($p < .05$), as in Figure 3. The result shows that Nage-SRCs were read faster than SRCs-Nage, and ORCs-Nage were read faster than Nage-ORCs.

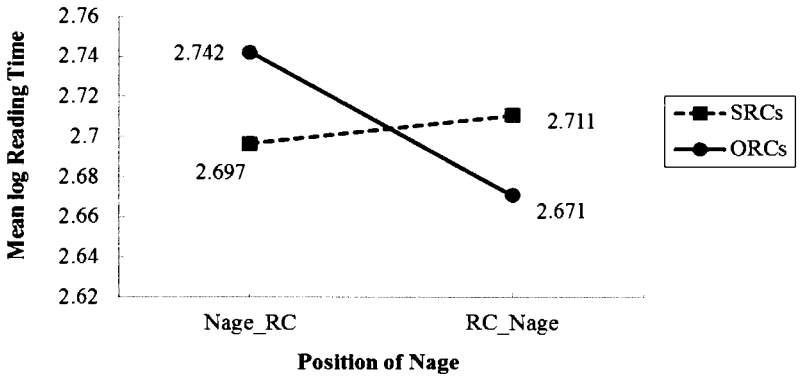


Figure 3 An interaction between the factors of Extraction Types and Position of *Nage* at the region of RV/RS ($p < .01$)

At the region of **RO/RV**, no significant effect of the Extraction Types was found ($p > .05$). However, a significant effect on Position of *Nage* ($p < .05$) and interaction between the Extraction Types and Position of *Nage* were observed ($p < .05$). In other words, *Nage* in pre-RCs was read more slowly than *Nage* in post-RCs. The result can be explained more clearly on the interaction effect, as in Figure 4. The difference between Nage-SRCs and SRCs-Nage is much less than the difference between Nage-ORCs and ORCs-Nage. Specifically, Nage-ORCs were read more slowly than ORCs-Nage.

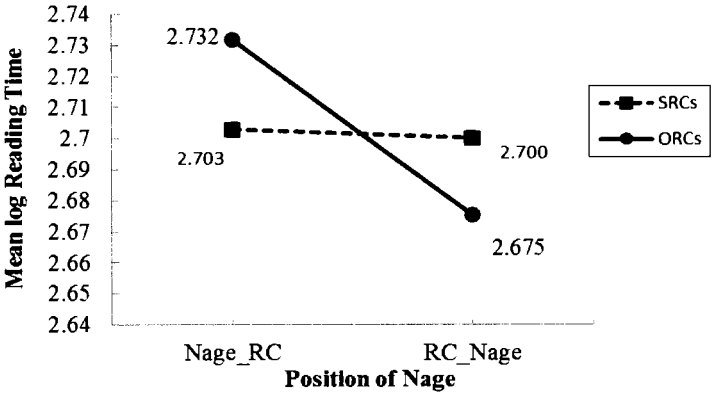


Figure 4 An interaction between the factors of Extraction Types and Position of *Nage* at the region of RO/RV ($p < .05$)

At the region of **DE**, there was no main effect and interaction ($p > .05$).

At the region of **MS**, there was a marginal interaction between the Extraction Types and Position of *Nage* ($p > .05$), as in Figure 5. The results show that Nage-SRCs were read faster than SRCs-Nage, whereas ORCs-Nage was read faster than Nage-ORCs. In other words, *Nage* shows the preference for the pre-SRCs and post-ORCs.

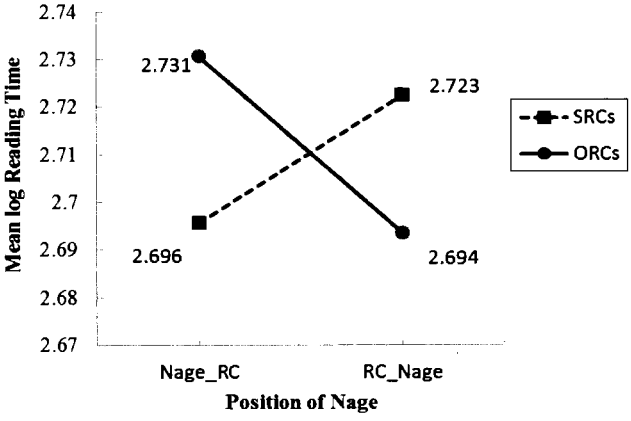


Figure 5 A marginal interaction between the factors of Extraction Types and Position of *Nage* ($p = .0554$) at the region of MS.

2.3 Discussion

In this experiment, two main factors (i.e. Extraction Types and Position of *Nage*) were examined in self-paced reading task. Importantly, the factor of Position of *Nage* was first evaluated in real-time processing, even though the previous literature has made contributions with the analysis of corpus data or/ and production experiment (Wu 2009, Ming 2010, Sheng and Wu 2012). All suggest that the positions of *Nage* denote different functions in discourse. That is, *Nage* in pre-RCs provides an early cue for listeners to anticipate RC structures, whereas *Nage* in post-RCs is able to avoid structural ambiguity (Sheng and Wu 2012). However, we propose that there is the other effect — the canonicity of thematic order in SVO languages, the default syntactic and semantic linking in online parsing.

The following sections will be discussed from two measures in self-paced reading experiment: (i) offline measures for the accuracy of yes/no comprehension questions in section 2.3.1 and (ii) online measures for log-transformed reading times in section 2.3.2.

2.3.1 Offline measures

The results show that Nage-SRCs were comprehended more accurately than SRCs-Nage (92% vs. 86%); by contrast, ORCs-Nage were comprehended more accurately than Nage-ORCs (90% vs. 86%). However, there are no main effects and interactions on the accuracy rate. This result is consistent with the findings from the sentence-production experiment (Sheng and Wu 2012) that the speakers had preference to produce Nage-SRCs, as compared to SRCs-Nage, whereas they had preference to produce ORCs-Nage, as compared to Nage-ORCs. In addition, our results were also consistent with the corpus-based analyses (Wu 2009, Ming 2010) that the frequencies of Nage-SRCs outnumber the frequencies of SRCs-Nage, whereas the frequencies of ORCs-Nage outnumber the frequencies of Nage-ORCs. Though a variety of the methodologies were employed above, they brought the same finding of the asymmetric patterns for the position of *Nage* in Chinese RCs.

2.3.2 Online measure

For the online data, the results were consistent with our predictions that Nage-SRCs is easier to process than SRCs-Nage; and by contrast, ORCs-Nage is easier to process than Nage-ORCs in accordance with the measures of reading times. This difference can be more clearly observed from the significant and the marginal interaction between the factors of Extraction Types and Positions of *Nage*, as shown in Figure 3, 4 and 5. The results for real-time reading also support the other corpus-based studies (Wu 2009, Ming 2010) and production experiment (Sheng and Wu 2012).

Moreover, the finding is attributed to the effect of the canonicity of thematic order (Lin 2012). That is, the structural preference (i.e. AGENT-ACTION-PATIENT for the dominant SVO word order in Chinese) for the readers plays a significant role in online parsing. Both Nage-SRCs and ORCs-Nage conform to the canonical thematic order in Chinese, whereas SRCs-Nage and Nage-ORCs do not. Thus, we suggest that

SRCs-Nage and Nage-ORCs may create additional processing cost due to a delayed thematic role assignment for their head noun. The examples illustrate in (12) and (13).

(12)a. ***Nage-SRCs* with canonical thematic order:**

那個 [上午 __ 幫助 村民 的] 農夫 問候了 村長
AGENT ACTION PATIENT AGENT ACTION PATIENT
DCL ADV RV RO DE MS MV MO
Nage shangwu bangzhu cunmin de nongfu wenhoule cunzhang
DCL morning help villager DE farmer greeted village head
"The farmer who helped the villager greeted the village head this morning."

b. ***SRCs-Nage* with non-canonical thematic order:**

[上午 __ 幫助 村民 的] **那個** 農夫 問候了 村長
ACTION PATIENT **AGENT** ACTION PATIENT
ADV RV RO DE DCL MS MV MO
Shangwu bangzhu cunmin de nage nongfu wenhoule cunzhang
morning help villager DE DCL farmer greeted village head
"The farmer who helped the villager greeted the village head this morning."

(13)a. ***Nage-ORCs* with non-canonical thematic order:**

那個 [上午 村民 幫助 __ 的] 農夫 問候了 村長
AGENT **AGENT ACTION PATIENT**
DCL ADV RS RV DE MS MV MO
Nage shangwu cunmin bangzhu de nongfu wenhoule cunzhang
DCL morning villager help DE farmer greeted village head
"The farmer who the villager helped greeted the village head this morning."

b. ***ORCs-Nage* with canonical thematic order:**

[上午 村民 幫助 __ 的] **那個** 農夫 問候了 村長
AGENT ACTION PATIENT ACTION PATIENT
ADV RS RV DE DCL MS MV MO
Shangwu cunmin bangzhu de nage nongfu wenhoule cunzhang
morning villager help DE DCL farmer greeted village head
"The farmer who the villager helped greeted the village head this morning."

In (12a), *Nage* in the initial position of the SRC can be assigned as a temporary AGENT so that the linear sequence follows the canonical thematic order. This AGENT role in the sentence-initial position can provide a cue for readers to anticipate an upcoming head noun. Thus, it facilitates the processing of head noun. However, *Nage*, which is adjacent to head noun *nongfu* in (12b), is not assigned as a temporary AGENT. In addition, when readers initially parse SRC with non-canonical thematic order (i.e. ACTION - PATIENT), they need to remain a track of AGENT for the later retrieval in the position of head noun. Thus, there is a delay in thematic role assignment when readers encounter the head noun which is assigned as an AGENT.

Consequently, since (12a) follows the canonical thematic order in its linear sentence, the regions of RV and MS (or head noun) were read faster than those in (12b).

On the other hand, in (13a), *Nage* in the initial position of the ORC can be assigned as a temporary AGENT role, but readers realize that *Nage* is not an AGENT when they encounter RS *cunmin*. Thus, readers need to remain the track of *Nage* until they encounter MS (or head noun) *nongfu* that is assigned a delayed thematic role. By contrast, *Nage*, which is adjacent to head noun *nongfu* in (13b), is not assigned as a temporary AGENT. Readers initially parse the ORC with canonical thematic order (i.e. AGENT-ACTION), so the head noun is directly assigned as PATIENT. Consequently, since (15b) follows the canonical thematic order in ORCs, the regions of RS, RV and MS (or head noun) were read faster than those in (13a).

To sum up, this experiment tested two factors: (i) Position of *Nage* and (ii) Extraction Types. The results are compatible with the previous findings of corpus-based studies and the production experiment (Sheng and Wu 2012). The results are attributed to the effect of canonicity of thematic order (i.e. AGENT-ACTION-PATIENT in Chinese). If relative clauses conform to the canonical thematic order, they facilitate online processing for the regions of RC and head noun, and vice versa. In addition to frequency effect in corpus, we provide another important evidence for default semantic/ syntactic linking in the online parsing. Lastly, we propose that Position of *Nage* indeed affects RC processing, and researchers should take this factor into account when they determine to use *Nage* into their experimental materials.

3. Conclusion

In this study, the position of *Nage* was examined to observe whether there is difference of RC processing for *Nage* in pre- vs. post-RC. Based on the previous corpus-based studies and production experiments, we expect that Nage-SRCs is easier to process than SRCs-Nage, whereas ORCs-Nage is easier to process than Nage-ORCs in accordance with online reading times. We evaluated four regions: the regions of RC (i.e. RV/RS and RO/RV) and the regions of matrix clauses (i.e. DE and MS). Our result was in line with the previous analyses (Sheng and Wu 2012). In addition to Sheng and Wu's (2012) discourse accounts, our findings also can be interpreted within the effect of canonicity of thematic order (Small et al. 2000, Lin 2012). The structures of Nage-SRCs and ORCs-Nage conform to the canonical thematic order like AGENT-ACTION-PATIENT, and hence this canonical order facilitates the processing at the regions of RC and head noun. By contrast, the structures of SRCs-Nage and Nage-ORCs do not conform to the canonical thematic order, and hence this non-canonical order interferes the processing at the regions of RC and head noun. The findings also suggest that there is a delayed thematic role assignment, and the extra processing cost in SRCs-Nage and Nage-ORCs during sentence processing. Importantly, the main processing difference for *Nage* position was interpreted as a processing demand for readers, and does not rely on the pragmatic functions only.

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