The two sides of Wh-indeterminates in Mandarin : a prosodic and processing account

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Chapter 5 The Processing Mechanism of *Wh*-questions and Declaratives with Indefinites — Evidence from Mandarin

5.1 Introduction

As we have introduced, Mandarin Chinese is a *wh*-in-situ language in which question words remain at their base position, just as their declarative counterparts do, as illustrated in (1a-b). In contrast, English is a *wh*-movement language in which *wh*-words are fronted to sentence initial position (Spec-CP), as illustrated in (1c).

(1) a. 张三 买了 什么？ [*wh*-question]
Zhāng Sān mǎi-le shénme?
Zhang San buy-PERF what
'What did Zhang San buy?'

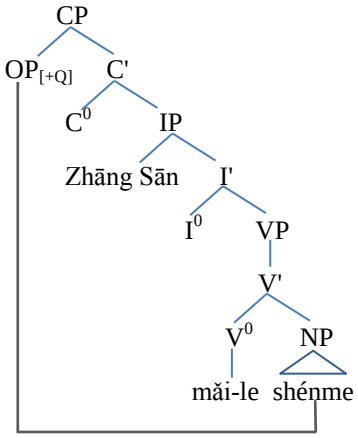
b. 张三 买了 一本 书。 [declarative]
Zhāng Sān mǎi-le yìběn shū.
Zhang San buy-PERF a CL book
'Zhang San bought a book.'

c. What$_i$ did Zhang San buy t_i? [*wh*-question]

In processing a *wh*-movement question like (1c), when the *wh*-word 'what' (filler) is encountered, the parser actively looks for its base position (gap) and establishes an overt dependency, according to existing psycholinguistic literature (Stowe, 1986; Frazier & Clifton, 1989). The filler-gap dependency has been widely investigated in many *wh*-movement languages. Nevertheless, for *wh*-in-situ questions like (1a), where there is no overt (non-local) dependency, little is known about how exactly an in-situ *wh*-word is processed.

As we have known in previous chapters, in addition to being in-situ, *wh*-words in Mandarin are on a par with indefinites in not having inherent quantificational force and their interpretations depend on operators/licensors. (Huang, 1982; Cheng, 1991; Aoun & Li, 1993; Tsai 1994, among others). When there is no overt licensor in the sentence as in example (1), the sentence is unambiguously a *wh*-question. In such cases, the *wh*-word is licensed by the interrogative operator (Q) at Spec-CP or C^o, and obtains the interrogative quantificational force, constructing a covert dependency between the in-situ *wh*-word and the interrogative operator (Q) at Spec-CP or C^o. The licensing/covert dependency in *wh*-questions is illustrated in (2).

(2)



The positing of a covert dependency in *wh*-in-situ questions has raised an interesting question for processing, namely, whether there is any processing evidence for establishing such a dependency in *wh*-in-situ languages like Mandarin. To the best of our knowledge, except for the pioneering work by Xiang, Dillon, Wagers, Liu and Guo (2013), no studies investigated the processing of Mandarin *wh*-in-situ questions, especially comparing *wh*-questions with their declarative counterparts. In the remaining part of this section, we discuss this article in detail.

Xiang et al. (2013) investigated the processing of Mandarin *wh*-questions with different lengths (mono-clausal and multiclausal), using the multiple-response speed-accuracy tradeoff paradigm (SAT)[23]. The *wh*-questions they tested are complex *wh*-questions, also called discourse-linked questions (i.e. *nǎxiē guānyuán* 'which officials'), as shown in (4). Xiang et al. found that in-situ *wh*-questions as in (4a) and (4b) were processed with longer reading times than their declarative counterparts as in (3a) and (3b) at the region of *wh*-phrases, indicating a higher processing cost in *wh*-questions.

(3) a. Declarative; Short

市政府	严惩了	那些官员.
Shìzhèngfǔ	yánchěng-le	nàxiē guānyuán.
city-council	punish	those officials

'The city council punished those officials.'

[23] There are more conditions in Xiang et al. (2013). We only reported the conditions that directly compared questions and declaratives.

b. Declarative; Long

市长	命令	市政府	严惩了	那些官员.
Shìzhǎng	mìnglìng	shìzhèngfǔ	yánchěng-le	nàxiē guānyuán.
mayor	order	city-council	punish	those officials

'The mayor ordered the city council to punish those officials.'

(4) a. *Wh*-question; Short

市政府	严惩了	哪些官员?
Shìzhèngfǔ	yánchěng-le	nǎxiē guānyuán?
city-council	punish	which officials

'Which officials did the city council punish?'

b. *Wh*-question; Long

市长	命令	市政府	严惩了	哪些官员?
Shìzhǎng	mìnglìng	shìzhèngfǔ	yánchěng-le	nǎxiē guānyuán?
mayor	order	city-council	punish	which officials

'Which officials did the mayor order the city council to punish?'

Xiang et al. (2013) interpreted the higher processing cost in *wh*-questions than in declaratives as empirical evidence for the establishment of a covert dependency between the in-situ *wh*-word and Spec-CP or C^o of the clause, as illustrated in (2). Despite of the insightful results bridging between the processing cost and the establishment of a covert dependency in in-situ questions, there are two issues in Xiang et al. (2013) that merit further discussions.

The first issue concerns the fact that the conclusion by Xiang et al. (2013), namely, *wh*-questions are more costly to be processed than declaratives, is based on *wh*-questions containing discourse-linked *wh*-phrase (i.e., a complex *wh*-phrase, *nǎxiē guānyuán* 'which officials') only. The notion "discourse-linking" was first defined by Pesetsky (1987). Similarly, Avrutin (2000) distinguished discourse-linked ('which x') and non-discourse-linked ('who') *wh*-phrase such that the former involves a discourse presupposition but the latter does not. That is, there is a mutual understanding in the discourse between the speaker and addressee that there is a presupposed set of items and the speaker wants to know which item in the presupposed set is the one in question. Rullmann and Beck (1998) also claimed that complex *wh*-phrases ('which x') are presuppositional elements, a particular kind of definites, different from other *wh*-words (i.e. simplex *wh*-phrases), which are indefinites in nature. It is also shown that the discourse-linking in complex *wh*-phrases incurs longer reading times as opposed to simplex *wh*-phrases in many languages (see De Vincenzi, 1996 for Italian; see Donkers, Hoeks & Stowe, 2013 for Dutch, among others). In other words, it remains a question whether the additional processing cost in *wh*-questions with discourse-linked *wh*-phrase can be extended to *wh*-questions with simplex *wh*-words. To address this issue, simplex *wh*-phrases (e.g. 'who') which entail no discourse-linking should be considered as compared with their declarative counterparts. We can then address the question of whether simplex *wh*-questions also result in higher processing cost than their declarative counterparts.

The second issue concerns the position of the critical region, namely, the *wh*-phrase in questions and the corresponding noun phrase in declaratives. In Xiang et al. (2013), all critical regions were posited at the sentence final position where the sentence-final wrap-up effects were often reported. According to the concept of wrap-up effects, readers tend to spend longer time in reading clause-final words than clause-internal words for an integration of information (Aaronson & Scarborough, 1976; Just & Carpenter, 1980; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). Although both *wh*-questions and declaratives may be affected by clause-final wrap-up effects, it remains unclear whether the two clause types are affected equally, which might weaken Xiang et al.'s empirical evidence of the additional processing cost they found at the *wh*-phrase. Given this, the processing cost incurred in *wh*-questions requires reinvestigation by excluding confounds involving sentence-final wrap-up effects.

To address the above issues and to attest whether the evidence of establishing a covert dependency in processing *wh*-questions can be extended to *wh*-questions without discourse-linking (i.e. containing simplex *wh*-words), we conducted altogether three self-paced reading studies on *wh*-questions and their declarative counterparts, with the *wh*-phrase and the corresponding noun phrase in the non-final position. Experiment 1 compared the processing of *wh*-questions of simplex *wh*-words (i.e. 'who') with their declarative counterparts with indefinites (i.e. 'someone'). The reason we compared *wh*-questions with simplex *wh*-words only with their declarative counterparts containing indefinites has to do with the definiteness of the noun phrase in declaratives. As we aim to examine whether simplex *wh*-questions result in higher processing cost than their declarative counterparts, the definiteness of the noun phrase in declaratives needs to be properly controlled. According to Warren & Gibson (2002), definite noun phrases are known to be more costly to process than their indefinite counterparts due to their different referential nature. Given that *wh*-phrases are indefinites in nature, comparing the processing of *wh*-questions with their declaratives counterparts containing indefinites would be a better comparison.

As the declaratives in Experiment 1 were shown to have ambiguous readings (see section 5.2.2 for details), we conducted Experiment 2 with a different set of stimuli. The stimuli constructed in Experiment 2 exclude the ambiguous readings on indefinites in declaratives and hence we can clearly detect the processing of simplex *wh*-questions and declaratives containing pure indefinites.

After comparing the processing of *wh*-questions containing simplex *wh*-phrases ('who') with their declaratives counterparts containing indefinites ('someone'), we conducted Experiment 3. In this experiment, we compared the processing of *wh*-questions containing complex *wh*-phrases (i.e. 'which x') with their declarative counterparts containing indefinites (i.e. 'an x'), different from Xiang et al. (2013) where complex *wh*-questions were compared with their declarative counterparts containing definites (i.e. 'the/those x'). The motivations for conducting Experiment 3 with a different comparison from Xiang et al. (2013) are two-fold. Firstly, we aim to investigate whether the processing cost resulted from the establishment of a covert dependency in *wh*-questions can be found in both types of *wh*-questions. Secondly, although Rullmann and Beck (1998) concluded that complex *wh*-phrases ('which x') are definites in nature, some studies also analyzed complex *wh*-phrases

as indefinites (see Karttunen, 1977 for details). Although we are not particularly interested about the exact nature of complex *wh*-phrases (definites or indefinites), a comparison between complex *wh*-questions and their declaratives counterparts containing indefinites might shed new light on our understanding of the processing of complex *wh*-questions, which have the discourse-linking feature and require the establishment of a covert dependency between the in-situ *wh*-word and the interrogative operator (Q).

5.2 Methodology

5.2.1 Experiment 1: Processing simplex *wh*-questions

5.2.1.1 Participants

Forty-two native speakers of Mandarin (10 males, $\bar{x}$ age = 20.4) participated in this experiment. All participants came from the northern part of Mainland China and at that time were students at Tsinghua University in Beijing. Participants were reimbursed for their participation and provided written informed consent prior to beginning the experiment.

5.2.1.2 Materials and design

Twenty-four sets of stimuli were constructed for this experiment, with a stimuli string "Det + Adj + Noun (human) + Verb-*le* + *shéi* (who) / *rén* (someone) + *jiù* (and then) + Verb-*le*". As illustrated in Example (5), each set contained 2 conditions[24], the simplex *wh*-questions with the *wh*-word *shéi* ('who') at the critical region, and the declarative counterpart with the indefinite *rén* ('someone') at the critical region. The word between slashes represents the reading region that participants encountered. See Appendix C for the specific list of materials used in the experiment.

(5) a. Simplex *wh*-question

那个/	优雅的/	绅士/	帮了/	谁/	就 /	离去了？
Nàgè	yōuyǎde	shēnshì	bāng-le	shéi	jiù	líqùle ?
that.CL	gracious	gentleman	help-PERF	who	then	left

'Who has the gracious gentleman helped and then left?'

[24] Our study includes one more condition that will be reported in a different paper. We only reported the two conditions relevant to our research question here. The same applies to the other two experiments.

b. Declarative with indefinite

那个/	优雅的/	绅士/	帮了/	人/	就/	离去了。
Nàgè	yōuyǎde	shēnshì	bāng-le	rén	jiù	líqùle.
that.CL	gracious	gentleman	help-PERF	person	then	left

'The gracious gentleman helped someone and then left.'

These twenty-four sets of stimuli were distributed into 2 lists in a Latin Square design and each list consisted of 24 sentences. In addition, 48 filler items were used to prevent participants from developing test-taking strategies. Twenty-four were *wh*-questions that contained the questions words *shénme shíhou* 'when' (n = 8), *nǎlǐ* 'where' (n = 8) and *zěnyàng* 'how' (n = 8) and 24 were declaratives. Each participant therefore read 72 sentences in total.

5.2.1.3 Procedure

A word-by-word moving-window self-paced reading experiment (Just, Carpenter & Wooley, 1982) was run on a PC laptop using Linger software (Doug Rhode, MIT). Participants were instructed to read the sentences carefully at their own pace by pressing the space bar. The experiment was preceded by eleven practice trials to help participants familiarize with the procedure.

All critical sentences and fillers were followed by comprehension questions. The questions asked about different parts of the sentence so that the participants could focus equally on all parts of each sentence. Half of the comprehension questions had ''yes'' answers, and the other half had ''no'' answers. Participants were instructed to answer the questions by pushing the F key for ''yes'' and the J key for ''no''. The computer showed ''Wrong answer" in Chinese if the questions were incorrectly answered, but no feedback was given if the answers were correct. The whole experiment lasted approximately 20 minutes.

The experimental procedure was the same for the other two self-paced readings reported in section 5.2.3 and 5.2.4.

5.2.1.4 Data analysis and results

Of the 42 participants, one participant's data was excluded from analysis due to scoring a low reading rate. Therefore, 41 participants were included in the following analysis.

5.2.1.4.1 Comprehension task results

The overall accuracy of the critical sentences across all participants was 97.4%. Further, per condition, the accuracy was 97.9% for the questions, 97.0% for the declaratives. The high accuracy rate showed that participants were attentive in reading.

5.2.1.4.2 Reading Times (RTs) analysis

For the raw RTs in each region, we first log-transformed them to adjust the heavily skewed distribution, following existing Mandarin studies (Wu, Kaiser & Andersen, 2012; Xiang, Wang & Cui, 2015) and other East Asian language studies (e.g. Kwon & Sturt, 2013 for Korean). Furthermore, data points more than 3 Standard Deviations (SD) above or below the mean for each region were excluded from the analysis, affecting 0.9% data. The resulting log-RTs at each region were analyzed with linear mixed effects models in R using the lmerTest package (Kuznetsova, Brockhoff & Christensen, 2013) with condition as a fixed effect factor, participants and items as random factors, allowing by-participant and by-item random intercepts, and by-participant and by-item random slopes for conditions[25].

We followed the same protocol of the RTs analysis in the other two self-paced readings reported in section 5.2.3 and 5.2.4.

5.2.1.4.3 Results

The mean log RTs per region across the two conditions are shown in Figure 1, which demonstrates that simplex *wh*-questions were processed much faster than their declarative counterparts at the region immediately after the *wh*-word, the conjunction *jiù* (‘then’).

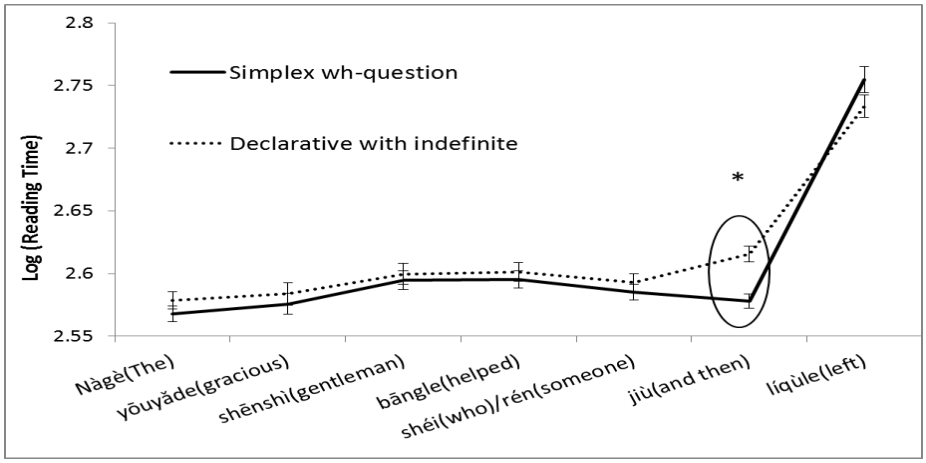


Figure 1. Mean log RTs per region with standard errors

[25] We allowed random slopes for all but after comparing models using the likelihood ratio test (Pinheiro & Bates, 2000; Bolker, Brooks, Clark, Geange, Poulsen, Stevens, & White, 2009), we found that adding random slopes didn’t improve the model. Hence the results we reported are based on the simpler model “Reading <- lmer (readingtime ~ condition + (1|subject) + (1|item), data=data)”.

A linear mixed effects model revealed a significant difference at the conjunction *jiù* ('then'). The reading time of questions is significantly shorter than that of the indefinite declarative condition ($\beta = -0.04$, $p < 0.001$). See Table 1 for the detailed results of the model.

Table 1. Summary of the linear mixed effects models at regions with significant reading time differences between conditions.

	Estimate β	Std. Error	t-value	p-value
conjunction (*jiù*)	-0.039	0.007	-5.582	< 0.001

To sum up, in the processing of simplex *wh*-questions and their declarative counterparts with indefinites, we found that questions were actually processed faster than declaratives. This processing pattern is contrary to the prediction that processing *wh*-questions should incur more cost than their declarative counterparts as a result of the establishment of a covert dependency in *wh*-questions. We will discuss the potential mechanism behind the unpredicted pattern in the following section.

5.2.2 Interim discussion

Our self-paced reading results show that simplex *wh*-questions with 'who' are processed with less cost than their declarative counterparts with 'someone', which was not expected based on the covert dependency theory discussed in section 5.1. Before we reach any conclusion, we must consider possible confounding factors such as word frequency or sentence stimuli in the current experiment.

Frequency. Word frequency has been shown to affect processing as readers tend to spend longer time when accessing infrequent words (Just & Carpenter, 1980; Kliegl, Grabner, Rolfs & Engbert, 2004, among others). In the current experiment, the simplex *wh*-questions and their declaratives counterparts only differ in the *wh*-word position. That is, the only differences are *shéi* 'who' and *rén* 'person'. In terms of frequency, both *shéi* and *rén* are highly frequently used words in Mandarin as shown by the Chinese online corpus (www.cncorpus.org). When used in isolation as one simple word, the word frequency of *shéi* and *rén* is 0.485‰ and 3.549‰ respectively. The fact that *rén* has a very high word frequency[26] exclude the possibility that the longer processing time at *rén* than *shéi* is due to their word frequency.

The interpretation of *rén* 'person'. Although *rén* in Mandarin normally receives an indefinite interpretation 'someone' at the object position, it can also obtain a definite interpretation under some conditions. For instance, as in our stimuli, when *rén* appeared within a bounded context (i.e., sentences containing a verb with a perfective marker *le*; see Sybesma, 1992 for details), *rén* can potentially be

[26] The *wh*-word *shéi* 'who' can have non-interrogative interpretations in other contexts (as introduced in section 1) and *rén* can also have other interpretations (see the discussion in the next paragraph). The reader should be aware that the word frequency reported here is a general word frequency without distinguishing the different usages or interpretations.

interpreted ambiguously between a definite and a specific indefinite interpretation (see Cheng & Sybesma, 1999). This ambiguity with respect to the interpretation on the noun phrase in declaratives may have incurred extra processing cost in the declarative condition. This can to some degree explain why the processing of declaratives with *rén* is slower than that of *wh*-questions, contrary to our expectations.

To restrict the interpretation of *rén* unambiguously to indefinite interpretation ('someone'), we created new stimuli that do not contain the perfective marker *le* or any bounded event in the sentence. With the new stimuli, we conducted the second self-paced reading study on *wh*-questions with simplex *wh*-phrases as compared with their declarative counterparts with indefinites, which will be reported in the next section.

5.2.3 Experiment 2: Processing simplex *wh*-questions with new stimuli

5.2.3.1 Participants

Thirty-six native speakers of Mandarin Chinese (20 males, $\bar{x}$ age = 20) participated in this experiment. They came from the northern part of Mainland China and were recruited from Tsinghua University (Beijing). None of them have participated in the other two self-paced reading experiments. Participants were reimbursed for their participation and provided written informed consent prior to beginning the experiment.

5.2.3.2 Materials and design

In this experiment, we compared in-situ *wh*-questions with *wh*-words *shéi* 'who' as in (6a), with declaratives that contained indefinites such as *rén* ('person') as in (6b). Crucially, by avoiding using the perfective marker '*le*' and by using intensional verbs[27] (e.g. 'want') instead, there is no bounded context that can bring ambiguous readings in declaratives. Hence *rén* ('person') can only be interpreted as an indefinite. Example (6) provides a set of sample stimuli. See Appendix D for the specific list of materials we used in the experiment.

(6) a. In-situ question with a simplex phrase

那个/	男生/	想要/	求/	谁/	解决/	问题?
Nàgè	nánshēng	xiǎngyào	qiú	shéi	jiějué	wèntí?
that.CL	boy	want	ask	who	solve	problem

'Who does the boy want to ask to solve the problem?'

[27] For the details of the discussions of the intensional verbs and their intensional readings, see Moltmann (1997).

b. Declarative with indefinite object noun phrase

那个/	男生/	想要/	求/	人/	解决/	问题。
Nàgè	nánshēng	xiǎngyào	qiú	rén	jiějué	wèntí.
that.CL	boy	want	ask	person	solve	problem

'The boy wants to ask someone to solve the problem.'

These 24 sets of stimuli were distributed into 2 lists in a Latin Square design and each list consists of 24 sentences. In addition, 72 filler items with 36 declaratives and 36 questions were used to prevent participants from developing test-taking strategies. Each participant therefore read 96 sentences in total.

5.2.3.3 Data analysis and results

All the 36 participants' data were included in the analysis.

5.2.3.3.1 Comprehension task results

The overall accuracy including fillers was 96.3%. Per condition, the accuracy was 97.6% for the simplex *wh*-questions and 97.9% for the declaratives. Again, the high accuracy rate demonstrated that participants were attentive in reading.

5.2.3.3.2 Results

Figure 2 presents the mean log RTs per region across the two conditions in (6a) and (6b). As we can see, simplex *wh*-questions were processed more slowly than their declarative counterparts immediately after the *wh*-phrase.

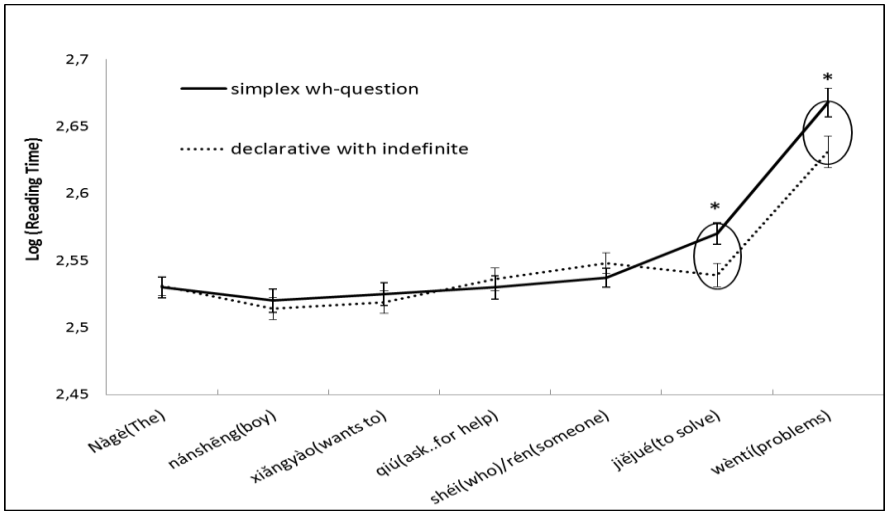


Figure 2. Mean log RTs per region with standard errors

A linear mixed effects model revealed a significant difference at the verb region immediately following the *wh*-word and at the final noun. In-situ questions with a simplex *wh*-phrase were processed with a significantly longer reading time than indefinite declarative conditions at the verb region (*jiějué* 'to solve') (β = 0.031, p < 0.01) and the sentence final noun region (*wèntí* 'problems'), (β = 0.037, p < 0.01). See Table 2 for the detailed results of the model.

Table 2. Summary of the linear mixed effects models at regions with significant reading time differences between conditions.

	Estimate β	Std. Error	t-value	p-value
verb (*jiějué*)	0.031	0.010	3.190	< 0.01
noun (*wèntí*)	0.037	0.012	3.104	< 0.01

In summary, by utilizing the new stimuli, we ruled out the definite interpretation of *rén*, restricting it to the indefinite interpretation ('someone'). And after addressing issues of the definiteness of noun phrases and the clause-final wrap-up issues we introduced in section 5.1, we found that at the region after the *wh*-word, simplex questions are processed significantly more slowly than declaratives containing indefinites. This points to a higher processing cost in *wh*-questions, which provides evidence for the establishment of a covert dependency in processing Mandarin *wh*-in-situ questions, in the case of simplex *wh*-questions. As mentioned in section 5.1, to obtain a comprehensive and a new perspective in understanding *wh*-questions with complex *wh*-phrases, in Experiment 3 we tested complex *wh*-questions using similar stimuli as in Experiment 2, which do not contain the perfective marker *le*.

5.2.4 Experiment 3: Processing complex *wh*-questions with new stimuli

5.2.4.1 Participants

54 native speakers of Mandarin Chinese (23 males, $\bar{x}$ age = 27) participated in this experiment. The participants came from the northern part of Mainland China and at that time were MA and PhD students studying at Leiden University, the Netherlands.[28] Participants were reimbursed for their participation and provided written informed consent prior to beginning the experiment.

5.2.4.2 Materials and design

The current experiment consisted of the same stimuli as that in Experiment 2, except for the *wh*-word region. In this experiment, we compared in-situ *wh*-questions with *wh*-phrases such as *nǎgè tóngxué* 'which classmate' in (7a), with declaratives that contained indefinite noun phrases such as *yígè tóngxué* 'a classmate' in (7b). Crucially, intensional verbs are used, and there is no bounded context. See Appendix E for the specific list of materials we used in the experiment.

[28] The students participating in our experiment had not been in the Netherlands for more than 3 years by the time of testing.

(7) a. In-situ question with a complex phrase

那个/	男生/	想要/	求/	哪个/	同学/	解决/	问题?
Nàgè	nánshēng	xiǎngyào	qiú	nǎgè	tóngxué	jiějué	wèntí?
that.CL	boy	want	ask	which	classmate	solve	problem

'Which classmate does the boy want to ask to solve the problem?'

b. Declarative with indefinite object noun phrase

那个/	男生/	想要/	求/	一个/	同学/	解决/	问题。
Nàgè	nánshēng	xiǎngyào	qiú	yígè	tóngxué	jiějué	wèntí.
that.CL	boy	want	ask	a	classmate	solve	problem

'The boy wants to ask a classmate to solve the problem.'

These 24 sets of stimuli were distributed into 2 lists in a Latin Square design and each list consisted of 24 sentences. In addition, the same 72 filler items as in Experiment 2 were used to prevent participants from developing test-taking strategies. Each participant therefore read 96 sentences in total.

5.2.4.3 Data analysis and results

All the 54 participants' data were included in the analysis.

5.2.4.3.1 Comprehension task results

The overall accuracy including fillers was 95.4%. Per condition, the accuracy was 94.2% for the complex *wh*-questions and 97.5% for the declaratives containing indefinites. The high accuracy rate showed that participants were attentive in reading.

5.2.4.3.2 Results

Figure 3 presents the mean log RTs per region across the two conditions. As shown, complex *wh*-questions were processed more slowly than declarative counterparts starting right at the determiner of the *wh*-phrase *nǎgè* 'which'.

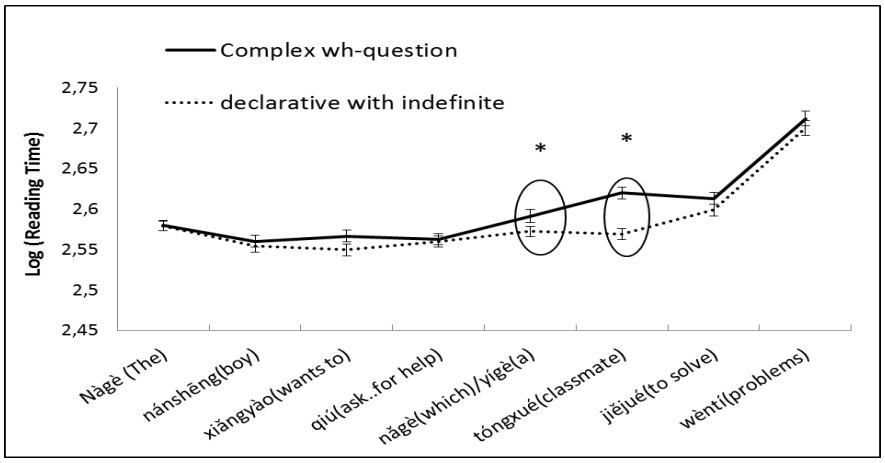


Figure 3. Mean log RTs per region with standard errors

A linear mixed model revealed a significant difference of the reading time at the region of the determiner (*nǎgè* 'which', *yígè* 'a'), where the in-situ questions with a complex *wh*-phrase were processed significantly more slowly than the indefinite declaratives ($\beta = 0.019$, $p < 0.05$). At the region of the noun (*tóngxué* 'classmate') immediately following the determiner, the results showed that in-situ questions were also processed significantly more slowly than declarative conditions ($\beta = 0.051$, $p < 0.001$). See Table 3 for the detailed results of the model.

Table 3. Summary of the linear mixed effects models at regions with significant reading time differences between conditions.

	Estimate β	Std. Error	t-value	p-value
nǎgè/yígè	0.019	0.008	2.434	< 0.05
noun (*tóngxué*)	0.051	0.008	6.530	< 0.001

To sum up, in the processing of complex *wh*-questions, we again found that *wh*-questions are processed with a significantly longer reading time than their declarative counterparts, consistent with our findings in the simplex *wh*-questions (Experiment 2). The results are also consistent with the findings in Xiang et al. (2013) that complex *wh*-questions are processed with more cost than declaratives, despite of the fact that our declaratives contain indefinites/indefinite noun phrase as the counterpart of *wh*-phrases.

5.3 Discussion and conclusion

The main focus of this chapter was to investigate whether processing Mandarin *wh*-in-situ questions in isolation incurs more processing cost than that in declaratives, by testing how Mandarin speakers process simplex and complex *wh*-questions with respect to their indefinite declarative counterparts. By designing new stimuli that eliminated the interpretation ambiguity of the indefinites, our studies on both

simplex and complex *wh*-questions reveal that in-situ *wh*-questions in Mandarin are processed with a longer time, suggesting a higher processing cost than their indefinite declarative counterparts.

The additional processing time/cost in *wh*-questions as opposed to declaratives provides evidence for the parser's establishing of a covert dependency between *wh*-words and the interrogative operator (Q) at a higher position in the clause. To be specific, when an in-situ *wh*-word is encountered during processing and when no other licensors can potentially license the *wh*-word, a covert dependency between the interrogative operator (Q) and the *wh*-word is established and the sentence is unambiguously a *wh*-question. Contrasting with question-words, indefinites like 'a classmate' or 'someone' in declaratives as in 'ask a classmate/someone' are locally selected by the verb and hence incur less processing cost than *wh*-questions.

In addition to the empirical evidence of the extra processing cost in *wh*-questions, we notice that the processing delay in complex questions and simplex questions as compared with their declarative counterparts starts at different regions. In particular, in the simplex ones, the processing delay starts immediately after the *wh*-word *shéi* 'who', covering two regions thereafter, whereas in the complex ones, the processing delay starts right at the *wh*-determiner, covering the two regions of the *wh*-phrase. In other words, the slowdown in processing complex *wh*-questions as compared with declaratives starts earlier than that in simplex questions.

For the different slowdown patterns observed between complex and simplex *wh*-questions, we assume that it is due to the fact that complex *wh*-phrase ('which x') involves discourse-linking, incurring extra processing cost. Complex *wh*-phrase (e.g. 'which classmate') is infelicitous when no set (of classmates) is pre-established in the discourse context whereas a simplex *wh*-word ('who') can be used without any existing contexts. Note that in our study, no previous context is provided to the participants. Hence, the additional processing cost in complex *wh*-questions because of discourse-linking can account for the slowdown timing differences between complex and simplex *wh*-questions when compared to their indefinite declarative counterparts.

To conclude, by comparing in-situ *wh*-questions containing simplex *wh*-phrases ('who') with declaratives containing indefinites ('someone'), we excluded other confounding factors such as definiteness and discourse-linking and scrutinized the processing evidence of establishing a covert dependency online between the in-situ question word and the interrogative operator at Spec-CP or C^o, supporting the theoretical account that the *wh*-word is licensed by the interrogative operator (Q) at Spec-CP or C^o, and obtains the interrogative quantificational force. In addition to the evidence of establishing a covert dependency in *wh*-questions, our studies also show that complex *wh*-questions are processed differently from simplex questions due to the discourse-linking of the former.