Prosodic and syntactic focus in speech processing in Mandarin Chinese

By

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Abstract

It is well established that focus plays an important role in facilitating language processing, i.e., focused words are recognised faster and remembered better. In addition, more recent research shows that alternatives to a word (e.g., *sailor* as an alternative to *captain*) are more activated when listeners hear the word with contrastive prominence (e.g., 'The **captain** put on the raincoat) (bold indicates contrastive prominence). The mechanism behind these processing advantages is focus. Focus has two broad conceptions in relation to its effect on language processing: focus as updating the common ground and focus as indicating alternatives. Considerable psycholinguistic evidence has been obtained for processing advantages consistent with the first conception, and this evidence comes from studies across a reasonably wide range of languages. But the evidence for the second conception only comes from a handful of closely related languages (i.e., English, Dutch and German). Further, it has largely been confined to contrastive accenting as a marker of focus. Therefore, it is not clear if other types of focus marking (e.g., clefts) have similar processing effects. It is also not known if all this is true in Mandarin, as there is very little research in these areas in Mandarin. Mandarin uses pitch expansion to mark contrastive prominence, rather than the pitch accenting found in Germanic languages. Therefore, the investigation of Mandarin expands our knowledge of these speech processing effects to a different language and language family. It also expands our knowledge of the relative roles of prosody and syntax in marking focus and in speech processing in Mandarin, and in general.

This thesis tested how different types of focus marking affect the perception of focus and two aspects of language processing related to focus: the *encoding* and *activation* of discourse information (focused words and focus alternatives). The aim was to see whether there is a link between the relative importance of prosodic and syntactic focus marking in Mandarin and their effectiveness in these aspects of language processing. For focus perception, contrastive prominence and clefting have been claimed to mark focus in Mandarin, but it has not been well tested whether listeners perceive them as focus marking. For the first aspect of processing, it is not yet clear what cues listeners use to encode focused information beyond prominence when processing a discourse. For the second aspect, there has been rapidly growing interest in the role of alternatives in language processing, but little is known regarding the effect of clefting. In addition, it is not clear whether the prosodic and syntactic cues are equally effective, and again little research has been devoted to Mandarin. Therefore, the following experiments were conducted to look at these cues in Mandarin.

Experiment 1, a norming study, was conducted to help select stimuli for the following Experiments 2, 3, 4A and 4B. **Experiment 2** investigated the relative weights of prosodic and

syntactic focus cues in a question-answer appropriateness rating task. The findings show that in canonical word order sentences, the focus was perceived to be on the word that was marked by contrastive prominence. In clefts where the prominence and syntactic cues were on the same word, that word was perceived as being in focus. However, in 'mismatch' cases, e.g., 是[船长]F 穿上的[雨衣]F 'It was the [captain]F who put on the [**raincoat**]F' (F indicates focus), the focus was perceived to be on *raincoat*, the word that had contrastive prominence. In other words, participants weighted prosodic cues more highly. This suggests that prosodic prominence is a stronger focus cue than syntax in Mandarin.

Experiment 3 looked at the role of prosodic and syntactic cues in listeners' encoding of discourse information in a speeded 'false alternative' rejection task. This experiment shows that false alternatives to a word in a sentence (e.g., *sailor* to *captain* in 'The captain put on the raincoat') were more easily rejected if *captain* was marked with prosodic cues than with syntactic cues. This experiment shows congruent results to those of **Experiment 2**, in that prosodic cues were more effective than syntactic cues in encoding discourse information. It seems that a more important marker of focus provides more effective encoding of discourse information.

Experiments 4A and 4B investigated the role of prosodic and syntactic focus cues in the activation of discourse information in Mandarin, using the cross-modal lexical priming paradigm. Both studies consistently show that prosodic focus marking, but not syntactic focus marking, facilitates the activation of identical targets (e.g., *captain* after hearing 'The captain put on the raincoat'). Similarly, prosodic focus marking, but not syntactic focus marking, primes alternatives (e.g., *sailor*). But focus marking does not prime noncontrastive associates (e.g., *deck*). These findings, together with previous findings on focus particles (e.g., *only*), suggest that alternative priming is particularly related to contrastive prominence, at least in languages looked at to date. The relative priming effects of prosodic and syntactic focus cues in **Experiments 4A and 4B** are in line with their relative weights in **Experiments 2 and 3**.

This thesis presents a crucial link between the relative weights of prosodic and syntactic cues in marking focus, their degrees of effectiveness in encoding discourse information and their ability to activate discourse information in Mandarin. This research contributes significantly to our cross-linguistic understanding of prosodic and syntactic focus in speech processing, showing the processing advantages of focus may be common across languages, but what cues trigger the effects differ by language.

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List of Abbreviations

Abbreviation	Full form
AIC	Akaike information criterion
ANOVA	Analysis of variance
APA	American Psychological Association
ASP	Aspect marker
CET	College English Test
COP	Copula (e.g., 是 'SHI')
CL	Classifier
CLMM	Cumulative link mixed model
F0	Fundamental frequency
GLMER	Generalized linear mixed effects regression
Hz	Hertz
IS	Information structure
IELTS	International English Language Testing System
ISI	Interstimulus interval
LMER	Linear mixed effects regression
O	Object
OQ	Object question
PRF	Perfective aspect
PST	Past tense
QUD	Question-under-discussion
RT	Reaction time
RQ	Research question
SD	Standard deviation
SOA	Stimulus onset asynchrony
S	Subject
SQ	Subject question
T0	The neutral tone
T1	Tone 1
T2	Tone 2
T3	Tone 3
T4	Tone 4
V	Verb
3SG	Third-person singular

Chapter 1 Introduction

1.1 What is this thesis about?

In conversation, successful communication is not simply about understanding the words that speakers say, but also the way they say them. The semantic interpretation of spoken versions of the sentences (1) and (2) below cannot be correctly understood without considering prosody (bold indicates contrastive prominence).

    (1) The **captain** put on the raincoat.
    (2) The captain put on the **raincoat**.

The key difference between the two examples is which information the speaker is updating and which is presupposed. The information being updated is also what the speaker implies alternatives to in the two examples. In (1), contrastive prominence on *captain* indicates that the word conveys information that updates an explicit or implicit 'question-under-discussion' (QUD) like 'Who put on the raincoat?' (Roberts, 1996). It also implies that someone else, such as *the sailor*, could have put on the raincoat, even if no-one else has been mentioned. In (2), however, contrastive prominence on *raincoat* indicates that the word conveys information that updates an explicit or implicit QUD like 'What did the captain put on?'. It also implies that *the captain* could have put on something else, such as *the jacket*, even if *jacket* has not been mentioned. As we shall see in section 2.1.1, these two types of difference in the interpretation of semantics of (1) and (2) come from two aspects of focus, i.e., focus as updating the common ground (QUD-focus) (Roberts, 1996; Vallduví, 2016) and focus as indicating alternatives (contrastive focus) (Krifka, 2008; Rooth, 1985, 1992).

To achieve successful communication, listeners must be able to accurately identify the focus and understand what QUDs they answer, and also infer alternatives to the focused word intended by speakers, even when these alternatives are not overtly available in the context. Studies show that listeners attend to focused words more, and infer alternatives to them (e.g., Akker & Cutler, 2003; Birch & Garnsey, 1995; Braun & Biezma, 2019; Braun & Tagliapietra, 2010; Cutler, 1976; Cutler & Fodor, 1979; Gotzner, 2017; Husband & Ferreira, 2016; Ip, 2019; Ip & Cutler, 2017). The main aim of this thesis is to link these functions of focus, established in the theoretical literature, to processing effects, using psycholinguistic

methods. A considerable amount of psycholinguistic evidence has shown that focused words are recognised faster and remembered better (English: Akker & Cutler, 2003; Birch, Albrecht, & Myers, 2000; Birch & Garnsey, 1995; Cutler, 1976; Cutler, Dahan, & van Donselaar, 1997; Cutler & Fodor, 1979; Kember, Choi, & Yu, 2016; Mandarin: Ip, 2019; Ip & Cutler, 2017; Korean: Kember, Choi, & Cutler, 2016; Kember, Choi, Yu, & Cutler, 2019). This has been found to be the case for a reasonably wide range of languages (e.g., English, Mandarin and Korean). Recently there has also been a rapid increase in psycholinguistic evidence for the role of focus in indicating alternatives (e.g., Braun, Asano, & Dehé, 2019; Braun & Biezma, 2019; Braun & Tagliapietra, 2010; Gotzner, 2017; Gotzner, Wartenburger, & Spalek, 2016; Husband & Ferreira, 2016), but this evidence only comes from a handful of closely related languages (i.e., English, Dutch and German). Further, this evidence has largely been confined to contrastive accenting as the marker of focus.

Across languages, focus can also be marked by a number of other linguistic means, e.g. by certain syntactic constructions such as clefts, as well as by morphological markers (see Chapters 31- 40 in Féry & Ishihara, 2016 for different ways of focus marking in a wide range of languages; Vallduví & Engdahl, 1996; Zimmermann & Onea, 2011). It is not clear if other types of focus marking (e.g., clefts) have similar processing effects. While some work has shown that clefting improves long-term memory for focused words (Birch et al., 2000; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019), little has been conducted on the role of clefting in more immediate processing.

Further, there is very little research in these areas in Mandarin Chinese (hereafter Mandarin). Mandarin can use both prosodic prominence and clefting to mark focus, as we shall see in section 2.1.2. However, whether listeners perceive them as focus marking is not clear, let alone the relative roles of prosodic and syntactic cues in perceiving focus and in processing speech. Mandarin is interesting to investigate, as unlike pitch accenting in Germanic languages, Mandarin uses pitch expansion to mark prosodic focus (e.g., Chen, Lee, & Pan, 2016; Xu, 1999). In addition, Mandarin seems to use prosodic and syntactic cues differently from each other – the primary cue being prosodic (Chen, Chen, & He, 2012), but this has not been well established as Chen, Chen, and He (2012) only used a verification task (see section 2.3.1) and the syntactic structure investigated was 是 'SHI'.

This thesis reports on a series of psycholinguistic experiments carried out in Mandarin to investigate the relative roles of prosodic and syntactic cues in the perception of focus and speech processing. This thesis tests two aspects of speech processing, i.e., the activation and encoding of discourse information. These two aspects tap into different levels of language processing: the activation of the lexical representations that stand for discourse referents, and the encoding of these discourse referents in discourse representation. In the course of speech processing, various words are activated. The first level, the activation of discourse referents, relates to the word-level lexical representation of discourse entities. For example, upon hearing 'The **captain** put on the raincoat', the lexical representation of *captain* is activated more strongly than after hearing 'The captain put on the **raincoat**'. The second level of language processing considered in this thesis, the encoding of discourse referents, relates to the discourse-level representation of these referents within the proposition conveyed by the entire utterance. For example, 'The **captain** put on the raincoat' encodes *captain* better in relation to 'WHO put on the raincoat', as opposed to the encoding of *raincoat* in relation to 'captain put on WHAT' if *raincoat* is focus-marked in 'The captain put on the **raincoat**'.

The greater activation and better encoding of focused words mentioned above result from one of the expected effects of QUD-focus on language processing, which is to enhance the salience of focused words, as has been indicated above and will be discussed further in section 2.3. One of the expected effects of contrastive focus on language processing is to enhance the salience of alternatives to the focused word. Following from this, alternatives should also be more strongly activated given focus marking, and they should be encoded better as part of discourse representation, so false alternatives should be more easily rejected (Fraundorf, Benjamin, & Watson, 2013; Fraundorf, Watson, & Benjamin, 2010).

More importantly, this thesis also investigates whether there is a link between the three above-mentioned components: the relative weights of prosodic and syntactic cues in perceiving focus, the effectiveness of these cues in helping listeners encode discourse information and the relative roles that these cues play in activating discourse information. This is referred to as the three components of the *focus marking-language processing* link from now on. Does a more important marker of focus provide more effective encoding and stronger activation of discourse information?

By investigating prosodic prominence, the research presented in this thesis builds on previous research by showing that pitch range expansion (in Mandarin) is as effective as pitch accenting (e.g., in Germanic languages) in marking focus and facilitating language processing. This also shows the cross-linguistic importance of prosodic prominence in language processing. By investigating clefting, the research in this thesis contributes to our understanding of whether and how other linguistic mechanisms, e.g. clefting, aid focus perception and speech processing. By investigating two different kinds of focus marking at the same time, this thesis is able to compare the relative roles of different kinds of focus marking. By comparing the results from this thesis with evidence found in other languages (e.g., syntactic cues were found to be more effective than prosodic cues in Korean, but they were equally effective in English, see Kember et al., 2019), this thesis sheds light on our cross-linguistic understanding of prosodic and syntactic focus in speech processing. This shows that the processing advantages of focus may be common across languages, but that the cues which trigger the effects differ by language. The effectiveness of the cues in speech processing may be linked to their importance in marking focus in that language.

1.2 The organisation of this thesis

The thesis has eight chapters. Chapter 2 presents an overview of the literature that forms the background to the research in this thesis. It defines focus and describes how focus is marked with prosodic and syntactic cues in Mandarin. It looks into how focus marking affects focus perception, and then turns to the effects of focus on language processing. At the end of Chapter 2, I identify open questions in the current literature, which led to the research questions described in Chapter 3.

In addition to stating the research questions, Chapter 3 offers a brief introduction to the statistical models and model selection procedures that were used to analyse the data from the research conducted in this thesis. It contains detailed explanations of motivations and justifications for the choice of different models.

The overarching goal of this thesis is to investigate the three components of the link between two types of focus marking (prosodic and syntactic) and their effects on focus perception and language processing (Chapters 5-7). Since two lexical priming tasks in Chapter 7 needed association norms and there were no association norms available for Mandarin, Experiment 1, which is reported in Chapter 4, was conducted to select experimental materials for the

subsequent experiments. This experiment was a relatedness rating task, which was used to provide information on semantic relatedness between prime words and visual targets used in the priming experiments. Experiment 1 also highlighted the importance of accounting for the context in which a prime occurs when collecting the relatedness scores between primes and targets, as the results showed that context may reduce the differences in relatedness scores between the prime word (subject noun) and its noncontrastive associate. By implication, other psycholinguistic studies investigating lexical priming (in and out of sentence contexts) in Mandarin should assess the relatedness of primes and targets in and out of the sentence contexts in which the primes will occur.

Chapter 5 describes Experiment 2, a question-answer appropriateness rating task, which investigated the first component of the *focus marking – language processing* link, i.e. the relative importance of prosodic and syntactic cues in focus perception. It is based on the definition of QUD-focus that focus marking updates an implicit or explicit QUD. The results from Experiment 2 showed that prosodic focus cues were more important in focus perception in Mandarin than syntactic cues, as prosodic focus cues were consistently privileged over syntactic cues by listeners. This experiment laid the foundation for the subsequent experiments on focus processing, as it enabled us to see whether the relative weights of prosodic and syntactic cues in marking focus predict the relative effects of these cues in language processing.

Chapter 6 describes Experiment 3, a speeded 'false alternative' rejection task, which investigated the second component of the *focus marking – language processing* link, i.e. the relative effects of prosodic and syntactic focus cues in listeners' encoding of discourse information. This experiment is based on both QUD-focus and contrastive focus. Following QUD-focus, focus enhances the salience of focused words in the discourse, so as opposed to presupposed information in the discourse, focused information is encoded better. Therefore, false alternatives to the focused word should be easier to detect than false alternatives to the presupposed material. Following contrastive focus, focus enhances the salience of focus alternatives in relation to the discourse, therefore focus alternatives are encoded better. It was found in Experiment 3 that syntactic focus cues were not as effective as prosodic focus cues for listeners' encoding of discourse information, reflected in the finding that false alternatives to the focused word were rejected faster when the word was marked with prosodic cues compared to when the word was marked with syntactic cues. This result is broadly consistent

with the relative weights of the two types of focus marking in focus perception as shown in Experiment 2. This shows that different forms of focus marking are not equally effective in encoding discourse information, and that the stronger marker of focus provides more effective encoding.

Chapter 7 presents two cross-modal lexical decision tasks (Experiments 4A and 4B), which investigated the third component of the *focus marking – language processing* link, i.e. the relative roles of prosodic and syntactic focus cues in the activation of discourse information. Experiment 3 is based on both QUD-focus and contrastive focus, which have processing consequences that focused words and focus alternatives should be more activated in listeners' mental lexicon, which should be reflected in faster lexical retrieval times. Experiments 4A and 4B showed that prosodic focus marking was more effective than syntactic focus marking in activating both the focused words and their contrastive alternatives (as measured by relative priming effects), probably due to the extra processing cost required by clefts. These results are consistent with the findings from Experiments 2 and 3 that prosodic focus marking plays a more important role in focus perception and in the encoding of discourse information. This suggests that the processing advantages of focus, including priming alternatives, might be particularly related to prosodic prominence in Mandarin.

Finally, Chapter 8 concludes the whole thesis by summarising the findings of the psycholinguistic experiments. In general, this thesis shows that prosodic focus marking is a more important cue than syntactic focus in perceiving focus, and in the encoding and activation of discourse information in Mandarin. Reasons why this might be, and whether this is true across all languages, are discussed. Chapter 8 then goes on to discuss the results in relation to the significance and relevance of this thesis to the field on the nature of focus and its relationship to speech processing. Chapter 8 also addresses the general implications of this thesis and possible avenues for future research.

Chapter 2 Literature review

This chapter presents an overview of the theoretical and empirical background that underpins the current research. Section 2.1 defines the concepts that are key to this research, including focus and the means of marking it. Section 2.2 focuses on the empirical research findings concerning the role of prosodic and syntactic cues in the perception of focus. Section 2.3, which is also the core interest of this thesis, provides a comprehensive review of studies on the effects of focus on language processing. Section 2.4 ends this chapter with a brief summary and with the identification of key open questions.

2.1 Focus and focus marking

2.1.1 Information structure and focus

Information structure (IS) describes the way in which information is packaged in a discourse to serve the purpose of communication (Chafe, 1976; Féry & Krifka, 2008; Krifka, 2008). Common ground forms the background of a discourse, i.e. the information (propositions) which interlocutors believe that they share (Stalnaker, 1974). This is continuously modified as the discourse proceeds. Each utterance has an information structure, which marks how the different parts of the utterance refer to and/or update the common ground.

Focus is a key notion of IS. It has received much attention in research on IS (e.g., Birch & Garnsey, 1995; Calhoun, 2015; Calhoun, Wollum, & Kruse-Va'ai, 2019; É Kiss, 1998; Kember et al., 2019; Rooth, 1985; Xu, 1999). However, focus lacks uniformity in its description, with researchers using different, but related definitions. Different terms such as 'prominent', 'the most important' or 'new' are often encountered in the literature in explanations of the notion of focus. In addition, the same term is encountered with different interpretations – for example, the term 'new information' has been used in many different senses: an information that is not recoverable from the preceding discourse instead of not being previously mentioned (Halliday, 1967), or that cannot be presupposed in the context (Chomsky, 1971), or that is not shared by speaker and addressee (Jackendoff, 1972).

Regardless of difficulties defining focus, two existing notions of focus are widely accepted in the current literature. One is that focus is the part of the utterance which updates the common ground, or is new in relation to an implicit or explicit question-under-discussion (hereafter

QUD) presupposed in the preceding discourse (Ginzburg, 1994; Roberts, 1996, 1998; Vallduví, 2016). For example, *the raincoat* is the focus in (5) (where […]$_F$ shows the focus), which answers an implicit or explicit QUD like (3) in the preceding discourse. The focus does not necessarily have to be newly introduced information, since *the raincoat* in (5) is still the focus when (5) is preceded by (4) which has an explicit mention of *the raincoat*. But *the raincoat* is new in relation to the QUD in (4). In (5), what the captain put on is the topic, which is the part presupposed in the common ground, or contained in the question like (3) or (4).

    (3) What did the captain put on?

    (4) What did the captain put on, raincoat or jacket?

    (5) [The captain put on]$_{Topic}$ [the raincoat]$_F$[1].

The use of focus to update the common ground or the information that is new to the current QUD will be called *QUD-focus* throughout the current thesis. Another widely held definition of focus involves contrastive alternatives. Starting from the perspective of alternative semantics (Rooth, 1985, 1992), Krifka (2008, p. 247) defines focus as indicating 'the presence of alternatives that are relevant for the interpretation of linguistic expressions'. This alternative semantic definition is illustrated in (6), where *x* is a set of alternatives (e.g., *the jacket*) that could substitute the focused element *the raincoat* in the sentence. When the subject is focused, as in (7), *y* is a set of alternatives (e.g., *the sailor)* that could substitute *the captain* in the sentence. This definition will be called *contrastive focus* throughout this thesis.

    (6) The captain put on [the raincoat]$_F$.

        put on(the captain, x) | x ∈ *E*, where *E* is the domain of items that can be put on.

    (7) [The captain]$_F$ put on the raincoat.

        put on(y, the raincoat) | y ∈ *E*, where *E* is the domain of individuals.

According to this focus theory in alternative semantics, focus triggers a set of alternatives for the focused element in the proposition (Krifka, 2008; Rooth, 1985, 1992). Therefore, noncontrastive associates, i.e. words that are semantically associated with the focused word but cannot replace it in the sentence, are not in the alternative set (Krifka, 2008; Rooth, 1985,

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[1] This is an English translation of one of the stimuli used in all the experiments reported in this thesis (see Appendix 9).

1992). This would include, for instance, *wet* as a noncontrastive associate to *raincoat* in (6), and *deck* as a noncontrastive associate to *captain* in (7).

Both mentioned and unmentioned alternatives to focused words are part of the alternative set, i.e. even when there is no mention of *sailor* in the preceding discourse, *sailor* could still be considered as part of the alternative set to the focus *captain* in (7). Rooth (1992) holds a permissive view that the set of alternatives may contain different sorts of possible replacements for a focused expression, including both related and unrelated alternatives (see a restrictive view proposed by Wagner, 2006, 2012). Unrelated alternatives are those that are unrelated to the focused word, e.g. *doctor* (*captain* and *sailor* are semantically related, but *doctor* and *captain* are not). Such unrelated alternatives have been experimentally shown to be part of the alternative set considered by listeners (see also a discussion of what is included in the alternative set in Chapter 5, Gotzner, 2017). As we will see in section 2.3, psycholinguistic studies have increasingly been looking at whether various types of alternatives (e.g., mentioned, unmentioned, related, unrelated) are part of the alternative set.

It is important to note here that no agreement has been reached as to whether these two types of focus (QUD focus and contrastive focus) are separate, or can be merged into one (see e.g., Krifka, 2008; Roberts, 1996, 1998; Rooth, 1992). Rooth (1992) and Krifka (2008) analysed both types of focus from an alternative semantic point of view, i.e. based on a contrast among members of an alternative set which includes the focused word. For example, the focus *the raincoat* in (6) indicates the presence of a set of alternatives, e.g. *the jacket*, no matter whether *jacket* has been previously mentioned in the discourse. As noted by Roberts (1996), in many cases a contrastive focus is also a QUD-focus. For example, in (8), the contrastive focus *the raincoat*, which contrasts with *the jacket*, answers an implicit or explicit QUD 'What did the captain put on?' presupposed in the preceding discourse.

(8) The captain put on [the raincoat]$_F$, not [the jacket]$_F$.

As we can see above, the two definitions do not identify mutually exclusive elements. Therefore, the best way to view the two kinds of focus (QUD-focus and contrastive focus), following Calhoun (2010a) and Vallduví (2016), is that these two are orthogonal to each other. We can see that *the raincoat* in (8) is the QUD-focus as well as the contrastive focus, as it answers an implicit QUD like 'What did the captain put on?', and implies a

contextually-appropriate alternative to *the raincoat*, e.g. *the jacket*. Therefore, the same constituent in a sentence can be focused by either definition. However, the two definitions express different functions of focus, and consequently different effects on language processing. In this thesis, as will be elaborated in section 2.3, the effect of QUD-focus on language processing refers to how focus affects the processing (e.g., memory, activation) of focused words, as opposed to other discourse information (see section 2.3.1), while the effect of contrastive focus on language processing refers to how focus affects the processing of alternatives to focused words (see section 2.3.2).

2.1.2 Focus marking

Across languages, focus can be signalled by a variety of means, e.g. phonological and morpho-syntactic (Féry & Ishihara, 2016; Vallduví & Engdahl, 1996; Zimmermann & Onea, 2011). Focus realisation is language-specific, which means that different languages employ different strategies for highlighting focus. Prosody looks to be most important for Mandarin and English. In this section, I first review the literature on prosodic prominence and its role in marking focus in general (primarily in English), as the research on English is relevant to understanding the effects in Mandarin. This section then addresses a few major ongoing debates in this area, before turning to how focus is marked via prosodic prominence and clefting in Mandarin.

2.1.2.1 Prosodic prominence and its role in focus marking

Prosody, and in particular prosodic prominence, plays an essential role in signalling information structure in many languages around the world (Botinis, Fourakis, & Gawronska, 1999; Breen, Fedorenko, Wagner, & Gibson, 2010; Cole, 2015; Kügler & Calhoun, to appear; Lee et al., 2015; Lee, Wang, & Liberman, 2016). The existing literature suggests two perspectives on the relationship between information structure (e.g., focus) and acoustic features of the speech signal, depending on whether there is an intermediate phonological layer: indirect-relationship approach and direct-relationship approach.

According to the indirect-relationship approach, focus is indirectly marked by phonetic cues through pitch accents (Ladd, 2008). For instance, in the Autosegmental Metrical approach, pitch accents, marked by * (such as H*, L*, bitonal pitch accents L*+H, L+H*, and H+!H*) are aligned with lexically stressed syllables. In English, focus is usually marked with an L+ H* (or contrastive/emphatic prosodic prominence) or H* (or noncontrastive/normal prosodic

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prominence) nuclear pitch accent. As shown in Figure 1 and Figure 2, *captain* in Figure 1 and *raincoat* in Figure 2 are foci, and these two focused words are both marked by L+H*. These accents are realised through the acoustic parameters, e.g. F0, duration and intensity. Since *captain* in Figure 1 and *raincoat* in Figure 2 carry (contrastive) nuclear accents, the pitch contours are realised with a steep rise in pitch on the stressed syllable of the focused word, and a reduced pitch range in the post-focal region as in Figure 1. In addition, the duration for these two words is longer than their unfocused counterparts, as indicated by the word boundaries.

Figure 1 Nuclear prominence on the subject in English (see text for details)
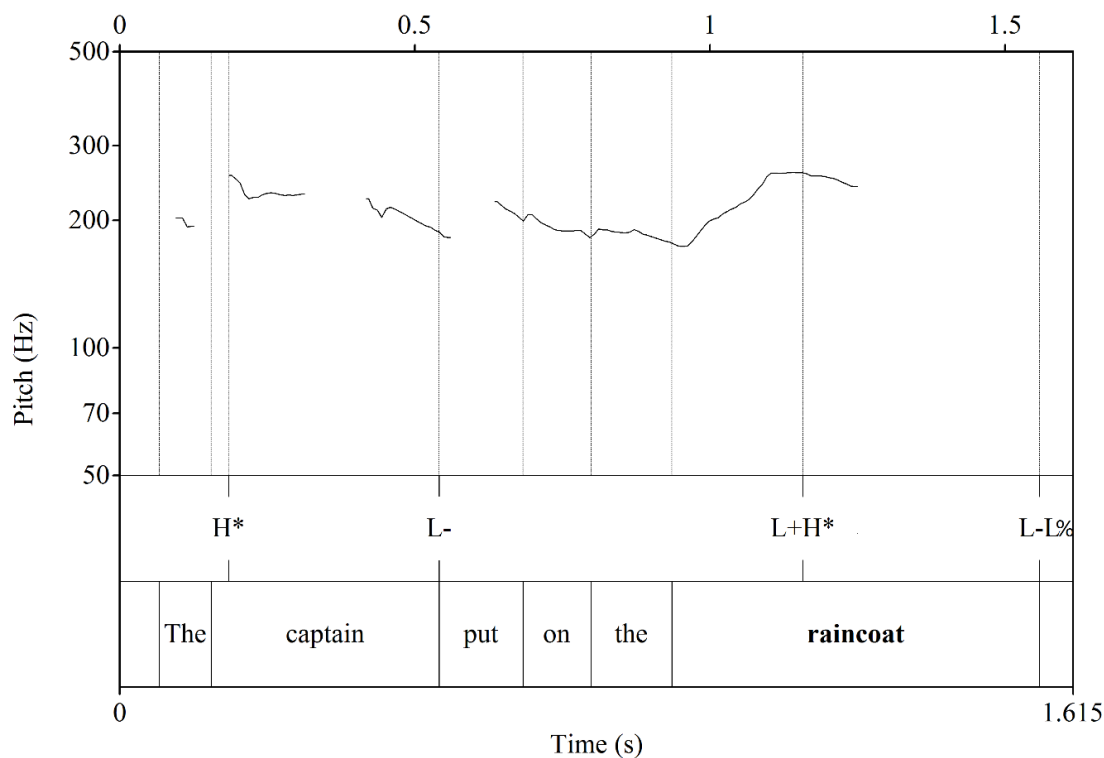
Figure 2 Nuclear prominence on the object in English (see text for details)

In many languages, such as English (and also Mandarin, see section 2.1.2.2), the phrase-final position is the default position for the nuclear prominence. As can be seen from Figure 2, when the object is contrastively accented, there is usually an accent (prenuclear accent) on the subject due to rhythmic reasons (Calhoun, 2010a). However, this does not apply to the object when the subject is contrastively accented, i.e. there can be an accent in the prenuclear region, but not in the postnuclear region (Calhoun, 2010a; Wagner, 2005). For example, as Figure 1 shows, there is no accent, or no big pitch movement, on *raincoat* when the *captain* is contrastively accented.

This prenuclear accent on the subject *captain* in Figure 2 is less prominent than the prominence on the object by virtue of position (Calhoun, 2010a), and it does not necessarily evoke contrastive focus, but it can mark focus if it is sufficiently prominent that no following nuclear accent will be expected (Calhoun, 2010a). A contrastive prominence is usually needed on the subject noun to unambiguously imply alternatives (Kügler & Gollrad, 2015).

Focus can also be marked by H*, which is normally realised with a smaller prominence than L+H*, i.e. L+H* normally has a larger F0 movement, longer duration and higher intensity.

However, the difference between H* and L+H* has long been debated. One line of studies by, e.g. Pierrehumbert and Hirschberg (1990), claimed that the two accent types (H* and L+H*) are associated with distinct categorical meanings, i.e. the H* accent signals new information (noncontrastive, QUD-focus), while the L+H* accent is associated with contrastive information (contrastive focus). Another line of studies showed that there may not be a clear distinction between the two accent types with regard to signalling contrast. For example, Watson, Tanenhaus, and Gunlogson (2008) demonstrated in their eye-tracking study that an L+H* accent leads listeners to look towards contrastive referents, whereas an H* accent leads them to consider either new or contrastive referents. This was supported by Hedberg and Sosa's (2008) corpus investigation of naturally occurring utterances. They showed a tendency for QUD-foci to be marked with the H* accent and for contrastive foci to be marked with both H* and L+ H* accents. Ladd and Schepman (2003) also suggested that the distinction between these two accents should be collapsed, arguing that in the latter case the H* can be claimed to be preceded by a separate L target. Calhoun (2010a) argued that the mapping between prosody and information structure is probabilistic, as it is affected by other linguistic and contextual factors.

There remains an ongoing debate concerning what kinds of prosodic prominence lead listeners to infer alternatives, e.g. only contrastive accents (contrastive foci and topics) (Braun et al., 2019; Braun & Biezma, 2019; Kügler & Gollrad, 2015), or increased prosodic prominence compared to what is expected in the context (e.g., Calhoun, 2009). Rooth (1992) made no distinction between different types of nuclear prominence. It is therefore assumed that any nuclear prominence is able to activate alternatives.

According to the direct-relationship approach, focus is directly signalled by phonetic cues, e.g. mainly F0, duration and intensity (Cooper, Eady, & Mueller, 1985; Eady, Cooper, Klouda, Mueller, & Lotts, 1986; Xu & Xu, 2005). The basic pattern for this approach is that the word that is the most prominent phonetically should be the focus. However, this approach is a little problematic, as it can occur that the focused word is not the most prominent element in an utterance, e.g. when the pitch accent of the focused word is downstepped (e.g., !H*). However, the downstepped pitch-accented word is still perceived as the most structurally prominent element due to listeners' implicit knowledge or expectation of the focus status (Calhoun, 2010a; Ladd, 2008). Therefore, the indirect approach, with pitch accents, or

prosodic prominence as the intermediate layer between the information structure and phonetic cues, seems to be more appropriate.

In the following, I review how focus is marked prosodically and syntactically in Mandarin. Prosody and syntax are not the only ways to signal focus in Mandarin. Mandarin also uses focus particles such as 只有 'only' (Chen et al., 2016), but they will not be addressed in this thesis.

2.1.2.2 Prosodic prominence and its role in focus marking in Mandarin

Prosodic prominence is also a key marker of focus in Mandarin (Chen & Gussenhoven, 2008; Wang & Xu, 2006, 2011; Xu, 1999). Similar to English, the rightmost position in a sentence is generally the default location for the prominent constituent in Mandarin (see e.g., Feng, 1996 and other sources referenced there; Xu, 2004). Also similar to English, prosodic focus in Mandarin is marked through prominence, i.e. expanded F0 (Chen & Gussenhoven, 2008; Ip, 2019; Wang & Xu, 2006; Xu, 1999), longer duration (Chen & Gussenhoven, 2008; Xu, 1999), and higher mean intensity (Chen, Wang, & Xu, 2009). However, prominence is not expressed as pitch accenting as in English. Rather, because Mandarin has lexical tones, prosodic prominence in Mandarin is realised through pitch register. Prominence modulates the global pitch contour, which in turn, influences the local contour of each syllable, but does not neutralize lexical tonal contrasts (Xu, 1999). How focus affects the contours of lexical tones will be presented further below, preceded by a brief introduction to Mandarin tone systems.

Mandarin has five tones: four full tones (T1, T2, T3 and T4) and one neutral tone (T0) (Duanmu, 2007; Tao, 1996). As shown in Figure 3, the first tone (T1) is a high level tone (H), the second (T2) a rising tone (LH), the third (T3) a falling-rising tone (L) and the fourth (T4) a falling tone (F or HL). Mandarin particles such as 的 'DE' and 了 'LE', which will be introduced in detail in section 2.1.2.3, normally carry the neutral tone, and the contour of the neutral tone is determined by its surrounding tones (Féry, 2016).

T1   T2   T3   T4
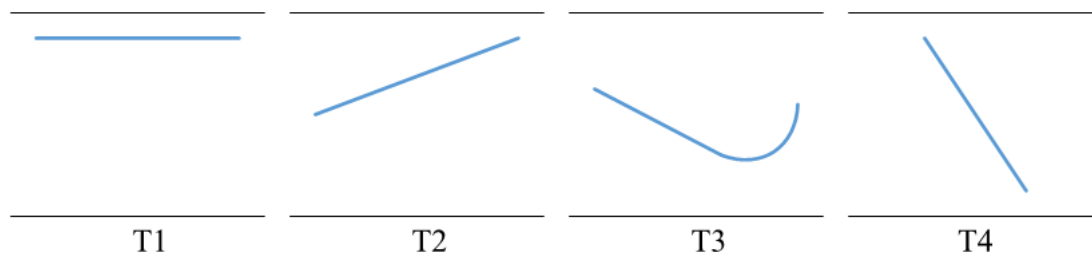
Figure 3 Beijing Mandarin lexical tones (Note that the pitch track of T3 is one of its allophonic variants)

Xu (1999) was one of the early studies that systematically investigated the effects of the interaction of lexical tones and focus on pitch contours. He used 3-word (5-syllable) sentences with different tone combinations, such as (9), in which all tones bear a high tone (marked with 1 in the second layer of the gloss). Four focus conditions were tested in his study, i.e. narrow focus on the subject (first word), e.g. *猫咪* 'kitty', narrow focus on the verb (second word), e.g. *摸* 'touch', narrow focus on the object (third word), e.g. *猫咪* 'kitty', and neutral focus/broad focus. Figure 4 demonstrates the general effects of the four focus conditions on F0 contours for (9). The different lines depict the F0 tracks under four conditions, as indicated in the figure caption.

(9) 猫咪   摸   猫咪

　　mao1mi1   mo1   mao1mi1

　　kitty   touch kitty

　　'A kitty touches a kitty.'

[subject][verb][object]

H H H H H [2]
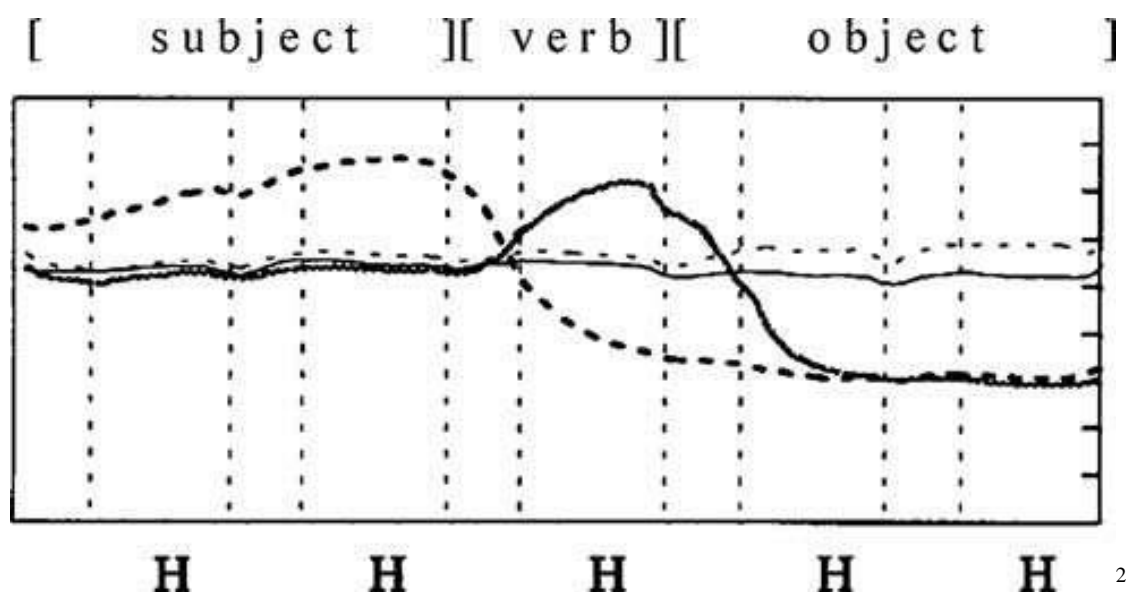
Figure 4 The effects of focus on F0 in Mandarin

(The picture is from Xu, 1999, p. 64 with the structure labels added on the top by Kabagema-Bilan, López-Jiménez, and Truckenbrodt (2011, p. 1894). Thin solid line - broad focus, thick dotted line - narrow focus on the subject, thick solid line - narrow focus on the verb and thin dotted line - narrow focus on the object.)

Xu (1999) suggested a tri-zone pitch range control as a result of the prosodic encoding of focus when the focus is non-sentence-final: on-focus pitch range expansion, post-focus pitch range compression and unaffected pre-focus pitch range, as shown in Figure 4. However, when the sentence-final object is in focus, there is nothing after the object to be lowered, which affects the implementation of on-focus expansion (Xu, 1999). As a result, the magnitude of the rise caused by focusing the object is smaller than that of non-final focused words. Xu (1999) looked closely at changes in maximum (max) and minimum (min) F0, and showed that the max F0 is raised in focused words and lowered in post-focus words, but no stable significant change is observed for the min F0. As a result of this, F0 range of on-focus words is expanded and F0 range of post-focus words is compressed. This finding has been supported by Wang and Xu (2006) and Ouyang and Kaiser (2015). Ouyang and Kaiser

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[2] Reprinted from Journal of Phonetics, 27(1), Xu, Y., Effects of tone and focus on the formation and alignment of F0 contours, 55-105, Copyright (1999), and from Lingua, 121(13), Kabagema-Bilan, E., López-Jiménez, B., & Truckenbrodt, H., Multiple focus in Mandarin Chinese, 1890-1905, Copyright (2011), with permissions from Elsevier (see Appendix 1).

(2015) further showed that both the max F0 was raised and the min F0 was lowered for corrective focus, which was generally observed with a greater prominence (larger pitch range, higher mean F0 and intensity, longer duration) compared to narrow focus as in Xu (1999).

In what follows, I show how focus affects other tone combinations using a stimulus recording that was used in the experiments in this thesis. Figure 5 shows a canonical word order sentence (10) in broad focus. Figure 6 shows the sentence with nuclear prominence on the subject. Figure 7 shows the sentence with nuclear prominence on the object.

(10)　　　船长　　　穿上　了　　雨衣。(S V O)

captain　　　put.on　PRF　raincoat

'The captain (has) put on the raincoat.'

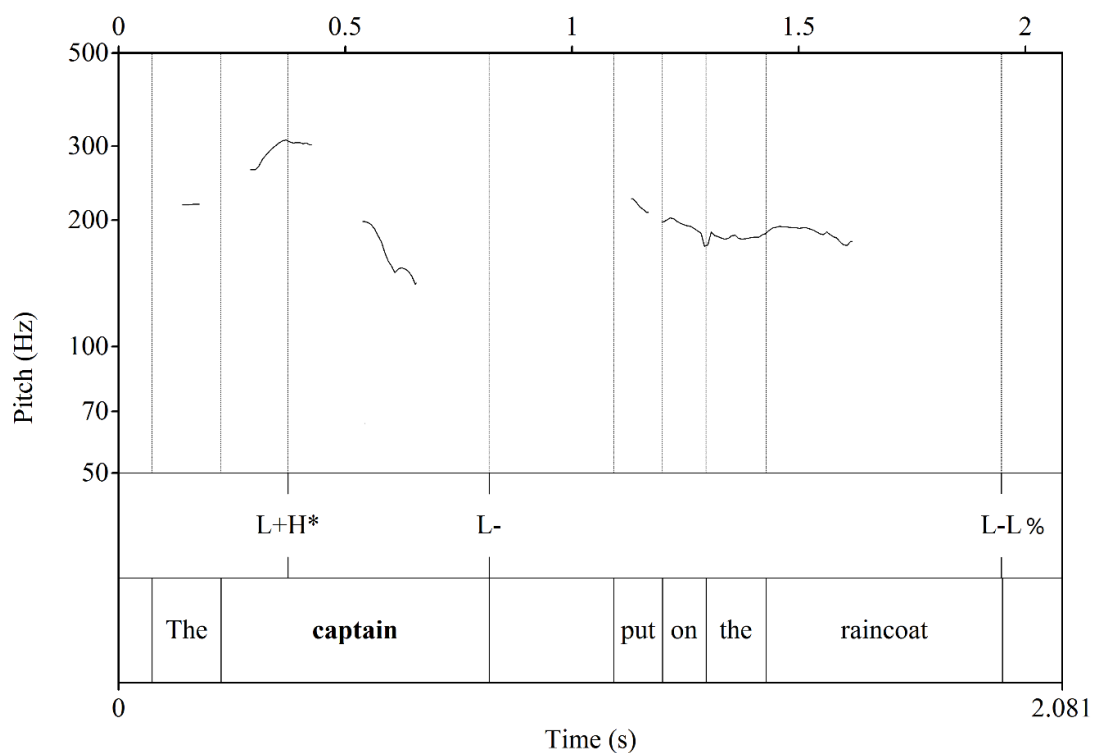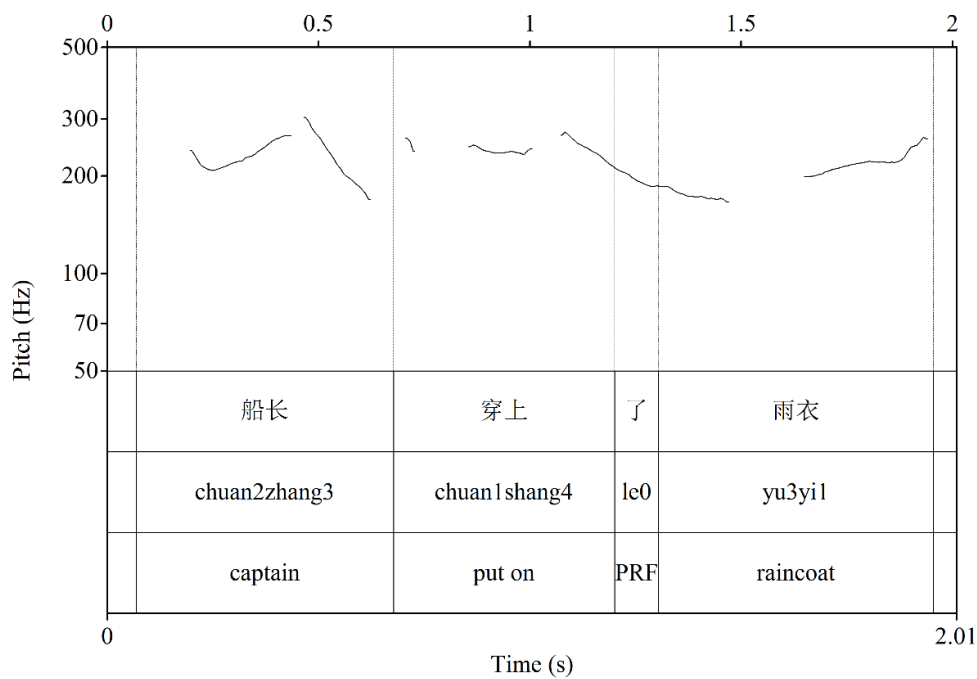**Figure 5 Broad focus condition in Mandarin (see text for details)**
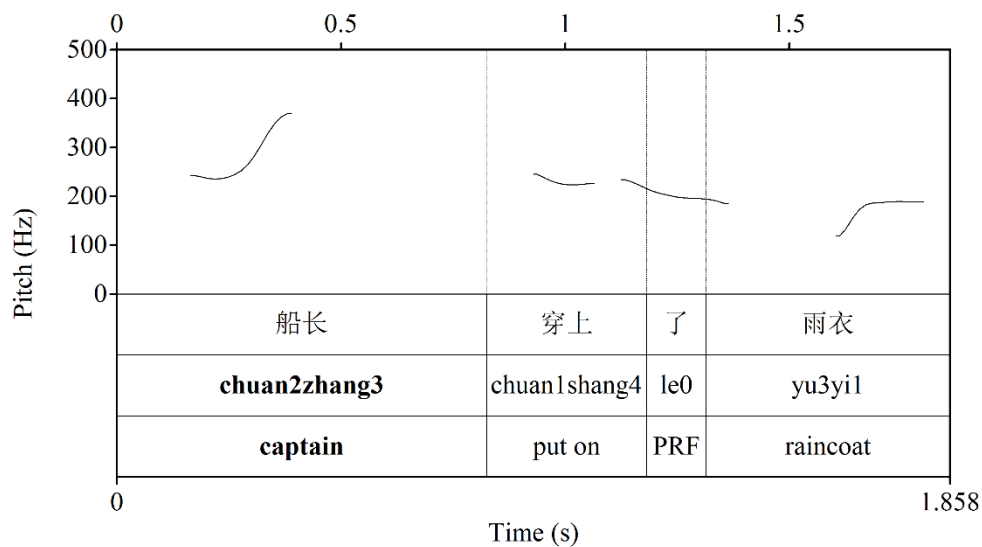
Figure 6 Nuclear prominence on the subject in Mandarin (see text for details)
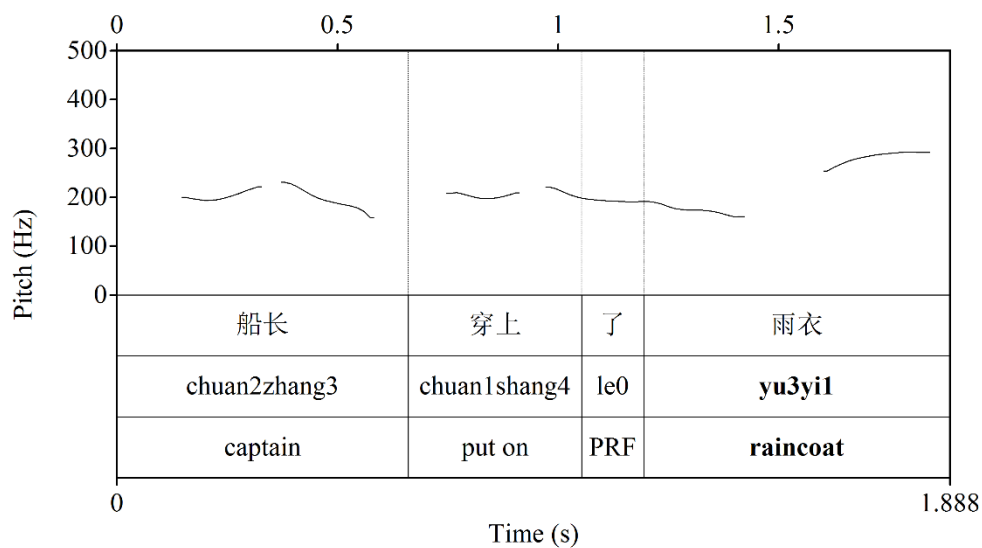
Figure 7 Nuclear prominence on the object in Mandarin (see text for details)

The nuclear prominence in Figures 6 and 7 is realised as a contrastive prominence, which is roughly equivalent to the L+H* in English as described in section 2.1.2.1. As will be discussed later in section 5.3.2, the purposes of using the contrastive prosodic prominence, rather than the noncontrastive prosodic prominence (roughly equivalent to H* in English), were that 1) I wanted stimuli to unambiguously mark prosodic focus on the subject vs. object, as in some cases the noncontrastive prosodic prominence could cause ambiguity; and 2) contrastive prosodic prominence is shown to prime alternatives, but this is not found for

noncontrastive prosodic prominence. This thesis investigates the priming effects of contrastive prominence in Mandarin, so contrastive prominence is used throughout the experiments.

As shown in Figure 6 when the subject carries the contrastive prominence, the pitch range of the subject 船长 'captain' is expanded, compared to when it does not carry the contrastive prominence, as in the broad focus condition in Figure 5. Similarly, as shown in Figure 7, when the object carries the contrastive prominence, the pitch range of the object 雨衣 'raincoat' is expanded, compared to when it does not carry the contrastive prominence in the broad focus condition as in Figure 5. In both cases, it is shown that the on-focus expansion results mainly in an increase in max F0. For example, the max F0 of both T2 and T3 in the subject 船长 'captain' increases when the subject is in focus in Figure 6. There is no consistent pattern of changes in min F0 as an effect of focus, which is in line with Xu (1999). However, the tonal shapes of T2 and T3 in the subject 船长 'captain' are largely preserved despite the pitch expansion. Similarly, the min F0 of T3 (the first syllable of the object 雨衣 'raincoat') in Figure 7 goes down and max F0 of T1 (the second syllable of the object 雨衣 'raincoat') goes up when the object is in focus. As with the subject 船长 'captain', the tonal shapes of T3 and T1 in the object 雨衣 'raincoat' are largely preserved.

The focused word is usually also realised with longer duration and higher mean intensity (e.g., Chen et al., 2009; Chen & Gussenhoven, 2008; Xu, 1999), although there is disagreement as to the duration change of sentence-final words under focus. Xu (1999) reports that focus induces significant lengthening regardless of the position in the utterance. However, Chen (2006) shows that focused words in sentence-final position are not significantly lengthened, suggesting that focal lengthening and final lengthening are not additive in Mandarin. Compared to the broad focus condition in Figure 5, in terms of duration, the focused words in Figure 6 and Figure 7 are lengthened regardless of word position, as indicated by the word boundaries in the two figures.

2.1.2.3 Syntactic focus marking in Mandarin

Prosodic prominence is not the only means of marking focus in Mandarin. In Mandarin, like in many languages, clefts can also mark focus (Lambrecht, 2001; Paul & Whitman, 2008). Clefts have been claimed to signal contrast in much of the theoretical literature (Fang, 1995;

Harries-Delisle, 1978; Lambrecht, 2001; Molnár, 2006; Patten, 2012; Sornicola, 1988; Umbach, 2004).

Previous studies have considered at least four Mandarin focus constructions, namely the 是... 的 'SHI...DE' construction as in (11), the bare 是 'SHI' construction as in (12), the ...的是... '...DE SHI...' construction as in (13) and verum focus using 是 'SHI' as in (14) (Chen et al., 2016; Cheng, 2008; Hole, 2011, 2012; Li & Thompson, 1981; Liu & Kempson, 2018; Paul & Whitman, 2008)[3]. Examples (11)- (14) were adapted from Paul and Whitman (2008).

(11)   SHI...DE

是   [他]$_F$ 在   北京   学   语言学   的

COP   3SG   at   Beijing   learn   Linguistics   DE[4]

'It was [**he**]$_F$ who learnt Linguistics in Beijing.' (Paul & Whitman, 2008)[5]

(12)   Bare SHI

是   [他]$_F$ 在   北京   学   语言学 (Sentence-initial bare SHI)

COP   3SG   at   Beijing   learn   Linguistics

'[**He**]$_F$ studies Linguistics in Beijing.'

他   是   在   北京   学   [语言学]$_F$ (Sentence-medial bare SHI)

3SG   COP   at   Beijing   learn   Linguistics

'He studies [**Linguistics**]$_F$ in Beijing.'

(13)   ...DE SHI...(pseudo-cleft)

他   在   北京   学   的   是   [语言学]$_F$

3SG   at   Beijing   learn   DE   COP   Linguistics

'What he learned in Beijing was [**Linguistics**]$_F$.'

---

[3] There is also bare 的 'DE' construction, which is a result of omitting 是 'SHI' from 是...的 'SHI...DE' construction.

[4] 的 'DE' is glossed as *DE* following the current literature such as Paul and Whitman (2008) and Hole (2011). Note that Mandarin Chinese 的 'DE' has multiple uses (apart from its association with past tense reading in this paper), which includes its function as a complementiser, a nominaliser and others (see e.g., Paul & Whitman, 2008; Xie, 2012).

[5] Note that I will largely use the *captain* example throughout the thesis for clarity and consistency. However, in cases where this example would be pragmatically or structurally odd, I will use other examples from published papers and reference them accordingly.

(14)   Verum focus

他   **是**   在   学习

3SG   COP   ASP   study

'He **IS** studying.'

In 是...的 'SHI...DE' as in (11), the focus position is fixed and is the element immediately following 是 'SHI' (an exception is object focus, which I will introduce later). The nuclear prominence is usually on the clefted word, e.g. 他 'he' in (11). For the bare 是 'SHI' constructions, there are at least two types of structure depending on the position of 是 'SHI', i.e. sentence-initial bare 是 'SHI' as in the first example in (12), and sentence-medial bare 是 'SHI' as in the second example in (12). For sentence-initial bare 是 'SHI', the focus position is usually the subject and the subject has the nuclear prominence. For sentence-medial bare 是 'SHI', the focus position is rather flexible, i.e. any element to the right of 是 'SHI' can be focused by having the nuclear prominence on that element. For example, in the second example in (12), the object 语言学 'Linguistics' is the focus, as it has the nuclear prominence. The construction ...的是... '...DE SHI ...' as in (13) is a pseudo-cleft construction, where the focus position is normally the element immediately following 是 'SHI', and that element normally carries the nuclear prominence. In the verum focus as in (14), 是 'SHI' carries the nuclear prominence, and no other constituents are specifically focused.

In the experiments in this thesis, I used the 是...的 'SHI...DE' construction, which has been claimed to be the canonical cleft construction (Hole, 2012; Liu & Kempson, 2018). Accordingly, the following description gives more detail of this canonical 是...的 'SHI...DE' cleft construction. 是...的 'SHI...DE' marks focus in Mandarin without changing the word order from the canonical order that the sentence would otherwise have. For instance, for subject focus, as in (15), the copula 是 'SHI' occurs immediately before the subject 船长 'the captain'.

(15)   是   [**船长**]F   穿上   的   雨衣

COP   captain   put.on   DE   raincoat

'It was [the **captain**]F who put on the raincoat.'

的 'DE' can occur either before or after the object. When 的 'DE' appears before the object, as in (15), the sentence is past tense (Chao, 1968; Hole, 2011; Paul & Whitman, 2008). When 的 'DE' appears after the object, the sentence, e.g. (11), can also be interpreted as a propositional assertion (sentence focus) if there is no obvious nuclear prominence on any of the words (e.g., 'it is the case that he studies Linguistics in Beijing'). In order to avoid this ambiguity between propositional assertion and subject focus, in the stimuli used in my experiments, there was always a strong nuclear prominence in the sentence. Chao (1968), Hole (2011) and Paul and Whitman (2008) further commented that there might be dialectal differences between Northern and Southern speakers of Mandarin Chinese in the use of a pre-object 的 'DE' cleft, with this kind of cleft largely restricted to Northern speakers. They did not specifically mention the exact geographic or provincial allocations that divide the speakers. However, in one of their footnotes, Paul and Whitman (2008, pp. 428-429) stated that: ' *"Northern" refers primarily to speakers of Beijing Mandarin, "Southern" to speakers of Taiwan Mandarin and perhaps other "Southern" varieties.*'[6]. In this thesis, I use the pre-object 的 'DE', which occupied the same position as the particle 了 'LE', which is a perfective aspect marker in its corresponding canonical word order sentence, as in (16).

(16) [船长]F   穿上   了   雨衣

captain   put.on PRF   raincoat

'[The **captain**]F (has) put on the raincoat.'

(17) 船长   是   穿上   的   [雨衣]F

captain COP   put.on DE   raincoat

'It was [the **raincoat**]F that the captain put on.'

Compared to subject clefts, object clefts in Mandarin have received very little attention. It is still under debate as to whether object focus can be marked by the 是...的 'SHI...DE' construction (Hedberg, 1999; Hole, 2011, 2012; Li, 2008; Paul & Whitman, 2008; Shi, 1994; Teng, 1979; Zhan & Sun, 2013). The more recent literature argues that the object can be focused with 的 'DE' in the pre-object position as in (17) (Hole, 2011; Paul & Whitman, 2008). Differences in the frequency or naturalness of subject and object clefts may cause

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[6] Paul and Whitman (2008) also pointed out that the object cleft requires verb-adjacent 的 'DE' for both Northern and Southern speakers (p. 429). However, because the pre-object 的 'DE' may not work for Southern speakers (e.g., Taiwanese Mandarin speakers), such speakers were intentionally not included when I recruited participants.

different processing effects, but this has not been previously investigated. Similar to subject clefts, object clefts do not involve word order changes. As in (17), the copula 是 'SHI' occurs before the verb 穿 'put on'. 的 'DE' occupies the same position that 了 'LE' would be found in. There is evidence that object clefts are less common in Mandarin, and may be harder to process, than subject clefts. Hedberg (1999) showed that, at least from examples in newspapers and a novel, 是...的 'SHI...DE' subject clefts are much more frequently used than object clefts.

Rather, pseudo-clefts ...的是... '...DE SHI ...' are widely held to mark object focus in Mandarin (Hedberg, 1999; Zhu, 1998). 的 'DE' in this case functions as a nominaliser. To the best of my knowledge, no studies have investigated spoken corpora on the frequency of use of the different cleft structures to mark subject and object focus, to provide evidence on which construction is most natural and common to use as marking subject and object focus. However, because in this thesis I wanted to compare subjects and objects in the same cleft construction, object 是...的 'SHI…DE' clefts were used to be comparable with subject 是... 的 'SHI…DE' clefts. Other issues would have arisen with the use of pseudo-clefts, such as positional issues which would affect the time course of priming in Experiments 4A and 4B (see Chapter 7). This is because the subject in pseudo-clefts is sentence-final, compared to the canonical word order where the subject is sentence-initial. There is a considerable amount of evidence in English that object clefts or object relative clauses, both of which involve a change of word order, are more difficult to process compared to subject clefts which involve 'regular' word order (MacDonald & Christiansen, 2002; Traxler, Morris, & Seely, 2002, also see a discussion of the asymmetry between subject and object clefts in Tily, Fedorenko, & Gibson, 2010).

The prosodic prominence normally falls on the cleft head, i.e. 船长 'captain' in Figure 8 (also see (15)) and 雨衣 'raincoat' in Figure 9 (also see (17)). Both QUD-focus and contrastive focus are analysed as being on the cleft head. This implies alternatives to the focused word (É Kiss, 1998; Fang, 1995; Lambrecht, 2001).

However, the prosodic prominence can also fall on a constituent that is different from the clefted constituent, i.e. 雨衣 'raincoat' in Figure 10 (see also (18)) and 船长 'captain' in Figure 11 (see also (19)).

(18)　　　是　　[船长]F　　穿上　的　　[雨衣]F

　　　　　　COP　captain　　　put.on　DE　　raincoat

　　　　　　'It was [the captain]F who put on [the **raincoat**]F.'

(19)　　　[船长]F　　　　是　　穿上　的　　[雨衣]F

　　　　　　captain　　　　COP　put.on　DE　　raincoat

　　　　　　'It was [the raincoat]F that [the **captain**]F put on.'

是	船长	穿上	的	雨衣
shi4	**chuan2zhang3**	chuan1shang4	de0	yu3yi1
COP	**captain**	put on	DE	raincoat
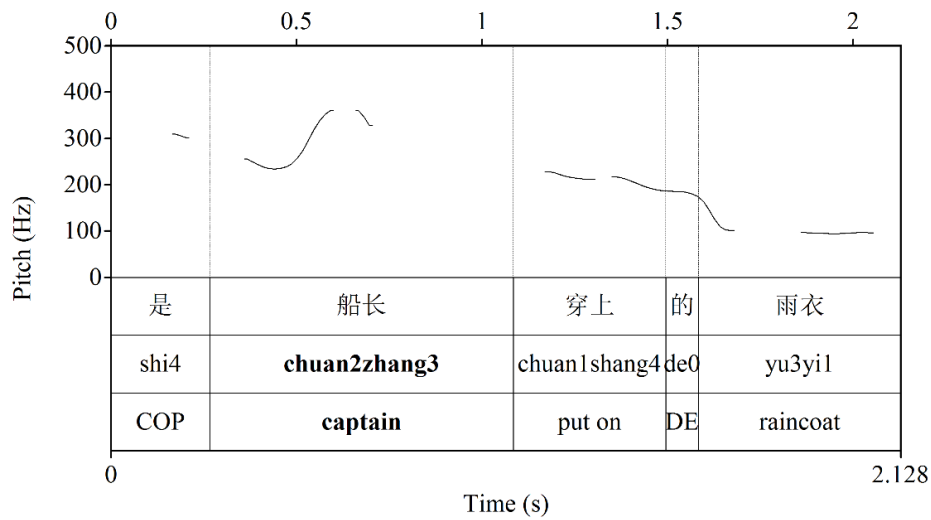
Figure 8 Subject cleft with nuclear prominence on the subject in Mandarin (example (15); see text for details)

船长	是	穿上	的	雨衣
chuan2zhang3	shi4	chuan1shang4	de0	**yu3yi1**
captain	COP	put on	DE	**raincoat**
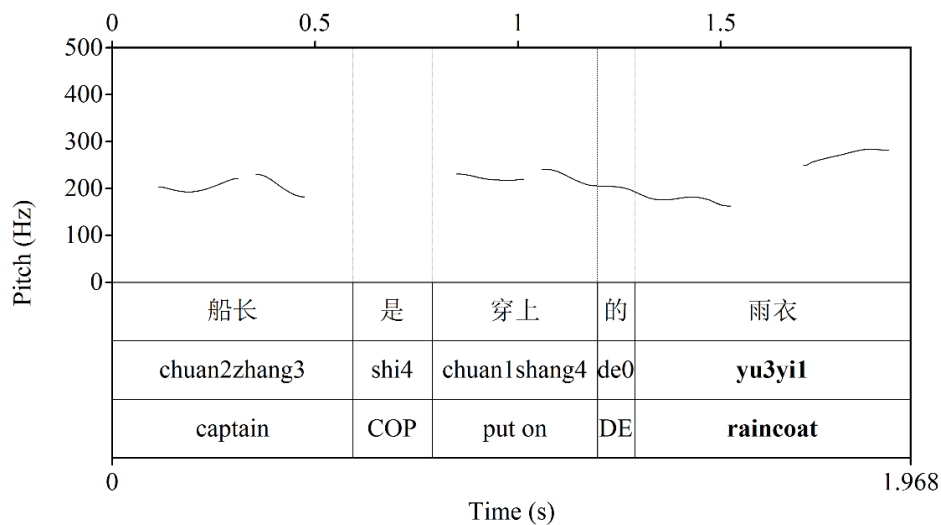
Figure 9 Object cleft with nuclear prominence on the object in Mandarin (example (17); see text for details)

24
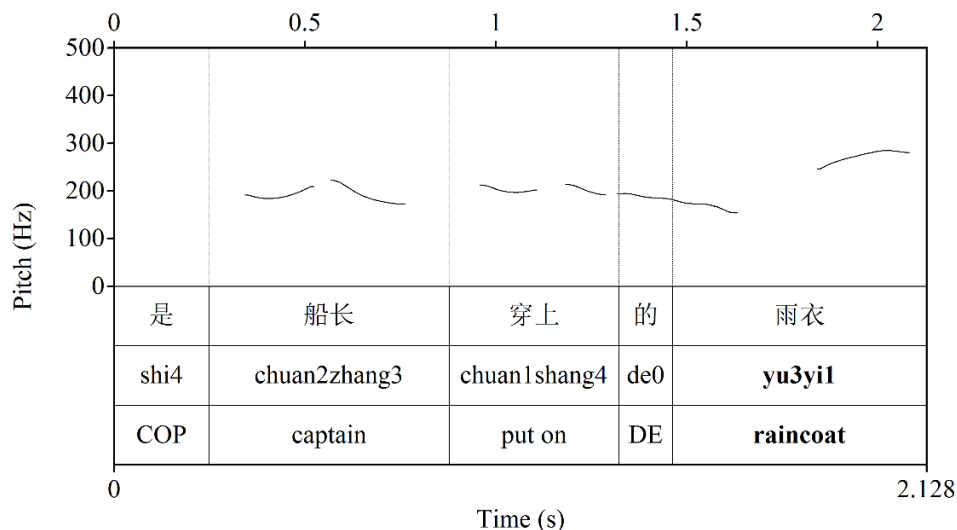
Figure 10 Subject cleft with nuclear prominence on the object in Mandarin (example (18); see text for details)
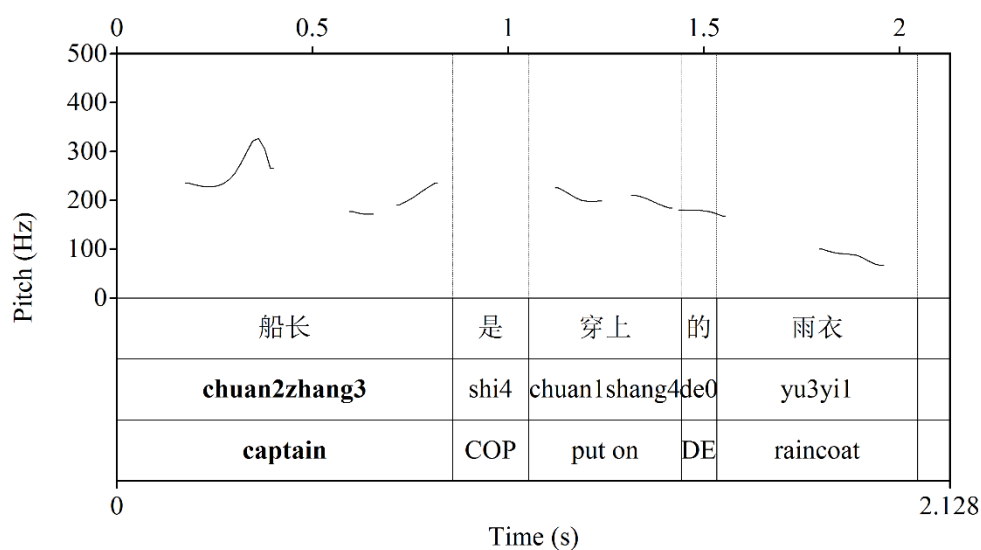
Figure 11 Object cleft with nuclear prominence on the subject in Mandarin (example (19); see text for details)

In these cases, the QUD-focus is usually analysed as being the word that has the prosodic prominence (Delin & Oberlander, 1995; Feldhausen & Vanrell, 2015; Hedberg, 2013; Hole, 2011; Prince, 1978). Alternatives are implied for both the subject 船长 'captain' and the object 雨衣 'raincoat'. Considering the context as shown in (20), 水手 'sailor' is the explicit alternative to the subject, i.e. to the person who actually put on the raincoat, 船长 'captain'.

夹克 'jacket' is the explicit alternative to object, or what was put on, 雨衣 'raincoat'. That is, in sentences (18) and (19) given the context in (20), the syntactic and prosodic cues mark contrastive focus on different words (the subject and object respectively).

(20)　　　天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克。[7]

'The weather got colder, and the captain and the sailor on the ship put on their raincoat and jacket.'

(21)　　是　　[水手]F　　　穿上　的　　[夹克]F

　　　　COP　sailor　　　put.on DE　jacket

'It was [the sailor]F who put on [the **jacket**]F.'

The syntactically-marked contrastive focus on the subject in (18) and (21) is often analysed as contrastive topic. It is presupposed that there were a number of individuals (e.g., 船长 'captain' and 水手 'sailor') and a number of different items to wear (e.g., 雨衣 'raincoat' and 夹克 'jacket'), and that various individuals put on various items. (18) and (21) answer the implicit QUD set up by the context in (20), e.g. 谁穿上了什么? 'Who put on what'. This QUD can be further divided into two sub-questions, e.g. 船长穿上了什么? 'What did the captain put on?' and 水手穿上了什么? 'What did the sailor put on?', which are answered by the second focus in each of the sentences (Büring, 2003).

In both Mandarin and English, it is possible to have a secondary prominence on the clefted constituent, i.e. 船长 'captain' in (23). Hole (2011) commented that 船长 'captain' in (23), which is a response to (22), is a second occurrence focus, and it is 'downgraded prosodically' as it already occurs in (22) (Beaver, Clark, Flemming, Jaeger, & Wolters, 2007).

(22)　　是　　[**船长**]F　　　穿上　的　　雨衣

　　　　COP　captain　　　put.on DE　raincoat

'It was [the **captain**]F who put on the raincoat.'

(23)　　不，　是　　[船长]F　　　穿上　的　　[夹克]F

　　　　No,　COP　captain　　　put.on DE　jacket

'No, it was [the captain]F who put on [the **jacket**]F.'

---

[7] This was used as one of the stimuli in Experiments 2 and 3.

While this kind of construction, a cleft with prosodic prominence not on the clefted head, has received little attention in the experimental literature, it is well attested in corpus-based studies of naturally occurring speech in English (Delin & Oberlander, 1995; Hedberg, 2013; Lambrecht, 2001; Prince, 1978), and it has been shown that it is used in certain contexts in natural speech in Mandarin (Hole, 2011) and Spanish (Feldhausen & Vanrell, 2015). For example, the 'mismatch' sentence, e.g. (23) is perfectly acceptable if (23) is a corrective reply to (22). As mentioned above, the cleft focus 船长 'captain' has the secondary prominence due to its status as a second occurrence focus, while the nuclear prominence is on the object 夹克 'jacket' as it updates the common ground.

In addition, Jia, Li, and Chen (2009) supported this construction with nuclear and secondary prominence experimentally with production data using question-answer pairs as in (24) and (25), showing that both foci induced prosodic prominence, but the QUD-focus 毛蓝 'Maolan' has a larger pitch range than the cleft focus 刘民 'Liumin'. Their study also shows that the prosodic prominence is bigger when the two foci are aligned on the same constituent (e.g., (27) as a reply to (26)) than when the two foci were on different constituents (e.g., (25)).

(24)　　是　　[刘民]$_F$　　提拔　谁　　的?
　　　　COP　Liumin　　　elevate who　DE
　　　　'It was [**Liumin**]$_F$ who elevated whom?'

(25)　　是　　[刘民]$_F$　　提拔　[毛蓝]$_F$　　的
　　　　COP　Liuming　　　elevate Maolan　　DE
　　　　'It was [**Liumin**]$_F$ who elevated [**Maolan**]$_F$.'

(26)　　是　　谁　　提拔　毛蓝　　　的?
　　　　COP　who　elevate Maolan　　　DE
　　　　'It was who that elevated Maolan?'

(27)　　是　　[刘民]$_F$　　提拔　毛蓝　　　的
　　　　COP　Liumin　　　elevate Maolan　　DE
　　　　'It was [**Liumin**]$_F$ who elevated Maolan.'

Additional pragmatic meanings of syntactic focus marking

It has been claimed that clefts involve existential presupposition (Hedberg, 2013; Hole, 2011; Lambrecht, 2001; Paul & Whitman, 2008). For example, for (15), repeated as (28) below, it is pragmatically presupposed that someone put on the raincoat.

(28)　　是　　[船长]F　　穿上　的　　雨衣
　　　　COP　captain　　put.on　DE　raincoat
　　　　'It was [the **captain**]F who put on the raincoat.'

(29)　　是　　[船长]F　　穿上　的　　[雨衣]F
　　　　COP　captain　　put.on　DE　raincoat
　　　　'It was [the captain]F who put on [the **raincoat**]F.'

For the 'mismatch' sentences, i.e. (18), repeated as (29), there is a more complex presupposition that there are a number of individuals (e.g., 船长 'captain' and 水手 'sailor') and a number of different items to wear (e.g., 雨衣 'raincoat' and 夹克 'jacket'), and that various individuals put on various items. This presupposition adds more difficulty and complexity to cleft structures, which might have some consequences for language processing. On a similar note, a great deal of literature has shown that the processing of scalar implicature (e.g., 'some of the students passed the exam' implies 'not all of them passed the exam') involves cognitive effects measured using behavioural and neural data, i.e. processing speed (see e.g., Alatawi, 2019; Degen & Tanenhaus, 2015; Sperber & Wilson, 2002; Zhao, Liu, Chen, & Chen, 2015). Also, Crain and Steedman (1985) argued that the many possibilities of referents may make it difficult to process 'garden path' sentences. For example, 'The horse raced past the barn fell' presupposes there is a number of horses, while the main clause 'The horse fell' only presupposes that there is one horse. Therefore, this complex presupposition adds processing cost.

To make the clefts pragmatically natural, and to reduce the potential difficulty of encoding complex presupposition, a context such as (20) is needed where the contrast to the clefted element should be present (Molnár, 2006). Or the contrast should at least be highly inferable from a set (e.g., *captain* - people on a ship) (Calhoun et al., 2019). Destruel, Beaver, and Coppock (2019) recently commented that clefts usually sound more natural when appearing as corrections, as in (30), than when they have a preceding context with alternative sets.

(30)   A: I wonder why Alex cooked so much beans.

            B: Actually, it was John who cooked the beans.

Clefts also have an exhaustive implication that focus-marking with prosodic prominence does not necessarily have (É Kiss, 1998; Krifka, 2008; Molnár, 2006). That is, the cleft rules out other alternatives in the context of the proposition. For example, (28) implies that no one else, but 船长 'the captain', put on the raincoat. Under this exhaustiveness condition, 'asserting that the property denoted by the presupposition also holds of an entity distinct from the focus of the cleft leads to a contradiction' (Paul & Whitman, 2008, pp. 419-420). Exhaustive focus is not compatible with additive particles, like *also* or *too*, so it would be not possible to have 'The sailor also did' as in (31) after 'It was the [**captain**]F who put on the raincoat' as in (28). In contrast, following 'The **captain** put on the raincoat' as in (16), it would not be odd to continue (31), as prosodic focus marking does not have to have the exhaustive interpretation.

(31)   水手   也   穿上   了

            sailor   also   put.on   PRF

            'The sailor also did.'

This exhaustiveness increases the competition between the focused word (e.g., 船长 'the captain') and its alternatives (e.g., 水手 'the sailor') by indicating there is a set of alternatives in the presupposition but highlighting that the proposition is only true for the entity that is in the cleft head. This may lead to a cost to initial processing, as encoding this complex presupposition and exhaustivity could potentially be difficult. However, this has not been experimentally tested in Mandarin.

The asymmetry between subjects and objects in Mandarin

In addition to the frequency and word order differences between subject and object clefts discussed above, subjects and objects in Mandarin differ in several ways, which may affect their processing. First, Mandarin is a topic-prominent language, where the new information tends to occur at the end of the sentence (Li & Thompson, 1981). In canonical word order sentences and clefts, objects are sentence-final, which is the default focus position (e.g., Feng, 1996; Xu, 2004). This default focus position has been shown to play a very important role in processing, in that, final objects have been previously found to have a default focus

bias, even if they are not otherwise focused marked (e.g., if they do not carry nuclear prominence) (see e.g., Chen, Chen, and He, 2012 in section 2.3.1).

Second, animacy also plays an important role in language processing in Mandarin (Chen, Chen, & He, 2012; Li, Bates, Liu, & MacWhinney, 1992). In many languages, including Mandarin, subjects tend to be animate, and animate elements are more likely to be mentioned before inanimate elements (Branigan, Pickering, & Tanaka, 2008). Animate referents tend to be more salient and therefore topics (i.e., what discourse is organised around). Inanimate referents tend to carry new information and likely to be perceived as being in focus, so they are likely to be in object position. These differences between subjects and objects in canonical word order sentences and clefts are likely to affect their processing.

2.2 The effects of prosody and syntax on focus perception

I separate focus perception (section 2.2) from focus processing (section 2.3) in this thesis, as focus perception studies establish the cues to focus in general, but mostly use meta-linguistic judgments. Once established, we can see their effects in processing. This also mirrors the structure of the experiments presented in Chapters 5-7.

As discussed in section 2.1.2, speakers use a number of cues (e.g., prosodic or syntactic) to mark focus, but how do listeners use these cues to perceive focus? How do listeners privilege one cue over another when there is more than one cue available and they potentially conflict with each other? In what follows, I review the literature that looks at the perception of different cues to focus, particularly how listeners use prosodic and syntactic cues to perceive focus, and the interplay between these cues.

There are two lines of research on the effects of prosody and syntax on focus perception in psycholinguistic research that are particularly related to this thesis: One looks at how listeners utilise these cues in focus perception (e.g., which word is the focus?); the other considers how listeners utilise these cues in prominence perception (e.g., which word is the most prominent/whether a word is prominent or not relative to other words in utterances.). Since there has been far more literature on prosody than syntax in focus perception, I first review research on prosody in focus perception in section 2.2.1, and then review research on syntax as well as the interacting effects between different focus cues, concentrating on a recent study by Calhoun et al. (2019), in section 2.2.2.

2.2.1 The effects of prosody on focus perception

As stated in section 2.1, one of the common markers of focus in languages like English and Mandarin is prosodic prominence, as expressed in pitch accenting in English and pitch expansion in Mandarin, along with other cues such as longer duration and higher intensity. It is well established in the literature that listeners are able to use prosodic cues in speech to identify focus and even to distinguish focus types if the language uses these cues to mark focus (Botinis et al., 1999; Breen et al., 2010; Lee et al., 2015; Lee et al., 2016). For example, Lee et al. (2015) used a paradigm based on digit strings as in (32) and (33) to investigate the production and perception of contrastive prosodic focus in English and Mandarin.

(32)   Is Mary's number 215-418-5623?

(33)   No, the number is 215-41**7**-5623.

In the production experiment, in English and Mandarin, the digit that is being corrected (e.g., *7* in (33)) had greater prosodic prominence (i.e., longer duration, higher F0, and higher intensity) than the unfocused counterparts. The perception experiment shows that identification accuracy was very high for English (94.9%) and Mandarin listeners (97.3%). This means that prosodic prominence is an effective cue in focus perception in Mandarin and English.

Prosodic prominence is a very useful cue for locating the focus in an utterance, so the position of prosodic prominence in a sentence should be crucial in determining whether that sentence is acceptable in a particular context (Birch & Clifton, 1995; Welby, 2003). For example, to answer the question (34), listeners may find (35) acceptable and (36) somewhat unacceptable and confusing, even though the two sentences are otherwise identical morphologically and syntactically. The (un)acceptability of the answers depends on the alignment between prosodic prominence and information structure. As an answer to (34), *the raincoat* in (35) is the focus that updates a QUD like (34), therefore *raincoat* is expected to bear the nuclear prominence. In (36), *captain*, which conveys old information, should not be accented. Therefore, accenting given information is somewhat unacceptable and may cause processing difficulties (Baumann & Schumacher, 2012; Cutler et al., 1997; Terken & Nooteboom, 1987).

(34)   What did the captain put on?

(35)   The captain put on the **raincoat**.

(36)   The **captain** put on the raincoat.

Acoustic prosodic prominence plays an important role in focus perception as presented above. Acoustic prosodic prominence of course also affects prosodic prominence perception. In turn, whether a word is likely to be in focus can also affect listeners' perception of prosodic prominence (Ayers, 1996; Bishop, 2012; Calhoun et al., 2019; Cole, Mo, & Baek, 2010). Two models, 'bottom-up' (signal-based) and 'top-down' (non-signal-based), can be used to account for the perception of prominence, which will be introduced further below.

The 'bottom-up' model refers to a process that results from acoustic cues, i.e. greater acoustic cues result in higher prominence (Bishop, 2012; Ito, Turnbull, & Speer, 2017; Turnbull, Royer, Ito, & Speer, 2017). Typically, the acoustic cues include duration, intensity and F0[8]. However, the results are mixed regarding which acoustic cues are the most effective. For example, the common assumption is that F0 is a highly important predictor of prosodic prominence (e.g., Eady et al., 1986; Gussenhoven, Repp, Rietveld, Rump, & Terken, 1997; Rietveld & Gussenhoven, 1985; Terken, 1991). Other studies show that duration and intensity are strong predictors of perceived prominence (Cole, Mo, & Baek, 2010; Turk & Sawusch, 1996). For example, Kochanski, Grabe, Coleman, and Rosner (2005) show that intensity and duration cues are more effective than F0 in conveying focus, and that intensity is the stronger predictor of the two.

The 'top-down' model refers to a process by which perception of prosodic prominence results from a range of non-signal-based factors, such as focus position (Ayers, 1996; Bishop, 2012), context (Turnbull, Royer, Ito, & Speer, 2014; Turnbull et al., 2017), listeners' awareness and the interplay between linguistic context, pragmatic context, and phonology in prominence perception (Turnbull et al., 2017). Krahmer and colleagues also showed in early studies that speakers' visual beats, including manual beat gestures, head nods and rapid eyebrow movements affected listeners' perceived prosodic prominence (e.g., Krahmer, Ruttkay, Swerts, & Wesselink, 2002; Krahmer & Swerts, 2007).

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[8] Voice Quality is also an important cue (see e.g., Murphy, Yanushevskaya, Chasaide, & Gobl, 2019), but will not be discussed further in this thesis.

Bishop (2012) showed that listeners' perception of prominence is highly affected by aspects of the signal and their information structural expectations about the signal. In a prominence-rating task where listeners were presented with the same recording, e.g. (40) under different conditions (broad focus, VP focus and object focus as responses to the examples (37)-(39)) and made judgements of the prominence of the verb and the object in (40).

(37)   What happened? (Broad focus)

(38)   What did you do? (VP focus)

(39)   What did you buy? (Object focus)

(40)   I bought a motorcycle.

The findings showed that when objects were under narrow focus as in (40) as a response to the question in (39), objects were perceived to be more prominent, and a preceding verb less prominent, compared to when objects were under VP focus, i.e when (40) was a response either to (38) or to the sentence focus in (37). The findings suggested that listeners' perception was affected by their experience-based knowledge about how speakers use prosody to express this difference in information structure. In a similar vein, the default position for nuclear accent in English is on the right-most strong element in the intonation phrase (Calhoun, 2010a; Ladd, 2008). Thus a phrase-final pitch accent has been shown to be perceived as relatively prominent even if it is downstepped (Ayers, 1996).

Cole, Mo, and Baek (2010) showed that listeners' perception of prominence is also affected by their prior experience of word frequency and repetition (expectation-driven perception). Cole, Mo, and Baek (2010) investigated spontaneous speech from the Buckeye corpus of conversational speech with speakers from Columbus, Ohio (Pitt, Johnson, Hume, Kiesling, & Raymond, 2005). In silent and auditory prominence rating tasks, Cole and colleagues also found that information status or informativeness played a role (e.g., Luchkina & Cole, 2014; Luchkina & Cole, 2019). The more informative and less predictable a word is, the more likely the word is to be in focus, and the more likely it is to be perceived as having greater prominence (Calhoun, 2010b).

As discussed above, a number of factors, both signal-based (acoustic cues) and non-signal-based (e.g., listener's expectation of focus position, discourse factors), could influence listeners' perceptions of prominence. In what follows, I explore how prosodic prominence affects focus perception in the presence of other cues, i.e. the interplay between acoustic

prosodic prominence and clefting in prominence perception and focus interpretation, concentrating on Calhoun et al. (2019), as their study is the most relevant to the current thesis.

2.2.2 The effects of syntax (interacting with prosody) on focus perception

We have so far seen that prosody plays an important role in focus perception. There are, however, studies – albeit fewer in number - on how other cues (e.g., syntactic) affect prominence perception and focus perception, especially on how these cues interact. For many languages that have a free word order, syntax is used primarily to mark focus (Donati & Nespor, 2003). Studies on languages with free word order (e.g., Finnish, Hindi and Russian) show that words in the preferred syntactic focus position (mostly via word order) are perceived as more prominent than words in the canonical position, and these cues seem to interact in complex ways (Cole, 2015; Cole, Mo, & Hasegawa-Johnson, 2010; Luchkina & Cole, 2019; Luchkina, Cole, Jyothi, & Puri, 2015; Vainio & Järvikivi, 2006).

Using a naturalness judgement study (similar to Welby, 2003), Clifton and Frazier (2016) tested the role of pitch accents, default focus position and syntactic form in the naturalness of corrective sentences as in (41)-(44).

(41)   **Parallel Subject**
          Sam brought the pasta.
          No, Mary brought the pasta.

(42)   **NonParallel Subject**
          Mary brought the pie.
          No, the pasta was brought by Mary.

(43)   **Parallel Object**
          Mary brought the pie.
          No, Mary brought the pasta.

(44)   **NonParallel Object**
          Sam brought the pasta
          No, the pasta was brought by Mary.

They manipulated the default focus by having the corrected information on the subject (default non-focus) as in (41) and (42) and on the object (default focus) as in (43) and (44).

They also manipulated syntactic form by having a parallel (active voice) condition as in (41) and (43) and a non-parallel (passive voice) condition as in (42) and (44). In two experiments, with written or auditory stimuli, participants were instructed to rate one of the four sentences (i.e., the second sentences in (41)-(44)) of a two-person dialogue on a five-point naturalness scale. They found that both parallelism and the default focus position increased the naturalness ratings, even in spoken processing where the subject (e.g., *Mary* in (43)) had a pitch accent (H* or L+H*).

The experiment with written stimuli confirmed the previous research that during reading, participants may have generated 'implicit prosody' that had a pitch accent on the object which is the default focus position (Clifton & Frazier, 2016; Fodor, 1998, 2002; Jun, 2010; Jun & Bishop, 2015; Stolterfoht, Friederici, Alter, & Steube, 2007). The experiment with auditory stimuli suggests that participants still had a default focus even when there was an accent on other words that were not in the default focus position. Clifton and Frazier's interpretation is that participants may have repeated the sentences in their heads. Clifton and Frazier (2016) provide important evidence concerning the role of default focus in focus interpretation in both written and spoken languages. Sentence-final objects also hold a default focus in Mandarin, but to the best of my knowledge, no studies in Mandarin have investigated the role of default focus in the perception of focus in Mandarin.

Calhoun et al. (2019) recently looked at the interplay between syntactic cues (*it*-clefts) and prosodic cues (contrastive prominence) to focus in prominence perception and focus interpretation in two unrelated intonation languages (i.e., English and Samoan). In a test of the relationship between the perceived prominence and intended stress, participants listened to isolated sentences in one of six sentence conditions that varied in syntax (canonical, subject cleft, object cleft) and prosody (nuclear prominence on the subject or on the object) in their native language. These are exemplified below in (45)-(50).

(45)   The **cow** kicked the horse. (canonical, prominence on the subject)

(46)   The cow kicked the **horse**. (canonical, prominence on the object)

(47)   It was the **cow** that kicked the horse. (subject cleft, prominence on the subject)

(48)   It was the cow that kicked the **horse**. (subject cleft, prominence on the object)

(49)   It was the horse that the **cow** kicked. (object cleft, prominence on the subject)

(50)   It was the **horse** that the cow kicked. (object cleft, prominence on the object)

(51)   Who kicked the horse? (Subject question)

(52)   What did the cow kick? (Object question)

They then were asked to choose the most prominent word. Results revealed that both English and Samoan participants listening to their native language could generally choose the intended stressed word successfully as the most prominent word, and English speakers were more consistent in doing so than the Samoan speakers. In a second set of experiments that tested the interpretation of the focus position using a forced-choice task, listeners had to choose one of two questions, i.e. a subject question like (51) or an object question like (52), as the most appropriate question for a given response, which was one of the six sentences, (45)-(50), they had heard prior to seeing the questions. The results showed that the way that listeners interpreted the two cues (syntactic and prosodic) broadly matched expectations about how these cues are used in their language, i.e. Samoan listeners privileged syntactic cues over prosodic cues, as the primary focus marker in Samoan is shown to be syntax (Calhoun, 2015). In English, prosody is seen as the primary marker of focus, as discussed in section 2.1.2.1, so prosody was a consistent cue in the interpretation of focus in canonical sentences. On the other hand, syntax seemed to outweigh prosody in the cases where the two cues clash as in (48) and (49). It should also be noted that there was a lot of variability between participants for Samoan, but not in English (see details in Calhoun et al., 2019).

2.3 The effects of focus on language processing

In this section, I review the literature showing the effects of focus on the processing of focus-related words (i.e., focused words, alternatives and noncontrastive associates to focused words). Most work on this has been confined to English and other Germanic languages, so most studies discussed below are on these languages. These studies are also mostly concerned with prosodic focus cues, reflecting the important role of prosody in processing focus. As mentioned in section 2.1, there are two main types of focus, which have effects on the processing of focused words and their contrastive alternatives respectively. I start by briefly reviewing studies looking at the processing of focus as updating the common ground in general (QUD-focus), and then review research on the role of focus in evoking alternatives to focused words (contrastive focus).

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2.3.1 Focus as updating the common ground

It has long been established that focused words enjoy a processing advantage over unfocused or defocused words (e.g., Akker & Cutler, 2003; Cutler, 1976; Cutler & Fodor, 1979; Ip, 2019; Ip & Cutler, 2017; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016). Focused words are recognised faster and remembered better. These studies assume a QUD-definition of focus. In phoneme-monitoring experiments, phonemes are recognised faster in focused words or in words where the preceding intonation contour predicts that they will be in focus (Akker & Cutler, 2003; Cutler, 1976; Cutler & Fodor, 1979; Ip, 2019; Ip & Cutler, 2017). For example, Akker and Cutler (2003) used stimuli like the following:

(53)   Which man was wearing the hat?

(54)   What hat was the man wearing?

(55)   The man on the **corner** was wearing the blue hat.

(56)   The man on the corner was wearing the **blue** hat.

The participants' task was to respond as quickly as possible when they heard the target phoneme /k/ in the sentence. The results showed that participants were faster to respond when they heard the phoneme /k/ in *corner,* after the statement followed the question in (53) than when it followed the question in (54), as (53) contextually cued *corner* as the focus. Participants were also faster on hearing (55), where *corner* was contrastively accented, than (56), where it was not. These two cues to focus were not additive, which means that there was no extra processing advantage when the contextual and prosodic cues to focus agreed (i.e., hearing (55) after (53)).

Not only the focus, but also the preceding prosodic contour which predicts the location of the main prominence, facilitated participants in their recognition of the target phoneme (Cutler, 1976; Ip, 2019; Ip & Cutler, 2017). For example, Cutler (1976) used similar phoneme-monitoring tasks to that mentioned above in order to investigate the effects of different preceding contours that predict an upcoming accent or not on the reaction times to target phonemes. It was found that the initial phoneme of the word was recognised faster when the preceding pitch contour predicted a focus prosody (stress) on the phoneme-bearing word, compared to when the preceding contour predicted a non-focus prosody (reduced stress). This suggests that the sentence comprehension process involves the prediction of upcoming prosody. In other words, cues in the intonation contour, as well as the contour of the focused

word, enables listeners to direct their attention to a part of the sentence where an accent was about to occur.

Using the same phoneme-monitoring paradigm, Ip and Cutler (2017) showed similar results for Mandarin, which uses pitch cues primarily for lexical tones. This shows cross-linguistic evidence that the use of pitch cues to focus may be universal for languages in which prosodic prominence is a major cue to focus. Together with the findings that post-focus compression also plays a significant role for focus perception (i.e., Botinis et al., 1999 for English; Xu, Xu, & Sun, 2004 for Mandarin), this result shows that it is not only the phonetic information in focused words that can be an indicator of focus, but also information in pre- and post-focus words.

Focused words are also remembered better (Birch et al., 2000; Birch & Garnsey, 1995; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019). Most early research dedicated to the effect of focus on memory showed that focused elements in written texts had an advantage in memory representation compared to non-focused constituents (Birch et al., 2000; Birch & Garnsey, 1995). For example, when a word (e.g., *friend*) in an *it*-cleft as in (57) was presented later in a memory task, participants were faster in confirming that they had previously seen the word than when it was not in focus as in (58) (Birch et al., 2000; Birch & Garnsey, 1995).

(57)   It was a friend who had done the most to lift her out of depression. (Cleft focus)

(58)   The call from her friend had caused Nancy to be late for a meeting. (No focus)

Birch et al. (2000) also used a continuation paradigm in which participants read a story fragment like (59), followed by either the sentence in (60) or that in (61), and were then asked to provide a continuation. The results showed that readers referred back to concepts (e.g., *mugger*) more often when the concepts were in syntactic focus, as in (60). In general, the results indicated that the syntactically focused concepts were more salient and accessible than the non-focused ones.

(59)   As Joan walked home from the subway, she saw a crowd of people near her apartment building.

(60)   There was this mugger who had attacked an elderly lady.

(61)   A mugger had attacked an elderly lady.

These experiments used written stimuli, so the primary cue to focus was syntactic. However, it has been shown that readers generate implicit prosody while reading (Clifton & Frazier, 2016; Fodor, 1998, 2002; Jun, 2010; Jun & Bishop, 2015; Stolterfoht et al., 2007). Here, it is most likely the implicit prosody would have the nuclear prominence on the clefted word (see section 2.1.2.3). More recently, Kember et al. (2019) used a similar memory task to look at the effect of focus in spoken sentences in Korean and English. They found that both prosodic and syntactic cues to focus enhanced memory for focused words, but the relative effects differed in the two languages, i.e. syntactic cues were more effective than prosodic cues in Korean, but they were equally effective in English with the combination of syntactic and prosodic cues most effective.

Sanford, Sanford, Molle, and Emmott (2006) used the change detection technique to test the effect of pitch accenting on memory for discourse information. In the task, participants first heard a short discourse that was in one of two different focus conditions (narrow or broad focus) as in (62) and (63). They then heard a second discourse that only differed in one word from the previous one, for example, *wallet* changed to *purse*. Participants were asked to detect the change, or the false alternative (*wallet → purse*) between the two discourses. Sanford et al. found that narrow focus increased the detection rate, which can be explained by their proposed *granularity account* which assumes that focus results in an encoding of a more detailed semantic specification of focused elements, e.g. *wallet*. Therefore, it is easier to retrieve the focused information and detect the false alternative. Note that in Sanford et al. (2006) the narrow focus was manipulated both by the semantic context 'which money had been stolen' and by the contrastive pitch accenting, so it was hard to tell which focus manipulations had the mnemonic effect.

(62)   They wanted to know which money had been stolen. The money from the
         [**wallet**]$_{L+H*}$ had gone missing. Thefts in the area were becoming all too
         common. (Narrow focus)

(63)   They wanted to find out what had happened. The money from the [**wallet**] $_{H*}$
         had gone missing. Thefts in the area were becoming all too common.
         (Broad focus)

Later, Ward and Sturt (2007) used reading materials with the same change detection technique combined with eye-tracking to examine the impact of semantic focus introduced by context (similar to (62)) on both eye movements and memory. They also found that focus facilitated the detection of false alternatives and also triggered more and longer fixations on the changed words. Similar effects were found in a reading task when italicisation was used to mark focus (Sanford et al., 2006), and in an earlier study when pseudo-clefts were used to mark focus (Sturt, Sanford, Stewart, & Dawydiak, 2004). Again, it is possible that the effect results from the implicit prosody generated during reading.

The evidence we have seen so far comes mostly from Germanic languages. It is still poorly understood how linguistic cues, such as prosodic prominence and clefting, are used in Mandarin, let alone the interaction between different cues. Chen, Chen, and He (2012) is among the very few studies that have been conducted on Mandarin. They investigated a number of linguistic cues that are used to encode focal information in both English and Taiwanese Mandarin, using a verification task. In the task, participants heard a question about an event including two entities, which were the subject and object of the sentence respectively. In the question, the likely focus was manipulated using different locations for prosodic prominence (subject vs. object), different sentence structures (cleft vs. noncleft), different word positions (pre-verbal default non-focus and post-verbal default focus position), and differences in the animacy of the target word (whether the word is animate or not). Some stimulus examples are shown in (64) and (65).

(64)   Does the turtle chase the **cat**?
        (Canonical with prosodic prominence on the object)
(65)   Is it the **turtle** that chases a cat?
        (Cleft with prosodic prominence on the subject)
(66)   Picture 1: The turtle chases the rabbit.
        Picture 2: The monkey chases the cat.
        (Description of pictures)

Participants were also visually presented with two pictures describing events in which one or other of the two entities were different to the question that they heard, e.g. (66). Participants were instructed to select one picture and then correctly describe the picture using a similar sentence structure to the stimulus recording. It was expected that participants would choose

the picture in which the entity that needed to be corrected was marked as the focus, e.g. for (64) they should be more likely to choose Picture 1 in (66), as *cat* is prosodically focused in (64) and replaced by *rabbit* in Picture 1; whereas for (65) they should choose Picture 2 in (66). The picture choice is therefore a measure of the strength of the different cues to focus in the questions. The theoretical evidence to support this hypothesis is that in discourse speakers mark new information or the information that updates the common ground (QUD-focus) to help listeners identify such types of information.

Different patterns were found for the two languages (Mandarin and English) in this task. The relative importance of the linguistic cues is shown in (67).

(67)   **Mandarin**: word positions > prosodic prominence > cleft
         English: cleft > word positions > prosodic prominence

Here, I only present the results for word positions, prosodic prominence and syntactic structure (cleft), as these are the most relevant factors for the current thesis. It was found that, in Mandarin, word position (whether it was pre-verbal or post-verbal) was the most important cue to signal focus for Mandarin, i.e. false information that was in the post-verbal position was more accurately corrected than the information that was in the pre-verbal position, showing that the default focus cue (post-verbal/sentence-final position) was a stronger cue than the actual prosodic and syntactic prominence. In Mandarin, prosodic prominence was preferred over clefts, while in English it was the other way around. In English, word order was more important than prosodic prominence, but less important than clefting. It is important to note here that the authors used the bare 是 'SHI' cleft construction and that participants were Taiwanese Mandarin speakers. It cannot be assumed that the canonical 是... 的 'SHI...DE' construction that this thesis investigates will lead to similar results to the bare SHI construction (see section 2.1.2.3 for the differences between the two focus constructions). Further, Taiwanese Mandarin speakers may interpret the 是...的 'SHI...DE' construction differently, as the 是...的 'SHI...DE' construction with pre-object 的 'DE' may not work for Taiwanese Mandarin speakers (see e.g., Chao, 1968). Measuring processing via eye movements during reading, Chen, Li, and Yang (2012) also showed that during reading focused words marked by 是 'SHI' were processed more quickly than unfocused words.

Another important role of focus in processing is to resolve ambiguity in otherwise ambiguous sentences (e.g., Filik, Paterson, & Liversedge, 2005; Frazier & Clifton, 1998; Kaiser, 2011; Ni, 1996; Schafer, Carlson, Clifton, & Frazier, 2000; Sedivy, 2002). For example, the referent of *who* in (68) is ambiguous between *somebody* and *someone*. The element which is focused is interpreted as the antecedent of *who*, e.g., *who* refers to *somebody* in (69) but to *someone* in (70).

(68)   Somebody claimed that the president fired someone, but no one knows who.

(69)   **Somebody** claimed that the president fired someone, but no one knows who.

(70)   Somebody claimed that the president fired **someone**, but no one knows who.

We have seen that focus cues play an important role in the processing of focal information. In the following, I go on to review studies using the definition of contrastive focus in alternative semantics, i.e. focus indicating the presence of alternatives, and to consider the processing advantages that such focus affords alternatives.

2.3.2 Focus as indicating contextual alternatives

The effects of focus on language processing have been researched for nearly half a century. However, it is only recently that we have seen psycholinguistic evidence for the role of focus in indicating alternatives. In what follows, I review the relevant literature according to the time course of the activation/representation of alternatives during processing: immediate activation (section 2.3.2.1) and long-term memory (2.3.2.2).

2.3.2.1 Focus in lexical activation

One line of studies, using the eye-tracking paradigm, provided the first psycholinguistic evidence that focus facilitates activation of alternatives. These studies showed that contrastive accenting biases listeners to look at contrastive referents that are available in their visual display, compared to noncontrastive accenting which shows no bias (Dahan, Tanenhaus, & Chambers, 2002; Dennison, 2010; Ito & Speer, 2008; Kurumada, Brown, Bibyk, Pontillo, & Tanenhaus, 2014; Watson et al., 2008; Weber, Braun, & Crocker, 2006). For example, Ito and Speer (2008) used a setting of decorating a holiday tree by selecting ornaments from a set of real-world objects (e.g., *ball*, *bell* and *candy*) of different colours (e.g., *blue*, *green*, and *orange*). In their experiment, after first hearing (71), participants then heard another instruction (72) or (73) with either *green* or *ball* with the contrastive pitch accent. The results showed that listeners had more and earlier fixations on the green ball in a visual display when

they heard (72) than when they heard (73) (Note that the results also depended on the presence of other objects in the array, e.g. *brown ball, blue drum* etc.).

(71)   First, hang the blue ball.

(72)   Now, hang the **green** ball.

(73)   Now, hang the green **ball**.

A recent study by Ito et al. (2017) extended these findings on interpreting contrast from the laboratory to a more general public place (a science museum), and also from students to a more general public group (museum visitors).

Braun and colleagues (2019) later added more evidence to the role of contrastive accents and focus particles (i.e., *also*) from eye-tracking data. They showed that contrastive prominence, but not focus particles, activated contrastive alternatives in listeners' visual display in German (Braun et al., 2019; Braun & Biezma, 2019). They investigated prenuclear L+H* (broad focus), nuclear L+H* (contrastive focus), nuclear H+ L* (accessible information) and an additive focus particle in Braun et al. (2019) and prenuclear L*+H (contrastive topic) and prenuclear L+H* in Braun and Biezma (2019), with printed words as targets. In their experiments, listeners heard sentences such as (74) in German with different pitch accents on the subject word, and had four types of words in their visual display (a contrastive alternative *diver*, a noncontrastive associate *sports*, the actual object noun *flippers* and an unrelated distractor).

(74)   The swimmer wanted to put on flippers.

They found that only nuclear L+H* (contrastive focus) and prenuclear L*+H (contrastive topic) directed more looks to the contrastive alternatives, while the fixations to the visually presented noncontrastive associates were not affected by the intonation contours. As the F0 excursion in prenuclear L*+H (marking contrastive topic) is larger than prenuclear L+H*, they further used resynthesized stimuli to manipulate the F0-excursion between the two prenuclear accents so that they were the same. The results again showed more looks to alternatives when the prime word was marked with prenuclear accent L*+H (contrastive topic), but the looks were delayed. This was possibly due to the general effects of resynthesized/unfamiliar/unnatural stimuli, or the absence of a contrast in the F0 excursion in

the resynthesized stimuli, meaning that listeners have to use the cues in the following stressed syllable (falling pitch in the case of the prenuclear L+H*). In sum, their results seem to suggest that F0 height, F0 excursion, and pitch accent status (nuclear or prenuclear) are not key to priming alternatives. Instead, pitch accent type (nuclear L+H* and prenuclear L*+H), or more accurately the (contrastive) interpretation of accents, is the key to priming alternatives.

These eye-tracking results show that listeners use contrastive accenting to rapidly identify referents that already exist in their visual display. But they did not show whether contrastive accenting can also activate unmentioned and/or visually unavailable alternatives. To investigate this, cross-modal lexical decision priming experiments have been used, to look at the effect of contrastive focus on unmentioned contextual alternatives.

A well-attested theory related to lexical activation is the spreading activation model (Collins & Loftus, 1975), developed from work by Quillian (1967). This model assumes that words are activated by their semantically-related words, which results in a priming effect. This model has considerable research support, but the kinds of semantic associates that are activated and when and how this happens are issues that are still debated. I first briefly present a few key studies with single word priming, and then move on to priming in context.

Semantic associative priming has been found in early visual-visual lexical decision tasks (Neely, 1977), showing different life times for words that have different kinds of semantic relationship. For example, semantic priming persisted over a longer time (at least 2000 ms) for the *bird - robin* type of relatedness where the second target *robin* is an instance of the category represented by the word *bird*. But the semantic priming decayed rapidly for the *body - heart* type of relatedness where the second target *heart* was not selected from the same category as represented by *body* (Neely, 1977). *Body - heart* has a part-whole relationship, which is different from the category membership shown by *bird - robin*. A visual-visual lexical decision task in Mandarin also showed strong semantic priming (e.g., 支票 'cheque' and 现金 'cash') at both short (57 ms) and longer (200 ms) stimulus onset asynchronies (SOAs) (Zhou & Marslen-Wilson, 2000), showing that semantic priming in visual-visual modalities could persist for some period of time in Mandarin.

This thesis tests the role of prosodic and syntactic focus marking in word activation. Cross-modal lexical decision priming studies are particularly relevant, as the two modalities allow listeners to do the visual task (lexical decision) while they are processing the auditory primes. There have been cross-modal lexical decision priming studies looking at the activation of words given different linguistic primes (single word primes, sentence primes, sentence primes with contrastive accenting) since the 1970s (Swinney, Onifer, Prather, & Hirshkowitz, 1979). These studies have shown that single words activate themselves (identity priming) and their semantic associates (semantic associative priming). For example, in their identity priming condition, Norris, Cutler, McQueen, and Butterfield (2006) showed that participants were quicker to respond that the visual target *seat* was a word when they had previously heard the auditory prime *seat*, compared to when they had heard an unrelated control target *river*. Likewise, in the associative priming condition they were quicker to respond to a semantically associated target *chair* after they heard *seat* than after *river*.

However, while strong semantic priming in auditory-auditory priming task has also been found in Mandarin, there was only weak semantic priming in cross-modal (auditory-visual) priming when the visual target appeared immediately after the auditory prime word, indicating that semantic priming does not go across modalities in languages such as Mandarin as easily (Chen & Cutler, 1997). I speculate that one language-specific reason to explain this might be due to the logographic writing system of Mandarin, that it could be more difficult to map the characters (visual) with the sound (auditory) in cross-modal tasks than for languages with segmental writing systems.

When the prime word is in a sentence in English, there are different effects on identity priming and semantic priming, i.e. while identity priming is consistent in sentence contexts, semantic associative priming is not (Norris et al., 2006). For example, after being presented with an auditory sentence such as (75), participants were still faster to respond to the identical target *seat*, relative to a control condition, but not to the semantic associate *chair*. Norris et al. (2006) then tested a number of variables that could affect semantic associative priming in sentence contexts. They found that this priming was only significant when the sentence was truncated immediately after the prime word, or when there was a contrastive accent in the sentence, whether or not this was on the prime word. They speculated that the latter result may be because the accent caused the listeners to attend to the sentence as a whole more

carefully. They also suggested that the contextual relevance of the target to the meaning of the prime in the sentence may affect priming, although they do not directly link this to focus.

(75)   He gave up the seat for me out of some form of courtesy.

There is further evidence showing that sentence context affects lexical retrieval of semantic associates to ambiguous words (Swinney, 1979). For instance, for ambiguous primes (*bug*), responses to words linked to both meanings (e.g., *spy* and *ant*) in both neutral (e.g., (76)) and biasing contexts (e.g., (77)) were facilitated in a cross-modal lexical decision task when the target word (e.g., *spy* or *ant*) was presented immediately following the prime word (e.g., *bug*). However, when the target word was presented three syllables (approximately 750 ms to 1000 ms) after the prime word, only the contextually appropriate meaning, i.e. *ant*, was primed. This shows that the priming of the contextually inappropriate meaning, i.e. *spy*, decayed, as it was not relevant for the interpretation of the utterance.

(76)   The man was not surprised when he found several bugs in the corner of his room.
(77)   The man was not surprised when he found several spiders, roaches, and other bugs in the corner of his room.

In a study involving Italian materials, Tabossi (1988) further found that sentence context affects lexical retrieval of semantic associates to unambiguous words. For instance, facilitation for the target *fat* was found in sentences such as (79) that are biased towards a related aspect of the meaning of the unambiguous prime *butter* compared to non-biased context as in (78). Tabossi (1988) did not find reliable semantic priming in the sentences that were biased toward an aspect of the meaning unrelated to the target.

(78)   To soften it, the woman heated a piece of butter.
(79)   To follow her diet, the woman eliminated the use of butter.

All of these studies indicate that semantic priming is context-sensitive. In other words, these meaning-biased sentences, e.g. (77) in Swinney (1979) and (79) in Tabossi (1988), served as an 'effective context' for the lexical access of semantic associates (Foss & Ross, 1983; Williams, 1988).

More recently, Braun and Tagliapietra (2010) showed that prosody (with contrastive prominence on the prime word) can also serve as an effective context, but the effect of contrastive prominence seems to be related to contrastive alternatives only. They also provided a key insight into why semantic priming effects were different in or out of sentence contexts, as reported by Norris et al. (2006): whether the prime word is contrastively focused or not. According to the alternative semantics theory discussed in section 2.1, contrastive focus marking should imply alternatives to the focused word. Hence, in a cross-modal lexical decision task, the activation of alternatives should be facilitated when the prime in a spoken sentence is contrastively accented, compared to when it is not. Braun and Tagliapietra (2010) compared alternative priming (priming of contrastive alternatives) and general semantic priming (priming of noncontrastive associates) of the sentence-final object word (e.g., *flamingo*) in sentences with one of two intonation patterns in Dutch: contrastive, with contrastive accents on both the first and last content word in a sentence (e.g., (80) and (82)); and neutral, with noncontrastive accents on these words (e.g., (81) and (83)):

(80)　　　In **Florida** he photographed a **flamingo**. (Contrastive, related prime)

(81)　　　In Florida he photographed a flamingo. (Neutral, related prime)

(82)　　　In **Florida** he photographed a **celebrity**. (Contrastive, control prime)

(83)　　　In Florida he photographed a celebrity. (Neutral, control prime)

In their first experiment, testing the role of contrastive accenting on the lexical activation of contrastive alternatives, participants heard the prime sentence and then saw a target word (e.g., *pelican*), about which they had to make a lexical decision. The target word, e.g. *pelican* was either related to, and was a contextual alternative, to the object in the prime sentence, e.g. *flamingo* in (80) or (81); or it was unrelated to the object, e.g. *celebrity* in (82) and (83). Participants were quicker to decide that the target *pelican* was a real word after hearing the related prime *flamingo* compared to the unrelated control prime *celebrity* when the sentence-final object was contrastively accented (alternative priming). However, there was no time advantage when the sentence-final object (*flamingo* or *celebrity*) was not contrastively accented. Their second experiment examined the priming of noncontrastive associates (e.g., *pink*) that were semantically related to but not plausible replacements for *flamingo*. They found that noncontrastive associates were weakly primed regardless of the prosody. The priming of contrastive and noncontrastive associates was not directly compared in the two experiments.

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Husband and Ferreira (2016) also looked at alternative and semantic priming in sentences with either contrastive or neutral accents in English, finding a somewhat different pattern of results to Braun and Tagliapietra (2010). In their study, the prime word was a sentence-medial word (e.g., object noun or adjective), for example, *sculptor* in the following two sentences:

(84)   The museum thrilled the **sculptor** when they called about his work.
           (Contrastive)
(85)   The museum thrilled the sculptor when they called about his work.
           (Neutral)

While participants were hearing the sentence, they saw a target which was either a contextual alternative (e.g., *painter*) or a noncontrastive associate (e.g., *statue*) to the prime word (*sculptor*). Husband and Ferreira (2016) were interested in the time course of activation of the prime, so they manipulated the interstimulus interval (ISI)[9] in their two experiments. In the first experiment, the ISI was 0 ms, which allowed researchers to tap into immediate processing. This was similar to Braun and Tagliapietra (2010). However, as the prime word (sentence-medial object or adjective) was non-final, lexical decisions were carried out while the sentence was still playing. Husband and Ferreira (2016) found that, when the ISI was set at 0 ms, and when the prime word was contrastively accented there was facilitation of both contrastive and noncontrastive targets, but when the prime word was unfocused (the neutral accent condition) contrastive associates were primed, but not noncontrastive associates. This last result is argued to show that noncontrastive associates were less strongly related to the semantic context and had less time to be activated (unfocused primes were shorter than focused primes). When the ISI was set at 750 ms, this allowed the researchers to tap into later processing. When the prime word was contrastively accented, the noncontrastive associates were responded to at the same speed as unrelated items while alternatives were faster, showing that there was priming only for the alternatives. When the prime word had a neutral accent, both contrastive and noncontrastive associates were faster than the controls. Husband and Ferreira (2016) claimed that this shows all semantically related words are initially

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[9] Husband and Ferreira (2016) called this stimulus onset asynchrony (SOA) to indicate the time from the **offset** of the prime word and the **onset** of the target. Following American Psychological Association (APA)'s definitions (VandenBos, 2007), I differentiate these two terms (SOA and ISI) in this thesis, and use SOA to indicate the time from the **onset** of the prime word to the onset of the target word and ISI to refer to the time between the **offset** of the prime word and the onset of the target word.

activated, but in later processing contrastive accenting prompts a selection mechanism whereby noncontrastive associates are rapidly deactivated, while contextual alternatives remain activated as they are likely to be relevant for interpretation.

Basically, both Braun and Tagliapietra (2010) and Husband and Ferreira (2016) agreed that focus (marked with contrastive accents) implies alternatives. The key difference between the two studies is the role that focus plays in the lexical activation of contrastive and noncontrastive associates. Braun and Tagliapietra (2010) suggested an accommodation mechanism that enables listeners to generate contrastive alternatives that had potential relevance to the interpretation of the context. For the lexical activation of noncontrastive associates, they did not offer any specific mechanism for the result, and attributed it to general semantic priming. In contrast, Husband and Ferreira (2016) proposed a selection mechanism, based on the evidence observed in their data, by which focus deactivates noncontrastive associates, leaving contrastive alternatives as the only associated items that are primed in the later processing as they are part of the alternative set. However, it should be noted that there were a number of other differences between the studies, including the details of how the contrastive/neutral accenting conditions were manipulated, the time course of when the target was presented, the position of the prime word in the sentence, the word class of the prime word, and whether they held the target constant and manipulated the prime by condition, or held the prime constant and manipulated the target. An overview of the role of contrastive/noncontrastive prominence in priming contrastive alternatives/noncontrastive associates in Braun and Tagliapietra (2010) and Husband and Ferreira (2016) is shown in Table 1.

Table 1 An overview of the role of contrastive/noncontrastive prominence in priming contrastive alternatives/noncontrastive associates in Braun and Tagliapietra (2010) and Husband and Ferreira (2016). + indicates priming relative to the unrelated control; - indicates no priming relative to the unrelated control; ContrasProm = contrastive prominence; NonContrasProm = noncontrastive prominence; Alt = alternative; Associate = noncontrastive associate.

	Language	ISI = 0 ms		ISI = 750 ms	
Braun and Tagliapietra (2010)	Dutch	ContrasProm-Alt:	+	#	
		ContrasProm-Associate:	+		
		NoncontrasProm-Alt:	-		
		NoncontrasProm-Associate:	+		
Husband and Ferreira (2016)	English	ContrasProm-Alt:	+	ContrasProm-Alt:	+
		ContrasProm-Associate:	+	ContrasProm-Associate:	-
		NoncontrasProm-Alt:	+	NoncontrasProm-Alt:	+
		NoncontrasProm-Associate:	-	NoncontrasProm-Associate:	+

Recently, there has also been interest in the role of focus particles (e.g., *only*, *also* and *even*) in processing focus alternatives (Byram-Washburn, 2013; Gotzner, 2017; Gotzner et al., 2016). For example, in German, Gotzner et al. (2016) used both probe recognition tasks and cross-modal lexical decision tasks, with a context sentence such as that in 0 in German introducing a set of three alternatives, i.e. *peaches*, *cherries* and *bananas*.

(86)   Context: In the fruit bowl, there are peaches, cherries, and bananas. I bet Carsten has eaten cherries and bananas.

(87)   Critical sentences No, he _ \only \even ate [**peaches**] $_{H*}$.

After hearing the auditory sentences as in (86) and (87), participants saw a target word and had to confirm or reject as quickly as possible whether the word had appeared in the context or not (probe recognition task) or whether the word was a real word or not (lexical decision task). The target words were mentioned alternatives (e.g., *cherries*), unmentioned alternatives (e.g., *melons*) and unrelated controls (e.g., *clubs*). They found that focus particles slowed the recognition times for mentioned alternatives and unmentioned alternatives in both tasks. They attributed the result to an interference effect of focus particles, due to increased competition between members of the alternative set.

The above-mentioned studies are concerned with alternatives that were in the same semantic category as the target word, i.e. semantic associates. In a post-hoc analysis of a cross-modal lexical priming study using German materials, Gotzner (2015) showed that unrelated alternatives, i.e. words that were possible replacements of a focused expression but were not related to the prime word, e.g. *lychees* to *jackets* in (89), were also part of the alternative set considered by listeners.

(88)   Context: There are shirts, trousers, and jackets in the catalogue. I bet Matthias has bought shirts and trousers.

(89)   Critical sentence: He bought [**jackets**]$_{H*}$.

This sentence was preceded by a context like (88), which would potentially restrict the set of alternatives to be clothing-related items. But her results indicated that unrelated alternatives were recognised as equally quickly as unmentioned alternatives, and they both were recognised more quickly than unrelated non-alternatives, and more slowly than related mentioned alternatives. Therefore, her finding suggested that listeners considered a broader set of alternatives, which supported the permissive view of the alternative set (as per Rooth, 1992).

This result is relevant to the design in Braun and Tagliapietra's study, where the target word was always the same word and the alternative and unrelated control words served as different objects in the prime sentence. This would potentially make the unrelated control condition an unrelated alternative condition, i.e. *pelican* was an alternative to *celebrity*. If Gotzner's (2015) analysis is correct and if Braun and Tagliapietra (2010) had included unrelated non-alternatives, these items would probably have been recognised much more slowly than related alternatives, as they would likely have been slower than the unrelated alternatives.

2.3.2.2 Focus in long-term memory

Another line of work has shown that focus facilitates memory for alternatives in discourse contexts (Fraundorf et al., 2013; Fraundorf et al., 2010; Spalek, Gotzner, & Wartenburger, 2014). One of the early studies was by Fraundorf et al. (2010). They found that focus improved not only memory for focused words but also memory for discourse-mentioned alternatives to focused words. In Fraundorf et al. (2010), listeners first heard a discourse containing two items in a contrast set such as (90). They then heard a continuation sentence

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that only mentioned one alternative from the set with the critical word *British* said with either an H* (noncontrastive) accent as in (91) or L+H* (contrastive) accent as in (92).

(90)   Context: Both the British and the French biologists had been searching Malaysia and Indonesia for the endangered monkeys.

(91)   Finally, the [**British**]$_{H*}$ spotted one of the monkeys in Malaysia and planted a radio tag on it.

(92)   Finally, the [**British**]$_{L+H*}$ spotted one of the monkeys in Malaysia and planted a radio tag on it.

In a forced-choice task after all the stories were presented (approximately 30 minutes), participants were more accurate in correctly recalling that it was the British who spotted the monkey when *British* was contrastively accented. As it was not clear whether the observed facilitation was due to the positive effect of L+H* on the memory of the word that carried the accent, or the negative effect of L+H* on other parts of discourse, or both, Fraundorf et al. (2010) ran a second experiment using the same technique. The experiment included conditions that had L+H* on two words in the discourse, or on one word or on none. They did not find any evidence that L+H* impaired memory for the words that did not carry the accent in the discourse. Therefore, they concluded that contrastive accenting facilitates memory for focused words.

In their third experiment, Fraundorf et al. (2010) tested the rejection of alternatives by including one more alternative that was not mentioned in the discourse (e.g., *Portuguese*). A true-false verification task was performed the following day. They found that contrastive accents facilitated the rejection of mentioned alternatives, but did not facilitate the rejection of unmentioned alternatives. Fraundorf et al. (2010) therefore proposed a *contrast representation account* to explain the finding that not only does pitch accenting encode the representations of focused words better, but it also leads to additional encoding of the alternatives in that established contrast set. In other words, contrastive pitch accenting results in better encoding for what did not happen in relation to the focus. Fraundorf et al. (2010) later found similar effects in a reading task when font emphasis (e.g., capitals and italics) was used to mark focus.

Spalek et al. (2014) further found similar effects with focus particles using delayed recall tasks in German. In their experiments, participants listened to short dialogues containing a

two-sentence context as in (93) and a critical continuation sentence that had either the inclusive scalar particle *even* or the exclusive particle *only* or none as in (94).

(93)   Context: There are shirts, trousers, and jackets in the catalogue. I bet Matthias has bought shirts and trousers.

(94)   Critical sentences: No, he _ \only \even bought [jackets]$_{H*}$.

Participants later performed a delayed recall task (with nine intervening discourses, approximately four minutes) on the elements mentioned in the story. Spalek et al. (2014) found that both types of particle increased memory for the alternatives compared to the no particle condition, which was consistent with the *contrast representation account* that focus leads to a better memory of alternatives to focused words. Combining the research on focus particles in initial processing using recognition tests and cross-modal lexical priming tasks presented earlier on, it is suggested that focus particles have an early processing cost but a later facilitatory effect.

2.4 Summary and key open questions in the literature

Summarizing, the studies cited above showed that focus marking plays a crucial role in focus perception and language processing. Mainly and most importantly to this thesis, the literature has shown the effects of focus marking in the following three areas. First, words with focus marking update the QUD, so they should be perceived as the focus by listeners. Second, words with focus marking are encoded and remembered better because focus marking enhances the salience of focal information, so false alternatives to focus-marked words should be more easily rejected, and focused words should be more activated in listeners' mental lexicon. Third, focus marking signals the presence of contextually-relevant alternatives to focused words, so focus alternatives should be accessed more easily. These three areas will be elaborated further below.

To elaborate the first area, one of the most important functions of QUD-focus, as discussed in section 2.1, is to update the common ground. Speakers use various focus cues, e.g. prosodic and/or syntactic, to mark the most important information that updates the QUD, and to help listeners identify focal information. Previous research has shown that a 'mismatch' between the intended focus of the QUD and the prosody of an answer results in lower naturalness ratings in judgements about whether a sentence is prosodically (or syntactically) appropriate

to an utterance (Clifton & Frazier, 2016; Welby, 2003). For example, *captain* in (95) is marked by prosodic prominence, and it updates an implicit QUD like (96). It would be odd if the presupposed information were focus-marked, i.e. if (95) were preceded by (97), and this would cause processing difficulties (Baumann & Schumacher, 2012; Cutler et al., 1997; Terken & Nooteboom, 1987).

(95)   The [**captain**]F put on the raincoat.

(96)   Who put on the raincoat?

(97)   What did the captain put on?

Prosodic prominence has been well tested as an effective cue that listeners use to locate focus across many languages (e.g., Botinis et al., 1999; Breen et al., 2010; Lee et al., 2015). However, morphosyntactic means of marking focus, e.g., clefts, have received far less attention in the psycholinguistic literature. Clefting is claimed to mark focus in Mandarin, but it has not been well tested whether listeners perceive clefts as focus marking, and what the relative importance is of morphosyntactic and prosodic cues in the perception of focus. Also, across languages, when multiple focus cues fall on one word, it is very likely that the word will be perceived as focal. However, it becomes much more interesting if the cues do not fall on the same word, which has not been looked at much (see Calhoun et al., 2019, for English).

The second area concerns the role of focus-marking in better encoding and remembering focused words. The QUD-focus updates the common ground, which should affect how listeners process focal information. Focus marking enhances the salience of focal information so that it is more attended to and better remembered (Cutler, 1976; Cutler & Fodor, 1979; Fraundorf et al., 2013; Fraundorf et al., 2010; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019; Sanford et al., 2006). The role of QUD-focus in the activation of focused words has been supported by evidence from various psycholinguistic studies, e.g. phoneme-monitoring and lexical decision tasks (Akker & Cutler, 2003; Cutler, 1976; Cutler & Fodor, 1979; Ip & Cutler, 2017; Norris et al., 2006). In addition, focus marking also helps listeners encode focal information better, as opposed to presupposed information. Therefore, compared to new information, presupposed information should be more difficult to correct.

Similar to the first area, it is not yet clear what cues listeners use to encode focal information beyond prosodic prominence when processing a discourse. What is the role of clefting in processing focal information? There have been a few studies that have looked at the effect of clefting on memory for focused words, but it is not clear whether clefting also facilitates more immediate processing (Birch et al., 2000; Birch & Garnsey, 1995; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019). The role of clefting, as well as its interaction with prosodic prominence has not been investigated much in Mandarin.

The third area concerns the role of focus-marking in activating and remembering alternatives to focused words. The role of contrastive focus in the activation of contrastive alternatives has been supported by a rapidly growing body of psycholinguistic research carried out in Germanic languages (e.g., Braun & Tagliapietra, 2010; Gotzner, 2017; Gotzner et al., 2016; Husband & Ferreira, 2016). Two ways in which focus indicates alternatives have been explored in the recent psycholinguistic literature are: (i) how focus marking constrains the interpretation of the discourse in context (e.g., Gotzner, 2017); and (ii) whether focus marking generates alternatives out of context (e.g., Braun & Tagliapietra, 2010; Husband & Ferreira, 2016).

However, the existing studies that have been discussed in section 2.3 are mostly concerned with focus marked by contrastive accents, so it is unclear whether the effect of contrastive focus is caused by greater phonetic prominence of the word or (contrastive) focus itself. It is still debated about what kind of focus (any focus, any pitch accents, only contrastive focus, or only contrastive prominence) should generate alternatives, as discussed in section 2.1.2.1 (Calhoun, 2010a; Kügler & Gollrad, 2015; Rooth, 1992). Therefore, it remains important to see whether other types of focus marking (other than contrastive prominence) are able to prime alternatives in Mandarin, e.g., clefting which is claimed to mark contrastive focus in Mandarin (see section 2.1.2.3).

More importantly, a great deal of research has shown a link between prosodic prominence in marking focus and its role in facilitating language processing. Two interesting questions arise here: which kind(s) of focus marking do listeners make most use of in perceiving focus, and how do the relative weights of focus types relate to degrees of facilitation in language processing? The relative roles of prosody and syntax in these aspects of speech processing are not clear. This thesis aims to answer these questions about Mandarin. This expands our

knowledge of these aspects of speech processing to a different language and language family, rather than Germanic languages that most studies have investigated. Mandarin also provides an interesting avenue for investigation because it uses the expansion of pitch range to mark contrastive prominence, rather than pitch accenting like in Germanic languages. This allows us to test whether the processing advantages of focus are due to specific pitch contours, or prosodic prominence in general.

In the following chapter, I first identify the research questions derived from the literature, and then give an overview of a series of psycholinguistic experiments set up to answer the research questions. As the experiments involved quantitative methods (reaction times, accuracies and rating scores), I also lay out the statistical analyses that were used in the analysis of the data collected from these experiments.

Chapter 3 Research questions and analysis methods

This chapter sets out the key research questions to be addressed in this thesis, drawing on the literature review in the last chapter. Five experiments, designed to investigate the research questions, are then briefly outlined. The chapter then presents an overview of the statistical models, model predictors and selection procedures that were used to analyse the data from the five experiments.

3.1 Research questions

As stated in section 2.4, the overarching research goal of this thesis is to investigate the effects of focus on spoken language processing in Mandarin. This thesis tests the link between the relative weights of prosodic and syntactic cues in perceiving focus, their degrees of effectiveness in encoding discourse information (i.e., focused words and focus alternatives) and their ability to activate discourse information. This is referred to as the *focus marking-language processing* link. As introduced in section 1.1, focus marking results in a better encoding and stronger activation of discourse information. The two different terms, encoding and activation, are used to refer to different levels of processing. In this thesis, Experiment 3, which was designed to investigate the role of focus in encoding, taps into the discourse-level representation of discourse referents. This is investigated through a task in which participants need to build a mental representation of the entire discourse, and reject the false alternative given the rest of the information in the discourse. Experiments 4A and 4B, which were designed to investigate the role of focus in word activation, tap into the word-level representation of discourse referents. This is investigated through a lexical decision task, which is a word-level judgement. Participants do not need to build a mental representation of the entire discourse to make lexical decision judgements, although discourse referents, especially focus alternatives, are activated as a result of the sentence prime being processed as part of a discourse.

There are three main research questions related to the *focus marking-language processing* link (RQs 1-3), addressing each of the three components of the link. These research questions are then broken down to multiple sub-questions in each corresponding chapter.

RQ 1. What are the relative weights of prosodic and syntactic focus cues in the perception of focus in Mandarin? **(Chapter 5)**

RQ 2. What is the relative effectiveness of prosodic and syntactic focus cues in encoding discourse information in Mandarin? **(Chapter 6)**

RQ 3. What is the relative effectiveness of prosodic and syntactic focus cues in activating discourse information in Mandarin? **(Chapter 7)**

3.2 Overview of the experiments

In order to find out answers to the research questions, five experiments were conducted. All experiments were carried out in accordance with the requirements of Victoria University of Wellington Human Ethics Committee (approval number 24735) with written informed consent from all participants (See Appendix 2 for a copy of the approval letter; Appendix 3 and Appendix 4 for a sample of the Participant Information Sheets in both the original Mandarin version and the English translation; Appendix 5 and Appendix 6 for a sample of the Participant Consent Forms in both the original Mandarin version and the English translation.).

The first experiment, a web-based relatedness rating task described in Chapter 4, aimed to help select plausible target words (prime words, contrastive alternatives, noncontrastive associates and unrelated controls) for the next four psycholinguistic experiments described in Chapters 5-7. The scores from this experiment were also used as a control variable for the relatedness between different target words in the analysis of the two lexical decision tasks described in Chapter 7. Ratings (*1* 'not related at all' to *7* 'highly related') were recorded as an indication of relatedness.

The second experiment, described in Chapter 5, used a question-answer appropriateness rating task. It aimed to answer the first research question, addressing the first component of the *focus marking-language processing* link: i.e. the relative effects of prosodic and syntactic cues on *perceiving* focus. This experiment was based on the QUD-focus definition that the focus is the part of the utterance which is new in relation to the current QUD (see section 2.1.1). This was also to check the assumption in the theoretical literature that both prosodic and syntactic cues mark focus in Mandarin. Ratings (*1* 'not appropriate at all' to *7* 'extremely appropriate') were recorded as an indication of appropriateness.

The next three experiments (Experiments 3, 4A and 4B) went on to test the relative effects of prosodic and syntactic focus cues on language processing in Mandarin. Experiment 3,

described in Chapter 6, was a speeded false alternative rejection task and aimed to answer the second research question. It addressed the second component of the *focus marking-language processing* link: i.e. the relative effects of prosodic and syntactic cues on listeners' *encoding* of discourse information. The experiment probed focus processing following from both the QUD-focus and the contrastive focus types of focus. Focus marking enhances the salience of focused words and alternatives to focused words in relation to the other elements in the proposition. Therefore, false alternatives to words should be easier to reject if the words are focus-marked, compared to when they are not. Both the responses to 'false alternative' questions and the response times to answer the questions were collected.

The final two experiments (Experiments 4A, 4B, described in Chapter 7) used the cross-modal lexical priming paradigm, a type of lexical decision task. It aimed to answer the last research question, addressing the third component of the *focus marking-language processing* link: i.e. the relative effects of prosodic and syntactic cues in *activating* discourse information. The experiment also probed focus processing by both QUD- and contrastive types of focus. These two types of focus are predicted to have processing effects on the activation of focused words and alternatives to focused words. Therefore, lexical decisions to words and their alternatives should be faster if the words are focus-marked, compared to when they are not. Both the lexical decision choices and the response times to make those decisions were collected.

3.3 Statistical analyses

To analyse the data collected from the five experiments outlined above, three types of statistical analyses were carried out using the *R* statistical software (R Core Team, 2018). I first present a brief introduction to the statistical analyses, and then a description of the model predictors and the selection procedure used to arrive at the optimal model.

3.3.1 Statistical models

Due to the diverse nature of the data collected, three main types of mixed effects regression models were used: cumulative link models, linear models and logistic models. All three model types were mixed effects models in that they included both fixed effect and random effects. Mixed effects models, rather than traditional *Anova* methods, have recently become widespread in the field of psycholinguistics due to their advantage in accounting for crossed random effects for subjects and items (Baayen, 2008; Baayen, Davidson, & Bates, 2008). The models and their relevant terms are explained briefly below.

3.3.1.1 Cumulative link mixed models

As the dependent variables of Experiments 1 and 2 were ordinal ratings, i.e. responses *1-7* on the scale ('2' means a higher response than '1', but not necessarily twice as high as '1'), the cumulative link mixed model (CLMM) in the *ordinal* package (Christensen, 2015) was used to analyse and interpret the data.

3.3.1.2 Linear mixed effects regression models

The response times (RTs) that were collected from Experiments 3, 4A and 4B were continuous, so the linear mixed effects regression (LMER) in the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015) was used. A linear relationship was modelled for RTs with various predictors. If the RTs were not normally distributed, they were transformed. The three most commonly-used transformations in the literature were compared: log transformation, inverse normal and square root transformation (Osborne, 2003). The best transformation that had the highest correlation in a quantile-quantile plot (qqplot) of the distribution was chosen. The y-axis of the qqplot plots the transformed RTs and x-axis plots quantiles of the standard normal distribution. The transformed RTs were used as the dependent variable in the LMER models.

3.3.1.3 Logistic mixed effects regression models

For the analysis of how the accuracy (coded binomially as 0 [incorrect] or 1 [correct]) of a response was predicted by various factors for Experiments 3, 4A and 4B, the logistic mixed effects model, a form of generalized linear mixed effects model (GLMER) (family: binomial) in the *lme4* package, was employed.

3.3.2 Model predictors and selection procedures

3.3.2.1 Predictors

Below is an overview of the predictors that were considered in the analysis of the experimental results in this thesis. For the sake of convenience in describing predictors, they were grouped into three categories: key experimental factors, participant factors and item factors.

Key experimental factors

The key experimental factors were the factors involved in the manipulation of the critical stimuli, e.g. stress (or prosodic prominence) location (subject, object), syntactic structure

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(canonical word order, subject cleft, object cleft), question type (subject question, object question), word position (subject, object), and target word type (identical, contrastive alternative, noncontrastive associate, unrelated control). The key experimental predictors differed across the experiments, so they will be specified for each model where appropriate.

Participant factors

Although I tried to recruit a homogeneous group of participants, I considered a few participant factors that might be relevant (see the Participant Information Questionnaire in Appendix 7 and Appendix 8 in both original Mandarin version and the English translations). Preliminary analyses of the participant factors showed that English proficiency (or the daily use of English/Mandarin), hometown and age were not significant factors in any of the experiments.

In what follows, I describe how I selected participants, which influenced the distribution of participant factors. For all the five experiments reported in this thesis, I had a total of 418 native Mandarin speakers from mainland China (Experiment 1: 167; Experiment 2: 36 participants; Experiment 3: 36 participants; Experiment 4A: 80 participants; Experiment 4B: 99 participants). I tried to recruit more or less homogeneous groups regarding participants' age, hometown and English proficiency, in order to minimize the effects that these factors might have, although I did not have specific predictions about how these factors would play a role. A number of participants' background factors were collected for all the experiments (see Appendix 7 and Appendix 8).

Experiment 2 was run in New Zealand (36 participants). Experiments 3-4B were run at Henan Polytechnic University (a total of 215 participants), and all participants were from the student community of that university. The participants in Experiments 3-4B had a similar background to the participants in Experiment 1 as they were from the same university, so it was assumed that the relatedness scores (Experiment 1) collected from people from a similar background would be relevant to the later experiments. However, the participants in Experiments 3-4B were not the same as those in Experiment 1, as I did not want them to have any previous exposure to the stimuli, especially for Experiments 4A and 4B.

English proficiency For Experiments 3-4B, which were conducted in China, the self-reported scores from the College English Test (CET) were used to determine participants' English

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proficiency. CET is a national English test for university students in China with two levels (CET4 and CET6), which takes places twice per year. CET6 is a higher level than CET4. One has to pass CET4 to be able to register for CET6. For the people who had not passed CET4 or had not taken CET4, their English proficiency was coded as none. Therefore, English proficiency appeared as a factor that had three levels: none, CET4, CET6. Seventy-four participants had CET6; 86 participants had CET4; 55 participants had none. CET was not collected for participants that completed Experiments 1 and 2. English proficiency (none, CET4, CET6) was treated as an ordered variable.

For the participants that were recruited for Experiment 2 in New Zealand, their International English Language Testing System (IELTS) scores were collected, as CET may not apply to them. IELTS scores are between 0 and 9 with intervals of 0.5 (e.g. 4.5, 5.5). The 36 participants had scores ranging from 5 to 7.5 (mean = 6.3, SD = 0.7). The IELTS scores were treated as a continuous variable.

Hometown Hometown appeared as a categorical variable. As the link to Experiment 1 was sent to university students in Henan province, and Experiments 3-4B were carried out in Henan province, a relatively small number of participants were not from Henan province (Henan province: 300 participants; Others: 112).

Considering that the object clefts with pre-object 的 'DE' may only work for Northern Mandarin speakers (see section 2.1.2.3), in the recruitment of my participants, I purposely did not recruit people from Taiwan. The participants in this research were monolingual or near monolingual Beijing Mandarin speaking participants (not counting dialects). The participants reported that they use Mandarin in all or most of their daily communication.

Age Age appeared as a continuous variable that recorded participants' self-reported age, ranging from 16 to 40 (mean = 22; SD = 2.9).

Sex Biological sex was a categorical factor with two levels: female and male. In total, I had 269 females and 149 males.

3.3.2.2 Item factors

In psycholinguistic experiments, especially lexical decision tasks (Experiments 4A and 4B), characteristics of the test items have been shown to affect lexical decision times. The item factors that were considered in this thesis were the log frequency of visual target words (e.g., Altarriba & Basnight-Brown, 2007; Braun & Tagliapietra, 2010), the transformed RT of the previous trial (the transformation was the same as the transformation of the dependent variable) (e.g., Braun & Tagliapietra, 2010), the accuracy of the response to the previous trial and whether the target of the previous trial was a real word (e.g., Braun & Tagliapietra, 2010), the centred position of a trial in the sequence of trials across the experiment (e.g., Braun & Tagliapietra, 2010; Gotzner, 2017), and the numbers of strokes (basic motions to write Mandarin characters) and radicals (building blocks of Mandarin characters) in the first and second character in the disyllabic target words (e.g., Peng & Wang, 1997). The number of strokes and radicals may have an effect, but the effect of strokes may only happen for low-frequency words (Peng & Wang, 1997). From this list, only the item factors relevant to each experiment were included.

The scaled variables (log frequency, centred trial etc.) were used. For example, word frequencies (range = 1.49 - 333.15 per million) were log transformed (range = 1.699 - 4.0483) as the raw frequencies were not normally distributed. In addition, in some models some of the variables were scaled to be on a similar scale as other independent variables in the same model, as variables varying highly in range resulted in model computation errors.

3.3.2.3 Model selection and analysis procedures

A series of mixed effects regression models was built to test how the dependent variables (i.e., ratings, RTs and accuracy) were affected by a number of factors. The fixed effects of initial models included key experimental predictors, participant factors and item factors, appropriate to each model. In addition to the fixed effects, following Barr, Levy, Scheepers, and Tily (2013), the maximal random effect structure, motivated by the literature and justified by the data, included intercepts for participants and target words, random slopes for trial (position in the experiment) by participants and by items and random slopes for the interactions between the key experimental factors by participants and by items, appropriate to each model.

If the initial model did not converge, the model was simplified by reducing random structures, i.e. taking out the slopes that had the lowest variance scores until the model converged. When the model converged, for LMERs, the *step* function in the *lmerTest* package (Kuznetsova, Brockhoff, & Christensen, 2017) was used to eliminate non-significant fixed and random effects (or the *Anova* function in the *car* package (Fox et al., 2012) for the elimination of fixed effects). The alpha-level we used for *step* function elimination was 0.1. For CLMMs, the *Anova.clmm* function in the *RVAideMemoire* package (Hervé, 2015) was used to eliminate non-significant fixed effects, and the standard R function *anova* was used to eliminate non-significant random slopes by comparison of models with and without one slope. For GLMMs, the *Anova* function in the *car* package was used to eliminate non-significant fixed effects, and *anova* was used to eliminate non-significant random effects. The *anova* comparison returns a likelihood ratio statistic with a chi-square distribution and a p value that indicates the significance of that factor (e.g., $p < 0.05$ indicates the factor compared is significant, otherwise not). If the p value was smaller than 0.1 (the so-called 'marginal' effect [when $0.05 \leq p < 0.1$]), the model with lower Akaike information criterion (AIC) was chosen as a better model. If the p value was larger than 0.1, the simpler model was chosen. After settling on the simplest fixed effects structure including all significant fixed effects, the random slopes that had been eliminated were added back to the model again as a sanity check to avoid the possibility that random effects were unnecessarily removed. In the end, only the factors that significantly or marginally significantly increased the model's fit were kept. The key predictors were always retained in the model, as they were the central interest of the study.

Further, if it was necessary to know whether two conditions were different from each other, according to a priori predictions, the *emmeans* function in the *emmeans* package (Lenth, Singmann, Love, Buerkner, & Herve, 2019) was used to carry out post-hoc planned comparisons for all three model types. Conducting further comparisons even when there is no significant interaction is also meaningful to help explore specific research questions (Wei, Carroll, Harden, & Wu, 2012). As multiple pairs were involved, in order to avoid false positives (incorrectly rejecting the null hypothesis), an adjustment was used. As the *bonferroni* adjustment is sometimes too conservative, especially when there are a lot of pairs of comparison (e.g., more than 15 pairs in Experiment 3), in order to avoid incorrectly accepting the null hypothesis, *fdr* adjustment was used. Finally, *ggplot* in the *ggplot2* package

(Wickham, Chang, & Wickham, 2016) was used to plot the predicted means for LMERs, GLMMs and CLMMs when desired.

Chapter 4 Context and lexical relatedness judgement

4.1 Background

Experiment 1, reported in this chapter, served as a norming study to measure the relatedness between pairs of words, aiming to help select stimuli for the subsequent experiments, especially Experiments 4A and 4B in this thesis which investigated the role of focus in the lexical activation of contrastive alternatives and noncontrastive associates in Mandarin. In this section, I briefly address the importance of controlling relatedness in lexical priming studies and then introduce types of semantic relatedness, including contrastive alternatives and noncontrastive associates. I then discuss how different types of relatedness might be affected by a context sentence, and how this might matter to how we think about priming. This led to the development of Experiment 1 in this chapter.

As in the current thesis, much psycholinguistic research uses a priming paradigm to measure lexical activation. Priming paradigms depend on prime and target words being related. The extent of the relatedness between prime and target is either used as an experimental factor or needs to be controlled across stimuli (e.g., Braun & Tagliapietra, 2010; Husband & Ferreira, 2016). In the current thesis, I focus on two types of semantically related words, contrastive alternatives and noncontrastive associates, as they are the most relevant. As mentioned in section 2.1.1, contrastive alternatives to a word are words that are related to and can replace that word in a sentence (e.g., *sailor* as an alternative to *captain* in 'The captain put on the raincoat'). Noncontrastive associates are words that are related to, but cannot replace, that word in a sentence (e.g., *deck* as a noncontrastive associate to *captain* in 'The captain put on the raincoat'). This thesis tests the priming of contrastive alternatives, but noncontrastive associates needed to be included in later experiments in order to separate the priming effect of (contrastive) focus from general semantic priming. The relatedness between the prime word and the alternative and between the prime word and the noncontrastive associate needs to be controlled, so that differences in relatedness strengths do not confound the results.

As in Braun and Tagliapietra (2010) and Husband and Ferreira (2016), Experiments 4A and 4B in this thesis involved a whole sentence as the prime, though only the subject noun in Experiments 4A and 4B was related to the contrastive alternative and noncontrastive associate. The questions addressed in these experiments include whether context matters for priming, and if so, how it matters. It has been well established that single words activate both

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themselves and semantically related words. However, results are mixed when the prime word is embedded in a context, i.e., some studies found priming but some did not. As mentioned in section 2.3.2, the priming effect gets even more complex when other factors are involved, e.g., whether the prime sentence has a contrastive accent or not (Norris et al., 2006), or whether the meaning of the semantic associate (visual target word) is related to the meaning of an ambiguous word in a biasing context, or whether this associate is presented immediately after the auditory sentence or a few syllables later (Swinney, 1979). For example, Norris et al. (2006) found a consistent identity priming effect with single primes, and also with prime words in contexts. But semantic priming was not consistent across context conditions.

Further, the sentence context might enhance or suppress the semantic relationship between two words (Kutas & Federmeier, 2000; Swinney, 1979), i.e., stronger contextual support may result in stronger semantic priming. For example, Husband and Ferreira (2016) found that noncontrastive associates in neutral prosody were not primed with an ISI of 0 ms, and they attributed this to the fact that noncontrastive associates were less strongly related to the semantic context, as discussed in section 2.3.2. Therefore, it appears to be important to measure the relatedness between words in context.

Since there are no published association norms for Mandarin, it was necessary to run a norming experiment before the experimental stimuli could be created for the two lexical decision tasks involving priming (Experiments 4A and 4B) (see Chapter 7). This was the primary goal of Experiment 1. For Experiments 4A and 4B, sets of four words were needed, each consisting of the noun to be used as the subject (e.g., *captain*) in a test sentence (e.g., 'The captain put on the raincoat'), a word that is contrastively associated with this noun (e.g., *sailor*), a word that is noncontrastively associated with it (e.g., *deck*), and an unrelated word (e.g., *pumpkin).* The semantic relatedness between the subject noun and the other three words in the set was measured so that relatedness could be controlled in the analysis of the lexical decision tasks.

The second goal of this experiment was to investigate whether a context sentence (e.g., 'The captain put on the raincoat') affects the relatedness between different types of words (e.g., subject noun - contrastive alternative '*captain - sailor*' and subject noun - noncontrastive

associate '*captain - deck*'), in order to show whether it is important to take context into account when collecting relatedness scores in lexical priming tasks.

4.2 Research question

As well as establishing a set of relatedness norms for the Mandarin words used in subsequent priming experiments, the experiment reported here aimed to answer the following research question:

RQ 1. Does context affect the reported relatedness between different types of words in Mandarin?

4.3 Method

4.3.1 Participants

One hundred and sixty-seven native Mandarin speakers (95 females and 72 males, mean age = 22.4, SD = 2.5, age range = 16 - 38) were recruited from Henan Polytechnic University (see section 3.3.2.1 for a detailed description of participants). In recognition of their participation, they were invited to enter a prize draw for one of five phone recharge vouchers. The participants who took part in the online questionnaire did not participate in the subsequent lexical decision tasks.

4.3.2 Materials and design

First, 75 common disyllabic nouns (e.g., 船长 'captain') were extracted from the Chinese word frequency corpus SUBTLEX-CH (Cai & Brysbaert, 2010). Sixty-seven of the nouns had more than ten occurrences per million; eight had fewer than ten occurrences per million, but more than two occurrences per million. Then 75 short sentences were constructed with the nouns as the subjects (e.g., 船长穿上了雨衣 'The captain put on the raincoat'). All 75 sentences described a simple, plausible event in the past tense, using commonly occurring nouns and verbs. All 75 sentences had seven syllables (characters). All nouns in the sentences were disyllabic (i.e., made up of two characters).

As Table 2 shows, three further words were selected from the SUBTLEX-CH corpus (Cai & Brysbaert, 2010) for each sentence: a contrastive alternative (e.g., 水手 'sailor') that was semantically related to the subject noun and was considered (by myself) to be a plausible replacement for the subject noun, a noncontrastive associate (e.g., 甲板 'deck') that was

semantically related to the subject noun and was considered *not* to be a plausible replacement for the subject noun, and an unrelated control (e.g., 南瓜 'pumpkin') that was considered to be *neither* semantically related to the subject noun *nor* a plausible replacement for the subject noun.[10] The three words were not phonologically similar to the subject noun except for one quadruplet where all four words share one same character (sharing a character also means sharing phonology), e.g. *篮球* 'basketball', *足球* 'football', *球场* 'ball field', *月球* 'moon'). I also tried to ensure that the subject noun and its contrastive alternative, its noncontrastive associate and its unrelated control did not share any radicals, even though the facilitatory effect of containing the same radical has only been found for low-frequency targets in previous research (Ding, Peng, & Taft, 2004).

Table 2 Examples of test materials used in Experiment 1

Sentence
船长穿上了雨衣。
The captain put on the raincoat.
Pairs of words
subject noun - contrastive alternative: 船长 'captain' - 水手 'sailor'
subject noun - noncontrastive associate: 船长 'captain' - 甲板 'deck'
subject noun - unrelated control: 船长 'captain' - 南瓜 'pumpkin'

In addition, the contrastive alternatives, noncontrastive associates and unrelated controls were not related to, and could not replace, any other word in the sentence. All the selected target words and sentences were checked carefully for the intended relationship between the subject noun and targets as well as between the sentence and targets by myself (a native speaker) and two other native Mandarin speakers who are linguistically naïve. Among the 300 selected target words (subject nouns, contrastive alternatives, noncontrastive associates and unrelated

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[10] The rationale behind this was that, as mentioned in section 2.3.2, in a post-hoc analysis, Gotzner (2015) showed that the unrelated alternatives, i.e. words that are possible replacements of a focused expression but are not related to each other, are also part of the alternative set. For example, in Gotzner's experiment on German, she used *lychees* as an unrelated alternative to *jackets* in 'He bought jackets', preceded by a context like 'There are shirts, trousers, and jackets in the catalogue. I bet Matthias has bought shirts and trousers'. This context would potentially restrict the set of alternatives to be cloth-related items. She found that participants still consider the unrelated unmentioned alternative as part of the alternative set, supporting the permissive view of alternative set (see Rooth, 1992). Therefore, it is rather important that the unrelated items are not replaceable with the prime word.

controls), 248 had more than ten occurrences per million; 52 had fewer than ten occurrences per million, but more than one occurrence per million.

There was therefore a total of 75 quadruplets, each resulting in three pairs of ratings: subject noun - contrastive alternative, subject noun - noncontrastive associate and subject noun - unrelated control (see examples of the pairs in Table 2; a full list of stimuli can be found in Appendix 9). In order to avoid the possibility that seeing a word previously might bias responses to items containing the same word later, each participant saw only one pair in each set. Therefore, all 225 pairs were divided into three lists with 75 pairs (or trials) in each list. Each list consisted of 25 subject noun - contrastive alternative pairs, 25 subject noun - noncontrastive associate pairs and 25 subject noun - unrelated control pairs.

To test the role of the context sentence, the three lists were then repeated but with the test words now placed in their context sentences, thus resulting in another three lists. The distribution of items across these lists is shown in Table 3. All trials were randomised for each participant within each list and no more than three trials from the same type of relatedness (contrastive alternative, noncontrastive associate, unrelated control) occurred in a row. Participants were randomly assigned to one of the six lists. To encourage participants to pay more attention to the sentences, the 'with context' lists 4-6 included fifteen multiple-choice comprehension questions asking about the content (subjects, verbs and objects) of the preceding sentence, e.g., 谁穿上了雨衣 'Who put on the raincoat?' with options such as 水手 'sailor', 船长 'captain' and 小偷 'shoplifter'.

Table 3 Stimuli design in Experiment 1 (Noncontra = Noncontrastive)

	List 1	List 2	List 3	List 4	List 5	List 6
	Without context			With context		
Pairs 1-25	Contrastive	Noncontra	Unrelated	Contrastive	Noncontra	Unrelated
Pairs 26-50	Noncontra	Unrelated	Contrastive	Noncontra	Unrelated	Contrastive
Pairs 51-75	Unrelated	Contrastive	Noncontra	Unrelated	Contrastive	Noncontra

Each list was preceded by a practice phase of six trials that were similar to the critical stimuli and consisted of two trials from each relatedness type. Two additional comprehension questions were added to the practice phase of lists with context sentences.

4.3.3 Procedure

The survey was administered online using Qualtrics (Qualtrics, 2017). The link to the survey was sent to participants. After clicking the link, they were shown a screen inviting them to give informed consent to participate in the experiment. They were then asked a few demographic questions (see Appendix 7 and Appendix 8). This was followed by a set of written instructions (see Appendix 10). The instructions for the lists with and without context sentences were slightly different, as in the former, participants were encouraged to read the sentences carefully in order to be able to answer the comprehension questions correctly. A description of types of relatedness was included in the instructions in order to encourage participants to consider various ways in which words can be associated: 'Words can be related in many ways. For example, they can mean something similar (*movie* and *video*); their referents can be associated with one another (*China* and *panda*); or they can be interchangeable in a certain context (*dog* and *cat* could both fit in the sentence 'My favourite pet is a _'.)'

Participants were asked to rate the relationship between two words from 1 一点也不相关 'not related at all' to 7 高度相关 'highly related' in the absence (Lists 1-3) or the presence (Lists 4-6) of a context sentence (e.g., '船长' 和 '水手' 有多相关 'How related are 'captain' and 'sailor'?' or 在句子 '船长穿上了雨衣' 中, '船长' 和 '水手' 有多相关 'How related are 'captain' and 'sailor' in the sentence 'The captain put on the raincoat'?'). One trial appeared individually on each screen. Participants had to click the corresponding choice number *1-7* to answer. There was no time limit for each trial, but a choice had to be made in order to be able to proceed to the next trial. The survey took 8-12 minutes to complete depending on whether it had context sentences and comprehension questions or not. The lists without context sentences took less time. The entire session was in Mandarin.

Participants who wished to enter a prize draw were directed to another questionnaire where they could enter their contact information. This was to ensure the anonymity of their responses.

4.4 Results

4.4.1 Data cleaning and analysis

A total of 12,525 rating responses were recorded, 75 from each of 167 participants. Both the rating responses and the answers to the comprehension questions (for lists with sentence contexts) were recorded. Overall accuracy for comprehension questions for the lists with context sentences was 84%. Six participants who scored lower than 66.7% (i.e., below 10/15) on the comprehension questions were excluded from the analysis (see the distribution of accuracy for the participants in Figure 12). These six participants also showed little difference (less than 1 on the 7-point scale) between the average ratings for related (subject noun - contrastive alternative and subject noun - noncontrastive associate) and unrelated items (subject noun - unrelated control), suggesting that they may not have paid attention to the items. Extrapolating to the lists without comprehension questions (i.e., the lists where words were presented without sentence contexts), excluding people with small differences between related and unrelated items should be a reasonable way to exclude people who are not paying attention to the items. Further, since this was an online survey, where participants' attention to the task cannot be controlled, a stringent approach to participant elimination was used. Therefore, participants were eliminated if the difference between their mean ratings for related and unrelated items was smaller than a value that was 2 standard deviations less than the mean of the entire participant group. This resulted in the removal of a further 25 participants. The mean difference between ratings for related and unrelated items in the remaining data was 3.1 (SD = 0.9).
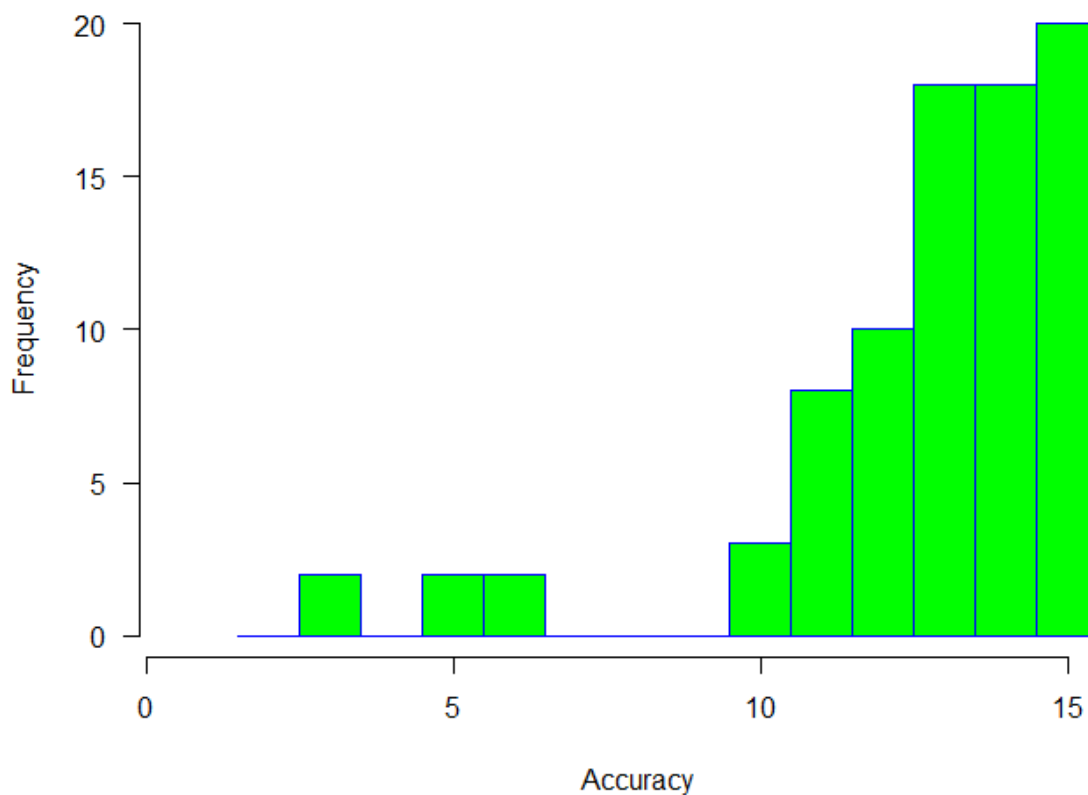
Figure 12 Distribution of the number of accurate responses to the comprehension questions (max = 15) in Lists 4-6

Further analysis was conducted on the remaining 10,200 responses to critical trials from 136 participants. Cumulative link mixed models (CLMM) using the *ordinal* package were built to test how related scores were affected by a number of factors (see the analysis method in section 3.3.1). This model type was chosen because the dependent variable was ordinal, i.e. not continuous (rating '2' is higher than '1', but '2' is not necessarily twice as high as '1'). Relatedness scores (1-7) were the ordinal dependent variable. The initial model had as fixed effects the type of relatedness between the two words in each pair (contrastive, noncontrastive and unrelated), the position of the trial in the course of the survey, and the speaker's age, sex, and hometown. The random effect structure included random intercepts for participants and items as well as random slopes for type of relatedness by participants and by items.

In the following, I will present the results in relation to the two goals stated in section 4.2: (i) to select materials for the following experiments, especially the two lexical decision tasks; and (ii) to test the effect of context on association strength. As the analysis for the second goal drew on the full dataset, I present the results for the second goal first. I then present the results regarding the first goal using partial datasets.

4.4.2 The role of context in association strength

The CLMM model was first run on the full dataset after exclusions, i.e. using 10,200 responses. Following the model selection procedures described in section 3.3.2.3, the final CLMM included the two key predictors (relatedness type and context) and their interaction in the fixed effect structure. The random effect structure included random intercepts for participants and items as well as random slopes for type of relatedness (contrastive, noncontrastive and unrelated) by items.

Table 4 ANOVA table of the final model for ratings in Experiment 1

Model: ratings ~ RelatednessType*Context+(1+ RelatednessType |Item)+(1|Participant)

	Chisq	Df	P
RelatednessType	220.0	2	< 0.001
Context	1.3	1	0.25
RelatednessType:Context	22.2	2	< 0.001

The ANOVA table of the final model is provided in Table 4 (the full table of coefficients is given in Appendix 11). The model shows a significant interaction between relatedness type and context, and significant simple effect of relatedness type, but no significant simple effect of context. The predicted ratings of items in different conditions as predicted by the final model are shown in Figure 13.
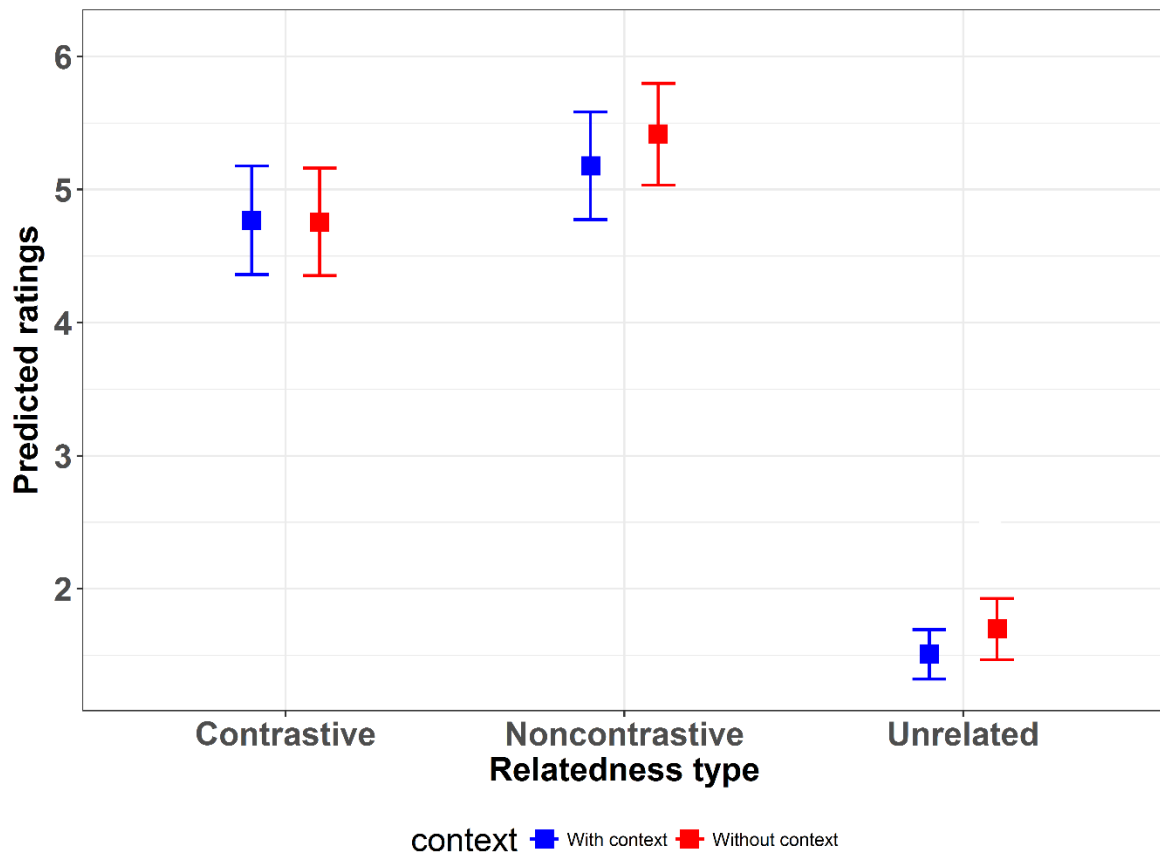
Figure 13 The predicted ratings for each condition in Experiment 1

(Contrastive = Contrastive alternative; Noncontrastive = Noncontrastive associate; Unrelated = Unrelated control)

In order to find out how different relatedness types were affected by the presence of context sentence, post-hoc comparisons for the interaction were conducted with the *emmeans* package. The planned comparisons included the comparisons of each relatedness type between context conditions and the comparisons of any two of the relatedness types within each context condition.

Within each context condition, the relatedness between the subject noun and each of the two related words was rated higher than that between the subject noun and the unrelated type (with context: subject noun - contrastive alternative vs subject noun - unrelated control: $z = 26.3$; $p < 0.001$; subject noun - noncontrastive associate vs subject noun - unrelated control: $z = 30.2$, $p < 0.001$; without context: subject noun - contrastive alternative vs subject noun - unrelated control: $z = 25.5$; $p < 0.001$; subject noun - noncontrastive associate vs subject noun - unrelated control: $z = 33.3$, $p < 0.001$). For the two relatedness types, the contrastive

associates were in general less strongly related to the subject nouns than the noncontrastive associates were. This was significant in the 'without context' condition (z = -4.77, p < 0.001) but only marginally significant in the 'with context' condition (z = -2.89, p = 0.09).

No significant effects of context were found for any of the three types of relatedness (subject noun - contrastive alternative: z = 0.07, p = 1; subject noun - noncontrastive associate: z = -1.51, p = 0.85; subject noun - unrelated control: z = -2.2, p = 0.4).

4.4.3 Item selection for Experiments 2-4B

The main aim of this experiment was to select experimental materials for the two experiments on lexical activation (Experiments 4A and 4B), as well as for Experiments 2 and 3. Following the survey, 40 items were chosen for Experiment 4A and 60 items for Experiment 4B. As Experiment 4B involved more experimental conditions than Experiment 4A (see Chapter 7), more items were selected for Experiment 4B than for Experiment 4A. The 60 items for Experiment 4B included the 40 items for Experiment 4A and another 20 items. The goal in the selection process was to choose items that have similar relatedness scores of the subject noun with each of the two types of associates, and also for the subject noun and the unrelated control to be as unrelated as possible. The analysis of these two subsets below serves to confirm that this selection process was successful.

The analysis of relatedness scores carried out in order to select items was based on results from the Lists 4-6 that included the context sentences. This is because the prime word was going to be presented in the same sentence in the lexical decision tasks. In order to check whether any differences could be found between associations of the subject noun with contrastive associates, noncontrastive associates and unrelated items, parallel CLMM tests were run on each of the two groups of 40 and 60 items selected for Experiments 4A and 4B.

4.4.3.1 40 items for Experiment 4A

The mean relatedness scores for the 40 items selected for Experiment 4A were 4.97 (SD = 1.88) for subject noun - contrastive alternative (e.g., *captain - sailor*), 5.06 (SD = 1.88) for subject noun - noncontrastive associate (e.g., *captain - deck*) and 1.81 (SD = 1.35) for subject noun - unrelated control (e.g., *captain - pumpkin*). The CLMM analysis showed no significant difference in the subject noun's relatedness with the contrastive alternative and the noncontrastive associate (t = - 0.81, p = 0.695). However, significant differences were found between each of these and the relatedness of the subject noun to the unrelated control (t =

76

16.00 and t = 17.84 respectively, p < 0.001 in both cases). This pattern shows that the selection of test and control items was effective, ensuring the conditions are reliably different as intended. Due to these significant differences across conditions and variation between items within each condition, the relatedness scores were included in the analysis of the experimental results later. The selected 40 items can be found in Appendix 9.

4.4.3.2 60 items for Experiment 4B

The mean relatedness scores for the 60 items selected for Experiment 4B were 5 (SD = 1.88) for subject noun – contrastive alternative (e.g., *captain - sailor*), 5.05 (SD = 1.89) for subject noun – noncontrastive associate (e.g., *captain - deck*) and 1.77 (SD = 1.34) for subject noun – unrelated control (e.g., *captain - pumpkin*). The CLMM analysis showed no significant difference in the subject noun's relatedness with the contrastive alternative and the noncontrastive associate (t = -1.586, p = 0.26). However, significant differences were found between each of these and the relatedness of the subject noun to the unrelated control (t = 21.17 and t = 22.00 respectively, p < 0.001 in both cases). As mentioned above, due to these significant differences across conditions and variation between items within each condition, the relatedness scores were included in the analysis of the experimental results later. The selected 60 items can be found in Appendix 9.

4.4.3.3 48 Items for Experiments 2 and 3

From the total set of 75 sentences, 48 sentences were chosen for use in Experiments 2 and 3 (see Chapters 5 and 6). These two experiments involved context sentences, which described a simple event and which established two contrast sets with two elements in each set, i.e. 天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克 'The weather got colder. The captain and the sailor put on their raincoat and jacket.'. The 48 sentences were therefore selected on the basis of how easy it would be to construct a simple and plausible discourse. In addition, the 48 sentences included as many of the sentences selected for Experiments 4A and 4B as possible, making comparisons between the experiments more reliable and straightforward. Thirty-three of the 48 sentences were also used in Experiment 4A (along with seven additional sentences not in the set of 48), and 39 of the 48 sentences were used in Experiment 4B (along with 21 additional sentences). The selected 48 items can be found in Appendix 12.

4.5 Discussion

The first part of the results (section 4.4.2) showed that the context might reduce the difference between *subject noun - contrastive alternative* and *subject noun - noncontrastive associate*, as the significant difference became marginally significant when including context sentences. The other words making up the context sentences were controlled so that they were as unrelated to the primes as possible. If this had not been controlled for, there might have been a larger effect of context. This suggests that, in priming studies, if researchers want to use primes in context sentences, they have to be aware of the possible effects of context.

The test items to be used in the two lexical decision tasks were successfully selected and tested in the second part of the results (section 4.4.3). The semantic relatedness between the non-identical targets and the subject nouns for each subset of items was tested, firstly to ensure that the selected materials for the lexical decision tasks have comparable association strengths of the subject noun with each of the two types of associates while also ensuring that the unrelated items really are unrelated to the subject noun, and secondly to provide rating data that can be included as a control variable in the analysis of the lexical decision data. For the relevant two sets of items to be used in Experiments 4A and 4B, no significant differences were found between the subject noun - contrastive pair and the subject noun - noncontrastive pair. In addition, significant differences were found between the subject noun's relatedness scores on the one hand with the contrastive alternative and the noncontrastive associate and on the other hand with the unrelated control.

It is hoped that the data collected and investigated here will not only be a useful resource for Experiments 4A and 4B described in this thesis, but also for other psycholinguistic studies investigating lexical priming in Mandarin. The association norms are available in Appendix 9.

Chapter 5 Focus marking and focus perception[11]

5.1 Background

This chapter presents the first component of the *focus marking - language processing* link, i.e., the relative weights of prosodic and syntactic cues in the perception of focus. In this section, I briefly restate the theoretical and empirical background on the role of prosodic and syntactic cues in perceiving focus, which led to the development of Experiment 2.

As set out in section 2.1, the QUD-focus is the part of an utterance which updates the common ground, or answers an implicit or explicit QUD which is presupposed given the preceding discourse. Speakers use various focus markings, e.g. prosodic or syntactic, to mark focus and to help listeners identify focal information. Therefore, words with focus marking should be perceived as the focus in a sentence. It is reasonably well established in the literature that listeners are able to use prosodic cues in speech to identify focus if that language uses these cues to mark focus (e.g., Botinis et al., 1999; Breen et al., 2010; Lee et al., 2015).

However, the literature is not that clear when it comes to the role of syntactic cues in focus perception. It is also not clear what happens if there are multiple cues to focus in an utterance, particularly if they indicate focus on different words. In English, listeners seem to weigh the clefting cue (e.g., *it*-clefts) more highly than the prosodic prominence cue. As discussed in section 2.2.2, Calhoun et al. (2019) have recently shown that, in English, prosodic prominence is a consistent and reliable cue to the perception of focus in canonical word order sentences, while clefting seems to be more important than prosodic prominence when the two cues indicate focus on two different words (e.g., 'It was [the cow]$_F$ that kicked [the **horse**]$_F$').

Also, for many languages that have a relatively free word order, the primary way of marking focus is through syntactic means (Donati & Nespor, 2003). Studies on languages with free word order (e.g., Finnish, Hindi and Russian) show that words in the syntactic focus position are perceived as more prominent than when they are in the canonical position (Calhoun, 2015; Cole, 2015; Cole, Mo, & Hasegawa-Johnson, 2010; Luchkina et al., 2015; Vainio & Järvikivi, 2006).

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[11] An earlier report of the Experiment 2 results is published in Yan, Calhoun, and Warren (2020).

So what are the relative roles of prosody and syntax in the perception of focus in Mandarin? Prosodic cues have been shown to be very effective in guiding listeners' search for focus in Mandarin (e.g., Lee et al., 2015; Lee et al., 2016). But to the best of my knowledge, no research has investigated the perception of syntactic cues, and especially the relative importance of prosodic and syntactic focus cues in the perception of focus. Further, in Mandarin (same as English), sentence-final objects are the places where new information tends to occur, and they are also places where the nuclear prominence occurs (Calhoun, 2010a; Chen, Chen, & He, 2012; Ladd, 2008). Previous research has experimentally confirmed in English that final objects have a default focus bias, even if they are not overtly focus-marked (e.g., Carlson, Dickey, Frazier, & Clifton, 2009; Clifton & Frazier, 2016; Harris & Carlson, 2018). But there is less work on this in Mandarin (though see e.g., Chen, Chen, and He, 2012). More importantly, the interaction between prosodic focus cues, syntactic focus cues and default focus position in focus perception is not at all clear.

The current experiment (Experiment 2) answered the question of the relative strength of different focus markers by investigating which cue(s) (prosodic, syntactic, both or none) native Mandarin listeners use to perceive focus in an untimed question-answer appropriateness rating task. Further, Experiment 2 examined the word position, sentence-final objects vs. non-final subject, to test whether sentence-final objects would be perceived as carrying focus in Mandarin. This question-answer appropriateness rating task was designed adopting Welby (2013) and Clifton and Frazier (2016). That is, participants judge how appropriate an answer (e.g., 'The **captain** put on the raincoat') sounds to a preceding question (e.g., 'Who put on the raincoat?'). As we shall see in section 5.3, this task involves interpreting the relationship between the question and the answer, but what listeners do is to perceive where the focus is using prosodic and/or syntactic cues. Thus focus perception will be used to describe the task, rather than focus interpretation.

5.2 Research questions

This experiment addressed the following four research questions:

RQ 1. Does prosodic F-marking result in higher appropriateness ratings?

RQ 2. Does consistent syntactic F-marking result in higher appropriateness ratings compared to no F-marking in Mandarin, and/or does inconsistent syntactic F-marking result in lower appropriateness ratings?

RQ 3. What are the relative weights of syntactic and prosodic cues in the perception of focus?

RQ 4. Is there any difference between sentence-final objects and non-final subjects in the perception of focus?

5.3 Method

5.3.1 Participants

Thirty-six native Mandarn speakers (32 females and four males; mean age = 24.6, SD = 5.4, age range = 18-40) were recruited in Wellington, New Zealand. They reported that they had received English education, but they did not speak other languages at home and were not fluent in any other language. They had not lived outside China for more than six months at the time of participation. They received supermarket vouchers in recognition of their participation. None of them reported any hearing or reading difficulties.

5.3.2 Materials and design

As stated in section 4.4.3 in Chapter 4, 48 experimental sentences were chosen from the 75 sentences in Experiment 1 (see a full list of stimuli in Appendix 12). In order to facilitate comparison with the cross-modal experiments to be presented in Chapter 7, similar test materials were used. But due to the constraints that word frequencies and relatedness scores need to be controlled (see section 4.4.3), the selected sentences included 33 of the 40 sentences to be used in Experiment 4A and 39 of the 60 sentences to be used in Experiment 4B (see Chapter 7). All 48 sentences appeared as the critical stimuli ('critical sentences' in Table 5). The sentences described a simple, plausible event in the past tense, using commonly occurring nouns and verbs. Both subject and object nouns had two syllables. All sentences had seven syllables in the canonical order version.

For each sentence, six versions were created, involving different focus markings on the subject and/or the object noun. The six versions, as shown in Table 5 and also in example (98) with glosses, were canonS (canonical word order with contrastive prominence on the subject noun), canonO (canonical word order with contrastive prominence on the object noun), ScleftS (subject cleft with contrastive prominence on the subject noun), ScleftO (subject cleft with contrastive prominence on the object noun), OcleftS (object cleft with

contrastive prominence on the subject noun), and OcleftO (object cleft with contrastive prominence on the object noun).

Contrastive (or emphatic) prosodic prominence was used in this experiment, rather than noncontrastive (or normal) prosodic prominence, because the word is always contrasted with another word in the same alternative set as shown in the context sentence in (a) in Table 5. I also wanted stimuli to unambiguously mark prosodic focus on the subject vs. object, as in some cases the noncontrastive prosodic prominence could cause ambiguity. In addition, the later experiments in this thesis (Experiments 4A and 4B in Chapter 7) investigated the priming effects of contrastive focus, and using the same contrastive prominence in Experiment 2 allowed me to compare whether there was a link between the importance of contrastive prominence in perceiving focus and its effectiveness in priming alternatives.

Table 5 Examples of test materials in Experiment 2

(bold indicates contrastive prominence; […]$_F$ indicates focus)

a. **Context**	天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克。
	The weather got colder. The captain and the sailor put on their raincoat and jacket.
b. **Focus probe questions**	SQ: 谁穿上了雨衣?
	Who put on the raincoat?
	OQ: 船长穿上了什么?
	What did the captain put on?
c. **Critical sentences**	canonS: [**船长**]$_F$穿上了雨衣 ([**S**]$_F$ V O)
	[The **captain**]$_F$ put on the raincoat.
	canonO: 船长穿上了[**雨衣**]$_F$ (S V [**O**]$_F$)
	The captain put on [the **raincoat**]$_F$.
	ScleftS: 是[**船长**]$_F$穿上的雨衣 (*COP* [**S**]$_F$ V *DE* O)
	It was [the **captain**]$_F$ who put on the raincoat.
	ScleftO: 是[船长]$_F$穿上的[**雨衣**]$_F$ (*COP* [S]$_F$ V *DE* [**O**]$_F$)
	It was [the captain]$_F$ who put on [the **raincoat**]$_F$.
	OcleftS: [**船长**]$_F$是穿上的[雨衣]$_F$ ([**S**]$_F$ *COP* V *DE* [O]$_F$)
	It was [the raincoat]$_F$ that [the **captain**]$_F$ put on.
	OcleftO: 船长是穿上的[**雨衣**]$_F$ (S *COP* V *DE* [**O**]$_F$)
	It was [the **raincoat**]$_F$ that the captain put on.

(98)　　　　a. canonS

[船长]_F　　　　穿上　　　了　　雨衣。

chuan2zhang3　　　chuan1shang4 le0　　yu3yi1

captain　　　　　put.on　　　PRF　raincoat

'[The **captain**]_F (has) put on the raincoat.'

b. canonO

[船长]_F　　穿上　　　了　　　　雨衣。

chuan2zhang3 chuan1shang4 le0　　　　yu3yi1

captain　　　　put.on　　　PRF　　raincoat

'[The captain]_F (has) put on the **raincoat**.'

c. ScleftS

是　　[船长]_F　　　　穿上　　　的　雨衣

shi4　chuan2zhang3　　chuan1shang4 de0　yu3yi1

COP　captain　　　　put.on　　　DE　raincoat

'It was [the **captain**]_F who put on the raincoat.'

d. ScleftO

是　　[船长]_F　穿上　　　的　　[雨衣]_F

shi4　chuan2zhang3 chuan1shang4 de0　yu3yi1

COP　captain　　　put.on　　　DE　raincoat

'It was [the captain]_F who put on [the **raincoat**]_F.'

e. OcleftS

[船长]_F　　　　是　穿上　　　的　　[雨衣]_F

chuan2zhang3　　shi4　chuan1shang4 de0　yu3yi1

captain　　　　COP　put.on　　　DE　raincoat

'It was [the raincoat]_F that [the **captain**]_F put on.'

f. OcleftO

船长	是	穿上	的	[雨衣]F
chuan2zhang3 shi4		chuan1shang4 de0		yu3yi1
captain	COP	put.on	DE	raincoat

'It was [the **raincoat**]F that the captain put on.'

For each answer, two questions were constructed: a subject question (SQ) that is intended to invoke subject focus, e.g. 'Who put on the raincoat?'; and an object question (OQ) that is intended to invoke object focus, e.g. 'What did the captain put on?' (see (b) in Table 5).

Six sentence conditions and two question types resulted in twelve experimental conditions. Each of the 48 critical sentences appeared in all twelve conditions, which gave a total of 576 experimental stimuli. Twelve lists of 48 experimental stimuli were constructed in a Latin square design so that each sentence was in a different condition in each list. Each participant saw only one list.

In addition, for each dialogue (i.e., question-answer pair), a short context (e.g., (a) in Table 5) was constructed which introduced a scenario that made the event plausible. The context included the subject (*captain*) and object (*raincoat*) nouns from (c), as well as an alternative to each of the subject (*sailor*) and object (*jacket*). The inclusion of the context and alternative sets for each of the subject and object made the cleft versions of the sentences pragmatically plausible, as discussed in section 2.1.2.3. The contexts were designed to be as short and as easy to understand as possible, while being plausible.

Finally, each trial ended with a visually-presented question that asked for participants' judgements on a 1-7 scale of the appropriateness of the question-answer pair. '1' was labelled 一点也不恰当 'not appropriate at all', and '7' was labelled 极其恰当 'extremely appropriate' on the computer screen. One complete trial included a written context introducing the alternative sets, an audio question, an audio answer and a written rating question, as shown in Table 5.

A further 24 filler trials were constructed, following the same structure as the critical trials. The purpose of the filler items was to have a variety of sentence structures and stress locations. This led to a total of 72 trials per participant. The contexts in the fillers were

different from the experimental stimuli, as they did not include two explicit contrast sets. The answers had different sentence structures, such as subject-verb, subject-adverbial-verb-object etc. (e.g., (99)). The answers also differed in length, ranging from four to sixteen characters (syllables). The questions in the fillers also asked about any part of the answers such as the adverbial (e.g., 'When did the scholar visit this city?'). Of these 24 fillers, six had answers whose sentence stress was not in the position that was required by the question. Eighteen had answers whose sentence stress was aligned with the focus that was intended by the question.

(99)	学者	两	年	前	来	过	这	个	城市
	xue2zhe3	liang3	nian2	qian2	lai2	guo4	zhe4	ge4	cheng2shi4
	scholar	two	year	ago	come	PST	this	CL	city

'The scholar visited this city two years ago.'

Recording and acoustic analysis

The critical sentences (see Table 5) were recorded directly to hard drive using Praat (Boersma & Weenink, 2018) by a trained female native Mandarin speaker (myself) in a soundproof room at Victoria University of Wellington through a USB-based microphone. The focus probe questions (see Table 5) were recorded by a male native Mandarin speaker. The critical sentences were checked impressionistically by two native Mandarin speakers for the location of contrastive prominence (see Figure 14 for examples of canonS and canonO, Figure 15 for examples of ScleftS and ScleftO, and Figure 16 for examples of OcleftS and OcleftO).

Top figure table:

船长	穿上	了	雨衣
chuan2zhang3	chuan1shang4	le0	yu3yi1
captain	put on	PRF	raincoat

Bottom figure table:

船长	穿上	了	雨衣
chuan2zhang3	chuan1shang4	le0	**yu3yi1**
captain	put on	PRF	**raincoat**
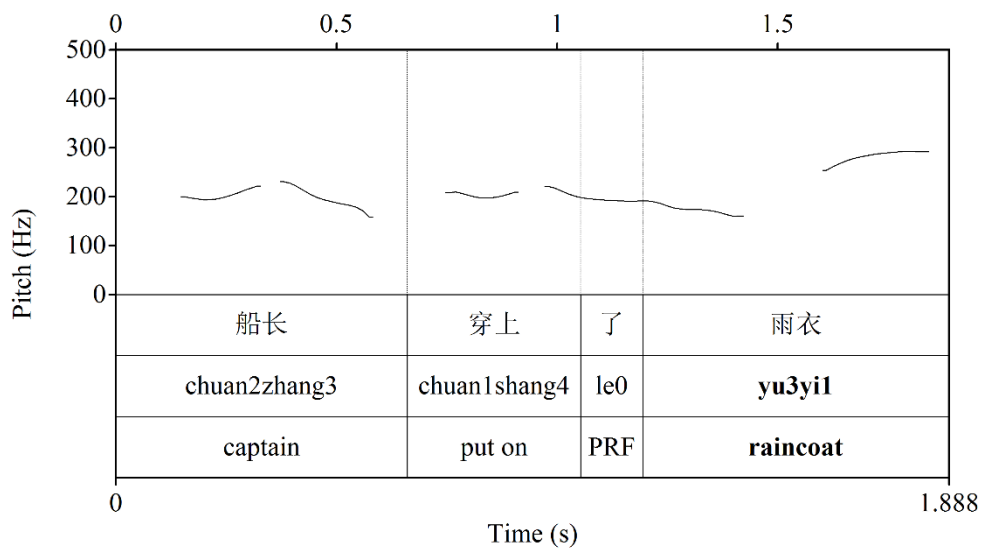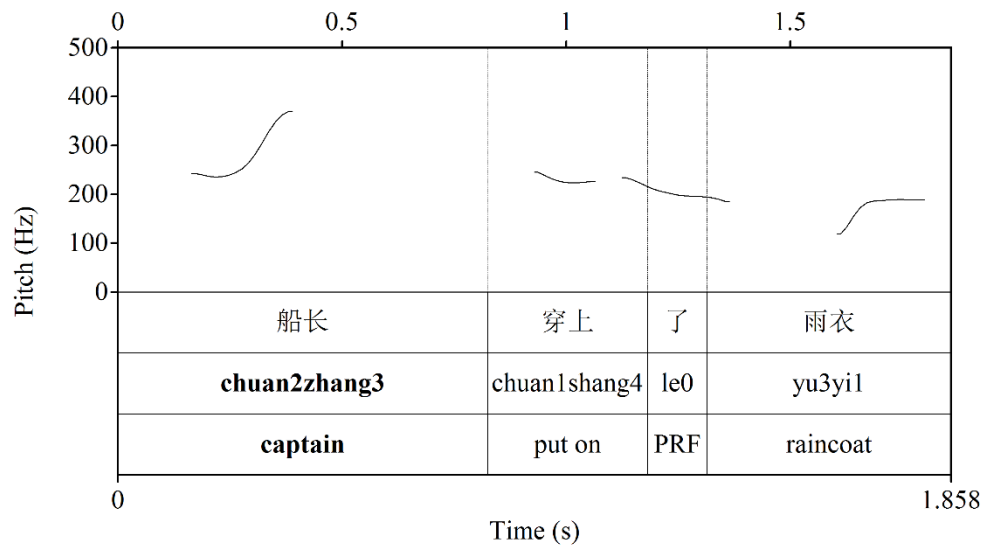
Figure 14 Examples of the prosody of a canonS (top) and canonO (bottom) sentence in Mandarin

Pitch (Hz) vs Time (s) — top plot

是	船长	穿上	的	雨衣
shi4	**chuan2zhang3**	chuan1shang4	de0	yu3yi1
COP	**captain**	put on	DE	raincoat

Time (s) 0 — 2.128

Pitch (Hz) vs Time (s) — bottom plot

是	船长	穿上	的	雨衣
shi4	chuan2zhang3	chuan1shang4	de0	**yu3yi1**
COP	captain	put on	DE	**raincoat**

Time (s) 0 — 2.128
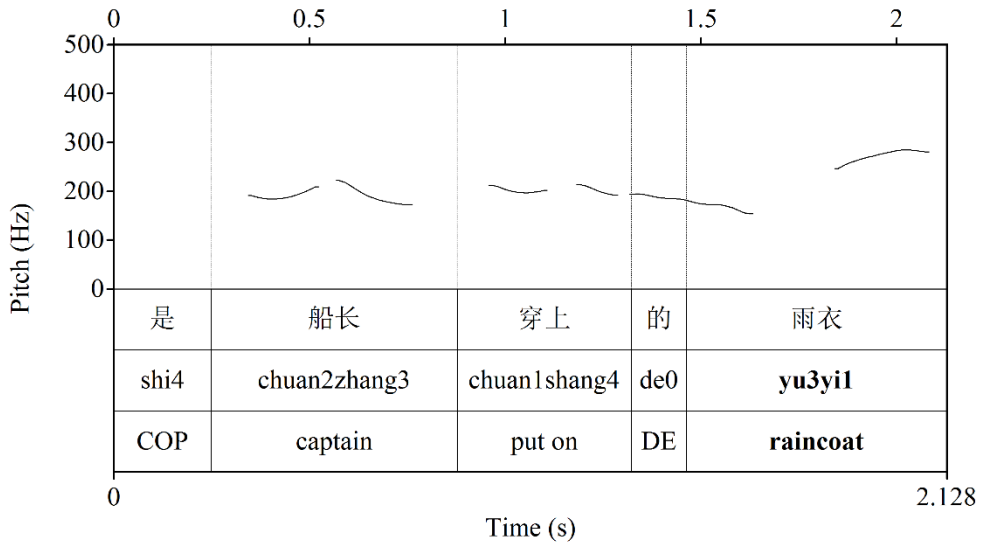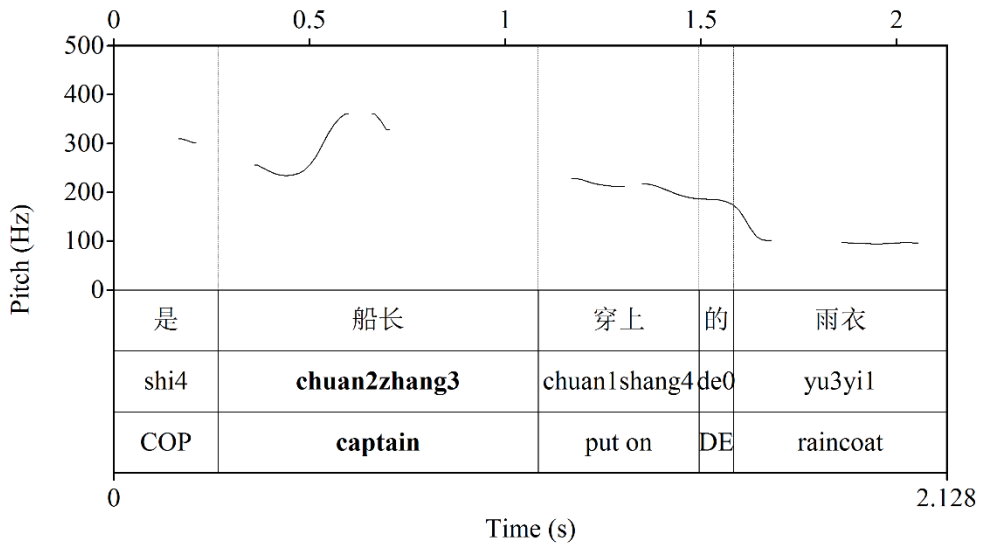
Figure 15 Examples of the prosody of an ScleftS (top) and ScleftO (bottom) sentence in Mandarin

Top figure:

船长	是	穿上	的	雨衣	
chuan2zhang3	shi4	chuan1shang4	de0	yu3yi1	
captain	COP	put on	DE	raincoat	

Time (s) 0 — 2.128

Bottom figure:

船长	是	穿上	的	雨衣
chuan2zhang3	shi4	chuan1shang4	de0	**yu3yi1**
captain	COP	put on	DE	**raincoat**

Time (s) 0 — 1.968
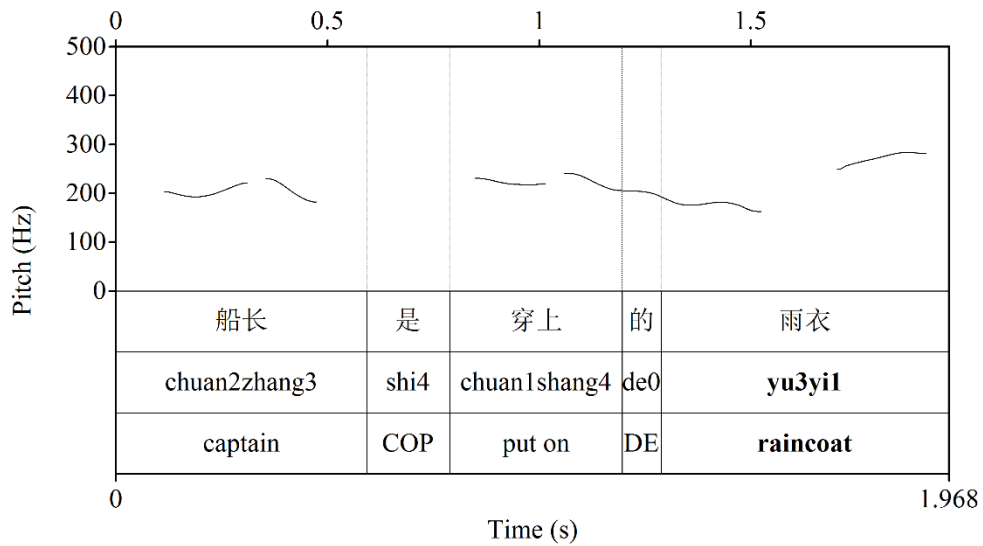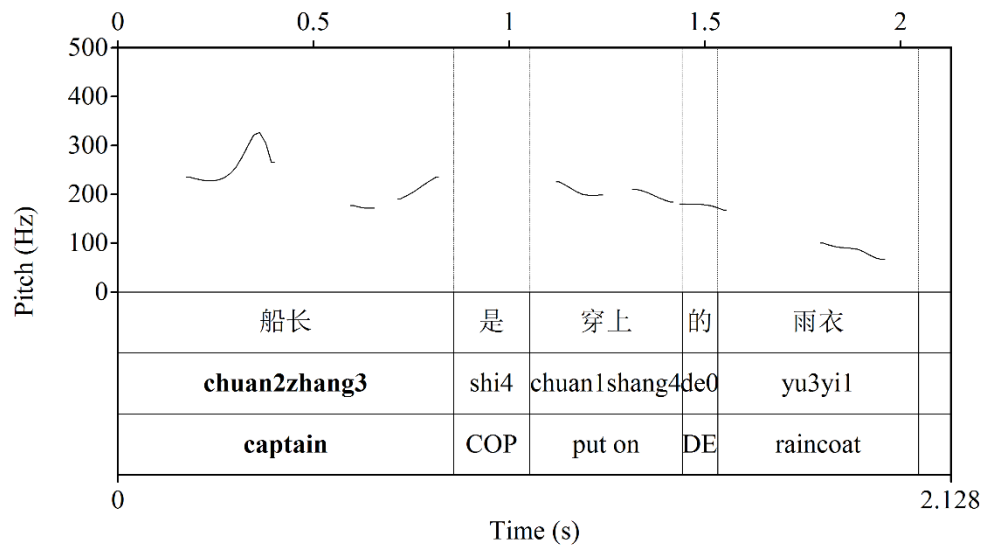
Figure 16 Examples of the prosody of an OcleftS (top) and OcleftO (bottom) sentence in Mandarin

In order to confirm that the critical sentences did indeed differ according to the intended position of the contrastive prominence, the sentences were automatically segmented at the word level using the Montreal Forced Aligner (McAuliffe, Socolof, Mihuc, Wagner, & Sonderegger, 2017) and manually corrected in Praat. Acoustic measurements (duration, mean F0, max F0, min F0 and mean intensity) of the subject and object nouns were obtained using ProsodyPro (Xu, 2013). As focus is marked through pitch range expansion in Mandarin, F0 range was also calculated, being the difference between max F0 and min F0. Duration, mean F0, F0 range, and mean intensity were each fitted as the dependent variable in separate linear mixed effects models, using the *R* package *lme4*. The fixed effects included syntactic structure (canon, Scleft, Ocleft), stress position (subject, object) and word position (subject, object) as well as all interactions between the three. Tone combination (the first and second tone in the disyllabic word) was also included as a single factor, as tone affects syllable duration and F0 (Feng, 1985). No interactions between tone combination and the other factors were included, as they were not the central interests of the experiment. Word was included as the random intercept. Syntactic structure and stress position as well as the two-way interaction between the two were included as by-Word slopes.

As we used four acoustic parameters to test one hypothesis whether intended stressed words are prosodically more prominent than unintended stressed words, which could lead to false positives, i.e. incorrectly rejecting the null hypothesis, the alpha level was adjusted downwards to 0.0125 using one of the approaches suggested by Roettger (2019): *Bonferroni*. For n tests, the alpha level should be the overall alpha level (0.05) divided by n (n = 4).

Following the analysis method detailed in section 3.3.2.3, each model was reduced to remove non-significant factors. The fitted values are provided in Table 6. The ANOVA tables of the final models for each measurement are provided in Table 7 (duration), Table 8 (mean F0), Table 9 (mean intensity), Table 10 (F0 range). The three-way interaction between word position, stress and syntax was only significant for intensity, but was included in all models in order to allow the calculation of the fitted values for each sentence condition. Also, as stated in the analysis method (section 3.3.2.3), key factors were always kept in the model, as they were of central interest no matter whether they were significant or not. All four models showed a significant interaction between word position and stress. Tone combination was a significant factor for mean F0 and F0 range.

In general, as Table 6 shows, in subject-stressed sentences (canonS, ScleftS and OcleftS), the subject was acoustically more prominent than the object, whereas in object-stressed sentences (canonO, ScleftO and OcleftO), the object was acoustically more prominent than the subject. Post-hoc comparisons, which were run using the *emmeans* function in the *emmeans* package, showed that within the same sentence condition, prosodically focused subjects or objects were acoustically more prominent than unfocused subjects or objects in terms of all four parameters (all p values < 0.0125). Across sentence conditions, subject words in the subject-stressed sentence conditions (canonS, ScleftS and OcleftS) had longer duration, higher mean F0, higher mean intensity and larger F0 range than those in the object-stressed sentence conditions (canonO, ScleftO and OcleftO) (all p values < 0.0125). Moreover, object words in canonS, OcleftS and ScleftS were less prominent on all four measures than those in canonO, OcleftO and ScleftO (all p values < 0.0125). The aforementioned differences confirm that the materials have the intended patterns of prominence location.

Table 6 Fitted mean values of duration (ms), mean F0 (Hz), mean intensity (dB) and F0 range (Hz) of the subject and object nouns in Experiment 2

Sentence condition	WordPosition	Duration	Mean F0	Intensity	F0 range
canonS	Subject	675	322	79	270
	Object	589	187	66	104
canonO	Subject	531	213	71	89
	Object	739	273	76	212
ScleftS	Subject	665	326	79	260
	Object	594	180	66	99
ScleftO	Subject	536	213	71	85
	Object	738	269	76	223
OcleftS	Subject	670	319	78	261
	Object	560	173	64	103
OcleftO	Subject	523	217	71	118
	Object	736	260	76	209

Table 7 ANOVA table for the duration analysis in Experiment 2

Model: WordPosition*Stress*Syntax+(1|Word)

	Chisq	Df	P
WordPosition	38.33	1	< 0.001
Stress	861.84	1	< 0.001
Syntax	14.9	2	< 0.001
WordPosition:Stress	2.87	1	0.09
WordPosition:Syntax	44.57	2	0.1
Stress:Syntax	13.25	2	0.001
WordPosition:Stress:Syntax	3.02	2	0.22

Table 8 ANOVA table for the mean F0 analysis in Experiment 2

Model: WordPosition*Stress*Syntax+ToneCombination+(1|Word)

	Chisq	Df	P
WordPosition	130.92	1	< 0.001
Stress	906.39	1	< 0.001
Syntax	25.6	2	< 0.001
ToneCombination	126.16	19	< 0.001
WordPosition:Stress	9.98	1	0.002
WordPosition:Syntax	27.95	2	< 0.001
Stress:Syntax	6.3	2	0.04
WordPosition:Stress:Syntax	4.95	2	0.08

Table 9 ANOVA table for the mean intensity analysis in Experiment 2

Model: WordPosition*Stress*Syntax+(1|Word)

	Chisq	Df	P
WordPosition	66.96	1	< 0.001
Stress	1628.6	1	< 0.001
Syntax	77.36	2	< 0.001
WordPosition:Stress	36.4	1	< 0.001
WordPosition:Syntax	33.56	2	< 0.001
Stress:Syntax	9.76	2	0.008
WordPosition:Stress:Syntax	53.11	2	< 0.001

Table 10 ANOVA table for the F0 range analysis in Experiment 2

Model: WordPosition*Stress*Syntax+ToneCombination+(1|Word)

	Chisq	Df	P
WordPosition	9.54	1	0.002
Stress	317.1	1	< 0.001
Syntax	1.38	2	0.5
ToneCombination	89.66	19	< 0.001
WordPosition:Stress	11.86	1	< 0.001
WordPosition:Syntax	4.5	2	0.1
Stress:Syntax	7.25	2	0.03
WordPosition:Stress:Syntax	3.57	2	0.17

5.3.3 Procedure

The experiment was administered using OpenSesame v. 3.1 (Mathôt, Schreij, & Theeuwes, 2012), and was run in a quiet computer room at Victoria University of Wellington. Participants listened to the sentences over closed-ear headphones. The entire session was conducted in Mandarin. Participants received written instructions on the computer screen, and the instructions were also repeated orally by the experimenter (myself). The instructions asked them not to judge appropriateness based on the context, i.e. whether the answer was appropriate in relation to the context. Rather, they were instructed to provide appropriateness ratings of the answer in relation to the question (see the instructions in Appendix 13). The instructions were carefully created, following Welby (2003) and Calhoun et al. (2019), so that participants would pay attention to 'emphasis' (which can refer to both syntactic and prosodic focus). These instructions were intended to reduce the risk that participants would be biased towards using one or other of the cues to focus.

As Figure 17 shows, participants first saw a context, and they were instructed to press any key to proceed when they had read the context, with no time limit. After pressing any key, they heard a dialogue including a question in a male voice and an answer in a female voice, with a 500 ms break between the two voices. The screen was blank with a black background while the audio sentences were being played. After that they saw a screen asking how appropriate the answer sounded to the question on a scale from 1 (not appropriate at all) to 7 (extremely appropriate). Participants had to press the key corresponding to their judgement

(1-7) within six seconds. After either a key press or six seconds the experiment moved to the next trial automatically. All 72 trials were randomised for each participant. Participants could have a break if they wanted when they were at the screen showing the context.
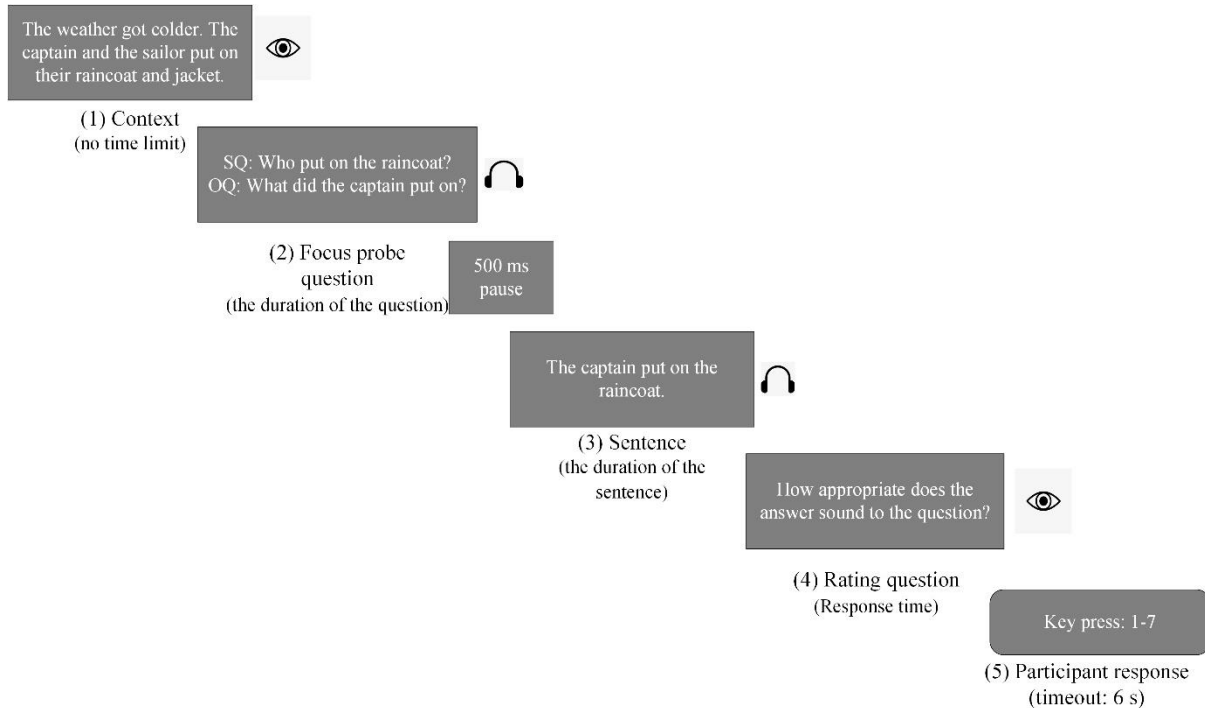
Figure 17 Procedure of Experiment 2

Six practice trials in a fixed order were played before the main experiment. The practice trials followed the same format as the main experiment. The entire experiment lasted approximately 20 minutes. Demographic information was collected using a paper form at the end of the experiment.

5.4 Results

5.4.1 Data cleaning and analysis

The rating responses (1-7) were recorded. The RTs were also recorded but were not used for the analysis as the response keys had different positions and the participants were not instructed to respond as fast as they could. A total of 2,592 responses were recorded, 72 from each of 36 participants. Excluding all fillers and 50 unanswered critical trials, the remaining 1,678 critical trials from 36 participants were used in the following analysis.

As the dependent variable (ratings) was ordinal, CLMMs were built to test how ratings were affected by a number of factors (see also section 3.3.1 for details about CLMMs). The initial model included key experimental predictors and participant factors. The key experimental predictors were stress position (subject, object), syntax (canonical, subject cleft, object cleft) and question type (subject question, object question). Their interactions were also included. The participant factors included the participants' age, sex, hometown and their daily use of English/Mandarin. In addition to the fixed effects, the random effects, motivated by the literature and justified by the data, included intercepts for participants and items, and random slopes for the interactions between the key experimental factors by participants and by items.

Following the analysis method detailed in section 3.3.2.3, the initial model was simplified. The final model included the three key experimental predictors and their interactions. The random effects in the final model were intercepts for participants and items, and the random slope for syntax by participants. None of the other factors included in the initial model were significant, thus they will not be discussed.

5.4.2 Ratings

The ANOVA table showing the significance of variables in the final model is given in Table 11 (the results of the fixed effects are summarised in Appendix 11). The final model showed a significant three-way interaction between syntax, stress and question type, three two-way interactions involving each pairing of these three factors, and simple effects for each factor. The predicted ratings calculated from the model are shown in Figure 18. The average fitted rating was 4.5 for subject questions and 4.2 for object questions. The average fitted rating was 4.45 when subject words carried stress (canonS, OcleftS and ScleftS) and 4.2 when object words carried stress (canonO, OcleftO and ScleftO). For manipulations of syntax, the average fitted rating was the highest following canonical order sentences (4.8), followed by subject clefts (4.1) and object clefts (4.1) averaged across both stress positions and question types.

Table 11 ANOVA table of the final model for ratings in Experiment 2

Model: Syntax*Stress*QuestionType+(1|Item)+(1+Syntax|Participant)

	LR Chisq	Df	P
Syntax	29.84	2	< 0.001
Stress	4.75	1	0.029
QuestionType	6.69	1	0.01
Syntax:Stress	20.48	2	< 0.001
Syntax:QuestionType	59.58	2	< 0.001
Stress:QuestionType	1128.01	1	< 0.001
Syntax:Stress:QuestionType	29.71	2	< 0.001
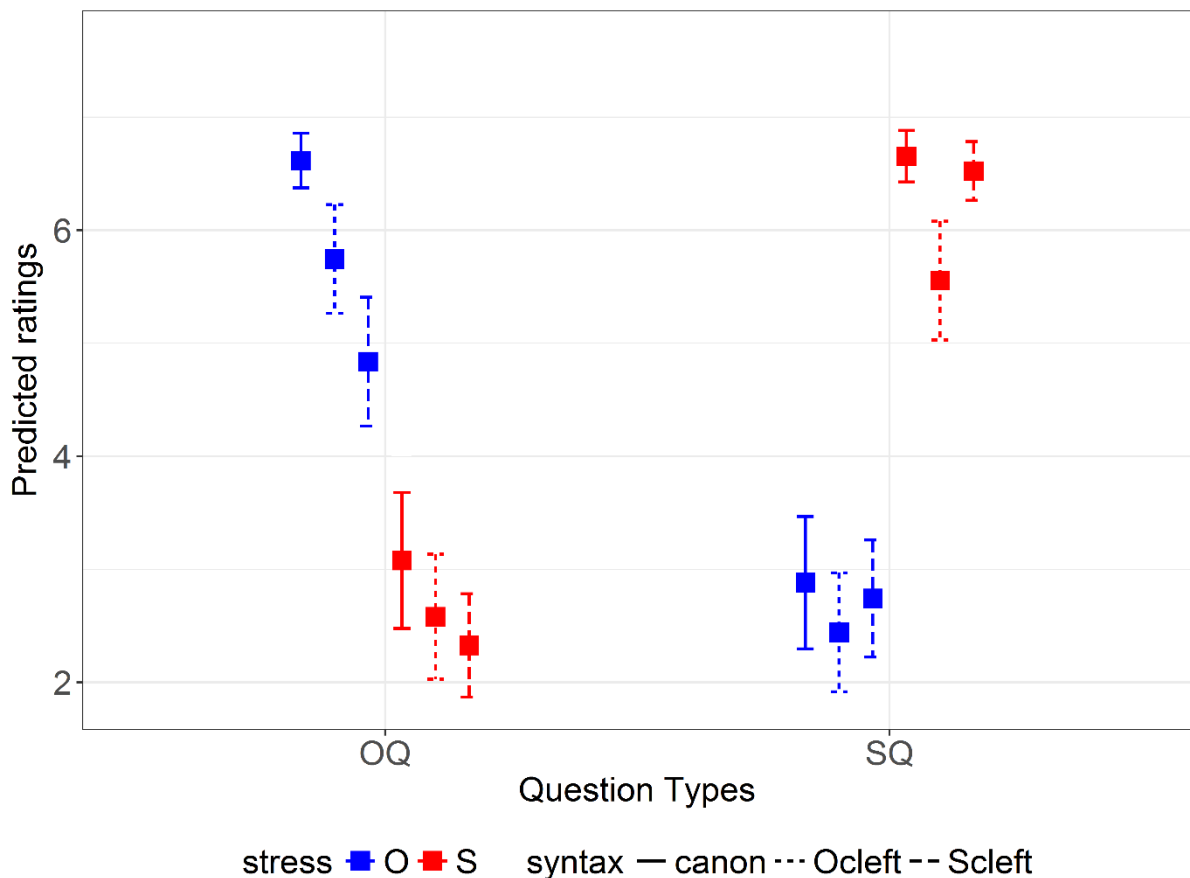
Figure 18 The predicted ratings for each condition in Experiment 2

In order to see how the response was affected by the interaction between these three factors, comparisons were run using the *emmeans* function in the *emmeans* package, following the analysis method in section 3.3.2.3. Planned comparisons were conducted between conditions with prosodic marking on the subject noun and prosodic marking on the object noun for each of the syntactic structures (canonical, subject clefts and object clefts) and for each of the two focus probe questions (SQ and OQ) (Table 12 for summary). The comparisons showed that when the question was about the object (OQ), object (O) stressed sentences received higher ratings than subject (S) stressed sentences (OQ: canonO vs. canonS: $z = 16$, $p < 0.001$; ScleftO vs. ScleftS: $z = 10.95$, $p < 0.001$; OcleftO vs. OcleftS: $z = 13.74$, $p < 0.001$). When the question was about the subject (SQ), object (O) stressed sentences received lower ratings than subject (S) stressed sentences (SQ: canonO vs. canonS: $z = -16.68$, $p < 0.001$; ScleftO vs. ScleftS: $z = -16.57$, $p < 0.001$; OcleftO vs. OcleftS: $z = -13.45$, $p < 0.001$). This shows that prosodic prominence is effective in marking focus in Mandarin for all the three syntactic structures examined (canonical, subject clefts and object clefts).

Planned comparisons were also conducted between the three syntactic structures (canonical, subject and object clefts) for each of the two prosodic prominence conditions (prosodic prominence on the subject noun, prosodic prominence on the object noun) and for each of the two focus probe questions (SQ and OQ) (Table 12 for summary). The results showed that when the stress position matched the question, ratings varied significantly by syntactic structure. For questions that were about the subject (SQ), both canonical sentences and subject clefts were rated higher than object clefts (SQ: canonS vs. OcleftS: $z = 6.1$, $p < 0.001$; ScleftS vs. OcleftS: $z = 5.85$, $p < 0.001$), but they did not differ from each other (SQ: canonS vs. ScleftS: $z = 1.26$, $p = 0.22$). For questions that were about the object (OQ), the rating was the highest when the syntax was canonical, followed by object clefts and then by subject clefts (OQ: canonO vs. OcleftO: $z = 5.11$, $p < 0.001$; OcleftO vs. ScleftO: $z = 4.21$, $p < 0.001$; canonO vs. ScleftO: $z = 9.39$, $p < 0.001$).

When the stress position did not match the question, and when the question was about the subject (SQ), canonical sentences were rated marginally significantly higher than objects (canonO vs. OcleftO: $z = 1.75$, $p = 0.09$), but they did not differ significantly from subject clefts in terms of rating (canonO vs. ScleftO: $z = 0.65$, $p = 0.51$; OcleftO vs. ScleftO: $z = -1.43$, $p = 0.17$). When the question was about the object (OQ), canonical sentences significantly differed from subject clefts (canonS vs. ScleftS: $z = 3.61$, $p < 0.001$), and

marginally significantly differed from object clefts (canonS vs. OcleftS: z = 1.915, p = 0.06), but subject and object clefts did not differ from each other (ScleftS vs. OcleftS: z = -1.254, p = 0.22).

Further comparisons were conducted between the two types of focus probe questions for each of the sentence conditions (syntactic structures + prosodic prominence conditions: canonS, canonO, ScleftS, ScleftO, OcleftS, OcleftO) (Table 12 for summary). The results showed that under the same sentence condition, changing the question type resulted in a significant change of ratings for all syntactic structures (all p values < 0.001). And also for all syntactic structures, ratings were higher when the prosodic prominence in the sentence matched the intended focus invoked by the question. This shows the importance of prosodic prominence in focus perception.

Table 12 Summary of planned comparisons by question type and prosodic and syntactic focus marking in Experiment 2

* = significant (p < 0.05), *! = significant in the opposite direction to predictions, • = marginally significant (0.05 ≤ p < 0.1), •! = marginally significant in the opposite direction to predictions, NS = not significant (p ⩾ 0.1). For each comparison, the condition on the left is predicted to be more appropriate. In each triple in b and c on syntactic marking, for the first comparison, the syntactic cue being compared should strengthen focus marking; for the last, the syntactic cue should clash with or inhibit focus marking; while the second is either neutral (for prosodic marking), or both strengthening and inhibitory.

a. Prosodic marking, with consistent or inconsistent syntax			
	Subject questions (SQ)		Object questions (OQ)
ScleftS-ScleftO	*	OcleftO-OcleftS	*
canonS-canonO	*	canonO-canonS	*
OcleftS-OcleftO	*	ScleftO-ScleftS	*

b. Syntactic marking, with consistent stress			
	Subject questions (SQ)		Object questions (OQ)
ScleftS-canonS	NS	OcleftO-canonO	*!
ScleftS-OcleftS	*	OcleftO-ScleftO	*
canonS-OcleftS	*	canonO-ScleftO	*

c. Syntactic marking, with inconsistent stress			
	Subject questions (SQ)		Object questions (OQ)
ScleftO-canonO	NS	OcleftS-canonS	•!
ScleftO-OcleftO	NS	OcleftS-ScleftS	NS
canonO-OcleftO	•	canonS-ScleftS	*

5.5 Discussion

The goal of this experiment was to investigate the relative effects of prosodic and syntactic cues in listeners' judgements of focus position using a question-answer appropriateness rating task. The experimental design manipulated focus probe question type (subject question, object question), stress position (subject, object) and syntax (canonical, subject cleft, object cleft). Regarding the research questions (see section 5.2), this experiment showed a significant three-way interaction between these three factors. Further analysis of the interaction showed that listeners use prosodic cues to identify the focus, which was reflected in their very high response ratings to the question-answer pairs where the stress location of the answer was consistent with the intended focus of the question. Further, syntactic cues do not seem to play as strong a role as prosodic cues. When prosodic and syntactic cues aligned, the word that had these cues were perceived as being in focus, but ratings were not higher than with prosodic cues alone. When these cues clashed, prosodic cues were clearly preferred by Mandarin listeners. These results will be discussed in detail further below. In general, this experiment showed that prosodic cues are more effective than syntactic cues in the perception of focus in Mandarin, at least for this task.

In relation to the **first research question**, whether listeners use prosodic focus cues in their perception of focus, the results showed that the appropriateness ratings of an answer to a question were very high when the prosodic focus of the answer matched what the question sought for all sentence conditions (i.e., SQ-canonS; OQ-canonO; SQ-ScleftS; OQ-ScleftO; SQ-OcleftS; OQ-OcleftO, for all of which the fitted ratings were higher than 4.5, see Figure 18); the appropriateness ratings were very low when the prosodic focus of the answer did not match what the question sought for all sentence conditions (e.g., OQ-canonS, SQ-canonO; OQ-ScleftS vs. SQ-ScleftO; OQ-ScleftS vs. SQ-OcleftO, for all of which the fitted ratings were lower than 3.5, see Figure 18). This means that prosody is an effective cue in focus perception in Mandarin. This is consistent with the previous findings that listeners are sensitive to prosody in focus perception in Mandarin (e.g., Lee et al., 2015) and in other languages (e.g., Ayers, 1996; Botinis et al., 1999; Calhoun et al., 2019; Welby, 2003).

As this experiment tested whether there is any difference between sentence-final objects and non-final subjects in the perception of focus (RQ 4), in discussing the rest of research questions, subjects and objects will be treated separately. In relation to **the second and third research questions** (see section 5.2), the role of syntactic focus marking and the relative

roles of prosodic and syntactic focus marking in the perception of focus, the results showed that although syntactic cues played a role, this was in general inhibitory rather than facilitatory. That is, consistent syntactic focus marking (i.e., when syntactic cues matched the focus probe question) did not enhance the cues to focus, but inconsistent syntactic focus marking (i.e., when syntactic cues did not match the focus probe question) lowered the appropriateness ratings. Syntactic cues are treated to be facilitatory if consistent syntactic focus marking resulted in higher appropriateness ratings relative to canonical word order, and inhibitory if inconsistent syntactic marking lowered appropriateness ratings.

For the question that was about the subject (SQ), no matter whether or not the prosodic cues matched the question, having an extra consistent syntactic cue aligned with the question did not improve the appropriateness ratings of the answer. For example, the canonical word order sentences with contrastive prominence on the subject (canonS) had similar ratings to the subject clefts with contrastive prominence on the subject (ScleftS). Similarly, the canonical word order sentences with contrastive prominence on the object (canonO) had as low ratings as the subject clefts with contrastive prominence on the object (ScleftO).

For the question that was about the subject (SQ), no matter whether or not the prosodic cues matched the question, having an inconsistent syntactic cue lowered the appropriateness ratings of the answer (canonS vs. OcleftS; canonO vs. OcleftO), though the difference between the ratings for canonO and OcleftO was only marginally significant. This shows that for subject questions, inconsistent syntax actually lowered the appropriateness ratings. However, for the comparison of canonS vs. OcleftS, it could also simply be that there are conflicting cues in the 'mismatch' sentence (OcleftS) which the listener needs to resolve. This adds uncertainty to their response, and therefore lowers appropriateness ratings.

For the question that was about the object (OQ), having a consistent syntactic cue generally made the answer less appropriate. For example, for the question that was about the object (OQ), the canonical word order sentences with contrastive prominence on the object (canonO) had significantly higher ratings than the object clefts with contrastive prominence on the object (OcleftO). Similarly, for the same question (OQ), the canonical word order sentences with contrastive prominence on the subject (canonS) had higher ratings than the object clefts with contrastive prominence on the subject (OcleftS), though the difference between canonS and OcleftS was only marginal. This shows that for object questions,

consistent syntactic cues did not have a facilitatory effect on the appropriateness ratings. Rather, it lowered ratings for object questions. It may be that the consistent syntactic cue for object questions is the object cleft, which is not widely accepted as a marker of object focus (see section 2.1.2.3). Pseudo-clefts are used more often than 是...的 'SHI…DE' clefts in conversation to mark the object focus, as discussed in section 2.1.2.3. Therefore, the infrequency of using object 是...的 'SHI…DE' clefts might make OcleftO somewhat less acceptable, compared to canonO. However, the ratings for OQ-OcleftO were still high, indicating object clefts were still broadly acceptable by the native Mandarin listeners, and they were more acceptable than the 'mismatch' sentences (e.g., OQ-ScleftO), as shown in Figure 18.

For the question that was about the object (OQ), an inconsistent syntactic cue also lowered the appropriateness ratings of the answer no matter whether or not the prosodic cues matched the question (canonO > ScleftO; canonS > ScleftS). This shows that inconsistent syntactic cues lowered the appropriateness ratings for object questions. However, for the comparison of canonO vs. ScleftO for object questions, it could also simply be that there are conflicting cues in the 'mismatch' sentence (ScleftO) which adds uncertainty to their response, and therefore lowers appropriateness ratings. This is similar to the comparison of canonS vs. OcleftS for subject questions.

In general, clefts are marked structures, so compared to the canonical word order sentence, clefts may be less acceptable to *wh*-questions like (e.g., 'What did the captain put on?'). This could have affected the appropriateness of clefts as the answer. This can be supported by the evidence that each of the average ratings for subject clefts and object clefts was 0.7 lower than canonical word order sentences. However, for subject questions, a consistent syntactic cue did not lower the appropriateness ratings, which rules out the possibility that clefts are less acceptable than canonical word order sentences simply due to their form and the lack of the supporting corrective context. Rather, this suggests an asymmetry between the subject question and object question: adding a consistent syntactic focus cue affects the appropriateness of the answer to the object question, but not the answer to the subject question. It may be that, as discussed above, the object cleft is not as widely accepted to mark object focus. The frequency or naturalness of subject and object clefts may have caused this asymmetry in appropriateness ratings. If pseudo-clefts had been used, there may not have been asymmetry as pseudo-clefts are commonly used to mark both subject and object focus.

However, it is also possible that the relative frequency of using pseudo-clefts to mark subject and object focus is different, as to the best of my knowledge, no studies have reported spoken corpus evidence on the frequency of use of the different cleft structures to mark subject and object focus, as mentioned in section 2.1.2.3. It would be good for future research to use spoken corpora to investigate the frequency of different clefts in marking subject and object focus. This would provide evidence on whether frequency is one of the causes of lower appropriateness ratings.

Further, concerning the relative weights of syntactic and prosodic cues in focus perception when the two cues clash, the results showed higher appropriateness ratings when prosodic cues matched what the question sought (OQ-ScleftO, SQ-OcleftS), compared to when they did not (OQ-OcleftS, SQ-ScleftO). This shows that prosodic cues were favoured over syntactic cues in these 'mismatch' conditions, if prosodic cues did not completely override syntactic cues (see further below). This indicates not only the importance of prosody (confirming the finding regarding the first research question), but also that prosodic focus marking is more important in the perception of focus than syntactic focus marking (at least by clefting) in Mandarin.

Previous literature suggests that English listeners perceived the focus to be in the cleft, i.e. weighing the syntactic cue more highly (Calhoun et al., 2019). This suggests that weighting of cues to focus varies across languages: prosodic prominence is a stronger cue to focus in Mandarin than syntax, while in English it is the other way around. This experiment provides the first evidence of the relative weights of prosodic and syntactic focus cues in focus perception in Mandarin, contributing to the small body of literature showing cross-linguistic differences in the weighting of prosodic and syntactic focus cues in the perception of focus. This is an important part of understanding speech comprehension processes in discourse contexts.

The fourth research question concerns whether there is any difference between sentence-final objects and non-final subjects in the perception of focus due to the default focus bias. The experiment did not seem to show any default focus bias in Mandarin using the question-answer appropriateness task. That is, in Experiment 2, we did not see any evidence that objects were perceived as in focus when there was no overt focus marking on objects. Why was there a strong default bias observed in Chen, Chen, and He (2012)? It may have

something to do with the nature of the tasks. Chen, Chen, and He's (2012) study is a processing task, where participants corrected a stimulus against pictures (see section 2.3.1). However, Experiment 2 is a meta-linguistic judgement task, where the focus probe question explicitly guided listeners' to look for the word that had focus marking, by having a focus probe question precede the sentence with focus marking. In a processing task, the effect of default bias may be shown (see Chapter 6).

Further, the experiment reported here has shown how different types of focus marking interact in the perception of focus in Mandarin. We know from a number of studies that focus marked by different devices (e.g., prosodic prominence, clefting, focus particles, context) facilitates many important aspects of language processing (e.g., Birch et al., 2000; Birch & Garnsey, 1995; Braun & Tagliapietra, 2010; Cutler & Fodor, 1979; Fraundorf et al., 2010; Gotzner, 2017; Husband & Ferreira, 2016; Ito et al., 2017). For example, focused words marked by clefts are remembered better (Birch et al., 2000; Birch & Garnsey, 1995; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019). Focus marked by contrastive accents enhances the memory for contrastive alternatives mentioned in a context (Fraundorf et al., 2010), and strengthens the activation of contrastive alternatives that were not in the context (Braun & Tagliapietra, 2010; Husband & Ferreira, 2016). But what is the link between the relative importance of different cues in the perception of focus and their relative effectiveness in facilitating language processing? This has been rarely looked at in general, and also for Mandarin. Therefore, three more psycholinguistic experiments are presented in the following chapters which explore the second and third components of the *focus marking - language processing* link.

Chapter 6 Focus and the encoding of discourse information[12]

6.1 Background

This chapter presents Experiment 3, which tests the second component of the *focus marking - language processing* link, i.e., the relative effectiveness of prosodic and syntactic focus cues in the encoding of discourse information. Compared to Experiment 2, which involved meta-linguistic judgements, Experiment 3 is a processing task. Experiment 3 probes the processing of linguistic cues to focus, i.e. prosodic prominence and clefting, in a speeded 'false alternative' rejection task involving the rejection of alternatives to the focus which are false in the discourse context. In this section, I briefly restate the theoretical background on the role of focus in the encoding of discourse information, and then I summarise some previous relevant studies, which led to the development of Experiment 3.

As set out in section 2.1.1, one main function of QUD-focus is to indicate the information which updates the common ground, or to answer an implicit or explicit 'question-under-discussion' which is presupposed in the preceding discourse. This should affect how listeners process the discourse information, e.g. the focused information should be more salient as it updates the common ground, whereas the presupposed information, e.g., the topic, should be backgrounded as it is already part of the common ground. If focus marking enhances the salience of focused words, it should follow that listeners pay more attention to words that are focus-marked (e.g., Akker & Cutler, 2003; Cutler, 1976; Cutler & Fodor,1979; Ip & Cutler, 2017; Kember, Choi, & Cutler, 2016; Kember, Choi, & Yu, 2016; Kember et al., 2019). It follows that QUD-focus marking should also help listeners identify focal information and detect false alternatives to it (see e.g., Sanford et al., 2006). In contrast, presupposed information, which is assumed to be established between the interlocutors and is more likely to be true, should be harder to correct, as presupposed information is not expected to be falsified.

The rejection of false alternatives to focused words is also expected to be faster than for unfocused words following from contrastive focus. As discussed in section 2.1.1, contrastive focus implies the presence of alternatives (Rooth, 1992). Therefore, it follows that one of the main processing effects is to enhance the encoding of a set of alternatives within the

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[12] An earlier report of the Experiment 3 results has been submitted to *Laboratory Phonology* (Yan & Calhoun, under review).

proposition conveyed by the whole utterance. In other words, focus marking not only strengthens the mental representation of *what has happened* but also *what has not happened* in relation to the focused word (Fraundorf et al., 2010). For example, for (100), contrastive prominence on *captain* leads to a better encoding of 'the sailor did not put on the raincoat', as one plausible member of the alternative set, than when there is no contrastive prominence on *captain* (e.g., (101)). Therefore, it is easier to reject *sailor* as putting on the raincoat, when *sailor* was encoded better as not putting on the raincoat.

Therefore, regardless of whether the type of focus is QUD-focus or contrastive focus, false alternatives to a focus-marked word should be rejected more quickly and more accurately compared to when the word is not focus-marked. For example, a question like (102) should be rejected more quickly and more accurately after hearing (100) than after (101).

(100)   The **captain** put on the raincoat.

(101)   The captain put on the **raincoat**.

(102)   Did the sailor put on the raincoat?

The focus marker that has been looked at most closely in this area is prosodic prominence. It is well-established that prosodic prominence results in a better encoding of discourse information (see e.g., Fraundorf et al., 2010; Sanford et al., 2006). However, it is still poorly understood how different kinds of focus marking affect the encoding of discourse information in spoken language. There has been little research in this area. A comparative study conducted by Chen, Chen, and He (2012) on Mandarin and English, using a verification task, showed that Mandarin and English participants gave different weightings to different focus cues (see section 2.3.1). Chen, Chen, and He (2012) showed that in Mandarin, prosodic focus cues were more effective than syntactic cues in encoding focal information. It was the other way around for English, i.e. syntactic cues were preferred. However, Chen, Chen, and He (2012)'s study used Taiwanese speakers and bare 是 'SHI' clefts, which are quite different from canonical 是…的 'SHI...DE' clefts (see section 2.1.2.3). The current thesis is interested in canonical 是…的 'SHI...DE' clefts, and more specifically the link between the relative effectiveness of prosodic and syntactic focus cues in encoding discourse information and their relative importance of marking focus (Experiment 2). This has not previously been studied. Further, Chen, Chen, and He (2012) also showed that the default object focus

position was an effective means of encoding focal information, and it was more effective than prosodic prominence in Mandarin.

Ayers (1996) found similar effects of positional differences in an early study of English. In her study, participants had to answer a yes/no question (e.g., 'Did the doctor admire the canyon?') after hearing a sentence with different types of accents (e.g., 'The poet admired the **canyon**'). For sentences where participants had to reject information which occurred later in the sentence (object nouns - *donut*), e.g. rejecting 'Did the parcel hold a donut?' after hearing 'The parcel held a **key**', no difference was found when object nouns in the source sentence carried nuclear accents, compared to when they did not. But when participants had to reject information which occurred early in the sentence (subject nouns - *doctor*), e.g., rejecting 'Did the doctor admire the canyon?' after hearing 'The poet admired the **canyon**', participants responded faster when the subject noun had the nuclear accent, compared to when the subject noun did not. Ayers (1996) conjectured that the difference between the two sentence conditions might have arisen because any effects of prosody for the object sentences might have been 'obscured by the effect of reprocessing right at the end of the sentence'. This can also be interpreted as the role of default focus position.

However, Experiment 2 in this thesis did not find any effect of default focus position (i.e., there was no subject vs. object asymmetry in rejecting false alternatives) on listeners' judgement of focus position. However, Experiment 2 involved meta-linguistic judgements of overt focus while Experiment 3 is a processing task. Experiment 3 tests the effects of prosodic and syntactic cues on the speed and accuracy of correct rejection of false alternatives to the focus-marked word. A speeded false alternative rejection task is used to investigate this, where the false alternative to a word needs to be rejected. Due to the distinct nature of the two tasks, we might observe an effect of default focus position in processing, even if the object is not overtly focus-marked.

6.2 Research questions

This experiment addressed the following research questions:

RQ 1. Does prosodic F-marking on the subject or the object noun result in faster and more accurate rejection of false alternatives compared to no F-marking[13] in Mandarin?

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[13] *No F-marking* is used to refer to no prosodic or syntactic F-marking on the word. There is always a prosodic

RQ 2. Does consistent syntactic F-marking on the subject or the object noun result in faster and more accurate rejection of false alternatives compared to no F-marking in Mandarin, and/or does inconsistent syntactic F-marking result in slower and less accurate rejection of false alternatives?

RQ 3. What is the relative effectiveness of prosodic F-marking and syntactic F-marking in the correct rejection of false alternatives?

RQ 4. Is there an asymmetry between the processing of sentence-final objects and non-final subjects in relation to the speed and accuracy of the rejection of false alternatives?

6.3 Method

6.3.1 Participants

A total of 36 near-monolingual native Mandarin speakers (13 females and 23 males; mean age = 21.4, SD = 2.1, age range = 16-27) were recruited from the student population at Henan Polytechnic University in China (see section 3.3.2.1 for details about the participants). They reported that they had received English education, but that they did not speak other languages at home and were not fluent in any other languages. They had not lived outside China for more than six months. The participants received supermarket vouchers in recognition of their participation. None of them reported any hearing or reading difficulties.

6.3.2 Materials and design

The 48 critical stimuli and corresponding contexts used in the appropriateness rating task in Experiment 2 were used in this experiment (see section 5.3.2 for a description of the stimuli, and Appendix 12 for the stimuli). Examples of test materials used in the experiment are shown in Table 13. The critical stimuli are the 'critical sentences' in Table 13. The other components of the test materials are explained below.

F-marking somewhere in all critical sentences.

Table 13 Examples of test materials in Experiment 3

a.	**Context**	天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克。	
		The weather got colder. The captain and the sailor put on their raincoat and jacket.	
b.	**Connecting question**	你可以再多告诉我一些信息吗？	
		Can you tell me more?	
c.	**Critical sentences**	canonS:	[船长]$_F$穿上了雨衣　　　　　（ [**S**]$_F$ V O ）
			[The **captain**]$_F$ put on the raincoat.
		canonO:	船长穿上了[雨衣]$_F$　　　　　（ S V [**O**]$_F$ ）
			The captain put on [the **raincoat**]$_F$.
		ScleftS:	是[船长]$_F$穿上的雨衣　　　　（ *COP* [**S**]$_F$ V *DE* O ）
			It was [the **captain**]$_F$ who put on the raincoat.
		ScleftO:	是[船长]$_F$穿上的[雨衣]$_F$　　（ *COP* [S]$_F$ V *DE* [**O**]$_F$ ）
			It was [the captain]$_F$ who put on [the **raincoat**]$_F$.
		OcleftS:	[船长]$_F$是穿上的[雨衣]$_F$　　（ [**S**]$_F$ *COP* V *DE* [O]$_F$ ）
			It was [the raincoat]$_F$ that [the **captain**]$_F$ put on.
		OcleftO:	船长是穿上的[雨衣]$_F$　　　　（ S *COP* V *DE* [**O**]$_F$ ）
			It was [the **raincoat**]$_F$ that the captain put on.
d.	'**False alternative' questions**	SQ:	水手穿上了雨衣吗？
			Did the sailor put on the raincoat?
		OQ:	船长穿上了夹克吗？
			Did the captain put on the jacket?

Each test item consisted of a written context (e.g., (a)), an auditorily-presented connecting question (e.g., (b)), an auditorily-presented critical stimulus with varying focus marking (e.g., (c)), and a written question about an alternative (e.g., (d)). The context contained two conjoint noun phrases, one in subject position and one in object position. These conjoint phrases established the alternatives to the subject and object nouns that appeared in the critical sentence. The context was followed by an open connecting question (你可以再多告诉我一些信息吗? 'Can you tell me more?') in order to make the context and the critical sentence connect more naturally. This connecting question was in turn followed by the critical sentence with one of six types of focus marking. Finally, this critical sentence was followed by a 'false alternative' question that asked about the false alternative, i.e. it asked about the alternative that was mentioned in the context but not repeated in the critical

stimulus. This question was either about the subject (SQ) or object (OQ) of the critical stimulus. The question required a 'no' response as the correct answer. For example, in Table 13, for SQ, *sailor* was a false alternative to the subject *captain*. For OQ, *jacket* was a false alternative to the object *raincoat*.

Six sentence conditions and two question types resulted in twelve experimental conditions. Each of the 48 critical sentences + contexts appeared in all twelve conditions, which gave a total of 576 experimental stimuli. Twelve lists of 48 experimental stimuli were constructed in a Latin square design so that each sentence was in a different condition in each list. Each participant saw only one list.

A further 48 filler trials were constructed following the same structure as the critical trials, i.e. a context sentence, a question, an answer and a 'false alternative' question. This led to a total of 96 trials per participant. The purpose of the filler items was to have a variety of sentence structures and stress locations, and to avoid biases towards 'yes' responses. Not all of the contexts in the fillers explicitly included two contrast sets. Five fillers contained two sets of explicit alternatives as in the context in the critical trials. Twelve fillers contained only one set of explicit alternatives, and the other set of alternatives were inferably introduced (e.g., 'small animals' introduced a set of alternatives such as *rats* and *rabbits*). Eight fillers had just one set of explicit alternatives. Twenty-three fillers mentioned no explicit alternative sets at all. Among the 48 fillers, 24 had answers which had the same structure as one of the critical sentences (canonO, canonS, OcleftO, OcleftS, ScleftO, ScleftS), i.e. four sentences in each of the six versions. These 24 fillers required 'yes' as the correct response. In the other half of the fillers, the answers had different sentence structures, such as subject-verb, subject-adverb-verb-object etc. The sentences also differed in length, ranging from four to sixteen characters (syllables). Of these 24 fillers, 12 required 'yes' as the correct response, and 12 required 'no' as the correct response. To keep the experiment manageable in terms of time, we did not add more trials with 'no' responses to balance the number of 'yes' and 'no' responses. The imbalance in expected responses did not seem to be an issue, and accuracy rates were high for both sets of fillers, i.e., those with 'yes' and 'no' responses. The 'false alternative' questions in fillers that required 'no' responses had wrong information about a range of parts of the answer, such as a verb (e.g., sentence: 上周画家卖了四幅画 'The painter sold four paintings last week.'; question: 上周画家画了四幅画吗? 'Did the painter paint four paintings last week?).

Recording and acoustic analysis

The procedures for recording the critical stimuli and the acoustic analysis have already been described in Experiment 2 (see section 5.3.2). Filler sentences were recorded by the same speaker (myself) in the same session as the critical stimuli. As with the focus probe questions (see Table 5), the connecting question (see Table 13) was recorded by a male native Mandarin speaker.

6.3.3 Procedure

The experiment was administered using Opensesame v. 3.1, and was run in a quiet computer room at Henan Polytechnic University. Participants listened to the sentences over closed-ear headphones. The entire session was conducted in Mandarin. Participants received written instructions (see Appendix 14) on the computer screen, and the instructions were also repeated orally by the experimenter (myself).

As Figure 19 shows, participants first saw a context in the centre of the computer screen, and were instructed to press any key to proceed when they had read it, with no time limit. After pressing a key, they heard a connecting question 你可以再多告诉我一些信息吗 (Can you tell me more?) in a male voice, and after a 500 ms pause an answer (one of the six versions of the critical sentences) in a female voice. The screen was blank with a black background during the playback of the audio sentences. After the continuation question they saw a 'false alternative' question in the centre of the computer screen, and had to decide whether the answer was 'yes' or 'no' by pressing 'z' key (labelled as 是 'yes') for a *yes* response by their non-dominant hand and 'm' key (labelled as 否 'no') for a *no* response by their dominant hand as fast as they could for right-handed participants. The assignment of keys was reversed for left-handed participants so that 'no' key was always pressed by the dominant hand. The time limit for this key press was six seconds. After the key press or six seconds, the experiment moved to the next trial automatically. All 96 trials were randomised for each participant. Participants could have a break if they wanted when they were at the screen showing the context.
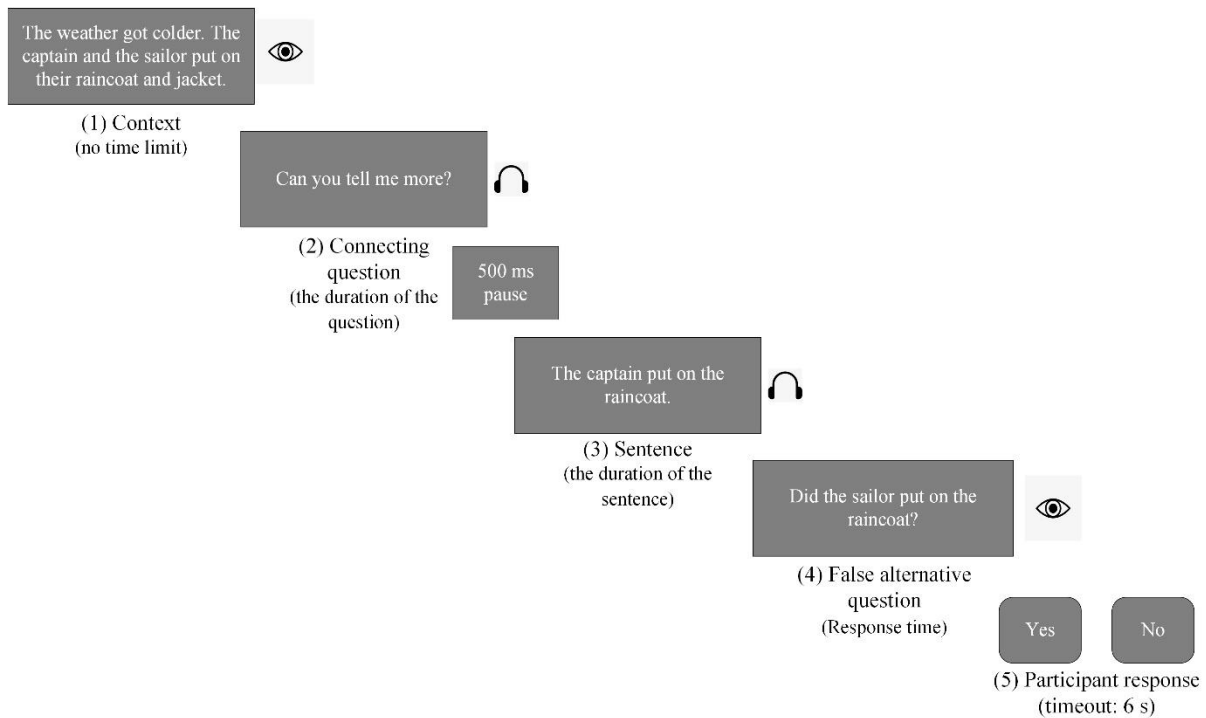
Figure 19 Procedure of Experiment 3

Six practice trials in a fixed order were played before the main experiment. The practice trials followed the same format as the main experiment, except that after six seconds participants heard a warning beep, but could still respond. They were told that the warning beep would happen in the practice phase if they do not respond within 6 s. They were also told that the warning beep would *not* happen in the main part of the experiment, but the experiment would still move onto the next trial if they do not respond within 6 s. They received feedback on their response in the practice phase, but not in the main phase. The entire experiment lasted approximately 25 minutes. Demographic information such as biological sex, age, hometown and English proficiency was collected using a paper form at the end of the experiment (same as in Experiment 2, see the questionnaire in Appendix 5 and Appendix 6).

6.4 Results

6.4.1 Data cleaning and analysis

A total of 3,456 responses were recorded, 96 from each of 36 participants. Both the question response as well as the response time were recorded. Overall accuracy for test and filler items was 96% with the lowest accuracy for any participant being 88.5%. No participants were excluded on the basis of accuracy levels. Excluding all fillers, the remaining 1,728 critical

trials from 36 participants were used for the accuracy analysis. The response time analysis was based on correct responses to critical trials, i.e. on 1,656 data points (excluding 72 [4.2%] incorrect responses, see below). The RTs were log transformed, which was the best transformation compared with no transformation, inverse transformation and square root transformation (see section 3.3.2 for details). Further, data points of residuals whose standard deviations were larger than 2.5 were further eliminated. The resulting count of trials for the RT analysis was 1624 (excluding 32 [1.9%] responses). Back-transformed data were used when plotting the predicted values.

Mixed effects regression models were built to test how accuracy and RTs were affected by a number of factors, using the *R* package *lme4*. Following the process set out in section 3.3.2.3, for the accuracy analysis, binary response choice was the dependent variable in logistic mixed effects models and for the RT analysis, transformed RTs were the dependent variable in linear mixed effects regression. The full models for both accuracy and RT included key experimental predictors, item factors and participant factors. The key experimental predictors were stress position (subject, object), syntax (canonical, subject cleft, object cleft) and 'false alternative' question type (subject question, object question). The item factors included the centred position of the trial in the experiment. The participant factors included their age, sex, hometown and their English language proficiency. In addition to the fixed effects, the random effects, motivated by the literature and justified by the data, included intercepts for participants and items, and random slopes for the interactions between the key experimental factors by participants and by items. The full model also included the random slope for the centred position of the trial in the experiment by participants. Only the factors that were significant or of central interest were kept and reported below.

6.4.2 Accuracy

The overall accuracy on the critical trials was 95.8%. The fixed effects in the final converged mixed effect logistic regression model were simple effects for the three key predictors (stress, syntax and question type) and centred position of the trial. The random effects structure consisted just of the intercepts for participants and items. The ANOVA table of the final model is provided in Table 14 (the fixed effects of the model are summarised in Appendix 11). As the table shows, only the centred position of the trial was significant with the later trial positions showing higher accuracy ($\beta = 0.02$, SD = 0.004) (β is the fitted estimate of log

odds). The absence of any other significant effects is most likely due to ceiling effects, since overall accuracy levels were very high.

Table 14 ANOVA table of the final model for the accuracy analysis in Experiment 3

Model: Syntax+Stress+QuestionType+CentredTrial+(1|Participant)+(1|Item)

	Chisq	Df	P
Syntax	2.95	2	0.23
Stress	0.01	1	0.92
QuestionType	1.29	1	0.26
CentredTrial	16.95	1	< 0.001

Table 15 ANOVA table of the final model for the RT analysis in Experiment 3

Model: Syntax*Stress*QuestionType+CentredTrial+Sex +(1|Participant) +(1|Item)

	Chisq	Df	P
Syntax	8.03	2	0.02
Stress	6.26	1	0.01
QuestionType	24.2	1	< 0.001
CentredTrial	196.1	1	< 0.001
Sex	6.32	1	0.01
Syntax: Stress	0.34	2	0.84
Syntax: QuestionType	8.28	2	0.02
Stress: QuestionType	37.41	1	< 0.001
Syntax: Stress: QuestionType	6.55	2	0.04

6.4.3 Reaction times

The fixed effects included in the final model for RTs are shown in the ANOVA table in Table 15 (the fixed effects of the model are summarised in Appendix 11), which also shows the significance of these effects. The random effects structure in the final model consisted of intercepts for participants and items. As expected, responses became faster over the course of the experiment when all other factors were at their intercept values (centred trial: $\beta = -0.003$, SD < 0.001). Male participants were faster than female participants at intercept (sex: $\beta = -0.16$, SD $= 0.064$). None of the other participant factors were significant.
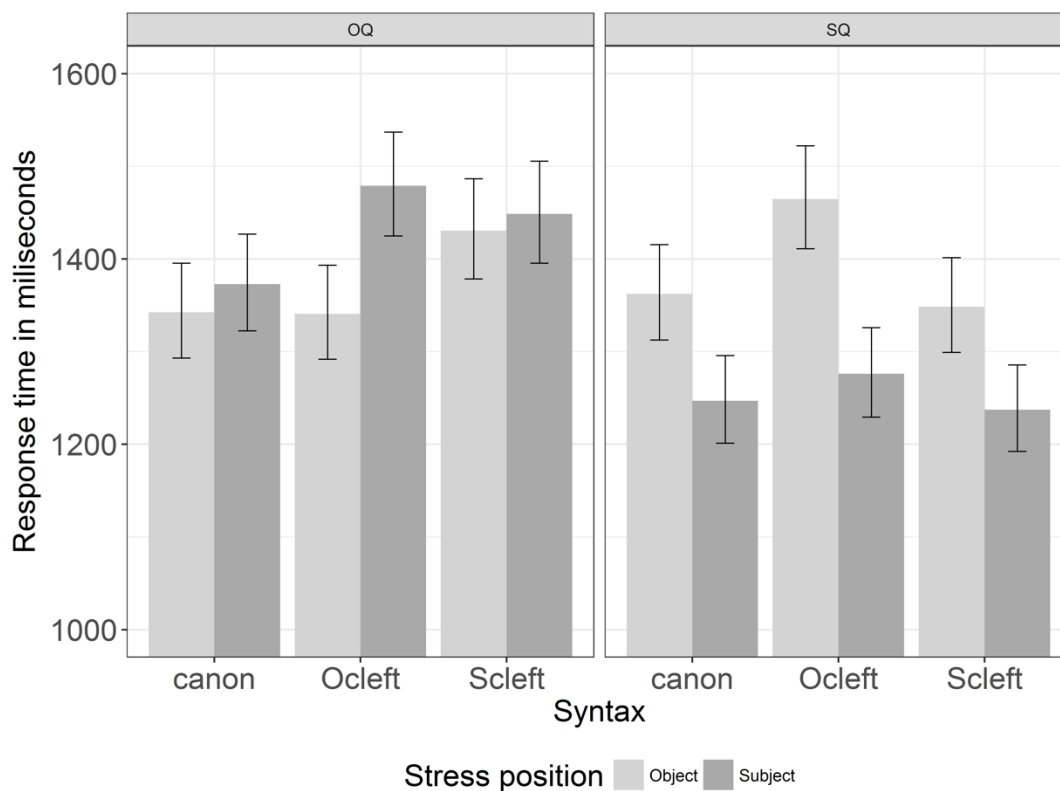
Figure 20 Back-transformed fitted RTs in milliseconds to three syntax conditions, two stress locations and two question types in Experiment 3. Error bars show standard error of the means.

The final model showed main effects of syntax, stress and question type, two-way interactions between question type and each of syntax and stress, as well as a three-way interaction between syntax, stress and question type (see Table 15). Back-transformed fitted RTs are shown in Figure 20. The average response time was 1323 ms when the questions were about subjects, and 1403 ms when the questions were about objects. The average response time was 1344 ms when the subject word in the critical stimulus carried stress (canonS, OcleftS and ScleftS), and 1382 ms when the object word carried stress (canonO, OcleftO and ScleftO). For manipulations of syntax, the average reaction times showed that answers to questions following canonical order sentences were the fastest (1331 ms), followed by subject clefts (1366 ms) and object clefts (1390 ms) averaged across both stress positions and question types.

Planned comparisons were conducted to investigate effects of prosodic marking on the subject noun compared with prosodic marking on the object noun for each of the syntactic structures (canonical, subject and object clefts) and for each of the two 'false alternative'

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question types (SQ and OQ) (see Table 16 for summary). For questions that were about subjects (SQ), the comparisons showed faster 'no' responses when these questions followed critical sentences with stress on the subject (canonS, OcleftS and ScleftS) than when they followed critical sentences with stress on the object, for the same syntactic structure (canonS-canonO: $z = -2.98$, $p = 0.01$; ScleftS-ScleftO: $z = -2.91$, $p = 0.01$; OcleftS-OcleftO: $z = -4.65$, $p < 0.001$). This shows that prosodic prominence was an effective and consistent cue across different syntactic structures in rejecting false alternatives for subject questions.

When the questions were about objects (OQ), the 'no' responses were faster when these questions followed object clefts with stress on objects (OcleftO) than when they followed object clefts with stress on subjects (OcleftS) (OcleftO-OcleftS: $z = -3.3$, $p = 0.005$). On the other hand, 'no' responses to object questions were equally fast after both stress versions of the canonical word order sentences (canonS-canonO: $z = 0.74$, $p = 0.55$) and after both stress versions of the subject clefts (ScleftS-ScleftO: $z = 0.42$, $p = 0.73$). This shows that prosodic prominence was not consistent across different syntactic structures in rejecting false alternatives for object questions.

Planned comparisons were also conducted between response times to questions following critical sentences with different syntax (canonical, subject and object clefts) for each of the two prosodic focus marking conditions (prosodic marking on the subject noun and prosodic marking on the object noun) and for each of the two 'false alternative' question types (SQ and OQ) (see Table 16 for summary). The comparisons showed that when the stress position matched the intended focus invoked by the question, then 'no' responses to subject questions (i.e. subject questions after canonS, ScleftS, and OcleftS) were equally fast across the syntactic structures (p values for each comparison > 0.1). 'No' responses to object questions were slower after subject clefts (ScleftO) than after canonical sentences (canonO) and object clefts (OcleftO), though the differences were only marginally significant (ScleftO-OcleftO: $z = 2.19$, $p = 0.051$; ScleftO-canonO: $z = 2.12$, $p = 0.058$). 'No' responses to object questions after canonical sentences with object stress did not differ from those after object clefts with object stress (canonO-OcleftO: $z = 0.04$, $p = 0.97$). This in general shows that syntactic cues were not effective in rejecting false alternatives for object questions. And syntactic cues which were inconsistent with the question slowed people down for OQ.

When the stress position did *not* match the intended focus invoked by the question, subject questions received faster 'no' responses after both canonical sentences with object stress (canonO) and subject clefts with object stress (ScleftO) than after object clefts with object stress (OcleftO) (canonO-OcleftO: z = -2.44, p = 0.03; ScleftO-OcleftO: z = -2.78, p = 0.02). There was no significant difference between responses to subject questions following canonical sentences and subject clefts (canonO-ScleftO: z = 0.34, p = 0.77). For object questions, when the stress position did not match the intended focus invoked by the question, 'no' responses to object questions were only faster after canonical sentences with subject stress (canonS) than after object clefts with subject stress (OcleftS) (canonS-OcleftS: z = -2.49, p = 0.03). Responses to questions after subject clefts (ScleftS) did not differ from those after either canonical sentences (canonS) or object clefts (OcleftS) (both p values > 0.1).

Table 16 Summary of planned comparisons by question type and prosodic and syntactic focus marking in Experiment 3

* = significant (p < 0.05), *! = significant in the opposite direction to predictions, • = marginally significant (0.05 ≤ p < 0.1), NS = not significant (p ⩾ 0.1). For each comparison, the condition on the left is predicted to be faster. In each triple in b and c on syntactic marking, for the first comparison, the syntactic cue being compared should strengthen focus marking; for the last, the syntactic cue should clash with or inhibit focus marking; while the second is either neutral (for prosodic marking), or both strengthening and inhibitory.

a. Prosodic marking, with consistent or inconsistent syntax

	Subject questions (SQ)		Object questions (OQ)
ScleftS-ScleftO	*	OcleftO-OcleftS	*
canonS-canonO	*	canonO-canonS	NS
OcleftS-OcleftO	*	ScleftO-ScleftS	NS

b. Syntactic marking, with consistent stress

	Subject questions (SQ)		Object questions (OQ)
ScleftS-canonS	NS	OcleftO-canonO	NS
ScleftS-OcleftS	NS	OcleftO-ScleftO	•
canonS-OcleftS	NS	canonO-ScleftO	•

c. Syntactic marking, with inconsistent stress

	Subject questions (SQ)		Object questions (OQ)
ScleftO-canonO	NS	OcleftS-canonS	*!
ScleftO-OcleftO	*	OcleftS-ScleftS	NS
canonO-OcleftO	*	canonS-ScleftS	NS

Additional analysis with animacy

As animacy plays an important role in language processing in Mandarin (see section 2.1.2.3), the animacy of subject and object nouns was included to check whether it plays any role in Experiment 3. There were 28 animate subjects (20 inanimate subjects) and 11 animate objects (37 inanimate objects). Animacy was included as a categorical variable (animate, inanimate) in the analysis with its interaction with prosodic cues, syntactic cues and 'false alternative' question type. The results showed no significant interactions between animacy and other two focus cues. The interaction between the question type and the animacy of object nouns was significant ($\chi^2(1) = 6.32$, p = 0.01), showing that when the object noun was inanimate, responses to object questions were faster than when the object noun was animate (t = 2.3, p = 0.04).

6.5 Discussion

A false alternative rejection task was conducted in Mandarin to look at the role of prosody (presence or absence of contrastive prominence on the target word) and syntax (canonical order sentences, object clefts and subject clefts) in the encoding of discourse information as shown by rejection of false alternatives to focus- or non-focus- marked words in sentences. Question type (subject question, object question), prosody and syntax were manipulated in this experiment. The experiment addressed four research questions (see section 6.2): whether prosodic focus marking results in faster and more accurate rejection of false alternatives compared to no focus marking in Mandarin (RQ 1), whether consistent syntactic focus marking results in faster and more accurate rejection of false alternatives compared to no focus marking in Mandarin, and/or whether inconsistent syntactic focus marking results in slower and less accurate rejection of false alternatives (RQ 2), what the relative effectiveness of these two types of focus marking is (RQ 3), and whether there is an asymmetry between the processing of subjects and objects (RQ 4). In general, the experiment showed that prosodic and syntactic focus marking affected the encoding of discourse information differently, with prosodic focus marking proving more effective than syntactic focus marking. There is an asymmetry between the processing of subjects and objects, as results showed that objects were processed largely equally fast no matter whether they had overt focus marking or not.

As with Experiment 2, Experiment 3 tested whether there is an asymmetry in the processing of subject and objects (RQ 4), so subjects and objects will be treated separately below. As

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with Experiment 2, syntactic cues are treated to be facilitatory if consistent syntactic focus marking resulted in faster response times relative to canonical word order, and inhibitory if inconsistent syntactic marking slowed responses compared to canonical order.

In relation to **the first research question** (see section 6.2), the results showed that for questions that relate to a false alternative to the subject of the critical sentence (SQ), prosodic focus marking facilitated the speed of correct rejections of false alternatives in Mandarin both in the presence and in the absence of syntactic focus marking. For example, for each of the syntactic structures (canonical sentence, subject and object clefts), subject questions received faster 'no' responses when contrastive prominence was on the subject, compared to when contrastive prominence was on the object, reflecting easier rejections of false alternatives. This suggests that prosodic prominence was very effective in facilitating the correct rejection of false alternatives to the subject noun. It could also be possible that the results come from an inhibition when responding to questions after object prosodic focus (relative to a possible non-focus condition), or both a facilitation when responding to questions after subject prosodic focus and an inhibition when responding to questions after object prosodic focus. When the prosodic prominence is on the irrelevant information (e.g., on object nouns after subject questions), it might draw listeners' attention to the irrelevant information, which might impair the processing of the relevant information (e.g., object nouns after object questions). Fraundorf et al. (2010) found similar results with contrastive prosodic prominence in memory tasks, and they tested whether the observed facilitation was due to the positive effect of L+H* on the memory of the word that carried the accent, or the negative effect of L+H* on other parts of the discourse, or both. In their follow-up experiment, Fraundorf et al. (2010) included conditions that had L+H* on two words in a discourse, or one word or none using the same technique. They did not find any evidence that L+H* impaired memory for the words that did not carry the accent in the discourse. Therefore, in my experiment, it is more likely that contrastive prominence had a facilitatory effect. But future studies with similar conditions as in Fraundorf et al. (2010) would be needed to confirm this.

However, for questions that relate to false alternatives to the object in the critical sentence (OQ), the differences between the two prosodic conditions (with or without contrastive prominence on the subject or the object noun) were not that clear. Changing the prosodic prominence location from the object noun to the subject noun only resulted in slower response times for the object clefts, but not for either the canonical sentences or subject

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clefts. Therefore, compared to the effect of prosodic prominence for subject focus, inconsistent effects were observed for the object focus.

The pattern of results reported above for responses to subject and object questions is largely consistent with the results reported by Ayers (1996). As discussed in section 6.1, in her study, participants responded 'no' more quickly to subject questions when the subject noun had the nuclear accent, compared to when the object noun had the nuclear accent. On the other hand, no such difference was found for object questions. In the case of object questions, the false alternative appears at the end of the utterance, so participants had to read the whole sentence in order to detect the false information conveyed by the object word before they could answer 'no'. There might have been reprocessing of the entire sentence right at the end of the sentence, which interfered with the focus effect. This is supported by the evidence that responses to object questions were 80 ms slower overall than to subject questions.

As mentioned in section 6.1, this reprocessing can also be interpreted as the role of default focus position, i.e. objects are likely to be perceived as being in focus in Mandarin even if they are not focus-marked. Default focus has effects on encoding focal information in Mandarin (Chen, Chen, & He, 2012). Chen, Chen, and He (2012) also showed that the default focus position could override the effect of prosodic prominence in encoding discourse information. Although focus locations were manipulated in the critical sentences that preceded the 'false alternative' questions, the effect of the default focus might still be too strong to show consistent effects of prosodic focus marking or syntactic focus marking. This also answered **the fourth research question**, laid out in section 6.2, that there was indeed an asymmetry in processing subjects and objects that final objects have a default bias, even if they are not otherwise focused marked (e.g., if they do not carry nuclear prominence). This is also consistent with the differences in terms of animacy and being topical between subjects and objects that were discussed in section 2.1.2.3. That is, subjects tend to be topical and animate, and objects tend to be inanimate and carry the new information. Animacy was included in an additional analysis, showing that responses to object questions were faster than when the object noun was animate. That is, false alternatives to inanimate objects/focused information were rejected faster compared to false alternatives to animate objects/non-focused information, because inanimate referents are more expected in object/focus position.

Regarding this lack of difference observed for responses to object questions for canonical sentences compared with subject clefts, one more reason might be the effect of recency. As the object words were sentence-final, the false information (alternatives) was the most recent information that participants saw before they pressed 'no'. It is possible that this recency effect overrode the effect of focus marking, masking any response times differences that might have reflected the different sentence conditions. Unfortunately, the effects of the default focus position and recency cannot be teased apart given the design of Experiment 3.

However, why were there no effects of default focus/recency in Experiment 2, but there were in Experiment 3? This might reflect the nature of the tasks. By asking participants' judgements about the focus position, Experiment 2 explored the effects of prosodic and syntactic cues on perceiving 'overt focus', which was a meta-linguistic judgement task. However, Experiment 3 was different, using a processing task. Both the prosodic/syntactic focus and the default focus can have consequences for language processing, by facilitating and/or inhibiting the correct rejections of false alternatives.

However, one might wonder why for the object clefts, there was a difference in response times to questions following the two prosodic focus marking conditions (OcleftO vs. OcleftS). I speculate that 'mismatch' sentences are in general harder to process, as they involve a more complex presupposition and exhaustivity (see section 2.1.2.3). For example, 'It was [the raincoat]$_F$ that [the **captain**]$_F$ put on' presupposes a number of people who put on a number of clothing items. But the sentence exhausts other possibilities and only shows that *the* captain, not anyone else, put on *the raincoat*, not something else. When the prosodic prominence is also unexpected, as in the 'mismatch' cases (OcleftS), these are very hard to process.

In relation to **the second and third research questions** (see section 6.2), the role of syntactic focus marking and the relative roles of prosodic and syntactic focus marking in the correct rejection of false alternatives, the results showed that although syntactic cues played a role, this was quite complicated. It seems that consistent syntactic focus marking did not enhance correct rejection, but inconsistent syntactic focus marking inhibited correct rejection. More specifically, syntactic focus marking did not really matter for subject focus when the prosodic prominence matched the 'false alternative' question. For example, when the subject carried

prosodic focus marking (canonS, OcleftS, ScleftS) and the 'false alternative' question was about the subject (SQ), there were no differences between the three syntactic conditions.

However, when prosodic focus marking on the critical sentence did not match the intended focus of the 'false alternative' question, syntax sometimes played a role, but the role was mostly to inhibit the rejections of false alternatives. For example, when the object had prosodic focus marking, subject questions were rejected more slowly after object clefts (OcleftO) than after canonical sentences (canonO) and subject clefts (ScleftO). This shows that having a syntactic focus on the subject which does not match the intended focus position of the 'false alternative' question slows down the correct rejections of false alternatives. However, as just mentioned above, it could also be the general effect that object clefts are harder to process, as they were the slowest of all the sentences conditions.

Similarly, for object questions, when the object carried the prosodic focus marking, false alternatives suggested by object questions were rejected more slowly after subject clefts (ScleftO) than after canonical sentences (canonO) and object clefts (OcleftO), but the latter two did not differ from each other. This shows that having an inconsistent syntactic cue on the subject slows down the correct rejections of false alternatives. It could also be that the 'mismatch' sentences are in general harder to process, as they involve a more complex presupposition and exhaustivity. However, this is a less likely explanation because we did not get the same 'mismatch' effect when subject questions followed subject clefts with prosodic prominence on the object (ScleftO), as the false alternatives in this case were rejected just as fast as in the case of the canonical sentences with prosodic prominence on the object (canonO).

Consistent syntax did not seem to enhance the rejection of false alternatives. For example, when the subject carried the prosodic focus marking (canonS, OcleftS, ScleftS), the alternatives suggested by the object questions were rejected more slowly after object clefts with prominence on the subject (OcleftS), than after canonical sentences (canonS). This shows that having a consistent syntactic cue on the object did not facilitate the correct rejection of false alternatives. In addition, both subject and object questions after object clefts with prominence on the subject (OcleftS) did not differ from those after subject clefts with prominence on the subject (ScleftS), showing no effect of syntactic focus marking. This is

consistent with the suggestions above about object clefts (particularly the 'mismatch' condition OcleftS), namely that they are in general harder to process.

Experiment 3 establishes the role of prosodic and syntactic focus marking and default focus position in encoding discourse information in Mandarin. In general, a robust and more effective role was found for prosodic focus marking, but a less consistent and less effective role was found for syntactic focus marking, in the encoding of discourse information. There was also a clear effect of default object focus position, as for objects, the effect of prosodic or syntactic markings was either absent or weak, while for subjects, prosodic and syntactic focus marking systematically affected response times. This suggests that different forms of focus marking are not equally effective in highlighting focused information/alternatives, a finding which contributes a great deal to our understanding of what kinds of focus markings affect listeners' attention and their memory of discourse information when they are questioned about it. This is similar to what was found by Chen, Chen, and He (2012), extending their findings on 是 'SHI' clefts to 是...的 'SHI...DE' clefts for Mandarin. The results from Experiment 3 are largely consistent with the finding from Experiment 2 that prosodic prominence is a stronger marker of focus than clefting in Mandarin. A link has been seen between Experiment 2 and Experiment 3, i.e., stronger marking of focus provides more effective encoding of discourse information in Mandarin.

The link in Mandarin suggests that different weightings of cues in language processing are related to the relative use of these cues to mark focus. It could be speculated that in languages in which syntactic cues to focus are more frequently used than prosodic, and which would hence be weighted higher by listeners in those languages, e.g. Kember et al.'s (2019) findings for Korean in a memory-based task. Also, Chen, Chen, and He (2012) found that syntactic cues were more effective than prosodic cues in English in encoding focal information, which was in accordance with what Calhoun et al., (2019) found in a focus position judgement task. They found that syntactic focus marker was a more important marker than prosodic focus marker when the two kinds of cues indicated focus on different words. This suggests a discourse processing model in which the weighting of different cues is affected by their relative use in the language. These cross-language similarities and differences will be further discussed in section 8.2.4. It would be good for future work to look at the relative importance and use of prosodic cues in relation to other cues in speech processing in more languages, to increase our understanding of how this varies across languages.

The following chapter investigates the third component of the *focus marking - language processing* link, i.e., the relative effectiveness of prosodic and syntactic cues in activating discourse information. As there might be a default focus bias in the processing of sentence-final objects, I only looked at the priming effect of subjects in the following chapter.

Chapter 7 Focus and lexical activation[14]

7.1 Background

The previous chapter investigated the second component of the *focus marking - language processing* link, i.e. relative roles of prosodic and syntactic cues in the encoding of discourse information. Using a false alternative rejection task, Experiment 3 looked at the correct rejection of false alternatives in relation to the representation of the whole discourse (i.e., to reject the false alternative *sailor* in 'Did the sailor put on the raincoat?' after hearing 'The captain put on the raincoat'). Thus it taps into the discourse-level encoding of discourse referents. In this chapter, I will move on to an investigation of the third component of the *focus marking - language processing* link, i.e. the relative effectiveness of prosodic and syntactic cues in the activation of discourse information. Different from Experiment 3, Experiments 4A and 4B, which are reported in this chapter, tap into the word-level activation of discourse referents. The experiments reported in this chapter investigate the role of QUD-focus and contrastive focus in lexical activation.

In this section, I briefly restate the theoretical background on the role of focus in the activation of discourse information, and then I review some previous studies relevant to this aspect, which led to the development of Experiments 4A and 4B described in this chapter (for more detail see section 2.3).

In communication, speakers use different kinds of focus marking to signal the important information that updates the common ground. Listeners, likewise, usually pay more attention to words with focus marking, thus focus facilitates the processing of focused words (e.g., Birch & Garnsey, 1995; Cutler, 1976; Cutler & Fodor, 1979). The type of focus investigated in relevant previous research has generally been QUD-focus.

Following the alternative semantics theory (Rooth, 1992), (contrastive) focus, which indicates contextually-relevant alternatives, has consequences for the processing of alternatives to focused words. An increasing number of studies show that listeners infer contextual alternatives to a focused word in a spoken utterance, when that word is marked with contrastive prominence, even when the alternatives are not explicitly mentioned (or in

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[14] An earlier report of the Experiment 4A results is published in Yan, Calhoun, and Warren (2019). An earlier report of the Experiment 4B results is published in Yan and Calhoun (2019).

the visual display) (Braun et al., 2019; Braun & Biezma, 2019; Braun & Tagliapietra, 2010; Dahan et al., 2002; Husband & Ferreira, 2016; Ito & Speer, 2008; Watson et al., 2008; Weber et al., 2006) (see section 2.3).

These previous studies have largely focused on the prosodic marking of focus and on Germanic languages, i.e. English, Dutch and German. The current research extends this in two ways. First, this research investigates Mandarin, in which contrastive prominence is marked by pitch range expansion, rather than pitch accenting as in these Germanic languages (e.g., L+H* in English). Second, this research tests clefting. To the best of my knowledge, whether syntactic focus marking indicates alternatives has not been investigated in any language. Based on the results from the previous experiments in this thesis, prosody seems to be the primary cue to focus, and syntax secondary in Mandarin, but the relative roles of prosodic and syntactic cues in activating both focused words and focus alternatives are yet known.

Previous studies have used lexical tasks to investigate the activation of focused words and focus alternatives (Braun & Tagliapietra, 2010; Husband & Ferreira, 2016; Norris et al., 2006) (also see section 2.3.2). For example, Braun and Tagliapietra (2010) looked at Dutch with an ISI of 0 ms between prime words and target words, using the cross-modal priming paradigm. They found that contrastive prominence on the prime word was necessary for contrastive alternatives to be primed, while noncontrastive associates were weakly primed regardless of prosody. Husband and Ferreira (2016) investigated English with ISIs of both 0 ms and 750 ms using the same paradigm. They found that when the ISI was set at 0 ms (immediate processing), contrastive alternatives but not noncontrastive associates were primed when there was neutral prosody on the prime, and both types of associates were primed when the prime word was contrastively accented. They argued that noncontrastive associates were less related to the semantic context and had less time to be activated. When the ISI was set at 750 ms (later processing), both types of associates were primed when there was neutral prosody on the prime. Contrastive alternatives but not noncontrastive associates were primed when the prime word was contrastively accented. In addition, the positions of the prime word were different in the two experiments (sentence-final objects in Braun and Tagliapietra vs. sentence-medial adjectives or noun in Husband and Ferreira), which could be a likely factor for the differences between the studies.

To my knowledge, no studies in this area have yet used this cross-modal lexical priming paradigm to investigate activation associated with subject nouns. There are four reasons to look at the subject nouns in Mandarin. First, subject nouns are typically in different positions to object nouns. Previous work has shown that positional cues to focus affect processing ease (see e.g., Repp & Drenhaus, 2015), so the priming effects might be different in different positions. Braun et al. (2019) measured participants' visual fixations on four words displayed on a computer screen while listening to test sentences. Their task was to click on a word (the object) that was in the sentence. The four displayed words were the object, the contrastive and noncontrastive associates of the subject, and a distractor. Braun et al. (2019) showed that listeners directed more fixations to the contrastive alternative to the subject when the subject was said with contrastive prominence, similar to previous findings for objects. However, the effect of contrastive focus on the activation of alternatives to the subject has not yet been tested using the cross-modal priming paradigm. Second, the results of Experiments 2 and 3 in this thesis support the possibility that object clefts are in general less acceptable and harder to process, and it is disputed in the theoretical literature whether object clefts mark object focus (see section 2.1.2.3). Therefore, a more promising area of investigation of the relative roles of syntactic and prosodic marking of focus would seem to be the subject position, comparing subject clefts and/or prosodic focus marking of the subject. Third, the results from Experiment 3 in this thesis suggest that objects have a default focus bias, which can override overt focus marking. Therefore, the effects of prosodic and syntactic focus marking may not be seen if looking at objects in Mandarin. A fourth advantage in testing subject nouns, which are in the sentence-initial position in canonical word order sentences in Mandarin, is that because the target words are presented after the sentence, the interval between the presentation of the prime (i.e. the subject noun) and the target will be long enough to allow the emergence of the types of priming effects that Husband and Ferreira (2016) observed in their later processing.

As in the previous two experiments, clefting was used to investigate the effect of syntactic focus cues. As discussed in section 2.1.2.3, an alternative could have been to use pseudo-clefts; however, these would have been problematic to investigate the priming associated with subject nouns. Subject nouns are sentence-final in pseudo-clefts, which makes subjects non-comparable between pseudo-clefts and canonical word order sentences, as the time course of priming would be quite different.

In the following sections (7.2 and 7.3), I report two cross-modal lexical priming studies, carried out in Mandarin, which investigated the effects of prosodic focus marking (both Experiment 4A in section 7.2 and Experiment 4B in section 7.3) and syntactic focus marking (Experiment 4B) on the activation of discourse information (e.g., focused words and focus alternatives). In order to test the role of prosodic focus marking, Experiment 4A involved Mandarin utterances in two sentence conditions with canonical word order, i.e. prosodic prominence on the subject (e.g., [船长]F 穿上了雨衣 '[The **captain**]F put on the raincoat') and prosodic prominence on the object (e.g., 船长穿上了[雨衣]F 'The captain put on [the **raincoat**]F'), i.e. the conditions previously introduced as canonS and canonO. In order to test the role of syntactic focus marking (in the absence of prosodic focus marking) and the role of prosodic focus marking (in the presence of syntactic focus marking), Experiment 4B involved Mandarin utterances in three sentence conditions, including one sentence condition in canonical order, with a prosodic prominence on the object (e.g., 船长穿上了[雨衣]F 'The captain put on [the **raincoat**]F'), and two subject clefts, one with prosodic prominence on the subject (e.g., 是[船长]F 穿上的雨衣 'It was [the **captain**]F who put on the raincoat') and one with prosodic prominence on the object (e.g., 是[船长]F 穿上的[雨衣]F 'It was [the captain]F who put on [the **raincoat**]F'). The conditions were split across two experiments in this way because including them all in a single experiment would have resulted in an unmanageable number of conditions.

Both Experiments 4A and 4B included an identity priming condition in which the visual target word (e.g., *captain*) was the same as the subject of the utterance. Contrastive and noncontrastive associates were also included to separate the alternative priming from general semantic priming. Both of these associates are related to the prime word but only the former can replace it in the context, e.g. *sailor* vs. *deck*. Finally, unrelated items (e.g., *pumpkin*) served as baseline controls.

7.2 Experiment 4A

7.2.1 Research questions

This experiment addressed the following three research questions:

RQ 1. Does prosodic F-marking prime *focused words* in Mandarin?

RQ 2. Does prosodic F-marking prime *contrastive alternatives* to focused words in Mandarin?

RQ 3. Does prosodic F-marking prime *noncontrastive associates* to focused words in Mandarin?

7.2.2 Method

7.2.2.1 Participants

A total of 80 near-monolingual native Mandarin speakers (50 females and 30 males; mean age = 21.91, SD = 2.11, age range = 18-27) from the student population at Henan Polytechnic University in China took part in the experiment. They reported that they had received English education, but that they did not speak other languages at home and were not fluent in any other languages (see details about participants in section 3.3.2.1). They had not lived outside China for more than six months. The participants received supermarket vouchers in recognition of their participation. None of them reported any hearing or reading difficulties.

7.2.2.2 Materials and design

Test sentences

Forty sentences were selected from Experiment 1, as described in section 4.4.3. Thirty-three of them were used in Experiments 2 and 3 (see the full list in Appendix 9). As mentioned in section 4.3.2, all sentences in Experiment 4A describe a simple, plausible event in the past tense, using commonly occurring nouns and verbs. As far as possible, the event described by the verb and the object was not semantically related to the subject, so there were no potential semantic priming relationships within the sentence. All sentences had seven syllables in the canonical order version.

For each of the 40 sentences, two sentence conditions were created, involving different focus marking on the subject noun (see examples in Table 17): *no F-marking*[15], i.e. canonical word order with contrastive prominence on the object (canonO); and *prosodic F-marking*, i.e. canonical word order with contrastive prominence on the subject (canonS). This resulted in a total of 80 experimental sentences.

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[15] Although contrastive prosodic focus marking is present on the object, *no F-marking* is used to refer to the condition that has no marking on the subject.

Table 17 Sentence conditions, with F-marking, and target types used in Experiment 4A

(the information on F-marking refers only to the subject noun in each case)

Sentence conditions	Examples
canonO (no F-marking)	船长穿上了[雨衣]F　　　　(S V [O]F)
	The captain put on [the **raincoat**]F.
canonS (prosodic F-marking)	[船长]F穿上了雨衣　　　　([S]F V O)
	[The **captain**]F put on the raincoat.

Target Types	Examples
Identical	船长
	'captain'
Contrastive	水手
	'sailor'
Noncontrastive	甲板
	'deck'
Control	南瓜
	'pumpkin'

Priming paradigm

I followed the methodology used in some recent studies on the activation of contrastive and noncontrastive associates, such as Husband and Ferreira (2016), Gotzner (2017) and Gotzner et al. (2016), whereby participants see different target words (e.g., identical, contrastive and noncontrastive associates) after the same prime word/sentence. This differs from the standard methodology which was used in almost all earlier studies, e.g., Swinney, 1979, Braun and Tagliapietra (2010), and Norris et al. (2006) (see also the references therein), where participants see the same target word after different prime words/sentences. The standard methodology rules out various factors which are related to the attributes of different target words (e.g., frequency and word length). These factors are known to affect lexical decision times.

There were two reasons for using this alternative approach. Firstly, for the noncontrastive associates, this would result in nonsensical sentences such as 'The deck put on the raincoat', as the form corresponding to the contrastive alternative sentence 'The sailor put on the

raincoat'. It would be possible to use a different sentence frame for noncontrastive associates (e.g., 'The deck is made from lumber'); however, the use of different sentence frames would potentially introduce additional confounding effects on lexical decision times. Secondly, as discussed in section 2.3.2, in Braun and Tagliapietra (2010), as the target word was always the same, the alternative and unrelated control served as different objects in the prime sentence (e.g., the same target word *pelican* after the contrastive prime *flamingo* in 'In Florida he photographed a flamingo', and after the unrelated prime *celebrity* in 'In Florida he photographed a celebrity'). This meant that the unrelated control was actually an unrelated alternative; unrelated alternatives have been shown to be primed by focus particles in a post-hoc analysis in Gotzner (2015). Therefore, with the standard methodology, it is not possible to use truly unrelated controls.

In the current design, variation is introduced by the use of different target words. In order to account for such differences and their potential impact on lexical decisions, both the selection of materials and the analysis of the results included a consideration of a number of factors that are known to affect lexical decision times in priming studies, such as lexical frequency, semantic association strength, word length, and the number of strokes and radicals in the first and second characters (see section 3.3.2). It should be noted here that there are a vast number of factors that could affect reaction times of lexical decisions beyond these factors, including the attributes of the target words, and those that are related to other factors (e.g., non-words) in the experiment setting (e.g., Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004; Ratcliff, Gomez, & McKoon, 2004). Nevertheless, using this approach, I could compare the same targets in different prime conditions (i.e., focus vs. non-focus), and this is the primary focus of the results (see sections 7.2.3.3 and 7.3.3.3).

Each sentence (N = 40) was paired with a quadruplet of target words, consisting of the subject noun, a contrastive alternative to the subject, a noncontrastive associate of the subject and an unrelated control item, as shown in Table 17. The selection criteria for these words can be found in section 4.3.2. Each sentence was paired with each target word in that quadruplet in each sentence condition, resulting in a total of 320 experimental stimuli. Eight lists of 40 experimental stimuli were distributed in a Latin square design, making five items per participant per condition. Each list therefore had 20 canonS sentences and 20 canonO sentences, and each list involved ten identical targets, ten contrastive alternatives, ten

noncontrastive associates and ten control items. The lists were rotated across participants so that each participant saw only one list.

There were several further steps involved in preparing the experimental stimuli, which are described below. First, semantic relatedness scores between different types of target words were obtained for inclusion in the analysis. Second, for similar reasons, the log frequency of target words was calculated between words across target types. Then other items (fillers) were constructed. Finally, the experimental stimuli were recorded and analysed acoustically.

Relatedness scores

The semantic relatedness between the non-identical targets and the subject nouns needed to be measured, so that this could be controlled in the design and analysis of the experiment. Relatedness scores between the non-identical targets and the subject nouns were tested and described in section 4.4.3, as there were no published association norms for Mandarin. The 40 test sentences had similar relatedness scores between the subject noun and each of the two types of associates. A further constraint was that the subject noun and the unrelated control had to be as unrelated as possible (see the statistical analysis of the items in section 4.4.3).

Frequency

The log frequency of each target word was collected from SUBTLEX-CH (Cai & Brysbaert, 2010). The mean log frequency of the chosen items was 3.07 (SD = 0.4) for subject nouns, 2.88 (SD = 0.45) for contrastive alternatives, 2.78 (SD = 0.42) for noncontrastive associates, and 2.88 (SD = 0.46) for unrelated controls. The log frequencies were analysed by ANOVA, with word type (subject noun, contrastive alternative, noncontrastive associate, unrelated control) as the independent variable. The ANOVA showed a significant effect of word type (F = 3.1, p = 0.03). A post-hoc Tukey test was then conducted, showing that word types were not significantly different from each other (all p values > 0.1), except for the comparison of noncontrastive associates and subject nouns (t (156) = -3.00, p = 0.016). Because of this significant difference between noncontrastive associates and subject nouns, as well as the variance in frequency between items with each condition, log frequency was included in the analysis of the experimental results later.

Other items

An additional 120 filler sentences were included with word and nonword visual targets, which led to a total of 160 trials per list (40 test items + 120 fillers). Forty of the filler

sentences had word targets but sentence structures that differed from the test items (SV, SVAdv etc.). As the participants' task in the experiment was to decide whether the two characters of the target make up a real word in Mandarin, trials with nonword targets were also included. To avoid response bias, a balance of word and nonword targets was needed, and so the filler trials included 80 with nonword targets. Among the 80 filler sentences, 40 had the same sentence conditions (canonO, canonS), and the other 40 had different sentence structures (SV, SVAdv etc.). Seven words and 15 nonwords were phonologically related to one of the words in the sentence to reduce possible strategic effects based on participants noticing semantic relationships between primes and targets.

Nonwords were selected from the lexical decision data provided by Cai and Brysbaert (2010), and only included items with 100% nonword accuracy. The nonwords consist of two real characters which do not make up a real word together, e.g., 手 'hand' 幻 'fantasy'.

Six practice sentences were also constructed, three with word targets and three with nonword targets. In addition, twenty comprehension questions were constructed (e.g., 谁饿了？ 'Who was hungry?'), which asked about the content of a previous filler (e.g., 老鹰饿了 'The eagle was hungry.') with two answer choices (老鹰 'eagle' and 兔子 'rabbit'). These questions were distributed unevenly across the experiments so that they could not be predicted by participants. Their purpose was to encourage participants to pay attention to the content of the sentences.

Recording and acoustic analysis

Similar to the procedure described in section 5.3.2, the 80 critical sentences were recorded directly to hard drive using Praat by a trained female native Mandarin speaker (myself) in a soundproof room at Victoria University of Wellington through a USB-based microphone. Duration, mean F0, mean intensity and F0 range for these 80 sentences were analysed with separate linear mixed effects models for each measurement using *lme4* in *R*. The fixed effects initially included sentence condition (canonO, canonS) and word position (subject, object) as well as the interaction between the two. Due to other crucial constraints (frequencies, relatedness etc.), the lexical tone combinations (the tone of the first character + the tone of the second character) of the subject nouns were not controlled. Therefore, tone combinations were also included. The distribution of tones is given in Table 18. Tone combination was

therefore included as a single factor. Word was the random intercept. Sentence condition was included as the by-Word slope. Each model was reduced to remove non-significant factors (see the analysis method in section 3.3.2.3).

Table 18 Distribution of tones of subject nouns in critical stimuli in Experiment 4A

(The numbers indicate the number of tone combinations)

	Tone 1 in the first syllable	Tone 2 in the first syllable	Tone 3 in the first syllable	Tone 4 in the first syllable
Tone 0[16] in the second syllable	NA	NA	NA	2
Tone 1 in the second syllable	4	1	4	3
Tone 2 in the second syllable	2	1	NA	4
Tone 3 in the second syllable	6	1	1	2
Tone 4 in the second syllable	2	3	1	3

Table 19 Fitted mean values of duration (ms), mean F0 (Hz), mean intensity (dB) and F0 range (Hz) of the subject and object nouns in Experiment 4A

Sentence condition	WordPosition	Duration	Mean F0	Intensity	F0 range
canonS	Subject	697	333	80	267
	Object	560	184	66	87
canonO	Subject	542	213	71	81
	Object	725	277	76	219

The fitted values are provided in Table 19. The ANOVA tables of the final models for each measurement are provided in Table 20 (duration), Table 21 (mean F0), Table 22 (mean intensity) and Table 23 (F0 range). All four models show a significant interaction between sentence condition and word position. Tone combination was a significant factor for mean F0 and F0 range. In general, as Table 19 shows, in subject-stressed sentences (canonS), the subject was acoustically more prominent than the object, whereas in object-stressed sentences (canonO), the object was acoustically more prominent than the subject. Planned comparisons through the *emmeans* function in the *emmeans* package showed that, within the same

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[16] Tone 0, the neutral tone, can only occur in the word-final position.

sentence condition, prosodically focused subjects or objects were acoustically more prominent than unfocused subjects or objects for all four parameters (all p values < 0.0125). Collapsing over sentence conditions, subject words in the subject-stressed sentence condition (canonS) had longer duration, higher mean F0, higher mean intensity and larger F0 range than those in the object-stressed sentence condition (canonO) (all p values < 0.0125). Moreover, object words in canonS were less prominent on all four measures than those in canonO (all p values < 0.0125). The aforementioned differences confirm that the materials have the intended patterns of prominence location.

Table 20 ANOVA table for the duration analysis in Experiment 4A

Model: SentenceCondition*WordPosition+(1|Word)

	Chisq	Df	P
SentenceCondition	0.12	1	0.73
WordPosition	3.65	1	0.06
SentenceCondition: WordPosition	463.64	1	< 0.001

Table 21 ANOVA table for the mean F0 analysis in Experiment 4A

Model: SentenceCondition*WordPosition +ToneCombination+(1|Word)

	Chisq	Df	P
SentenceCondition	20.77	1	< 0.001
WordPosition	103.31	1	< 0.001
ToneCombination	79.66	18	< 0.001
SentenceCondition: WordPosition	821.19	1	< 0.001

Table 22 ANOVA table for the mean intensity analysis in Experiment 4A

Model: SentenceCondition*WordPosition+(1|Word)

	Chisq	Df	P
SentenceCondition	7.82	1	0.005
WordPosition	47.62	1	< 0.001
SentenceCondition: WordPosition	164.47	1	< 0.001

Table 23 ANOVA table for the F0 range analysis in Experiment 4A

Model: SentenceCondition*WordPosition+ToneCombination+(1|Word)

	Chisq	Df	P
SentenceCondition	10.53	1	0.001
WordPosition	4.03	1	0.045
ToneCombination	82.54	18	< 0.001
SentenceCondition: WordPosition	317.26	1	< 0.001

As mentioned in sections 2.3.2 and 7.1, ISI, the duration between the offset of the prime word and the onset of the visual target, was shown to influence the priming of target words in Husband and Ferreira (2016). In addition, when visual targets are shown while the sentences are playing, as in Husband and Ferreira (2016), the continuing auditory input and associated processing of the spoken sentence might interfere with the process of making a lexical decision on the visual target. In order to achieve a constant interval of 1500 ms, which also allowed all sentences to finish with a reasonable interval between the end of the sentence and the onset of the display of the visual target, silent intervals of between 121 and 538 ms were added to the sound file after the offset of the sentence, with the visual target presented immediately at the offset of the sound file.

7.2.2.3 Procedure

The experiment was administered using Opensesame v. 3.1, and was run in a quiet computer room at Henan Polytechnic University. The entire session was conducted in Mandarin. Participants were seated in front of a computer screen with closed-ear headphones. At the start of the experiment, participants received written instructions on the computer screen, and the instructions were also repeated orally by the experimenter (myself) after the participants had read them. In the practice phase, participants first heard a sentence, and while the sentence was being played, they concentrated on a fixation point in the middle of the screen. They then saw two characters, and had to decide whether these two characters made up a real word by pressing the 'm' key (labelled as 是 'yes') for *yes* and the 'z' key (labelled as 否 'no') for *no,* if their dominant hand was the right hand. The labels were swapped for the left-handed participants. They had to make this response as quickly as they could. In the practice phase, participants received feedback on their lexical decision responses (if their answer was

wrong) and RT (if their response time exceeded 1000 ms). These criteria were in the instructions prior to the practice phase (see Appendix 15).

The procedure of the main experiment was similar to the practice phase, but no feedback was provided. The main experiment moved to the next trial automatically if no key was pressed within three seconds from the presentation of the visual target. The stimuli were divided into four blocks with a compulsory break of at least 10 seconds between blocks. Both the order of stimuli within a block and the order of the blocks were randomised. Twenty of the filler trials were followed by the twenty comprehension questions which appeared randomly across the experiment. The comprehension questions required 'x' or 'n' key press (rather than 'm' or 'z') to adjust to the comprehension questions being a different task (from lexical decision) and therefore avoid mistakes. There was always a filler trial following a comprehension question. The entire experiment lasted approximately 12 minutes. Demographic information such as sex, age, hometown and English proficiency was collected using a paper form at the end of the experiment (as in Experiments 2 and 3).

7.2.3 Results

7.2.3.1 Data cleaning and analysis

A total of 12,800 lexical decision responses were recorded, 160 from each of 80 participants. 3,200 of them were from the critical trials. Data from three participants (120 responses) were discarded due to low response accuracy over all trials ($< 80\%$). The resulting count of trials for the accuracy analysis was 3,080. A further 57 incorrect critical trials (1.85%) were excluded from the RT analysis but not from the accuracy analysis. The RTs were inverse transformed, which was the best transformation compared with no transformation, log transformation and square root transformation (see section 3.3.2.3 for details). The transformed RTs were then multiplied by 10000 in order to make the estimates and SDs more readable. Further, data points of residuals whose standard deviations were larger than 2.5 were eliminated. This resulted in the removal of a further 75 trials (2.5%). The back-transformed data were used when plotting the predicted values.

Mixed effects regression models were built to test how accuracy and RTs were affected by a number of factors, using the *R* package *lme4*. For the accuracy analysis, response choice was the dependent variable in logistic mixed effects models. I report on the accuracy results for completeness, as is standard in such studies. For the RT analysis, transformed reaction time

was the dependent variable in linear mixed effects regression. The full model for accuracy included key experimental predictors, item factors and participant factors, as mentioned in section 3.3.2. The key experimental predictors were stress position (subject, object), target type (subject noun, contrastive alternative, noncontrastive associate and unrelated control) and their interaction. The item factors included the centred position of the trial in the experiment and the log frequency of target words. The participant factors included sex, level of English, hometown and age. As mentioned in 3.3.2, motivated by the literature and justified by the data, the random effects included intercepts for participants and items, and random slopes for the interactions between the key experimental factors by participants and by items, as well as the random slope for the centred position of the trial in the experiment by participants.

The full model for RTs also included, besides the factors mentioned above, item factors such as the number of strokes and radicals in the first and second character, as they may have an effect as discussed in section 3.3.2. The RT and accuracy of the response to the previous trial, and whether the target of the previous trial was a real word were also included, as they can have spillover effects on the subsequent trial. Silence duration was also included as a predictor in the model, as this was variable between stimuli[17]. As the tones of subject nouns in the experimental stimuli were not controlled, the tone combination of the two elements making up the nouns was included in the analysis to test whether tone had an effect. As with the acoustic analysis of the experimental sentences, tone combination was included as a categorical variable.

7.2.3.2 Accuracy

The overall accuracy on critical trials is 98.15%. Following the model selection procedure detailed in section 3.3.1, the final model for accuracy included simple effects of sentence condition and target type, as well as a random effect of participants. The ANOVA table of the final model showing the marginal significance of the fixed effects is given in Table 24 (the fixed effects of the model are summarised in Appendix 11). In order to test which target types

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[17] Note that silence duration was correlated with sentence type, as canonO sentences were longer than canonS sentences because of the stress on the object noun. One possible way to deal with collinearity is to regress silence duration against sentence type, and use the residuals (the difference of the actual silence duration from the predicted silence duration for each sentence) as a predictor. However, this way seems to be problematic (Wurm & Fisicaro, 2014). Therefore, silence duration as an unresidualised variable was used in the model. Neither residualised nor unresidualised silence duration significantly improved the model fit ($p > 0.1$), so it was not kept in the final model.

differed from each other, planned comparisons using the *emmeans* function in the *emmeans* package were conducted. Identical items received marginally higher accuracy rates than control items (z = 2.5, p = 0.07), but no significant differences were found between other target types (all p values > 0.1). In general, canonS also received marginally higher accuracy rates than canonO (z = 1.74, p = 0.08).

Table 24 ANOVA table of the final model for the accuracy analysis in Experiment 4A

Model: SentenceCondition+TargetType+(1|Participant)

	Chisq	Df	P
SentenceCondition	3.03	1	0.08
TargetType	6.93	3	0.07

Table 25 ANOVA table of the final model for the RT analysis in Experiment 4A

Model:
TargetType*SentenceCondition+LogFrequency+CentredTrial+PreviousRT+(1|Participant)
+(1|Item)

	Chisq	Df	P
TargetType	50.13	3	< 0.001
SentenceCondition	21.71	1	< 0.001
LogFrequency	23.18	1	< 0.001
CentredTrial	99.61	1	< 0.001
PreviousRT	120.52	1	< 0.001
TargetType:SentenceCondition	3.22	3	0.31

7.2.3.3 Reaction times

The ANOVA table showing the significance of fixed effects in the final model is given in Table 25 (the fixed effects of the model are summarised in Appendix 11). The final model for RTs included the two key variables and their interaction, and also the centred position of the trial, the log frequency of target words and the RT of the previous trial in the fixed effect structure. The non-significant interaction of the two key variables was kept in the final model, as it was of interest in this thesis. The final model also had random intercepts for participants

and items. Responses became faster over the course of the experiment (β = 0.01[18], SD = 0.001). Words of higher frequency were recognised faster (β = 0.76, SD = 0.16). Participants responded faster when the transformed RT to the previous trial was fast (β = 0.17, SD = 0.02). None of the other factors included in the initial model were significant, thus I will not discuss them.
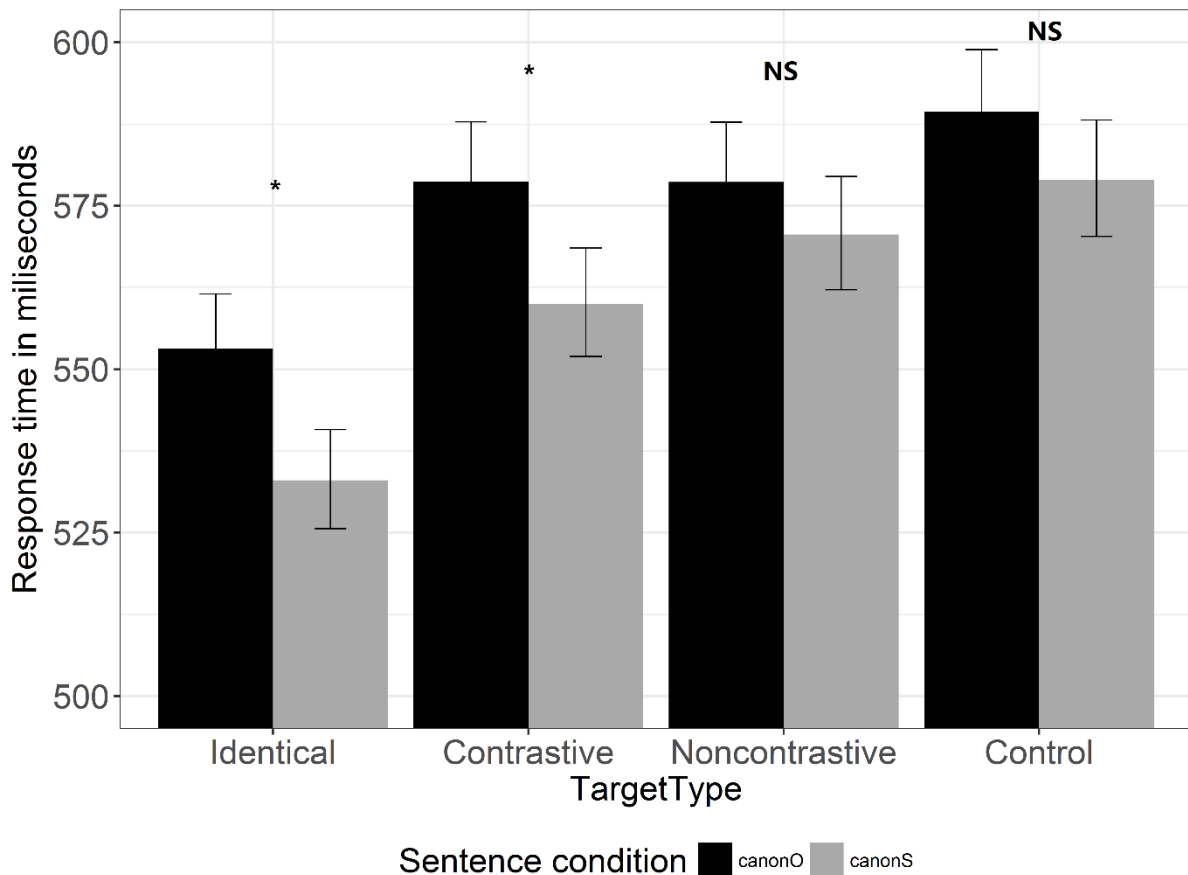
Figure 21 Back-transformed fitted RTs in milliseconds to four target types in canonO and canonS conditions in Experiment 4A. Error bars show standard error of the means. Asterisks (*) show significant comparisons (p < 0.05). NS stands for non-significant.

The final model showed significant effects of sentence condition and target type (see Table 25). The fitted RTs are shown in Figure 21. Averaging the two sentence conditions, identical words were recognised the fastest at 543.1 ms, then contrastive alternatives (569.4 ms), and then the other two target types (noncontrastive: 574.6 ms; control: 584.1 ms). For sentence

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[18] Since the dependent variable is an inverse transform of RT, negative coefficient estimates represent slower responses, and positive coefficient estimates represent faster responses.

condition, averaging across the four target types, canonS received faster responses (560.6 ms) than canonO (575 ms).

In order to find out how different target types were affected by sentence condition, planned comparisons on the interaction using the *emmeans* function in the *emmeans* package were conducted. As discussed in section 3.3.2.3, it is still meaningful to conduct further planned comparisons when there is no significant interaction. This can help explore specific research questions (Wei et al., 2012). The planned comparisons concentrated on the comparisons of same targets across different focus conditions, as discussed in section 7.2.2.2. However, the comparisons of unrelated controls and other target items in each sentence condition were also conducted to be used as supporting evidence.

Planned comparisons were conducted between the no F-marking and prosodic F-marking conditions (i.e., between canonO and canonS respectively) for all four target types. The results showed that the recognition of identical items and contrastive alternatives was facilitated in the prosodic F-marking condition compared to the no F-marking condition (identical: $t = 3.53$, $p = 0.001$; contrastive alternatives: $t = 2.97$, $p = 0.008$) (see Table 26). Both the other comparisons were not significant (all p values > 0.1) (see Table 26).

Table 26 Comparisons of target words (identical, contrastive, noncontrastive, unrelated controls) across the two sentence conditions (canonO, canonS). An asterisk (*) indicates a significant comparison ($p < 0.05$).

	canonO vs. canonS (no F-marking vs. prosodic F-marking)
Identical	*
Contrastive	*
Noncontrastive	NS
Control	NS

Planned comparisons were also conducted between the related target types (identical, contrastive and noncontrastive associates) and unrelated controls in the no F-marking condition (canonO) and in the prosodic F-marking condition (canonS). The results showed that identical items (subject nouns) had significant facilitation over unrelated controls in both sentence conditions (canonO: $t = 4.68$, $p < 0.001$; canonS: $t = 6.31$, $p < 0.001$). Contrastive

alternatives were facilitated over unrelated controls in the canonS condition (t = 2.49, p = 0.026), but not in the canonO condition (t = 1.32, p = 0.23). Neither of the comparisons between noncontrastive associates and unrelated controls in the two sentence conditions was significant (both p values > 0.1). These comparisons showed similar patterns to the within sentence condition comparisons above, that the recognition of identical items and contrastive associates was facilitated by prosodic focus marking.

An additional analysis testing for effects of the relatedness of the prime word to the visual target was conducted. This analysis excluded trials with identical targets, as the relatedness would be between a prime word and itself. An ANOVA model comparison showed that relatedness did not significantly improve the model fit ($\chi^2(1) = 0.4$, p = 0.53).

7.2.4 Discussion

A cross-modal priming lexical decision experiment was conducted, to investigate partly the third component of the *focus marking - language processing* link, i.e. the role of prosodic cues in the activation of discourse information. This experiment involved two sentence conditions: no focus marking (canonO, i.e., canonical order with contrastive prominence on the object), and prosodic focus marking (canonS, i.e., canonical order with contrastive prominence on the subject). This experiment also had four target types (identical, contrastive, noncontrastive, control) related to subject nouns with a fixed ISI of 1500 ms. This experiment addressed three main questions (see section 7.2.1): whether prosodic focus marking primes *focused words*, *their contrastive alternatives* and *noncontrastive associates*. In general, the experiment showed that prosodic focus marking facilitated the activation of identical items and contrastive alternatives, but not that of noncontrastive associates and unrelated controls.

In relation to **the first research question** (see section 7.2.1), whether prosodic focus marking primes focused words, the results showed that prosodic focus marking facilitated the recognition of identical targets. This identity priming found in this experiment is in line with the previous research findings from phoneme-monitoring and memory tasks as shown in section 2.3.2. This is consistent with Norris et al. (2006) for English, therefore the findings also validate the effectiveness of the methodology in Mandarin (though the presentation of identity priming is different across the two studies). These results together show that prosodic focus marking increases attention to and activation of the focused word.

In relation to **the second research question** (see section 7.2.1), whether prosodic focus marking primes *contrastive alternatives*, the results showed that prosodic focus marking facilitated the recognition of contrastive alternatives. The results provide the first psycholinguistic evidence of the effect of prosodic focus marking on the lexical activation of unmentioned alternatives in Mandarin. These findings are in line with Braun and Tagliapietra (2010) for Dutch (note the method of measuring priming in this experiment is different), showing alternative priming is still alive in later processing (ISI = 1500 ms). The results are also consistent with the related findings using eye-tracking and other findings in Germanic languages reported in section 2.3.2. All these results provide support to Rooth's (1992) alternative theory that focus marking signals the presence of contextually-relevant alternatives.

In relation to **the third research question** (see section 7.2.1), whether prosodic focus marking primes *noncontrastive associates*, the results showed that prosodic focus marking did not facilitate the recognition of noncontrastive associates. Noncontrastive associates are not plausible replacements for the focused words in sentences, so listeners do not consider them as part of the alternative set, re Rooth (1992).

In general, the results are largely consistent with Braun and Tagliapietra (2010), who found a facilitatory role of contrastive prosodic prominence on contrastive alternatives, but no effects on noncontrastive associates. Therefore, this experiment, together with previous findings on Germanic languages, provides cross-linguistic behavioural evidence for Rooth's (1992) theory, showing that contrastive alternatives differ from noncontrastive associates in the processing of focus. Considering the results from this experiment and Braun and Tagliapietra (2010), the time course of activation seems to be that the activation of contrastive alternatives was facilitated at 0 ms (Dutch), and persists to 1500 ms (Mandarin), but noncontrastive associates showed no facilitation by contrastive prominence at 0 ms or later. This might suggest that the role of prosodic prominence in priming contrastive alternatives is immediate and persists for a considerable time (beyond the processing of the utterance).

This experiment extends previous research findings, suggesting that prosodic prominence as manifested in global F0 range is also effective, along with pitch accenting, in priming implicit contextual alternatives in languages that use prosodic prominence as one of the main markers of focus. The effectiveness of prosodic prominence in priming discourse information is also

congruent with its importance in the perception of focus (Experiment 2) and in the encoding of discourse information (Experiment 3). In the following Experiment 4B, I also investigated the role of syntactic focus marking in priming discourse information. Together with the findings from Experiment 4A, Experiment 4B addresses the third component of the *focus marking - language processing* link, i.e. the relative roles of prosodic and syntactic cues in priming discourse information.

7.3 Experiment 4B

To investigate the role of syntactic focus marking in the activation of discourse information in Mandarin, a second cross-modal lexical priming experiment was run (Experiment 4B). Two kinds of focus marking were investigated in this experiment: prosodic and syntactic. Prosodic prominence was investigated in the presence of syntactic marking, as prosodic prominence in the absence of clefting had already been investigated in Experiment 4A. This was to confirm whether prosodic prominence still primes alternatives in the presence of other kinds of focus marking, and whether prosodic + syntactic cues have an additive effect on lexical activation. Syntactic focus marking was also investigated in the absence of prosodic focus marking, in order to tease it apart the priming effect of contrastive prosodic prominence. As with Experiment 4A, Experiment 4B also tests activation associated with subject nouns.

7.3.1 Research questions

This experiment addressed the following three sets of research questions:

RQ 1. Does prosodic F-marking (in the presence of syntactic F-marking) prime *focused words* in Mandarin?

Does syntactic F-marking (in the absence of prosodic F-marking) prime *focused words* in Mandarin?

RQ 2. Does prosodic F-marking (in the presence of syntactic F-marking) prime *contrastive alternatives* to focused words in Mandarin?

Does syntactic F-marking (in the absence of prosodic F-marking) prime *contrastive alternatives* to focused words in Mandarin?

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RQ 3. Does prosodic F-marking (in the presence of syntactic F-marking) prime *noncontrastive associates* to focused words in Mandarin?

Does syntactic F-marking (in the absence of prosodic F-marking) prime *noncontrastive associates* to focused words in Mandarin?

7.3.2 Method

7.3.2.1 Participants

Ninety-nine near-monolingual native Mandarin speakers (79 females and 20 males, mean age = 20.77, SD = 1.92, age range = 18–26) were recruited from students at Henan Polytechnic University in China with similar characteristics as the participants described in section 7.2.2.1.

7.3.2.2 Materials and design

Sixty critical sentences were constructed for Experiment 4B (see the full list in Appendix 9). Forty of them were used in Experiment 4A. As with the materials in Experiment 4A, all sentences in Experiment 4B described a simple, plausible event in the past tense, using commonly occurring nouns and verbs. As far as possible, the event described by the verb and the object was not semantically related to the subject, so there were no potential semantic priming relationships within the sentence. All sentences had seven syllables in the canonical order version.

Table 27 Sentence conditions, with F-marking, and target types used in Experiment 4B

(the information on F-marking refers only to the subject noun in each case)

Sentence conditions	Examples	
canonO (no F-marking)	船长穿上了[雨衣]F	(S V [**O**]F)
	The captain put on the [**raincoat**]F.	
ScleftO (syntactic F-marking)	是[船长]F穿上的[雨衣]F	(COP [S]F V DE [**O**]F
	It was the [captain]F who put on the [**raincoat**]F.	
ScleftS (prosodic + syntactic F-marking)	是[**船长**]F穿上的雨衣	(COP [**S**]F V DE O)
	It was the [**captain**]F who put on the raincoat.	

Target Types	Examples
Identical	船长
	'captain'
Contrastive	水手
	'sailor'
Noncontrastive	甲板
	'deck'
Control	南瓜
	'pumpkin'

For each sentence, three versions were created, involving different kinds of focus marking on the subject noun (see examples in Table 27): *no F-marking*, i.e. canonical word order with contrastive prominence on the object (canonO); *syntactic F-marking*, i.e. subject cleft with contrastive prominence on the object (ScleftO); and *prosodic+syntactic F-marking*, i.e. subject cleft with contrastive prominence on the subject (ScleftS). This resulted in 180 experimental sentences (60 sentences * 3 sentence conditions).

As in Experiment 4A, for each sentence, a quadruplet of four target types was constructed (identical item, contrastive alternative, noncontrastive associate, unrelated control) (see examples in Table 27). Three sentence conditions and four target types resulted in twelve experimental conditions. For 60 sentences, this gave a total of 720 experimental stimuli. Twelve lists of 60 experimental stimuli were constructed in a Latin square design. Each participant saw only one list.

As with Experiment 4A, there were several further steps involved in preparing the experimental stimuli: semantic relatedness scores, word frequencies, fillers and acoustic analyses of the experimental stimuli.

Relatedness scores

As with Experiment 4A, the relatedness scores between the non-identical targets and the subject nouns were tested and described in section 4.4.3. The 60 test sentences had similar relatedness scores between the subject noun and each of the two types of associates. A further constraint was that the subject noun and the unrelated control had to be as unrelated as possible (see the statistical analysis of the items in section 4.4.3).

Frequency

The mean log frequency of the chosen items was 3.1 (SD = 0.44) for subject nouns, 2.9 (SD = 0.43) for contrastive alternatives, 2.8 (SD = 0.43) for noncontrastive associates and 2.9 (SD = 0.44) for unrelated controls. The log frequencies were tested by ANOVA, which showed a significant effect of log frequency (F = 4.6, p = 0.004). A post-hoc Tukey test was then conducted, showing a significant difference between subject nouns and noncontrastive associates (t (236) = 3.70, p = 0.002), despite the attempt to match the target types for frequency. Due to the significant difference across conditions and variation between items within each condition, log frequency was included in the analysis of the experimental results later. No significant differences were found between the other groups (all p values > 0.1).

Other items

A further 150 filler sentences with word and nonword targets were constructed, which led to a total of 210 trials per list (60 test items + 150 fillers). Among these fillers, 45 sentences had different sentence structures (SV, SVAdv etc.) with words as targets. To counterbalance yes/no responses across the whole experiment, 105 trials with nonword targets were also included. Among the 105 filler sentences, 60 had the same syntactic structures as the test items (canonO, ScleftO, ScleftS), and 45 had different sentence structures (SV, SVAdv etc.) with words as targets. Ten word and 20 nonword targets for fillers were phonologically related to one of the words in the sentence. As with Experiment 4A, nonwords were selected from Cai and Brysbaert's (2010) corpus of lexical decision data, limited to items with 100% nonword accuracy. Six practice sentences were also prepared, three of which had word and three of which had nonword visual targets. Further, twelve comprehension questions asking

about the content of a previous filler were included to encourage participants to pay attention to the sentences.

Recording and acoustic analysis

Similar to the procedure described in section 5.3.2, the 180 critical sentences were recorded directly to hard drive using Praat by a trained female native Mandarin speaker (myself) in a soundproof room at Victoria University of Wellington through a USB-based microphone. The duration, mean F0, mean intensity and F0 range of words were fitted as the dependent variable in separate linear mixed effects models. The fixed effects initially included sentence condition (canonO, ScleftO, ScleftS) and word position (subject, object) as well as the interaction between the two. Due to other crucial constraints (frequencies, relatedness etc.), the tone combinations on the subject nouns were not controlled in the creation of the stimuli. The distribution of tones is given in Table 28. Tone combination was therefore included as a single factor. Word was the random intercept. Sentence condition was included as the by-Word slope.

Table 28 Distribution of tones of subject nouns in critical stimuli in Experiment 4B

	Tone 1 in the first syllable	Tone 2 in the first syllable	Tone 3 in the first syllable	Tone 4 in the first syllable
Tone 0 in the second syllable	3	NA	NA	2
Tone 1 in the second syllable	4	2	5	4
Tone 2 in the second syllable	3	3	3	4
Tone 3 in the second syllable	6	2	1	5
Tone 4 in the second syllable	2	5	2	4

Each model was reduced to remove non-significant factors (see further section 3.3.2.3). The fitted values from the final models are provided in Table 29. The ANOVA tables of the final models for each measurement are provided in Table 30 (duration), Table 31 (mean F0), Table 32 (mean intensity) and Table 33 (F0 range). Tone combination was a significant factor for duration, mean F0 and F0 range. All four models showed a significant interaction between

sentence condition and word position. In general, as Table 29 shows, in subject-stressed sentences, the subject was acoustically more prominent than the object, whereas in object-stressed sentences, the object was acoustically more prominent than the subject. Planned comparisons, which were run using the *emmeans* function in the *emmeans* package, showed that, within the same sentence condition prosodically focused subjects or objects were acoustically more prominent than unfocused subjects or objects in terms of all three parameters (all p values < 0.0125). Across sentence conditions, subject words in the subject-stressed sentence condition (ScleftS) had longer duration, higher mean F0, higher mean intensity and larger F0 range than those in the object-stressed sentence condition (canonO and ScleftO) (all p values < 0.0125). Moreover, object words in ScleftS were less prominent than those in canonO and ScleftO on all the four measures (all p values < 0.0125). The aforementioned differences confirm that the materials have the intended patterns of prominence location.

Table 29 Fitted mean values of duration (ms), mean F0 (Hz), mean intensity (dB) and F0 range (Hz) of the subject and object nouns in Experiment 4B

Sentence condition	WordPosition	Duration	Mean F0	Intensity	F0 range
canonO	Subject	566	216	70	81
	Object	740	288	75	243
ScleftO	Subject	535	210	70	72
	Object	732	283	75	243
ScleftS	Subject	680	336	79	264
	Object	585	180	64	85

Table 30 ANOVA table for the duration analysis in Experiment 4B

Model: SentenceCondition*WordPosition+ ToneCombination +(1|Word)

	Chisq	Df	P
SentenceCondition	15.87	2	< 0.001
WordPosition	103.56	1	< 0.001
ToneCombination	40.01	19	0.003
SentenceCondition: WordPosition	738.84	2	< 0.001

Table 31 ANOVA table for the mean F0 analysis in Experiment 4B

Model: SentenceCondition*WordPosition +ToneCombination+(1|Word)

	Chisq	Df	P
SentenceCondition	18.02	2	< 0.001
WordPosition	0.24	1	0.62
ToneCombination	139.99	19	< 0.001
SentenceCondition: WordPosition	1781.49	2	< 0.001

Table 32 ANOVA table for the mean intensity analysis in Experiment 4B

Model: SentenceCondition*WordPosition+(1|Word)

	Chisq	Df	P
SentenceCondition	32.7	2	< 0.001
WordPosition	6.51	1	0.011
SentenceCondition: WordPosition	2950.44	2	< 0.001

Table 33 ANOVA table for the F0 range analysis in Experiment 4B

Model: SentenceCondition*WordPosition+ToneCombination+(1|Word)

	Chisq	Df	P
SentenceCondition	6.64	2	0.036
WordPosition	45.57	1	< 0.001
ToneCombination	70	19	< 0.001
SentenceCondition: WordPosition	666.54	2	< 0.001

As in Experiment 4A, in order to keep the ISI between prime word and visual target constant, a variable duration of silence (0 ms to 607 ms) was added to the end of each sound file, so that the ISI was always 1500 ms.

7.3.2.3 Procedure

The procedure is the same as described in section 7.2.2.3 for Experiment 4A.

7.3.3 Results

7.3.3.1 Data cleaning and analysis

A total of 20,790 lexical decision responses were recorded, 210 from each of 99 participants. Data from three participants were excluded for low accuracy on target word responses, and from one further participant because the 'yes' button was not pressed with the dominant hand. The remaining 5,700 critical trials, i.e. 60 from each of 95 participants, were used for the accuracy analysis. One hundred twenty-three trials of these trials had incorrect responses (2.2%) and were excluded from the response time analysis, leaving 5,577 responses. The remaining RTs were inverse transformed, which was the best transformation compared with no transformation, log transformation and square root transformation. The transformed RTs were then multiplied by 10,000 in order to make the estimates and standard errors more readable. Further, data points of residuals whose standard deviations were larger than 2.5 were further eliminated. This resulted in the removal of 116 trials (2%).

For the accuracy analysis, response choice was the dependent variable in logistic mixed effects regression and for the RT analysis, transformed RT was the dependent variable in linear mixed effects regression. Apart from the sentence conditions, the full models for both the accuracy and the RT analysis in this experiment included the same fixed effects and random effects as in Experiment 4A (see section 7.2.3.1).

7.3.3.2 Accuracy

The overall accuracy on the critical trials was 97.8%. The final model for accuracy included target type, the log frequency of target words and the centred position of the trial in the experiment as fixed effects. The final model also had a random intercept of participants. The ANOVA table of the final model showing the significance of the fixed effects is given in Table 34 (the fixed effects of the model are summarised in Appendix 11). Participants were more accurate for target words that had higher lexical frequency ($\beta = 0.73$, SD = 0.22) and which occurred later in the experiment ($\beta = 0.01$, SD < 0.01). In order to test which target types differed from each other, planned comparisons were conducted using the *emmeans* function in the *emmeans* package. Identical and contrastive items received higher accuracy rates than control items (identical: z = 3.1, p = 0.01; contrastive: z = 2.8, p = 0.03), but no significant differences were found between other target types (identical vs. contrastive; identical vs. noncontrastive; contrastive vs. noncontrastive; all p values > 0.1).

Table 34 ANOVA table of the final model for the accuracy analysis in Experiment 4B

Model: TargetType+LogFrequency+CentredTrial+(1|Participant)

	Chisq	Df	P
TargetType	13.34	3	0.004
LogFrequency	11.12	1	< 0.001
CentredTrial	10.25	1	0.001

Table 35 ANOVA table of the final model for the RT analysis in Experiment 4B

Model: SentenceCondition* TargetType+LogFrequency+CentredTrial+
PreviousCorrectness+PreviousRT+PreviousWordness+(1|Participant) +(1|Item)

	Chisq	Df	P
SentenceCondition	18.11	2	< 0.001
TargetType	49.38	3	< 0.001
LogFrequency	36.21	1	< 0.001
CentredTrial	99.99	1	< 0.001
PreviousCorrectness	9.05	1	0.003
PreviousRT	181.82	1	< 0.001
PreviousWordness	23.96	1	< 0.001
SentenceCondition:TargetType	14.96	6	0.02

7.3.3.3 Reaction times

The fixed effects in the final model for RTs were sentence condition, target type, the interaction between sentence condition and target type, the log frequency of target words, the centred position of the trial, the RT of the previous trial, whether the previous response was correct, and whether the previous target was a word. The ANOVA table showing the significance of variables in the final model is given in Table 35 (the fixed effects of the model are summarised in Appendix 11). The random effect structure included just intercepts for participants and items. Participants became faster over the course of the experiment (centred trial: $\beta = 0.006$, SD = 0.001; recall that the inverse transformation means that higher coefficient values correspond to faster response times). Words of higher frequency were recognised faster (log frequency: $\beta = 0.82$, SD = 0.14). Participants responded more quickly when the previous response was correct (PreviousCorrectness: $\beta = 0.57$, SD = 0.19); and when the previous trial was a word (PreviousWordness: $\beta = 0.39$, SD = 0.08). Participants

responded more quickly when the transformed RT to the previous trial was slower (PreviousRT: β = -0.003, SD < 0.001).
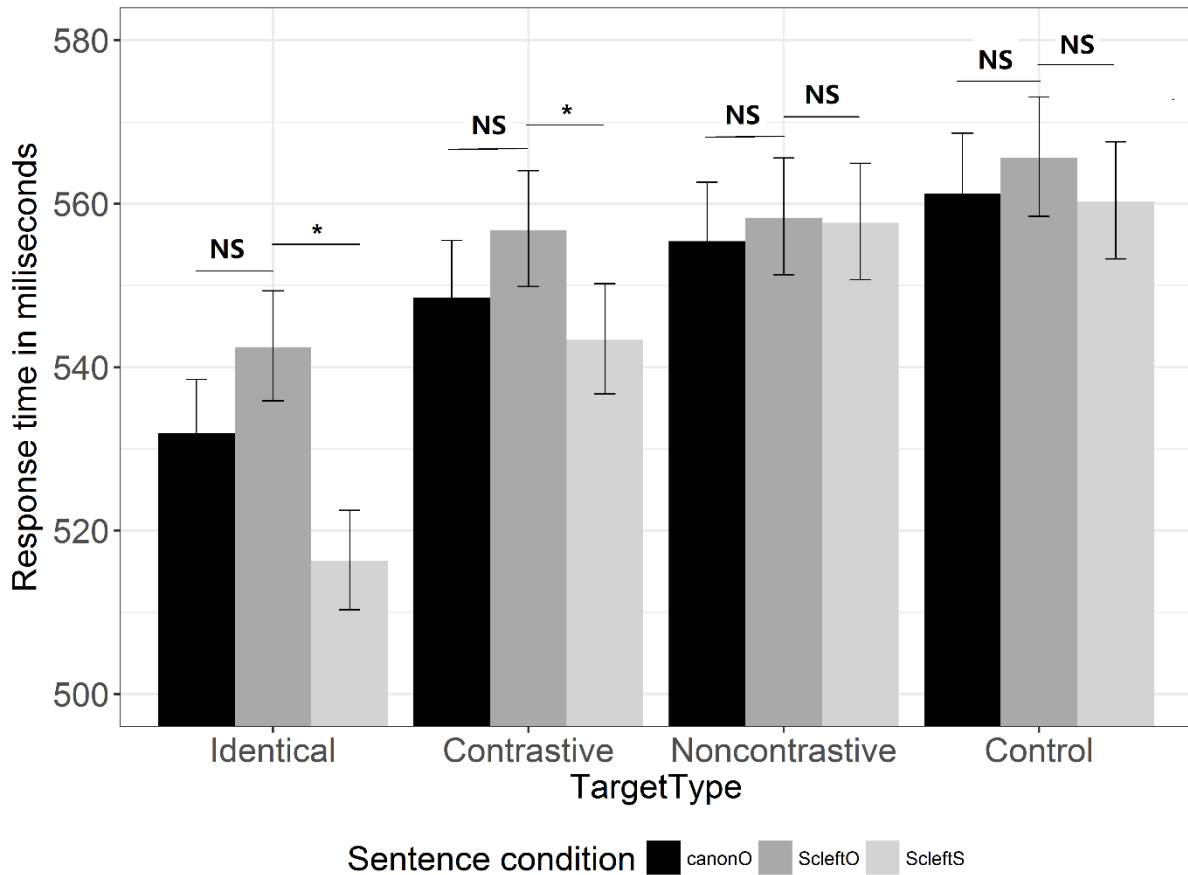
Figure 22 Back-transformed fitted RTs in milliseconds to four target types in canonO, ScleftO and ScleftS conditions in Experiment 4B. Error bars show standard error of the means. Asterisks (*) show significant comparisons (p < 0.05). NS stands for non-significant.

The final model showed main effects of sentence condition and target type, as well as their interaction (see Table 35). The fitted RTs are shown in Figure 22. As expected, identical words were recognised the fastest (mean of 530 ms across sentence conditions), then contrastive alternatives (549.5 ms), and then the other two target types (noncontrastive: 557.1 ms; control: 562.4 ms). For sentence condition, averaging over target types, ScleftS was the fastest (543.1 ms), followed by canonO (548.3 ms) and ScleftO (555.6 ms). In order to find out how different target types were affected by sentence condition, planned comparisons were conducted on the interaction using the *emmeans* function in the *emmeans* package.

Planned comparisons were conducted for each of the four target types between the syntactic F-marking condition and each of the no F-marking and the prosodic+syntactic F-marking conditions (canonO vs. ScleftO; ScleftS vs. ScleftO). The results showed that responses to identical items and contrastive alternatives were facilitated in the prosodic+syntactic condition compared to the syntactic condition (identical: $t = 4.96$, $p < 0.001$; contrastive alternatives: $t = 2.4$, $p = 0.047$) (see Table 36). All the other comparisons were not significant (all p values > 0.1) (see Table 36).

Table 36 Comparisons of target words (identical, contrastive, noncontrastive, unrelated controls) across the three sentence conditions (canonO, ScleftO, ScleftS). An asterisk (*) indicates a significant comparison ($p < 0.05$).

	canonO vs. ScleftO (no F-marking vs. syntactic F-marking)	ScleftO vs. ScleftS (syntactic F-marking vs. syntatcic + prosodic F-marking)
Identical	NS	*
Contrastive	NS	*
Noncontrastive	NS	NS
Control	NS	NS

As with Experiment 4A, planned comparisons were also conducted between related targets (identical, contrastive and noncontrastive associates) and unrelated controls in the three focus conditions. The results showed that identical items (subject nouns) were facilitated over unrelated controls in all sentence conditions (in the no F-marking condition, canonO: $t = 4.37$, $p < 0.001$; in the syntactic F-marking condition, ScleftO: $t = 3.37$, $p = 0.003$; in the prosodic+syntactic F-marking condition, ScleftS: $t = 6.79$, $p < 0.001$). Contrastive alternatives were facilitated over unrelated controls in the ScleftS condition (ScleftS: $t = 2.5$, $p = 0.043$), but not in the other two conditions (canonO: $t = 1.86$, $p = 0.135$; ScleftO: $t = 1.25$, $p = 0.358$). None of the comparisons between noncontrastive associates and unrelated controls in the three focus conditions were significant (all p values > 0.1). These comparisons showed similar patterns to the comparisons above, that the recognition of identical items and contrastive associates was facilitated by prosodic focus marking in the presence of syntactic focus marking.

An additional analysis was conducted to test the effects of the relatedness of the prime word to the visual target, using the relatedness scores from the questionnaire (see section 4.4.3). An ANOVA model comparison showed that relatedness did not significantly improve the model fit($\chi^2(1) = 2.04$, p = 0.15).

7.3.4 Discussion

This second cross-modal lexical priming experiment investigated the relative roles of prosodic and syntactic focus marking in the activation of discourse information in Mandarin. This experiment investigated the third component of the *focus marking - language processing* link. The experimental presentation of stimuli in Experiment 4B was the same as in Experiment 4A, in that prime words were always subject nouns in spoken sentences, and target words were presented after the sentences, with a fixed ISI between prime word and visual target of 1500 ms. As in Experiment 4A, Experiment 4B examined four target types: identical items, contrastive alternatives, noncontrastive associates and unrelated controls. Unlike Experiment 4A (which used only canonical word order sentences with stress on either the subject or the object), Experiment 4B investigated three sentence conditions: no focus marking (canonO, canonical order with contrastive prominence on the object), syntactic focus marking (ScleftO, subject cleft with contrastive prominence on the object), or prosodic+syntactic focus marking (ScleftS, subject cleft with contrastive prominence on the subject). In general, Experiment 4B shows that prosodic focus marking facilitated the recognition of identical items and contrastive alternatives, but not that of noncontrastive associates and unrelated controls. However, syntactic focus marking did not affect the facilitation of any of the four types of words. This suggests that different forms of focus marking are not equally effective in priming discourse information.

This experiment addressed three sets of research questions (see section 7.3.1). In relation to **the first set of research questions**, whether prosodic (in the presence of syntactic) and/or syntactic focus marking (in the absence of prosodic) primes focused words, the results showed different roles of prosodic and syntactic focus marking, i.e. prosodic focus marking facilitates the recognition of focused words, but syntactic focus marking does not. The results are consistent with those in Experiment 4A, showing the effective role of prosodic prominence in activating focused words, regardless of whether there is syntactic focus marking or not. As for the syntactic focus marking, it generally slows down the lexical decisions of identical items (e.g., the average of ScleftO (555.6 ms) was slowest, followed by

canonO (548.3 ms) and ScleftS (543.1 ms), see section 7.3.3.3), showing that syntactic focus marking does not facilitate the activation of focused words. The role of syntactic focus marking will be discussed in detail later.

In relation to **the second set of research questions**, whether prosodic focus marking (in the presence of syntactic focus marking) and/or syntactic focus marking (in the absence of prosodic focus marking) primes *contrastive alternatives*, the results again showed different roles of prosodic and syntactic focus marking. The activation of contrastive alternatives was facilitated in the prosodic+syntactic focus marking condition, compared to the syntactic focus marking condition. The finding is again consistent with that in Experiment 4A on the role of prosodic focus marking in the absence of syntactic focus marking, but it additionally shows that syntactic focus marking does not play a similar role in the priming of contrastive alternatives.

In relation to **the third set of research questions**, whether prosodic and/or syntactic focus marking facilitated the activation of *noncontrastive associates*, the results did not show any effect of either prosodic or syntactic marking. These results, together with those from Experiment 4A, show for the first time in Mandarin, a non-Germanic language, evidence for prosodic focus marking as activating alternatives, but not noncontrastive associates, to the focused word, consistent with Rooth's (1992) theory.

As for the role of syntactic focus marking in the activation of lexical items related to the discourse, syntactic focus marking without prosodic prominence (ScleftO) seemed to slow recognition times in general, although the differences were not significant. There might be three reasons for this. One likely reason is related, as mentioned in section 2.3.2, to Gotzner's (2017) finding of an interference effect with the exclusive focus particle *only* due to the stronger competition among members of the alternative set. Along similar lines, clefts in my experiment have added implicatures that focus marking with prosodic prominence does not necessarily have (see section 2.1.2.3). Therefore, the responses could be slowed by the difficulty of encoding the presuppositions required by the clefts. On the other hand, Gotzner (2017) showed that in memory, *only* had a processing advantage. It could be that more complex ways of marking focus have an immediate processing cost, but a later processing advantage. In future work, it would be interesting to look at the effect of syntactic focus in memory tasks.

The second likely reason is that, as discussed in section 2.1.2.3, it is usually the case that some additional context is necessary for clefts to sound fully natural, e.g. when appearing as corrections as in (103) and (104) (Destruel et al., 2019). Listeners in Experiment 4B were presented with a single sentence as the prime, so the lack of a proper context for cleft sentences might have imposed an extra load on their processing.

(103)   I wonder why Alex cooked so much beans.
(104)   Actually, it was John who cooked the beans.

The third likely reason is that, as the results from Experiments 2 and 3 showed, syntactic focus marking does not play a facilitatory role in the perception of focus and the encoding of discourse information. It is therefore possible that syntactic focus marking does not facilitate the priming of discourse information either. This also speaks to the link between the relative importance of prosodic and syntactic cues in marking focus, their effectiveness in encoding discourse information (focus words and focus alternatives), and their ability in activating discourse information.

One significant contribution of this thesis concerning priming is the longer time interval (1500 ms) between the prime word and the visual target (ISI). Previous studies using the cross-modal lexical priming paradigm, such as Braun and Tagliapietra (2010) and Husband and Ferreira (2016), looked at sentence-final (objects) or sentence-medial elements (see Table 37 for summary). This thesis tested the priming effect after a longer course of processing, rather than immediate processing (0 ms), as this is when the focus effects should be stronger (Husband & Ferreira, 2016). This thesis provided evidence for the activation of (sentence-initial) subjects with an ISI of 1500 ms for the first time using the cross-modal lexical priming paradigm. This evidence further suggests that identical items and contrastive alternatives continue to be activated while participants are listening to the rest of the sentence (and the silence at the end of the sentence). This indicates that the activation of focus-related information (focused words and focus alternatives) is not only related to the focus itself, but also related to the entire sentence or discourse-level processing. This is because focus is a property of an element within a sentence.

As this thesis tests whether the focus marking on the subject noun affects the activation of different target words, the ISI was controlled at 1500 ms, which was longer than the ISI

controlled for Dutch (0 ms) (Braun & Tagliapietra, 2010) and English (0 ms and 750 ms) (Husband & Ferreira, 2016) in the previous experiments. This thesis has shown that the role of contrastive prosodic prominence in Mandarin is similar to Dutch and English regarding alternative priming, i.e., alternatives are primed given contrastive prosodic prominence (see Table 37 for summary). Given that the ISI was 0 ms in the Dutch study, 0 ms and 750 ms in the English study, and 1500 ms in my thesis, this indicates that the time course may not be a factor with regard to the role of contrastive prosodic prominence in alternative priming. This is also consistent with the evidence that alternatives are remembered better in memory tasks, where alternatives to words marked with focus particles are shown to be remembered better. This suggests that the facilitatory role of contrastive focus marking is long-lasting. The more immediate processing of focus marked by focus particles in Gotzner (2017) and in this thesis, also suggests that there might be a cost in the processing of some focused-marked sentences.

This thesis did not test different time courses in Mandarin, which makes it difficult to draw any firm conclusions about how alternative priming and general semantic priming develop over time in Mandarin. By investigating a shorter or a longer ISI using the same experimental materials, we may be able to understand how alternative priming and general semantic priming change over time in Mandarin. Further, this thesis could not test the relative priming of contrastive alternatives and noncontrastive associates, as it was not possible to use the same target after both contrastive and noncontrastive primes to test both alternative priming and general semantic priming (see section 7.2.2.2). However, the results comparing the same target word across different sentence conditions (e.g., non-focus vs. focus in Experiment 4A, and non-focus vs. syntactic focus vs. syntactic + prosodic focus in Experiment 4B) showed that contrastive alternatives, but not noncontrastive associates, were facilitated. This likely suggests that alternative priming is larger than general semantic priming (if there was any). A separate visual lexical decision task, as a control experiment, would be good to confirm this. The reaction times to the targets from Experiment 4 could be collected from such a control experiment and used as a factor in the RT analysis of Experiments 4A and 4B to account for the differences between contrastive alternatives and noncontrastive associates.

In summary, this chapter addressed the third component of the *focus marking - language processing* link, i.e. the relative roles of prosodic and syntactic cues in activating discourse information. This experiment shows that not all kinds of contrastive focus marking prime alternatives, as clefting did not. Therefore, there is a potential link between focus marking

and language processing. That is, prosodic prominence, as a stronger marker of focus thus has a more effective role in encoding and activating discourse information.

Also importantly, together with the previous research on focus particles (see section 2.3.2), the results in this thesis suggest that the processing advantages of focus, including the priming of alternatives, might be specifically related to contrastive prosodic prominence, at least in Mandarin and the Germanic languages looked at to date. This will be discussed further in section 8.2 in the following chapter.

Table 37 An overview of the role of contrastive/noncontrastive prominence and clefting in priming contrastive alternatives/noncontrastive associates in Braun and Tagliapietra (2010), Husband and Ferreira (2016) and Experiments 4A and 4B. + indicates priming relative to the unrelated control; - indicates no priming relative to the unrelated control; ContrasProm = contrastive prominence; NonContrasProm = noncontrastive prominence; NoProm = no prominence; Alt = alternative; Associate = noncontrastive associate.

	Language	ISI = 0 ms	ISI = 750 ms	ISI = 1500 ms
Braun and Tagliapietra (2010)	Dutch	**ContrasProm-Alt:** + ContrasProm-Associate: + NoncontrasProm-Alt: **-** NoncontrasProm-Associate: +	#	#
Husband and Ferreira (2016)	English	**ContrasProm-Alt:** + ContrasProm-Associate: + NoncontrasProm-Alt: + NoncontrasProm-Associate: -	**ContrasProm-Alt:** + ContrasProm-Associate: **-** NoncontrasProm-Alt: + NoncontrasProm-Associate: +	#
Experiments 4A, 4B	Mandarin	#	#	**ContrasProm-Alt:** + ContrasProm-Associate: - NoProm-Alt: - NoProm-Associate: -
Experiment 4B	Mandarin	#	#	Clefting-Alt**:** - Clefting -Associate: - Non-clefting -Alt: - Non-clefting -Associate: -

Chapter 8 General discussion and conclusion

In this chapter, first, I summarise the findings of the psycholinguistic experiments reported in this thesis. Next, I discuss the significance and relevance of the results to current theoretical claims and empirical findings on the nature of focus and its relationship to speech processing. Last, I present the general conclusions of this thesis. Possible avenues for future research are discussed throughout.

8.1 Summary of the findings

This thesis explored the link between different types of focus marking and the effects of focus on language processing in Mandarin. This is referred to as the *focus marking-language processing* link. Four experiments were carried out in this thesis, addressing the three components of the link: What are the relative weights of prosodic and syntactic cues in the perception of focus in Mandarin? (Experiment 2 in Chapter 5); what is the relative effectiveness of prosodic and syntactic cues in encoding discourse information in Mandarin? (Experiment 3 in Chapter 6); and what is the relative effectiveness of prosodic and syntactic cues in activating discourse information in Mandarin? (Experiments 4A and 4B in Chapter 7).

As there were no association norms available for Mandarin to be used for the lexical priming tasks (Experiments 4A and 4B), Experiment 1 was necessary for the calculation of semantic relatedness scores between the subject noun (prime word) and the non-identical targets, both to facilitate selection of non-identical target items, and to provide a relatedness score that could be used as a control variable in statistical analyses of experimental results. The relatedness scores in and out of context were collected from an online survey to additionally test the effect of context on lexical association strength. Experiment 1 showed that a sentence context may reduce the relatedness between a subject noun and its noncontrastive associate, as the noncontrastive associate is less relevant for the interpretation of the sentence, compared to the contrastive alternative. Therefore, it is important to use the relatedness scores from sentence contexts when creating materials for experiments that use words in context (for example Experiments 4A and 4B). In addition, this thesis provides rigorous association norms for a set of 75 Mandarin items, which have potential for use in future psycholinguistic research (e.g., priming). These association norms are available in Appendix 9.

The subsequent four experiments (Experiments 2, 3, 4A and 4B) represent the core of this thesis, investigating the three components of the *focus marking-language processing* link: i.e. between the relative effects of prosodic and syntactic cues on *perceiving* focus, and their effectiveness in *encoding* and *activating* discourse information in Mandarin. Experiment 2 in Chapter 5 addressed the first component. It explored the relative weights of prosodic and syntactic cues in the perception of focus through native listeners' judgements in a question-answer appropriateness rating task. The previous literature suggests that both prosodic and syntactic cues can mark focus. This experiment was designed to test whether listeners perceive words marked by prosodic and/or syntactic cues as being in QUD-focus (focus as updating the common ground). In this experiment, participants were first visually presented with context sentences in which two sets of alternatives were explicitly mentioned as shown in (a) in Table 38. Participants then heard a question-answer pair, i.e., one of the 'focus probe questions' in (b) and one of the critical sentences in (d), and rated the appropriateness of the sentence as a response to the question. There were two types of questions which were intended to invoke subject focus (SQ) or object focus (OQ) (see (b)). The subjects and objects in the answers were marked with prosodic cues, syntactic cues, or both prosodic and syntactic cues (see (d)).

Table 38 Examples of test materials in Experiments 2 and 3

a. **Context**	天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克。 The weather got colder. The captain and the sailor put on their raincoat and jacket.		
b. (Experiment 2 only) **Focus probe questions**	SQ: OQ:	谁穿上了雨衣? Who put on the raincoat? 船长穿上了什么? What did the captain put on?	
c. (Experiment 3 only) **Connecting question**	你可以再多告诉我一些信息吗? Can you tell me more?		
d. **Critical sentences**	canonO: canonS: OcleftO: OcleftS: ScleftO: ScleftS:	船长穿上了[雨衣]_F The captain put on [the **raincoat**]_F. [**船长**]_F穿上了雨衣 [The **captain**]_F put on the raincoat. 船长是穿上的[雨衣]_F It was [the **raincoat**]_F that the captain put on. [**船长**]_F是穿上的[雨衣]_F It was [the raincoat]_F that [the **captain**]_F put on. 是[船长]_F穿上的[雨衣]_F It was [the captain]_F who put on [the **raincoat**]_F. 是[**船长**]_F穿上的雨衣 It was [the **captain**]_F who put on the raincoat.	(S V [**O**]_F) ([**S**]_F V O) (S *COP* V *DE* [**O**]_F) ([**S**]_F *COP* V *DE* [O]_F) (*COP* [S]_F V *DE* [**O**]_F) (*COP* [**S**]_F V *DE* O)
e. (Experiment 3 only) '**False alternative**' questions	SQ: OQ:	水手穿上了雨衣吗? Did the sailor put on the raincoat? 船长穿上了夹克吗? Did the captain put on the jacket?	

The results showed that in canonical sentences and in clefts where prosodic cues were on the clefted constituent (canonS, canonO, ScleftS, OcleftO in (d)), the word that had the focus marking(s) was perceived as being in focus. In 'mismatch' sentences, i.e. clefts where prosodic cues were not on the clefted constituent (ScleftO and OcleftS in (d)), prosodic cues were privileged by native listeners as marking focus.

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Experiment 2 also found that appropriate syntax does not seem to improve acceptability ratings, but inappropriate syntax lowers them. For example, when the syntactic cue was consistent with the intended focus of the question (e.g., canonS-SQ vs. ScleftS-SQ), the answers were not judged as more appropriate, i.e. these answers were equally appropriate regardless of different syntactic structures. When the syntactic cue was not consistent with the intended focus of the question (e.g., ScleftO-OQ vs. OcleftO-OQ, OcleftS-SQ vs. ScleftS-SQ, or ScleftS-OQ vs. canonS-OQ), the inconsistent syntactic cue mostly caused the answers to be judged less appropriate. This could be due to a number of reasons, e.g., the marked structure of clefts, harder processing of 'mismatch' syntax, etc.

Experiment 3 in Chapter 6 addressed the second component of the *focus marking-language processing* link, i.e. the role of prosodic and syntactic cues in encoding discourse information (i.e., focused words and focus alternatives). Experiment 3 investigated the effects of focus on language processing that should follow from the two types of focus explored in the thesis: QUD-focus and contrastive focus. In contrast to Experiment 2, which involved meta-linguistic judgements, Experiment 3 was a processing experiment, which employed a speeded false alternative rejection task, where participants answered a question after hearing a sentence with various kinds of focus marking (e.g., (d) in Table 38). As in Experiment 2, participants first saw a context (e.g., (a)). But unlike Experiment 2, they then heard a connecting question (e.g., (c)), that naturally introduced the critical sentence that contained focus marking on the subject and/or object (e.g., sentences in (d)). Finally, participants saw a 'false alternative' question where the previous subject or object was replaced by a false alternative which had already been mentioned in the context sentence, e.g., SQ or OQ in 'false alternative' questions in (e). Both questions required a 'no' response as the correct answer. Participants had to answer the question as quickly as possible. This experiment investigated whether prosodic and/or syntactic focus marking speeded rejection of false alternatives. The experiment taps into the discourse-level encoding of discourse referents.

The results showed that there were processing differences between sentence-final objects and non-final subject. For non-final subjects, prosodic focus cues were very effective in helping participants reject false alternatives to subject nouns, as subject questions were rejected faster when the subject noun was marked with contrastive prominence (canonS, ScleftS, OcleftS) than when it was not (canonO, ScleftO, OcleftO). In contrast, syntactic cues did not always play a role. For subject questions, when prosodic focus matched the intended focus of the

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'false alternative' question (i.e., canonS, ScleftS, OcleftS under SQ), there were no differences between the three syntactic conditions. This suggests that syntax did not play a facilitatory role. However, syntax sometimes played an inhibitory role when the syntactic cues did not match the intended focus of the 'false alternative' question. For example, when the object was in prosodic focus (i.e., canonO, ScleftO, OcleftO), subject questions (SQ) were rejected more slowly after object clefts than after canonical sentences and subject clefts. However, the role of syntactic focus marking might be confounded with the processing difficulties of certain clefts.

For sentence-final objects, the rejection speed was largely the same for canonical sentences and subject clefts, regardless of whether the prosodic or syntactic focus marking was consistent with object focus. This was suggested to be due to the effect of default focus position or recency (see section 6.5). But prosodic cues speeded the rejection of object clefts (OcleftO v OcleftS). The reason why there was a difference observed for object clefts was speculated as that 'mismatch' clefts (OcleftS) are generally harder to process than 'match' clefts (OcleftO), and OcleftS had inconsistent prosodic cues to object questions, making the rejection speed to object questions after OcleftS much slower than OcleftO.

In conclusion, Mandarin listeners use prosodic cues more to encode discourse information, but mismatching syntactic cues appear to only inhibit processing speed. Together with the findings from Experiment 2 on the relative weights of these cues in perceiving focus, results from Experiment 3 further suggest a link between the relative weights of different focus markers and their effectiveness in encoding discourse information, i.e., a more important marker of focus provides more effective encoding of discourse information.

The last two experiments (Experiments 4A and 4B), presented in Chapter 7, addressed the third component of the *focus marking-language processing* link, i.e. the role of prosodic and syntactic cues in activating focused words (identity priming) and focus alternatives (alternative priming). In these two cross-modal lexical priming tasks, native Mandarin listeners first heard a sentence prime (e.g., canonS or canonO in Experiment 4A in section 7.2; canonO, ScleftO, or ScleftS in Experiment 4B in section 7.3, see examples in Table 38). They then saw a visual target (identical 船长 '*captain*', contrastive alternative 水手 '*sailor*', noncontrastive associate 甲板 '*deck*', or unrelated control 南瓜 '*pumpkin*') with a fixed ISI of 1500 ms from the offset of the prime word in the auditory stimulus to the onset of the

visual target. The task was to decide whether or not the visual target was a real Mandarin word.

The results from Experiment 4A showed that prosodic focus marking facilitated identity priming and alternative priming, since both identical targets and contrastive alternatives were recognised faster when they had prosodic focus marking. Prosodic focus marking did not facilitate the priming of noncontrastive associates and unrelated controls, since there was no statistical difference between noncontrastive associates and unrelated controls in the two focus conditions. The role of prosodic focus marking was true in the absence (Experiment 4A) and presence (Experiment 4B) of syntactic focus marking.

In Experiment 4B, the role of syntactic focus marking was different from the role of prosodic focus marking, as syntactic focus marking did not facilitate identity and alternative priming. Rather, it was found that words with syntactic focus marking were recognised more slowly, potentially because of their more complex presuppositions and exhaustivity (see section 2.1.2.3). Neither prosodic nor syntactic focus marking primed noncontrastive associates in the two experiments.

The role of prosodic focus marking in Experiments 4A and 4B is consistent with Rooth's (1992) theory that focus marking signals the presence of a set of alternatives to the focused words. In this theory, focus marking is not predicted to facilitate the priming of noncontrastive associates, as they are not part of the alternative set that focus marking signals, and this is indeed what was found. However, syntactic focus marking was not found to prime alternatives, suggesting that alternative priming in Mandarin is specifically related to contrastive prominence.

In conclusion, the relative ability of prosodic and syntactic focus marking to activate discourse information is largely consistent with the relative roles of prosodic and syntactic focus marking in perceiving focus and in encoding discourse information. Prosodic focus marking, as a more important marker of focus, provides more effective encoding of discourse information, and more activation of focused entities in discourse. A relationship between *focus marking* and *language processing* can be seen.

8.2 General discussion

Through a series of psycholinguistic experiments, this thesis has investigated the role of prosodic and syntactic focus marking in speech processing in Mandarin, forging new ground in Chinese psycholinguistics. This thesis also makes a significant contribution to psycholinguistics more generally with regard to the role of syntactic focus marking in speech processing. In this section, I discuss the implications of this thesis in the following four areas: (1) the role of prosodic focus in speech processing; (2) the role of syntactic focus in speech processing; (3) the role of focus in speech processing; (4) cross-linguistic similarities and differences of focus marking and their effects in language processing.

8.2.1 The role of prosodic focus in speech processing

Research over many decades has shown that many languages, such as English, use prosodic prominence to mark focus, and the word that is marked by prosodic prominence is usually interpreted as being in focus (e.g., Botinis et al., 1999; Breen et al., 2010; Kügler & Calhoun, to appear; Lee et al., 2015). Prosodic prominence enhances the salience of focused words, and thus gives processing advantages to focused words. Considerable psycholinguistic work across a reasonably wide range of languages has shown that prosodic focus marking (such as with H* or L+H* in English) provides a processing advantage in language processing, i.e., focused words are more attended to, so they are recognised faster and remembered better (e.g., Akker & Cutler, 2003; Cutler, 1976; Cutler & Fodor, 1979; Cutler et al., 1997; Kember et al., 2019). More recently, there has been increasing interest in the consequences for language processing of the role of focus in invoking alternatives to focused words (e.g., Braun et al., 2019; Braun & Biezma, 2019; Braun & Tagliapietra, 2010; Gotzner, 2017; Husband & Ferreira, 2016). Contrastive prosodic prominence signals the presence of contextually-relevant alternatives, so it facilitates the activation and recognition of focus alternatives. A crucial link can be seen here between the importance of prosodic prominence in focus perception and its effectiveness in facilitating language processing including activating alternatives to the focus.

Is prosodic prominence important for processing for all languages that use prosodic prominence primarily to mark focus? What is the role of prosodic prominence in language processing in Mandarin? In Mandarin, prosodic prominence is realised through a larger global F0 range, as pitch contours in Mandarin have a great variety due to the lexical tones. This thesis has shown evidence that contrastive prominence results in a better encoding

(discourse-level processing) and a stronger activation (word-level processing) of focused words compared to non-focus words in Mandarin, showing focus marking by prosodic prominence, rather than specific pitch contours, triggers these speech processing advantages. The word that carries prosodic focus marking stands out in the utterance, and listeners direct more attention to the word and perceive the word as being in focus. As a result of this, the word marked by prosodic prominence is more easily processed.

If, as discussed above, the mechanism underlying these processing effects is focus marking by prosodic prominence, this raises the question as to whether a less prominent type of prosodic prominence (noncontrastive or normal prominence), which marks narrow but normally noncontrastive focus, also has these effects in Mandarin. As other types of prosodic prominence were not looked at in this thesis, this thesis did not directly address whether other types of prosodic prominence in Mandarin, including noncontrastive prominence, also have processing advantages. With regard to QUD-focus, as mentioned in section 2.3, previous results show that a less prominent type of pitch accenting (H*, compared to a more prominent type of pitch accenting L+H*) has the same processing advantages on focused words. Therefore, noncontrastive prosodic prominence in Mandarin, which has a smaller pitch expansion than contrastive prominence, might also have similar effects. However, the effects are likely to be found for subjects if other cues (e.g., post-focus compression) are also present, creating a larger contrast in F0 height in the post-focal region. As subjects normally carry a pre-nuclear prosodic prominence when there is a nuclear prominence on the object (see section 2.1.2), the subject needs to be sufficiently prominent to be perceived as in focus. Or the processing effects would be delayed to the post-focal region, when it is not clear that the main prominence is on the subject. For objects, as for Experiment 3 which investigated the encoding of discourse information, no consistent effect of contrastive prominence was found, so it is even less likely for a less prominent type of prosodic prominence to further enhance this. But this has not been studied for Mandarin in similar experiments. Future studies using similar paradigms could be conducted to confirm whether noncontrastive prominence in Mandarin has processing advantages of QUD-focus.

It is further found in this thesis that contrastive prominence facilitated the priming of alternatives (alternative priming) in Mandarin out of context, which is an expected effect of contrastive focus. Contrastive prosodic prominence assigns a contrastive interpretation of the focus in relation to the proposition in the utterance, and therefore increases the salience of

contrastive alternatives. It is important to note that it is the contrastive focus marking via contrastive prominence that drives the priming, rather than contrastive prominence itself. As Braun and Tagliapietra (2010) discussed, if the priming effect comes from the prosodic prominence per se, then this would have also primed noncontrastive associates, but the results did not show this. Therefore, the priming effect is more likely to be from the contrastive focus marking (via contrastive prosodic prominence in this thesis). Though Experiments 4A and 4B compared contrastive prominence to no prominence, rather to noncontrastive prominence, it is likely that noncontrastive prominence does not prime alternatives out of context given Braun and Tagliapietra (2010) who compared contrastive prominence to noncontrastive prominence. But when the alternatives are available in the context or in the visual search, a less prominent cue such as noncontrastive prominence may generate alternatives, as shown by the evidence that noncontrastive prominence H* in English is associated with both contrastive and new referents in the visual search (Watson et al., 2008). This will be further elaborated in section 8.2.3.

The findings from this thesis, together with previous findings, have shown that both contrastive prominence and noncontrastive prominence have the expected effects of QUD-focus on language processing, but only contrastive prominence has the expected effects of contrastive focus. Drawing on these findings, this thesis suggests a key difference between QUD-focus and contrastive focus. That is, contrastive prosodic prominence can mark both QUD-focus and contrastive focus, while noncontrastive prosodic prominence may only mark QUD-focus. More specifically, alternatives can be encoded better and more strongly activated by contrastive prominence (e.g., this thesis and Fraundorf et al., 2010), but not necessarily by noncontrastive prosodic prominence (such as H* in English in Fraundorf et al., 2010). However, both contrastive and noncontrastive prosodic prominence have processing effects on focused words. The finding that contrastive prosodic prominence has processing effects on focused words suggests that words in contrastive focus also contain the information that updates the common ground or new information in relative to the current QUD. In other words, focused words are also part of the alternative set, so the processing of alternatives necessarily involves the processing of focused words, but not the other way around.

Drawing on the previous findings (e.g., Akker & Cutler, 2003; Braun et al., 2019; Braun & Biezma, 2019; Braun & Tagliapietra, 2010; Cutler, 1976; Cutler & Fodor, 1979; Cutler et al.,

1997; Gotzner, 2017; Husband & Ferreira, 2016; Kember et al., 2019) as well as the findings from this thesis, this thesis suggests that the effect of prosodic prominence in language processing may be common across languages that primarily use prosodic prominence to mark focus. For languages that do not primarily use prosodic prominence to mark focus, prosodic prominence may not be as effective. This will be elaborated further in section 8.2.4.

8.2.2 The role of syntactic focus in speech processing

What is the role of syntactic focus cues in language processing in Mandarin? What happens when there is more than one focus marking cue in the same utterance, especially when the two cues conflict with each other? How do listeners weigh these two cues? How do the relative weights of the two cues affect their relative effectiveness in facilitating processing? Experiments 2, 3, and 4B in this thesis have investigated the effect of clefting on more immediate processing. It should be noted that 'more immediate processing' here does not mean that the target words (e.g., focused words or focus alternatives) were presented immediately after the prime word. Rather, it is used to contrast with the long-term memory that was used with focus particles in Spalek et al. (2014) and with prosodic and syntactic focus marking in Kember et al. (2019).

It was found that in Mandarin in this thesis, clefting is less effective than prosodic prominence in listeners' perception of focus, and in their encoding and activation of discourse information. The role of clefting is rather complex but largely consistent in the three components of the *focus marking – language processing* link. For the role of clefting in perceiving focus (QUD-focus) and in encoding discourse information (QUD- and contrastive focus), results from Experiments 2 and 3 have shown that consistent syntactic cues do not play a facilitatory role, but inconsistent syntactic cues mostly play an inhibitory role, e.g. lower ratings in Experiment 2 and slower responses in Experiment 3 (see summary above and detailed results and discussions in Chapters 5 and 6). The inhibitory role of inconsistent syntactic focus marking could simply be that certain clefts are less acceptable or harder to process. It could also be that inconsistent syntactic cues inhibit the perception of focus or the encoding of discourse information. This is expected, as because of inconsistent syntactic cues, the listener may pay attention to irrelevant information (Experiment 2) or to encode irrelevant information (Experiment 3).

For the role of clefting in activating focused words and focus alternatives (QUD- and contrastive focus), results from Experiment 4B have shown that consistent syntactic focus marking does not facilitate the activation of focused words and focus alternatives. Instead, consistent syntactic focus marking plays an inhibitory role, i.e. slower reaction times in general (though differences were not significant for each type of target word), which is probably because of the processing difficulty of encoding the presuppositions and exhaustivity required by the clefts, especially by the 'mismatch' clefts (ScleftO). This inhibition is similar to what has been reported for focus particles which have similar processing cost (Gotzner et al., 2016). However, for Experiments 2 and 3, consistent syntactic cues on the subject were not found to play an inhibitory role, suggesting the role of consistent syntactic cues may be related to the task. This difference is unlikely to be related to the type of focus: Experiment 2 involved QUD-focus, while Experiments 3 and 4B involved both QUD-focus and contrastive focus. Though activating contextually-relevant but unmentioned alternatives (contrastive focus) might involve a greater processing load than activating subject nouns that are already in the prime sentence, responses to both subject nouns and focus alternatives were generally slower in the syntactic focus marking condition, compared to no syntactic marking condition, meaning that syntactic focus slowed responses for both types of focus in the lexical decision task.

Rather, syntactic focus is likely to have caused particular processing difficulties in Experiment 4B because the sentences were presented out of context. In Experiments 2 and 3, the context established two sets of explicitly mentioned alternatives which provided enough contextual support for appropriate clefts in the critical sentence, while in Experiment 4B, clefts were presented out of context, which probably introduced a larger degree of processing difficulty.

However, if syntactic focus marking does not facilitate the encoding and activation of discourse information, then why did Birch et al. (2000) and Kember et al. (2019) find that clefting facilitated the memory of focused words? This is most likely due to the time course of processing, i.e. immediate vs. long term. Previous studies were mostly memory tasks, as opposed to immediate processing in this thesis. As discussed in section 2.1.2.3, clefts involve an existential presupposition (Hedberg, 2013; Hole, 2011; Lambrecht, 2001; Paul & Whitman, 2008). For example, for (105), the presupposition is that someone put on the raincoat. The presupposition is even more complex for (106), when the contrastive

prominence is not on the clefted constituent. That is, there were some people (e.g., *captain* and *sailor*) and some items to wear (e.g., *raincoat* and *jacket*), and that various people put on various items. Encoding this presupposition is perhaps challenging in initial processing.

(105)   It was [the **captain**]$_F$ who put on the raincoat.

(106)   It was [the captain]$_F$ who put on [the **raincoat**]$_F$.

In addition, clefts have an exhaustive implication that focus marking with prosodic prominence does not necessarily have (É Kiss, 1998; Krifka, 2008; Molnár, 2006). For example, (105) presupposes that there is someone who put on the raincoat, but also exhausts these alternatives and shows no one else, but the *captain*, put on the raincoat. This additional implication may interfere with the processing of focused words and focus alternatives, adding extra cognitive load during the comprehension of clefts. However, this interference may fade over time and clefting becomes only facilitatory in later processing. And the extra encoding needed for clefts means they are better remembered. That is, clefting has an initial processing cost but a later processing advantage. Therefore, it would be valuable to explore the effect of clefting on processing in memory tasks in Mandarin in future work.

This thesis only investigated consistent syntactic cues with inconsistent prosodic cues in the lexical decision task (Experiment 4B). How about syntactic focus marking in the presence of prosodic focus marking? As the canonS condition (contrastive prominence on the subject noun) was absent from Experiment 4B (due to the complexity of the experimental design), the current thesis is not able to test whether syntactic focus marking in the presence of prosodic focus marking facilitates the priming (canonS vs. ScleftS). CanonS did appear as a condition in Experiment 4A, but the priming effects cannot be directly compared across experiments. In Experiment 4A, testing the effect of prosodic focus marking, responses in the canonS condition were on average 18.7 ms faster than those in the canonO condition for contrastive alternatives and 20.2 ms for identity primes. In Experiment 4B, which tested the effect of both prosodic and syntactic focus marking, responses in the ScleftS condition were 5.2 ms faster than those in the canonO condition for contrastive alternatives and 5 ms for identity primes. Although we cannot compare the two statistically, these numbers suggest that syntactic focus marking in the presence of prosodic focus marking does not facilitate the recognition of focused words and focus alternatives. Instead, like consistent syntactic cues in the presence of inconsistent prosodic cues in Experiment 4B (canonO vs. ScleftO), consistent

syntactic cues in the presence of consistent prosodic cues seem to slow responses as shown by an indirect comparison of canonS in Experiment 4A and ScleftS in Experiment 4B, but this cannot be verified given the current design of Experiment 4B. To conclude, priming effects of consistent syntactic cues may not be observed in the presence of consistent prosodic cues. Further studies are needed to confirm this.

Further, inconsistent syntactic cues were not investigated in Experiment 4B (as they were in Experiments 2 and 3), but they would be likely to have an inhibitory role, due to a possible combination of reasons including a lack of context, the complex encoding of presupposition and exhaustivity required by clefts and syntactic cues on irrelevant information that listeners need to pay attention to, as discussed above.

However, in the experiments in this thesis, contrastive prominence was always present in the critical sentences, which could have overridden the effects of syntax. In Experiment 3, for subject focus, the effect of inconsistent syntax was overridden by consistent prosodic cues, showing the strong effect of prosodic prominence. It is likely that syntax would have a stronger effect if sentences with only noncontrastive prosodic prominence were used.

The lack of a facilitatory effect of syntax on processing could also be language-specific. In Mandarin, clefting does not seem to be an effective marker of focus in focus perception. However, for English, although prosodic prominence is believed to be used primarily to mark focus, Calhoun et al. (2019) surprisingly found clefting to be more important than prosodic prominence in a focus judgement task. Therefore, it is not that surprising that syntactic focus does not facilitate language processing in these tasks in Mandarin, but it does in some tasks in English (e.g., memory-based tasks in Kember et al., 2019). This is congruent with the *focus marking – language processing* link that this thesis established (see further in section 8.2.4).

The thesis only investigated syntactic cues marked by 是...的 'SHI...DE' clefts. Therefore, the finding that 是...的 'SHI...DE' was less effective than contrastive prominence in language processing does not necessarily mean that all syntactic focus cues play a less effective role. As discussed in section 2.1.2.3, pseudo-clefts can also mark focus, and in fact pseudo-clefts are more commonly used structures to mark object focus. Pseudo-clefts have a dedicated focus position which is in the sentence-final position. In this thesis, pseudo-clefts were not chosen as the word order change (from the canonical word order) would have been

confounded the effect of syntactic cues. However, it would be valuable to investigate pseudo-clefts in future studies to draw a fuller picture of the roles of different syntactic cues in language processing in Mandarin. It would not be surprising to find a stronger role for pseudo-clefts than 是...的 'SHI...DE' in language processing due to the salient focus position in pseudo-clefts.

Another useful study would be to look at spoken corpora to investigate the frequency of different clefts (pseudo-clefts and 是...的 'SHI...DE') and their frequency of marking subject and object focus. As discussed in section 5.5, adding a consistent syntactic focus cue affects the appropriateness of the answer to the object question, but not the answer to the subject question. This may be due to the frequency or naturalness of subject and object clefts. By looking at their frequency in corpora with naturally occurring sentences, this would provide evidence on whether frequency is one of the causes of lower appropriateness ratings or processing difficulty with certain cleft types.

8.2.3 The role of focus in speech processing

This thesis tests three overlapping and interrelated types of speech processing: perception (meta-linguistic), encoding (discourse-level) and activation (word-level) of discourse information. In perceiving focus, listeners use different cues to identify the most important information in the speaker's utterance and then update the implicit or explicit QUD presupposed in the discourse. In this way, listeners keep up with the speaker to share a common ground of understanding. This updating is essential, as comprehension involves integrating new information with old information that is already established in the common ground. This thesis has shown that in Mandarin QUD-focus is clearly on the prosodic constituent when it is marked by contrastive prominence or by both contrastive prominence and clefting. QUD-focus is also on the prosodic constituent (e.g., *raincoat*) in a 'mismatch' cleft (ScleftO: 'It was [the captain]$_F$ who put on [the **raincoat**]$_F$'), although the findings need to be confirmed with more evidence with different types of tasks and in different contexts. In Mandarin, both the subject and object in the 'mismatch' cleft are marked by contrastive focus, as they are analysed as implying alternatives, though the psycholinguistic evidence presented in this thesis did not support the expected processing effect of contrastive focus for the subject *captain* in ScleftO (see explanations in section 8.2.2 and further below). This indicates that contrastive focus and QUD-focus often indicate focus on the same word, but the words on which they indicate focus are not mutually exclusive, i.e., *raincoat* is both

QUD- and contrastive focus-marked, while *captain* may only be contrastive focus-marked. This supports a model where contrastive focus is orthogonal to QUD-focus (Calhoun, 2010a; Vallduví, 2016), as mentioned in section 2.1.1. In other languages, e.g., in English, the word with syntactic focus marking, e.g. *captain* in the above-mentioned ScleftO is judged as being in QUD-focus, updating the common ground (Calhoun et al., 2019). This shows language-specific use of cues to perceive focus. This is also an important part of understanding speech comprehension processes in discourse contexts.

In the course of processing speech, various words are activated, including focused words and focus alternatives, as they are relevant to the interpretation of the utterance. What is the role of focus in lexical activation of these discourse referents? Particularly interestingly, what linguistic device drives or does not drive alternative priming? According to Rooth (1992), all kinds of focus marking should signal alternatives, while others think that only contrastive prosodic prominence is able to generate alternatives (e.g., Kügler & Gollrad, 2015), or prenuclear accents can if they are sufficiently prosodically prominent (Calhoun, 2010a). This thesis contributes to the growing body of psycholinguistic research which is trying to test this experimentally, by looking at when contrastive alternatives are primed (see section 2.1.2). Braun et al. (2019) and Braun and Biezma (2019) show that some prenuclear accents, e.g. L+H*, do not prime alternatives, but other prenuclear accents can, e.g. L*+H which is claimed to mark contrastive topics in German. Gotzner (2017) shows that focus particles do not prime alternatives in immediate processing, but they have a later processing advantage for alternatives.

Together with previous evidence mentioned above, this thesis has suggested that the underlying mechanism may not simply be any (contrastive) focus marking, since syntactic focus marking in this thesis (see explanations in section 8.2.2 and further below), and focus particles in previous studies, did not have a clear priming effect. This has implications for the relationship between focus as described in the theoretical literature and focus effects as found in speech processing. From a theoretical point of view, Rooth (1992) assumes that all foci are contrastive, as they signal a set of plausible alternatives. However, from a processing point of view, as shown by psycholinguistic evidence in this thesis and in other studies, only focus marked by contrastive prosodic prominence has effects on contrastive alternatives in immediate processing.

As discussed in section 8.2.1, contrastive prosodic prominence assigns a contrastive interpretation of the focus in relation to the proposition in the utterance, which increases the salience of contrastive alternatives. This reinforces the idea that alternative priming is triggered by the contrastive interpretation of the utterance in relation to focus marked by contrastive prosodic prominence (i.e., larger pitch expansion), rather than specific pitch contours (e.g., L+H* in English). This thesis has shed light on the role of focus in lexical activation, and particularly, on the linguistic cues which listeners use to activate alternatives in spoken sentences. This is an important part of understanding the processes by which listeners understand implicatures related to alternatives in speech.

In encoding discourse referents as part of discourse representation, listeners use different cues to keep track of discourse referents, and subsequently to reject false alternatives to referents in the discourse model. This discourse-level encoding is a higher level of processing than the word-level activation, as the later is not necessarily associated with the entire discourse representation (see section 7.1). This thesis has shown that the use of different cues is complex. Listeners seem to be sensitive to different focus cues, but the degree of sensitivity may be different at different stages of processing, in different tasks and in different languages depending on the importance of these cues in their language. For example, this thesis has presented evidence that in the immediate processing of discourse in Mandarin prosodic prominence plays a facilitatory role, which could be overridden by positional cues, while syntax only plays an inhibitory role.

The lack of a facilitatory role for syntax in the activation and encoding of discourse entities suggests that the use of different focus cues may be related to their pragmatic use: as mentioned in section 8.2.2, clefts carry additional presuppositions of alternatives to the focused element(s) and exhaustivity, which prosodic prominence does not necessarily do (É Kiss, 1998; Krifka, 2008; Molnár, 2006). This could explain the difference between the role of prosodic prominence and clefting: prosodic prominence seems to be facilitatory in both short- and long-term processing, but clefting is costly to integrate in short-term processing, but could have a facilitatory effect in longer-term processing. This shows that different focus cues could have different effects at different stages of processing due to their added implicatures. These processing costs would also not necessarily be found for syntactic markers that do not have these added implicatures.

In addition to the costly process of encoding the presupposition and exhaustivity required by clefts, generating contextually unavailable alternatives may also be a costly process, in comparison to perceiving focus and activating focal information which is already in the context. These two costly processes are interrelated, as the encoding of presupposition involves the generation of alternatives. Although inferring alternatives is an essential part of pragmatic processing, listeners may not activate or encode extra information that is not required for understanding the discourse, as it takes cognitive effort to infer implicature in utterances, as discussed in section 2.1.2.3. There has been mounting behavioural and neurological evidence showing the large cognitive effort involved in the process of implicature computation (or 'mind reading') (see e.g., Alatawi, 2019; Degen & Tanenhaus, 2015; Sperber & Wilson, 2002; Zhao et al., 2015). Therefore, listeners may only do this when it is clear that they need to. For example, the listener may only generate alternatives when the speaker implies alternatives in a very explicit way, such as using saliently contrastive prosodic prominence in spoken utterances. This may especially be the case in lexical decision tasks where the main task for the listener is to make a lexical decision, rather than in a real-world communication situation, where listeners are more likely to make the effort to understand the alternatives implied by speakers. Thus participants in these laboratory tasks may not undergo the process of inferring alternatives, unless there is an overt contrastive prominence on the word that they need to infer alternatives to.

Generating alternatives may be complex depending on the context. As mentioned above, when alternatives are not available in the context or in the visual search, a very strong cue such as contrastive prominence may be needed to prompt a contrastive interpretation of the prime sentence, and thus to prime alternatives. However, the priming effect may be affected by context (Calhoun, 2009). With additional context that encourages a contrastive interpretation, noncontrastive prosodic prominence, such as an H* accent, may also mark contrastive focus, and generate alternatives. Gotzner (2017) tested the effect of focus particles in a contrastive context, e.g. (107) followed by (108). They found that when there were no focus particles (when there is only noncontrastive prominence on *peaches*), alternatives were recognised faster than unrelated controls in a lexical decision task, which could be taken as evidence that alternatives were more highly activated than unrelated controls.[19] But this

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[19] However, this could simply be semantic priming, as in their study, they did not have noncontrastive associates to measure general semantic priming.

marking may not generate alternatives without sufficient context (i.e., when listeners hear 'He ate [**peaches**] H*.' without explicit mention of alternatives).

(107)   Context: In the fruit bowl, there are peaches, cherries, and bananas. I bet Carsten has eaten cherries and bananas.

(108)   Critical sentences No, he _ \only \even ate [**peaches**] H*.

However, it is still surprising that syntactic focus marking did not prime alternatives. Clefts are claimed to mark contrastive focus on the cleft head, so theoretically speaking a cleft, e.g. 'It was [peaches]F that he ate', should always imply a contrast between *peaches* and other fruit. Future studies could try to reduce the additional cost of clefts in encoding implicature, e.g. using a 'corrective' context which was claimed to make clefts appear natural (Destruel et al., 2019). Further studies are also needed to separate the effects of the added presupposition and exhaustivity of clefts from the priming effect. In future work, a more online method, e.g., the eye-tracking paradigm used in Braun et al. (2019) and Braun and Biezma (2019), might be able to capture the processing at the moment when the listeners hear the prime word (subject noun), before the whole utterance unfolds. In this way, the processing cost of clefts might be minimalised. However, this approach would not be ideal, because any processing effects measured at this point would reflect the processing of the subject noun before it has been integrated into the sentence context.

This thesis establishes for the first time the relative roles of prosodic and syntactic focus marking in focus perception and speech processing in Mandarin, suggesting a model in which the processing effect of focus cues is affected by their importance in marking focus, the processing costs associated with different types of cue, particularly syntactic and non-syntactic, and the availability of plausible alternatives in the context.

8.2.4 Cross-language similarities and differences

This thesis has shown a *focus marking – language processing* link, showing that prosodic prominence, as a more important marker of focus, has a greater impact on language processing than clefting, in Mandarin. This thesis contributes considerably to the small body of cross-linguistic evidence of the effects of different kinds of focus marking in speech processing. Through comparison with previous research findings on other languages, this thesis also offers insights into the language-specific weighting of different focus cues in

speech processing. In what follows, I briefly discuss cross-linguistic similarities and differences in the processing effects of focus, based on the established evidence and my predictions.

Prosodic prominence, which is realised via pitch expansion in Mandarin and via pitch accenting in Germanic languages, has been shown to facilitate language processing. In future work, it would be good to test the role of prosodic prominence using similar tasks in other languages such as Korean and Japanese that use a different prosodic focus marking system, e.g. based on prosodic phrasing. Evidence on Korean shows that prosodic phrasing is also effective in language processing (Kember et al., 2019; Kügler & Calhoun, to appear). Similar findings would be expected in Japanese. This would help us understand whether prosodic prominence or only a specific way of marking prosodic prominence is the underlying mechanism for language processing advantages.

Further, the languages that have been looked at to date are mostly Germanic languages, along with Mandarin in this thesis, and prosody seems to be an important marker of focus in these languages. It would be interesting to look at languages where prosody is an optional marker of focus or is not used at all to mark focus (such as Yucatec Maya and other languages discussed in Kügler & Calhoun, to appear). For example, the preverbal position is the syntactic focus position in Yucatec Maya, and evidence shows that focused words in preverbal positions are not prosodically different from their non-focused counterparts (Kügler & Skopeteas, 2006). Prosodic prominence in Yucatec Maya would be expected to have less significance in language processing given that it does not play an important role in marking focus. Instead, positional cues should facilitate language processing in Yucatec Maya given their important status in marking focus. It would be interesting to investigate whether and how these positional effects are different from those resulting from prosodic prominence.

This thesis has also shown that positional cues (default subject non-focus vs. default object focus) overrode overt prosodic focus marking in the rejection of false alternatives in Experiment 3. In English, similar effects have been found with positional cues (Yan & Calhoun, under review), as final objects have been previously found to have a default focus bias, even without overt focus marking in English. This positional final focus bias would be expected not to occur in a language that does not have a final focus bias, such as Hungarian where the default focus position is preverbal (Kügler & Calhoun, to appear). Instead, it is

likely the preverbal words would be perceived as focused in Hungarian, even when there is no overt focus marking on that word. This would be the same in cases like Samoan where initial focus position is likely to have a focus bias or focus expectation (Calhoun, 2015; Calhoun et al., 2019). Such cross-linguistic comparisons would help us understand the specificity and universality of the weighting of different linguistic cues in human speech, an area of increasing interest in psycholinguistic research.

In Mandarin and many Germanic languages, prosodic focus marking seems to be a more important marker of focus. But for languages where syntactic focus marking is more important than prosodic, a stronger effect of syntactic focus on encoding and priming would be expected (see e.g., Kember et al., 2019 on Korean). This would tell us whether the finding that syntactic focus marking does not result in better encoding and stronger activation of discourse information is specific to Mandarin, or is the same across languages. In addition, in languages like Russian, prosodic and syntactic cues seem to be equally important in the perception of prominence, and these cues interact with each other in a complex way (Luchkina & Cole, 2019). It would be valuable to see whether prosodic and syntactic cues affect language processing equally in Russian. It could be a fruitful area for future research to investigate how and whether the same cues are attended to differently in different languages given their role in focus marking in those languages.

8.3 Conclusion

This thesis has investigated the role of prosodic and syntactic focus marking in speech processing in Mandarin, showing that Mandarin listeners use prosodic focus cues more than syntactic focus cues to identify the focus in an utterance, and to keep track of presupposed and new information, thus facilitating the rejection of false alternatives to the focused item. Listeners also use prosodic cues more to infer alternatives to focus-marked words in utterances. This thesis has therefore established a crucial link between *focus marking* and *language processing*, i.e., prosodic prominence, since a stronger marker of focus provides better encoding and stronger activation of discourse information in Mandarin.

Regarding the rapidly growing interest in the role of focus in invoking alternatives in language processing, which is an important part of understanding the processes by which listeners understand implicature, this thesis looked at the effect of contrastive prominence in Mandarin for the first time, providing cross-linguistic validation of this effect in Mandarin. This research also brings Chinese psycholinguistics a significant step forward, showing that

contrastive prominence through a larger global F0 range is as effective as pitch accenting in facilitating aspects of speech processing related to focus. This thesis sheds light on the crucial role of prosody in semantic interpretation: we cannot understand discourse semantics without considering prosody.

This thesis also extends previous research by looking at another focus marker, i.e. clefting. It shows that clefting is not effective in priming alternatives, probably due to its added implicature, i.e., more complex presuppositions and exhaustivity. This thesis, together with previous findings on prosodic prominence and focus particles, suggests that priming of alternatives seems to be largely related to contrastive prosodic prominence. As generating alternatives may be a costly activity, in speech salient contrastive prominence is needed to trigger a contrastive interpretation of the focus-marked word in an utterance, which enhances the salience of alternatives to that word. More studies are needed to verify this in a larger variety of experimental tasks with more types of focus markers across different languages. We could also compare the immediate processing of and long-term memory for the alternatives with various kinds of focus markers. This allows us to look further at the role of time course in language processing with complex ways of marking focus.

To conclude, this thesis investigated the linguistic cues that Mandarin listeners use to perceive focus, to encode discourse information, and to understand implicature as part of achieving a successful communication. This research contributes significantly to our cross-linguistic understanding of prosodic and syntactic focus in speech processing. Together with existing research on other languages (e.g., English and Korean), this thesis suggests a discourse processing model in which the weighting of different cues is affected by their relative use in the language, but also by the processing costs associated with different types of cue. This thesis prompts further work on the relative importance of various linguistic cues in speech processing, to increase our understanding of how this varies across languages.

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Appendices

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Appendix 2 Ethics approval

Phone 0-4-463 5480
Email susan.corbett@vuw.ac.nz

MEMORANDUM

TO	Mengzhu Yan
COPY TO	Dr Sasha Calhoun
FROM	AProf Susan Corbett, Convener, Human Ethics Committee

DATE	5 July 2017
PAGES	1

SUBJECT	**Ethics Approval: 24753** The effects of focus on spoken language processing in Mandarin

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 1 November 2019. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards

Susan Corbett

Convener, Victoria University Human Ethics Committee

Appendix 3 Information sheet (Mandarin version)

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

VICTORIA
UNIVERSITY OF WELLINGTON

<center>言语理解研究</center>

<center>参与实验信息介绍表</center>

感谢您对此项目感兴趣，在决定是否参与前请阅读以下信息。如果您决定参与，感谢您的合作；如果决定不参与，感谢您的关注。

研究者介绍
闫梦珠，惠灵顿维多利亚大学语言学博士生。我的导师分别是维多利亚大学语言学与应用语言学系的 Sasha Calhoun 博士和 Paul Warren 教授。

研究目标
这个项目是为了研究在汉语中听者是如何使用讲话人话语中不同的提示信号，来理解他们表达的意思。该项目旨在更好地了解言语理解所涉及的过程。

该研究已通过惠灵顿维多利亚大学人类伦理道德委员会审批立项 [编号为:24753]。

研究过程与参与者的贡献
如果您同意参加，您将会在河南理工大学进行一个实验。在实验中，您将听到一系列句子，并回答有关他们的简单问题。您的回答和您回答的时间将被记录。实验时长大概 30 分钟。在 2018 年 7 月 1 日前任何时间，您可以选择退出这个研究。如果您退出，您提供的信息将被销毁或退回给您。

如果您是学生，您是否参加这个研究不会以任何方式影响您的成绩。
您将获得 30 人民币的代金券作为报酬。

实验信息保存与处理
研究收集的信息为保密文件。您的姓名和可识别您身份的信息不会在任何研究报告中出现。可识别您身份的数据只有研究者本人和其导师可见。本实验收集的数据将会匿名保存。匿名数据将被安全并无限期地保存。匿名数据可能会分享给同领域的研究者以助于未来关于跨语言言语理解的研究。

研究结果呈现
本项目所获信息及研究结果将用于研究者博士论文，会议展示和学术报告。任何汇报过程中，研究者会确保您的个人信息不被识别。

如接收邀请参与实验，参与者的权利：
    接受邀请参与实验为自愿行为。作为参与者您有以下权利：

- 选择不回答任何问题
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- 要求查看您提供的数据
- 在2019年7月1日前，申请撤回所有提供的信息
- 随时询问有关研究的任何问题;
- 通过邮件向研究者索取和阅读研究所得报告副本

如有任何疑问，可以通过以下联系方式咨询我:

学生:
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Mengzhu.Yan@vuw.ac.nz

第一导师:
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人类道德伦理委员会信息

如对此研究的伦理道德行为有任何疑虑，可与维多利亚大学人伦委员会负责人 Susan Corbett 副教授联系。邮箱是 susan.corbett@vuw.ac.nz， 电话是 +64-4-463 5480。

Speech Comprehension Study

INFORMATION SHEET FOR PARTICIPANTS

Thank you for your interest in this project. Please read this information before deciding whether or not to take part. If you decide to participate, thank you. If you decide not to take part, thank you for considering my request.

Who am I?
My name is Mengzhu Yan. I am a Doctoral student in Linguistics at Victoria University of Wellington. This research project is work towards my dissertation. My supervisors are Dr Sasha Calhoun and Prof Paul Warren in the School of Linguistics and Applied Language Studies.

What is the aim of the project?
This project is looking at how listeners use different cues in a person's speech to understand what they mean in Mandarin. The project is aiming to better understand the processes involved in speech comprehension.

This research has been approved by the Victoria University of Wellington Human Ethics Committee (Approval number 24753).

How can you help?
If you agree to take part you will be asked to come in for an experiment session at Henan Polytechnic University. In the experiment, you will hear a series of sentences and be asked simple questions about them. Your responses, and the time it takes you to respond, will be recorded. The experiment session will take about 30 minutes. You can withdraw from the study up to July 1st 2018. If you withdraw, the information you provided will be destroyed or returned to you.

If you are a student, your decision whether or not to participate will not affect your grades in any way.

You will get a voucher of CNY 30 in recognition of your efforts in participating.

What will happen to the information you give?
This research is confidential. I will not name you in any reports, and I will not include any information that would identify you. Only my supervisors and I will have access to the data in a form where you can be identified. The data from the experiments will be anonymised. The anonymised data will be stored securely and kept indefinitely. It may be made available to any other researchers in the field at any time to inform future research about cross-linguistic speech comprehension.

What will the project produce?
The information from my research will be used in my PhD dissertation, academic reports and conference presentations reporting the results of this research. I will take care not to identify you in any presentation or report.

If you accept this invitation, what are your rights as a research participant?
You do not have to accept this invitation if you don't want to. If you do decide to participate, you have the right to:
- choose not to answer any question;
- ask to stop the experiment at any time;
- ask to review the data you have provided;
- withdraw from the study July 1st 2018;
- ask any questions about the study at any time;
- be able to read any reports of this research by emailing the researcher to request a copy.

If you have any questions or problems, who can you contact?
If you have any questions, either now or in the future, please feel free to contact me:

Student:	**Primary supervisor:**	**Secondary supervisor:**
Mengzhu Yan	Dr Sasha Calhoun	Prof Paul Warren
Mengzhu.Yan@vuw.ac.nz	Senior Lecturer	School of Linguistics and Applied
	School of Linguistics and	Language Studies, Victoria
	Applied Language Studies,	University of Wellington
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	PO Box 600	Phone: +64 4 4635631
	Wellington 6140, NZ	Paul.Warren@vuw.ac.nz
	Phone: +64 4 463 9537	
	Sasha.Calhoun@vuw.ac.nz	

Human Ethics Committee information
If you have any concerns about the ethical conduct of the research you may contact the Victoria University HEC Convener: Associate Professor Susan Corbett. Email susan.corbett@vuw.ac.nz or telephone +64-4-463 5480.

Appendix 5 Participant consent form (Mandarin version)

言语理解研究

参与实验同意书

（文件保存至 2019 年 11 月 1 日）
研究者信息： 闫梦珠
惠灵顿维多利亚大学
语言学与应用语言研究学院

- 我已阅读《参与实验信息介绍表》并了解项目内容。有关疑问已得到明确解答。我明白，如有疑问我可以随时提问。

- 我同意参与此实验。

我明白：

- 在 2018 年 7 月 1 日前任何时间，我可以退出这个研究。我提供的任何信息将被退还给我或被销毁。
- 所有参与者的数据将无限期地安全地以匿名形式保存，这些数据可能会分享给同领域的其他研究者以助于未来类似研究（如信息介绍表中所述）。任何可以从本实验数据识别我身份的信息将在本研究结束时被销毁。
- 我所提供的所有个人信息会被妥善保管，仅对研究者本人及其导师可见。我明白实验结果将用于博士论文或者学术探讨中，研究结果可能会在学术报告或在学术会议中呈现。
- 我的姓名或者可以识别我个人身份的信息不会出现于任何研究报告中。
- 我想收到本研究结果的摘要，并在下面添加了我 的电子邮件地址。是 □ 否 □

参与者签名：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

参与者姓名：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

参与日期： ＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

邮箱（或其他联系方式）： ＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

Appendix 6 Participant consent form (English translation)

Speech Comprehension Study
CONSENT TO COLLECT EXPERIMENT DATA

This consent form will be held until 01/11/2019

Researcher: *Mengzhu Yan*
School of Linguistics and Applied Language Studies
Victoria University of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree to take part in this experiment.

I understand that:

- I may withdraw from this study up to July 1st 2018, and any information that I have provided will be returned to me or destroyed.
- The data from all participants will be kept securely in an anonymised form indefinitely. It may be made available to any other researchers in the field at any time to inform future research about cross-linguistic speech comprehension (as set out in the Information Sheet). Any information linking me to the data I provide in this experimental session will be destroyed at the conclusion of this research.
- Any information I provide which could identify me will be kept confidential to the researcher and the supervisors. I understand that the results will be used for a PhD dissertation, academic research and a summary of the results may be used in academic reports and/or presented at conferences.
- My name will not be used in reports, nor will any information that would identify me.
- I would like to receive a summary of the findings of this study and have   Yes ☐   No ☐ added my email address below.

Signature of participant: _____

Name of participant: _____

Date: _____

Email (or other contact details): _____

Appendix 7 Participant information questionnaire (Mandarin version)

言语理解研究

实验参与者调查问卷

性别：_____

出生地: 城市: _____ 国家: _____

出生年份:_____

职业: _____

会说哪些语言？请说明每个语言的流利度（母语，接近母语，流利，中等，差）：

_____

英语测试成绩总分（如有）（比如雅思，托福）:_____

在中国以外待的时间，并且请说明国家: _____

在上述语言中您平均每天和家人朋友同学讲每种语言的比例（百分数之和应为一百）：

中文：_____英语：_____其他：_____

听力状况 (请打勾):   好   中等   差

母亲的出生地: 城市 _____ 国家: _____

　　　母亲的第一语言: _____

父亲的出生地: 城市 _____ 国家: _____

　　父亲的第一语言: _____

Appendix 8 Participant information questionnaire (English translation)

Speech Comprehension Study

PARTICIPANT QUESTIONNAIRE

Gender: _____

Place of birth: Town: _____Country: _____

Year of birth:_____

Occupation: _____

Which languages do you speak? Please state your proficiency for each language (native, near-native, fluent, intermediate, poor): _____

Overall English test scores if available (e.g. IELTS, TOEFL[20]): _____

Total length of time outside China, please specify the country/countries:

_____

On average, what percentage of the time do you use each of the languages you listed above everyday with family, friends and classmates? (Percentages should add to 100%):

Mandarin: _____   English: _____   Other: _____

Hearing (please circle one):   good   moderate   poor

Mother's place of origin: Town _____ Country: _____

         Mother's first language: _____

Father's place of origin: Town _____Country: _____

         Father's first language: _____

---

[20] In the copy that was used in Experiments 1, 3, 4A and 4B, which were conducted with participants living in China, CET 4 and CET 6 scores were asked instead of IELTS, TOEFL (see details in section 3.3.2.1.)

Appendix 9 Full stimulus list (Experiments 1, 4A, 4B)

The first 40 were used in Experiment 4A (Chapter 7). The first 60 were used in Experiment 4B (Chapter 7). For Experiments 4A and 4B, the prime word was the subject noun. Only the canonical sentences are listed here.

No.	Sentence	Subject	Alternative	Noncontrastive	Unrelated
1	婴儿吃完了饼干 The infant finished the biscuits	婴儿 Infant	保姆 nanny	摇篮 cradle	武器 weapon
2	香蕉摆满了货架 The banana occupied the shelf	香蕉 banana	苹果 apple	猴子 monkey	天空 sky
3	海滩迷住了姐姐 The beach captivated my sister	海滩 beach	灯塔 lighthouse	假期 holiday	绷带 bandage
4	蛋糕招来了虫子 The cake attracted insects	蛋糕 cake	面包 bread	生日 birthday	邮件 mail
5	船长穿上了雨衣 The captain put on the raincoat	船长 captain	水手 sailor	甲板 deck	南瓜 pumpkin
6	香槟洒满了桌子 The champagne spilled over the table	香槟 champagne	啤酒 beer	法国 France	角色 role
7	硬币掉进了口袋 The coin fell into the pocket	硬币 coin	金子 gold	银行 bank	例子 example
8	乌鸦躲进了草丛 The crow hid in the grass	乌鸦 crow	鸽子 pigeon	羽毛 feather	股票 stock
9	顾客关上了窗户 The customer closed the window	顾客 customer	店主 shop owner	产品 product	陆地 land
10	晚餐提供了可乐 The dinner came with the coke	晚餐 dinner	早饭 breakfast	日落 sunset	地震 earthquake
11	英语打击了张三 English discouraged Zhangsan	英语 English	数学 math	字母 letter	地盘 domain
12	国王写完了日记 The king finished writing the diary	国王 king	皇后 queen	皇冠 crown	馅饼 pie

13	律师摔碎了杯子 The lawyer smashed the glass	律师 lawyer	法官 judge	法院 court	生意 business
14	经理租借了相机 The manager rented the camera	经理 manager	秘书 secretary	职位 position	隧道 tunnel
15	镜子弄破了手指 The mirror cut the finger	镜子 mirror	玻璃 glass	图像 image	数据 data
16	报纸掉进了袋子 The newspaper fell into the bag	报纸 newspaper	杂志 magazine	新闻 news	英雄 hero
17	小说感动了张三 The fiction moved Zhangsan	小说 novel	诗歌 poetry	版权 copyright	坚果 nut
18	乘客捡到了钱包 The passenger found the wallet	乘客 passenger	司机 driver	公交 bus	天堂 heaven
19	病人吃完了葡萄 The patient ate up the grapes	病人 patient	护士 nurse	诊所 clinic	环境 environment
20	博士阅读了散文 The Ph.D. student read the novel	博士 PhD	教授 professor	学位 degree	机器 machine
21	手枪吓坏了青蛙 The gun scared the frog	手枪 gun	子弹 bullet	军事 military affair	答案 answer
22	裁判出席了会议 The referee attended the meeting	裁判 referee	教练 coach	规则 rule	公园 park
23	餐馆雇佣了会计 The restaurant hired the accountant	餐馆 restaurant	酒店 hotel	食物 food	颜色 colour
24	戒指装满了抽屉 The rings filled up the drawer	戒指 ring	项链 necklace	左手 left hand	广场 square
25	玫瑰划破了大腿 The roses pierced my thigh	玫瑰 rose	树叶 leaves	花园 garden	快餐 fast food
26	香肠引来了狐狸 The sausage attracted the fox	香肠 sausage	热狗 hot dog	脂肪 fat	奖金 bonus
27	海豹抢到了气球 The seal grabbed the balloon	海豹 seal	海豚 dolphin	海洋 sea	海关 Customs

28	歌手收养了孤儿 The singer adopted the orphan	歌手 singer	画家 painter	专辑 album	草坪 lawn
29	士兵弄丢了钥匙 The soldier lost the key	士兵 soldier	将军 General	战争 war	太阳 sun
30	间谍拿走了芯片 The spy took the chip	间谍 spy	侦探 detective	阴谋 conspiracy	舞会 ball
31	风暴摧毁了植物 The storm destroyed the plants	风暴 storm	大雪 heavy snow	气象 meteorology	蜡笔 crayon
32	老师喝完了绿茶 The teacher finished the green tea	老师 teacher	校长 principal	小学 primary school	太空 space
33	老虎喝完了雨水 The tiger drank up the rain water	老虎 tiger	狮子 lion	笼子 cage	月亮 moon
34	电视预报了小雨 TV forecast light rain	电视 TV	广播 broadcast	屏幕 screen	码头 pier
35	大学雇佣了哥哥 The university hired (my) brother	大学 university	高中 high school	专业 major	舞台 stage
36	蔬菜堆满了仓库 The vegetables occupied the storage room	蔬菜 vegetables	水果 fruits	营养 nutrition	路线 route
37	病毒引发了头痛 The virus caused the headache	病毒 virus	细菌 bacteria	细胞 cell	标签 tag
38	妻子购买了手表 The wife bought the watch	妻子 wife	丈夫 husband	女性 female	节目 program
39	记者捡起了铅笔 The journalist picked up the pencil	记者 journalist	作家 writer	电台 radio station	宇宙 universe
40	公主扔掉了木偶 The princess threw away the puppet	公主 princess	王子 prince	城堡 castle	地板 floor
41	坦克压折了树木 The tank burst into the woods	坦克 tank	货车 truck	炮弹 bomb	广告 advertisement

42	玉米掉出了篮子 The corn fell out of a basket	玉米 corn	花生 peanut	农场 farm	脉搏 pulse
43	咖啡弄脏了衬衣 The coffee dirtied the shirt	咖啡 coffee	牛奶 milk	早晨 morning	卫星 satellite
44	钢琴吵醒了叔叔 The piano woke (my) uncle up	钢琴 piano	吉他 guitar	节奏 rhythm	海岸 coast
45	模特赢得了冠军 The model won the first prize	模特 model	明星 celebrity	身材 body shape	信号 signal
46	蜜蜂闯进了厕所 The bee broke into the toilet	蜜蜂 bee	蝴蝶 butterfly	鲜花 flower	小费 tip
47	苍蝇弄伤了眼睛 The fly hurt the eyes	苍蝇 fly	蚊子 mosquito	垃圾 garbage	深渊 abyss
48	围巾塞满了书包 The scarves occupied the school bag	围巾 scarf	袜子 sock	脖子 neck	闪电 lightning
49	小孩错过了火车 The kid missed the train	小孩 kid	大人 adult	玩具 toy	地球 earth
50	厨房安装了空调 The kitchen was equipped with the air conditioner	厨房 kitchen	浴室 bathroom	饭菜 meal	飞船 spaceship
51	警察写下了地址 The policeman wrote down the address	警察 policeman	保安 security guard	手铐 handcuffs	空气 air
52	女儿喝完了果汁 The daughter finished the juice	女儿 daughter	侄子 nephew	裙子 dress	炸药 explosive
53	胳膊碰倒了花瓶 The arm knocked the vase over	胳膊 arm	肩膀 shoulder	肌肉 muscle	沙漠 desert
54	室友打破了茶杯 The roommate broke the cup	室友 roommate	同学 classmate	宿舍 dorm	电梯 lift
55	篮球砸伤了张三 The basketball hit and hurt Zhangsan	篮球 basketball	足球 football	球场 ball field	月球 moon

56	卧室传出了笑声 There were laughs coming from the bedroom	卧室 bedroom	客厅 living room	枕头 pillow	轨道 track
57	老板捡起了橡皮 The boss picked up the eraser	老板 boss	同事 colleague	公司 company	阳光 sunlight
58	电脑损伤了视力 Computers damaged the eyesight	电脑 computers	手机 mobile phone	网站 website	城市 city
59	书桌压住了毛巾 The desk scrooched the towel	书桌 desk	椅子 chair	功课 homework	癌症 cancer
60	夹克阻挡了大雨 The jacket blocked the rain	夹克 jacket	裤子 pants	纽扣 button	偶像 idol
61	演员吃掉了糖果 The actor ate the candies	演员 actor	观众 audience	剧本 script	部落 tribe
62	牛排滋生了虫子 The beef steak bred flies	牛排 beef steak	鸡肉 chicken	菜单 menu	家乡 hometown
63	新娘喂饱了小狗 The bride saved the puppy	新娘 bride	伴郎 best man	婚礼 wedding	沼泽 swamp
64	农民修好了皮带 The farmer fixed the belt	农民 farmer	猎人 hunter	庄稼 crop	纤维 fibre
65	公寓支撑了大树 The flat supported the tree	公寓 flat	房子 house	房租 rent	消息 message
66	帽子掉进了水池 The hat fell into the pool	帽子 hat	手套 glove	脑袋 head	舌头 tongue
67	主妇准备了饮料 The housewife prepared the drinks	主妇 housewife	厨师 chef	婚姻 marriage	牢房 prison
68	日本出口了轮船 Japan exported the ships	日本 Japan	韩国 Korea	总统 president	火灾 fire
69	领导参观了教室 The leader visited the classroom	领导 leader	主席 chairman	权力 power	基因 gene

70	电影逗乐了阿姨 The movie entertained my auntie	电影 movie	书籍 book	剧院 theatre	绿灯 green light
71	塑料污染了水源 The plastics polluted the water	塑料 plastics	金属 metal	弹性 elasticity	喜剧 comedy
72	兔子偷吃了米饭 The rabbit stole the rice	兔子 rabbit	老鼠 mouse	耳朵 ear	支票 stock
73	亲戚摘下了草莓 The relative brought the strawberries	亲戚 relative	邻居 neighbour	血缘 blood relationship	机场 airport
74	学校提出了问题 The school raised the problems	学校 school	政府 government	课程 course	手术 surgery
75	歌声激怒了爷爷 The singing irritated grandpa	歌声 singing	噪音 noise	喉咙 throat	裂缝 crack

Appendix 10 Instructions for Experiment 1

Instructions in Mandarin (with context)	**English translation**
您将会看到一个句子，然后会被问及两个词有多相关。两个词可以在多方面相关，例如：两个词词义相近（电影和视频），两个词有联系（中国和熊猫），两个词在一定语境下可以相互替换。例如狗和猫都适用于句子'我最喜欢的宠物是…'。	You will see a sentence, and then be asked how related two words are. Words can be related in many ways. For example, they can mean something similar (*movie* and *video*); their referents can be associated with one another (*China* and *panda*); or they can be interchangeable in a certain context, e.g. *dog* and *cat* could both fit in the sentence 'My favourite pet is a…').
请认真阅读句子。对于某些句子，您也可能会被问及关于句子内容的问题。	Please read the sentences carefully, as for some sentences you may also be asked follow-up questions about the content of the sentences.

Instructions in Mandarin (without context)	**English translation**
您会被问及两个词有多相关。两个词可以在多方面相关，例如：两个词词义相近（电影和视频），两个词有联系（中国和熊猫），两个词在一定语境下可以相互替换。例如狗和猫都适用于句子'我最喜欢的宠物是…'。	You will be asked how related two words are. Words can be related in many ways. For example, they can mean something similar (*movie* and *video*); their referents can be associated with one another (*China* and *panda*); or they can be interchangeable in a certain context, e.g. *dog* and *cat* could both fit in the sentence 'My favourite pet is a…').

Appendix 11 Summary of models

Experiment 1 (ratings)

Intercepts: RelatednessType = Contrastive; Context = withContext

```
Coefficients:
```

	Estimate	Std. Error	z value	Pr(>|z|)	
RelatednessType(nonConR)	0.4626	0.1608	2.88	0.004	**
RelatednessType(unrelated)	-4.2074	0.1555	-27.06	< 0.001	***
Context(withoutContext)	-0.0127	0.1854	-0.07	0.945	
RelatednessType:Context(nonConR:withoutContext)	0.2942	0.0886	3.32	< 0.001	***
RelatednessType:Context(unrelated:withoutContext)	0.4370	0.0984	4.44	< 0.001	***

```
nonConR = noncontrastive
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Experiment 2 (ratings)

Intercepts: QuestionType = OQ; Stress = O; Syntax = canon

```
Coefficients:
```

	Estimate	Std. Error	z value	Pr(>|z|)	
QuestionType(SQ)	-4.529	0.271	-16.70	< 0.001	***
Stress(S)	-4.326	0.269	-16.06	< 0.001	***
Syntax(Ocleft)	-1.598	0.313	-5.11	< 0.001	***
Syntax(Scleft)	-2.623	0.279	-9.39	< 0.001	***
QuestionType:Stress(SQ:S)	8.979	0.418	21.48	< 0.001	***
QuestionType:Syntax(SQ:Ocleft)	1.113	0.338	3.30	< 0.001	***
QuestionType:Syntax(SQ:Scleft)	2.473	0.340	7.27	< 0.001	***
Stress:Syntax(S:Ocleft)	1.069	0.338	3.16	0.00157	**
Stress:Syntax(S:Scleft)	1.795	0.340	5.28	< 0.001	***
QuestionType:Stress:Syntax(SQ:S:Ocleft)	-2.543	0.492	-5.17	< 0.001	***
QuestionType:Stress:Syntax(SQ:S:Scleft)	-2.025	0.503	-4.03	< 0.001	***

Experiment 3 (accuracy)

Intercepts: Stress = O; Syntax = canon; QuestionType = OQ

```
Fixed effects:
                  Estimate Std. Error z value         Pr(>|z|)
(Intercept)        3.27697    0.33050    9.92      < 0.001 ***
Stress(S)         -0.02645    0.24898   -0.11        0.915
Syntax(Ocleft)     0.29891    0.29329    1.02        0.308
Syntax(Scleft)     0.51972    0.30918    1.68        0.093 .
QuestionType(SQ)   0.28468    0.25113    1.13        0.257
CentredTrial       0.01954    0.00474    4.12      < 0.001 ***
```

Experiment 3 (RTs)

Intercepts: Syntax = canon; Stress = O; QuestionType = OQ

```
Fixed effects:
                                            Estimate  Std. Error          df t value    Pr(>|t|)
(Intercept)                                 7.303067    0.055721   48.586913  131.07   < 0.001 ***
Syntax(Ocleft)                             -0.001173    0.030008 1530.834652   -0.04     0.9688
Syntax(Scleft)                              0.063562    0.029960 1530.971841    2.12     0.0340 *
Stress(S)                                   0.022359    0.030166 1530.574277    0.74     0.4587
QuestionType(SQ)                            0.014626    0.030019 1530.923009    0.49     0.6262
CentredTrial                               -0.003159    0.000226 1553.995615  -14.00   < 0.001 ***
Sex(Male)                                  -0.160131    0.063707   33.968962   -2.51     0.0169 *
Syntax:Stress(Ocleft:S)                     0.075627    0.042341 1530.621454    1.79     0.0743 .
Syntax:Stress(Scleft:S)                    -0.009793    0.042300 1530.446357   -0.23     0.8169
Syntax:QuestionType(Ocleft:SQ)              0.073682    0.042202 1531.079871    1.75     0.0810 .
Syntax:QuestionType(Scleft:SQ)             -0.073703    0.042120 1530.748876   -1.75     0.0803 .
Stress:QuestionType(S:SQ)                  -0.110786    0.042294 1530.138242   -2.62     0.0089 **
Syntax:Stress:QuestionType(Ocleft:S:SQ)    -0.125087    0.059590 1530.465018   -2.10     0.0360 *
Syntax:Stress:QuestionType(Scleft:S:SQ)     0.012215    0.059512 1530.499480    0.21     0.8374
```

Experiment 4A (accuracy)

Intercepts: SentenceCondition = canonO; TargetType = contrastive

```
Fixed effects:
                              Estimate Std. Error z value  Pr(>|z|)
(Intercept)                    4.16251    0.35475  11.734  < 0.001 ***
SentenceCondition(canonS)      0.48189    0.27702   1.740    0.0819 .
TargetType(control)           -0.47223    0.34922  -1.352    0.1763
TargetType(identical)          0.57480    0.44889   1.281    0.2004
TargetType(noncontrastive)     0.06764    0.39178   0.173    0.8629
```

Experiment 4A (RTs)

Intercepts: SentenceCondition = canonO; TargetType = contrastive

```
Fixed effects:
                                                    Estimate Std. Error      df t value    Pr(>|t|)
(Intercept)                                          12.39057    0.57970  301.99124   21.37  < 0.001 ***
TargetType(control)                                  -0.31193    0.23616  347.75080   -1.32    0.1874
TargetType(identical)                                 0.79731    0.23553  329.32369    3.39  < 0.001 ***
TargetType(noncontrastive)                            0.00210    0.23560  339.75335    0.01    0.9929
SentenceCondition(canonS)                             0.57664    0.19416 2696.61389    2.97    0.0030 **
PreviousRT                                            0.17370    0.01582 2885.72744   10.98  < 0.001 ***
LogFrequency                                          0.75816    0.15748  147.29486    4.81  < 0.001 ***
CentredTrial                                          0.01178    0.00118 2661.87241    9.98  < 0.001 ***
TargetType:SentenceCondition(control:canonS)         -0.27177    0.27637 2698.28578   -0.98    0.3255
TargetType:SentenceCondition(identical:canonS)        0.10795    0.27428 2697.67589    0.39    0.6939
TargetType:SentenceCondition(noncontrastive:canonS)  -0.33240    0.27526 2699.84974   -1.21    0.2273
```

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Experiment 4B (accuracy)

Intercepts: TargetType = contrastive

```
Fixed effects:
                            Estimate Std. Error z value Pr(>|z|)
(Intercept)                  2.41925    0.65275    3.71  < 0.001 ***
TargetType(control)         -0.71350    0.25692   -2.78  0.00548 **
TargetType(identical)        0.16487    0.31831    0.52  0.60448
TargetType(noncontrastive)  -0.25980    0.27502   -0.94  0.34482
LogFrequency                 0.72692    0.21801    3.33  < 0.001 ***
CentredTrial                 0.00531    0.00166    3.20  0.00136 **
```

Experiment 4B (RTs)

Intercepts: SentenceCondition = canonO; TargetType = contrastive

```
Fixed effects:
                                                          Estimate   Std. Error df          t value  Pr(>|t|)
(Intercept)                                              16.987276   0.513288   519.367920   33.09 < 0.001 ***
SentenceCondition(ScleftO)                              -0.270420   0.184818  5109.910847   -1.46  0.1435
SentenceCondition(ScleftS)                               0.174769   0.184418  5111.277438    0.95  0.3433
TargetType(control)                                     -0.413319   0.222782   761.966289   -1.86  0.0639 .
TargetType(identical)                                    0.569925   0.223116   739.346388    2.55  0.0108 *
TargetType(noncontrastive)                              -0.226287   0.222039   741.374214   -1.02  0.3085
LogFrequency                                             0.815973   0.135602   226.952418    6.02 < 0.001 ***
CentredTrial                                             0.006672   0.000699  5274.254522    9.54 < 0.001 ***
PreviousCorrectnessyes                                   0.568071   0.188862  5276.399874    3.01  0.0026 **
PreviousRT                                              -0.002838   0.000210  5329.349877  -13.48 < 0.001 ***
PreviousWordnessword                                     0.391705   0.080018  5273.684240    4.90  <0.001 ***
SentenceCondition:TargetType(ScleftO:control)            0.133714   0.262761  5113.845055    0.51  0.6109
SentenceCondition:TargetType(ScleftS:control)           -0.142861   0.262366  5113.253734   -0.54  0.5861
SentenceCondition:TargetType(ScleftO:identical)         -0.095790   0.261526  5112.828259   -0.37  0.7142
SentenceCondition:TargetType(ScleftS:identical)          0.394088   0.261426  5113.516523    1.5   0.1318
SentenceCondition:TargetType(ScleftO:noncontrastive) 0.177891   0.261849  5112.202867    0.68  0.4969
SentenceCondition:TargetType(ScleftS:noncontrastive)-0.247180   0.261337  5113.082086   -0.95  0.3443
```

Appendix 12 Full stimulus list (Experiments 2 and 3)

In the following experimental materials, the first set of questions (SQ and OQ) were used in Experiment 2, and the second set of questions (SQ and OQ) were used in Experiment 3. 'Sentence' was the critical sentence in the experiments. Only the canonical word order is listed.

1. Context: 张三和他爸爸各参加了一场篮球和足球比赛。不幸的是，他们都被球砸伤了。
Zhangsan went to a basketball match and his dad went to a football match. Unluckily, they both got hit and hurt.

SQ: 什么砸伤了张三？ What hit Zhangsan?
OQ: 篮球砸伤了谁？ What did the basketball hit?

Sentence: 篮球砸伤了张三 The basketball hit (and hurt) Zhangsan

SQ: 足球砸伤了张三吗? Did the football hit Zhangsan?
OQ: 篮球砸伤了爸爸吗? Did the basketball hit dad?

2. Context: 我和姐姐去海边度假。我们被海滩和顶塔迷住了。
My sister and I went to a beach. The beach and sea captivated us.

SQ: 什么迷住了姐姐? What captivated the sister?
OQ: 海滩迷住了什么? What did the beach captivate?

Sentence: 海滩迷住了姐姐 The beach captivated my sister

SQ: 灯塔迷住了姐姐吗? Did the lighthouse captivate the sister?
OQ: 海滩迷住了小明吗? Did the beach captivate Xiaoming?

3. Context: 这些腐烂的牛排和鸡肉滋生了很多苍蝇和细菌。
The rotten beef steak and chicken bred some flies and bacteria.

SQ: 什么滋生了苍蝇? What bred flies?
OQ: 牛排滋生了什么？ What did the beef steak breed?

Sentence: 牛排滋生了苍蝇 The beef steak bred flies

SQ: 鸡肉滋生了苍蝇吗? Did the chicken breed flies?
OQ: 牛排滋生了细菌吗？ Did the beef steak breed bacteria?

4. Context: 客厅里有一些蛋糕和面包，它们引来了虫子和老鼠。
There were cakes and bread in the dining room, which attracted insects and mice.

SQ: 什么招来了虫子? What attracted insects?
OQ:蛋糕招来了什么? What did the cake attract?

Sentence: 蛋糕招来了虫子 The cake attracted insects

SQ: 面包招来了虫子吗? Did the bread attract insects?
OQ:蛋糕招来了老鼠吗? Did the cake attract mice?
5. Context: 天气渐渐变冷，船长和水手穿上了他们的雨衣和夹克。
The weather got colder, and the captain and the sailor on the ship put on their raincoat and jacket.

SQ: 谁穿上了雨衣? Who put on the raincoat?
OQ: 船长穿上了什么? What did the captain put on?

Sentence: 船长穿上了雨衣 The captain put on the raincoat

SQ: 水手穿上了雨衣吗? Did the sailor put on the raincoat?
OQ: 船长穿上了夹克吗? Did the captain put on the jacket?

6. Context: 张三下午喝了一杯绿茶和一杯咖啡。绿茶和咖啡都溅在了张三的衬衫和裤子上。
Zhangsan drank a cup of coffee and a cup of green tea. They spilled over his shirt and pants.

SQ:什么弄脏了衬衣? What dirtied the shirt?
OQ:咖啡弄脏了什么? What did the coffee dirty?

Sentence: 咖啡弄脏了衬衣 The coffee dirtied the shirt

SQ:绿茶弄脏了衬衣吗? Did the green tea dirty the shirt?
OQ:咖啡弄脏了裤子吗? Did the coffee dirty the pants?

7. Context: 在店主的办公室，一位顾客想给店主讲一些秘密，所以他俩关上了门和窗。
A customer was telling the shop owner some secrets in the owner's office, so they closed the door and the window.

SQ: 谁关上了窗户? Who closed the window?
OQ: 顾客关上了什么? What did the customer close?

Sentence: 顾客关上了窗户 The customer closed the window

SQ: 店主关上了窗户吗? Did the shop owner close the window?
OQ: 顾客关上了门吗? Did the customer close the door?

8. Context: 我的女儿和侄子都喝完了午餐时点的果汁和可乐。
My daughter and my nephew ordered some juice and coke, and they finished the drinks.

SQ:谁喝完了果汁? Who finished the juice?
OQ:女儿喝完了什么? What did the daughter finish?

Sentence: 女儿喝完了果汁 The daughter finished the juice

SQ:侄子喝完了果汁吗? Did the nephew finish the juice?
OQ:女儿喝完了可乐吗? Did the daughter finish the coke?

9. Context: 这家酒店的早餐和晚餐提供免费的雪碧和可乐。
The hotel rates included free breakfast and dinner. The meals came with coke or sprite.

SQ: 什么提供了可乐? What came with coke?
OQ: 晚餐提供了什么? What did the dinner come with?

Sentence: 晚餐提供了可乐 The dinner came with coke

SQ:早餐提供了可乐吗? Did the breakfast come with coke?
OQ: 晚餐提供了雪碧吗? Did the dinner come with sprite?

10. Context: 在期末考试中，张三和李四的薄弱科目没有考好。英语和数学打击了他们。
In the final exam, Zhangsan and Lisi didn't do well in their weak subject. English and Math discouraged them.

SQ:什么打击了张三? What discouraged Zhangsan?
OQ:英语打击了谁? Who did English discourage?

Sentence: 英语打击了张三 English discouraged Zhangsan

SQ:数学打击了张三吗? Did Math discourage Zhangsan?
OQ:英语打击了李四吗? Did English discourage Lisi?

11. Context: 猎人和农民互相帮助修理彼此破损的皮带和鞋子。
A hunter and a farmer were helping each other fix their broken belts and shoes.

SQ:谁修好了皮带吗? Who fixed the belt?
OQ:农民修好了什么? What did the farmer fix?

Sentence: 农民修好了皮带 The farmer fixed the belt

SQ:猎人修好了皮带吗? Did the hunter fix the belt?
OQ:农民修好了鞋子吗? Did the farmer fix the shoes?

12. Context: 昨晚的飓风差点吹倒了树木和狗窝，幸好 一所房子和公寓支撑了他们。
The house and the apartment supported the falling tree and kennel.

SQ: 什么支撑了大树? What supported the tree?
OQ:公寓支撑了什么? What did the apartment support?

Sentence: 公寓支撑了大树 The apartment supported the tree

SQ: 房子支撑了大树吗? Did the house support the tree?
OQ:公寓支撑了狗窝吗? Did the apartment support the kennel?

13. Context: 兔子和青蛙偷偷溜进了猎人的房子，他们发现了一把枪和一张弓箭，这把它们吓坏了。
A rabbit and a frog were sneaking into a hunter's house. They found a gun and a bow, which scared them.

SQ:什么吓坏了青蛙? What scared the frog?
OQ:手枪吓坏了什么? What did the gun scare?

Sentence: 手枪吓坏了青蛙 The gun scared the frog

SQ:弓箭吓坏了青蛙吗? Did the bow scare the frog?
OQ:手枪吓坏了兔子吗? Did the gun scare the rabbit?

---

14. Context: 主妇和丈夫为晚餐准备了面条和饺子。
The housewife and the husband prepared some noodles and dumplings.

SQ: 谁准备了饺子? Who prepared the dumplings?
OQ: 主妇准备了什么? What did the housewife prepare?

Sentence: 主妇准备了饺子 The housewife prepared the dumplings

SQ: 丈夫准备了饺子吗? Did the husband prepare the dumplings?
OQ: 主妇准备了面条吗? Did the housewife prepare the noodles?

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15. Context: 保姆刚才喂了婴儿和她自己米粥和饼干。他们俩把东西吃完了。
The nanny was feeding the infant and herself biscuits and porridge. They finished them.

SQ: 谁吃完了饼干? Who finished the biscuits?
OQ: 婴儿吃完了什么? What did the infant finish?

Sentence: 婴儿吃完了饼干 The infant finished the biscuits

SQ: 保姆吃完了饼干吗? Did the nanny finish the biscuits?
OQ: 婴儿吃完了米粥吗? Did the infant finish the porridge?

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16. Context: 日本和韩国去年向中国出口了大量的船只和电子产品。
Japan and Korea exported ships and electronic products to China last year.

SQ: 哪里出口了轮船? Which country exported ships?
OQ: 日本出口了什么? What did Japan export?

Sentence: 日本出口了轮船 Japan exported ships

SQ: 韩国出口了轮船吗? Did Korea export ships?
OQ: 日本出口了电子产品吗? Did Japan export electronic products?

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17. Context: 记者和作家在采访期间捡起了掉在地板上的铅笔和白纸。
A journalist was interviewing a writer. During the interview, a pencil and a piece of paper fell on the floor. They picked them up.

SQ: 谁捡起了铅笔? Who picked up the pencil?
OQ: 记者捡起了什么? What did the journalist pick up?

Sentence: 记者捡起了铅笔 The journalist picked up the pencil

SQ: 作家捡起了铅笔吗? Did the writer pick up the pencil?
OQ: 记者捡起了白纸吗? Did the journalist pick up the paper?

---

18. Context: 国王和皇后在写日记和书信。十分钟之后，都写完了。
The king and the queen wrote a diary and a letter. They finished in 10 minutes.

SQ: 谁写完了日记? Who finished the diary?
OQ: 国王写完了什么? What did the king finish?

Sentence: 国王写完了日记 The king finished the diary

SQ: 皇后写完了日记吗? Did the queen finish the diary?
OQ: 国王写完了书信吗? Did the king finish the letter?

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19. Context: 律师和法官在互相争执，最后他们砸碎了很多杯子和盘子。
The lawyer and the judge were arguing with each other, and they ended up smashing glasses and plates.

SQ: 谁摔碎了杯子? Who smashed the glass?
OQ:律师摔碎了什么? What did the lawyer smash?

Sentence: 律师摔碎了杯子 The lawyer smashed the glass

SQ: 法官摔碎了杯子吗? Did the judge smash the glass?
OQ:律师摔碎了盘子吗? Did the lawyer smash the plate?

---

20. Context: 领导和一些部长参观了这所大学新建的教室和食堂。
The leader and some ministers came to visit the newly-built classrooms and canteens of the university.

SQ: 谁参观了教室? Who visited the classrooms?
OQ: 领导参观了哪里? Where did the leader visit?

Sentence: 领导参观了教室 The leader visited the classrooms

SQ: 部长参观了教室吗? Did the minister visit the classrooms?
OQ: 领导参观了食堂吗? Did the leader visit the canteens?

21. Context: 经理和秘书为会议租了相机和录音机。
The manager and the secretary rented a camera and a recorder for the meeting.

SQ: 谁租借了相机? Who rent the camera?
OQ: 经理租借了什么? What did the manager rent?

Sentence: 经理租借了相机 The manager rented the camera

SQ: 秘书租借了相机吗? Did the secretary rent the camera?
OQ: 经理租借了录音机吗? Did the manager rent the recorder?

22. Context: 在收拾房间的时候，我的手指和手臂都被镜子和椅子弄破了。
I was tidying my room. My finger and arm got hurt by the mirror and the chair.

SQ: 什么弄破了手指? What cut the finger?
OQ: 镜子弄破了什么? What did the mirror cut?

Sentence: 镜子弄破了手指 The mirror cut (my) finger

SQ: 椅子弄破了手指吗? Did the chair cut the finger?
OQ: 镜子弄破了手臂吗? Dud the mirror cut the arm?

23. Context: 模特和影星在争夺一个选美比赛的冠亚军。
A model and a movie star were competing for first prize and runner-up in a beauty contest.

SQ: 谁赢得了冠军? Who won the first prize?
OQ: 模特赢得了什么? What did the model win?

Sentence: 模特赢得了冠军 The model won the first prize

SQ: 影星赢得了冠军吗? Did the movie star win the first prize?
OQ: 模特赢得了亚军吗? Did the model win the second prize?

24. Context: 阿姨和叔叔昨天晚上看了一本书和一部电影。电影和书把他们逗乐了。
The auntie and uncle read a book and then watched a movie last night, which entertained them.

SQ: 什么逗乐了阿姨? What entertained the auntie?
OQ: 电影逗乐了谁? Who did the movie entertain?

Sentence: 电影逗乐了阿姨 The movie entertained the auntie

SQ: 书逗乐了阿姨吗? Did the book entertain the auntie?
OQ: 电影逗乐了叔叔吗? Did the movie entertain the uncle?

25. Context: 张三和李四去图书馆阅读诗歌和小说，读过之后都被感动了。
Zhangsan and Lisi went to read poetry and fiction at the library. They were both moved after reading.

SQ: 什么感动了李四? What moved Lisi?
OQ: 小说感动了谁? Who did the fiction move?

Sentence: 小说感动了张三 The fiction moved Zhangsan

SQ: 诗歌感动了李四吗? Did the poetry move Lisi?
OQ: 小说感动了张三吗? Did the fiction move Zhangsan?

---

26. Context: 司机和一个乘客找到了那位年轻男子丢失的相机和钱包。
A young man lost his camera and wallet in the bus. The driver and a passenger found them.

SQ: 谁捡到了钱包? Who found the wallet?
OQ:乘客捡到了什么? What did the passenger find?

Sentence: 乘客捡到了钱包 The passenger found the wallet

SQ: 司机捡到了钱包吗? Did the driver find the wallet?
OQ:乘客捡到了相机吗? Did the passenger find the camera?

---

27. Context: 长时间的手术之后，护士和病人都饿了。他们吃完了桌子上的香蕉和葡萄。
After a long surgery, the nurse and the patient were hungry. They ate up the bananas and grapes on the table.

SQ: 谁吃完了葡萄? Who ate up the grapes?
OQ: 病人吃完了什么? What did the patient eat up?

Sentence: 病人吃完了葡萄 The patient ate up the grapes

SQ: 护士吃完了葡萄吗? Did the nurse eat up the grapes?
OQ: 病人吃完了香蕉吗? Did the patient eat up the bananas?

---

28. Context: 一位博士和他的教授去图书馆阅读了散文和诗歌。
A Ph.D. student and a professor came to the library to read poetry and novels.

SQ: 谁阅读了散文? Who read the novel?
OQ: 博士阅读了什么? What did the Ph.D. student read?

Sentence: 博士阅读了散文 The Ph.D. student read the novel

SQ: 教授阅读了散文吗? Did the professor read the novel?
OQ: 博士阅读了诗歌吗? Did the Ph.D. student read the poetry?

29. Context: 警察和保安人员写下了报案人的电话和地址。

The police and the security guard wrote down the telephone number and the address of the person who reported robbery.

SQ: 谁写下了地址？ Who wrote down the address?
OQ: 警察写下了什么？ What did the police write down?

Sentence: 警察写下了地址 The police wrote down the address

SQ: 保安写下了地址吗？ Did the security guard write down the address?
OQ: 警察写下了电话吗？ Did the police write down the telephone number?

---

30. Context: 公主和王子扔掉了许多旧玩具，包括一些木偶和洋娃娃。

The princess and the prince threw away many old toys. They threw away their puppets and dolls.

SQ: 谁扔掉了木偶? Who threw away the puppets?
OQ: 公主扔掉了什么? What did the princess throw away?

Sentence: 公主扔掉了木偶 The princess threw away the puppets

SQ: 王子扔掉了木偶吗? Did the prince throw away the puppets?
OQ: 公主扔掉了洋娃娃吗? Did the princess throw away the dolls?

---

31. Context: 兔子和老鼠溜进了农民的房子偷吃了米饭和蔬菜。

A rabbit and a mouse went to a farmer's house and stole rice and vegetables.

SQ: 什么偷吃了米饭? What stole the rice?
OQ: 兔子偷吃了什么? What did the rabbit steal?

Sentence: 兔子偷吃了米饭 The rabbit stole (and ate) the rice

SQ: 老鼠偷吃了米饭吗? Did the mouse steal the rice?
OQ: 兔子偷吃了蔬菜吗? Did the rabbit steal the vegetable?

---

32. Context: 裁判和教练昨天都很忙。他们出席了一个会议和一个面试。

The referee and the coach were busy at a meeting and an interview.

SQ: 谁出席了会议? Who attended the meeting?
OQ: 裁判出席了什么? What did the referee attend?

Sentence: 裁判出席了会议 The referee attended the meeting

SQ: 教练出席了会议吗? Did the coach attend the meeting?
OQ: 裁判出席了面试吗? Did the referee attend the interview?

33. Context: 今天邻居和亲戚给我送来了很多香蕉和草莓。
My neighbour and my relative gave me many bananas and strawberries today.

SQ: 谁带来了草莓? Who brought the strawberries?
OQ: 亲戚带来了什么? What did the relative bring?

Sentence: 亲戚带来了草莓 The relative brought the strawberries

SQ: 邻居带来了草莓吗? Did the neighbour bring the strawberries?
OQ: 亲戚带来了香蕉吗? Did the relative bring the bananas?

34. Context: 很多地方都出现了员工短缺。上个星期，一家餐馆和一家酒店雇佣了会计和服务员。
There was in need of staff in many places. A restaurant and a hotel hired an accountant and a waiter last week.

SQ: 哪里雇佣了会计? Which place hired the accountant?
OQ: 餐馆雇佣了谁? Who did the restaurant hire?

Sentence: 餐馆雇佣了会计 The restaurant hired the accountant

SQ: 酒店雇佣了会计吗? Did the hotel hire the accountant?
OQ: 餐馆雇佣了服务员吗? Did the restaurant hire the waiter?

35. Context: 我的同学和室友在聚会上打破了一个盘子和一个茶杯。
My classmate and my roommate broke a cup and a plate at a party.

SQ: 谁打破了茶杯? Who broke the cup?
OQ: 室友打破了什么? What did the roommate break?

Sentence: 室友打破了茶杯 The roommate broke the cup

SQ: 同学打破了茶杯吗? Did the classmate break the cup?
OQ: 室友打破了盘子吗? Did the roommate break the plate?

36. Context: 我在植物园里跌倒了，玫瑰和树枝划破了我的大腿和膝盖。
I was walking in the botanic garden and stumbled. The roses and leaves there pierced my thigh and my knee.

SQ: 什么划破了大腿? What pierced the thigh?
OQ: 玫瑰划破了什么? What did the roses pierce?

Sentence: 玫瑰划破了大腿 The roses pierced the thigh

SQ: 树枝划破了大腿吗? Did the leaves pierce the thigh?
OQ: 玫瑰划破了膝盖吗? Did the roses pierce the knee?

37. Context: 一个摊位正在出售香肠和蔬菜，这引来了饥饿的狐狸和狼。
The stall was selling sausages and vegetables. A hungry fox and wolf were walking towards them.

SQ: 什么引来了狐狸? What attracted the fox?
OQ: 香肠引来了什么? What did the sausage attract?

Sentence: 香肠引来了狐狸 The sausage attracted the fox

SQ: 蔬菜引来了狐狸吗? Did the vegetable attract the fox?
OQ: 香肠引来了狼吗? Did the sausage attract the wolf?

---

38. Context: 海豹和海豚正在为一个表演练习抢气球和足球。
The seal and a dolphin were practising grabbing balloons and footballs for a show.

SQ: 什么抢到了气球? What grabbed the balloon?
OQ: 海豹抢到了什么? What did the seal grab?

Sentence: 海豹抢到了气球 The shark grabbed the balloon

SQ: 海豚抢到了气球吗? Did the dolphin grab the balloon?
OQ: 海豹抢到了足球吗? Did the seal grab the football?

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39. Context: 现在的名人都在做慈善。一位歌手和一位画家收养了孤儿和流浪狗。
Famous people are trying to do charity nowadays. A singer and a painter adopted an orphan and a homeless dog.

SQ: 谁收养了孤儿? Who adopted the orphan?
OQ: 歌手收养了什么? What did the singer adopt?

Sentence: 歌手收养了孤儿 The singer adopted the orphan

SQ: 画家收养了孤儿吗? Did the painter adopt the orphan?
OQ: 歌手收养了流浪狗吗? Did the singer adopt the dog?

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40. Context: 一名士兵和将军保管着军队的钥匙和枪支，但他们不小心弄丢了一把钥匙和一支枪。
Keys and weapons are kept separately by a soldier and the General. They lost one key and one gun.

SQ: 谁弄丢了钥匙? Who lost the key?
OQ: 士兵弄丢了什么? What did the soldier lose?

Sentence: 士兵弄丢了钥匙 The soldier lost the key

SQ: 将军弄丢了钥匙吗? Did the General lose the key?
OQ: 士兵弄丢了枪支吗? Did the soldier lose the gun?

41. Context: 间谍和侦探闯进了董事长的办公室，拿走了那个装有秘密的芯片和光盘。
A spy and a detective broke into a CEO's office and took the chip and the CD that were full of secrets.

SQ: 谁拿走了芯片? Who took the chip?
OQ: 间谍拿走了什么? What did the spy take?

Sentence: 间谍拿走了芯片 The spy took the chip

SQ: 侦探拿走了芯片吗? Did the detective take the chip?
OQ: 间谍拿走了光盘吗? Did the spy take the CD?

42. Context: 昨晚的风暴和大雪摧毁了老伯伯农场的许多植物和器具。
The windstorm and heavy snow last night destroyed many plants and tools on the old man's farm.

SQ: 什么摧毁了植物? What destroyed the plants?
OQ: 风暴摧毁了什么? What did the windstorm destroy?

Sentence: 风暴摧毁了植物 The windstorm destroyed the plants

SQ: 大雪摧毁了植物吗? Did the snow destroy the plants?
OQ: 风暴摧毁了器具吗? Did the windstorm destroy the tools?

43. Context: 老师和校长在会议期间喝完了他们的绿茶和红酒。
A teacher and a principal finished their green tea and wine during the meeting.

SQ: 谁喝完了绿茶? Who finished the green tea?
OQ: 老师喝完了什么? What did the teacher finish?

Sentence: 老师喝完了绿茶 The teacher finished the green tea

SQ: 校长喝完了绿茶吗? Did the principal finish the green tea?
OQ: 老师喝完了红酒吗? Did the teacher finish the red wine?

44. Context: 午餐时，动物饲养员给老虎和狮子拿来了一些雨水和牛奶。
At lunchtime, the animal feeder brought tiger and lion some rainwater and milk.

SQ: 什么喝完了雨水? What drank up the rain water?
OQ: 老虎喝完了什么? What did the tiger drink up?

Sentence: 老虎喝完了雨水 The tiger drank up the rain water

SQ: 狮子喝完了雨水吗? Did the lion drink up the rain water?
OQ: 老虎喝完了牛奶吗? Did the tiger drink up the milk?

45. Context: 电视和广播的天气预报不一样。一个预报的是小雨，另一个预报的是大雨。
TV and broadcast forecast different weather for tomorrow. One forecast light rain and one forecast heavy rain.

SQ: 什么预报了小雨？What forecast light rain?
OQ: 电视预报了什么？What did TV forecast?

Sentence: 电视预报了小雨 TV forecast light rain

SQ: 广播预报了小雨吗？Did the broadcast forecast light rain?
OQ: 电视预报了大雨吗？Did TV forecast heavy rain?

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46. Context: 我的哥哥和姐姐上周参加了大学和高中的面试。他们都被录用了。
My brother and sister had a job interview both at a university and a high school. One week later, they both got a job.

SQ: 哪里雇佣了哥哥？Which place hired the brother?
OQ: 大学雇佣了谁？Who did the university hire?

Sentence: 大学雇佣了哥哥 The university hired the brother

SQ: 高中雇佣了哥哥吗？Did the high school hire the brother?
OQ: 大学雇佣了姐姐吗？Did the university hire the sister?

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47. Context: 现在很多人因病毒和细菌感染生病了。张三的头和喉咙很痛。
Many people got sick these days because of the inflammation caused by virus and bacteria. Zhangsan has a headache and a sore throat.

SQ: 什么引发了头痛？What caused the headache?
OQ: 病毒引发了什么？What did the virus cause?

Sentence: 病毒引发了头痛 The virus caused the headache

SQ: 细菌引发了头痛吗？Did bacteria cause the headache?
OQ: 病毒引发了喉咙痛吗？Did the virus cause the sore throat?

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48. Context: 男人和他的妻子星期天去购物，他们买了手表和皮鞋。
The man and his wife went shopping on Sunday. They bought a watch and a pair of leather shoes.

SQ: 谁购买了手表？Who bought the watch?
OQ: 妻子购买了什么？What did the wife buy?

Sentence: 妻子购买了手表 The wife bought the watch

SQ: 男人购买了手表吗？Did the man buy the watch?
OQ: 妻子购买了皮鞋吗？Did the wife buy the shoes?

Appendix 13 Instructions for Experiment 2

Instructions in Mandarin	English translation
Screen 1: 欢迎参加实验！请仔细阅读下列实验说明。 说明：首先，您会看到一个文字描述的场景，例如： *一个小孩和一个成年人急匆匆地去赶火车和出租车。他们两个都没赶上...* 读完后按任意键继续，您会听到一个关于场景的对话。例如： *问：小孩错过了什么？* *答：小孩错过了火车。* 请按任意键继续阅读实验说明	Welcome to the experiment! Please read the following instructions carefully. Instructions: you will see a context, e.g.: *A kid and an adult were running to catch a train and a cab. Neither of them made it.* Then you will hear a dialogue about the context after you've read the sentence and press any key, e.g.: *Question: What did the kid miss?* *Answer: The kid missed the train.* Press any key to proceed with the instructions
Screen 2: 随后，您需要判断对话中问题的回答方式听起来是否恰当(从 1. 一点儿也不恰当 到 7. 极其恰当 2-6 的恰当度在 1 和 7 之间，数字越大，恰当程度越高) 请注意：所有回答的字面意思和逻辑相对于场景都是正确的，场景仅提供对话背景信息，与回答的恰当度无关！ 例如: 对于情景'一个小孩和一个成年人急匆匆地去赶火车和出租车。 他们两个都没赶上......' 针对问题'谁错过了火车'，回答 1'小孩错过了火车'，2'成年人错过了火车'，3'小孩和成年人都错过了火车'都是恰当的。	Then you will be asked to rate how appropriate the answer is to the question on a scale from 1 (not appropriate at all) to 7 (extremely appropriate) using the corresponding number key. The higher the number is, the more appropriate the answer is to the question. Please note: The answer is correct as a response to its question in terms of the words that are used in the answer. The context only provides background information, and it is not relevant to the appropriateness of the answer. For example: For the question 'Who missed the train?', Answer 1 'The kid missed the train', Answer 2 'The adult missed the train', and Answer 3

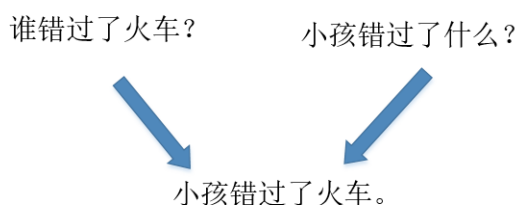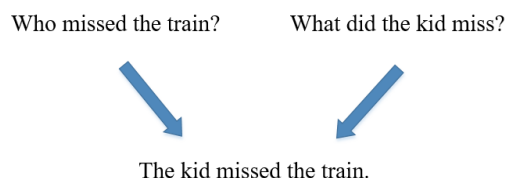|	
回答的恰当度可能取决于回答者以什么样的方式回答问题，句子的侧重点的变化可能会影响回答的恰当度。 请按任意键继续阅读实验说明	'Both the kid and the adult missed the train' are all appropriate. However, the appropriateness of the answer to the question may depend on the way that the words are said. The change of the emphasis may affect the appropriateness of the answer. Press any key to proceed with the instructions
Screen 3: 说话人的问题会根据他们想要寻求的答案变化： 谁错过了火车？ 小孩错过了什么？ 小孩错过了火车。 在对话中，如果问题不同，回答者说话的侧重点也会有所不同。'谁错过了火车?' 寻求的答案是'小孩'。'小孩错过了什么?'寻求的答案是'火车'。回答者对这两个问题的说话的侧重点不同。 请按任意键继续阅读实验说明	The questions differ in terms of what answer they are seeking: Who missed the train? What did the kid miss? The kid missed the train. In a dialogue, if the questions are different, the emphasis would be different in answers. The question 'Who missed the train' seeks the answer *kid*, while 'What did the kid miss?' seeks the answer *train*. People say the answers to questions differently depending on what is being asked about. Press any key to proceed with the instructions
Screen 4: 请听下面两个句子，句子都为'小孩错过了火车。', 但说话人的侧重点不同。(请按任意键播放)	Please listen to the following two sentences. The sentences are 'The kid missed the train', but the speaker's emphasis is different. Please press any key to play.
Screen 5: 回答的恰当度可能取决于回答者以什么样的方式回答问题，句子的侧重点的变化可能会影响回答的恰当度。	The appropriateness of the answer to the question may depend on the way that the words are said. The change of the emphasis may affect the appropriateness of the answer. We hope you listen to dialogues carefully, and rate the appropriateness based on the question

| 我们希望您认真听问答，最后基于问题及其回答方式，判断其恰当度。 | and the way how the question is being answered. |
| 请按任意键继续阅读实验说明 | Press any key to proceed with the instructions |

| **Screen 6:**
如果您有任何问题，请向主试人员举手示意！

如果您需要在第一个声音文件之后调整音量，请向主试人员举手示意！

当屏幕显示场景的时候，如您需要，您可在此休息。休息完毕后，按任意键继续。

正式实验前您可以做几个练习。

请按任意键进入练习阶段 | Please signal the experimenter if you have any questions!

If you need to adjust the volume after the first sound file, please signal the experimenter!

If you need a break at any point, pause on the screen showing the context, and then press any key when you are ready to continue.

There are some practice items before the main experiment.

Press any key to proceed with the practice items |

| **Screen 7:**
3 秒钟后自动开始练习 | The practices starts automatically in 3 s. |

| **Screen 8:**
练习阶段结束。

如果您不确定如何操作此实验，或者您有任何疑问，请向主试人员举手示意。

请注意，在正式实验中，如果您在 6 秒钟内没有回答问题，实验将自动跳往下一场景。

当屏幕显示场景的时候，如您需要，您可在此休息。休息完毕后，按任意键继续。

请按任意键进入正式实验阶段 | End of the practice.

Please raise your hand if you are unsure what to do, or if you have any questions.

Please note that in the main experiment, if you do not make a decision within 6 s, it will move on to the next dialogue.

If you need a break at any point, pause on the screen showing the context, and then press any key when you are ready to continue.

Press any key to move on to the main experiment |

Appendix 14 Instructions for Experiment 3

Instructions in Mandarin	English translation
Screen 1:	Welcome to the experiment! Please read the following instructions carefully.
欢迎参加实验！请仔细阅读下列实验说明。	
说明：该实验中会有关于不同情景的对话。两个人谈论一件事。	Instructions: In the experiment, there will be a series of dialogues about different events. There are two people talking about each event
首先，您会看到一个文字描述的场景，例如：	You will firstly see a context, e.g.:
	A kid and an adult were running to catch a train and a cab. Neither of them made it.
一个小孩和一个成年人急匆匆地去赶火车和出租车。他们两个都没赶上。	
	Press the space key to proceed with the instructions
请按空格键继续阅读实验说明	
Screen 2:	You will then hear one person ask a question about the event, e.g.:
随后，您会听到一个人问这件事。例如：	
你可以再多告诉我一些信息吗？	*Can you tell me more?*
	The other person will then answer the question, e.g.:
另外一个人将会回答这个问题。例如：	
	The kid missed the train.
小孩错过了火车。	
	Press the space key to proceed with the instructions
请按空格键继续阅读实验说明	
Screen 3:	A question will then appear on the screen, e.g.:
随后，屏幕上会出现一个问题。例如：	
大人错过了火车吗？	*Did the adult miss the train?*
此问题是用来检测您是否听明白回答者的回答内容。	This question is to check you understood what the two people just said.

您需要根据上述听到的对话内容来判断这个问题的正误。如您看到的问题和听到的回答的意思一致，应按键盘上贴有'是'的标签，如不一致，应按键盘上的'否'。 我们希望您能以最快的速度作答，因为实验会记录您的反应时间。 在练习阶段，如果您在 6 秒钟没有作答，您会听到'哔'的提醒。在正式实验阶段，如果您在 6 秒钟没有作答，实验将继续跳往下一个。 请按空格键继续阅读实验说明	You should answer 'yes' or 'no' by pressing the key labelled 'Y' to choose YES, and 'N' to choose NO. You should choose YES or NO as quickly as you can, based on what you heard. We are recording how long it takes you to respond. In the practice, if you don't respond in 6 s, there will be a warning beep. In the main experiment, after 6 s it will move on to the next dialogue. Press the space key to proceed with the instructions
Screen 4: 正式实验前您可以做几个练习。 在练习阶段，您会收到答案正误的反馈。正式实验中您将不会收到任何反馈。 当屏幕显示场景的时候，如您需要，您可在此休息。休息完毕后，按任意键继续。 如果您有任何问题，请向主试人员举手示意！ 请按空格键继续开始练习	We will start some practices, and then move on to the main experiment. For the practices, you will receive feedback on your response, but not in the main experiment. If you need a break at any point, pause on the screen showing the context, and then press any key when you are ready to continue. Please signal the experimenter if you have any questions! Press the space key to proceed with the practice items!
Screen 5: 3 秒钟后自动开始练习，请把手指放在键盘上贴有'是''否'的标签上，准备作答	The practices start automatically in 3 s. Please put your fingers on the keys labelled 'Y' and 'N' to be ready.
Screen 6: 练习阶段结束。	End of the practice. Please raise your hand if you are unsure what to do, or if you have any questions.

如果您不确定如何操作此实验，或者您有任何疑问，请向主试人员举手示意。

请注意，在正式实验中，如果您在 6 秒钟内没有回答问题，实验将自动跳往下一场景。请您用最快的速度回答问题。

当屏幕显示场景的时候，如您需要，您可在此休息。休息完毕后，按空格键继续。

请按空格键进入正式实验阶段

Please note that in the main experiment, if you do not make a decision within 6 s, it will move on to the next dialogue. Please respond as fast as possible.

If you need a break at any point, pause on the screen showing the context, and then press any key when you are ready to continue.

Press the space key to move on to the main experiment

Appendix 15 Instructions for Experiments 4A and 4B

Instructions in Mandarin	English translation
Screen 1: 欢迎参加实验！该实验旨在探究汉语词组识别的速度。 请仔细阅读下列实验说明。 说明：首先，电脑屏幕上会出现一个白点，您需要把您的注意力集中在这个白点上。 之后，您会听到一句话，例如： *工人弄丢了手机。* 随后，电脑屏幕上会出现两个汉字，您需要以最快的速度判断这两个汉字组成的是否是一个词。比如'书包'是一个词，'提浪'不是。 请按空格键继续阅读实验说明	Welcome to the experiment! This experiment tests how quickly people can recognise words in Mandarin. Please read the following instructions carefully. Instructions: First, you will see a white dot on the screen. Your focus should be on this dot. Next, you will hear a sentence, for example: *The worker lost the phone.* Next, two characters will appear on the screen. You need to decide whether the two characters make up a real word in Mandarin. For example: '书包' is a word, '提浪' is not. Press the space key to proceed with the instructions
Screen 2: 如果是一个词，请按'是'，如果不是一个词，请按'否'。 我们会记录您回答问题的时间，所以请您用最快的速度做答。实验过程中请您把手指放在'是'，'否'两个键上做好准备。 除了关于词组的判断之外，您还将被问到句子内容的问题。希望您认真听句子，准确作答。 请按空格键继续阅读实验说明	If it is a word, please press the key labelled 'Y', if not, press the key labelled 'N'. We are recording how long it takes to press the 'Y' or 'N' key. Therefore, please respond as fast as possible while still being accurate. Please put your fingers on the keys labelled 'Y' and 'N' to be ready. There are also several comprehension questions asking about the content of the sentences you will hear. Please listen to the sentences carefully, and answer the questions accurately.

	Press the space key to proceed with the instructions
Screen 3: 正式实验前您可以做几个练习。 在练习阶段，您会收到答案正误和反应速度快慢的反馈。正式实验中您将不会收到任何反馈。 如果您有任何问题，请向主试人员举手示意！ 请按空格键进入练习阶段	There are some practice items before the main experiment. In the practice trials, you will receive feedback on your response and reaction time. However, you will not receive the feedback in the main experiment. Please raise your hand if you have any questions. Press any key to proceed with the practice items.
Screen 4: 练习阶段结束。 如果您不确定如何操作此实验，或者您有任何疑问，请向主试人员举手示意。 请注意，在正式实验中，如果您在 3 秒之内没有做出回答，实验将自动跳往下一个。所以请您用最快的速度来回答。 此实验分为四小部分，每部分之间有 10s 的休息时间。 请按空格键进入正式实验阶段	End of the practice. Please signal the experimenter by raising your hand. Please raise your hand if you are unsure what to do, or if you have any questions. Please note that in the main experiment, if you do not respond within 3 s, it will move on to the next item. Please respond as fast as possible. There is a 10-second break after each block. There are four blocks in total. Press the space bar to proceed with the main experiment
Screen 5: 3 秒钟后开始实验，请手指放在贴有'是'和'否'的键盘上，做好准备。	The main experiment starts automatically in 3 s. Please put your fingers on the keys labelled 'Y' and 'N' to be ready.