Speech Comprehension in a Tone Language: The Role of Lexical Tone, Context, and Intonation in Cantonese-Chinese

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謹以此文獻俾

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Chapter 1

General Introduction

'There is as much eloquence in the tone of voice, in the eyes, and in the air of a speaker as in his choice of words.' (de la Rochefoucauld, 1871)

This quote illustrates one of the many important functions of the tone of voice—and technically speaking, intonation. As suggested by its alternative name—tone of voice—intonation uses pitch variations to mark phrase structure and to express discourse meaning, and it is a universal feature in all languages (Gussenhoven, 2004). Take the following example: If a speaker says 'all good' with a rising pitch, it is a question inquiring whether things are fine or not. By contrast, if the speaker says 'all good' with a falling pitch, it is a statement indicating to the listener that everything is fine. Tying back to this example, if the speaker tries to convince the listener that things are fine using a question intonation, the speaker will probably fail his or her purpose and invite more questions from the listener. In addition to intonation, some languages use pitch variations to distinguish between words (Gussenhoven, 2004). These pitch-variation patterns are called lexical tones. For example, in Cantonese Chinese—the language investigated in this dissertation—the two words "husband" (夫/fu1/) and "wife" (婦 /fu5/) only differ by the lexical tone. Mistaking the tone of these two words can be detrimental; it can lead to very awkward situations during conversations. Languages that use lexical tones to tell words apart are referred to as tonal languages (e.g. Cantonese Chinese); they constitute 60-70% of the world's languages (Yip, 2002, p. 1).

Even though the majority of the world's languages are tone languages, little is known about how speakers of tone languages process lexical tones during spoken language comprehension. One of the possible reasons is that most psycholinguistic studies focus on Indo-European languages, which are mostly non-tonal (see Levelt, 2012 for a history of psycholinguistics). In recent years, there is an increasing interest in the role of lexical tone in spech comprehension (Brown-Schmidt & Canseco-Gonzalez, 2004; Chandrasekaran, Krishnan, & Gandour, 2007; Cutler & Chen, 1997; Cutler, Dahan, & van Donselaar, 1997; Gandour, 1981; Khouw & Ciocca, 2007; S.-P. Law, Fung, & Kung, 2013; X. Li, Yang, & Hagoort, 2008; Liu, Chen, & Schiller, 2016; Schirmer, Tang, Penney, Gunter, & Chen, 2005; Su, Lau, Zhang, Yan, & Law, 2011; Tsang, Jia, Huang, & Chen, 2011; van Lancker & Fromkin, 1973; Xi, Zhang, Shu, Zhang, & Li, 2010; Ye & Connine, 1999; X. Zhou, Ye, Cheung, & Chen, 2009). Particularly, more recent research has focused on the neural processes underlying lexical-tone perception and processing using event-related potentials (ERPs)—a method with excellent temporal resolution that can track real-time language processing and the on-going brain activity underlying such processing (see Box 1, which is largely based on Kutas & Federmeier, 2000; Luck, 2014). Note that most of these studies focus on lexical-tone perception per se. Only very few studies investigate how lexical tone influences speech comprehension. Below, we first briefly review previous studies on how lexical tone is perceived. Then, we provide a more detailed review of the few studies on how lexical tone affects speech-comprehension processes.

1.1. The role of lexical-tone perception in on-line spoken language comprehension

1.1.1. Lexical-tone perception

As stated above, lexical tones are mainly characterised by pitch variations. In addition to pitch variations, lexical tones can also differ by duration and voice quality (Yip, 2002). However, the majority of research on tone perception focuses on how the variation of pitch—and more specifically, fundamental frequency (F_0), which is the acoustic correlate of pitch—can alter tone perception (Gandour, 1981; Gandour & Harshman, 1978; Jongman, Yue, Moore, & Sereno, 2006; Kaan, Barkley, Bao, & Wayland, 2008; Kaan, Wayland, Bao, & Barkley, 2007; Khouw & Ciocca, 2007; Tsang et al., 2011). These studies focus on how tone perception is affected by three cues: F_0 direction (the direction of F_0 change), F_0 shape (the magnitude of F_0 change; F_0 direction and F_0 shape together can be referred to as F_0 contour) and F_0 level (the average F_0 height).

These three F_0 cues have shown to play a role in tone perception of both tone-language and non-tonal-language listeners, but listeners of tone languages rely on different F_0 cues than those of non-tonal languages (Gandour & Harshman, 1978; Guion & Pederson, 2007; Kaan et al., 2008, 2007). For example, Gandour and Harshman (1978) studied how speakers of English, Thai, and Yoruba perceive 13 types of pitch patterns. These three languages are of interest because they differ in their tone systems: English does not have any tones at all; Yoruba only has register (i.e. level) tones, whereas Thai has both contour and level tones. They found that English speakers paid attention to F_0 height (and also the F_0 onset and offset point), but ignore the F_0 shape and F_0 direction. By contrast, speakers of the two tonal languages paid attention to (almost) all three F_0 cues. One exception was that Yoruba speakers did not use (or only to a small degree) F_0 shape. This is presumably the case because Yoruba does not have contour tones, which are characterised by F_0 shape.

The role of the three F_0 cues in tone perception can also vary between tonal languages. For example, Gandour (1984) tested listeners of three varieties of Chinese (all tonal languages)—Cantonese, Mandarin, and Taiwanese—on their use of F_0 height, F_0 shape, and F_0 direction in perceiving 19 synthetic tones. The results showed that Cantonese listeners paid more attention to F_0 height than the Mandarin and Taiwanese listeners. This is presumably the case because, compared to Mandarin and Taiwanese, two of the three contour tones in Cantonese show the same direction and differ by F_0 height. Similar observations about Cantonese listeners were reported by Ma et al. (2006), who tested the perception of lexical tones at the end of questions and statements. The majority of the participants had difficulty identifying low tones (Tones 4, 5, and 6) at the end of questions because the F_0 contours of these tones were modified by the question intonation. However, some participants managed to identify these tones despite the intonation-induced F_0-contour modifications. Ma et al. (2006) propose that it is likely that these participants rely more on F_0 height for tone perception, rather than F_0 shape and F_0 direction, which have been altered by intonation.

Box 1. Electroencephalogram (EEG) and event-related potentials (ERPs)

How can we study the brain processes underlying on-line cognitive processes, such as speech comprehension, non-invasively? One of the most direct yet non-invasive ways is to measure event-related potentials (ERPs), which are extracted from recordings of ongoing brain activity, i.e. electroencephalogram (EEG).

The EEG is recorded by placing at least two electrodes on the scalp: One of these electrodes is a reference electrode, which is placed at a location insulated from brain activities, while the other electrode(s) is/are distributed over the scalp. The EEG at the single electrodes is a record of the post-synaptic electrical activity generated by the flow of electrochemical signals across the neural membranes. Since the electrical activity generated by one neuron is very small, the recorded EEG is a field potential, i.e. it reflects the summed flow of electrochemical signals within a large population of neurons that fire synchronously.

However, the EEG alone cannot inform us about the cognitive process of interest. This is because the recorded EEG contains both the background noise and the brain responses to the cognitive event of interest. Therefore, one measures event-related potentials (ERPs) by time-locking the EEG to the cognitive event or stimulus of interests. The amplitude of a single ERP (5-10 μV) is very small compared to that of the background EEG (50-100 μV). Because of the relative small amplitude of ERPs, one has to record the brain responses to repeated presentations of the same kind of cognitive events (i.e. multiple trials) and to average across trials in order to extract the ERP from the EEG.

The resulting ERP at each electrode is a waveform in time containing both negative and positive voltage deflections relative to the brain activity in a short time interval before the event of interest, a so-called pre-stimulus baseline (usually 100 to 200 ms). The voltage deflections in the first 200 ms post-stimulus onset of an ERP waveform generally reflect the brain activity related to the sensory processing of that stimulus. Later deflections reflect the cognitive processing of that stimulus. In the ERP literature, the ERP waveforms associated with a particular stimulus event over time are referred to as ERP components. These ERP components are defined by their latency, scalp distribution, and their sensitivity to experimental manipulations, and occasionally, by their neural generators.

Because of the multidimensionality, ERPs have been shown to be an excellent tool to study the neural processes underlying speech comprehension. ERPs have an exquisite temporal resolution at the millisecond-level. This is especially important for capturing the dynamics of speech comprehension: In only hundreds of millisecond, listeners can perceive and make sense of a string of unfolding speech signals by retrieving information from long-term memory and by integrating this information with the ongoing discourse.

In addition to studying the acoustic correlates of tone perception, previous studies also investigated the neural mechanisms underlying tone perception. The findings appear to be inconsistent. It has been proposed that there is hemispheric specialisation in pitch processing. In particular, pitch patterns with more linguistic relevance, such as lexical tone, are processed in the left hemisphere. On the other hand, pitch patterns with less linguistic relevance (e.g., emotional prosody) are processed in the right hemisphere. This functional account has been supported by studies using a variety of techniques, such as dichotic listening, studying patients with brain lesions, and neuroimaging techniques—Positron Emission Tomography (PET), Magnetoencephalography (MEG), and functional Magnetic Resonance Imaging (fMRI; (Fournier, Gussenhoven, Jensen, & Hagoort, 2010; Gandour et al., 2003, 2006; Gandour & Dardarananda, 1983; van Lancker & Fromkin, 1973; Witteman, van IJzendoorn, van de Velde, van Heuven, & Schiller, 2011). However, a comprehensive review of pitch processing by Wong (2002) questioned this functional view. In particular, he argued that, since the stimuli used in the studies, which support the functional account, were all meaningful words, it is likely that the lateralisation may be related to lexical processing rather than pitch processing per se. Thus, these studies do not disentangle lexical-tone processing from pitch processing. Further contradictory evidence comes from the study by Witteman et al. (2014), who systematically examined the functional account. To this end, they tested two separate groups of particiants, each listening to pseudowords carrying emotional or linguistic prosody using dichotic listening while participants' brain activities were recorded using EEG. Their results did not show any hemispheric difference at either the behavioural or electrophysiological level for the processing of linguistic and emotional prosody.

1.1.2. The processing of lexical tone and phonological segments

Besides being able to perceive tone, it is important for speakers of tone languages to process tonal information when it becomes available and to relate this tonal information to lexical processing during speech comprehension. In spoken language, lexical tone is realised on top of phonological segments. Several studies have assessed the time-course of the processing of tonal information and of segmental information.

Two off-line behavioural studies, one in Cantonese Chinese (Cutler & Chen, 1997) and one in Mandarin Chinese (Ye & Connine, 1999), examined the processing of tonal and segmental information using a speeded same-different-judgment task. Both studies found that listeners were slower and less accurate when they had to distinguish between tones than when they had to distinguish between segments. Based on these findings, it was argued that tonal information is accessed later than segmental information. An alternative account holds that the two types of information are accessed equally fast and that the observed difference in judgment time reflects decision processes.

A different account is supported by the results of Schirmer, Tang, Penney, Gunter, and Chen (2005). Instead of studying the behavioural response, they examined the on-line processing of tonal and segmental information using event-related potentials (ERPs). (see Box 1 above for a brief introduction of ERPs). The researchers were particularly interested in the N400, a language-related ERP component (see Box 2 for a description of the N400 component).

The amplitude of the N400 is larger for a word that is semantically incongruous with a preceding context in comparison with a word that is semantically congruous. For example, the N400 to 'socks' in 'I take coffee with cream and...' is larger than the N400 to 'sugar' in the same sentence. Using the N400, Schirmer and colleagues (2005) compared the onset latency and the amplitude of the N400 between words that were semantically congruous or semantically incongruous with a preceding context. The incongruous words differed from the congruous words by only the tone, only the phonological segments, or by both. All three types of semantic incongruities elicited an N400 effect with similar onset latency. Based on the similarity in onset latency, the authors argued that tonal and segmental information are accessed simultaneously and integrated immediately with the previous context (for further evidence, see also Brown-Schmidt & Canseco-Gonzalez, 2004; X. Li et al., 2008 for studies on Mandarin Chinese). This contradicts the claim of Cutler and Chen (1997) and Ye and Connine (1999) that tonal information is accessed after segmental information. In sum, the time-course of the processing of tonal and segmental information is a matter of debate. To date, studies yield inconsistent findings.

Box 2. The N400 and P600 components and language processing

Several ERP components have been associated with language comprehension (see Friederici, 2011; Kutas et al., 2006 for reviews of the language-relevant ERP components). Here, we provide a brief description of two ERP components—N400 and P600—which are of special interest for the present dissertation.

The N400 component is a negative-going waveform with a centro-parietal maximum that peaks around 400 ms after the onset of a critical word (see Kutas & Federmeier, 2011; Lau, Phillips, & Poeppel, 2008 for reviews). The amplitude of the N400 is sensitive to the processing of semantic information. Specifically, the amplitude of the N400 is more negative when a word is semantically incongruous with a preceding context in comparison to when a word is semantically congruous. Taking the classic example of Kutas and Hillyard (1980), the N400 to 'socks' in 'I take coffee with cream and...' has a larger amplitude than the N400 to 'sugar' in the same sentence. This difference in the N400 amplitude is called the N400 effect.
The functional interpretation of the N400 effect remains an ongoing debate in the literature. It may reflect orthographic/phonological analyses (Deacon, Dynowska, Ritter, & Grose-Fifer, 2004), integration difficulties (Chwilla, Kolk, & Vissers, 2007;

van Berkum, Hagoort, & Brown, 1999), or semantic-memory retrieval difficulties (Kutas & Federmeier, 2000; van Berkum, 2012).

The other ERP component that is central to the present thesis is the P600 component, which is a late centro-parietally distributed positivity starting at about 500ms and typically extending until 800 ms after critical word onset. The P600 can start as early as 200 ms and often exhibits no peak, but a long-lasting positive shift. The component was first associated with morphosyntactic processing (Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992). A larger P600 (i.e. a P600 effect) is often observed with various morphosyntactic violations (e.g., subject-verb agreement, verb inflection, phrase structure) compared with morphosyntactically well-formed sentences. The P600 effect is also found for the processing of syntactically complex sentence structures relative to syntactically less complex sentence structures.

On top of syntactic processing, later studies have also reported P600 effects in the processing of semantic violations, thematic violations, and irony. In this case, a word with a very low cloze probability elicits a P600 compared with a word with a high-cloze probability in a highly-constraining context (Kutas, DeLong, & Smith, 2011; van de Meerendonk, Kolk, Vissers, & Chwilla, 2010; Vissers, Chwilla, & Kolk, 2006).

Similar to the N400, the functionality of the P600 is still under debate. One proposal is that the P600 effect reflects the construction of a coherent mental representation of the linguistic input (Hoeks, Stowe, Hendriks, & Brouwer, 2013). Another proposal is that the P600 effect reflects reanalysis (see Kuperberg, 2007), but the purpose of the reanalysis remains a topic of discussion (Kolk & Chwilla, 2007). The reanalysis can be purely syntactic in nature (Hagoort, 2003), can be a structural repair (Friederici, 2002), or can be more general in nature, e.g, a check for possible processing errors after a strong conflict between two incompatible representations of the same linguistic input (Kolk, Chwilla, van Herten, & Oor, 2003). Alternatively, the P600 has also been suggested to be a variant of P3b—a well-known ERP component which is usually observed for a rare odd-ball event in a sequence of standard events (Coulson, King, & Kutas, 1998; Sassenhagen, Schlesewsky, & Bornkessel-Schlesewsky, 2014).

1.1.3. The processing of lexical tone and intonation

Intonation and tone are both realised by F_0 but serve different functions. Only a few studies have examined whether listeners process intonation and lexical tone differently (Fournier et al., 2010; X. Li et al., 2008; Liu et al., 2016). Fournier et al. (2010) tested how speakers of Limburgish—a tonal variant of Dutch—distinguish between two tones and between two intonation patterns using an oddball paradigm, in which there are infrequent stimuli (so-called oddballs) that differ from a train of frequent stimuli (so-called standards). In their MEG measurements, the detection of the difference between the oddball and the standard stimuli was reflected in a magnetic mismatch negativity (MMNm). The results showed that, when Limburgish speakers listened to the oddball that differed by lexical tone, they showed an MMNm between 150 and 250 ms with a left temporal distribution. However, when the same participants listened to the oddball that differed by intonation pattern, they showed an MMNm with the same latency but with a right-hemisphere dominance. More importantly, when the speakers listened to an oddball that differed by a combination of tone and intonation, the speakers demonstrated a summation of the brain activation patterns of tone and intonation. These results show that Limburgish speakers rapidly detect the differences between lexical tones and intonation patterns. Furthermore, the difference in brain-activation patterns suggested that pitch processing varies as a function of linguistic complexity.

Similar to Fourier et al. (2010), Liu et al. (2016) investigated the processing of lexical tone and intonation, especially in cases where intonation is realised at the same time as the lexical tone. However, different from Fourier et al. (2010), this study examined another tonal language, namely Mandarin Chinese, and used another electrophysiological measure (i.e. EEG) and paradigm. To elaborate, Liu et al. (2016) recorded participants brain activities while they were listening to semantically-neutral questions and statements ending with a target word carrying either the rising tone 2 or the falling tone 4. At the end of half of the trials, participants were asked to complete a 2-alternative-forced-choice (2AFC) pitch- identification task, and a 2AFC intonation-identification task for the other half of the trials. For the ERP results, when compared to the same tone in statements, the falling tone 4 in questions elicited a centro-parietally distributed P300 effect between 250 ms and 450 ms in the lateral electrodes (and between 250 and 400 ms in the midline electrodes). In contrast, the rising tone 2 in questions yielded no ERP effect when compared to the same tone in statements. Contrasting to the clear pattern observed for the ERP results, the pattern was more complex for the behavioural results. Participants showed differential performance for pitch and intonation identification: For the pitch-identification task, the accuracy rate was lower for the falling tone 4 than the rising tone 2 in questions, but not in statements (even though the accuracy rates for the tone identification task were at ceiling). For the intonation-identification task, the accuracy rate was generally lower for questions than statements, regardless of the lexical tones while the accuracy rate for the falling tone 4 was better than that for the rising tone 2 in statements. Together, these behavioural and ERP results demonstrated an interaction between intonation and lexical tone in Mandarin Chinese.

X. Li et al. (2008) also examined the processing of intonation and lexical tone. However, different from Fournier et al. (2010) and Liu et al. (2016), they studied the violation of the expectation of a pitch accent, a lexical tone, and a combination of both types of expectation in Mandarin Chinese. All three types of violation elicited an N400 effect with the same topography. But the N400 effect occurred approximately 90 ms earlier in the lexical-tone violation than in the pitch-accent violation. Based on these results, X. Li et al. (2008) conclude that speakers of Mandarin Chinese very rapidly relate the information from lexical tone and pitch accent to the wider discourse context (that was used to induce the different types of expectation), with lexical tone information being accessed and integrated with the discourse slightly faster than pitch accent information. The similar scalp distribution of the two N400 effects was taken to suggest that the processing of pitch accent and lexical tone share similar neural mechanism.

1.2. Open questions

Despite the fact that more research is starting to explore the role of lexical tone in on-line speech comprehension, some important questions remain unanswered: First, previous studies have shown how lexical tone interacts with segmental information and with intonation in an additive manner during processing. In other words, all three types of information are available simultaneously during processing, but neither intonational information nor segmental information interferes with the processing of tonal information. However, it is possible that intonational information can interfere with the availability of tonal information in some tone languages, such as various varieties of Chinese, Vietnamese, and Thai (Chao, 1968; Gandour et al., 1997; Ha, 2012; Ma et al., 2006). In particular, the realisation of lexical tones can be altered by other linguistic factors, for example, intonation—as both are characterised by F_0. Previous studies showed that when tone and intonation yield conflicting F_0 information, it can lead to the misidentification of lexical tones (Ma et al., 2006). But little is known about how listeners process the interaction between the conflicting tonal and intonational information during on-line speech comprehension. This topic is inverstigated in Chapter 2 of this dissertation.

Another important but yet to be investigated question concerns the fact that in some languages lexical tone can also differentiate between different types of pragmatic meaning. For example, languages like Cantonese Chinese, Mandarin Chinese, Thai, Laos, Vietnamese, and Yoruba, use discourse particles to convey linguistic modality, register or other pragmatic functions (Akinlabi & Liberman, 2000; Cooke, 1989; Enfield, 2007; Ha, 2012; Kwok, 1984; Wu, 2004). In these tone languages, these particles can differ just by lexical tone. A change in lexical tone can thus alter the pragmatic meaning of an utterance. It is not well-understood, however, how these particles are processed in the on-line comprehension of pragmatic meaning. These two questions will be addressed in Chapters 3 and 4 of the present dissertation using Cantonese Chinese as testing ground. Before explaining how experiments on Cantonese Chinese can shed light on these questions, we will first provide a brief introduction to some basic characteristics of Cantonese Chinese.

1.3. Cantonese Chinese

Cantonese Chinese is a dialect of Yue Chinese and part of the Sino-Tibetan language family (Matthews & Yip, 2011). Similar to a lot of Sino-Tibetan languages, Cantonese Chinese is tonal and analytical. Analytical means that Cantonese contains only minimal inflectional morphology. Words in Cantonese are monosyllabic and associated with a lexical tone. Also similar to a lot of other dialects in Yue Chinese, Cantonese Chinese is a vernacular and does not have a standard written form (Luke, 2007; Matthews & Yip, 2011).

Cantonese Chinese is the lingua franca in Hong Kong, Macao, Guangdong province in China and oversea Chinese communities. The phonology of the Cantonese spoken in the former three regions differ slightly (Bauer & Benedict, 1997). In this dissertation, we will mainly focus on Hong Kong Cantonese—the variety of Cantonese spoken in Hong Kong. Thus, in this dissertation, and unless specified otherwise, we use Cantonese Chinese or simply Cantonese to refer to the variety of Cantonese Chinese spoken in Hong Kong.

1.3.1. The tone system of Cantonese Chinese

Cantonese words are monosyllabic, and the syllable structure of Cantonese is CV(C). In other words, consonant clusters are not permitted. Cantonese Chinese is also one of the most conservative varieties of Chinese because it preserved most of the oral-stop codas and nasal-stop codas from Middle Chinese (Bauer & Benedict, 1997). This property of codas will be relevant for the description of the tone system in Cantonese.

As mentioned above, Cantonese Chinese has six contrastive lexical tones. However, in diachronic descriptions of Cantonese, the languages was said to have nine lexical tones in (See Table 1.1 and Figure 1.1; Bauer & Benedict, 1997). The last three tones—Tones 7, 8 and 9—only appear in closed syllables with oral-stop codas. These three tones have the same pitch height and contour as the three level tones—Tones 1, 3, and 6. Thus in Modern Cantonese Phonology, Tones 7, 8, and 9 are considered the phonetic variant of three level Tones 1, 3, and 6 and there are only six contrastive lexical tones in Cantonese. Since the six Cantonese tones have pitch levels spanning from high to low and with overlapping pitch contours, the tone space in Cantonese Chinese is rather crowded compared to a lot of other tone languages that have only two to four tones.

Table 1.1
The tones in Cantonese Chinese. The first six are contrastive, and the last three are the phonetic variants of Tones 1, 3 and 6, respectively, and only occur in closed (CVC) syllables (Adapted from Bauer & Benedict, 1997).

Tone number	Descriptive name	Pitch contour in Chao tone letters[1]	Example words
1	High-level	55	/si^{55}/ 師 'teacher'
2	High-rising	25	/si^{25}/ 史 'history'
3	Mid-level	33	/si^{33}/ 試 'to try'
4	Low-falling	21	/si^{21}/ 時 'time'
5	Low-rising	23	/si^{23}/ 市 'town'
6	Low-level	22	/si^{22}/ 事 'matter'
7(1)	High	5	/sik^{5}/ 色 'colour'
8(3)	Mid	3	/sek^{3}/ 石 'stone'
9(6)	Low	2	/sik^{2}/ 食 'to eat'

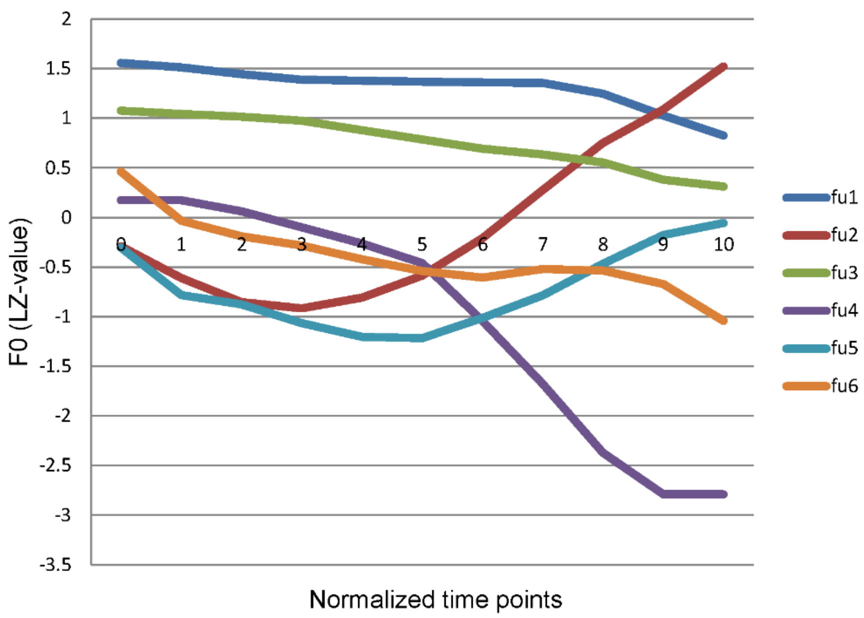

Figure 1.1.
Pitch contours of the six contrastive tones for the time-normalised syllable fu in Cantonese. (Adapted from Law, Fung, & Kung, 2013)

[1] The numbers in the column are the Chao tone letters (Chao, 1968), which is a numerical tonal notation system that uses a string of numbers to describe a pitch pattern. Most strings consist of two digits, one for the starting pitch level and the second one for the ending pitch level. The number corresponds to one of the five relative pitch levels, ranging from '1' for the lowest pitch level to '5' for the highest pitch level.

1.4. The main topics of this dissertation

1.4.1. Interaction between intonation and lexical tones

Cantonese has six contrastive lexical tones and the tone space in Cantonese is thus pretty crowded. In connected speech, not only lexical tones but also intonation are realised using F_0. Thus, intonation can superimpose on the lexical tones, and thus a particular pitch pattern may be the result of both a lexical tone and an intonational pattern (Bauer & Benedict, 1997; Flynn, 2003; Fok-Chan, 1974; Lam, 2002; Ma et al., 2004, 2006; Vance, 1976). In cases when the pitch of intonation and the pitch of lexical tone exhibit opposite directions, it may become difficult to disentangle these two functions, and thus, difficult to identify the lexical tone. For instance, echo questions in Cantonese Chinese, as in example (2), end with a rising question intonation (indicated by "-5")[2], which is added to the utterance-final syllable of a statement (Flynn, 2003; Lam, 2002; S.-P. Law, 1990). Due to this intonation-induced pitch change, the utterance-final low-rising tone 5 in example (1) now ends with a final pitch rise (fu$^{23\text{-}5}$; see example (2)). The resulting pitch pattern in example (2) resembles that of the high-rising tone 2 (fu^{25}) as in example (3).

(1)	Chinese:	佢	頭	先	答	婦。
	Jyutping:	keoi^{33}	tau^{21}	sin^{55}	tap^{33}	**fu^{23}**
	Translation:	"He just answered married woman."				
(2)	Chinese:	佢	頭	先	答	婦?
	Jyutping:	keoi^{33}	tau^{21}	sin^{55}	tap^{33}	**fu$^{23\text{-}5}$**
	Translation:	"He just answered married woman?"				
(3)	Chinese:	佢	頭	先	答	苦。
	Jyutping:	keoi^{33}	tau^{21}	sin^{55}	tap^{33}	**fu^{25}**
	Translation:	"He just answered bitterness."				

Previous studies have shown that intonation-induced pitch changes can profoundly disrupt the lexical identification of low-tone words as in example (2) (Fok-Chan, 1974; Ma et al., 2006). Using a tone identification task., Ma et al. (2006) found that, compared with the same words in statements, Cantonese listeners were significantly worse at identifying words with low tones in questions (e.g., Tones 4, 5, and 6). These low-tone words were misidentified as the high-rising tone equivalents between 62% and 78.5% of the time. In contrast to the words with low tones, the words with high-mid tones (e.g., Tones 1, 2 and 3) maintained high accuracy in both questions and statements.

Even though previous studies have shown that a conflict between lexical tone and intonation can impair tone perception and subsequent lexical identification, it remains unclear how lexical tone and intonation interact during on-line speech

[2] The Chao tone letter will be used interchangeably with the tone number in the rest of the dissertation. Chao tone letter will be given as superscripts while the tone number will be shown in normal fonts. The tone letter is used for providing a better demonstration of the pitch patterns.

comprehension. In particular, it is not known whether intonation-induced pitch changes in a lexical tone will activate conflicting tonal and lexical representations during on-line lexical processing. Moreover, given that question intonation can alter tone perception and lexical identification, it is supposed to disrupt daily communication. To circumvent this problem, speakers of Cantonese must rely on other cues. One very likely candidate is context. Context has been shown to differentiate between identical phonological segments carrying different tones in Cantonese Chinese (P. Li & Yip, 1998) and homophones (i.e. same segments and same tone; P. Li & Yip, 1996). Context can thus facilitate the processing of tonal information (Ye & Connine, 1999). Yet, it is unclear whether a highly constraining context can help Cantonese speakers in the recognition of low-tone words in, for example, questions. These issues are explored experimentally in Chapter 2.

1.4.2. The relation between context, intonation, tone, and sentence-final particles (SFPs)

1.4.2.1. Introduction to Cantonese sentence-final particles (SFPs)

Lexical tones in Cantonese Chinese also play a significant role in distinguishing between pragmatic meanings. More specifically, lexical tones differentiate between sentence-final particles (SFPs) in Cantonese Chinese. SFPs are bound morphemes that occur in utterance-final position (Matthews & Yip, 2011). Cantonese Chinese has a huge inventory of SFPs. The number ranges from 30 monosyllabic basic forms to 90 including both basic forms and SFP clusters, which are combinations of more than one monosyllabic form (Kwok, 1984; Leung, 1992). These SFPs serve important pragmatic-communicative functions in Cantonese, which include expressing speech acts, evidentiality, speaker's attitude and emotion (Fung, 2000; Kwok, 1984; Leung, 1992; Luke, 1990; Matthews & Yip, 2011; Yau, 1965).

In the following, we will provide examples of SFPs in Cantonese Chinese and we will show how lexical tone can mark different pragmatic meanings. Example (4) shows an utterance ending without a SFP. Examples (5), (6), and (7) show the identical utterance ending with three different SFPs, which differ only by tone. Each of the SFPs marks a different pragmatic meaning. When referring to SFPs, we use a notation that first gives the phonemes of the monosyllable (e.g., laa) followed by a number that indicates the associated lexical tone. The utterance in example (4)—without an SFP—is a declarative. Adding the SFP laa1 turns the declarative into a directive (e.g., advice, suggestion, persuasion or command [Fung, 2000]), as in example (5). The SFP laa3 in example (6) expresses a declarative stating the realisation of a state. The SFP laa4 in example (7) turns a declarative into a question to check for factual confirmation when a speaker is in doubt.

(4) Chinese: 你 幫 我 整 番 好 隻 枱 腳。
Jyutping : nei5 bong1 ngo5 zing2 faan1 ho2 zek3 toi2goek3
Translation: “You repair the table leg for me.”

(5) Chinese: 你 幫 我 整 番 好 隻 枱 腳 啦!
Jyutping: nei5 bong1 ngo5 zing2 faan1 ho2 zek3 toi2goek3 **laa1**
Translation: “Please repair the table leg for me!” (request)

(6) Chinese: 你 幫 我 整 番 好 隻 枱 腳 喇。
Jyutping: nei5 bong1 ngo5 zing2 faan1 ho2 zek3 toi2goek3 **laa3**
Translation: “You have repaired the table leg for me.” (statement)

(7) Chinese: 你 幫 我 整 番 好 隻 枱 腳 啍?
Jyutping: nei5 bong1 ngo5 zing2 faan1 ho2 zek3 toi2goek3 **laa4**
Translation: “You have repaired the table leg for me?” (clarification question)

In the literature, extensive research has been devoted to the description of the functions and linguistic properties of Cantonese SFPs. However, to the best of my knowledge, there has been no research on how SFPs are actually used in the comprehension of pragmatic meaning in Cantonese SFPs. This topic is explored in Chapters 3 and 5. Chapter 3 explores the relative importance of intonation and discourse context for the comprehension of pragmatic meaning. Chapter 5 aims at identifying the electrophysiological correlates of pragmatic meaning comprehension. Both chapters make use of the fact that in Cantonese pragmatic meaning can be encoded in clearly identifiable units, SFPs.

1.4.2.2. The on-line interpretation of the pragmatic meaning of SFPs in discourse

How do listeners process pragmatic meaning—in particular speech acts—carried by Cantonese SFPs during on-line speech comprehension? So far, only three studies in Japanese have examined the processing of SFPs. But these studies focused on the syntactic processing of SFPs, and in particular, on how a violation in the syntactic dependency between a WH-word and an SFP affects the processing of SFPs (Nakagome et al., 2001; Takazawa et al., 2002; Ueno & Kluender, 2009). There are also two studies using German focus particles, but they focused on how these particles affect the processing of forthcoming focus structures (Heim & Alter, 2007; Stolterfoht, Friederici, Alter, & Steube, 2007). Other than that, there is no research available on the processing of discourse particles, such as SFPs. It remains thus unknown how the pragmatic processing of these particles takes place.

Chapter 5 addresses this issue: As mentioned above, a change in the lexical tone of an SFP can alter the pragmatic meaning of SFPs, and—as we will see in Chapter 3—discourse context can bias towards a certain pragmatic meaning and thus to the choice of an SFP. Combining these two factors provides us with an ideal testing ground to examine the on-line comprehension of pragmatic meaning carried by SFP. In particular, it allows one to compare the on-line comprehension of the pragmatic meaning of an

SFP that matches and mismatches the pragmatic bias of a discourse context at a precise point in the utterance.

1.5. A note on the structure of the dissertation

In the following chapters, we will explore how the interaction between lexical tone, intonation, and context influences the comprehension of literal meaning (Chapter 2) and pragmatic meaning in Cantonese Chinese (Chapters 3 and 5). The dissertation ends with Chapter 6, which includes a general discussion of the findings of the experimental chapters, implications of the findings on speech comprehension in Cantonese and current models of language comprehension, limitations of the current studies, and directions for future research.

Since the experimental chapters of this dissertation have been published (Chapter 2) or submitted (Chapter 3 and 5) as separate journal articles, they are included in the present dissertation in their published or submitted form, and can be read as independent chapters. This has two implications: First, the present general introduction overlaps partially with the introduction of each of the experimental chapters. Second, the Cantonese phonemic transcription can differ between chapters: Chapter 2 uses IPA and Chao tone letters, whereas the rest of the chapters use Jyutping and only tone number. Tables and figures are numbered consecutively within each chapter. The full set of experimental materials and acoustic analyses for each experimental chapter are included in the appendices, but note that for Chapter 3 and Chapter 5, the acoustic analyses are detailed in Chapter 4, which documents the acoustic analyses of the intonation patterns associated with the three SFPs of interest produced by three Cantonese female speakers. Footnotes are numbered consecutively throughout the dissertation. References can be found at the end of the dissertation. All appendices can be found after the References.

Chapter 2

The Interaction of Lexical Tone, Intonation, and Semantic Context in On-line Spoken Word Recognition: An ERP Study on Cantonese Chinese

Based on:
Kung, C., Chwilla, D. J., & Schriefers, H. (2014). The interaction of lexical tone, intonation and semantic context in on-line spoken word recognition: an ERP study on Cantonese Chinese. *Neuropsychologia*, 53, 293–309.
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Abstract

In two ERP experiments, we investigate the on-line interplay of lexical tone, intonation and semantic context during spoken word recognition in Cantonese Chinese. Experiment 1 shows that lexical tone and intonation interact immediately. Words with a low lexical tone at the end of questions (with a rising question intonation) lead to a processing conflict. This is reflected in a low accuracy in lexical identification and in a P600 effect compared to the same words at the end of a statement. Experiment 2 shows that a strongly biasing semantic context leads to much better lexical-identification performance for words with a low tone at the end of questions and to a disappearance of the P600 effect. These results support the claim that semantic context plays a major role in disentangling the tonal information from the intonational information, and thus, in resolving the on-line conflict between intonation and tone. However, the ERP data indicate that the introduction of a semantic context does not entirely eliminate on-line processing problems for words at the end of questions. This is revealed by the presence of an N400 effect for words with a low lexical tone and for words with a high-mid lexical tone at the end of questions. The ERP data thus show that, while semantic context helps in the eventual lexical identification, it makes the deviation of the contextually-expected lexical tone from the actual acoustic signal more salient.

Keywords: speech comprehension, lexical tone, intonation, context, Chinese, Event-related potentials

2.1. Introduction

Spoken word recognition has been extensively studied in non-tonal Indo-European languages. These studies have resulted in explicit processing models. In particular, many studies focused on the processing of segmental information during spoken word recognition (e.g., Elman & McClelland, 1988; Grosjean, 1980; Marslen-Wilson, 1987; Mattys, Brooks, & Cooke, 2009; Mattys, White, & Melhorn, 2005; McQueen, Cutler, & Norris, 2003; Zwitserlood, 1989). Most models of speech comprehension agree that the first phonological segment of a word activates in parallel multiple word candidates starting with that segment. As the acoustic input unfolds further, this set of candidates is reduced to those still matching the input. In addition to this bottom-up process, the set of candidates can also be reduced on the basis of contextual constraints (top-down processes). Thus, spoken word recognition in non-tonal languages is characterized by the interaction of bottom-up and top-down processes.

Compared to non-tonal Indo-European languages, much less is known about spoken word recognition in tonal languages. This is surprising as 60-70% of the world's languages are tonal languages (Yip, 2002, p. 1). The processes underlying spoken word recognition in tonal languages are presumably more complex than those of non-tonal languages due to the presence of lexical tones. On top of phonological-segmental information, tonal information is required for successful word recognition in tonal languages. It appears reasonable to assume that, with respect to phonological-segmental information, spoken word recognition in tonal languages will follow the same basic principles as those that have been identified for non-tonal languages. However, it is not clear how precisely tonal information enters the process of spoken word recognition. More specifically, little is known about how speakers of tonal languages recognise a word when the realisation of its lexical tone is distorted by the intonational information occurring at the same point in the signal as the tonal information. The present study addresses this question.

In Cantonese Chinese (the tonal language investigated in the present study), there are six different lexical tones. For example, combining the syllable */fu/* with these six different lexical tones gives rise to six different meanings: 'husband' with the high-level tone (55); 'bitterness' with the high-rising tone (25); 'rich' with the mid-level tone (33); 'symbol' with the low-falling tone (21); 'married woman' with the low-rising tone (23); and 'negative' with the low-level tone (22) (Bauer & Benedict, 1997)[3]. The realisation of lexical tone can be radically modified by intonation (Bauer & Benedict, 1997; Fok-Chan, 1974; Lam, 2002; S.-P. Law, 1990; Ma, Ciocca, & Whitehill, 2004; Ma et al., 2006; Vance,

[3] The numbers in brackets are the Chao tone letters (Chao, 1968), which is a numerical tonal notation system that uses a string of numbers to describe a pitch pattern. Most strings consist of two digits, one for the starting pitch level and the second one for the ending pitch level. The number corresponds to one of the five relative pitch levels, ranging from '1' the lowest to '5' the highest. The Chao tone letters will be superscripted when written together with a syllable in the present paper.

1976). Intonation is a universal feature of languages that allows speakers to use pitch variations to mark phrase structure and express discourse meaning (Gussenhoven, 2004). For example, questions are usually signalled by a rising pitch while statements are signalled by a falling one. Since intonation and lexical tones are both characterised by pitch in tonal languages, a particular pitch pattern may express both a lexical tone and an intonational pattern (Bauer & Benedict, 1997; Flynn, 2003; Fok-Chan, 1974; Lam, 2002; Ma et al., 2004, 2006; Vance, 1976). However, when the pitch of intonation and the pitch of lexical tone move in opposite directions, it may become difficult to disentangle these two functions, and thus, difficult to identify the lexical tone. For instance, echo questions in Cantonese Chinese, such as example (2), are formed by adding a rising question intonation (indicated by "-5")[4] to the utterance-final syllable of a statement (Flynn, 2003; Lam, 2002; S.-P. Law, 1990). Because of this intonation-induced pitch change, the utterance-final low-level tone (23) in example (1) now ends with a final pitch rise (23-5), as in example (2), and shares a high resemblance with the high-rising tone (25) in example (3).

(1)	佢	頭　先	答	婦。
	k^{h}ɵy^{33}	t^{h}ɐu^{21}-sin^{55}	tɐp^{33}	**fu^{23}**
	"He	just	answered	married woman."
(2)	佢	頭　先	答	婦?
	k^{h}ɵy^{33}	t^{h}ɐu^{21}-sin^{55}	tɐp^{33}	**fu$^{23-5}$**
	"He	just	answered	married woman?"
(3)	佢	頭　先	答	苦。
	k^{h}ɵy^{33}	t^{h}ɐu^{21}-s	in^{55}　tɐp^{33}	**fu^{25}**
	"He	just	answered	bitterness"

Even though the pitch pattern (23-5) in example (2) initially comes to express both a low-level tone and a question intonation, it can be mistaken as a high-rising tone. Hereafter, we will refer to the original or default lexical tone (such as the low-rising tone (23) in example (1)) as the *canonical tone*; and we will refer to the potentially incorrectly perceived tone (such as the high-rising tone (25) in example (3)), as the *misperceived tone*.

Previous studies have shown that intonation-induced pitch changes can profoundly disturb lexical identification in Cantonese Chinese (Fok-Chan, 1974; Ma et al., 2006). However, the on-line processes underlying this phenomenon still remain unclear. The goal of the present study is to investigate whether intonation-induced pitch changes in a lexical tone will activate conflicting tonal and lexical representations during

[4] In Cantonese, there are various ways other than intonation to express questions, which include question constructions and sentence-final particles (Matthews & Yip, 2011). However, echo questions, which are used to repeat a factual statement out of surprise, can only be expressed by means of intonation, or sentence-final particles /wa^{25}/ and /aa^{21}/.

on-line lexical processing. Before we describe the design of the present study, we briefly review the relevant literature on Chinese speech comprehension.

A behavioural study on Cantonese Chinese by Ma and colleagues (2006) showed that intonation strongly influences both the production and the perception of lexical tones. In terms of production, Ma and colleagues (2006) measured the fundamental frequency (F_0; the acoustic measure of pitch) of the six lexical tones at three positions (sentence-initial, sentence-medial, and sentence-final) in semantically-neutral statements and echo questions. They found that the F_0 patterns of all six lexical tones adapted themselves to those of intonation. The modification was strongest at the sentence-final position of questions. Regardless of the canonical tone, all lexical tones showed a rising F_0 pattern at the end of questions. The perception of lexical tones was also affected by intonation, especially in questions. While the high-level (55), high-rising (25), and mid-level (33) tones at the end of questions maintained a high accuracy rate (between 71.5% and 100% correct), the low-level (22), low-falling (21) and low-rising (23) tones at the same location were misperceived as the high-rising tone (25) between 62% and 78.5% of the time. These results show that the intonation-induced F_0 changes have a strong distorting effect on the identification of the low tones, but a much weaker effect on the identification of the high-mid tones.

The findings of Ma and colleagues (2006) show that the intonation-induced F_0 changes can influence tone perception and can lead to eventual lexical misidentification. However, the underlying on-line processes leading to such misidentifications cannot be specified on the basis of these results. The present study addresses this question using Event-related potentials (ERPs), i.e. a measure of language comprehension with a high temporal resolution. If tone and intonation elicit conflicting representations during on-line processing, this would imply that segmental, tonal and intonational information become available more or less simultaneously and that tonal and intonational information interact. Until now, little is known about the precise time-course in which tonal and intonational information become available in a sentence context (but see Fournier, Gussenhoven, Jensen, & Hagoort, 2010, for a Magnetoencephalography (MEG) study on the perception of Limburgish tone and intonation; and X. Li, Yang, & Hagoort, 2008 for an ERP study on the processing of pitch accent and lexical tone in Mandarin Chinese), but several studies have addressed the question of the time-course with which tonal and segmental information become available.

Two reaction-time studies, one in Cantonese Chinese (Cutler & Chen, 1997) and one in Mandarin Chinese (Ye & Connine, 1999) examined the processing of tonal and segmental information using a speeded same-different-judgment task. In both studies, listeners were slower and less accurate when the judgment was based on tonal information than when the judgment was based on segmental information. Based on these findings, it was argued that tonal information is accessed later than segmental information. An alternative account holds that the two types of information are accessed equally fast and that the observed difference in judgment time reflects decision processes. The latter account is supported by ERP results of Schirmer, Tang, Penney, Gunter, and Chen (2005) using a language-related ERP component, the N400. The N400 is a negative wave with a centro-parietal maximum, which peaks around 400 ms after the onset of a critical word. The amplitude of the N400 is more negative when a word is semantically incongruous with a preceding context in comparison to the case when a word is semantically congruous (Kutas & Hillyard, 1980; see also Kutas, van Petten, & Kluender, 2006 for a review of the N400). This difference in N400 amplitude is referred to as the N400 effect. The N400 effect has been proposed to reflect processes of lexical access (e.g., Kutas & Federmeier, 2000) or to reflect how well a word fits into a given context, which can be a single word (e.g., Chwilla, Hagoort, & Brown, 1998), a sentence (e.g., Schirmer et al., 2005), or a discourse (e.g., van Berkum, Hagoort, & Brown, 1999). Schirmer and colleagues (2005) compared the onset latency and the amplitude of the N400 between words that were semantically congruous with a preceding context and words that were semantically incongruous. The incongruous words differed from the congruous words only with respect to the tone, the segments or with respect to both tone and segments. All three types of semantic incongruities elicited an N400 effect with similar onset latency. Based on the similarity in onset latency, the authors argued that tonal and segmental information are accessed simultaneously and integrated immediately with the previous context (for further evidence, see also Brown-Schmidt & Canseco-Gonzalez, 2004; X. Li et al., 2008 for studies on Mandarin Chinese). This contradicts the claim of Cutler and Chen (1997) and Ye and Connine (1999) that tonal information is accessed after segmental information.

From what we have discussed so far, it is evident (a) that the actual realization of a lexical tone can be affected by intonation, (b) that the off-line identification of (low) lexical tones can be heavily distorted by intonation, and (c) that tonal information is accessed in the same time window as segmental information. However, it remains unclear whether tonal and intonational information interact during on-line processing, and what the processing consequences of such a potential interaction are.

In the present article, we address these questions by contrasting the identification and processing of monosyllabic words occurring at the end of semantically-neutral carrier sentences with either a question intonation or a statement intonation. Participants' lexical-identification performance was checked in a lexical-identification task similar to the one used by Ma and colleagues' (2006). For this lexical-identification task, we expect to replicate the results of Ma and colleagues (2006): Words with low tones (21, 23, and 22) in question-final position should be misperceived as the high-rising tone on a large proportion of the experimental trials. To assess how conflicts between lexical tone and intonation are reflected in on-line processing, we measured the ERPs time-locked to the critical sentence-final words. Since the error patterns in Ma and colleagues' (2006) study indicate that intonation primarily affects the identification of the low tones (21, 23, 22) but not of the high-mid tones (55, 25, 33), we divided the six lexical tones into two corresponding groups, high-mid tones (55, 25, 33) and low tones (21, 23, 22). Crossing the factor Tone (low, high-mid) with the factor Intonation (question, statement) results in a 2 by 2 design (see Table 2.1).

Before turning to the predictions for the ERPs, we will introduce two language-related ERP components which are relevant for the present article: the P600 and the N400. The P600 component is a late centro-parietally distributed positivity, starting at about 500 ms and typically extending until 800 ms after critical word onset (Kolk & Chwilla, 2007). Some authors have proposed that the reanalysis is of a (pure) syntactic nature (e.g., Hagoort, Brown, & Groothusen, 1993) while others have proposed that the function of the reanalysis is to check for possible processing errors after strong conflicts like the simultaneous activation of two incompatible representations of the linguistic input (e.g., Kolk, Chwilla, van Herten, & Oor, 2003). The second ERP component—the N400—has already been introduced above. The N400 is hypothesized to either index the ease of integrating an item into a higher-order meaning representation of the context (e.g., Chwilla, Brown, & Hagoort, 1995; Chwilla et al., 1998) or the ease with which an item can be accessed from the lexicon (the lexical access hypothesis; see Kutas & Federmeier, 2000).

Table 2.1.

Design of the present study with examples of the materials.

Conditions		Examples
Intonation	Tone	
Question	High-mid (HTQ)	(4) 你 頭先 答 **苦?** nei^{35} tʰɐu^{21}sin^{55} tɐp^{33} **fu$^{25\text{-}5}$?** "You just answered **bitterness**?"
	Low (LTQ)	(5) 你 頭先 答 **婦?** nei^{35} tʰɐu^{21}sin^{55} tɐp^{33} **fu$^{23\text{-}5}$?** "You just answered **married woman**?"
Statement	High-mid (HTS)	(6) 我 頭先 答 **苦。** ŋɔ^{35} tʰɐu^{21}sin^{55} tɐp^{33} **fu^{25}** "I just answered **bitterness.**"
	Low (LTS)	(7) 我 頭先 答 **婦。** ŋɔ^{35} tʰɐu^{21}sin^{55} tɐp^{33} **fu^{23}** "I just answered **married woman.**"

Note. The critical words are in bold. The additional rising contour of question intonation is represented by *-5* after the canonical tone numbers.

The predicted high error rates in lexical identification for the low-tone words at the end of questions can stem from two different scenarios during the on-line processing of tonal and intonational information. The first scenario holds that, at the end of questions, the misidentification of a low canonical tone as a high-rising tone is due to the fact that the F_0 contour resulting from the combination of the low canonical tone and the intonation-induced F_0 change resembles the F_0 contour of the high-rising lexical tone. However, at the same time, listeners might interpret the final F_0 rise as stemming from the question intonation, and in doing so, they can recover the canonical low tone. Under this scenario, listeners would thus perceive two tones, a low tone and a high-rising tone, at the same time. These two tones might then activate two competing lexical representations. The resulting competition should lead to processing difficulties which can be reflected in the following ERP components. First, if one subscribes to the assumption that the N400 effect reflects the ease with which an item can be accessed in the mental lexicon (Kutas & Federmeier, 2000), one might expect an N400 effect. Second, the conflict between the two representations might trigger a reanalysis process which should be reflected in a P600 (e.g., Kolk et al., 2003).

Alternatively, according to the second scenario, listeners may perceive only a high-rising tone without recovering the canonical low tone. More specifically, the F_0 contour of a question-final low-tone word (e.g., 23-5) would only activate the high-rising tone (25). This could be the case because the high-rising tone (25) is the only lexical tone in Cantonese Chinese that ends with a high rise. Thus, under this second scenario, no competition should occur, and thus no corresponding ERP signatures should be observed. Before turning to the experiments, a note on the relation between offline lexical identification results like the ones reported by Ma et al. (2006) and the two scenarios with respect to on-line processing is in place. One could argue that the results of Ma et al. (2006) speak in favour of the second scenario as listeners did misperceive a canonical low tone at the end of questions as a high-rising tone very frequently. However, the results of this lexical identification task reflect the eventual choice of a response, but do not speak to the issue of the on-line processes preceding this choice.

2.2. Experiment 1

2.2.1. Methods

2.2.1.1. Participants

Twenty-one right-handed native speakers of Cantonese Chinese living in the Netherlands participated in the present study. One was excluded from the analysis due to excessive eye movements. The remaining 20 participants (15 female) had an age range from 21 to 57 (mean age = 37.1). Fifteen participants were originally from Cantonese-speaking regions (Hong Kong, Macau, and Guangdong Province in People's Republic of China) and five were born in the Netherlands but grew up in a Cantonese-speaking environment (Cantonese-Chinese was the only language used for communicating with their parents and relatives). None of them had reading and/or hearing problems. All participants were given a tone-discrimination test before the start of the experiment. The tone-discrimination test consisted of eight tone pairs: four pairs with identical tones and four with different tones. The performance on this test was very good. Fourteen participants did not make any errors. The remaining six participants made only one error. The participants were paid for their participation.

2.2.1.2. Materials

The target word-stimuli consisted of five sets of monosyllabic words[5] derived from the following five root syllables: /*wɐi*/, /*jɐn*/, /*si*/, /*søy*/ and /*fu*/ ("A Chinese Character Database: With word-formations phonologically disambiguated according to the Cantonese Dialect," n.d.). When combined with the six lexical tones, each syllable forms a minimal tonal sextuplet, i.e. six monosyllabic words sharing the same onset and rime but differing in lexical tone. The resulting 30 monosyllabic words are part of the 2,600 most-commonly-used characters listed in the Hong Kong Chinese Lexical Lists for Primary Learning ("Hong Kong Chinese Lexical Lists for Primary Learning," n.d.) developed by the Education Bureau of the Hong Kong SAR government. The subset of stimuli derived from /*wɐi*/ was only used in the practice block while the remaining four sets of six words were used as target stimuli in the critical trials (see Table A1 in Appendix A for the complete list of the materials).

All critical words appeared at the final position of the carrier sentences because intonation-induced F_0 variation is the largest at this location (Flynn, 2003; Ma et al., 2004, 2006). In order to ensure that the intonation-induced F_0 change was not influenced by potential tone carryover effects from the syllable preceding the critical word (Flynn, 2003), the critical words were always preceded by the mid-tone verb /*tap*^{33}/"to answer".

We used two types of carrier sentences, echo question and statement. Both types of sentences are meaningful but semantically neutral (i.e. the carrier sentences do not contain any semantic or syntactic information towards a specific sentence-final critical word.), but they differed in subject pronouns and intonation patterns. An echo question always began with a second-person singular pronoun and had a rising F_0 contour at the end of the utterance. An echo question always carried the meaning "you just answered…?". A statement always began with a first-person singular pronoun and had a declination of F_0 throughout the utterance. A statement always carried the meaning "I just answered…." (see Appendix B in Supplementary material for acoustic analyses). Table 2.1 provides examples of the echo questions and statements.

Two female native speakers of Cantonese Chinese produced the sentences for the recordings. One speaker recorded the questions and the other speaker recorded the statements in order to mimic a conversational context in which a statement is usually easily distinguishable from a question. The speakers were instructed to avoid exaggerated emotional prosody. Each speaker produced each utterance three times. The recording was made in a sound-proof room with a DAT recorder and digitised at a 16-bit/44-kHz sampling rate. The overall loudness of all utterances was equalised by modifying the overall amplitude. For each utterance, the best recording was chosen for the experiment on the basis of the judgment of the first author and two other native speakers of Cantonese Chinese who did not participate in the experiments.

[5] Chinese morphemes are monosyllabic, and most of these monosyllabic morphemes can stand alone as a word (Matthews & Yip, 2011).

Four randomizations of the 24 questions and 24 statements were constructed. Each participant received one of the resulting four randomized lists. Each of the four lists was used for five participants.

2.2.1.3. Task

Participants had to carry out a lexical-identification task for the critical word after the presentation of each sentence. They had to choose one out of six possible response alternatives. The response alternatives were the six words of the tonal sextuplets of the critical word and were presented on the screen in the form of Chinese characters. The positions of the characters on the screen were arranged according to the positions of the response buttons (two rows of three buttons) on a button box placed in front of the participant. Participants had to push the corresponding button within a five-second time limit[6] after the onset of the six characters. Since participants had to make a choice out of six buttons within five seconds, they were free to choose how to arrange their two hands on the button box for making a button press. They were also free to choose either hand or both hands to respond. Accuracy of the response was measured.

2.2.1.4. Procedure

Participants were comfortably seated in a dimly-lit soundproof room in front of a computer monitor and a button box with six buttons. Before the experiment began, instructions were given to the participants in Cantonese Chinese. The participants were instructed to listen to randomly presented questions and statements, which were produced by two different speakers. They were also instructed that they had to identify the sentence-final word after having listened to the sentence. To avoid eye movements, participants were asked to look at a fixation point and not to blink while the sentence was presented. A practice block was given to familiarise participants with the task and to train them to control their eye movements.

A trial started with a warning beep of 100 ms, followed by a silent pause of 500 ms, and the presentation of the sentence. The behavioural off-line identification task was presented one second after sentence offset in order to avoid the ERP effects of interest being confounded by motor-related processes. The participants were instructed to rest their hands on the button box from the onset of a sentence until the moment at which the response alternatives appeared on the screen. Furthermore, participants were told that they could blink and move their eyes during the identification task. After the identification response, there was a pause of two seconds before the next trial began.

[6] A five-second time limit was set, on the one hand, to prevent participants from spending too much time on making a decision; and on the other hand, to allow enough time for participants to make a response. We conducted a pilot study using the same behavioural task. The mean response time was 1419 ms (SD = 1007 ms). Therefore, an upper time limit of five seconds was set to provide enough but not too much time for participants to make a choice.

2.2.1.5. EEG data acquisition

The EEG was recorded from 25-tin electrodes mounted in an elastic cap according to the international 10% system. Three midline electrodes (Fz, Cz, and Pz) and 22 lateral electrodes (AF7/8, F7/8, F3/4, FT7/8, FC3/4, T7/8, C3/4, CP5/6, P7/8, P3/4, and PO7/8) were used. The electrode montage was the same as in earlier auditory ERP studies conducted in our laboratory (e.g., Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs, 2010). The left-mastoid was used as a reference during the recording, but the signal was re-referenced to software-linked mastoids before the analysis. Eye blinks were monitored by vertical EOG electrodes above and below the right eye and horizontal eye movements by two electrodes at the outer canthi. Electrode impedance was kept below 5 kΩ for EOG-electrodes and below 3 kΩ for EEG-electrodes. Signals were amplified with a time constant of 8 seconds and a bandpass filter of .02 to 100 Hz and digitized with a 16-bit A/D converter at a sampling frequency of 500 Hz.

2.2.1.6. EEG data analysis

BrainVision Analyser (Brainproducts GmbH, Munich, Germany) was used for the EEG analysis. All EEG data were time-locked to the onset of the critical word at the sentence-final position. An infinite impulse response (IIR) filter with a bandpass of .05 to 30 Hz was applied to the EEG data. The filter was implemented as a phase-shift free Butterworth filter and the slope of the filter was 12 dB/octave. ERPs were measured from 100 ms preceding the critical word (pre-stimulus baseline) to 1000 ms after the onset of the critical word. Trials with amplifier blocking, as well as excessive EEG (>100 μV) and EOG amplitude (>75 μV) were excluded from the analysis (19% of all trials). The proportion of excluded trials did not differ between experimental conditions. Trials with incorrect identification were not excluded from the data analysis because a potential on-line conflict between lexical tone and intonation should be present irrespective of the eventual judgment given.

In order to explore the onset and the duration of the ERP effects, separate time-course analyses were performed for the low-tone words and the high-mid-tone words by computing mean amplitudes for 20 successive 50-ms time windows starting from the onset of the critical word up to 1000 ms. For the midline electrodes, these analyses had the within-subject factors Intonation (with the levels Question versus Statement) and Midline Electrode (Fz, Cz, Pz). The analyses for the lateral electrodes had the within-subject factors Intonation (Question versus Statement), Hemisphere (Left, Right), and Electrode (AF7/8, F7/8, F3/4, FT7/8, FC3/4, T7/8, C3/4, CP5/6, P7/8, P3/4, PO7/8). Because of the increased chance of Type-I errors, only effects that reached significance in two or more consecutive time windows were considered significant. The Greenhouse-Geisser procedure was applied when the assumption of sphericity was violated. All reported *p*-values are based on corrected degrees of freedom, but to help readers in interpreting our statistical design, we report the degrees of freedom before correction.

On the basis of the time-course analyses, larger time windows were determined to quantify the ERP effects. For each of these larger time-windows, overall ANOVAs were computed separately for the midline and lateral electrodes. For the midline electrodes, the overall analysis included the within-subject factors Tone (High-mid, Low), Intonation (Question, Statement), and Midline Electrodes. For the lateral electrodes, the overall analysis included the within-subject factors Tone (High-mid, Low), Intonation (Question, Statement), Hemisphere (Left, Right) and Electrodes. If an interaction was present (between Intonation and Tone; between Intonation, Tone, and Electrodes, and/or between Intonation, Tone, Hemisphere and Electrodes), follow-up ANOVAs were performed separately on high-mid tones and low tones to examine the effect of Intonation on the high-mid tones and low tones, respectively. Furthermore, if an interaction between Intonation and Electrode and/or between Intonation, Hemisphere and Electrode was significant, follow-up single electrode analyses were conducted to explore the topography of the ERP effects.

2.2.2. Results

2.2.2.1. Behavioural results

Table 2.2 shows the results of the lexical-identification task in the form of a confusion matrix for the six lexical tones at the end of questions and statements. The high-level tone (55) had the highest mean accuracy rate regardless of intonation (question: 94.9% correct; statement: 93.7% correct).The low-rising tone (23) in questions had the lowest mean accuracy rate (8.8% correct). This was followed by the low-level tone (22) in questions (12.7% correct), and the low-falling tone (21) in questions (23.8% correct).

Since the perceptual accuracy for the high-level tone was at ceiling and the assumption of normal distribution was violated, we used Wilcoxon signed rank tests and Friedman tests to compare the proportion of correct identification responses for each tone in the various conditions. Wilcoxon signed rank tests were conducted to evaluate the difference in perceptual accuracy of each tone between questions and statements. Bonferroni correction was used to adjust the p-value (new critical p = .008) and to control for family-wise errors across comparisons.

Table 2.2.
Experiment 1: Confusion Matrix for the Perceptual Accuracy of the Target Tone at the End of Questions and Statements

	Intonation											
	Question						Statement					
Target	Perceived tone						Perceived tone					
tone	55	25	33	21	23	22	55	25	33	21	23	22
55	**94.9**	2.5	1.3	0	1.3	0	**93.7**	0	2.5	1.3	2.5	0
25	0	**87.5**	2.5	1.3	6.3	2.5	0	**88.8**	0	0	11.3	0
33	0	2.5	**83.5**	1.3	3.8	8.9	3.8	1.3	**78.8**	0	12.5	3.8
21	2.5	60.0	0	**23.8**	11.3	2.5	0	1.3	0	**90.0**	0	8.8
23	0	67.5	3.8	0	**8.8**	20.0	1.3	12.7	27.9	8.9	**44.3**	5.1
22	0	46.8	29.1	3.8	7.6	**12.7**	0	0	18.8	7.5	15.0	**58.8**

Note. High-level tone (55), high-rising tone (25) and mid-level tone (33) constituted the high-mid tones, low-falling tone (21), low-rising tone (23) and low-falling tone (22) constituted the low tones. Cell numbers represent the mean percentage of response for each target tone. The numbers in bold appearing on the diagonal of the matrix are the mean rate of correct identifications.

Low tones (21, 23 and 22) at the end of questions had a significantly lower accuracy rate than the same tones at the end of statements (all *ps* <.001). On the other hand, there was no reliable difference in the accuracy rate between the high-mid tones (55, 25 and 33) at the end of questions and at the end of statements (all *ps* >.05). We also compared the perceptual accuracy between the six tones when they were at the end of questions and statements using Friedman tests. There was a significant difference between tones at the end of questions, χ^2 (5, N = 20) = 75.53, p < .001. Follow-up pairwise comparisons were conducted using a Wilcoxon signed-rank test. Bonferroni correction was used to adjust the p-value (new critical p = .003). At the end of questions, low tones (21, 23, 22) were misidentified more frequently than high-mid tones (55, 25, 33) (all *ps* < .003). The majority of the observed errors were misidentifications of these low tones as the high-rising tone (the proportion of misidentification was 60.0%, 67.5% and 46.8% respectively). There was no significant difference in accuracy rates between the low-tones (all *ps* > .003) and no significant difference between the high-mid tones (all *ps* > .003).

There was also a difference in perceptual accuracy between tones at the end of statements, χ^2 (5, N = 20) = 50.31, p < .001. Follow-up pairwise comparisons were conducted using a Wilcoxon test and Bonferroni correction was used to adjust the p-value (new critical p = .003). A significant difference in perceptual accuracy was found between tone 25 and tone 23 (p < .003), as well as between tone 55 and the other two low tones (23, 22) (all *ps* < .003).

To summarize, the results of the lexical-identification task show that low tones at the end of questions yield the highest error rate. A large percentage of these tones (between 46.8% and 67.5 %) are misperceived as the high-rising tone. These results are highly parallel to those reported by Ma et al. (2006).

2.2.2.2. ERP results

Figure 2.1 shows the grand average waveforms time-locked to the sentence-final critical words for all 25 electrodes. The topographical maps are given in the first row of Figure 2.2. Visual inspection of the waveforms suggests that, at anterior sites, words with a high-mid tone in questions (hereafter HTQ) and words with a low tone in questions (hereafter LTQ) elicit an early increase in negativity between 200 and 350 ms compared to words with a high-mid tone in statements (hereafter HTS) and words with a low tone in statements (hereafter LTS). This early negative effect is followed by a more positive-going waveform between 400 and 650 ms for LTQ compared to LTS at the centro-parietal sites. No such effect seems to be present for HTQ in comparison to HTS.

Early effects. A summary of the time-course analyses for the low-tone words and high-mid tone words are presented in Tables C1 and C2 in Appendix C, respectively. Based on the time-course analyses for the low-tone words (LTQ vs. LTS) presented in Table C1 in Appendix C, in particular the presence of three-way interactions of Intonation by Hemisphere by Electrode from 200 to 350 ms for the lateral sites, this window was chosen to quantify the early effect. The overall midline ANOVA did not yield main effects of Intonation (F (1,19) = 2.93, p = .10) and Tone ($F < 1$), or an Intonation by Tone interaction ($F < 1$). The overall lateral ANOVA also did not show main effects of Intonation ($F < 2$) and Tone ($F < 1$), or an Intonation by Tone interaction ($F < 1$). In sum, the overall analyses for the early window did not yield any significant effect.

Late effects. The results for the time-course analyses for the low-tone words presented in Table C1 in Appendix C were as follows: The ANOVAs for the lateral electrodes revealed three-way Intonation by Hemisphere by Electrode interactions from 400 ms up to 650 ms. The time-course analyses for the midline electrodes yielded Intonation by Electrode interactions from 500 ms up to 700 ms. Since the time-course analyses indicate different latencies for the late effect for the midline (500-700 ms) and for the lateral electrodes (400-650 ms), different time windows were used for the midline electrodes and the lateral electrodes to quantify these late effects.

The overall ANOVA for the lateral electrodes for the 400-650 ms time window did not reveal main effects of Intonation ($F < 1$) and Tone (F(1, 19) = 2.98, p = .10) or an Intonation by Tone interaction ($F < 1$). However, a significant Intonation by Tone by Electrode interaction was found (F (10,190) = 2.98, $p < .05$). Based on this interaction, separate ANOVAs were performed on low tones and high-mid tones. The analysis comparing LTQ with LTS revealed no main effect of intonation ($F < 1$), but two interactions: an Intonation by Electrode interaction (F (10,190) = 2.83, $p < .05$), and an Intonation by Hemisphere by Electrode interaction (F(10,190) = 4.41, $p < .01$). Follow-up analyses indicated that the mean amplitudes were more positive for LTQ than LTS at the following sites of the right hemisphere: T8, CP6, P4, P8, PO8 (all *ps* $< .05$). The analysis comparing HTQ with HTS did not yield an effect of Intonation (F

< 1) but the interaction between Intonation, Hemisphere and Electrode interaction was significant ($F(10, 190) = 5.02$, $p < .01$). Hence, separate analyses were performed for the two hemispheres. For the right hemisphere, no main effect of Intonation ($F < 1$) and no interaction between Intonation and Electrodes ($F < 1$) was found. Likewise for the left hemisphere, no main effect of Intonation ($F < 1$) or interaction between Intonation and Electrodes ($F < 1$) was present.

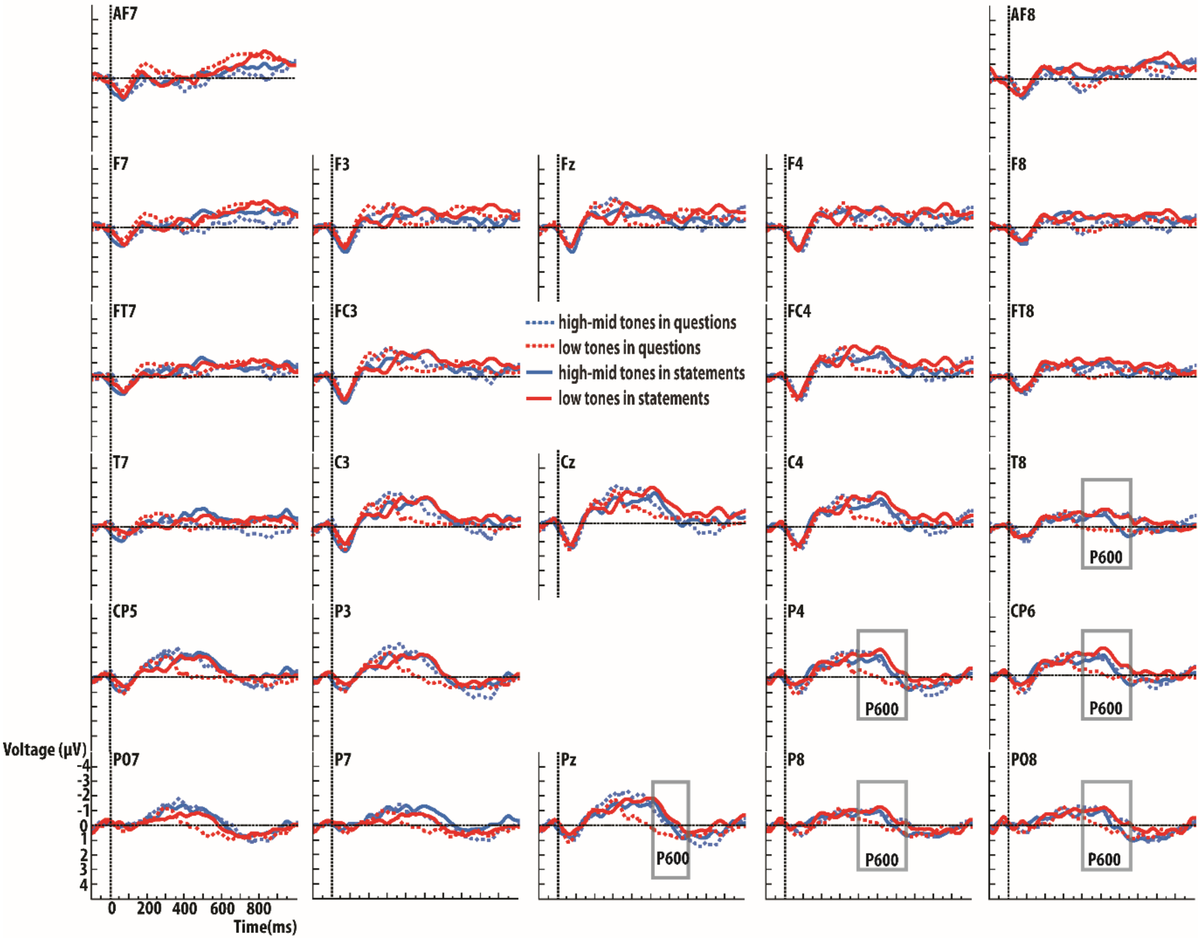

Figure 2.1.

Grand average waveforms of all 25 electrodes time-locked to the onset of the sentence-final critical words in Experiment 1. Negativity is plotted upwards.

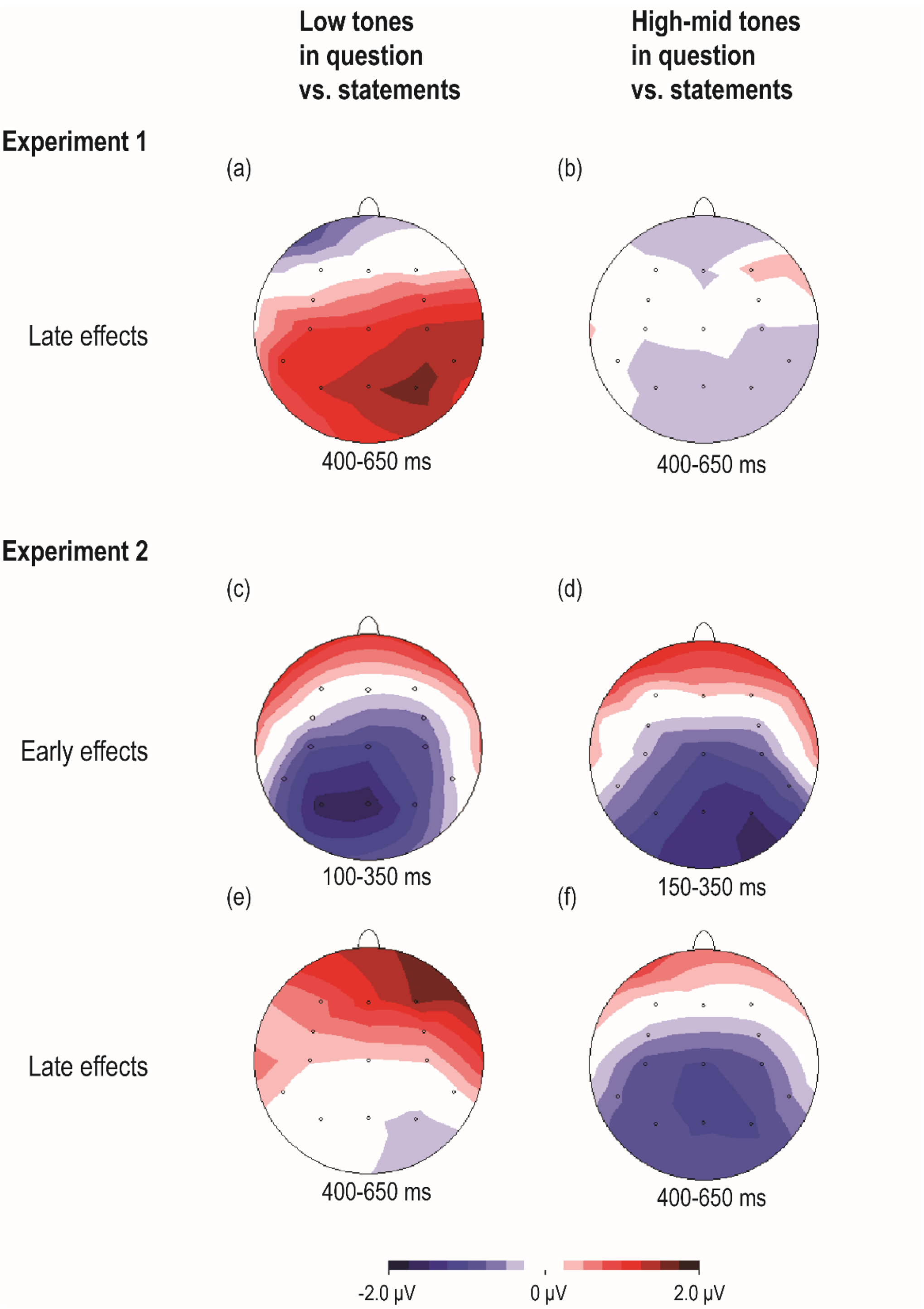

Figure 2.2.
Topographical maps obtained by interpolation from 25 electrode sites. The left column shows the topographical maps computed by subtracting the waveforms in the low tones in statements (LTS) from the low tones in questions (LTQ). The right column shows the topographical maps computed by subtracting the waveforms in the high-mid tones in statements (HTS) from the high-mid tones in questions (HTQ). The first row shows the topographical maps for the late effects in Experiment 1. The second and third rows show the topographical maps for the early and late effects in Experiment 2, respectively.

Follow-up comparisons between HTQ and HTS across electrodes showed that the mean amplitudes for HTQ at a subset of fronto-central electrodes (e.g., F3/4, FC3/4, C3/4) were more negative than those for HTS at a subset of temporo-parietal electrodes (e.g., T7/8, P7/8, PO7/8). In contrast, the mean amplitudes for HTQ at a subset of temporo-parietal electrodes (e.g., T7/8, P7/8, PO7/8) were more positive than those for HTS at a subset of fronto-central electrodes (e.g., F3/4, FC3/4, C3/4). In sum, the three-way interaction between Intonation, Hemisphere and Electrodes reflected overall differences in the mean amplitudes across different electrodes and across different conditions. Relevant for the present goals, follow-up analyses comparing HTQ to HTS at the single electrodes did not reveal an effect of Intonation at any of the electrode sites (all *ps* > .05).

The overall ANOVA for the midline electrodes for the 500-700 ms time window did not reveal main effects of Intonation ($F < 1$) and Tone ($F < 1$) or an interaction between Intonation and Tone ($F < 1$). However, it showed an Intonation by Midline Electrode interaction ($F(2, 38) = 8.26$, $p < .01$), a Tone by Electrode interaction ($F(2, 38) = 3.41$, $p < .05$), and an Intonation by Tone by Midline Electrode interaction ($F(2, 38) = 13.15$, $p < .001$). Based on the Intonation by Tone interaction, separate ANOVAs were performed on low tones and high-mid tones. The analysis comparing LTQ to LTS did not reveal a main effect of intonation ($F < 1$), but showed an Intonation by Electrode interaction ($F(2, 38) = 8.55$, $p < .01$). However, follow-up analyses did not disclose significant differences between LTQ and LTS at any of the midline electrodes. The interaction between Intonation and Electrodes presumably reflects that there were some differences in overall amplitudes across electrodes, in particular, LTQ at Pz was more positive than LTS at Fz and Cz (all *ps* <.05). The analysis comparing HTQ to HTS did not disclose effects of Intonation or an Intonation by Electrode Interaction (both *F*-values <1).

To summarise, the results of the ANOVAs for the midline and the lateral electrodes support the presence of different ERP patterns for the low-tone words and the high mid-tone words: a P600 effect was found for LTQ versus LTS while a corresponding difference was absent for HTQ versus HTS. Finally, although Figure 2.1 suggests the presence of a positive-going waveform between 650 to 900 ms at the centro-parietal sites for HTQ versus HTS, the time-course analyses (see Table C2 in Appendix C) did not show any significant ERP effects in this late time window.

2.2.3. Discussion

In the lexical-identification task, a large proportion of the question-final words with low tones (21, 23, 22) were misidentified as words with the high-rising tone (25). By contrast, the majority of question-final critical words with the high-mid tones (55, 25, 33) were identified correctly. Thus, intonation-induced F_0 changes in questions hamper the identification of question-final words with the low tones but not of those with the high-mid tones. These results are thus very similar to those obtained by Ma et al. (2006)[7]. Before turning to a discussion of the ERP results, a more general point about the ERP analyses should be noted. Trials with correct and incorrect behavioural responses are included in the ERP analyses. The reasons for doing so are different for the LTQ and the LTS conditions. For the LTQ condition, one could argue that only including the incorrect trials would be the most adequate procedure because, for these trials, the tone-intonation conflict has led to an eventual incorrect behavioural identification response. For the correct trials, by contrast, one could argue that no conflict was noticed, and thus, a correct response resulted. However, a closer look at the behavioural data shows that this position is not justified. The mean accuracy rate for LTQ was 15.1 % (ranging from 23.8% to 8.8% for the three different low lexical tones). Given that participants had to choose one out of 6 response alternatives, the value of 15.1 % is almost precisely at chance level (with just guessing, participants should arrive at 1/6 = 16.6% correct). This, in turn, means that one cannot maintain that trials with correct responses reflect the absence of a tone-intonation conflict. Rather, the most likely conclusion is that a conflict between tone and intontion was presumably present on all trials irrespective of the eventual behavioural response.

For the LTS condition, the mean accuracy rate is 64% (averaged across the three low lexical tones), and thus, clearly above chance level. Therefore, here, one could consider to include only the correct trials. However, given that in the LTS condition, we have a reasonable number of observations with correct as well as with incorrect responses, it is possible to empirically sort out whether correct and incorrect trials in LTS lead to different ERP responses. We contrasted the ERP average of incorrect trials in LTS with that of correct trials in LTS. These supplementary analyses were computed on the original P600 time-windows (midline: 500-700 ms; lateral 400-650 ms). These analyses yield neither any significant main effects of Correctness ($Fs < 1$) nor any significant interaction between Correctness and other factors (all $Fs < 2$). In sum, these analyses show that the ERPs of incorrect LTS trials did not differ from those of correct LTS trials, and thus, these trials appear not to differ with respect to on-line processing.

Returning to the discussion of the ERP results, intonation-induced F_0 changes elicited different ERP patterns for the critical words with a low tone and for the critical words with a high-mid tone. This is parallel to the asymmetric pattern observed for the

[7] The relatively low accuracy rate of tone 23 and tone 22 can be explained as follows. Statement intonation in Cantonese Chinese has a cumulative declination of F_0 from the sentence-initial to the sentence-final position, referred to as downdrift (Bauer & Benedict, 1997; Lee, 2004; Ma et al., 2004, 2006; Vance, 1976; for detailed acoustic analysis, see Lee (2004) and Ma and colleagues (2004, 2006)). Because of the downdrift, there is a paradigmatic lowering of the F_0 of the six statement-final tones, in particular of the F_0 level of these tones. However, the paradigmatic lowering does not alter the F_0 contour of the six tones. Also, it does not alter the relative F_0 relationship between the six tones, upon which the identity of a lexical tone is based. As a result, the rising tones (Tone 25, 23) and the level tones (Tone 33, 22) now share a similar F_0 level. This resemblance of F_0 level can affect tone identification for the following reason. F_0 level and F_0 contour are the two cues for tone identification in Cantonese Chinese and the majority of Cantonese-Chinese speakers rely more on F_0 contour than F_0 level. Hence, the lowering of F_0 level affects the tone identification of only some speakers of Cantonese Chinese, namely those who rely more on F_0 level than F_0 contour, just as observed in Vance (1976) and also in the present study.

low and high-mid tones in the identification task. Compared to LTS, LTQ elicited a positivity between 400 and 700 ms (400 to 650 ms for lateral electrodes and 500 to 700 ms for midline electrodes) with a centro-parietal maximum (T8, CP6, Pz, P4, P8, PO8). This positivity is taken as an instance of a P600 effect according to its timing and centro-parietal distribution. The P600 effect has been interpreted as a reflection of a reanalysis which checks for potential processing errors in the case of a strong conflict (e.g., Kolk & Chwilla, 2007; Kolk et al., 2003; van de Meerendonk, Kolk, Chwilla, & Vissers, 2009; Vissers, Kolk, van de Meerendonk, & Chwilla, 2008). By contrast, no P600 was present for high-mid tones (comparison of HTQ with HTS).

The presence of a P600 for LTQ relative to LTS, and its absence for HTQ relative to HTS, supports the prediction of the first scenario for on-line processing. It appears that, in LTQ, intonation-induced F_0 changes lead to a strong conflict and thus processing difficulties. This conflict presumably stems from the activation of two competing representations, a lexical representation with a low tone and a lexical representation with a high-rising tone. No such conflict is observed for the high-mid tone words (HTS versus HTQ). This pattern nicely parallels the results from the identification task.

The processing difficulty for canonical low tones in questions suggests that listeners are able to perceive two different tones simultaneously, the canonical low tone of the critical word and the high-rising (misperceived) tone. Thus, listeners appear to activate the lexical representation corresponding to the high-rising lexical tone because the F_0 contour of a question is similar to the F_0 contour of the high- rising lexical tone. But they also appear to identify the final F_0 rise as intonational information, and in doing so, the lexical representation corresponding to the low canonical tone is also activated.

The presence of an on-line conflict between the two competing representations obviously raises the question how participants arrive at the eventual decision in favour of the high-rising tone in the lexical-identification task. The combined pattern of ERPs and identification responses suggests that the on-line conflict is resolved in a later stage of decision-making for the lexical-identification task. Furthermore, it appears that, in LTQ, listeners base this eventual decision primarily on the overall resemblance of the intonation-induced F_0 contour and the high-rising tone (25).

Taken together, the results of Experiment 1 show that, for question-final words with a low tone, tonal and intonational information interact, and that this interaction leads to a conflict between two representations. This conflict leads to on-line processing difficulties (reflected in the ERPs) and a high likelihood of lexical misidentification (reflected in the lexical identification performance).

The results reported so far suggest that the misidentification of low-tone words in questions can lead to potential miscommunication. To avoid such miscommunication, it is likely that speakers of Cantonese Chinese use additional cues for lexical identification. A likely candidate for such an additional cue is context information. For non-tonal languages, it has been shown that listeners rely on context information to recognise a word in situations where the acoustic input is ambiguous or degraded (e.g., the phoneme restoration effect; see Sivonen, Maess, Lattner, & Friederici, 2006; Warren, 1970). Likewise, it has been shown that, in tonal languages, context can facilitate the processing of tonal information (Ye & Connine, 1999). Context helps to disambiguate between words which share identical phonological-segmental content but differ in lexical tone (P. Li & Yip, 1998). On the basis of these findings, one could expect that context information also helps in the recognition of low-tone words in questions.

In Experiment 2, we test the hypothesis that a highly-constraining semantic context helps to resolve the on-line conflict between intonation and tone demonstrated in Experiment 1.

2.3. Experiment 2

The design of Experiment 2 was the same as the design of Experiment 1, except that the critical words were the second part of disyllabic compounds, such as /fu^{23}/ 'married woman' in the compound /jɐn^{21}-fu^{23}/ 'pregnant woman'. Disyllabic compounds were used to create a highly-constraining lexical context: The first part of the disyllabic compounds (e.g., /jɐn^{21}/ 'pregnant') was selected such that it elicits a strong expectation of the second part, i.e. the critical word (e.g. /fu^{23}/ 'married woman'; see Materials section for details).

If the lexical context has a facilitating effect on lexical identification, one would expect that listeners use the information provided by the first part of the compound to identify the critical words. In that case, listeners should be better at identifying the low-tone words at the end of questions than in Experiment 1.

To anticipate, the lexical-identification results of Experiment 2 show that lexical context does indeed lead to much better identification performance, in particular for the low-tone words. Concerning the on-line processes contributing to the conflict resolution, two possibilities can be distinguished. First, lexical context might immediately prevent the activation of conflicting lexical representations. If this is the case, the P600 effect observed for LTQ in Experiment 1 should disappear in Experiment 2. Second, context might exert an influence in a later stage of decision-making, biasing listeners towards the canonical tone as the eventual response. In this case, the P600 effect for LTQ should still be observed during on-line processing.

2.3.1. Methods

2.3.1.1. Participants, Task, Procedure, EEG data acquisition

Participants, task, procedure, and EEG data acquisition were the same as in Experiment 1. Experiment 2 was conducted concurrently with Experiment 1 in the same session.

2.3.1.2. Materials

The carrier sentences were the same as in Experiment 1, except that the critical words in Experiment 2 consisted of the second part of disyllabic compounds. The second part of these disyllabic compounds consisted of the 24 critical words used in Experiment 1. These critical words were preceded by 24 monosyllabic words forming the first part of the compounds. The first part of the compounds were all common words found in the Hong Kong Chinese Lexical Lists for Primary Learning ("Hong Kong Chinese Lexical Lists for Primary Learning," n.d.). These words had the same or a similar tone as the corresponding second part of the compound (i.e. the critical words) in order to avoid carryover effects from the tone of the previous word onto the critical word (see Table A1 in Appendix A).

A pilot study was carried out to establish the strength of the semantic constraint between the first part and the second part of the compounds. Fifteen native speakers, who did not participate in Experiments 1 and 2, were given the first part (i.e. the first syllable) of the disyllabic compounds. They were asked to complete each compound with one out of 30 choices[8]. On average, participants selected the critical words that were used in the actual materials in 92% of the cases as completions (SD = 16%).

As mentioned above, Experiment 2 was run concurrently with Experiment 1 in the same session. The stimuli from Experiments 1 and 2 were randomised together. Four differently randomised lists were generated. On average, a given critical sentence-final word from Experiment 1 was preceded or followed by the same critical word from Experiment 2 equally frequently. Therefore, potential or assimilation to the materials were on average counterbalanced across the four lists.

2.3.1.3. EEG data analysis

The data were preprocessed using the same procedure as in Experiment 1. In Experiment 2, 23.2 % of the trials were excluded because of artefacts. The proportion of excluded trials did not differ significantly between experimental conditions. The same set of analyses as in Experiment 1 was carried out.

2.3.2. Results

2.3.2.1. Behavioural results

Table 2.3 shows the results of the lexical-identification task in the form of a confusion matrix for the six lexical tones embedded in a compound at the end of

[8] Cantonese-Chinese single words are highly lexically-ambiguous. On average, every 7.6 Chinese characters (a character is used here to refer to a one-syllable word in a dictionary entry) share the same syllable, and in addition, every 2.95 characters share the same tone and there are a vast number of possible compounds in the language (e.g., P. Li et al., 2002; P. Li & Yip, 1998; Zhang & Zhang, 1987). Since we are primarily interested in how well the first part of the compounds predicts the second part compared to the five other words which only differ by their lexical tone, we restricted the number of choices available to 30, which consisted of five different sets of tonal sextuplets. Four out of these five sets of tonal sextuplets were used in the actual test trials and the remaining set was used in the practice trials.

questions and statements. Since ceiling effects were observed for several target tones, we used Wilcoxon signed rank tests and Friedman tests to compare the perceptual accuracy for each tone among various conditions. A series of Wilcoxon signed rank tests were conducted to test if there was a difference in the perception of tones at the end of questions and statements. Bonferroni correction was used to adjust the *p*-value and to control for family-wise errors across comparisons (the new critical p = .008). The accuracy rate was similar for five of the six tones between questions and statements (all *ps* > .01). The only tone that showed a difference in accuracy rate between questions and statements was tone 22 (p <.001).

Table 2.3.

Experiment 2: Confusion Matrix for the Perceptual Accuracy of the Target Tones embedded in Compounds at the End of Questions and Statements.

	Intonation											
	Question						Statement					
Target	Perceived tone						Perceived tone					
tone	55	25	33	21	23	22	55	25	33	21	23	22
55	**95.0**	3.8	0	0	1.3	0	**100.0**	0	0	0	0	0
25	0	**100.0**	0	0	0	0	0	**98.7**	0	0	1.3	0
33	0	0	**93.8**	1.3	0	5.0	0	0	**96.2**	1.3	1.3	1.3
21	0	1.3	0	**93.7**	3.8	1.3	0	0	0	**97.5**	1.3	1.3
23	0	2.5	2.5	0	**73.8**	21.3	1.3	0	1.3	1.3	**96.2**	0
22	0	2.5	1.3	2.5	21.3	**72.5**	0	0	6.3	0	2.5	**91.3**

Note. High-level tone (55), high-rising tone (25) and mid-level tone (33) constituted the high-mid tones, low-falling tone (21), low-rising tone (23) and low-falling tone (22) constituted the low tones. Cell numbers represent the mean percentage of response for each target tone. The numbers in bold appearing on the diagonal of the matrix are the mean rate of correct identifications.

We also assessed whether there was a difference in the perceptual accuracy among the six tones when they appeared at the end of questions and statements using Friedman test. The test showed that there was a significant difference among tones at the end of questions, χ^2 (5, N = 20) = 75.53, p < .001, but not for statements, χ^2 (5, N = 20) = 5.51, p > .05. Follow-up pairwise comparisons were conducted for the tones in questions using a Wilcoxon signed-rank test. Bonferroni correction was used to adjust the *p*-value (new critical p = .003). A significant difference was found between the low tones (23, 22) and the high-mid tones at the end of questions (all *ps* < .003), and between tone 23 and tone 21 (p < .003).

In addition, a series of Wilcoxon tests were conducted to compare if there was a difference in the percentages of correct identification of tones between Experiment 1 (where the critical words were presented without a preceding lexical context) and Experiment 2 (where the critical words were the second part of a compound).

Bonferroni correction was used to adjust the *p*-value (new critical $p = .008$). The tests showed significant differences in the correct identification rate for all low tones (21, 23, 22) at the end of questions between Experiment 1 and Experiment 2, but not for the high-mid tones (all $ps > .01$). At the end of statements, the low tones (23, 22) had higher perceptual accuracy rates in Experiment 2 than in Experiment 1 (all $ps < .008$). Thus, the behavioural data show that lexical context helps to resolve the conflict between lexical tone and intonation as far as offline judgments are concerned.

2.3.2.2. ERP results

Figure 2.3 shows the grand average waveforms for all 25 electrodes time-locked to the sentence-final critical words (see the second and third row of Figure 2 for topographical maps). Visual inspection suggests that words with a high-mid tone in questions (HTQ) as well as words with a low tone in questions (LTQ) elicit an increase in negativity between 100 and 350 ms compared to their counterparts in statements (HTS and LTS). This negativity seems to be maximal at the centro-parietal midline and bilateral electrodes. The early negativity for HTQ seems to be larger than that for LTQ. The early negativity seems to be followed by a centro-parietally distributed positivity starting around 400 and extending up to 900 ms which seems largest for the low-tone words in statements compared to all other conditions (i.e. high-mid tone words in questions, low-tone words in statements and high-mid tone words in statements).

Early effects. A summary of the time-course analyses for the low-tone words and high-mid tone words are presented in Tables C3 and C4 in Appendix C, respectively. The time-course analyses for the low-tone words presented in Table C3 in Appendix C revealed Intonation by Electrode interactions from 100 to 350 ms for the lateral electrodes. Therefore, this negativity for the low-tone words was quantified in the 100-350 ms time window. For the midline electrodes, no significant main effects or interactions (i.e. an effect in at least two consecutive time-windows) were found. For the high-mid-tone words, the time-course analyses presented in Table C4 in Appendix C showed Intonation by Hemisphere interactions for the lateral sites from 150 to 350 ms. Therefore, the 150 to 350 time-window was used to quantify the negativity for the high-mid-tone words. As for the low-tone words for the midline electrodes, no reliable effects or interactions were present.

Since the time-course analyses yielded different time-windows for the early negative effects observed in the low tones and high-mid tones, separate ANOVAs were performed on the low tones and the high-mid tones. The results of the ANOVAs for the low-tone words for the 100-350 ms time-window yielded the following picture: For the lateral sites, there was no main effect of Intonation ($F < 1$) but an Intonation by Electrode interaction ($F(10, 190) = 9.58$, $p < .001$). Follow-up analyses indicated that the amplitude of the early negativity for LTQ was larger than that for LTS at two posterior sites of the left hemisphere (P3 and PO7: $ps < .05$). Based on the posterior scalp distribution, this early negativity is taken to reflect an N400-like effect. For the midline electrodes, the comparison of LTQ with LTS did not disclose a main effect of Intonation (F<2) but showed an Intonation by Electrode interaction ($F(2, 38) = 5.38$, $p < .05$). Follow-up analyses indicated that the early negativity at the parietal midline electrode (Pz) was larger for LTQ than LTS ($p < .05$).

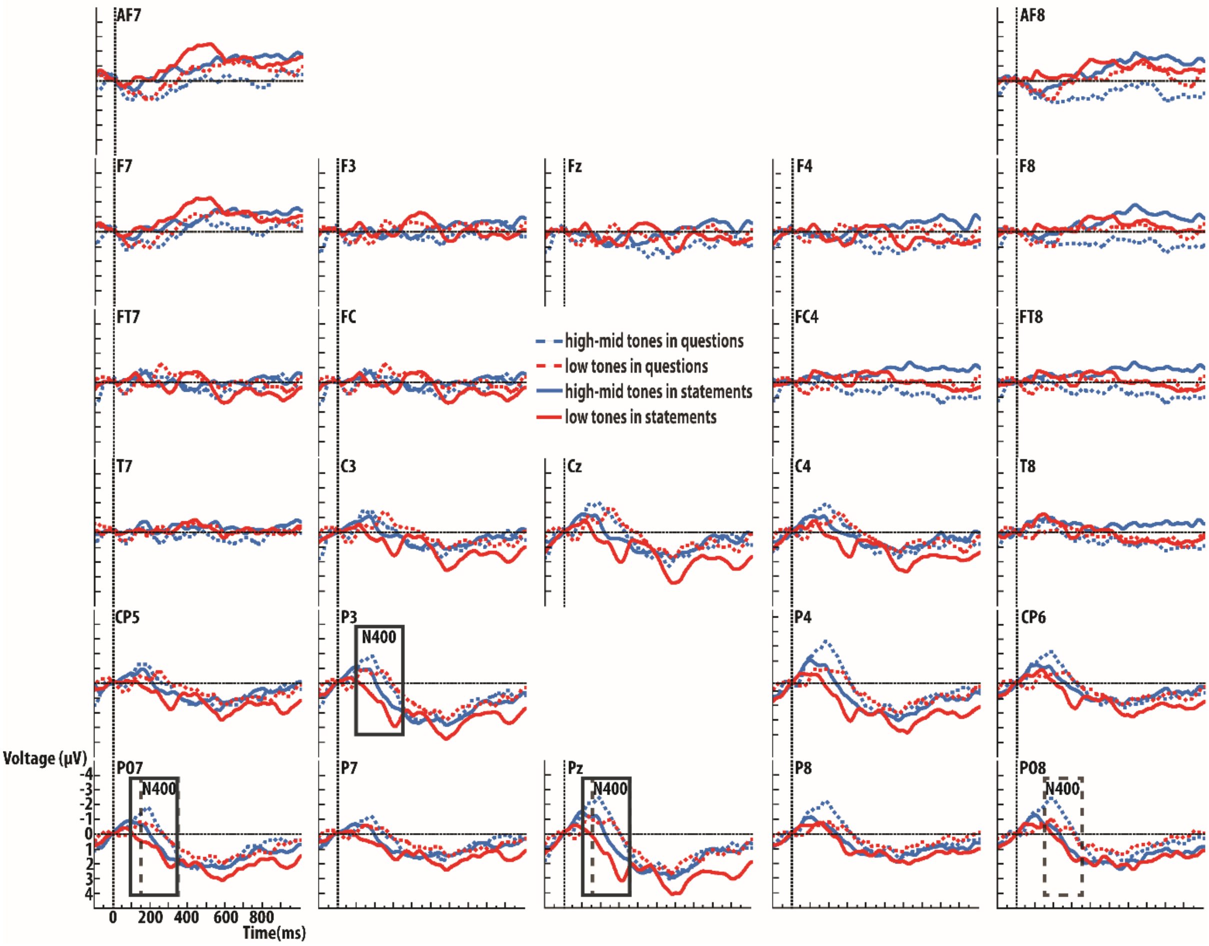

Figure 2.3.

Grand average waveforms of all 25 electrodes time-locked to the onset of the sentence-final critical words in Experiment 2. Negativity is plotted upwards. The grey boxes with solid lines mark the N400 time-window for the low tones while the grey boxes with dash lines mark the N400 time-window for the high-mid tones.

The results for the high-mid tone words in the 150-350 ms time-window yielded the following pattern: The lateral analysis did not yield a main effect of Intonation (F< 2). However, an Intonation by Electrode interaction was found ($F(10, 190) = 5.08$, $p < .01$). Follow-up analyses indicated that the mean amplitude for HTQ was more negative going than that for HTS at two posterior electrodes (PO7, PO8: $ps < .05$). In addition, an Intonation by Hemisphere by Electrode interaction was obtained ($F(10,190) = 3.87$, $p < .01$). Separate ANOVAs were conducted for each of the Hemispheres with Intonation and Electrodes as factors. For the left hemisphere, there was no main effect of intonation (F< 2) but an Intonation by Electrode interaction ($F(10,190) = 4.37$, p

$< .05$). The interaction reflected that HTQ yielded a significantly larger negativity than HTS at PO7 ($p < .05$). Similarly for the right hemisphere, there was no main effect of intonation ($F < 2$) but an Intonation by Electrode interaction ($F(10,190) = 5.24, p < .01$). The interaction reflected that HTQ yielded a significantly larger negativity than HTS at PO8 ($p < .05$). Taken together, the supplementary analyses for the two hemispheres indicated that the mean amplitude of HTQ was more negative than HTS at two posterior sites at PO7 and PO8.

Likewise, the analysis for the midline electrodes did not disclose a main effect of Intonation ($F(1, 19) = 2.71$, $p = .12$), but an Intonation by Electrode interaction, ($F(2,38) = 5.73$, $p < .05$). Follow-up analyses revealed that the early negativity was significantly larger for HTQ than HTS at Pz ($p < .05$). To summarize, an increase in early posterior distributed negativity for the lateral sites was present not only for LTQ, but also for HTQ. As stated above, the posterior scalp distribution of the early negativity is consistent with the interpretation that this effect reflects an N400-like effect.

A supplementary overall ANOVA with the additional factor Tone with the levels low-tone words versus high-mid tone words was performed for the 150-350 ms time window (i.e. the time window that, according to the time-course analyses, was shared by high tone words (150 to 350 ms) and by low tone words (100 to 350 ms)). The lateral analysis did not yield an effect of Intonation ($F < 1$), no effect of Tone ($F(1, 19) = 2.22$, $p = .15$) and no interaction between these two factors ($F < 1$). The interaction between Intonation and Electrode was significant ($F(10, 190) = 15.04$, $p < .01$) and the same was the case for the interaction between Tone and Electrode ($F(10, 190) = 4.06$, $p < .05$). More importantly, no three-way interaction between Intonation, Tone and Electrodes ($F < 2$) or four-way interaction between Intonation, Tone, Hemisphere and Electrodes was present ($F < 2$). Even though the main effects of Intonation and Tone were absent, the presence of an interaction between Intonation and Electrode and also between Tone and Electrode suggests the presence of an Intonation and/or a Tone effect on the single-electrode level. To check this, additional ANOVAs with Intonation and Tone as factors were conducted on the single electrodes. The results of the ANOVAs showed that there was a main effect of Intonation at CP5 ($F(1, 19) = 4.47$, $p < .05$), P3 ($F(1, 19) = 10.51, p < .01$), P4 ($F(1,19) = 5.89, p < .05$), P7 ($F(1, 19) = 8.03$, $p < .05$), and PO8 ($F(1, 19) = 10.77$, $p < .01$); and a main effect of Tone at CP5 ($F(1, 19) = 4.62$, $p < .05$), P3 ($F(1, 19) = 5.12$, $p < .05$), and PO7 ($F(1, 19) = 5.51$, $p < .05$). However, no significant interaction between Intonation and Tone was found at any single electrode. For the midline electrodes, the overall ANOVAs yielded a main effect of Intonation ($F(1, 19) = 5.12$, $p < .05$), in the absence of an effect of Tone ($F(1, 19) = 2.11$, $p = .17$). In addition, the interaction between Intonation and Electrode ($F(2, 38) = 7.79, p < .01$) was significant. This suggests the presence of an effect of Intonation at the single electrodes. To check this, additional ANOVAs with Intonation and Tone as factors were conducted on the single electrodes. The results of the ANOVAs showed that there was a main effect of Intonation at Cz ($F(1, 19) = 5.92$, $p < .05$), and Pz (F(1,

19) = 8.63, p <.01) in the absence of an Intonation by Tone interaction. In sum, the results of the overall ANOVAs, in particular the absence of interactions between Intonation and Tone and the presence of main effects of Intonation, support that N400-like effects of the same size occurred for the low-tone words and the high-mid tone words.

Late effect. The results of the time-course analyses for the low-tone words presented in Tables C3 and C4 in Appendix C for the high-mid-tone words reveal that there were no significant main effects of intonation or interactions of Intonation with Electrode and/or Hemisphere for two consecutive time-windows starting from 350-400 ms up to 950 to 1000 ms measured from critical word onset. Thus, although visual inspection suggested the presence of a late positivity to low-tone words in statements (see Figure 2.3), the time-course analyses do not statistically support the presence of differences in ERPs between conditions (LTQ vs. LTS, and HTQ vs. HTS) for the later time windows. In other words, in contrast with Experiment 1, in which a late positivity to LTQ was obtained, adding a lexical context led to the disappearance of the late positivity in Experiment 2.

2.3.3. Discussion

The results of Experiment 2 show that lexical context helps to resolve the conflict between lexical tone and intonation in lexical identification. This is indicated by the significant improvement in accuracy rate in the LTQ condition in Experiment 2 as compared to Experiment 1. Moreover, the P600 effect, which was observed for LTQ relative to LTS in Experiment 1, was no longer present in Experiment 2.

However, in Experiment 2, we still observed a difference in ERP effects between critical words in questions and statements for a subset of posterior sites (specifically at P3, PO7 and PZ for low tones, and PO7, PO8 and Pz for high tones). In contrast to Experiment 1, this difference was present for both low-tone words and high-tone words and it resembled an N400 in terms of timing and scalp distribution. We will return to this finding in the General Discussion.

2.4. General Discussion

In two experiments, we investigated the effect of intonation and context on the on-line processing and identification of lexical tone in Cantonese Chinese. In Experiment 1, the intonation-induced F_0 changes to question-final words with a low tone led to on-line processing problems (reflected in a P600 effect) and to a large proportion of misidentifications of low-tone words. By contrast, no such problems were present for high-mid-tone words. This pattern suggests that for low-tone words at the end of questions, two lexical representations get into competition. The introduction of a constraining lexical context in Experiment 2 abolished the P600 effect for low-tone words, and led to a much higher proportion of correct identifications of the low-tone words. However, in Experiment 2, we still observed a difference between the critical words in questions and statements. This difference took the form of an N400 for critical words in questions relative to critical words in statements, and it was observed for words with a canonical low tone and for words with a canonical high-mid tone (see Figure 2.4 for a summary of results of Experiments 1 and 2 in the form of bar graphs).

At first sight, this finding appears to be paradoxical: While the lexical context clearly helps in lexical identification (in particular for low-tone words in questions), it introduces on-line processing problems which now also appear for high-mid tone words, i.e. for the condition that did not show any processing problems in Experiment 1. Below, we will propose a potential account for these findings.

The observed on-line effects of intonation and context on the processing of lexical tone indicate that all three types of information, lexical tone, intonation, and contextually-induced expectation of a lexical tone become available more or less simultaneously. In the following, we will discuss the present findings in light of the available studies on the following two topics: the effect of intonation on the processing and identification of lexical tone, and the role of Context in Cantonese speech comprehension.

2.4.1. The effect of intonation on the processing and identification of Cantonese lexical tone

Consistent with earlier findings (Fok-Chan, 1974; Ma et al., 2006), we found that intonation affects the identification of low lexical tones, but not of high-mid tones. In the discussion of Experiment 1, we have briefly explained why such an asymmetric pattern might arise. In the following, we will elaborate on this topic in more detail. As mentioned above, each of the six lexical tones has its own distinctive F_0 pattern. The primary acoustic correlates of Cantonese lexical tones are F_0 direction (the direction of F_0 change), F_0 shape (the magnitude of F_0 change; F_0 direction and F_0 shape together can be referred to as F_0 contour) and F_0 level (the average F_0 height of the F_0 pattern; Gandour, 1981; Khouw & Ciocca, 2007). Previous studies have shown that Cantonese lexical tones are identified by these individual features and not by the F_0 pattern as a whole (Gandour, 1981; Khouw & Ciocca, 2007; Ma et al., 2006). Furthermore, it has been shown that listeners give more weight to F_0 contour (i.e. F_0 direction and F_0 shape) than to F_0 level.

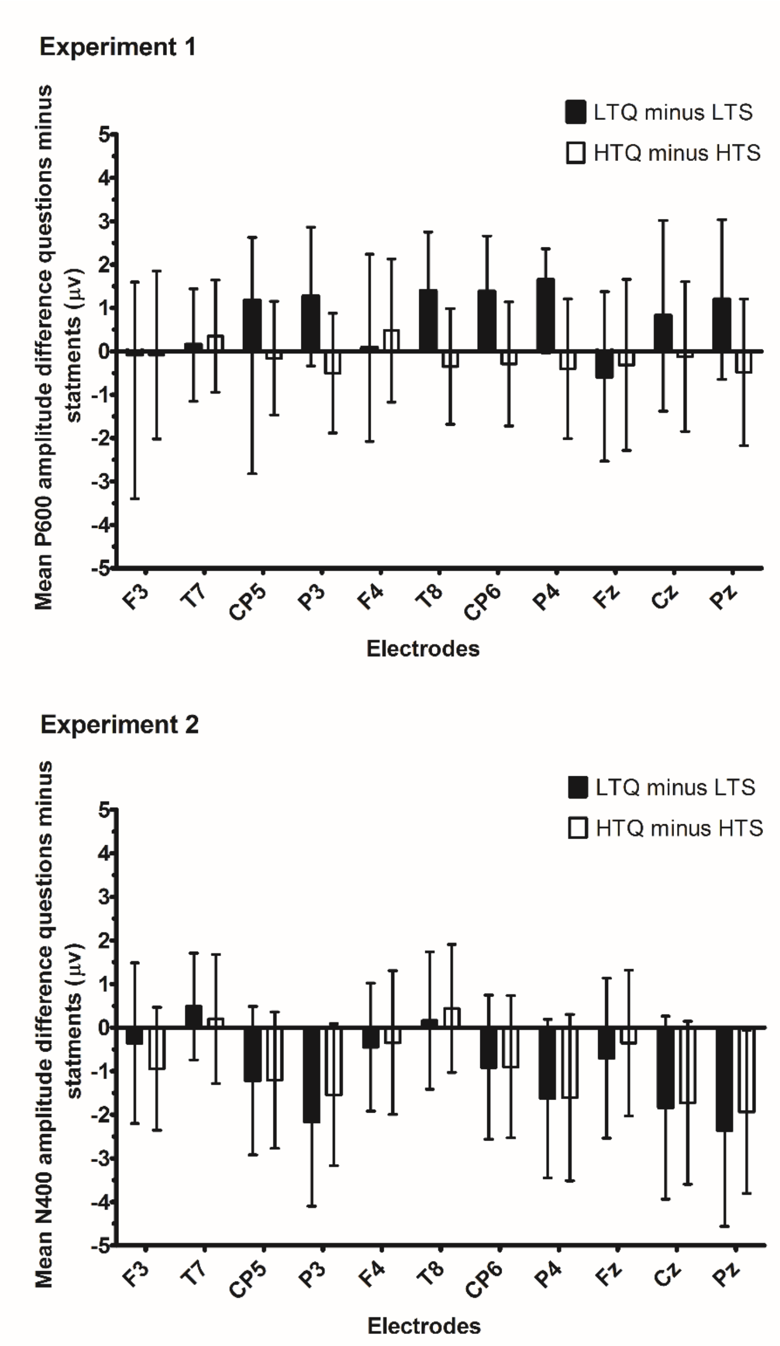

Figure 2.4.

Bar graphs showing the differences in mean amplitude between LTQ and LTS (LTQ minus LTS) and between HTQ and HTS (HTQ minus HTS) for a subset of 11 electrodes in Experiment 1 (upper panel) and Experiment 2 (lower panel). The mean amplitudes are computed for the P600-effect in Experiment 1 (time window for the lateral electrodes: 450-600 ms; midline electrodes: 500-700 ms). The mean amplitudes are computed for the N400-effect in Experiment 2 in the 100-350 ms time window (LTQ minus LTS) and in the 150-350 ms time window (HTQ minus HTS). Error bars are upper-half and lower-half 95% confidence intervals of the differences in mean amplitudes.

2.4.2. The role of context in the processing and identification of Cantonese lexical tone

In Experiment 2, we show that the introduction of a highly-constraining lexical context clearly helps eventual lexical identification as indicated in the clear increase of correct lexical identifications for low-tone words in questions compared to Experiment 1. This is in accordance with previous studies showing that speech comprehension in Cantonese Chinese and other varieties of Chinese has a strong reliance on contextual information (e.g., Chen, 1992; Chen, Cheung, Tang, & Wong, 2000; P. Li & Yip, 1998; Ye & Connine, 1999). The strong reliance on context has presumably its basis in the fact that lexical ambiguity is very pervasive in different varieties of Chinese (P. Li, Shu, Yip, Zhang, & Tang, 2002; P. Li & Yip, 1998; Zhang & Zhang, 1987).

Nevertheless, there still appears to be an on-line processing problem which now holds for LTQ and HTQ. This processing problem shows up as an N400 for LTQ relative to LTS, and for HTQ relative to HTS. The N400 has been proposed to index processes of lexical access (e.g., Kutas & Federmeier, 2000) in particular the ease with which an item can be retrieved from the lexicon (e.g., Kutas & Federmeier, 2000), or the ease with which a word can be integrated into the current context (e.g., Chwilla et al., 1995, 1998). From an integration perspective, the finding of an N400 in questions (LTQ and HTQ) relative to statements (LTS and HTS) might at first sight be somewhat surprising. After all, one might expect that a strong contextual bias towards a specific lexical tone for the sentence final word should make its integration easy, and it should do so for statements and questions equally. So what could be going on here?

A possible scenario looks as follows. The context introduces a strong expectation for a specific lexical tone. But for question-final critical words, the actual acoustic signal deviates from this expected tone. The expectation of a specific lexical tone appears to make this deviation so salient that it is not only noted for question-final words with a low lexical tone, but also for question-final words with a high-mid lexical tone. This deviation from expectation could lead to greater difficulty in integrating the critical words with the lexical context in questions than in statements. Note that this semantic-integration difficulty is not observed for the critical words in statements or those in the semantically-neutral carrier sentences in Experiment 1.

The hypothesis that the context-driven expectation of a specific lexical tone might make the deviation of the actual acoustic signal from the expected tone more salient has an interesting–though admittedly speculative–potential analogue in research on semantic context effects in the comprehension of degraded speech in non-tonal languages. Strauss et al. (2013), in an ERP study on German, found evidence for the hypothesis "… that acoustic degradation would … elicit a sharpening and more narrow adjusting of linguistic predictions." (p. 1390). In their case, this was reflected in the fact that in degraded speech (in contrast to undegraded speech) only words that are very likely and highly typical continuations of a sentence lead to a reduction of the N400 amplitude.

If we now assume that the effect of a question intonation on lexical tone is similar to what happens in degraded speech in non-tonal languages, we would arrive at the following parallelism. Just as contextually-induced lexical expectations are made sharp by degraded speech, contextually-induced expectations of a specific lexical tone are sharpened by a question intonation. This sharpened expectation of a lexical tone, in turn, makes deviations of the actual acoustic signal from the expected lexical tone more salient (see also Mattys et al., 2009, for evidence that degraded speech can lead to a higher weighting of acoustic cues in speech segmentation in non-tonal languages).

2.5. Conclusion

In two experiments, we investigated the interaction of tonal, intonational and contextual information in on-line speech comprehension of Cantonese Chinese. The results of Experiment 1 show that intonation affects lexical processing and the identification of lexical tone when intonation leads to changes in the primary acoustic correlates of lexical tone. In Experiment 2, with the introduction of a highly-constraining context, the on-line conflict observed in Experiment 1 is resolved. This is illustrated by the absence of a P600 effect and the significant improvement in lexical identification. However, an N400 effect is now observed for question-final words with low tones as well as for those with high-mid tones. This N400 effect is taken to reflect a mismatch between the intonation-induced F_0 changes and the expectation of a specific lexical tone. Thus, context is helpful in the on-line processing of lexical tone, but it does not take away completely potential processing difficulties arising from a mismatch between lexical tone and intonational information.

Chapter 3

The Effects of Discourse Context and Intonation on the Comprehension of Pragmatic Meaning: A Study on the Choice of Sentence-Final Particles in Cantonese Chinese

Based on:
Kung, C., Schriefers, H., Chwilla, D., & Fung, R. (2017). *The effects of discourse context and intonation on the comprehension of pragmatic meaning: A study on the choice of sentence-final particles in Cantonese Chinese.* Manuscript in Preparation.

Abstract

In Cantonese Chinese, pragmatic meaning can be coded in clearly identifiable units, called sentence-final particles (SFP). An SFP consists of a single syllable plus an associated tone and appears at the end of an utterance. In three experiments, we asked speakers of Cantonese Chinese to listen to sentences or short discourses and to provide the SFP that according to their intuition would complete the input most naturally. In Experiment 1, we show that a discourse context can systematically affect the choice of an SFP and thus the comprehension of pragmatic meaning. In Experiment 2, we show that intonation can also affect the choice of an SFP. Finally, in Experiment 3 we cross the discourse-context bias and the intonation bias established in Experiments 1 and 2. It turns out that the effect of discourse context is not enhanced by a converging intonation bias. By contrast, the effect of discourse context does decrease when it is combined with a diverging intonation bias. Based on these results, we propose the 'speaker perspective hypothesis' of pragmatic-meaning comprehension. For a speaker, intonation is a consequence of context (and communicative intention). Therefore, if the listener adopts a speaker perspective, s/he will consider intonation as an additional source of information on pragmatic meaning only in cases in which the pragmatic meaning signalled by discourse context deviates from the pragmatic meaning signalled by intonation.

Keywords: pragmatic meaning, discourse context, intonation, sentence-final particles, Cantonese Chinese

3.1. Introduction

Conversation requires the active participation of a speaker and a listener (Clark, 1996). The speaker does not only have to get across the literal meaning to the listener, but (s)he has also to get across what (s)he actually wants to convey. This latter aspect of meaning is referred to as the pragmatic meaning of an utterance. In turn, the listener has to understand the literal and the pragmatic meaning of the speaker's utterance to plan an appropriate reply to the speaker's utterance.

The difference between literal and pragmatic meaning can be demonstrated by the following example: When Mary says to John *'the report is due tomorrow'*, John can take the utterance literally as a statement indicating the deadline for the report. However, Mary might want to convey a pragmatic meaning that goes beyond a statement about the deadline. For example, the pragmatic meaning could concern different speech acts such as a request that John should start working on the report as soon as possible, or a clarification question to check whether the report is really due tomorrow (for discussions of different aspects of pragmatic meaning see, for example, Austin, 1962; Levinson, 1983; Mey, 2001; Searle, 1965). But how can John recognise the pragmatic meaning of Mary's utterance? Obviously, he has to rely on information that goes beyond the literal meaning of the utterance. Two important sources of information for the recognition of pragmatic meaning are intonation and discourse context. As for discourse context, when Mary utters 'John, you have not even started to work on the report. The report is due tomorrow', John will presumably interpret the utterance 'The report is due tomorrow' as an urgent request to start to work on the report immediately. By contrast, when Mary says 'John, I do not recall the deadline of the report anymore. The report is due tomorrow', John presumably interprets Mary's utterance as a clarification question on the report's deadline. As for intonation, the pragmatic meaning of a request can, for example, be coded by a statement intonation with a pitch accent on 'tomorrow' while the clarification question can be coded by a rising question intonation.

However, discourse context and intonation do not necessarily point towards the same pragmatic meaning. Let us again consider Mary saying 'John, you have not even started to work on the report. The report is due tomorrow', but now with a question intonation on the second sentence. Here, the discourse context provided by Mary's utterances suggests that Mary wants to express a request that John should start to work on the report immediately, but the question intonation on the second sentence could nevertheless indicate that Mary is asking a clarification question on the report's deadline. In such a case, John could interpret Mary's utterances as conveying two separate pragmatic meanings, a request followed by a clarification question. Alternatively, John could interpret Mary's utterances as conveying one pragmatic meaning. When doing so, he has to give a relative weight to the information provided by the discourse context and the information provided by intonation in order to derive the pragmatic meaning.

So far, little is known about the relative weight that listeners assign to discourse context and intonation in the recognition of pragmatic meaning, and more specifically the recognition of speech acts. In the present article, we will address this question using Cantonese Chinese. Cantonese Chinese provides an ideal testing ground because in Cantonese Chinese, pragmatic meaning can be coded in clearly identifiable units, called sentence-final particles (hereafter SFPs, for details see below). Instead of asking for a metalinguistic judgment (e.g., 'is the utterance a request or a statement or a …?'), we can thus ask listeners to provide an SFP that most naturally completes a discourse. This procedure resembles the way one measures the expectation of a certain word in a cloze task except that we are not asking for a completion with a content word but rather for a completion with an SFP. This procedure allows us to test to what extent Cantonese listeners use discourse context and/or intonation to choose an SFP and thus reveals the pragmatic meaning the listener assigns to an utterance without using any explicit metalinguistic judgment task.

In what follows, we will briefly discuss the literature relevant to the following topics: (a) empirical studies on the role of discourse context and intonation in the recognition of pragmatic meaning; (b) the relation between intonation and Cantonese SFPs; and (c) theories on how listeners derive pragmatic meaning from an utterance.

The role of discourse context in the comprehension of pragmatic meaning has been studied by Holtgraves and Ashley (2001; see also Holtgraves, 2008). Holtgraves and Ashley (2001) presented their participants with short discourses ending in a sentence that strongly biased towards a certain pragmatic meaning (in their case towards the so-called illocutionary force of a speech act, for example, 'begging'). The discourse did not contain the verb that explicitly codes this pragmatic meaning, the so-called performative verb (e.g., it did not contain the verb 'to beg'). After the discourse, this performative verb was presented and participants had to decide as quickly as possible whether this verb had been occurring in the preceding discourse. The results showed that the correct (no-)response to such a verb was slower than in a control condition that did not bias towards the pragmatic meaning indicated by this verb. These results suggest that the discourse context on the critical trials did indeed activate the verb that corresponds to the pragmatic meaning of the discourse, despite the fact that the verb was not part of the discourse.

Next to the discourse context, listeners also rely on intonation to recognize pragmatic meaning. Several linguists have proposed that intonation can highlight the pragmatic meaning of an utterance and functions as a contextualisation cue: it relates the content of an utterance to the preceding utterances in the conversation (Gumperz, 1982; Holmes, 1984; House, 2006; Vandepitte, 1989). This proposal is supported by findings from recent behavioural, eye-tracking and ERP studies (Astésano, Besson, & Alter, 2004; Hellbernd & Sammler, 2016; P. Zhou, Crain, & Zhan, 2012). For example, Hellbernd and Sammler (2016) showed that German listeners can link six intonation patterns—represented by six different acoustic patterns—to six different speech acts (criticism, doubt, naming, suggestion, warning, and wish) using a 6-alternative forced-choice categorisation task. These results were further corroborated by Experiment 3 of the same study, which revealed that acoustic measures can be used to predict how listeners identify speech acts in a speech-act rating task. Together, these results demonstrated the role of intonation in the recognition of speech acts in German. In addition to German, similar findings were reported in Mandarin Chinese: Using eye-tracking, P. Zhou et al. (2012) investigated whether young children and adults can use intonation to disambiguate speech-act ambiguities created by in-situ wh-words in Mandarin Chinese: In Mandarin Chinese, the identical sentence containing the same wh-word can indicate a question or mark an indefinite noun phrase in a statement. These two structures can be distinguished by intonation: Wh-words in questions carry a rising intonation, whereas wh-words in statements carry a level intonation. P. Zhou et al. found that both adults and young children rely on intonation to disambiguate the question from the statements. Similar findings were also reported by Astésano et al. (2004) using ERPs: They showed that listeners have problems with processing statements or questions that are uttered with mismatching intonations (e.g., statements beginning with a falling statement intonation and ending with a rising question intonation). These findings indicate that intonation can also play an important role in speech-act comprehension.

In summary, these studies show that listeners can use both discourse context and intonation to extract the pragmatic meaning of an utterance. However, these studies do not speak to the question whether listeners rely more on discourse context or more on intonation, and how they cope with a situation in which discourse context and intonation yield converging or diverging evidence for a certain pragmatic meaning. To our knowledge, only one study has addressed this question. This study focused on children, and adult listeners were included only as a control group (Aguert, Laval, Le Bigot, & Bernicot, 2010). The results showed that adult listeners preferred intonation over context in the comprehension of pragmatic meaning (expressive speech acts in this study, such as praise [e.g., 'that's great!'] and criticisms [e.g., 'That movie really disappoints me']). It should be noted, however, that this study did not use a discourse context but a situational context (e.g., information about where the interlocutors are located, what they look like and what they have been doing).

Other studies have investigated the relative contribution of intonation and (discourse-) context in the recognition of other kinds of pragmatic meaning, like irony and sarcasm. Regel, Gunter and Friederici (2010) manipulated discourse context and intonation to examine the effect of these two factors on irony comprehension. They only found a context effect in the absence of an intonation effect. Cappeli et al. (1990) examined to what extent listeners use discourse context, intonation or a combination of both to comprehend sarcasm. They focused mainly on children and included adults only as a control group. The results indicated that adult listeners understood sarcasm equally well when the relevant information was carried by context, by intonation, or by converging evidence from intonation and context. Taken together, the few studies on the relative contribution of (discourse-) context and intonation to the comprehension of pragmatic meaning provide mixed results.

Next, we will briefly discuss sentence-final particles (SFPs) in Cantonese Chinese. A SFP consists of a single syllable plus an associated tone and appears at the end of an utterance. The addition of a SFP to an utterance does not alter the literal meaning of the utterance, but it adds a communicative function to the utterance. These functions include pragmatic meaning (including speech acts), evidentiality, speaker's attitude and emotion (Fung, 2000; Kwok, 1984; Luke, 1990; Matthews & Yip, 2011; Sybesma & Li, 2007; Yau, 1965). To illustrate how SFPs work, we will use an example of an utterance ending without a SFP (1) and the identical utterance ending with three different SFPs ((2), (3) and (4)). The three SFPs only differ in tone and they mark different pragmatic meanings.

When referring to SFPs, we use a notation that first gives the phonemes of the syllable (e.g., laa) followed by a number that indicates the associated lexical tone. In Cantonese Chinese, there are six contrastive lexical tones (Bauer & Benedict, 1997): a high-level tone (Tone 1), a high-rising tone (Tone 2), a mid-level tone (Tone 3), a low-falling tone (Tone 4), a low-rising tone (Tone 5), and a low-level tone (Tone 6). The lexical tones relevant for the present study are Tone 1, Tone 3, and Tone 4. The utterance in example (1)—without an SFP—is a declarative. In example (2), adding the SFP laa1 turns the declarative of example (1) into a directive (e.g., advice, suggestion, persuasion or command [Fung, 2000]). The SFP laa3 in example (3) expresses a declarative stating the actual realisation of a state. The SFP laa4 in example (4) turns a declarative into a question to check for factual confirmation when a speaker is in doubt.

(1)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	
	Jyutping[9]:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	
	Glossary:	'You repair the table leg for me'									
(2)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**啦**!
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa1**
	Translation:	"Please repair the table leg for me!" (request)									
(3)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**喇**。
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa3**
	Translation:	"You have repaired the table leg for me." (statement)									
(4)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**啍**?
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa4**
	Translation:	"You have repaired the table leg for me?" (clarification question)									

Because there are six contrastive lexical tones in Cantonese Chinese, the pitch space is crowded. Furthermore, not only lexical tones, but also intonation, are manifested in pitch movements. This leaves limited pitch space for the realisation of

[9] Jyutping is the romanisation system for Cantonese developed by the Linguistic Society of Hong Kong (LSHK).

intonation without altering the pitch movement of the lexical tones in an utterance. Hence, Cantonese intonation is separated into utterance-body intonation and utterance-final intonation. The pitch movement in the former is more limited due to lexical tone whereas the pitch movement in the latter is less restricted (Fang, 2003; Fox, Luke, & Nancarrow, 2008; Lam, 2002; Mai, 1998). Even though the pitch space of the utterance body is limited, variations in the global pitch register can be used to signal different pragmatic meanings (e.g., assertion, question and command). Due to the restricted forms of intonation, SFPs are used—in addition to intonation—to mark pragmatic meaning in Cantonese (Cheung, 1986; Fang, 2003). Since SFPs and intonation are both used to code the pragmatic meaning of an utterance, it has been suggested that utterance body-intonation leads towards the tone of SFP (Fang, 2003; Flynn, 2003; Fox et al., 2008).

Let us now turn to two theories on how listeners do recognise speech acts, and pragmatic meaning in general: the standard pragmatic model (derived from the work of Grice, 1975; see Gibbs, 2002; Glucksberg, 1991 for a review); and the relevance theory (Sperber & Wilson, 1986; Wilson & Sperber, 2004). The standard pragmatic model evolved from the theory of conversational implicatures by Grice (1975). According to this theory, the literal meaning of an utterance has to be fully constructed before it is evaluated against the information from the preceding discourse context. This evaluation is constrained by the maxims of Quality (truthfulness), Quantity (informativeness), Relation (relevance), and Manner (clarity). These maxims ensure effective communication between the participants in a conversation and the participants in the conversation are expected to observe these maxims. If these maxims are violated, the listener has to derive an alternative interpretation of the pragmatic meaning that best matches the maxims.

Relevance theory also aims to account for how listeners recognise pragmatic meaning (Sperber & Wilson, 1986; Wilson & Sperber, 2004). However, relevance theory assumes that the Maxim of relation (relevance) is sufficient for a listener to successfully derive the pragmatic meaning of an utterance: 'The expectations of relevance raised by an utterance are precise enough, and predictable enough, to guide the hearer towards the speaker's meaning' (Wilson & Sperber, 2004, p. 250). In other words, relevance theory assumes that a speaker purposefully provides the necessary information to the listener about what s/he intends to communicate. Relevance theory assumes that, in doing so, the speaker can, besides other cues, also use intonation to make (parts of) the utterance perceptually more salient (Wilson & Wharton, 2006). In turn, the listener can presume that the utterance contains all the relevant information necessary for interpreting the pragmatic meaning of the speaker's utterance.

In sum, both theories agree that discourse context contributes to the derivation of speaker's meaning. In addition, relevance theory explicitly assumes a role for intonation in the recognition of pragmatic meaning. However, neither of the two theories allows for clear predictions about the relative role of discourse context and intonation in the recognition of pragmatic meaning.

In the remainder of this article, we will address the relative contribution of discourse context vs. intonation in the comprehension of pragmatic meaning in a series of experiments on Cantonese Chinese. As explained above, Cantonese Chinese provides an ideal testing ground as we can ask participants to complete spoken discourses with an SFP. The choice of the SFP by a listener thus provides information about the pragmatic meaning that the listener assigns to the discourse without requiring any kind of explicit metalinguistic judgment task.

3.2. Preview of the experiments

In all three experiments of the present study, participants were asked to listen to short discourses and to provide the SFP that, according to their intuition, would complete the discourse in the most natural way. In Experiment 1, we tested if, and to what extent, a biasing discourse context (biasing towards the SFP laa1 or towards the SFP laa4) can lead participants to choose the corresponding SFP (hereafter called the target SFPs). Then, in Experiment 2, we examined if, and to what extent, a biasing intonation (either towards laa1 or towards laa4) yields more target SFPs. After having established that both discourse context and intonation can introduce a bias towards laa1 and laa4, we tested, in Experiment 3, to what extent listeners rely on the biasing discourse contexts and/or sentence intonation to recognise the pragmatic meaning of the discourse (which is reflected in their choice of an SFP). This was tested by comparing the listeners' choice of an SFP in conditions in which either the intonation bias matches the context bias or the intonation bias mismatches the context bias.

3.2.1. General materials

To investigate to what extent listeners use intonation vs. discourse context in choosing a sentence-final particle, we had to anticipate on all experiments reported in the present study in the construction of the materials. We will therefore describe the construction of the materials in one separate section before reporting the individual experiments. In a first step, we constructed 100 sentence-items. All sentence-items were semantically-neutral statements (see example (5)).

(5)								
Chinese:	你	幫	我	整	番	好隻	枱	腳
Jyutping :	nei5	bong1	ngo5	zing2	faan1	ho2 zek3	toi2goek3	
Translation:	"You repair the table leg for me."							

Semantically-neutral means that the sentence-item could be combined with the SFPs laa1, laa3, or laa4 equally well. Each sentence ended in a sentence-final particle preceded by a word carrying the mid-level tone 3 in order to avoid tone-carryover effects to the SFP during later recording.

Combining the SFPs laa1, laa4 and laa3 with each sentence-item yielded a triplet of sentences for each sentence-item: a laa1 sentence (see example (6)), a laa3 sentence (see example (7)), and a laa4 sentence (see example (8)).

(6)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**啦!**
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa1**
	Translation:	"Please repair the table leg for me!" (request)									
(7)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**喇。**
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa3**
	Translation:	"You have repaired the table leg for me." (statement)									
(8)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**嗱?**
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa4**
	Translation:	"You have repaired the table leg for me?" (clarification question)									

In a next step, we created two discourse contexts for each sentence-item. Each context preceded the respective sentence-item and was one or two sentences long. For each sentence-item, one context was constructed such that it biased towards a completion of the semantically-neutral sentence-item with laa1, and the other context such that it biased towards a completion of the semantically-neutral sentence-item with laa4 (for the empirical calibration of the strength of these discourse contexts see Experiment 1). As a result, we have 100 semantically-neutral sentence-items and two biasing contexts for each sentence-item.

The next step concerned the recording of the materials. First, we recorded the 100 sentence-items with laa3 as SFP. This should yield an intonation pattern in the sentence part preceding the SFP which does not bias towards laa1 or laa4, but should yield an intonation pattern corresponding to a statement. We will refer to this intonation pattern as neutral intonation hereafter.

Then, we recorded each of the 100 sentence items in each of the two contexts. That is, each recording consisted either of a laa1-biasing context followed by the corresponding sentence item ending in the SFP laa1, or of a laa4-biasing context followed by the corresponding sentence-item ending in the SFP laa4. This yields 200 recordings of a context plus its critical sentence. Given the biasing contexts, the critical sentence has an intonation that is compatible with either the SFP laa1 (100 recordings) or the SFP laa4 (100 recordings; see Appendix D for the full list of experimental items).

With respect to the technical details of the recording sessions, the following holds: The 200 discourse contexts were read together with the corresponding sentence-tokens as short paragraphs as in example (9) (for a laa1-biasing context with its critical sentence) and (10) (for a laa4-biasing context with its critical sentence).

(9)	Chinese: (context)	呢張枱其中一隻枱腳跛跛哋，搞到張枱成日扢嚟扢去啊,
	(critical sentence)	你幫我整番好隻枱腳**啦**
	Glossary: (context)	'One of the table legs is damaged and it makes the table wobbly....'
	(critical sentence)	'Can you repair the table leg for me?'
(10)	Chinese: (context)	咦，張枱冇再屹嚟屹去喇喎,
	(critical sentence)	你幫我整番好隻枱腳**嗱**
	Glossary: (context)	'Hey! This table used to be wobbly but now it's not wobbly anymore…'
	(critical sentence)	'You repaired the table leg for me?' (clarification question)

A female native speaker of Cantonese-Chinese recorded the 200 paragraphs, and the 100 laa3 (neutral intonation) sentences in isolation. The recording was made with Apple Protools 5.2 software and digitised at 16-bit/44.1 KHz sampling rate. During the recording, the speaker first read each paragraph/sentence silently to herself and then read it out loud twice. The better take of the two was then chosen by the first author—a native Cantonese Chinese speaker—based on intuition. The chosen versions were normalised to 70 dB SPL using Audacity (http://audacity.sourceforge.net) so that the acoustic volume was approximately matched across all paragraphs and tokens.

After these recording sessions, we thus have 100 discourse contexts biasing towards the SFP laa1 with the critical sentence ending in the SFP laa1; 100 discourse contexts biasing towards the SFP laa4 with the critical sentence ending in the SFP laa4, and 100 recordings of the critical sentences ending in laa3 in isolation, with a neutral intonation. Acoustic measurements using Praat (Boersma & Weenink, 2011; version 5.03) confirmed that the sentence intonation of the critical sentences ending in laa1, laa4 and laa3 differed from each other, especially in terms of the global pitch span. The details of these acoustics measurements are given in Chapter 4.

In the next step, we spliced the recordings using Praat (Boersma & Weenink, 2011; version 5.03). For the two times 100 recordings with a biasing context, we first spliced off the contexts preceding the critical sentence, giving us two times 100 context recordings. From the corresponding two times 100 critical sentences, we spliced off the sentence-final particle, giving us 100 sentence-fragments with a laa1-compatible intonation and 100 sentence-fragments with a laa4-compatible intonation. From the 100 recordings of the critical sentences recorded in isolation with the SFP laa3, we also spliced off the SFP, giving us 100 sentence-fragments with a neutral intonation (i.e. laa3-compatible intonation).

This cross splicing procedure gives us all the ingredients we need for the construction of the materials to be used in our experiments. First, combining the two biasing discourse contexts with the critical sentence-fragments with a neutral intonation gives us the material to calibrate the strength of the two discourse contexts in the absence of any specific intonational cues in the critical sentence-fragment (Experiment

1). Second, the sentence-fragments with a laa1-compatible intonation, a laa4-compatible intonation, and a neutral intonation will be used in an experiment testing whether the intonation contour of the sentence-fragments preceding the (spliced off) SFP influences the choice of SFPs (Experiment 2). Finally, we can fully cross the two discourse contexts (pro-laa1 vs. pro-laa4) with the corresponding critical sentence fragments with the laa1- and laa4-compatible intonation patterns to assess whether the effects of intonation within the critical sentence fragment and the effects of discourse context are independent of each other (i.e. additive effects of discourse context and intonation on the choice of SFPs), or whether one of the biases (sentence fragment intonation or discourse bias) is so strong that it (partly) overrules the other effect (Experiment 3).

3.3. Experiment 1

Experiment 1 investigates whether the constructed discourse contexts do indeed bias towards laa1 or laa4 as completions of the sentence-fragments in the absence of intonation cues. For this aim, the critical sentence-fragments carried a neutral (laa3-compatible) intonation.

3.3.1. Methods

3.3.1.1. Participants

Sixty-four native Cantonese-Chinese speakers (mean age = 26.6 years, 32 female) participated in the experiment conducted at the Polytechnic University of Hong Kong. None of the participants reported any problem with hearing or any neurological or psychiatric disorders. All participants gave written informed consent and received HKD 80 for their participation.

3.3.1.2. Materials

The stimuli were created by combining each of the 100 critical sentence-fragments carrying a neutral intonation with its corresponding laa1-biasing context. Hereafter, we refer to this combination as the pro-laa1 context. The same 100 critical sentence-fragments were also combined with its corresponding laa4-biasing context. Hereafter, we refer to this combination as the pro-laa4 context (see General materials section above on how these fragments and contexts were constructed).

Next, we constructed two experimental lists. The first list comprised 50 sentence fragments with a neutral (laa3-) intonation preceded by the corresponding laa1-biasing contexts, and the other 50 sentence fragments with a neutral (laa3-) intonation preceded by the corresponding laa4-biasing contexts. For the second list, we reversed the assignment of contexts (laa1-biasing context vs. laa4-biasing context) to the critical sentence fragments. Thus within a list, each critical sentence fragment occurred only once, and across lists each critical sentence fragment contributed equally often to the two context bias conditions. The order of the experimental trials (each trial consisting of a context and its corresponding sentence fragment) was randomised within each list.

3.3.1.3. Task and procedure

Participants were comfortably seated in a sound-attenuated room. The experiment consisted of a practice block of five trials and an experimental block of 100 trials. A trial began with a warning beep of 50 ms, and 450 ms after the beep, a context and its corresponding sentence-fragment was presented via headphones. Participants were instructed to listen to the context and its sentence-fragment carefully and then to write down one of the four SFP-choices—laa1, laa4, laa3, aa3—that according to their intuition formed the best completion of the sentence-fragment. Participants wrote down their choice on an answer sheet with each line corresponding to an experimental trial. Participants had eight seconds to respond before the next trial began. Half of the participants received the first experimental list, and the other half of the participants received the second experimental list.

Three points on the procedure used in the present experiments should be noted here. First, we used a forced-choice task ('choose one out of four SFPs') rather than asking participants to provide the first response that came to their mind. We decided to use a forced-choice task because the use of some SFPs is interchangeable and the differences between these SFPs are very subtle (Kwok, 1984). Such differences usually are a matter of the speaker's assumption of the hearer's knowledge (and vice versa) and of the degree of illocutionary force (i.e. the speaker's intended effect on a hearer by producing an utterance, [Searle, 1965]). For example, Kwok (1984) reported that laa1 and aa1 can be used interchangeably in many instances even though they are two different imperative markers. In a case such as '買過個波' (buy another ball), adding laa1 or aa1 will both result in an imperative 'buy another ball!'. The only subtle difference is that laa1 signals a stronger and more insisting imperative. A forced-choice task can prevent such ambiguities in the participants' responses.

The specific SFP choices used in the present experiments (laa1, laa4, laa3, and aa3) are provided for the following reasons: The SFPs laa1, laa4 and laa3 are the SFPs that have been used in the stimulus construction. The SFP aa3 is included because aa3 can be put at the end of all types of sentences. It does not convey a specific speech act but serves to make an utterance sound more natural. Thus, aa3 provides our participants with the possibility to respond with an SFP that does not carry a specific pragmatic meaning in case that they feel that the discourse does not provide such a specific pragmatic meaning.

A final note concerns the way participants were asked to respond in the task. Since SFPs are primarily a property of spoken Chinese and there are no specific written forms for Cantonese SFPs (Fang, 2003; Kwok, 1984; A. C. Lau, 1995), the mapping between the sound form of an SFP and its written form is not necessarily the same for all Cantonese speakers (e.g., the SFP laa1 can be written as 喇 or 啦; Luke, 2007). Therefore, to ensure that the written responses can be interpreted in an unambiguous way, the sentence-fragment completion test was preceded by a dictation of the four SFP-choices (i.e. laa1, laa4, laa3, and aa3). The participants listened to four sentences ending with the SFPs laa1, laa4, laa3, and aa3 respectively. The four sentences were also printed on the top of each answer sheet, with a blank for the SFPs. Participants had to write down the SFP for each sentence in these blanks. Since three of the four SFP-choices can be expressed by the same Chinese character, participants were also asked to make sure to use different characters for the four SFP-choices. If they could not think of another character and used the same character for more than one SFP, they were told to use punctuation marks or numbers to distinguish between the SFP-choices. After writing down all four answers, participants had to repeat their answers again on top of the two pages of the answer sheet that was used during the sentence-fragment completion test. This way, we ensured that participants used the same written form for the four SFP-choices throughout the experiment.

3.3.1.4. Data analyses

The data were analysed using R (version 3.4.4) and RStudio (version 1.1.383). To assess the effect of context on the choice of SFPs, multinomial logistic regression was chosen. Multinomial logistic regression is similar to logistic regression, except that the probability distribution is multinomial instead of binomial. Thus, it is suited for examining the effect(s) of predictor variable(s) on a participant's choice when there are more than two choices (Agresti, 2003; Field, Miles, & Fields, 2012), as in the present case.

The multinomial logistic regression model produces a series of comparisons between the baseline choice category and the other choice categories, and at each level of predictor variables. This is done by calculating the log of odds-ratio (i.e. log-odds) for each of the other choice categories relative to the baseline, and then to use the log-odds as a linear function of the predictors. The significance of a predictor is assessed by z-statistics to indicate whether the regression coefficient (*b*) for a predictor differs significantly from zero. As estimates of effect size of the predictor, odd ratios (the upper and lower 95% confident interval of the odd ratio) were included. An odd ratio is the exponential of the *b* coefficient, and shows the relative amount of change from the baseline category to the outcome category due to the increase in one unit of a predictor variable. The recommended minimum odd ratio is 2.0, an odd ratio of 3.0 indicates a moderate effect, and a 4.0 shows a strong effect.

The multinomial regression model used the mlogit function from the package of the same name (Croissant, 2018). For the regression, the predictor variable was Context (pro-laa1 context, pro-laa4 context), and the contrast was coded using deviation coding (pro-laa1 context = 1, pro-laa4 context = -1), and the outcome variable was SFP-response (laa1, laa4, laa3, aa3). Two models were computed with two different baseline choice categories, one with laa1-response and the other with laa4-response as baseline choice category, in order to examine the effect of the two context biases on their respective target SFP-responses. In other words, each model served to compare the occurrence of laa1-response and laa4-response separately with the occurrence of other types of SFP-responses.

3.3.2. Results

Table 3.1 gives the mean proportion of the four SFP-response types in the pro-laa1 and the pro-laa4 contexts[10]. The proportions in each line do not necessarily always add up to 1.0 as a small number of cases in the pro-laa4 context ($M = .01$) have missing responses. The results of the two models are shown in Table 3.2 and Table 3.3 respectively.

Table 3.1.
Means, standard deviation of means (SD), and 95% confidence interval (95% CI) for the proportion of SFP-response as a function of Context conditions.

SFP-response	Conditions			
	Pro-laa1 context		Pro-laa4 context	
	M (SD)	95% CI	M (SD)	95% CI
laa1	0.83 (0.15)	[0.79, 0.87]	0.07 (0.05)	[0.06, 0.08]
laa4	0.05 (0.05)	[0.04, 0.06]	0.65 (0.17)	[0.61, 0.69]
laa3	0.09 (0.13)	[0.05, 0.12]	0.08 (0.07)	[0.06, 0.09]
aa3	0.03 (0.04)	[0.02, 0.04]	0.19 (0.16)	[0.15, 0.23]

In sum, the results of the two models indicated that, in the pro-laa1 context, participants were more likely to choose laa1-responses than the other three types of SFP-responses, and more likely to choose laa3-responses but less likely to choose aa3-responses than the laa4-responses. In the pro-laa4 context, participants were more likely to choose laa4-responses than the other three types of SFP-responses, and less likely to choose laa1-responses than the other three types of SFP-responses.

[10] Since Experiment 1 was conducted in the same session as Experiment 2 (even though the presentation order was counter-balanced), one might ask whether presenting Experiment 2 first affected the results of Experiment 1. The results were descriptively similar in the two presentation orders. Here are the mean proportion of responses for the pro-laa1 context condition when Experiment 1 is presented first vs. second: laa1-response (0.81 vs. 0.86), laa4-response (0.05 vs. 0.05), laa3-response (0.11 vs. 0.07), and aa3-response (0.03 vs. 0.02). Below are the mean proportion of responses for the pro-laa4 comtext condition when Experiment 1 is presented first vs. second: laa1-response (0.08 vs. 0.06), laa4-response (0.62 vs. 0.68), laa3-response (0.09 vs. 0.07), and aa3-response (0.20 vs. 0.18).

Table 3.2.
Experiment 1: Results of the multinomial logistic regression using Context as the predictor variable and SFP-response as the outcome variable with laa1-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa1 vs. laa4					
Intercept	-2.81 (0.08)	-34.57***	0.05	0.06	0.07
pro-laa4	5.05 (0.11)	46.89***	126.02	155.62	192.18
laa1 vs. laa3					
Intercept	-2.25 (0.06)	-35.88***	0.09	0.11	0.12
pro-laa4	2.35 (0.11)	21.02***	8.41	10.47	13.03
laa1 vs. aa3					
Intercept	-3.37 (0.11)	-31.75***	0.03	0.03	0.04
pro-laa4	4.37 (0.13)	33.20***	61.35	79.43	102.84

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 context. ***$p < .001$

Table 3.3.
Experiment 1: Results of the multinomial logistic regression using Context as the predictor variable and SFP-response as the outcome variable with laa4-response as the baseline choice category.

SFP-response	*b* (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa4 vs. laa1					
Intercept	2.81 (0.08)	34.57***	14.21	16.67	19.55
pro-laa4	-5.05 (0.11)	-46.89***	0.005	0.006	0.008
laa4 vs. laa3					
Intercept	0.56 (0.10)	5.69***	1.45	1.76	2.13
pro-laa4	-2.70 (0.12)	-22.53***	0.05	0.07	0.09
laa4 vs. aa3					
Intercept	-0.55 (0.13)	-4.23***	0.44	0.58	0.74
pro-laa4	-0.67 (0.14)	-4.85***	0.39	0.51	0.67

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 context. ***$p < .001$

3.3.3. Discussion

The results of Experiment 1 show that the pro-laa1 and pro-laa4 contexts successfully bias towards a completion of the sentence fragments (with neutral intonation) with the SFPs laa1 or laa4, respectively. At first sight, it seems as if the pro-laa1 context is stronger in inducing laa1-responses (83%) than the pro-laa4 context is in inducing laa4-responses (65%). However, this difference can almost completely be accounted for by the fact that in the pro-laa4 context, participants provided more aa3-responses (19%) than in the pro-laa1 context (3%). This is presumably the case because they treated aa3 as a variant of laa4. As mentioned above, some SFPs have very similar meaning and can be used interchangeably. This holds for the SFPs laa4 and aa4; both laa4 and aa4 serve to pose a clarification question to check for factual confirmation. However, one can only use laa4 to check whether the subject of enquiry is going to happen or has just happened. In contrast, aa4 has a broader usage; it serves to check whether the subject or enquiry is, in general, true or not. Some participants indeed reported after the experiment that they tend to treat laa4 and aa4 interchangeably. Furthermore, Cantonese listeners tend to use the written form of aa3 and aa4 interchangeably (Luke, 2007). It is, therefore, likely that some participants wrote down aa3 but actually meant aa4.

3.4. Experiment 2

Having established that our contexts do provide a bias towards the respective SFPs (laa1 or laa4), we now investigate potential effects of intonation. Can an intonation bias alone in the sentence fragments (without a preceding discourse context) bias towards a completion with laa1 or laa4, respectively? This question is addressed in Experiment 2.

As mentioned in the general introduction, previous studies suggest that utterance body-intonation can lead towards the eventually chosen SFP in Cantonese Chinese. Yet, so far this question has not been empirically addressed. The aim of Experiment 2 is to fill this gap by investigating whether the intonation of isolated semantically-neutral sentences can bias towards the choice of an SFP.

Methods

3.4.1.1. Participants

The participants were the same as those in Experiment 1. The presentation order of Experiments 1 and 2 was counter-balanced across participants. That is, half of the participants were first tested in Experiment 2 and then in Experiment 1 while the order of experiments was reversed for the other half of the participants. This way, we were able to test the context-bias effect and the intonation-bias effect within the same participants.

3.4.1.2. Materials

The stimuli were the 100 critical sentence-fragments carrying a laa1-compatible intonation (referred to as pro-laa1 intonation hereafter) and the other 100 critical sentence-fragments carrying a laa4-compatible intonation (referred to as pro-laa4 intonation hereafter; see General materials section above on how these sentence-fragments were constructed). The stimuli were divided into two experimental lists. The first list comprised 50 critical sentence-fragments with a laa1-compatible intonation and the remaining 50 sentence fragments with a laa4-compatible intonation. For the second list, we reversed the assignment of intonation bias (pro-laa1 intonation vs. pro-laa4 intonation) to the critical fragments. As a consequence, within a list, each critical sentence fragment occurred only once, and across lists each critical sentence fragment contributed equally often to each intonation condition. The order of the sentence-fragments was randomised within each list.

3.4.1.3. Task and procedure

Task and procedure were the same as in Experiment 1.

3.4.1.4. Data analyses

The analyses were the same as in Experiment 1 except that the factor Context was replaced by Intonation (with the levels pro-laa1 intonation vs. pro-laa4 intonation).

3.4.2. Results

Table 3.4 shows the mean proportion of the four SFP-response types in the pro-laa1 intonation and the pro-laa4 intonation conditions[11]. Note that the proportions in each line do not necessarily always add up to 1.0 as there was a small proportion of missing responses (pro-laa1 intonation: .006; pro-laa4 intonation: .004; neutral intonation: .003). Table 3.4 also contains a condition indicated as neutral intonation. These data were gathered on an independent sample of 64 participants. We will discuss these data below after the data of the pro-laa1 and pro-laa4 intonation conditions.

Table 3.4.
Means, standard deviation of means (SD), and 95% confidence interval (95% CI) for the proportion of SFP-response as a function of Intonation conditions.

SFP-response	Conditions					
	Pro-laa1 intonation		Pro-laa4 intonation		Neutral intonation	
	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI
laa1	0.57 (0.15)	[0.79, 0.87]	0.34 (0.11)	[0.32, 0.37]	0.43 (0.11)	[0.40, 0.46]
laa4	0.24 (0.10)	[0.22, 0.27]	0.41 (0.12)	[0.38, 0.44]	0.33 (0.10)	[0.30, 0.35]
laa3	0.10 (0.11)	[0.07, 0.13]	0.11 (0.09)	[0.09, 0.13]	0.10 (0.09)	[0.08, 0.13]
aa3	0.09 (0.07)	[0.07, 0.10]	0.13 (0.11)	[0.11, 0.16]	0.13 (0.11)	[0.10, 0.16]

[11] Since Experiment 2 was conducted in the same session as Experiment 1 (even though the presentation order was counter-balanced), one might ask whether presenting Experiment 1 first affected the results of Experiment 2. The results were descriptively similar in the two presentation orders. Here are the mean proportion of responses for the pro-laa1 intonation condition when Experiment 2 is presented first vs. second: laa1-response (0.57 vs. 0.56), laa4-response (0.2 vs. 0.28), laa3-response (0.12 vs. 0.08), and aa3-response (0.09 vs. 0.08). Below are the mean proportion of responses for the pro-laa4 intonation condition when Experiment 2 is presented first vs. second: laa1-response (0.35 vs. 0.34), laa4-response (0.39 vs. 0.44), laa3-response (0.13 vs. 0.09), and aa3-response (0.13 vs. 0.13).

The results of the model are shown in Table 3.5. and Table 3.6 respectively. The model demonstrated that, in the pro-laa1 intonation condition, laa1-responses were more likely to be chosen than the other three types of responses, and laa4-responses were more likely to be chosen than laa3- and aa3-responses. In the pro-laa4 condition, laa4-responses were more likely to be chosen than the other three types of responses while laa1-responses were less likely to be chosen than the other three types of responses.

The results of Experiment 2 show that the pro-laa1 intonation leads to more laa1-responses than the pro-laa4 intonation, and likewise, the pro-laa4 intonation leads to more laa4-responses than the pro-laa1 intonation. Again, as in Experiment 1 (context bias), the effect appears to be more pronounced for the pro-laa1 than for pro-laa4 intonation. But again, as in Experiment 1, this difference is largely compensated for by the aa3-responses as aa3 is treated as a variant of laa4 in Cantonese Chinese. Thus, the same account as given in the discussion of Experiment 1 holds here as well. When taking this into account, the biasing effect of the pro-laa1 and pro-laa4 intonation appears to be symmetrical.

Table 3.5.
Experiment 2: Results of the multinomial logistic regression using Intonation as the predictor variable and SFP-response as the outcome variable with laa1-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa1 vs. laa4					
Intercept	-0.88 (0.04)	-20.43***	0.38	0.41	0.45
pro-laa4	1.09 (0.06)	18.30***	2.64	2.97	3.33
laa1 vs. laa3					
Intercept	-1.74 (0.06)	-28.78***	0.16	0.17	0.20
pro-laa4	0.59 (0.09)	6.76***	1.52	1.80	2.13
laa1 vs. aa3					
Intercept	-1.90 (0.06)	-29.32***	0.13	0.15	0.17
pro-laa4	0.94 (0.09)	10.90***	2.17	2.57	3.05

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 intonation. ****p* < .001

To provide us with a comparison standard for the pro-laa1 and pro-laa4 intonation, we conducted an additional experimental session in which we presented the corresponding sentence fragments carrying a neutral (laa3-compatible) intonation (taken from Experiment 1). The data for the neutral intonation condition were gathered on an independent sample of 64 participants in order to avoid any carryover effects between the biasing intonation patterns and a neutral intonation pattern.

Sixty-four native Cantonese-Chinese speakers (mean age = 26.2 years; female = 38) participated in the neutral intonation condition. None reported any problem with hearing or any neurological or psychiatric disorders.

Table 3.6.
Experiment 1: Results of the multinomial logistic regression using Intonation as the predictor variable and SFP-response as the outcome variable with laa4-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa4 vs. laa1					
Intercept	0.88 (0.04)	20.43***	2.22	2.42	2.63
pro-laa4	-1.09 (0.06)	-18.30***	0.30	0.34	0.38
laa4 vs. laa3					
Intercept	-0.86 (0.07)	-12.91***	0.37	0.42	0.48
pro-laa4	-0.50 (0.09)	-5.58***	0.51	0.61	0.72
laa4 vs. aa3					
Intercept	-1.02 (0.07)	-14.41***	0.32	0.36	0.42
pro-laa4	-0.14 (0.09)	-1.60	0.73	0.87	1.03

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 intonation. *** $p < .001$

The stimuli were the 100 critical sentence-fragments carrying a laa3-compatible intonation, i.e. an intonation pattern in the sentence part preceding the SFP which should not bias towards laa1 or laa4 (see General materials section above for details on how the sentences with a laa3-compatible intonation were recorded). Four random orders of the 100 critical sentence fragments were generated. An equal number of participants were tested on each randomization.

The rightmost two columns of Table 3.4 show the mean proportion (and 95% confidence interval of the mean) of the four SFP-responses in the neutral intonation. Two multinomial logistic regression models were computed using Intonation as the predictor variable (neutral intonation [as intercept], pro-laa1 intonation, pro-laa4 intonation), and the contrast was coded using Helmert coding (neutral intonation = 2/3 vs. pro-laa1 intonation = -1/3 and pro-laa4 intonation = -1/3; pro-laa1 intonation = 1/2 vs. pro-laa4 intonation = -1/2), and the outcome variable was SFP-response (laa1, laa4, laa3, aa3). The two models used a different baseline choice category, one with laa1-response and the other with laa4-response, in order to examine the effect of the three intonation biases on the occurrence of laa1-response, and that of laa4-response relative to other types of SFP-responses. The results of the models are shown in Table 3.7 and Table 3.8 respectively

The model using laa1-response as the baseline choice category indicated laa1-responses were more likely to be chosen than laa4-responses in neutral intonation, and even more likely to be chosen when in the pro-laa1 intonation condition. In contrast, laa1-responses were less likely to be chosen than laa4-responses when in the pro-laa4 intonation than in the pro-laa1 condition. The same pattern was observed when comparing laa1-responses with the laa3- and aa3-responses..

Table 3.7.
Experiment 2: Results of the multinomial logistic regression using Intonation (neutral, pro-laa1, pro-laa4) as the predictor variable and SFP-response as the outcome variable with laa1-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa1 vs. laa4					
Intercept	-0.28 (0.03)	-9.66***	0.71	0.76	0.80
pro-laa1	-0.60 (0.05)	-11.60***	0.49	0.55	0.61
pro-laa4	0.48 (0.05)	9.68***	1.47	1.62	1.79
laa1 vs. laa3					
Intercept	-1.44 (0.04)	-33.23***	0.22	0.24	0.26
pro-laa1	-0.30 (0.07)	-4.01***	0.64	0.74	0.86
pro-laa4	0.29 (0.08)	3.78***	1.15	1.33	1.54
laa1 vs. aa3					
Intercept	-1.17 (0.04)	-30.01***	0.29	0.31	0.33
pro-laa1	-0.73 (0.08)	-9.61***	0.42	0.48	0.56
pro-laa4	0.22 (0.07)	3.12**	1.08	1.24	1.42

Note. CI = confidence interval, SE = standard error, Intercept = neutral intonation. $^{**}p < .01$, $^{***}p < .001$

Table 3.8.
Experiment 1: Results of the multinomial logistic regression using Intonation (neutral, pro-laa1, pro-laa4) as the predictor variable and SFP-response as the outcome variable with laa4-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa4 vs. laa1					
Intercept	0.28 (0.03)	9.66***	1.25	1.32	1.40
pro-laa1	0.60 (0.05)	11.60***	1.65	1.83	2.02
pro-laa4	-0.48 (0.05)	-9.68***	0.56	0.62	0.68
laa4 vs. laa3					
Intercept	-1.17 (0.04)	-26.02***	0.29	0.31	0.34
pro-laa1	0.30 (0.08)	3.79***	1.16	1.36	1.59
pro-laa4	-0.20 (0.08)	-2.63**	0.71	0.82	0.95
laa4 vs. aa3					
Intercept	-0.89 (0.04)	-22.03***	0.38	0.41	0.44
pro-laa1	-0.12 (0.08)	-1.52	0.75	0.88	1.04
pro-laa4	-0.27 (0.07)	-1.60***	0.67	0.77	0.88

Note. CI = confidence interval, SE = standard error, Intercept = neutral intonation. $^{**}p < .01$, $^{***}p < .001$

In addition, the model using laa4-response as the baseline choice category indicated that participants were more likely to choose laa4-responses than the other three types of SFP-responses when in the pro-laa4 intonation than in the other two intonation conditions. Participants were less likely to choose laa4-responses than laa3-

responses in the pro-laa1 intonation condition but more likely to choose laa4-responses than laa3-responses in the neutral condition. They were also more likely to choose laa4-responses than aa3-responses in the neutral intonation condition.

These results thus show that the pro-laa1 and pro-laa4 intonation conditions lead to an increase in the likelihood in the choice of the corresponding SFP-responses compared to the neutral intonation condition. Before turning to the discussion of Experiment 2, we will address the question whether the intonation patterns produced by the speaker recording our materials are representative for other speakers of Cantonese Chinese. We asked two other female native speakers of Cantonese Chinese to record our materials following the procedure documented above (see General materials section). Then we compared the pitch tracks of the three intonation conditions (pro-laa1, pro-laa2, neutral) within and between the three speakers. The results show systematic differences between the three intonation conditions for all three speakers, but only small differences between the three speakers within each intonation condition (see Chapter 4 for a summary of the results).

3.4.3. Discussion

The complete pattern of results shows that the proportion of laa1-responses was boosted by the pro-laa1 intonation compared to the neutral intonation (.57 vs. .43) and reduced by the pro-laa4 intonation compared to the neutral intonation (.34 vs. .43). A corresponding pattern is found for the laa4-responses: An increase in the pro-laa4 intonation was found relative to the neutral intonation (.41 vs. .33) whereas a decrease relative to the neutral baseline was found in the pro-laa1 intonation condition (.24 vs. .33). These results demonstrate that the pro-laa1 and the pro-laa4 intonation lead to more target SFP responses compared with the neutral intonation. This is, to our knowledge, the first empirical demonstration supporting previous suggestions that, in Chinese, intonation can provide a bias towards certain SFPs (Fang, 2003; Flynn, 2003; Fox et al., 2008).

One may wonder, however, why the neutral intonation condition yielded more laa1- and laa4-responses than laa3-responses. This could potentially be explained by how frequently Cantonese speakers use these three SFPs. To assess this, we asked the participants of the neutral intonation condition to indicate on a 7-point scale how frequently they used the specific SFPs laa1, laa4, laa3 and aa3 in their daily speech (from 1: very infrequent to 7: very frequent). This yielded mean ratings of 5.22 for laa1, 5.97 for laa4, 4.69 for laa3, and 4.81 for aa3, and median ratings of 6 for laa1 and laa4, and 5 for laa3, and aa3.

A Friedman test showed significant differences between the subjective frequencies of the SFP-responses, $\chi = 50.75$, $p < .001$. Follow-up Wilcoxon signed-rank tests using Bonferroni-adjusted alpha-level ($p = .006$) showed that participants tend to use laa1 more frequently than laa3, $W = 809$, $Z = 2.64$, $p = .008$, $r = .33$; and aa3, $W = 731.5$, Z = 1.78, $p = .07$, $r = .223$; and to use laa1 less frequently than laa4, $W = 131$, Z

= 131, $p < .001$, $r = .44$. They also tend to use laa4 more frequently than laa3, $W = 1155$, $Z = 5.05$, $p < .001$, $r = .63$; and aa3, $W = 904.5$, $Z = 4.40$, $p < .001$, $r = .55$. There is no significant difference between the subjective frequency of laa3 and aa3, $W = 427.5$, $Z = 0.56$, $p = .58$, $r = .07$. The results indicate that the participants tend to use laa1 and laa4 more frequently than laa3 and that laa3 is the least frequently used SFP amongst the four SFP-responses. This finding is consistent with the proportion of laa3-responses observed in the neutral intonation condition. Therefore, it is possible that, in the neutral intonation condition (where there is no specific SFP-bias) participants tend to choose the more frequently used SFPs, such as laa1 and laa4, instead of laa3.

To sum up, the experiments so far have established the following findings: In Experiment 1, we demonstrated that discourse context, in the absence of any specific intonation cues, systematically influences listeners' comprehension of pragmatic meaning. In Experiment 2, we showed that intonation, in the absence of a discourse context, also systematically influences listeners' comprehension of pragmatic meaning. This gives us the possibility to pit the effects of discourse context and intonation against each other. Therefore, the next step is to assess the relative impact of discourse context and intonation to listeners' understanding of speaker's meaning. This topic is addressed in Experiment 3

3.5. Experiment 3

The goal of Experiment 3 is to investigate whether the effects of discourse context and intonation for a listener's comprehension of pragmatic meaning are independent of each other (which would predict additive effects of discourse context and intonation), or whether one of the two biases (discourse context or intonation) is stronger than the other. To this end, we compare participants' choice of an SFP between the following conditions: a) a match condition (i.e. intonation bias matches the context bias), b) a mismatch condition (intonation bias mismatches the context bias), and c) a neutral condition (a biasing discourse context with no intonation bias). The last condition was taken from Experiment 1 to provide a comparison standard for the match and the mismatch conditions.

As discussed in the introduction, the available evidence on this question is not clear, primarily because the relevant studies do not provide independent measurements of the impact of discourse context vs. intonation (as obtained in the present Experiments 1 and 2). Therefore in terms of predictions, it is possible that, similar to the findings of Aguert et al. (2010) in French, Cantonese listeners may prefer intonation to context, more specifically discourse context in the case of the current experiment, for the recognition of pragmatic meaning. On the other hand, Cantonese listeners may prefer discourse context to intonation as shown in Regel et al.'s study (2010) for German, or may use both equally in the recognition of pragmatic meaning, as in the study by Capelli et al. (1990) for English.

3.5.1. Methods

3.5.1.1. Participants

The participants were the same as in the neutral (laa3-) intonation condition of Experiment 2. The presentation order of the two experimental sessions was counter-balanced across participants.

3.5.1.2. Materials

The stimuli were created by cross-splicing each of the 100 critical sentence-fragments carrying laa1-compatible intonation and laa4-compatible intonation with its corresponding laa1-biasing and laa4-biasing context. This resulted in the following four conditions: a) laa1-biasing context with a laa1-compatible intonation (referred to as pro-laa1 match condition hereafter); b) laa1-biasing context with a laa4-compatible intonation (pro-laa1 mismatch condition hereafter); c) laa4-biasing context with a laa4-compatible intonation (pro-laa4 match condition hereafter); and d) laa4-biasing context with a laa1-compatible intonation (pro-laa4 mismatch condition hereafter; see General materials section above on how these fragments and contexts were constructed).

Next, the 400 stimuli were equally divided into four experimental lists. Each list contained 100 critical sentence-fragments with 25 contributing to each of the four conditions. As a consequence, within each list, each critical sentence fragment occurred only once, and across the four lists each critical sentence fragment contributed equally often to the four conditions. The order of the sentence-fragments was randomised within each list.

3.5.1.3. Data analyses

The analyses were similar to Experiment 1 with an additional factor Match (i.e. match between context bias and intonation bias) coded using deviation coding (match = 1 vs. mismatch = -1).

3.5.2. Results

Table 3.9 shows the mean proportion of the four SFP-response types given in the four conditions. For ease of comparison, we also repeat the results of the pro-laa1 context and the pro-laa4 context conditions of Experiment 1 (i.e. with neutral intonation) in this table. Table 3.9 shows that the pro-laa1 match condition of the present experiment gives very similar results as the pro-laa1 condition of Experiment 1, and that the pro-laa4 match condition of the present experiment gives very similar results as the pro-laa4 condition of Experiment 1. Thus, an intonation bias (of which we know that it has an effect on its own, Experiment 2) that goes in the same direction as the context bias does not affect the overall bias.

The picture is clearly different for the mismatch conditions. The pro-laa1 mismatch condition of the present experiment has a lower proportion of laa1 choices (.77) than the pro-laa1 condition of Experiment 1 (.83), and the pro-laa4 mismatch condition of the present experiment has a lower proportion of laa4 choices (.58) than the pro-laa4 condition of Experiment 1 (.65). These lower proportions of laa1 and laa4 choices in the respective mismatch conditions go together with a corresponding increase in the proportion of intonation consistent SFPs (i.e., laa4 in the pro-laa1 mismatch condition and laa1 in the pro-laa4 mismatch condition). Thus, an intonation bias that goes in the opposite direction of the context bias appears to reduce the effect of the context bias. The results of the models can be found in Table 3.10 and Table 3.11.

For the results of the model using laa1-response as the baseline choice category, laa1-responses were more likely to be chosen than the other three types of SFP-responses in the pro-laa1 match condition. However, laa1-responses were less likely to be chosen than laa4-responses, but not the other two responses when comparing the pro-laa1 match with the pro-laa1 mismatch condition. The opposite pattern was observed in the pro-laa4 conditions, that is, laa1-responses were less likely to be chosen than the other three types of SFP-responses when comparing the pro-laa4 match condition with the pro-laa1 match condition, but laa1-responses were more likely to be chosen than the other three types of SFP-responses when comparing the pro-laa4 mismatch condition with the pro-laa4 match condition.

For the results of the model using laa4-response as the baseline choice category, laa4-responses were more likely to be chosen than the other three types of SFP-responses when comparing the pro-laa4 match condition with the pro-laa1 match condition. Also, laa4-responses were more likely to be chosen than laa1-responses but not the other two types of responses when comparing the pro-laa1 match with the pro-laa1 mismatch condition. When comparing the pro-laa4 mismatch condition with the pro-laa4 match condition, laa4-responses were less likely to be chosen than laa1- and laa3-responses but not aa3-responses.

In sum, the results thus show that a mismatch in the SFP-bias between discourse context and intonation reduces the likelihood of the SFP-responses corresponding to the discourse-context bias: Participants were less likely to choose laa1-responses in the pro-laa1 mismatch condition than in the pro-laa1 match condition; likewise, they were less likely to choose laa4-responses in the pro-laa4 mismatch condition than in the pro-laa4 match condition. The mismatch also increased the likelihood of choosing SFP-responses corresponding to the mismatching intonation bias: The pro-laa1 mismatch condition was more likely to elicit laa4-responses than the pro-laa1 match condition. Similarly, the pro-laa4 mismatch condition was more likely to elicit laa1-responses than the pro-laa4 match condition.

Table 3.9.
Means, standard deviation of means (SD), and 95% confidence interval (95% CI) for the proportion of SFP-responses in the four experimental conditions in Experiment 3. The results of Experiment 1 are added under the heading "neutral intonation" to allow for a direct comparison.

SFP-response	Match				Mismatch				Neutral Intonation			
	Pro-laa1		Pro-laa4		Pro-laa1		Pro-laa4		Pro-laa1		Pro-laa4	
	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI
laa1	0.82 (0.07)	[0.78, 0.86]	0.07 (0.09)	[0.04, 0.09]	0.77 (0.19)	[0.72, 0.82]	0.13 (0.13)	[0.10, 0.16]	0.83 (0.15)	[0.79, 0.87]	0.07 (0.05)	[0.06, 0.08]
laa4	0.05 (0.08)	[0.03, 0.07]	0.63 (0.23)	[0.58, 0.69]	0.08 (0.09)	[0.05, 0.10]	0.58 (0.23)	[0.52, 0.63]	0.05 (0.05)	[0.04, 0.06]	0.65 (0.17)	[0.61, 0.69]
laa3	0.09 (0.13)	[0.05, 0.12]	0.07 (0.11)	[0.05, 0.10]	0.10 (0.13)	[0.07, 0.13]	0.09 (0.09)	[0.07, 0.11]	0.09 (0.13)	[0.05, 0.12]	0.08 (0.07)	[0.06, 0.09]
aa3	0.04 (0.07)	[0.02, 0.06]	0.22 (0.19)	[0.17, 0.26]	0.05 (0.07)	[0.03, 0.07]	0.19 (0.16)	[0.15, 0.23]	0.03 (0.04)	[0.02, 0.04]	0.19 (0.16)	[0.15, 0.23]

Table 3.10.
Experiment 3: Results of the multinomial logistic regression using Context and Match as the predictor variable and SFP-response as the outcome variable with laa1-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa1 vs. laa4					
Intercept	-2.77 (0.11)	-24.34***	0.05	0.06	0.08
pro-laa1 mismatch	0.44 (0.15)	2.98**	1.16	1.56	2.08
pro-laa4 match	5.00 (0.15)	32.86***	109.88	148.03	199.43
pro-laa4 mismatch	-1.17 (0.20)	-6.00***	0.21	0.31	0.45
laa1 vs. laa3					
Intercept	-2.24 (0.09)	-25.15***	0.09	0.11	0.13
pro-laa1 mismatch	0.22 (0.12)	1.81	0.98	1.25	1.59
pro-laa4 match	2.35 (0.16)	14.73***	7.66	10.46	14.30
pro-laa4 mismatch	-0.67 (0.21)	-3.19**	0.34	0.51	0.77
laa1 vs. aa3					
Intercept	-2.99 (0.13)	-23.69***	0.04	0.05	0.06
pro-laa1 mismatch	0.30 (0.17)	1.79	0.97	1.35	1.89
pro-laa4 match	4.14 (0.17)	24.75***	45.26	62.82	87.20
pro-laa4 mismatch	-1.05 (0.22)	-4.75***	0.23	0.35	0.54

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 match. ***p* < .01, ****p* < .001

Table 3.11.
Experiment 3: Results of the multinomial logistic regression using Context and Match as the predictor variable and SFP-response as the outcome variable with laa4-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa4 vs. laa1					
Intercept	2.77 (0.11)	24.34***	12.78	15.98	19.97
pro-laa1 mismatch	-0.44 (0.15)	-2.98**	0.48	0.64	0.86
pro-laa4 match	-5.00 (0.15)	-32.86***	0.01	0.01	0.01
pro-laa4 mismatch	1.17 (0.20)	6.00***	2.20	3.23	4.74
laa4 vs. laa3					
Intercept	0.53 (0.14)	3.79***	1.29	1.70	2.23
pro-laa1 mismatch	-0.22 (0.18)	-1.20	0.56	0.80	1.15
pro-laa4 match	-2.65 (0.17)	-15.66***	0.05	0.07	0.10
pro-laa4 mismatch	0.50 (0.213	2.22*	1.06	1.65	2.57
laa4 vs. aa3					
Intercept	-0.22 (0.17)	-1.31	1.29	1.70	2.23
pro-laa1 mismatch	-0.14 (0.22)	-0.64	0.56	0.80	1.15
pro-laa4 match	-0.86 (0.18)	-4.85***	0.05	0.07	0.10
pro-laa4 mismatch	0.12 (0.24)	0.52	1.06	1.65	2.57

*Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 intonation. *p < 05, **p < .01, ***p < .001*

3.5.3. Discussion

In Experiment 3, we tested whether discourse context and intonation contribute independently to a listener's comprehension of pragmatic meaning (which would predict additive effects of discourse context and intonation), or whether one of the biases (discourse context or intonation) has a stronger influence than the other. To this end, we compared the proportion of SFP responses between the mismatch conditions and the match conditions. The mismatch conditions encompassed an intonation that has a different SFP-bias than the discourse context (e.g., pro-laa1 mismatch condition consists of a pro-laa1 discourse context with a pro-laa4 intonation) while the match conditions consisted of an intonation with the same SFP bias as the discourse context (e.g., pro-laa1 match consists of a pro-laa1 context and a pro-laa1 intonation).

The results of Experiment 3 demonstrate that a mismatch between intonation and discourse bias shifts the SFP responses towards the SFP that matches the intonation. That is, there was a decrease in laa1-response and an increase in laa4-response in the pro-laa1 mismatch condition compared to the pro-laa1 match condition. The same holds for the pro-laa4 mismatch condition when compared to the pro-laa4 match condition: a decrease of laa4-responses but an increase of laa1-responses. The mismatch did not affect laa3-responses and aa3-responses.

However, the influence of intonation appears to be quite restricted, as illustrated by the following two points: First, even though intonation moderates the effect of discourse-context bias on the choice of an SFP, the choice of an SFP is still mainly determined by the discourse context. The majority of SFP-responses corresponded to the SFP-bias of the discourse context in the mismatch conditions (0.77 and 0.58 for pro-laa1 mismatch and pro-laa4 mismatch, respectively). Second, an additive effect of intonation and discourse context is not present when we compare the data of Experiment 3 with those of Experiment 1 by two additional multinomial regression models using three levels of Match with Helmert coding (neutral = 2/3 vs. match = -1/3 and mismatch = -1/3; match =1/2 vs. mismatch = -1/2) and laa1-responses and laa4-responses as the respective baseline categories (see Table 3.12 and Table 3.13). Importantly, the results show that the occurrence of laa1-responses do not differ between pro-laa1 match condition in Experiment 3 (when intonation and discourse context match in SFP-bias) and that of pro-laa1 condition of Experiment 1 (where the discourse context biases towards the SFPs laa1 or laa4, respectively, and the intonation is neutral). The same holds for laa4-responses. That means, when intonation bias and discourse bias converge, this convergence does not strengthen the SFP-bias of the discourse context alone, i.e. in the absence of an intonation bias.

To summarize, the results of Experiment 3 indicate that discourse context is the primary cue for selecting a SFP, which is similar to the findings of Regel et al. (2010). However, different from Regel et al., intonation can still moderate the strength of the context bias, even though the effect of intonation on context bias is rather restricted. In particular, intonation only slightly moderates context bias if the SFP-bias of intonation does not match that of discourse context. On the other hand, when intonation and discourse context match in their SFP-bias, the intonation does not add to the bias induced by a context.

3.6. General Discussion

The present study examined the (relative) contribution of discourse context and intonation to the comprehension of pragmatic meaning, in particular the recognition of speech acts. The influence of the two kinds of information was measured by the choice of sentence-final particles in Cantonese Chinese. In the first two experiments, we established that discourse context and intonation affect the choice of an SFP and thus comprehension of pragmatic meaning. Experiments 1 and 2 demonstrate that context alone (in the absence of an intonation bias) and intonation alone (in the absence of a context bias) can both contribute to the comprehension of pragmatic meaning. Experiment 3 pitted the intonation bias against the context bias to investigate to what extent listeners rely on context versus intonation in comprehending pragmatic meaning. In the match conditions, context and intonation biased towards the same SFP. In the mismatch conditions, context and intonation biased towards two different SFPs. The results of Experiment 3 showed that, compared with the match conditions, the mismatch conditions shifted the distribution of the SFP-responses from the context bias towards the intonation bias. Nevertheless, context was still the primary determinant of SFP choice: Regardless of whether the intonation bias matched or mismatched the context bias, there were still more SFP-responses matching the context bias relative to the other SFP responses in all conditions.

We also compared the results of the match conditions in Experiment 3 with the results of a biasing context with neutral intonation in Experiment 1. They did not differ. This indicates that adding an intonation bias that converges with the context bias does not add to the bias carried by the context. By contrast, an intonation bias that diverges from the context bias does reduce the impact of the context bias, as shown by the comparison of the results of the mismatch conditions of Experiment 3 with the results of a biasing context with neutral intonation in Experiment 1.

In the following, we will discuss the findings of the three experiments in light of two topics: a) the relative role of context, intonation, and SFP in the interpretation of pragmatic meaning in Cantonese Chinese; and b) implications for models of the comprehension of pragmatic meaning.

Table 3.12.
Experiment 3 vs. Experiment 1: Results of the multinomial logistic regression using Context and Match (match, neutral, neutral) as the predictor variable and SFP-response as the outcome variable with laa1-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa1 vs. laa4					
Intercept	-2.81 (0.08)	-34.57***	0.47	0.57	0.69
pro-laa1 neutral	0.04 (0.14)	0.30	0.74	1.04	1.45
pro-laa1 mismatch	0.49 (0.13)	3.87***	0.95	1.29	1.75
pro-laa4 match	5.05 (0.12)	46.89***	11.75	14.86	18.80
pro-laa4 neutral	-0.05 (0.19)	-0.27	0.63	0.95	1.43
pro-laa4 mismatch	-1.22 (0.16)	-7.49***	0.40	0.58	0.84
laa1 vs. laa3					
Intercept	-2.25 (0.06)	-35.88***	8.39	9.49	10.73
pro-laa1 neutral	0.23 (0.10)	2.19*	0.65	0.80	0.98
pro-laa1 mismatch	0.01 (0.11)	0.06	0.80	0.99	1.23
pro-laa4 match	2.35 (0.11)	21.02***	0.08	0.10	0.12
pro-laa4 neutral	0.00 (0.19)	0.00	0.68	1.00	1.47
pro-laa4 mismatch	-0.67 (0.18)	-3.80**	1.38	1.96	2.76
laa1 vs. aa3					
Intercept	-3.37 (0.11)	-31.75***	0.26	0.33	0.41
pro-laa1 neutral	0.68 (0.15)	4.41***	1.11	1.57	2.24
pro-laa1 mismatch	0.38 (0.16)	2.30*	1.00	1.45	2.11
pro-laa4 match	4.37 (0.13)	33.20***	5.74	7.59	10.02
pro-laa4 neutral	-0.23 (0.21)	-1.10	0.50	0.79	1.25
pro-laa4 mismatch	-1.28 (0.20)	-6.57***	0.35	0.54	0.83

*Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 match. * $p < .05$, ** $p < .01$, *** $p < .001$*

Table 3.13.
Experiment 1 vs. Experiment 3: Results of the multinomial logistic regression using Context and Match (match, neutral, neutral) as the predictor variable and SFP-response as the outcome variable with laa4-response as the baseline choice category.

SFP-response	b (SE)	Z	95% CI for odds ratios		
			Lower	Odds ratio	Upper
laa4 vs. laa1					
Intercept	2.81 (0.08)	34.57***	8.39	9.49	10.73
pro-laa1 neutral	-0.04 (0.14)	-0.30	0.80	0.99	1.23
pro-laa1 mismatch	-0.49 (0.13)	-3.87**	0.65	0.80	0.98
pro-laa4 match	-5.05 (0.12)	-46.89***	0.08	0.10	0.12
pro-laa4 neutral	0.05 (0.19)	0.27	0.68	1.00	1.47
pro-laa4 mismatch	1.22 (0.16)	7.49***	1.38	1.96	2.76
laa4 vs. laa3					
Intercept	0.56 (0.10)	5.69***	0.47	0.57	0.69
pro-laa1 neutral	0.05 (0.21))	0.24	0.63	0.95	1.43
pro-laa1 mismatch	-2.70 (0.12)	-22.53***	11.75	14.86	18.80
pro-laa4 match	0.55 (0.19)	2.88**	0.40	0.58	0.84
pro-laa4 neutral	-0.26 (0.16)	-1.65	0.95	1.29	1.75
pro-laa4 mismatch	-0.04 (0.17)	-0.21	0.74	1.04	1.45
laa4 vs. aa3					
Intercept	-0.55 (0.13)	-4.23***	0.26	0.33	0.41
pro-laa1 neutral	-0.67 (0.14)	-4.85***	5.74	7.59	10.02
pro-laa1 mismatch	-0.18 (0.22)	-0.82	0.50	0.79	1.25
pro-laa4 match	-0.06 (0.21)	-0.30	0.35	0.54	0.83
pro-laa4 neutral	0.34 (0.21)	1.59	1.00	1.45	2.11
pro-laa4 mismatch	0.20 (0.19)	1.02	1.11	1.57	2.24

Note. CI = confidence interval, SE = standard error, Intercept = pro-laa1 match. * $p < .05$, ** $p < .01$, *** $p < .001$

3.6.1. The relative role of discourse context and intonation in the comprehension of pragmatic meaning in Cantonese Chinese

To the best of our knowledge, the present study is the first to empirically test the role of discourse context and intonation and to compare the relative importance of these two factors for the comprehension of pragmatic meaning in Cantonese Chinese. The present study shows that both discourse context and intonation individually contribute to the comprehension of pragmatic meaning. However, Cantonese listeners rely more on discourse context than on intonation for the comprehension of pragmatic meaning, as reflected in their choice of SFPs.

Why does discourse context have a more dominant role over intonation in the comprehension of pragmatic meaning? This can be accounted for by two considerations: The strong reliance on discourse context in Cantonese speech comprehension, and the reduced role of intonation in Cantonese.

As for the latter consideration, it is generally agreed upon that both SFPs and intonation are used for expressing pragmatic meaning in Cantonese Chinese. However, speakers of Cantonese Chinese appear to rely more on SFPs than on intonation for this purpose (Cheung, 1986; Kwok, 1984; S.-P. Law, 1990; J. P. W. Li, Law, Lam, & To, 2012; Yau, 1980). Why is this the case? In a tonal language like Cantonese, intonation is much more restricted in its patterns and its functions as compared to intonation in non-tonal languages, like English (Cheung, 1986; Fang, 2003; Kwok, 1984; S.-P. Law, 1990; Pennington & Ellis, 2000; Wakefield, 2012; Yau, 1980). This is due to the fact that Cantonese Chinese has six lexical tones, which are contrasted by their pitch height and pitch contour (Bauer & Benedict, 1997). Since intonation is also characterised by the same pitch parameters, this leaves limited space for intonation without altering the relative pitch height and contour of the lexical tones (Chao, 1968; Cheung, 1986; Fang, 2003; Lam, 2002; Mai, 1998).

In contrast to the limited role of intonation, Cantonese Chinese has a rich inventory of SFPs, which amount to more than 30 monosyllabic SFPs (Kwok, 1984; Leung, 1992) and about 45 so-called particle clusters (Leung, 1992). The size of the SFP inventory in Cantonese has been reported to be the largest amongst all languages studied so far (Leung, 1992; Luke, 1990; Yau, 1980). Given these observations, linguists as Yau (1980, p. 51) have proposed that 'there is a mutual compensation between SP and intonation patterns and that the more a language relies on the use of SP in expressing sentential connotations, the less significant will be the role played by intonation patterns, and vice versa'[12]. Yau (1980) further suggests that English and Cantonese mark two extremes on this continuum: English has only a very limited number of SFPs (e.g., 'huh' and 'oh') and uses mainly intonation for conveying pragmatic meaning, whereas Cantonese has a large inventory of SFPs and uses intonation restrictively for expressing pragmatic meaning (i.e. this function is largely taken over by SFPs).

Despite the fact that SFPs take over a large portion of the pragmatic function of intonation in Cantonese Chinese, the use of intonation and SFPs for expressing pragmatic meaning are not mutually exclusive (Fang, 2003; Fox et al., 2008; Mai, 1998). Most of the time, Cantonese-Chinese speakers use both kinds of information for expressing pragmatic meaning: Intonation indicates the broad category of sentential mood of the utterance (e.g., interrogative, imperative, declarative, expressive) while SFPs strengthen and fine tune the pragmatic meaning of the utterance (Fang, 2003).

A second possible reason for Cantonese listeners' preference for discourse context over intonation in the comprehension of pragmatic meaning can be attributed to the strong reliance on discourse context in general in Cantonese Chinese. Previous studies on various varieties of Chinese, and particularly on Cantonese, have shown that listeners in these languages rely very strongly on contextual information during speech comprehension (Chen, 1992; Chen et al., 2000; Kung, Chwilla, & Schriefers, 2014; S.-P. Law et al., 2013; P. Li & Yip, 1998; Ye & Connine, 1999). The main reason for this is

[12] Yau uses the abbreviation SP to refer to sentence-final particles

that lexical ambiguity is very common in these languages, and therefore listeners rely a lot on discourse context to disambiguate these lexical ambiguities.

Against the background of the limited role of intonation and the strong role of discourse context in Cantonese, it is likely that, in Cantonese Chinese, listeners rely more on discourse context than intonation to comprehend pragmatic meaning. Thus it could easily be that the relative role of discourse context and intonation may be different in other languages, in particular in languages in which intonation plays a more dominant role and has more varied forms. Further studies will be required to explore this question.

3.6.2. Implications for models of the comprehension of pragmatic meaning

Current models on the comprehension of pragmatic meaning do not make clear predictions as to how contextual and intonational information are combined in the process of comprehending pragmatic meaning. In particular, the models cannot account for the main finding of the present study, namely that context and intonational information are weighted differently depending on whether they converge on the same pragmatic meaning or whether they diverge on different pragmatic meanings. Here, we will discuss some options and evaluate them in the light of the present data.

A first theoretical option would be a compositional strictly additive model. In such a model, context bias and intonation bias would be of equal importance, and the strength of the intonation bias and the strength of the context bias would be combined in an additive way to provide evidence for a certain pragmatic meaning. Such a model would be reminiscent of the competition model of Bates and MacWhinney (e.g., Bates & MacWhinney, 1987; Bates et al., 1984; MacWhinney & Bates, 1989) though the latter model was proposed to account for the comprehension of literal meaning (but see Aguert et al., [2010] for a related proposal for pragmatic meaning).

The extreme opposite position would hold that one cue dominates completely: In the present studies, context bias—as the stronger bias—might completely overrule intonation bias. Both options are contradicted by our data. The first option is clearly contradicted by the results of Experiment 3 which show that a convergence of the context cue and the intonation cue does not result in a stronger bias towards a pragmatic meaning than the context cue alone (i.e. context bias with neutral intonation). The second option is contradicted by the fact that, in Experiment 3, a divergence of the context cue and the intonation cue leads to a weaker bias towards the contextually signalled pragmatic meaning than the context cue alone.

These results thus show that our intonation manipulation was strong enough to affect SFP choice (Experiment 2 and the mismatch conditions of Experiment 3). Still the intonation cue only comes into play when context and intonation diverge onto different pragmatic meanings. By contrast, if context and intonation converge, then the intonation bias is not considered in comprehending pragmatic meaning.

Based on these results, we propose the 'speaker perspective hypothesis' of pragmatic meaning comprehension. According to this hypothesis, listeners compute pragmatic meaning from the perspective of a speaker. This hypothesis is similar to Pickering and Garrod's (2013) proposal about prediction in language comprehension. According to Pickering and Garrod, listeners predict upcoming words of an utterance via the language production system, i.e. by taking a speaker perspective.

With respect to the role of intonation in the comprehension of pragmatic meaning, from the speaker's perspective, intonation is a contextualisation cue, i.e. it relates the content of an utterance to the preceding utterances in the conversation (Gumperz, 1982; Holmes, 1984; House, 2006; Vandepitte, 1989). Put differently, intonation is the speaker's means of expressing a contextually (or intentionally) defined pragmatic meaning. Following this logic, intonation should adhere to the speaker's context and intention: When the listener adopts this speaker perspective, only a divergence between intonation and context will affect comprehension of pragmatic meaning, because it signals that the speaker deviates from the normal state of affairs in which intonation follows context bias and intention. By contrast, a convergence of context bias and intonation bias simply signals the 'normal state of affairs' and thus intonation is simply taken as the result of context bias and intention.

The 'speaker perspective hypothesis' makes some interesting predictions for future research. Above, we indicated that a tonal language like Cantonese Chinese has only limited pitch space for realizing intonation compared to non-tonal languages like English. So when running a similar study as the present one in non-tonal languages, it might turn out that intonation can provide a stronger bias than the one established for Cantonese Chinese. Nevertheless, the 'speaker perspective hypothesis' would predict that also in this case, intonation only affects pragmatic meaning comprehension when context bias and intonation bias diverge, but not when they converge.

To conclude, the present study provides an interesting starting point for a systematic cross-language comparison of the effects of intonation and context on the comprehension of pragmatic meaning. By first independently assessing the strength of discourse context and intonation and then pitting them against each other, we can systematically examine their relative role in different languages. As stated above, the 'speaker perspective hypothesis' predicts that such cross-language variation should only occur in cases of divergence between context bias and intonation bias, but not in case of convergence.

Chapter 4

An Investigation of the Realisation of Utterance-body Intonation as a Function of Sentence-Final Particles (SFPs)

4.1. Introduction

Compared to lexical tones in Cantonese or intonation in English, intonation in Cantonese is substantially understudied (Cheung, 1986; Fang, 2003; Flynn, 2003; Fok-Chan, 1974; Fox et al., 2008; Kwok & Luke, 1986; Lam, 2002; S.-P. Law, 1990; Ma et al., 2006; Mai, 1998; Vance, 1976; Xu & Mok, 2011), and even less is known about whether, and how, the realisation of intonation can be affected by SFPs (Fang, 2003; Fox et al., 2008; Mai, 1998). The limited number of studies that investigated the latter question suggests that the tone of the SFPs can affect the realisation of utterance-body intonation (i.e. the intonation contour leading up to the utterance-final syllable). That is, if the tone of the SFP is high, it can lead to a global rise in pitch register of the utterance-body intonation, and if the tone of the SFP is low it can lead to a global drop. However, these studies are descriptive in nature. To the best of our knowledge, this proposal has not been supported by any empirical data.

This issue is addressed in the present chapter by investigating the pitch realisation of the intonation contours of identical carrier sentences preceding three different SFPs (laa1, laa3, and laa4). These three SFPs occupy the high extreme, mid-level, and the low-extreme of the tone space, respectively. Based on the proposal mentioned above, the pitch of the utterance-body intonation will be realised as a function of the pitch height of the tone of the SFP: That is, the pitch of the intonation contour preceding laa1 (hereafter pro-laa1 intonation) would be higher than that of the pitch of the intonation contour preceding laa3 (hereafter neutral intonation), which is subsequently higher than the pitch of the intonation contour preceding laa4 (hereafter pro-laa4 intonation).

Another issue addressed by the present chapter is to check the generalisability of the materials of Chapter 3 and 4; that is, to check whether the intonation patterns of the speaker who recorded our stimuli (hereafter Speaker 1) are comparable to those of other speakers of Cantonese Chinese. To this end, the intonation patterns produced by Speaker1 were compared with those produced by another two female speakers of Cantonese Chinese.

To collect the acoustic data, three female native Hong Kong Cantonese-Chinese speakers aged from 27 to 60 years (mean age= 38 years) were recorded. None of the speakers had any speech or motor disorders. The three speakers each read the 300 sentence-tokens used in Chapter 3, which consisted of 100 carrier sentences each ending with 3 different SFPs (laa1, laa3, laa4). The recording of Speaker 1 was used for the stimuli for the experiments reported in Chapters 3 and 4. The details of the design of the stimuli can be found in the General Materials section of Chapter 3. Below, we first describe the data analyses and results of Speaker 1 which will be followed by the data analyses and results of all three speakers together. The latter part is to check whether the intonation patterns produced by Speaker 1 are generalisable to the other two speakers.

4.2. Speaker 1

4.2.1. Data Analyses

In order to validate whether there is a difference in pitch between the three intonation contours (pro-laa1, neutral, pro-laa4), we performed acoustic measurements on the pitch tracks of the sentence-tokens used in the experiments of Chapter 3. We first extracted the pitch contours of the sentence-tokens in semitones using Praat (Boersma & Weenink, 2011, version 5.03). Since the 300 sentence-tokens differ in duration, we normalised the duration of the pitch contours of all these tokens by dividing each token in 10 equally long intervals. Then, we calculated the pitch value of the start and end of the token and the pitch values of each of the 10 intervals by averaging the fundamental frequency (F_0) within each interval. The end of a token refers to the time point just before the onset of the SFP. Next, we performed z-score normalization on the pitch values of all tracks. This procedure allows us to conduct comparisons of the pitch tracks of different speakers, so that we can ensure that the intonation patterns of our experimental materials are representative for other speakers of Cantonese Chinese.

To analyse the pitch contours of the three intonation patterns, three separate repeated-measures ANOVAs were performed on the mean pitch value at the start (beginning of pitch contour), at the end point (end of pitch contour), and at the average 10 time-points within the utterances. For the first two ANOVAs, Intonation (pro-laa1, neutral, pro-laa4) was included as the within-subject factor; as for the last ANOVA, Intonation and Time-point (1 to 10) were included as the within-subject factors. ANOVAs and other analyses were by-item (i.e. the 100 carrier sentences were the observational units).

4.2.2. Results for Speaker 1

For the ANOVA at the start point, the results for Speaker 1 did not show a main effect of Intonation, $F(2, 198) = 2.65$, $MSE = 3.14$, $p > .05$, $\eta^2 = .03$. The ANOVA for the 10 time-points show a main effect of Intonation, $F(2, 198) = 19.73$, $MSE = 9.20$, $p < .0001$, $\eta^2 = .02$; and an interaction between Intonation and Time-point, $F(18, 1782) = 5.11$, $MSE = 1.42$, $p < .0001$, $\eta^2 = .006$. To follow-up on this interaction, separate ANOVAs with Intonation as within-subject factor were computed for each of the 10 time-points. The results showed only a significant main effect of Intonation from time-point 3 to time-point 10 (see Table 4.2.1).

To examine the simple effects of Intonation, follow-up pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) were computed to compare the differences between the intonation patterns at time points 3 to 10. The results of the pairwise t-tests can be found in Table 4.2.2: The pitch of the pro-laa1 intonation was significantly higher than the pro-laa3 intonation at time-points 3 to10, and higher than the pro-laa4 intonation at time-points 3, and at time points 6 to 10. No significant difference was found between the neutral intonation and the pro-laa4 intonation at these time-points.

Table 4.2.1.
Results of the ANOVAs at the 10-time points for Speaker 1

Time-point	df	*MSE*	*F*	*p*	η^2
1	2, 198	2.26	0.86	0.42	0.01
2	2, 198	2.03	0.75	0.48	0.01
3	2, 198	1.98	4.59	0.01	0.04
4	2, 198	2.12	4.51	0.01	0.04
5	2, 198	2.14	6.77	0.001	0.06
6	2, 198	2.18	8.17	0.0004	0.08
7	2, 198	2.32	10.15	<.0001	0.09
8	2, 198	2.32	20.53	<.0001	0.09
9	2, 198	1.95	37.00	<.0001	0.27
10	2, 198	2.78	18.07	<.0001	0.15

Regarding the ANOVA for the end point, there was a main effect of Intonation, $F(2,198) = 1.38$, $MSE = 4.30$, $p = .25$, $\eta^2 = .002$. Post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) demonstrated a higher pitch value for the pro-laa1 intonation than for the neutral intonation, $t(99) = 7.31$, $p < .001$, 98.3% CI[2.56 2.57], $d = 0.78$; and also for the pro-laa4 intonation, $t(99) = 11.86$, $p < .001$, 98.3% CI[3.45 3.46], $d = 1.23$. Subsequently, the neutral intonation also had a higher pitch than the pro-laa4 intonation, $t(99) = 2.64$, $p = .009$, 98.3% CI[0.88 0.90], $d = 0.32$.

To summarise, the results of Speaker 1 showed significant differences in pitch between the intonation patterns. In particular, the pitch of the pro-laa1 intonation was significantly higher than that of the neutral and pro-laa4 intonation in the second-half of the pitch contour, and the pitch of the neutral intonation was higher than the pro-laa4 intonation at the very end of the pitch contour (see Panel (B) of Figure 4.2.1 for an illustration)

Table 4.2.2.
Results of t-tests comparing the pitch values between the pro-laa1 intonation (laa1), the neutral intonation (laa3), and the pro-laa4 intonation (laa4) at time-points 3 to 10 for Speaker 1. The 98.3% confidence interval (98.3% CI) is computed for the mean difference between the pro-laa1 and pro-laa4 contexts.

Time-point	Comparisons	df	*t*	*p*	98.3% CI		*d*
3	laa1 vs. laa3	99	2.49	.01	[0.421	0.422]	0.25
	laa3 vs. laa4	99	0.81	.42	[0.162	0.163]	0.08
	laa1 vs. laa4	99	2.63	.01	[0.584	0.585]	0.27
4	laa1 vs. laa3	99	2.72	.01	[0.585	0.586]	0.27
	laa3 vs. laa4	99	-0.65	.52	[-0.122	-0.121]	0.07
	laa1 vs. laa4	99	2.17	.03	[0.463	0.464]	0.22
5	laa1 vs. laa3	99	3.99	.0001	[0.726	0.726]	0.40
	laa3 vs. laa4	99	-0.83	.41	[-0.168	-0.167]	0.08
	laa1 vs. laa4	99	2.39	.02	[0.558	0.559]	0.24
6	laa1 vs. laa3	99	3.97	.0001	[0.753	0.754]	0.40
	laa3 vs. laa4	99	-0.23	.82	[-0.049	-0.048]	0.02
	laa1 vs. laa4	99	3.11	.002	[0.704	0.705]	0.31
7	laa1 vs. laa3	99	4.83	<.0001	[0.935	0.936]	0.48
	laa3 vs. laa4	99	-1.09	.27	[-0.247	-0.246]	0.11
	laa1 vs. laa4	99	3.08	.002	[0.689	0.690]	0.31
8	laa1 vs. laa3	99	5.40	<.0001	[1.226	1.227]	0.54
	laa3 vs. laa4	99	-0.50	.62	[-0.096	-0.095]	0.05
	laa1 vs. laa4	99	5.20	<.0001	[1.131	1.132]	0.52
9	laa1 vs. laa3	99	8.61	<.0001	[1.406	1.407]	0.86
	laa3 vs. laa4	99	0.62	.54	[0.124	0.125]	0.06
	laa1 vs. laa4	99	6.86	<.0001	[1.531	1.532]	0.69
10	laa1 vs. laa3	99	5.28	<.0001	[1.261	1.262]	0.53
	laa3 vs. laa4	99	-0.34	.74	[-0.071	-0.070]	0.03
	laa1 vs. laa4	99	4.65	<.0001	[1.190	1.191]	0.46

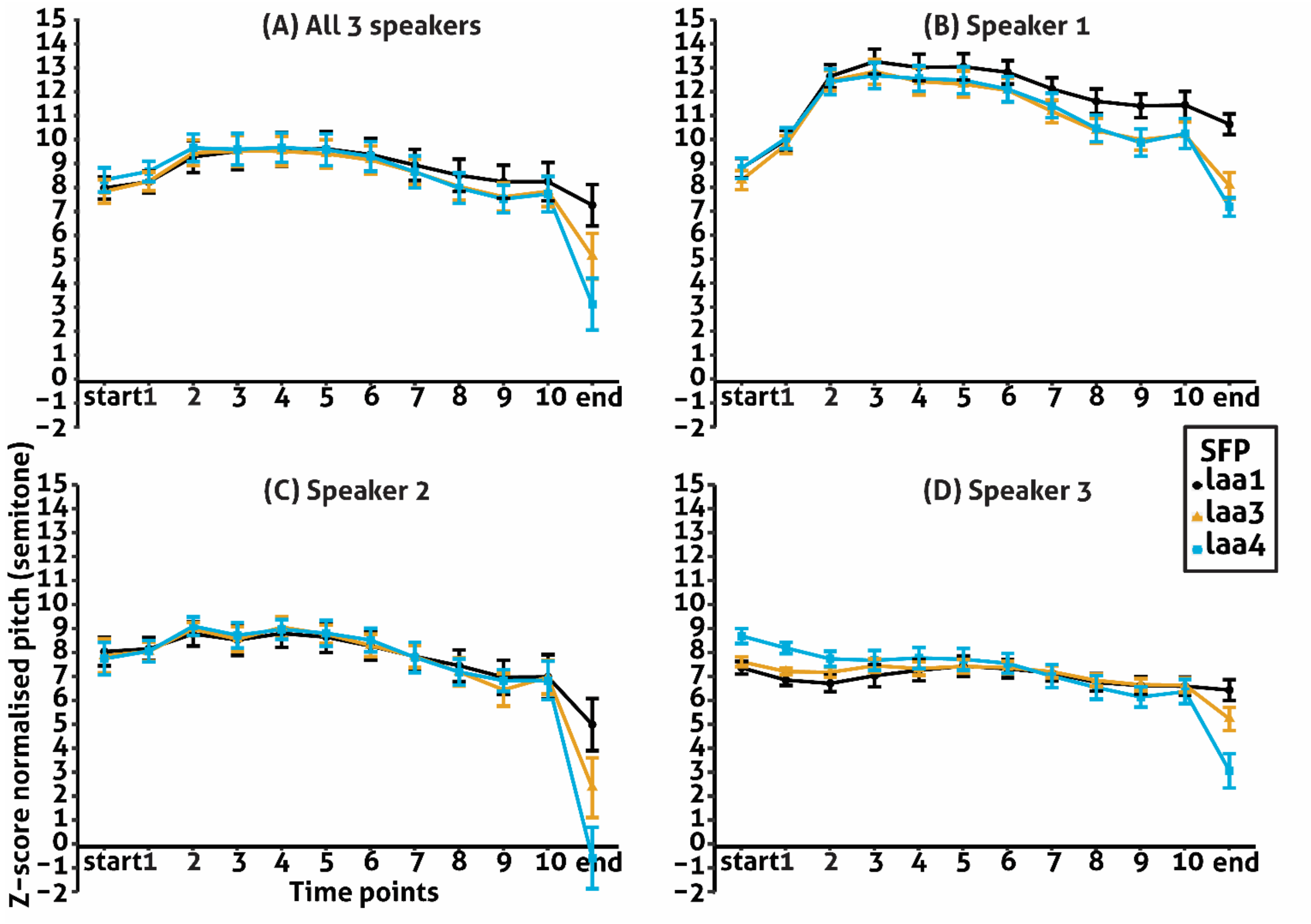

Figure 4.2.1.

Mean z-score normalized pitch (semitone) of the three time-normalised intonation contours for 10 equally long intervals and for the start and end of each token (preceding SFP) for Speaker 1 in Panel (B), Speaker 2 in Panel (C), Speaker 3 in Panel (D), and for the average of all three speakers in Panel (A). The black line shows the pro-laa1 intonation. The orange line shows the pro-laa4 intonation. The blue line shows the neutral intonation. Error bars represent upper/lower 95% confidence intervals of the mean.

4.3. Speaker 1 compared to other speakers

4.3.1. Data analyses

In order to check whether the intonation patterns produced by Speaker 1 are representative for other speakers of Cantonese Chinese, we asked another two female speakers of Cantonese Chinese to record the 300 sentence-tokens in the same way as originally done (see General materials section in Chapter 3). A check of the overall pitch of the three speakers showed that they had very different pitch registers. Therefore, to ensure the pitch values were comparable across speakers, z-score normalisation was performed on the pitch tracks for each of the three speakers separately.

In the next step, we analysed the pitch contours of the three intonation patterns from all three speakers by performing three separate repeated-measures ANOVAs on the mean pitch values at the start (beginning of pitch contour), at the end point (end of pitch contour), and at the average 10 time-points within the utterances. For the first two ANOVAs, Intonation (pro-laa1, neutral, pro-laa4), and Speaker were included as the within-item factors; as for the last ANOVA, Intonation, Speaker and Time-point (1 to 10) were included as the within-item factors. All analyses are by-item analyses treating the 100 carrier sentences as observational units.

4.3.2. Results

Start point. For the ANOVA at the start point, the results showed a main effect of Intonation, $F(2, 198) = 3.75$, $MSE = 4.92$, $p = .03$, $\eta^2 = .008$, a main effect of Speaker, $F(2, 198) = 9.83$, $MSE = 6.28$, $p < .001$, $\eta^2 = .008$, and an interaction between Intonation and Speaker, $F(4, 396) = 3.99$, $MSE = 5.24$, $p = .003$, $\eta^2 = .02$. Follow-up comparisons were performed on the main effect of Intonation, and the interaction between Intonation and Speaker. For the former, post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) disclosed a lower pitch for the neutral intonation than the pro-laa4 intonation after the adjusted alpha level, $t(99) = -2.46$, $p = .0158$, 98.3% CI[-0.49 -0.48], $d = 0.25$.

To examine the interaction between Intonation and Speaker, post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) were used for comparing the F_0 between the three intonation patterns for each Speaker. For Speaker 1, same as above, the results did not disclose a difference between the three intonation patterns (all $ps > .04$). For Speaker 2, the results also did not reveal a difference between the three intonation patterns, (all $ps > .10$). For Speaker 3, the results demonstrated a higher pitch for the pro-laa4 intonation than the neutral intonation, $t(99) = 6.33$, $p < .001$, 98.3% CI[1.08 1.08], $d = 0.63$, and also the pro-laa1 intonation, $t(99) = 6.77$, $p < .001$, 98.3% CI[1.32 1.33], $d = 0.67$, but no difference between the pro-laa1 intonation and the neutral intonation ($p > .1$).

Timepoints 1-10. The ANOVA for the 10 time-points showed two main effects: Intonation, $F(2, 198) = 3.65$, $MSE = 9.37$, $p = .03$, $\eta^2 = .0007$, and Speaker, $F(2, 198) = 1592.47$, $MSE = 10.82$, $p < .001$, $\eta^2 = .39$. The ANOVA also found an interaction between Intonation and Speaker, $F(4, 396) = 8.55$, $MSE = 9.98$, $p < .001$, $\eta^2 = .004$, between Intonation and Time-point, $F(18, 1782) = 4.91$, $MSE = 2.43$, $p < .0001$, $\eta^2 = .02$, and between Intonation, Speaker, and Time-point, $F(36, 3564) = 1.57$, $MSE = 2.26$, $p = .016$, $\eta^2 = .001$.

To follow-up on the interaction between Intonation, Speaker, and Time-point, separate ANOVAs with Intonation as within-subject factor were computed at each of the 10 time points. The results showed a significant main effect of Intonation at time-points 1, 2, 8, 9 and 10, a main effect of Speaker, and an interaction between Intonation and Speaker across all time-points (see Table 4.2.3).

To examine the simple effects of Intonation, follow-up pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) were computed to compare the differences between the intonation patterns at the time-points 1, 2, 8, 9, and 10. The results of the pairwise t-tests can be found in Table 4.2.4. The pitch of the pro-laa4 intonation was significantly higher than that of the neutral intonation at time-points 1 and 2, and higher than the pro-laa1 intonation at time-point 1. Furthermore, the pitch of the pro-laa1 intonation was significantly higher than the pro-laa3 intonation at time-points 8, and 9, and than the pro-laa4 intonation at time-points 8, 9, and 10.

Table 4.2.3.
Results of the ANOVAs with Intonation (I) and Speaker (S) as within-subject factors at each of the 10-time points

Time-	Intonation (I)					Speaker (S)					I*S				
point	df	*MSE*	*F*	*p*	η^2	df	*MSE*	*F*	*p*	η^2	df	*MSE*	*F*	*p*	η^2
1	2, 198	2.31	8.06	<.001	.01	2, 198	3.82	136.07	<.001	.31	4, 396	2.62	6.08	<.001	.02
2	2, 198	2.00	5.16	.007	.003	2, 198	3.21	684.54	<.001	.71	4, 396	1.87	5.36	<.001	.006
3	2, 198	2.60	.25	.78	.0002	2, 198	4.83	529.88	<.001	.66	4, 396	2.70	3.74	.005	.005
4	2, 198	2.36	0.79	.45	.0006	2, 198	4.90	443.19	<.001	.65	4, 396	2.18	3.92	.003	.005
5	2, 198	2.63	1.36	.25	.001	2, 198	4.37	488.02	<.001	.64	4, 396	2.38	3.03	.017	.004
6	2, 198	2.63	1.50	.23	.001	2, 198	4.05	506.64	<.001	.63	4, 396	2.64	3.23	.012	.005
7	2, 198	3.18	2.64	.07	.003	2, 198	4.98	348.79	<.001	.55	4, 396	3.05	2.63	.03	.005
8	2, 198	3.94	6.50	.002	.008	2, 198	4.92	304.99	<.001	.49	4, 396	3.30	3.87	.004	.008
9	2, 198	3.36	13.74	<.001	.02	2, 198	4.54	326.15	<.001	.49	4, 396	3.24	6.45	<.001	.014
10	2, 198	6.27	3.60	.03	.005	2, 198	7.00	220.96	<.001	.37	4, 396	6.28	2.43	.047	.007

Table 4.2.4.

Results of t-tests comparing the pitch values between the pro-laa1intonation (laa1), the neutral intonation (laa3), and the pro-laa4 intonation (laa4) at time-points 3 to 10. The 98.3% confidence interval (98.3% CI) is computed for the mean difference between the pro-laa1 and pro-laa4 contexts.

Time-point	Comparisons	df	*t*	*p*	98.3% CI		*d*
1	laa1 vs. laa3	99	-0.14	.89	[-0.021	-0.016]	0.01
	laa3 vs. laa4	99	-3.48	<.001	[-0.424	-0.419]	0.35
	laa1 vs. laa4	99	-3.72	<.001	[-0.443	-0.439]	0.37
2	laa1 vs. laa3	99	-1.33	.19	[-0.165	-0.159]	0.13
	laa3 vs. laa4	99	-2.12	.04	[-0.210	-0.206]	0.21
	laa1 vs. laa4	99	-2.98	.004	[-0.372	-.367]	0.30
8	laa1 vs. laa3	99	3.15	.002	[0.467	0.473]	0.32
	laa3 vs. laa4	99	0.41	.68	[0.062	0.069]	0.04
	laa1 vs. laa4	99	3.05	.003	[0.532	0.539]	0.31
9	laa1 vs. laa3	99	4.10	<.001	[0.630	0.637]	0.41
	laa3 vs. laa4	99	0.59	.56	[0.081	0.087]	0.06
	laa1 vs. laa4	99	4.71	<.001	[0.714	0.721]	0.47
10	laa1 vs. laa3	99	2.17	.03	[0.405	0.413]	0.22
	laa3 vs. laa4	99	0.55	.58	[0.108	0.116]	0.06
	laa1 vs. laa4	99	2.36	.002	[0.516	0.525]	0.24

To follow up on the interaction between Intonation and Speaker at each time-point, separate ANOVAs with Intonation as within-subject factor were computed for each of the 10 time-points for each speaker. The results of all speakers can be found in Table 4.2.5. As mentioned above, for Speaker 1, the pitch of the three intonation patterns differed from time-points 3 to 10. Post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level (p = .0167) were computed to compare between the three intonation patterns for Speaker 1 from time-points 3 to 10. The results of the pairwise t-tests can be found in Table 4.2.2: The pitch of the pro-laa1 intonation was significantly higher than the pro-laa3 intonation at time-points 3 to10, and higher than the pro-laa4 intonation at time-points 3, and at time points 6 to 10. No significance difference was found between the neutral intonation and the pro-laa4 intonation at these time-points (see the pitch tracks in panel (B) of Figure 4.2.1).

For Speaker 2, the ANOVAs did not show a difference between the three intonation patterns in all time-points 1 to 10 (see also the pitch tracks in panel (C) of Figure 4.2.1). For Speaker 3, the ANOVAs show a difference between the three intonation patterns from time points 1 to 4. To test the simple effect of Intonation for Speaker 3, post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level (p = .0167) were performed on time-points 1 to 4. The results can be found in Table 4.2.6: Speaker 3 had a higher pitch for the pro-laa4 intonation than the pro-laa1 intonation from time-points 1 to 4, and than the neutral intonation at time-points 1, 2, and 4. The neutral intonation also showed a higher pitch than the pro-laa1 intonation at time-points 1 and 2 (see the pitch tracks in panel (D) of Figure 4.2.1).

End point. The ANOVA for the end point showed a main effect of Intonation, $F(2, 198) = 78.12$, $MSE = 14.24$, $p < .001$, $\eta^2 = .13$, a main effect of Speaker, $F(2, 198) = 219.83$, $p < .001$, $\eta^2 = .31$; and an interaction between Intonation and Speaker, $F(4, 396) = 4.13$, $p < .003$, $\eta^2 = .01$. To examine the simple effect of Intonation, post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level ($p = .0167$) were computed. The results demonstrated a higher pitch value for the pro-laa1 intonation than for the neutral intonation, $t(99) = 6.85$, $p < .001$, 98.3% CI[2.13 2.14], $d = 0.69$, and also for the pro-laa4 intonation, $t(99) = 12.61$, $p < .001$, 98.3% CI[4.13 4.14], $d = 1.26$. The neutral intonation also had a higher pitch than the pro-laa4 intonation, $t(99) = 5.69$, $p < .001$, 98.3% CI[1.99 2.01], $d = 0.57$.

Table 4.2.5.

Results of the ANOVAs with Intonation as the within-subject factor at each of the 10-time points for all three speakers

Time-point	df	Speaker 1				Speaker 2				Speaker 3			
		MSE	*F*	*p*	η^2	*MSE*	*F*	*p*	η^2	*MSE*	*F*	*p*	η^2
1	2, 198	2.26	0.86	0.42	0.01	4.45	0.08	.92	.001	0.84	57.55	<.001	.37
2	2, 198	2.03	0.75	0.48	0.01	2.61	1.01	.36	.01	0.19	23.59	<.001	.19
3	2, 198	1.98	4.59	0.01	0.04	4.53	0.25	.78	.002	1.49	7.16	<.001	.07
4	2, 198	2.12	4.51	0.01	0.04	3.24	0.53	.59	.01	1.36	5.67	.004	.05
5	2, 198	2.14	6.77	0.001	0.06	3.92	0.18	.83	.002	1.34	2.14	.12	.02
6	2, 198	2.18	8.17	0.0004	0.08	4.13	0.45	.64	.004	1.61	0.88	.41	.01
7	2, 198	2.32	10.15	<.0001	0.09	4.90	0.01	.99	<.0001	2.07	0.44	.65	.004
8	2, 198	2.32	20.53	<.0001	0.09	6.18	0.38	.69	.004	2.09	1.09	.33	.01
9	2, 198	1.95	37.00	<.0001	0.27	6.51	1.14	0.32	.01	1.39	5.97	<.001	.06
10	2, 198	2.78	18.07	<.0001	0.15	13.64	.05	.95	.001	2.40	0.86	.42	.01

Table 4.2.6.

Results of t-tests comparing the pitch values between the pro-laa1 intonation (laa1), the neutral intonation (laa3), and the pro-laa4 intonation (laa4) at time-points 1 to 4 for Speaker 3. The 98.3% confidence interval (98.3% CI) is computed for the mean difference between the pro-laa1 and pro-laa4 contexts.

Time-point	Comparisons	*t*	*p*	98.3% CI	*d*
1	laa1 vs. laa3	-3.13	.002	[-0.359 -0.359]	.31
	laa3 vs. laa4	-7.91	<.001	[-0.982 -0.981]	.79
	laa1 vs. laa4	-9.10	<.001	[-1.341 -1.340]	.91
2	laa1 vs. laa3	-3.09	.003	[-0.462 -0.462]	.31
	laa3 vs. laa4	-4.16	<.001	[-0.561 -0.561]	.42
	laa1 vs. laa4	-6.32	<.001	[-1.024 -1.023]	.63
3	laa1 vs. laa3	-2.20	.03	[-0.418 -0.417]	.22
	laa3 vs. laa4	-1.43	.16	[-0.226 -0.225]	.14
	laa1 vs. laa4	-3.82	<.001	[-0.643 -0.643]	.38
4	laa1 vs. laa3	-0.41	.67	[-0.072 -0.072]	.04
	laa3 vs. laa4	-2.77	.007	[-0.442 -0.441]	.28
	laa1 vs. laa4	-3.26	.002	[-0.513 -0.513]	.33

To examine the interaction between Intonation and Speaker, post-hoc pairwise t-tests using Bonferroni-adjusted alpha-level (p = .0167) were used for comparing the F_0 between the three intonation patterns for each Speaker. For Speaker 1, same as above, the results show a higher pitch for the pro-laa1 intonation than the neutral intonation, $t(99) = 7.79$, $p < .001$, 98.3% CI[2.56 2.57], $d = 0.78$, and also the pro-laa4 intonation, $t(99) = 12.66$, $p < .001$, 98.3% CI[3.45 3.46], $d = 1.27$. The neutral intonation also showed a higher pitch than the pro-laa4 intonation, $t(99) = 3.24$, $p = .002$, 98.3% CI[0.88 0.90], $d = 0.32$. For Speaker 2, the results also revealed a higher pitch for the pro-laa1 intonation than the neutral intonation, $t(99) = 3.61$, $p < .001$, 98.3% CI[2.62 2.66], $d = 0.36$, and also the pro-laa4 intonation, $t(99) = 6.91$, $p < .001$, 98.3% CI[5.55 5.59], $d = 0.69$. The neutral intonation also showed a higher pitch than the pro-laa4 intonation, $t(99) = 3.41$, $p < .001$, 98.3% CI[2.92 2.96], $d = 0.34$. For Speaker 3, similar to Speaker 1 and 2, the results also demonstrated a higher pitch for pro-laa1 intonation than neutral intonation, $t(99) = 3.73$, $p < .001$, 98.3% CI[1.20 1.21], $d = 0.37$, and also pro-laa4 intonation, $t(99) = 9.33$, $p < .001$, 98.3% CI[3.37 3.38], $d = 0.93$. The neutral intonation also showed a higher pitch than the pro-laa4 intonation, $t(99) = 5.56$, $p < .001$, 98.3% CI[2.16 2.18], $d = 0.56$.

To summarise, the results of all three speakers together resembled the results of Speaker 1 only: Importantly, there are significant differences in pitch between the intonation patterns. In particular, the pitch of the pro-laa1 intonation is significantly higher than that of the neutral and pro-laa4 intonation in the second-half of the pitch contour, and the pitch of the neutral intonation is higher than the pro-laa4 intonation at the very end of the pitch contour (see Panel (A) of Figure 4.2.1 for the average pitch tracks of all three speakers, and Panel (B, C, and D) for the pitch tracks of Speaker 1, 2, and 3, respectively). However, note that there was a general difference in pitch register between the three speakers to begin with, and there is also a difference in the results between only Speaker 1 and all three speakers together: For the latter, the pro-laa4 intonation had a higher pitch at the beginning compared to the other two intonation contours, which is likely attributed by Speaker 3.

4.4. Discussion

The present results did not support the previous proposal that the tone of a SFP can affect the realisation of utterance-body intonation (Fang, 2003; Fox et al., 2008; Mai, 1998). That is, if the tone of a SFP is high, it can lead to a global rise in pitch register of the utterance-body intonation, and if the tone of a SFP is low it can lead to a global drop. Instead of a global change in pitch register, the present results only show an effect of the tone of a SFP on the last parts of the utterance-body intonation (i.e. time-points 8 to the end of the utterance), and especially on the degree of declination—i.e. the gradual lowering of F_0 in the course of the utterance, which is commonly observed in Cantonese and other tonal and non-tonal languages (Flynn, 2003; Gussenhoven, 2004; Lee, 2004; Ma et al., 2006; Yuen, 2007). In particular, the degree of declination depends on the F_0 height of the tone of a SFP: such that if the SFP has a high tone (e.g., the high-level tone 1), the degree of declination is small, but if the SFP has a low tone (e.g., the low-falling tone 4), the degree of declination is large (see Figure 4.2.1). The reason for this different degree of declination could be related to speakers' anticipation of the F_0 reset at the start of the following intonational phrase (Flynn, 2003). In this case, the next intonational phrase consists solely of the SFP, and thus the F_0 reset hinges on the F_0 of the tone of the SFP.

The present results provide one of the first pieces of empirical evidence on the effect of SFPs on the realisation of the utterance-body intonation. However, it is important to note that we had only a small number of speakers and a large degree of variation in the pitch register between speakers. Further replication and research, therefore, is needed.

Chapter 5

Tracking Pragmatic-Meaning Computation On-Line in the Pragmatic-Violation Paradigm: An ERP Study on Cantonese Sentence-Final Particles

Based on:
Kung, C., Chwilla, D., Fung, R., & Schriefers, H. (Submitted). Tracking pragmatic-meaning computation on-line in the pragmatic-violation paradigm: An ERP study on Cantonese sentence-final particles.

Abstract

We investigated the neural processes underlying the on-line interpretation of pragmatic meaning in Cantonese-Chinese speakers. In contrast with Indo-European languages, pragmatic meaning in Cantonese Chinese can be coded in clearly identifiable units, the so-called sentence-final particles (SFPs). These SFPs provide a precise point in time at which pragmatic meaning becomes available, and therefore, allow us to track pragmatic meaning computation in real time.

We use a pragmatic-violation paradigm similar to the standard semantic-violation paradigm. Cantonese-Chinese speakers listened to two types of discourse contexts ending with a SFP. One context strongly biased towards an SFP (laa1) which conveys a request. The other context strongly biased towards a different SFP (laa4) which signals an echo question. The contexts thus build up a strong expectation towards a specific SFP. We manipulated the SFP such that it either matched or mismatched this context bias.

The mismatching SFPs, compared to the matching SFPs, elicited a broadly distributed positivity from 318 to 816 ms measured from SFP onset. This positivity is taken to reflect a reanalysis triggered by the conflict between the pragmatic meaning carried by the context bias and the pragmatic meaning carried by the mismatching SFP. The early onset of the positivity shows that the computation of pragmatic meaning is very rapid and that an SFP's pragmatic meaning is related to the wider discourse immediately.

Keywords: pragmatic processing, speech acts, event-related potentials, sentence-final particles, Cantonese Chinese

5.1. Introduction

When listening to a sentence like 'I take coffee with cream and...', a listener is very likely to complete the utterance with 'sugar' rather than 'socks'. This classic example from Kutas and Hillyard (1980) demonstrates that a listener constructs the meaning of an utterance incrementally as the utterance unfolds. Numerous studies have demonstrated this incremental computation of meaning using a semantic-violation paradigm (see Kutas, van Petten, & Kluender, 2006 and van Berkum, 2012 for reviews). This paradigm has two main components: a context and a target word. The context ('I take coffee with cream and...' in the example above) builds up an expectation towards a target word. The target word, such as 'sugar' (congruent target word) or 'socks' (incongruent target word) in the example above, provides a precise point at which the semantic expectation is violated or not. Previous studies have shown time and again that a semantic violation (e.g., the target word 'socks' in the example above) triggers an immediate brain response—the so-called N400 effect, and occasionally a P600 effect (for details, see section 5.1.1).

In contrast to the large amount of research on the processing of literal meaning, the research on the on-line processing of pragmatic meaning has only emerged recently (Astésano et al., 2004; Coulson & Kutas, 2001; Coulson & Lovett, 2010; Egorova, Shtyrov, & Pulvermuller, 2013; Filik, Leuthold, Wallington, & Page, 2014; Gisladottir, Chwilla, & Levinson, 2015; Hoeks et al., 2013; Nieuwland, Ditman, & Kuperberg, 2010; Nieuwland & Kuperberg, 2008; Noveck & Posada, 2003; Otten, Mann, van Berkum, & Jonas, 2016; Paulmann, Jessen, & Kotz, 2012; Politzer-Ahles, Fiorentino, Jiang, & Zhou, 2013; Regel, Coulson, & Gunter, 2010; Regel, Gunter, et al., 2010; Regel, Meyer, & Gunter, 2014; Spotorno, Cheylus, Van Der Henst, & Noveck, 2013; van Berkum, Holleman, Nieuwland, Otten, & Murre, 2009; van Berkum, van den Brink, Tesink, Kos, & Hagoort, 2008). In particular, only very few studies have examined the processing of speech acts.

Why is there such a gap between the research efforts concerning literal meaning and pragmatic meaning, and particularly speech acts? This can in part be explained by the fact that, in Indo-European languages (e.g., French, Dutch and English)—the languages used most frequently in psycholinguistic research—literal meaning is rather straightforward and explicitly coded while pragmatic meaning is often not explicitly coded. Pragmatic meaning goes beyond literal meaning and is based on the context in which an utterance is made and/or various other means, such as intonation and multiple syntactic markers. As a result, it is difficult to determine the precise point in an utterance that reveals the pragmatic meaning of the utterance. This poses a problem for research on the on-line computation of pragmatic meaning in Indo-European languages.

Here, Cantonese Chinese comes into play. Pragmatic meaning in this language can be coded in clearly identifiable units—so-called sentence-final particles (SFPs, for details see section 5.1.2 below). Sentence-final particles in Cantonese Chinese provide a precise point in an utterance at which its pragmatic meaning becomes available, and thus provide an ideal testing ground to investigate the on-line comprehension of pragmatic meaning by means of ERPs. To this aim, in the present study, we will use a paradigm similar to the semantic-violation paradigm mentioned above. But instead of a semantic violation, we will induce a pragmatic violation of speech acts using SFPs.

Before providing the details of the present study, we will first discuss the literature on the following topics: the on-line comprehension of speech acts and other kinds of pragmatic meaning in spoken language, and a description of Cantonese SFPs.

5.1.1. The on-line comprehension of speech acts and other kinds of pragmatic meaning in spoken language

Compared to the extensive ERP literature on the on-line comprehension of literal meaning, relatively few ERP studies have examined the on-line comprehension of pragmatic meaning. Amongst these studies, many use a word-by-word reading paradigm, which suffers from a low ecological validity for generalising to understanding the processing of pragmatic meaning in spoken language, which is conveyed by a variety of acoustic cues that are absent in reading. Only a handful of these studies have investigated how pragmatic meaning is computed in spoken language (Astésano et al., 2004; Filik et al., 2014; Gisladottir et al., 2015; Paulmann et al., 2012; Regel, Coulson, et al., 2010; Regel, Gunter, et al., 2010; Regel et al., 2014; van Berkum et al., 2008), and even fewer examined how listeners process speech acts (Astésano et al., 2004; Gisladottir et al., 2015; Paulmann et al., 2012). In the following, we will briefly review previous ERP studies that examined the processing of various types of pragmatic meaning in spoken language, such as irony and speaker's characteristics. Then, we will turn to a more detailed review of previous ERP studies on the on-line processing of direct and indirect speech acts, which is central to the present study.

The on-line processing of irony has received increasing interests in recent years (Filik et al., 2014; Regel, Coulson, et al., 2010; Regel, Gunter, et al., 2010; Regel et al., 2014; Spotorno et al., 2013). One of the first studies was by Regel, Gunter et al. (2010): They examined irony processing by comparing the on-line processing of ironic sentences to that of literal sentences, using a paradigm similar to the semantic-violation paradigm mentioned above, in both spoken and written German. To this end, they presented the participants with identical sentences (e.g., 'These artists are gifted') preceded by a discourse context that biased towards an ironic interpretation or a non-ironic (i.e. literal) interpretation. All ERPs were time-locked to the sentence-final word. Since very little had been known about the processing of irony, Regel, Gunter, et al. (2010) expected that, compared to the literal interpretation, the ironic interpretation could possibly evoke two ERP components, namely the N400 and the P600, which have been observed for semantic-violation paradigms (for reviews, see Kutas & Federmeier, 2011; Kutas et al., 2006; Swaab, Ledoux, Camblin, & Boudewyn, 2012).

The N400 is a negative wave with a centro-parietal maximum that peaks around 400 ms after the onset of a critical word. The amplitude of the N400 is sensitive to semantic manipulations, and in particular to semantic incongruity, be it at the word level, sentence level, or discourse level: The semantically incongruous word evokes a larger N400 than the semantic congruous one, and the difference is coined the N400 effect.

The functional interpretation of the N400 effect remains an ongoing debate in the literature (see Kutas & Federmeier, 2011 and Lau, Phillips, & Poeppel, 2008 for a review). It may reflect orthographic/phonological analyses (Deacon et al., 2004), integration difficulties (Chwilla et al., 2007; van Berkum et al., 1999), or semantic-memory retrieval difficulties (Kutas & Federmeier, 2000; van Berkum, 2012).

Another relevant ERP component is the P600, which is a late positivity that is typically largest at the centro-parietal electrodes (but can occasionally display an anterior maximum [Kutas, DeLong, & Smith, 2011; Kutas et al., 2006]). It is usually observed between 500 and 900 ms after the onset of the critical word and has a peak at around 600 ms. However, it can start as early as 200 ms and often exhibits no peak, but a long-lasting positive shift. The P600 effect has been observed for syntactic violations, but it often also occurs in a semantic-congruity manipulation: Words with a very low cloze probability tend to elicit a larger P600 than words with a high-cloze probability in a highly-constraining context (e.g., see DeLong, Urbach, Groppe, & Kutas, 2011; Ericsson, Olofsson, Nordin, Rudolfsson, & Sandströ, 2008; Federmeier, Wlotko, De Ochoa-Dewald, & Kutas, 2007; Kemmerer, Weber-Fox, Price, Zdanczyk, & Way, 2007; Kutas et al., 2011; Münte, Heinze, Matzke, Wieringa, & Johannes, 1998; van de Meerendonk, Kolk, Vissers, & Chwilla, 2010; Vissers, Chwilla, & Kolk, 2006).

Since the P600 is found not only in syntactic violations—but in various other types of violations, such as the semantic violations mentioned above, the functionality of the P600 is still under debate. One proposal is that modulations in P600 amplitude reflect the construction of a coherent mental representation (Hoeks et al., 2013). Another proposal is that P600 is a variant of the P3b, which is a well-known ERP component usually observed for a rare odd-ball event in a sequence of standard events (Coulson et al., 1998; Sassenhagen et al., 2014). A third proposal suggests that differences in P600 amplitude reflect reanalysis (see Kuperberg, 2007), but the purpose of the reanalysis remains disputed (Kolk & Chwilla, 2007): The reanalysis can be purely syntactic in nature (Hagoort et al., 1993), can be a structural repair (Friederici, 2002), or can be more general in nature, for example, a check for possible processing errors after strong conflicts between two incompatible representations of the same linguistic input (Kolk et al., 2003).

Returning to the results of Regel, Gunter et al. (2010), compared to the literal interpretation, the ironic interpretation consistently yielded a larger P600 in the 500 to 900 ms time-window with a centro-parietal scalp distribution in both auditory and visual modality. But no N400 effect was observed. Regel, Gunter et al. (2010) take the absence of an N400 effect to imply that irony processing does not involve access to the literal meaning, and thus it does not evoke a semantic-integration or semantic-memory-retrieval difficulty in a biasing context. Instead, the comprehension of irony requires additional analysis of the utterance to arrive at the ironic interpretation. These findings have been replicated by other studies (Filik et al., 2014; Regel, Coulson, et al., 2010; Regel et al., 2014; Spotorno et al., 2013). But note that amongst these studies, one study reported an N400-like effect in addition to a P600 effect when processing unfamiliar irony (Filik et al., 2014). This N400 effect is taken to reflect that unfamiliar irony requires more effortful semantic processing than familiar irony. Taken together, previous studies on irony processing mainly reported a P600 effect, but depending on the familiarity of the irony, additional N400 effect can be observed.

Compared to the processing of irony, the processing of speaker's characteristics—namely speaker's identity, attitude and communicative styles—appeared to yield less consistent results. For example, van Berkum et al. (2008) examined how listeners exploit the voice of the speaker to infer the identity and attitude of the speaker. To test this, Dutch participants heard utterances that described various scenarios, which match or mismatch the inferences based on the speaker's voice (e.g., "Every evening I drink wine before I go to sleep" spoken by an adult or a young child's voice). Van Berkum et al. (2008) time-locked the ERPs to a critical word that is inconsistent to the speaker's identity, such as 'wine' in the previous example. Speaker-inconsistent critical words evoked a small classical N400 effect in the 200-700 ms time-window but no positivities. The authors took this N400 effect to indicate difficulties in processing the inconsistency between the speaker's voice and the stereotypical activity associated with the voice.

Also investigating the processing of speaker's characteristics, Regel, Coulson et al. (2010) examined how speaker's communicative styles—an ironic speaker vs. a non-ironic speaker—modulate the processing of literal and ironic utterances in German. To this end, the experiment was divided into two sessions: In the first session, participants learnt the communication styles of the two speakers, in particular, the ironic speaker produced significantly more ironic utterances than the non-ironic speaker. Then in the second session, the same listeners were presented with utterances produced by the same speakers, but this time, both speakers were equally likely to produce ironic utterances. The results showed that listeners responded differently to the sentence type depending on the communicative style: A larger P200 for the ironic utterances when spoken by the ironic speaker, and for the literal utterances spoken by the non-ironic speaker. The P200 was suggested to be modulated by the expectancy of communicative style. Moreover, listeners showed a P600 effect to ironic utterances, but only when spoken by the ironic speaker. Based on these findings, Regel, Coulson et al. (2010) concluded that speakers' characteristics dynamically influence the on-line interpretation of ironic utterances.

To sum up what we have discussed so far, mixed ERP findings—N400, P600, or a combination of both—have been found for the processing of pragmatic meaning in spoken language. In the remainder of this section, we will review previous ERP studies on direct and indirect speech acts.

Related to the processing of direct speech acts, Astésano et al. (2004) investigated the ERP signatures evoked by the match or mismatch between intonation contours (question intonation and statement intonation) and direct speech acts (question, statement) in French. The matching intonation contours were created from natural speech, while the mismatching intonation contours were created by cross-splicing the first part of a natural statement intonation (or question intonation) with the second part of a natural question intonation (or statement intonation), and vice versa. The ERPs, time-locked to the cross-splicing point, showed that a mismatch between intonation and direct speech act elicited a left temporo-parietal positivity between 700 ms and 1500 ms (peaking around 800 ms). This positivity was interpreted as a P800 and was taken to reflect a "reanalysis of the prosodic cue (F_0) that violates the expected intonation contour in an attempt to integrate prosodic incongruous information." (Astésano et al., 2004, p. 181). Interestingly, this P800 was only obtained when participants were explicitly asked to pay attention to the match or mismatch between prosody and speech act. The findings of Astesano et al. (2004) have been replicated by Paulmann et al. (2012) in German but without a judgement task, and similarly, Paulmann et al. (2012) concluded that P800 is related to a reanalysis or repair of a deviation from a prosodic expectation deviance. Based on their findings, the authors further argue that the latency of the P800 depends on the prominence of the deviation. However, it is important to point out that, in these two ERP studies, the late onset of the P800 can be related to the cross-splicing point per se: The question intonation and statement intonation of the utterances used in these studies differ at more than one time-point in the utterance, and the difference can be more prominent at one point than the other. Notably, from the acoustic analyses of these studies, it appears as if the cross-splicing point was chosen earlier than the point that yields the most prominent acoustic difference. This may have implications for the latency of the P800 observed in these two studies.

Similar to the processing of direct speech acts, the processing of indirect speech acts also evokes positive ERP effects (Coulson & Lovett, 2010; Gisladottir et al., 2015). Different from the two studies mentioned above, the ERP studies on the processing of indirect speech acts employ multiple time-locking points because the coding of indirect speech acts in Indo-European languages is spread out through an utterance, using prosodic, semantic and syntactic cues. Coulson and Lovett (2010) presented written indirect requests in a certain (visual) context (e.g., 'My soup is too cold to eat' in a restaurant context) and observed a frontal positivity to indirect requests compared to literal statements. The positivity occurred in the absence of ERP effects at the sentence-final word.

In the auditory domain, Gisladottir et al. (2015) examined how context—preceding turns of a conversation—affects the time-course of processing spoken speech acts in Dutch. The critical utterances (e.g., 'I have a credit card') could, depending on the preceding context, stand for one of three speech acts: an answer, a declination, or a pre-offer. Compared to answers (which served as a baseline condition), the pre-offers and the declinations—which are the more indirect speech acts—elicited early frontal positivities that are time-locked to sentence onset. The positivities in the pre-offers lasted from 200 to 600 ms after sentence-onset while the positivities in the declinations lasted from 400 to 600 ms after sentence-onset. The ERPs to pre-offers and declinations also differed in scalp distribution: The positivities in the pre-offers were restricted to the right frontal electrodes, whereas the positivities in the declinations extended from the right frontal electrodes to the medial frontal electrodes. Gisladottir et al. (2015) interpret these early frontal positivities as evidence that listeners start to recognise the speech act in the beginning of the turn before the utterance is fully processed.

In addition to sentence onset, the authors also used the sentence-final word as time-locking point to examine potential late ERP effects. The results show a late posterior negativity in the pre-offers compared to the answers and declinations. Gisladottir et al. (2015) interpret this negativity as additional processing of the pre-offers that is necessary because they were preceded by a less-constrainig context. Based on these results, the authors suggest that speech-act recognition begins early in the utterance and differs as a function of the type of speech act and the given sequential context.

Taken together, previous studies on pragmatic processing have observed various ERP effects, while those examining speech-act comprehension all reported positivities, but with different latencies. Moreover, the ERP effects differ depending on the type of speech acts. These inconsistencies may stem from the fact that speech acts are coded by more than one linguistic device or more than one time-locking point in these studies. The novel approach taken in this article is to address this question in the pragmatic-violation paradigm (see below) by using Cantonese sentence-final particles (SFPs) which provide a precise time locking point for pragmatic information.

5.1.1.1. Cantonese Sentence-final particles (SFPs)

As mentioned above, Cantonese Chinese provides an ideal testing ground for investigating the on-line processing of pragmatic meaning because pragmatic meaning can be expressed at one specific point in time by a sentence-final particle (SFP). A SFP consists of a single syllable and a lexical tone. An SFP appears at the end of an utterance, and occasionally at the end of a phrase. Adding an SFP to an utterance does not alter the literal meaning of the utterance, but changes its pragmatic and communicative function. These functions include speech acts, evidentiality, and speaker's attitude and emotion (Fang, 2003; Fung, 2000; Kwok, 1984; S.-P. Law, 1990; Leung, 1992; Luke, 1990; Matthews & Yip, 2011; Sybesma & Li, 2007). In other words, the functions of SFPs are similar to those of intonation in non-tonal languages.

To illustrate how SFPs work, we use an utterance ending without an SFP (example [1]) and the identical utterance ending with three different SFPs (examples [2], [3], and [4]). The three SFPs differ in lexical tone. When referring to SFPs, we use a notation that gives the phonemes of the SFP (e.g., laa) followed by a number that indicates the associated lexical tone. In Cantonese Chinese, there are six contrastive lexical tones (Bauer & Benedict, 1997): Tone 1 (high-level tone), Tone 2 (high-rising tone), Tone 3 (mid-level tone), Tone 4 (low-falling tone), Tone 5 (low-rising tone), and Tone 6 (low-level tone). The lexical tones relevant for the present study are Tone 1, Tone 3, and Tone 4.

The utterance in example (1)—without an SFP—is a declarative. In example (2), adding the SFP laa1 turns the declarative of example (1) into a directive (e.g., advice, request, suggestion, persuasion or command [Fung, 2000]). The SFP laa3 in example (3) expresses a declarative stating the realisation of a state and indicating a new piece of information to the listener. The SFP laa4 in example (4) turns a declarative into an echo question checking whether something has been realised.

(1)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	
	Jyutping :	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	
	Translation:	"You repair the table leg for me."									
(2)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**啦**!
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa1**
	Translation:	"Please repair the table leg for me!" (request)									
(3)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**喇**。
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa3**
	Translation:	"You have repaired the table leg for me." (statement)									
(4)	Chinese:	你	幫	我	整	番	好	隻	枱	腳	**嗱**?
	Jyutping:	nei5	bong1	ngo5	zing2	faan1	ho2	zek3	toi2	goek3	**laa4**
	Translation:	"You have repaired the table leg for me?" (clarification question)									

5.1.2. Design and predictions for the present study

The fact that an SFP alters the pragmatic meaning of an utterance provides a precise time-locking point to examine the time-course of the processing of pragmatic meaning. In the present study, we use a pragmatic-violation paradigm similar to the well-established semantic-violation paradigm, which manipulates the semantic fit of a content word with a preceding context (see Kutas et al., 2006 and van Berkum, 2012 for a review). In the pragmatic-violation paradigm, instead of the content word, we manipulate the SFPs (laa1 and laa4) and thus the pragmatic meaning that is signalled by the SFPs. We use two types of discourse context that bias either towards the SFP laa1 (request) or towards the SFP laa4 (echo question checking whether something has been realised). The discourse context is followed by a sentence ending with an SFP that matches or mismatches the SFP bias of the context. Crossing the factor SFP-bias of the context (pro-laa1 vs. pro-laa4) and Match (context bias matches vs. mismatches SFP) results in a two by two design. Table 5.1 provides an example of the four conditions.

Note that the English translations in Table 5.1 can only provide a general approximation to the actual pragmatic meaning carried by the SFPs.

With respect to predictions, we will consider three scenarios for the pragmatic violation of SFPs based on the review in section 5.1.1. The first scenario holds that a pragmatic violation will evoke a late positivity, such as a P600 effect, as observed in the processing of irony (Filik et al., 2014; Regel, Coulson, et al., 2010; Regel, Gunter, et al., 2010; Regel et al., 2014) and the processing of a mismatch between prosody and direct speech act (Astésano et al., 2004; Paulmann et al., 2012).

In the second scenario, the pragmatic violation can elicit an N400 effect, similar to that observed in a mismatch between the expected and actual speaker's characteristics (van Berkum et al., 2008). The N400 effect can be taken to reflect listeners'difficulty in integrating the pragmatic meaning of the mismatching SFP with the pragmatic meaning established by the discourse context (integration view), or difficulty in retrieving the pragmatic meaning of the mismatching SFP (semantic-memory retrieval view).

Table 5.1.

Design of the experiment and examples of experimental items. The critical sentence is printed in italics and the SFP is printed in bold.

Context bias	Match	Examples
pro-laa1	match	呢張枱其中一隻枱腳跛跛哋，搞到張枱成日抭嚟抭去啊，*你幫我整番好隻枱腳* ***laa1****!* "One of the table legs is damaged and it makes the table wobbly. *Please repair the table leg for me!*"
	mismatch	咦，張枱冇再屹嚟屹去喇喎，*你幫我整番好隻枱腳* ***laa1****!* "Hey! This table used to be wobbly but now it's not wobbly anymore. *Please repair the table leg for me!*"
pro-laa4	match	咦，張枱冇再屹嚟屹去喇喎，*你幫我整番好隻枱腳* ***laa4****?* "Hey! This table used to be wobbly but now it's not wobbly anymore. *You have repaired the table leg for me?*"
	mismatch	呢張枱其中一隻枱腳跛跛哋，搞到張枱成日抭嚟抭去啊，*你幫我整番好隻枱腳* ***laa4****?* "One of the table legs is damaged and it makes the table wobbly. *You have repaired the table leg for me?*"

In the third scenario, given that the discourse context is highly constraining towards the target SFP, the mismatch between the expected SFP and the actual SFP can result in a combination of N400 and P600 effect reflecting an integration/retrieval difficulty and a reanalysis of the pragmatic meaning similar to what has been observed for low probability words in a high-constraining context (e.g., van de Meerendonk et al., 2010), or what has been observed for the processing of unfamiliar irony (Filik et al., 2014).

Furthermore, in case that the two types of speech act (request and echo questions) are processed differently, this could likely be reflected by an interaction between Context bias and Match, or even by different ERP effects. Finally, the onset of the ERP effects will show whether the pragmatic meaning carried by an SFP is immediately related to the pragmatic meaning bias of the preceding discourse.

5.2. Methods

5.2.1. Participants

Twenty five native speakers of Hong Kong Cantonese Chinese, without neurological disorder or known hearing deficits, participated in the experiment. One participant was excluded from the analyses due to excessive muscle artefacts. The remaining 24 participants (12 female) had an age range from 18 to 55 (mean age = 28.0). All participants, except one ambidextrous participant, were right-handed according to The Edinburgh Inventory (Oldfield, 1971). All participants gave written consent and were paid for their participation.

5.2.2. Materials

The stimuli used in the present experiment are adopted from a previous study (see Kung, Chwilla, Fung, & Schriefers, 2017 for details; see also General materials section of Chapter 3 of this dissertation). In a first step, we constructed 100 sentence-items. All sentence-items were semantically-neutral statements. Semantically-neutral means that each sentence-item could be combined with the SFPs laa1, laa3, or laa4 equally well. In all sentence-items, the SFP was preceded by a word carrying the mid-level lexical tone 3 in order to avoid tone carryover effects to the SFP during later recording.

Next we created two discourse contexts for each sentence-item: One context biased towards a completion of the semantically-neutral sentence-items with laa1, and the other biased towards a completion of the semantically-neutral sentence-items with laa4 (for the calibration of the strength of these discourse contexts see below). The discourse contexts always preceded the respective sentence-item and were one or two sentences long. As a result, we had 100 semantically-neutral sentence-items and two biasing contexts for each sentence-item.

The following step concerned the recording of the materials. First, we recorded the 100 sentence-items with the SFP laa3 (laa3 conveys a declarative). This should yield an intonation pattern in the part of the sentence-item preceding the SFP that corresponds to a statement intonation. We will refer to this statement intonation pattern as neutral intonation hereafter.

Next, we recorded each of the 100 sentence-items in each of the two contexts. That is, each recording consisted of either a laa1-biasing context followed by the corresponding sentence-item ending in the SFP laa1, or a laa4-biasing context followed by the corresponding sentence-item ending in the SFP laa4. This yielded 200 recordings of a context together with its critical sentence.

A female native Cantonese-Chinese speaker recorded the 200 paragraphs, and the 100 laa3 (neutral intonation) sentence-items. The recording was made with Apple Protools 5.2 software and digitised at 16-bit/44.1 KHz sampling rate. During the recording, the speaker first read each paragraph/sentence silently to herself and then read it out loud twice. The better take of the two was then chosen by the first author and two other native Cantonese-Chinese speakers based on intuition. The chosen versions were normalised to 70 dB SPL using Audacity (http://audacity.sourceforge.net) so that the acoustic volume was approximately matched across all paragraphs and tokens.

After these recording sessions, we had recordings of 100 discourse contexts biasing towards the SFP laa1 with the critical sentence ending in the SFP laa1, 100 recordings of discourse contexts biasing towards the SFP laa4 with the critical sentence ending in the SFP laa4, and 100 recordings of the critical sentences in isolation ending in laa3, with a neutral intonation.

In the following step, we spliced the recordings. For the recordings with a laa1- or a laa4-biasing context, we first spliced off the context preceding the critical sentence. This gave us two times 100 context recordings. From the corresponding two times 100 critical sentences, we spliced off the SFPs. This resulted in 100 recordings of the SFP laa1 and 100 recordings of the SFP laa4. From the 100 recordings of the sentence-items recorded in isolation with the SFP laa3, we also spliced off the SFP laa3, giving us 100 sentence-fragments with a neutral intonation without a SFP (See Chapter 4 for the acoustic analyses of the F_0 differences between the three intonation patterns—pro-laa1, pro-laa4, and neutral intonation). The resulting three parts (context, sentence-item recorded with neutral intonation without SFP, and SFPs laa1 and laa4 from the recordings of the critical sentences in context) were then combined to yield the items for the four critical experimental conditions.

The stimuli of the four critical experimental conditions were constructed as follows: We combined the laa1- and laa4-biasing contexts with the critical sentence-fragments carrying a neutral intonation and the SFPs corresponding to the context bias (i.e. either laa1 or laa4). This yielded the pro-laa1 match condition and the pro-laa4 match condition, where the SFP matches the context bias. By replacing the SFP laa1 in the pro-laa1 match condition with the corresponding SFP laa4, and vice versa, we created the items for the pro-laa1 mismatch and the pro-laa4 mismatch condition, respectively. In the latter two conditions, the SFP did not match the context bias (See Appendix D for the full list of 400 experimental stimuli).

The construction of the materials resulted in four experimental conditions, i.e. a two by two design with the factors Context bias (pro-laa1 vs. pro-laa4) and Match between context bias and actual SFP (hereafter Match, with the levels Match vs. Mismatch). Each condition consists of 100 items (for the construction of experimental lists see below). Table 5.1 above gives an example of the four experimental conditions.

In addition to the 400 experimental stimuli, we also included 200 fillers. These fillers were comparable to the stimuli for the match conditions: they were similar in length (i.e. about 2-sentence-long) and semantically and pragmatically coherent. Different from the experimental stimuli, the fillers ended with SFPs other than laa1 and laa4 or without any SFP. The fillers were included to reduce the proportion of stimuli with a mismatch between context-bias and SFP and to conceal the manipulation (i.e. the critical SFPs laa1 and laa4). These fillers were recorded by the same female native speaker of Hong Kong Cantonese Chinese who recorded the critical items.

We compiled four experimental lists. Each list was divided into two halves with 100 experimental stimuli and 100 fillers in each half. Within a list, each sentence-item appeared once in the first half of the list and once in the second half of the list. As a result, a given critical sentence ending with the SFP laa1 or laa4 appeared once in the match condition in one half of the list and once in the mismatch condition in the other half of the list. Across the four lists, each sentence-item appeared once in all four conditions in the first halves of the four lists and once in the second halves of the four lists. To construct these lists, the 100 experimental sentence-items were divided into four quarters. The quarters were counterbalanced across four conditions and across each half of the four lists in a Latin square design. Within each half of the list, the 100 experimental stimuli and the 100 fillers were pseudo-randomised. A list was divided into eight blocks of 50 sentences. No more than two experimental stimuli or fillers occurred in a row. Each participant received one of the four pseudo-randomised lists. Each of the four lists was used for six participants.

Until now, we assumed, on the basis of intuition, that the contexts used in the items were biasing towards laa1 or laa4, respectively. In order to have an objective measure of the biasing force of the contexts, we calibrated the materials in a separate off-line study. We presented the items of the pro-laa1 condition without the SFP and the items of the pro-laa4 condition without the SFP. Sixty-four Cantonese-Chinese speakers, who did not participate in the present ERP study, listened to these items and were asked to select the most appropriate SFP out of a choice of four SFPs (laa1, laa4, laa3, and aa3; for details of the calibration see Kung et al, in prep.). The results of the calibration study are presented in Table 5.2 (which repeats Table 3.1 of Chapter 3).

As can be seen in Table 5.2, the pro-laa1 and pro-laa4 contexts do give a clear bias to laa1 and laa4 choices, respectively. However, it also appears that the laa1-biasing context provides a stronger bias (.83 laa1 responses) than the laa4-biasing contexts (.65 laa4 responses). It has to be noted in this context that aa3 can be considered as an equally adequate response to laa4-biasing contexts as a laa4-response. This is because some native Cantonese-Chinese speakers write aa3 and aa4 with the same Chinese character and they also use laa4 and aa4 interchangeably. For this reason, some participants choose aa3 as an intended answer for aa4 in the laa4-biasing context. In summary, the calibration of our stimuli shows that the discourse context does provide a clear bias towards laa1 or laa4 (see Table 5.2).

5.2.3. Task and Procedure

The experiment took place in the Laboratory for Communication Science in the Division of Speech and Hearing Sciences at the University of Hong Kong. Before the experiment began, the participants were seated comfortably approximately one meter in front of a computer screen. The participants were instructed to listen to short paragraphs for comprehension and minimise movements. The short paragraphs were presented over headphones.

Table 5.2.

Means (M), standard deviations of means (SD), and the upper limit and lower limit of the 95% confidence interval for the means (95% CI) of the proportion of SFP responses in the different Context conditions.

SFP-response	Conditions			
	Pro-laa1 context		Pro-laa4 context	
	M (SD)	95% CI	M (SD)	95% CI
laa1	0.83 (0.15)	[0.79, 0.87]	0.07 (0.05)	[0.06, 0.08]
laa4	0.05 (0.05)	[0.04, 0.06]	0.65 (0.17)	[0.61, 0.69]
laa3	0.09 (0.13)	[0.05, 0.12]	0.08 (0.07)	[0.06, 0.09]
aa3	0.03 (0.04)	[0.02, 0.04]	0.19 (0.16)	[0.15, 0.23]

A practice block with five trials was given to familiarise participants with the experiment. The block was repeated if necessary. A trial started with a warning beep of 50 ms, which was followed by 450 ms of silence and then the short paragraph. After the end of the trial, there was a 3000 ms pause before the next trial began.

The experiment consisted of eight blocks of 50 sentences each. Each block started with five filler sentences. After each block, participants received a sentence-recognition task consisting of two sentence pairs. For each of the two pairs, they had to indicate which of the two sentences had appeared in the previous block. The task ensured that participants paid attention to the sentences. After each block, participants could take a short break before starting the next block. The entire experiment lasted about 90 minutes.

5.2.4. EEG data acquisition

The EEG was recorded using SynAmps2 Neuroscan Inc. system (Compumedics Ltd., USA) in an electrically and acoustically shielded booth. The EEG activity was recorded from 62 silver-silver-chloride (Ag/AgCl) electrode sites (Midline: Fpz, Fz, FCz, Cz, CPz, Pz, POz, Oz; Lateral: Fp1/2, F1/2, F3/4, F5/6, F7/8, FT7/8, FC1/2, FC3/4, FC5/6, FC7/8, T7/8, C1/2, C3/4, C5/6, TP7/8, CP1/2, CP3/4, CP5/6, P1/2, P3/4, P5/6, P7/8, PO3/4, PO5/6, PO7/8, O1/2). The electrodes were arranged in an extended montage based on the International 10-20 system (using a Neuroscan 64-channel Quik-cap, Compumedics Ltd., USA). The vertex functioned as the reference and AFz served as the ground electrode. The impedance was kept below 10 kΩ. Additional electrodes were placed above and below the left orbit and on the outer canthus of each eye to monitor electro-oculographic (EOG) activity with a bipolar recording. Continuous data were digitized at a sampling rate of 500 Hz with a bandpass of 0.05 Hz to 200 Hz.

5.2.5. EEG data analysis

The raw EEG data was preprocessed with FieldTrip (version 2013-09-16), a programme developed at the Donders Institute for Brain, Cognition, and Behaviour (Oostenveld, Fries, Maris, & Schoffelen, 2011), using Matlab R2012a (MathWorks). The data were first filtered with a phase-shift free Butterworth bandpass filter between 1 Hz and 30 Hz with a 12 dB/octave slope for noise reduction. Then, the data were divided into epochs of 1200 ms, from 200 ms before the onset of the SFPs to 1000 ms after the onset of the SFPs. Trials with amplitude larger than ±300 μV were then removed before entering all trials into Independent Component Analysis (ICA). The purpose of the ICA was to remove ocular and muscular artefacts[13], by identifying any components resembling eye blinks, horizontal eye movements, noisy channels and other focal artefacts (see Jung et al., 2000). An average of 32 components (*SD* = 5) were identified. They were then mathematically removed from the data and signals were reconstructed by back-projecting the remaining components to the original unfiltered data. After ICA, each epoch was baseline corrected by subtracting the mean of the 200-ms interval preceding the SFP onset, and was re-referenced to the mean mastoids to remove any lateral bias. Trials with artefacts that exceeded 100 μV, drifts greater than 75 μV, abnormal distributions or improbable data exceeding 5 *SD*s were rejected. This procedure removed 1.63% (78 trials) of all trials—across all conditions and participants: 1.67% (20 trials) for laa1-match; 1.25% (15 trials) for laa1-mismatch; 1.83 (22 trials) for laa4-match; and 1.75 (21 trials) for laa4-mismatch. The Friedman test did not show a difference in the number of removed trials between conditions, χ^2 (3, N = 24) = 2.50, $p > .05$. Subsequent to artefact rejection, average waveforms were computed for each participant for each condition. A 30-Hz low-pass Butterworth filter with a 12 dB/octave slope was applied to the grand average waveforms in the figures for illustration purposes, but the statistical analyses were performed on the original unfiltered data.

[13] ICA has been shown to be a useful tool for removing ocular and muscular artefacts in EEG signals in studies where participants listen to long stretches of speech per trial and thus have difficulties withholding eye blinks (see Groppe et al., 2010; Keil et al., 2014; van Berkum et al., 2009; van Berkum, Koornneef, Otten, & Nieuwland, 2007).

To test for the main effects of Match, Context bias and the interaction between these two factors, we performed three non-parametric cluster-based permutation tests (Groppe, Urbach, & Kutas, 2011; Maris & Oostenveld, 2007) on the ERPs in the interval between the SFP onset and 1000 ms after the SFP onset. The cluster-based permutation test allows us to identify the latency and scalp distribution of an effect without assuming prior knowledge. The test identifies clusters—adjacent time points and channels that exhibit a similar difference across conditions—among all time-channel pairs available. Moreover, the test effectively controls the Type-1 error rate in multiple comparisons by identifying clusters of significant differences over space and time instead of performing a separate test on each channel-time pair. Below, we will briefly describe the procedure of the cluster-based permutation test (see Maris & Oostenveld, 2007 for a detailed description of the approach), and the parameters that were relevant for the present analyses.

The cluster-based permutation test first identified significant time-channel pairs, which have a t-statistic exceeding a critical threshold ($t = \pm 2.07$, $p < .05$, two-tailed, $df = 23$) in a dependent-samples t-test. Then, temporally connected significant pairs were clustered based on their neighbouring channels (each channel was set to have, on average, 6.6 neighbours). Sampling points with positive and negative t-values were assembled separately. For each cluster, the cluster-level statistic was computed using the sum of all individual t-values within a cluster. Its significance was evaluated using a Monte Carlo estimate. To this end, a permutation distribution was created in the following steps: in the first step, a random partition was generated by randomly assigning participants' average waveforms to one of two conditions depending on the comparisons (i.e. match or mismatch, pro-laa1 or pro-laa4, the difference between pro-laa1 mismatch and pro-laa1 match or the difference between pro-laa4 mismatch and pro-laa4 match). This was followed by calculating dependent-samples t-tests on this partition. Significant time-channel pairs were then grouped together using the temporal and spatial criteria mentioned above. The largest cluster-level statistic (i.e. the summed t-values within a cluster) was entered to the permutation distribution. The last three steps were repeated 10,000 times. After the construction of the permutation distribution, the *p*-value of each observed cluster was derived using a Monte Carlo estimate. This was done by approximating the proportion of random partitions that resulted in a larger test statistic than that of the observed cluster. A cluster was significant if its *p*-value fell in the highest or the lowest 2.5^{th} percentile of the corresponding distribution. In other words, the critical alpha level was set to .05, two-tailed.

5.3. Results

Figure 5.1 presents the ERP averages of the match and mismatch conditions time-locked to the critical SFPs. It shows a difference in ERP waveforms starting around 200 ms across all 9 electrodes between the match and mismatch conditions. Figure 5.2 presents the ERP averages of each of the four conditions time-locked to the critical SFP. It shows that the two mismatch conditions differ from the two corresponding match conditions: A larger positivity for pro-laa1 mismatch than pro-laa1 match from 300 ms onwards. The same holds for pro-laa4 mismatch compared to pro-laa4 match. The positive deflections seem largest at the centroparietal electrodes. Furthermore, the positive deflection for pro-laa1 mismatch seems larger than that for pro-laa4 mismatch from 400 ms onwards. The difference appears largest at the midline and right centroparietal electrodes.

Three separate cluster-based permutation tests were conducted: Two to examine the main effects of Match and Context bias, and one to examine the interaction between Match and Context bias. The tests only reveal a main effect of Match (*ps* = .0002), as indicated by a larger positivity from 318 to 816 ms in the mismatch condition than in the match condition. As shown in Figure 5.3 (topographical maps in the third row), the positivity is broadly distributed. However, the tests show neither a main effect of Context bias nor an interaction between Match and Context bias[14].

To sum up, the cluster-based permutation tests showed a main effect of Match, as indicated by a long-lasting increase in positivity (318-816 ms) with a broad distribution, irrespective of the context bias.

5.4. Discussion

The present study used a pragmatic-violation paradigm in which we manipulated the pragmatic fit between a discourse context and a critical SFP. A comparison of the match and mismatch between context bias and SFP showed a widely distributed increase in positivity in the mismatch condition between 318 and 816 ms in the absence of an N400 effect. This mismatch positivity did not differ between laa1 and laa4 as indicated by the absence of an interaction between Context bias and Match. Based on the timing and scalp topography, we take the positivity to reflect modulations in P600 amplitude. More specifically, we propose that the difference in P600 amplitude between the match and the mismatch conditions (P600 effect) indexes an immediate reanalysis of the utterance. The purpose of this reanalysis—in line with the monitoring hypothesis (Kolk & Chwilla, 2007; van de Meerendonk et al., 2010)—is to check for potential processing errors triggered by a conflict between the pragmatic meaning of the mismatching SFP and the pragmatic bias of the discourse context.

[14] To check for a two-way interaction between Match and Context bias, additional ANOVAs were performed separately on the midline and lateral electrodes based on the time-window yielded from the cluster-based permutation test. The ANOVAs on the midline electrodes used Match (match, mismatch), Context bias (pro-laa1, pro-laa4), and Anteriority (front, central, parietal) as within-Subject factors while the ANOVA on the Lateral electrodes used the same factors as the previous ANOVA with the addition of Hemisphere (left, right) as within-subject factors. For the Midline ANOVA, there is only a main effect of Match, $F(1, 23) = 9.44$, $p = .006$, $\eta^2 = .06$. For the lateral ANOVA, there is a main effect of Match, $F(1, 23) = 9.49$, $p = .005$, $\eta^2 = .06$, and an interaction between Match and Anteriority, $F(2, 46) = 4.76$, $p = .04$, $\eta^2 = .007$. To follow up on this interaction, post-hoc comparisons using Bonferoni corrected p-value (.017) showed a marginal difference between match and mismatch at the parietal electrodes, $t(23) = -2.26$, $p = .03$, 98.3%CI[-1.45 -1.42]. Thus, the results converge with the cluster-based permutation tests on the absence of an interaction between Match and Context bias.

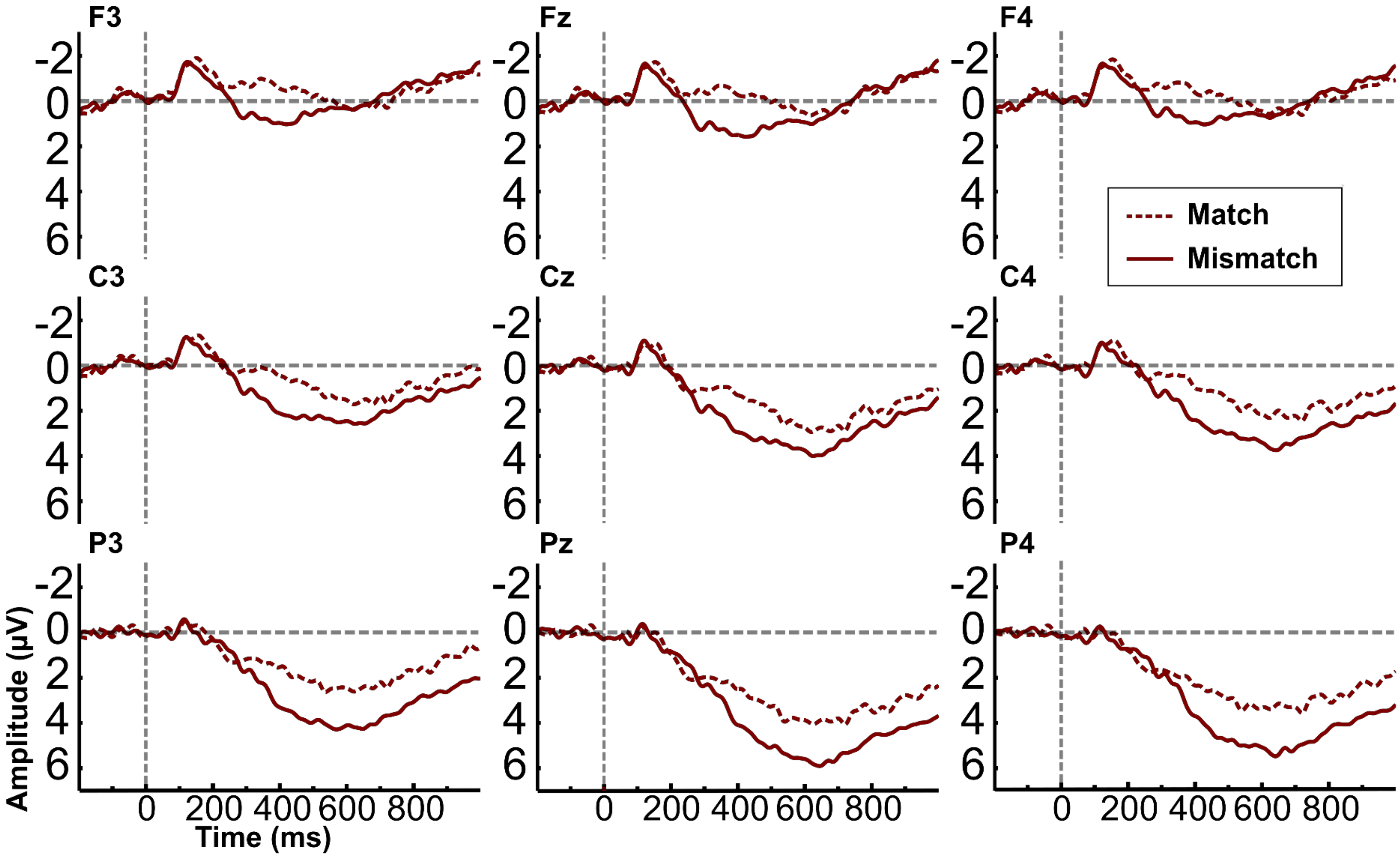

Figure 5.1.

The grand-average waveforms of the match condition and mismatch condition (collapsed over Context bias) time-locked to the SFPs for nine representative electrodes. The dashed line represents the match condition while the solid line represents the mismatch condition. Negativity is plotted upwards.

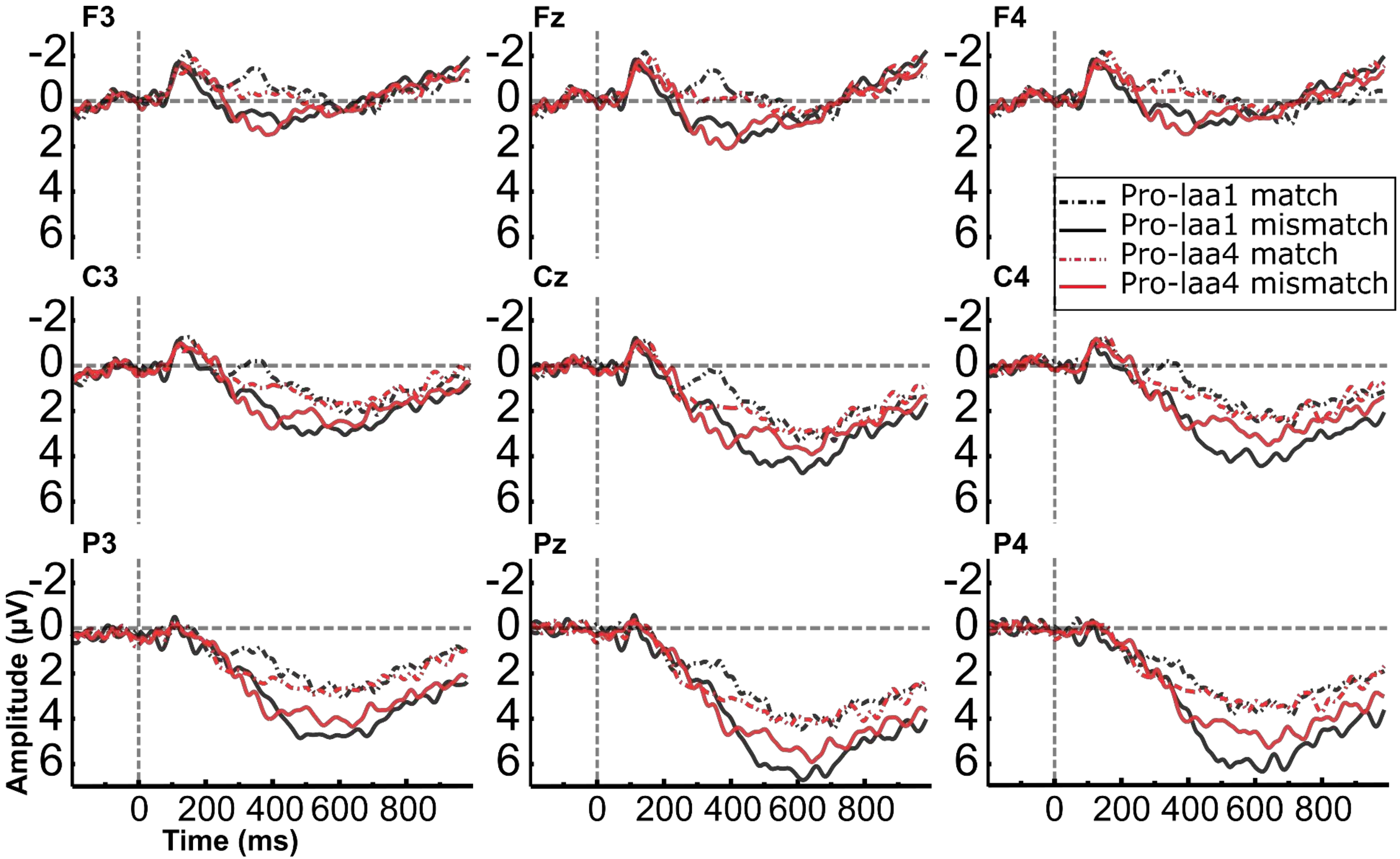

Figure 5.2.

The grand-average waveforms of all the four conditions time-locked to the SFPs for nine representative electrodes. The black lines represent the pro-laa1 conditions while the red lines represent the pro-laa4 conditions. The dashed lines show the match conditions. The solid lines show the mismatch conditions. Negativity is plotted upwards.

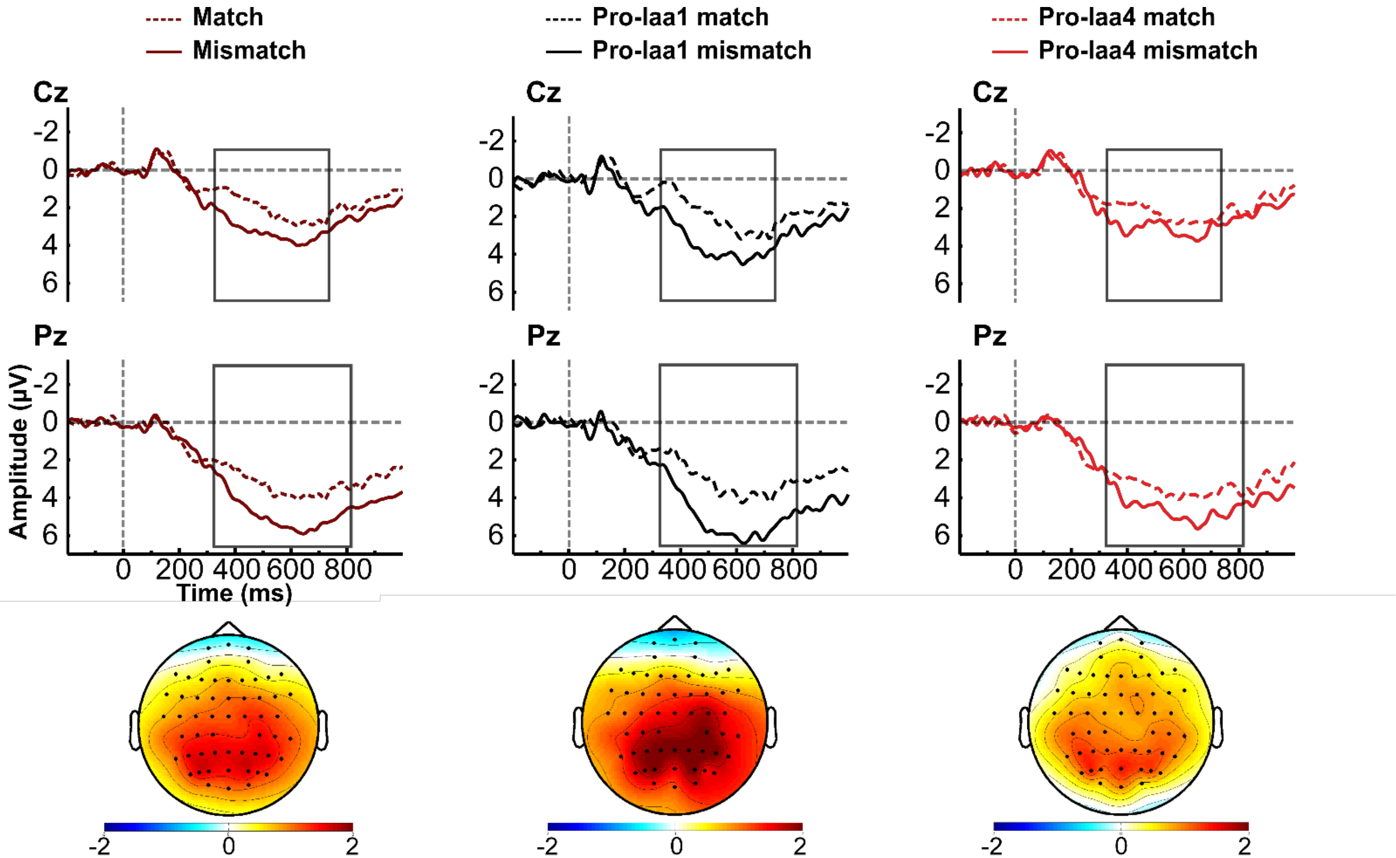

Figure 5.3.

The main effect of Match and the effect of Match by each of the two Context biases (pro-laa1 context in the second column, and pro-laa4 context in the third column) at two midline electrodes and their scalp topographies. Topographic maps were obtained by an interpolation from 62 electrodes. The topographic maps in the third row are computed by subtracting the grand averages of match from mismatch, pro-laa1 match from pro-laa1 mismatch, and pro-laa4 match from pro-laa4 mismatch, respectively. Electrodes in the significant clusters are indicated with a black dot. The first and second rows show the grand-average waveforms at two midline electrodes (Cz and Pz, respectively). The first column shows the grand-average waveforms for the match and mismatch conditions while the second and third column show the grand-average waveforms for the pro-laa1 and pro-laa4 conditions, respectively. Negativity is plotted upwards. The grey boxes with solid lines mark the time-window (318-816 ms) of the significant main effect of Match.

5.4.1. Implications for the processing of speech acts and other kinds of pragmatic meaning

As shown in section 5.1.1, previous ERP studies on pragmatic meaning have yielded mixed results, while those on the processing of direct speech acts (Astésano et al., 2004) and indirect speech acts (Coulson & Lovett, 2010; Gisladottir et al., 2015) have quite consistently observed positivities, but with different latencies (early vs. late). The difference in latencies in these studies could be due to the fact that all of these studies made use of Indo-European languages, which mark pragmatic meaning by more than one linguistic device that span across the utterance (e.g., intonation and multiple syntactic markers). As a result, in Indo-European languages, it is very difficult to determine a precise time-locking point for measuring ERPs reflecting the computation of pragmatic meaning.

The novel approach taken in this article is to use Cantonese sentence-final particles (SFPs) to track the time-course of the computation of pragmatic meaning in real time. These SFPs are clearly identifiable units expressing pragmatic meaning. They thus provide a precise time-locking point to investigate when pragmatic meaning becomes available and is integrated into a higher order meaning representation of the wider context. We examined the processing of direct speech acts (request and echo question) by manipulating the pragmatic fit between a discourse context and SFPs. A pragmatic violation was induced by a mismatch between the pragmatic meaning carried by the discourse contexts and that carried by the sentence-final particles.

If pragmatic violations would involve only difficulties with the retrieval of the pragmatic meaning carried by an SFP or only difficulties with the integration of the SFP with the discourse context, one would expect an N400 effect similar to that observed in semantic-violation studies (e.g., Kutas & Federmeier, 2011), or in the processing of pragmatically inconsistent speaker identity (e.g., "Every evening I drink wine before I go to sleep" spoken by an adult vs. a young voice; van Berkum et al., 2008). The present study, however, showed that a pragmatic violation with respect to a speech act yields a different ERP signature, namely, a broadly distributed P600 effect starting around 318 ms and continuing up to 816 ms. The finding of a P600 effect is consistent with those of previous ERP studies on the processing of irony (Filik et al., 2014; Regel, Coulson, et al., 2010; Regel, Gunter, et al., 2010; Regel et al., 2014; Spotorno et al., 2013). The finding of a P600 effect is also broadly in line with previous studies on the processing of indirect speech acts (Coulson & Lovett, 2010; Gisladottir et al., 2015), and with studies on a mismatch between prosody and direct speech acts (Astésano et al., 2004; Paulmann et al., 2012). All these studies report a positivity but with different latency or scalp distribution.

The presence of a P600 effect, as mentioned above, is taken to reflect a reanalysis of the utterance at the discourse level. The purpose of the reanalysis is—in line with the monitoring hypothesis (Kolk & Chwilla, 2007)—to check for possible processing errors, which are triggered by a clash between the pragmatic meaning of the mismatching SFP and the pragmatic meaning carried by the discourse context.

In addition, the presence of a P600 effect in the absence of an N400 effect can have two further implications: First, it is likely that the pragmatic violation does not yield integration or memory retrieval difficulties. This might be the case because the critical sentence per se could end with both the matching and the mismatching SFP, and thus a listener could construct a plausible interpretation of the carrier sentence based on either type of SFPs (thus not taking into account the discourse context [see Kolk & Chwilla, 2007 for an account of the absence of an N400 effect; Regel, Gunter, et al., 2010 for a similar argument with respect to the processing of irony]).

The second implication, according to Kuperberg (2007, p. 38), indicates that the absence of an N400 effect in the presence of a P600 effect can signal a temporary 'semantic illusion'. This happens when there is a conflict between the outputs of two processing streams—a semantic-memory based mechanism and a combinatorial mechanism. The conflict triggers a reanalysis that is indexed by a P600 effect. This reanalysis starts already early within the N400 window, and can thus suspend the retrieval and integration processes, leading to an attenuation effect.

Note that the design of the present study does not allow us to pinpoint either implication. However, we can conclude that the presence of a P600 effect indexes a reanalysis of the pragmatic meaning of the utterance. Furthermore, the early onset of the P600 effect (~318 ms) reveals that listeners very rapidly pick up the mismatch between the pragmatic meaning signalled by the discourse context and the pragmatic meaning carried by the mismatching SFP. An important implication of this finding is that the pragmatic meaning carried by the SFP is immediately related to the wider discourse.

The early onset, together with the broad distribution, of the positivity found in the present study also has implications in relation to previous findings on the processing of direct and indirect speech acts. Despite yielding a positivity, the one observed in the present study has an earlier onset than those reported for the processing of direct speech acts (Astésano et al., 2004; Paulmann et al., 2012), and a broader distribution than the ones reported for indirect speech acts (Coulson & Lovett, 2010; Gisladottir et al., 2015). This difference is presumably due to the fact that the above-mentioned studies on Indo-European languages do not have a clear time point in the utterance at which (mis)matches of pragmatic meaning can be noticed. For example, in the case of the mismatch between intonation and direct speech act, the difference in intonation contour is not restricted to the time-locking point, and the deviation of the intonation contour can even become larger further down in the utterance. By contrast, Cantonese Chinese SFPs have the great advantage of inducing a mismatch at one specific point of the utterance, and thus provide a precise time-locking point for the computation of pragmatic meaning.

The present study is one of the first to study the computation of pragmatic meaning of SFPs. Nevertheless, many aspects involving the pragmatic processing of SFPs still remain unexplored, as, for example, whether similar ERP effects in response to pragmatic violations can be substantiated in other languages with SFPs.

5.5. Conclusion

The present study explored the neural processes underlying the on-line interpretation of pragmatic meaning encoded by Cantonese-Chinese SFPs. To address this question, we used a pragmatic-violation paradigm, which is similar to the standard semantic-violation paradigm. In this paradigm, Cantonese-Chinese speakers listened to two types of discourse contexts ending with a SFP. One context strongly biased towards the SFP laa1, which conveys a request (the pro-laa1 context). The other strongly biased towards a different SFP (laa4), which signals an echo question checking whether something has been realized (the pro-laa4 context). The contexts thus build up an expectation towards the SFP laa1 or laa4, and the SFP was manipulated such that it could match or mismatch the context bias, resulting in the presence or absence of a pragmatic violation.

Compared to the matching SFPs, the mismatching SFPs elicited a widely distributed positivity between 318 and 816 ms. The positivity is taken to signal a reanalysis triggered by a conflict between the pragmatic meaning carried by the context bias and the pragmatic meaning carried by the mismatching SFP. Furthermore, the early onset of the P600 effect indicates that the computation of pragmatic meaning is very rapid and that an SFP's pragmatic meaning is related to the wider discourse immediately.

Chapter 6

Summary and General Discussion

6.1. Summary of the dissertation

Spoken word recognition has been studied comprehensively in non-tonal Indo-European languages. This line of research has resulted in several major explicit processing models. However, this research mainly concerns the processing of segmental information during spoken word recognition (e.g., Elman & McClelland, 1988; Grosjean, 1980; Marslen-Wilson, 1987; Mattys, Brooks, & Cooke, 2009; Mattys, White, & Melhorn, 2005; McQueen, Cutler, & Norris, 2003; Zwitserlood, 1989). In contrast, our knowledge about spoken language comprehension in tonal languages is rather limited. It has been established that lexical tone plays a crucial role for discerning lexical meaning for all tonal languages, and pragmatic meaning for some tonal languages. However in daily communication, there are linguistic factors, other than lexical tone, that contribute to the understanding of lexical meaning and pragmatic meaning. During connected speech, various sources of linguistic information are available simultaneously. A key question is how listeners integrate these different types of information to arrive at the appropriate interpretation. The main goal of the present dissertation was to shed light on how lexical tone, in connection with two other linguistic factors—namely context and intonation—influences the comprehension of lexical and pragmatic meaning in Cantonese Chinese.

Chapter 2 investigated if, and if so how, the interaction between lexical tone, intonation, and context affects spoken word recognition. Lexical tones play a critical role in spoken word recognition in tonal languages, such as Cantonese Chinese: A change in lexical tone can signal a change in lexical meaning. Notably, by altering the recognisability of lexical tones, intonation can affect spoken work recognition in Cantonese (Ma et al., 2006): Since both lexical tones and intonation are realised using the same acoustic measure(i.e. F_0), the F_0 contour of the lexical tone can be distorted when intonation with conflicting F_0 information is superimposed onto the lexical tone (Bauer & Benedict, 1997; Fok-Chan, 1974; Lam, 2002; S.-P. Law, 1990; Ma et al., 2004, 2006; Vance, 1976). This is especially the case for words with low tones at the end of echo questions. For example, the low-level-tone word ‘fu^{22}’ (wife/married woman)—after receiving a rising pitch contour from question intonation—shows a rising pitch contour (‘fu^{22-5}’), which resembles that of the high-rising-tone word ‘fu^{25}’ (bitterness). The modification of the F_0 contour by intonation can lead to misidentification of words with low tones (but not for high-mid tone words) as words with high-rising tones at the end of questions because they show similar rising F_0 contours (Ma et al., 2006). The on-line processes that underlie the misidentification are far from clear: Do listeners simply misperceive the low lexical tone as the high-rising tone in the first place, or is the misidentification due to a processing conflict elicited by an interaction between tonal and intonational information? This is the central question addressed in Experiment 1 of Chapter 2. To this aim, we used an off-line behavioural lexical-identification task similar to that of Ma et al. (2006), in which participants listened to words at the end of questions and statements. In addition, we examined how conflicts between lexical tone and intonation are reflected in on-line processing by measuring the ERPs time-locked to the critical sentence-final words. Since the error patterns in Ma and colleagues' (2006) study indicate that intonation primarily affects the identification of the low tones (21, 23, 22) but not of the high-mid tones (55, 25, 33), we divided the six lexical tones into two corresponding groups, high-mid tones (55, 25, 33) and low tones (21, 23, 22). Crossing the factor Tone (low, high-mid) with the factor Intonation (question, statement) results in a 2 by 2 design.

The results of the off-line behavioural task (Experiment 1), replicated the findings of Ma et al. (2006): Words with low tones were mostly misidentified as words with a high-rising tone at the end of questions. More importantly, the ERP results reveal that the on-line processing underlying the misidentification of these low-tone words in questions involves an interaction between tonal and intonational information: Compared to the same words in statements, the low-tone words in questions elicited a P600 effect in the 400 to 700 ms time window with a centro-parietal maximum. Similar to the pattern of the behavioural results, no P600 effect was observed to the high-mid-level tones. The P600 effect to the low-tone words in questions is taken to reflect a reanalysis caused by a strong conflict elicited by two simultaneously activated linguistic representations (Kolk & Chwilla, 2007). In this case, the conflict is induced by the interaction between tonal and intonational information, which led to an activation of two distinct lexical representations: the word carrying the low-tone and the word carrying the high-rising tone. Taken together, the ERP results and the behavioural results reveal that adding a question intonation to the low-tone words does not yield merely a tone misperception but an immediate interaction between lexical tone and intonation during on-line spoken word recognition, and eventually leads to the misidentification of the low-tone word as a high-rising-tone word.

In Experiment 2, a highly-constraining lexical context was introduced by embedding the target sentence-final words used in Experiment 1 in the second part of disyllabic compounds, such that encountering the first part of the compound creates a strong expectation for the second part. The purpose of introducing this highly-constraining lexical context was to examine if, and if so to what extent, context can help to resolve the on-line processing conflict, and improve the identification of the low-tone words in questions using the same experimental design and procedure. This was indeed the case: Compared with Experiment 1, adding a strongly biasing semantic context improved the identification of the low-tone words significantly. Moreover, the on-line processing conflict previously observed in Experiment 1—reflected in a P600 effect—disappeared in Experiment 2. This demonstrates that context information immediately interacts with tonal and intonational information to resolve the on-line processing conflict. However, the highly-constraining lexical context did not eliminate the on-line processing problem entirely. There still was an N400 effect to all question-final words compared to their statement-final counterparts, regardless of their lexical tone. This N400 effect is taken to reflect a mismatch between the intonation-induced F_0 changes and the expectation of a specific lexical tone.

Together, the results of Chapter 2 show that tonal, intonational, and contextual information interact immediately during spoken word recognition in Cantonese Chinese: When tone and intonation yield conflicting F_0 information, this yields a processing conflict during on-line spoken word recognition, and leads to an eventual lexical misidentification. Context contributes to a resolution of this conflict, but it does not take away completely the potential processing difficulties arising from a mismatch between tonal and intonational information.

Besides literal meaning, lexical tone can also distinguish between different types of pragmatic meanings in some tonal languages. Pragmatic meaning in these languages is expressed by means of sentence-final particles (SFPs), and these particles can differ by their lexical tone. To date, important questions concerning the comprehension of these SFPs have remained unanswered: One important question concerns, similar to the interpretation of lexical meaning, whether the interpretation of pragmatic meaning, as expressed by SFPs, is affected by discourse context and intonation. Another underexplored question concerns the on-line comprehension of pragmatic meaning: It is not clear to what extent discourse context and lexical tone affect the on-line comprehension of pragmatic meaning. These two questions were examined in Chapters 3 and 5.

Chapter 3 investigated the relative role of discourse context and intonation in the comprehension of pragmatic meaning. In three experiments, listeners were presented with short passages of spoken input and had to choose one out of four SFPs—laa1, laa4, laa3, aa3 (which differ by lexical tone and/or onset)—that best completed the utterance. Experiment 1 and 2 tested if, and if so how, discourse context and intonation respectively affect the comprehension of SFPs. After showing that discourse context (Experiment 1) and intonation (Experiment 2) individually can bias towards the choice of a certain SFP, in Experiment 3 the factors discourse-context bias and intonation bias were crossed. The main result of Experiment 3 was that the effect of discourse context was not enhanced by a converging intonation bias. In contrast, the effect of discourse context decreased when it was combined with a mismatching intonation bias. However, discourse context still dominated over the effects of intonation in the comprehension of pragmatic meaning. These findings are interpreted in terms of the speaker-perspective hypothesis, which proposes that intonation is a consequence of context (and communicative intention) of a speaker. Therefore, if the listener adopts a speaker perspective, s/he will consider intonation as an additional source of information on pragmatic meaning only when the pragmatic meaning signalled by intonation differs from the pragmatic meaning signalled by discourse context.

The goal of Chapter 5 was to gain a better understanding of the factors that can affect the comprehension of pragmatic meaning carried by SFPs. A second goal was to investigate the time-course of the processing of sentence final particles during on-line speech comprehension. This was accomplished by studying how SFP-induced pragmatic violations are processed. We used a pragmatic-violation paradigm similar to the standard semantic-violation paradigm: Cantonese-Chinese speakers listen to two types of discourse contexts that end with identical carrier sentences. One discourse context strongly biased towards the SFP laa1, which conveys a request. The other context strongly biased towards the different SFP laa4, which signals an echo question. The contexts thus build up a strong expectation towards completing the carrier sentences with either laa1 or laa4. We manipulated the SFP such that it matched or mismatched the context bias. The mismatching SFPs, compared to the matching SFPs, elicited a broadly distributed positivity in the 318 to 816 ms time window measured from SFP onset. This positivity is taken to reflect a reanalysis triggered by the conflict between the pragmatic meaning carried by the context bias and the pragmatic meaning carried by the mismatching SFP. The early onset of the positivity indicates that Cantonese listeners are sensitive to the tonal information and the pragmatic information carried by SFPs, and that these two types of information interact immediately with context to derive the pragmatic meaning of an utterance.

To summarize, the findings from all three experimental chapters support the claim that Cantonese listeners' strongly rely on context information during the comprehension of lexical and pragmatic meaning. Possible reasons for this strong contribution of context are discussed in the next section. The chapter ends with a discussion of the limitations of the present dissertation and directions for future research.

6.2. Why is there a strong reliance on context in Cantonese speech comprehension?

Previous studies on Cantonese focused mainly on lexical-tone perception and the processing of tonal information. So far, very little was known about the interplay between lexical tone and other kinds of linguistic information, such as contextual and intonational information. The goal of the present dissertation was to fill this gap by investigating the interaction of lexical tone, context and intonation by exploiting special properties of the Cantonese Chinese language: Results from the experimental chapters show that lexical tone interacts with intonation and context during the comprehension of lexical meaning and pragmatic meaning in Cantonese. Importantly, be it off-line or on-line comprehension, Cantonese listeners show a strong reliance on context information during speech comprehension.

The reasons for Cantonese listeners' reliance on context might be different for the comprehension of lexical meaning on the one hand and pragmatic meaning on the other hand. Regarding the comprehension of lexical meaning, a strong reliance on context can be related to the high degree of homophony of monosyllabic words in various varieties of Chinese, including Cantonese. Cantonese has a large inventory of monosyllabic monomorphemic words, amounting to 8500 documented in the

Cantonese dictionary (*中華新字典[Chung Hwa New Dictionary]*, 2007). The large inventory of monosyllabic words is actually realized by only 753 syllable-plus-tone combinations. This results in a large number of homophones in the language: A syllable-plus-tone combination, on average, denotes 9.83 words (SD = 10.36), ranging from 1 to 106 words (see Table E1 in Appendix E for the details on number of possible words per syllable-plus-tone combination).

Given this high degree of homophony, listening to the syllable-plus-tone combination alone can be challenging. One could assume that lexical frequency could help here, such that high frequency homophonic words are more likely to be retrieved than their low frequency lexical counterparts. However, there are many syllable-plus-tone combinations representing more than one lexical item with high lexical frequency. Taking *ji4* for example (a syllable-plus-tone combination denoting 91 different words), the syllable can represent several highly frequent words, such as 'child(兒)', 'move (移)', '宜(suitable)', 'appearance(儀)', 'doubt(疑)', 'happy (怡)', 'friendship(誼)', 'maternal aunt(姨)'. Thus, simply hearing *ji4* is highly ambiguous and it is very challenging for a Cantonese listener to pinpoint which lexical item is being said.

A common solution for this problem is to provide a context—often in the form of a compound—in which the homophonic monosyllabic word occurs. This bring us back to the example of *ji4*, which has more than one homophone, such as 'appearance(儀)' and 'child(兒)'. Both are frequent words and commonly used as Cantonese first names[15]. To clarify to a listener which *ji4* it is, a speaker usually produces *ji4* as the second word in a compound, e.g., the *ji4* in '*laai2ji4* 'manners [rite appearance] (禮儀)', or the *ji4* in *hai4 ji4* 'children[child child](孩兒)' It is important to note that even though compounding is very productive, not all combinations are equally likely: Returning to the example above, it is unlikely to combine 'rite' and 'child' or 'appearance' and 'child'. Thus in daily communication, it is very common to use a highly-constraining lexical (compound) context such as above to clarify the meaning of a monosyllabic word.

Because context serves as a reliable cue in the comprehension of lexical meaning, it is likely that Cantonese speakers extend this strong reliance on context to the comprehension of other types of meaning, e.g., pragmatic meaning, when other linguistic information is less informative and less reliable. This could be the case in the comprehension of pragmatic meaning carried by SFPs, which is influenced by two sources of information, namely discourse context and intonation.

Even though it is generally agreed that intonation is used for expressing pragmatic meaning in Cantonese, the functions of intonation in Cantonese are more restricted compared to its functions in other non-tonal languages, such as English (Cheung, 1986; Fang, 2003; Kwok, 1984; S.-P. Law, 1990; Pennington & Ellis, 2000; Wakefield, 2012; Yau, 1980). This is because, compared to intonation in non-tonal languages, the number of intonation patterns is limited in Cantonese due to the large number of lexical tones in the language (Chao, 1968; Cheung, 1986; Fang, 2003; Lam,

[15] Both 'appearance(儀)' and 'child(兒)' can be first names in Cantonese, just like Peter and Mary in English.

2002; Mai, 1998): Cantonese Chinese has six lexical tones, which are contrasted by their pitch height and pitch contour (Bauer & Benedict, 1997). Given that intonation is also characterised by the same pitch parameters, this leaves limited space for intonation without altering the relative pitch height and contour of the lexical tones (Chao, 1968; Cheung, 1986; Fang, 2003; Lam, 2002; Mai, 1998).

To compensate for the limited role of intonation patterns in conveying pragmatic meaning, Cantonese Chinese has a rich inventory of SFPs, which amount to more than 30 monosyllabic SFPs (Kwok, 1984; Leung, 1992) and about 45 so-called particle clusters (Leung, 1992). The size of the SFP inventory in Cantonese has been reported to be the largest amongst all languages studied so far (Leung, 1992; Luke, 1990; Yau, 1980).

It is generally agreed upon that both SFPs and intonation serve pragmatic functions in Cantonese Chinese, and the use of intonation and SFPs is not mutually exclusive (Fang, 2003; Fox et al., 2008; Mai, 1998). Most of the time, Cantonese-Chinese speakers use both kinds of information for expressing pragmatic meaning: Intonation indicates the broad category of sentential mood of the utterance (e.g., interrogative, imperative, declarative, expressive) while SFPs strengthen and fine tune the pragmatic meaning of the utterance (Fang, 2003). Given the more general nature of intonation and the more fine-tuned nature of SFPs, it has been suggested that Cantonese speakers rely more on SFPs than on intonation for communicating pragmatic meaning (Cheung, 1986; Kwok, 1984; S.-P. Law, 1990; J. P. W. Li et al., 2012; Yau, 1980).

6.3. Limitations and future questions

6.3.1. Limitations

Before providing suggestions for future directions and concluding the dissertation, it is important to point out a few limitations of the experimental chapters: In Chapter 2, the target words contain only five minimal sextuplets, which could be argued to yield a low signal-to-noise ratio in the ERP results. Even though there are more full sets of tonal sextuplets in the language (see Table E1 in Appendix E), only these five sets met the stimuli selection criteria: The sextuplets should yield words with similar lexical frequency and with unambiguous pronunciation (i.e. no heteronym). But notably, even though the signal-to-noise ratio is not optimal, the ERP effects reported in Chapter 2 are robust and significant.

As for Chapter 3 and 5, one could argue that one should study more SFPs that differ in tone or in segment. However, in this case it would have been very difficult to design the cloze task for the following reasons: First of all, the SFPs do not have a specific written form. That is, the same SFP can be written differently by different speakers, or different SFPs can share the same written form. To circumvent this problem, we asked participants to perform a dictation for the four SFPs used in the cloze test and asked them to repeat their answers on top of each answer sheet at the spaces provided (at the end of the carrier sentences used in the dictation). The purpose of this was to remind them of the written forms they chose for each SFP. The dictation and asking participants to remember the written forms already requires a higher task demand than a usual cloze task. By increasing the number of SFPs tested, the cloze task would become even more memory taxing. Also, using more SFPs can potentially make the task confusing because the differences between the SFPs can be very subtle. For example, we could potentially include another SFP aa4 in the task. This SFP has a very similar pragmatic function as laa4, one of the target SFPs used in the current task: Both laa4 and aa4 are used for signalling a clarification question, but laa4 has an additional meaning for indicating if the matter of query has been realised. Additionally, aa4 is closely related to aa3—another target SFP used in the cloze task. These two SFPs can share the same written form but they serve different pragmatic functions: aa3 is used for signalling a statement and to "soften the tone of the speaker" (Fung, 2000). Thus, given the subtle differences in pragmatic functions and in written forms between these three SFPs, including more SFPs (e.g., aa4) can make the task potentially highly confusing.

By and large, even though the paradigms developed for the present dissertation are not free from limitations, they can serve as stepping stones for future studies on the interaction between lexical tone and other types of linguistic information in speech comprehension, be it in Cantonese or in other tonal languages. Moreover, by pointing out the potential limitations, hopefully this raises awareness in researchers about potential obstacles when designing future experiments tackling these issues.

6.3.2. Future questions

The experimental chapters in the present dissertation have addressed some major questions about the role of context, intonation and tone in speech comprehension in a tone language—Cantonese Chinese. But they also raised some new questions that require further investigation. These questions will be detailed in the following.

The findings of Experiment 1 of Chapter 2 show that, despite the eventual misidentification of the question-final low-tone words as high-rising-tone words, Cantonese listeners are able to perceive and activate the representation of the underlying low tone during on-line speech comprehension. This raises the question if, and how well, the listeners can perceive—despite the resemblance in F_0 contour—the subtle difference in F_0 register between words with low tones and their counterparts with the high-rising tone at the end of questions. A further question is if such an ability is correlated with the accuracy in identifying the low tones in questions in a tone identification task.

Turning to Chapter 3, the three experiments showed that both discourse context and intonation play a role in the comprehension of pragmatic meaning signalled by SFPs in Cantonese. However, discourse context has a more dominant role than intonation. This raises the question whether these factors are weighed in a similar way in other languages: One possibility is to test this in other tonal languages (e.g., Thai and

Vietnamese), which use SFPs and also have intonation contours that are equally restricted. Equally, it would be interesting to investigate languages, which also use SFPs but have more variable intonation contours (e.g., Korean and Japanese). This question can be explored in the future using the paradigm and the 'speaker perspective hypothesis' introduced in Chapter 3. The 'speaker perspective hypothesis' predicts that a greater role for intonation should actually only matter for cases of a mismatch between context and intonation, but not for a case of a match (see sections 3.5 and 3.6.2 of Chapter 3 for further details).

With respect to Chapter 5, this is the first ERP study that examines the processing of pragmatic meaning carried by SFPs. It leaves ample room for further exploration. For example, in the current ERP experiment, only the lexical tone of the SFP was manipulated. It remains unknown if a manipulation of the segmental information of the SFP or a combination of both tone and segmental information would yield similar or different results. Another possible follow-up is to investigate if, and to what extent, the processing of SFPs involves semantic processing: Cantonese SFPs can be used individually, but they can also be combined to form particle clusters to signal pragmatic meaning. To illustrate this with an example, the SFP laa3 marks the realisation of a state (Fung, 2000; Sybesma & Li, 2007), while the SPF gaa3 serves the function to remind the hearer that the fact in discussion is relevant (Fung, 2000). Combining these two, the particle cluster gaa3 laa3 signals 'this is a matter of fact'. Note that the ordering of the SFPs within such clusters is restricted (A. Law, 2002; S.-P. Law, 1990): For example, it is impossible to say 'laa3 gaa3'. Given that very little is known about the processes underlying the comprehension of these compound SFPs, it requires further exploration.

The last but not least (and in fact the most important) issue, which has been raised in the beginning of the chapter is the lack of neurobiological and/or psycholinguistic models that can be applied to tone languages. All of the current models are based on findings from non-tonal Indo-European Languages. As a result, little is known about the role of linguistic structures that do not exist in Indo-European languages. This applies to lexical tone, which does not exist in the majority of Indo-European languages but is present in the majority of the world's languages (Yip, 2002). In order to account for language processing in tone languages, it is important for these models to explain when, where, and how tonal information is processed and interacts with other types of linguistic information, such as intonation and context. For future neurocognitive models on language processing, it would be important to take these concerns into consideration in order to provide a comprehensive picture of *when* and *how* various types of linguistic information are processed in the brain.

6.4. Conclusion

The present dissertation provides an experimental investigation of different aspects of spoken language comprehension in a tone language, namely Cantonese Chinese. The results reveal an immediate interaction between the processing of lexical tone, intonation and context, be it lexical or discourse, in which these two types of context appear to be the dominating factor. In addition, the empirical chapters provide experimental paradigms and approaches that can be used, in future research, as tools for investigations of speech comprehension in other tone languages.

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Appendices

Appendix A: Word and compound stimuli used in Chapter 2

Table A1

List of the single-word and compound Stimuli used in Experiments 1 and 2 of Chapter 2

Single Word			Compound		
IPA	Chinese	Translation	IPA	Chinese	Translation
jɐn^{55}	欣	joy	fun^{55} jɐn^{55}	歡欣	joy
jɐn^{25}	忍	to endure	jʊŋ^{21} jɐn^{25}	容忍	to tolerate
jɐn^{33}	印	to print	kœk^{33} jɐn^{33}	腳印	foot print
jɐn^{21}	人	human	hou^{25} jɐn^{21}	好人	nice person
jɐn^{23}	引	to pull/draw	k^{h}ɐp^{5} jɐn^{23}	吸引	to attract
jɐn^{22}	孕	pregnancy	wai^{21} jɐn^{22}	懷孕	to be pregnant
si:^{55}	師	teacher/instructor	lou^{35} si:^{55}	老師	teacher
si:^{25}	史	past/history	lɪk^{22} si:^{25}	歷史	history
si:^{33}	試	to try	hau^{25} si:^{33}	考試	exam
si:^{21}	時	time	tsam^{22} si:^{21}	暫時	temporary
si:^{23}	市	market/town	kai^{55} si:^{23}	街市	market
si:^{22}	事	matter	ku:^{33} si:^{22}	故事	story
sɵy^{55}	衰	bad	jœŋ^{25} sɵy^{55}	樣衰	ugly
sɵy^{25}	水	water	hei^{33} sɵy^{25}	汽水	soft drink
sɵy^{33}	稅	tax	min^{35} sɵy^{33}	免稅	tax-free
sɵy^{21}	垂	to hang down	ha:^{22} sɵy^{21}	下垂	hanging down
sɵy^{23}	緒	mental state	tsɪŋ^{21} sɵy^{23}	情緒	emotion
sɵy^{22}	睡	sleep	ŋ^{21} sɵy^{22}	午睡	nap/siesta
fu:^{55}	夫	husband; married man	tʃœŋ^{22} fu:^{55}	丈夫	husband
fu:^{25}	苦	bitterness	t^{h}ʊŋ^{33} fu:^{25}	痛苦	suffering
fu:^{33}	富	rich	tʃ^{h}ɔɪ^{21} fu:^{33}	財富	wealth
fu:^{21}	符	symbol	lɪŋ^{21} fu:^{21}	靈符	charm
fu:^{23}	婦	wife; married woman	jɐn^{22} fu:^{23}	孕婦	pregnant woman
fu:^{22}	負	negative; burden	p^{h}ou^{23} fu:^{22}	抱負	aspiration
wɐi^{55}	威	might	fa:t^{33} wɐi^{55}	發威	to become powerful
wɐi^{25}	毀	to destroy	tsa:^{33} wɐi25	炸毀	to bomb
wɐi^{33}	慰	comfort	ɔn^{55} wɐi^{33}	安慰	to console/consolation
wɐi^{21}	圍	to encircle	fa:n^{33} wɐi^{21}	範圍	scope, range
wɐi^{23}	偉	great	wɐŋ^{21} wɐi^{23}	宏偉	spectacular
wɐi^{22}	位	position	pou^{22} wɐi^{22}	部位	parts

Appendix B: Acoustic Analyses

Acoustic analyses showing the F_0 pattern of the four syllables (*/fu/*, */si/*, */søy/* and */jɐn/*) carrying the six lexical tones at the end of questions and at the end of statements. In all figures, 0 ms marks the onset of the syllable.

Experiment 1

Figures B1-B8 show the F_0 patterns of the four syllables (*/fu/*, */si/*, */søy/* and */jɐn/*) carrying the six lexical tones at the end of questions (left column) and statements (right column). Visual inspection shows that all tones have a rising tail at the end of questions regardless of their canonical form compared to the corresponding tone at the end of statements. In particular, the F0 contours of the low tones (21, 23, 22) in questions shared a high resemblance with each other as well as the F_0 contour of the high-rising tone (25) in questions. Even though there was a resemblance in the F_0 contour, the low tones and the high-rising tone in questions still differ from each other in their average F_0 height.

Experiment 2

Figures B9-B16 show the F_0 patterns of the four syllables (*/fu/*, */si/*, */søy/* and */jɐn/*) in a compound carrying the six lexical tones at the end of questions (left column) and statements (right column). Consistent with Experiment 1, visual inspection shows that all tones have a rising tail at the end of questions regardless of their canonical form compared to the corresponding tone at the end of statements. In particular, the F_0 - contours of the low tones (21, 23, 22) in questions shared a high resemblance with each other as well as the F_0 contour of the high-rising tone (25) in questions. Even though there was a resemblance in the F_0 contour, the low tones and the high-rising tone in questions still differ from each other in their average F_0 height.

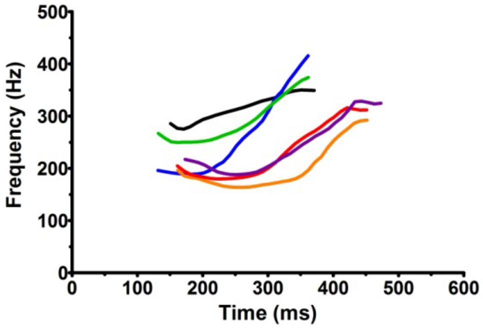

Figure B1.
Syllable /fu/ at the end of questions.

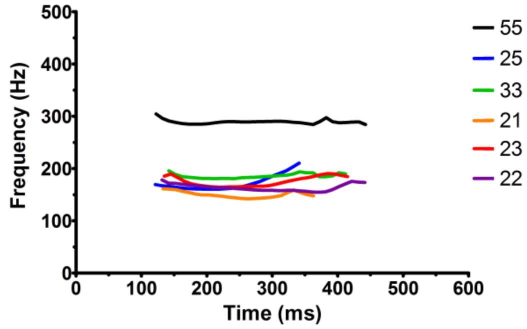

Figure B2.
Syllable /fu/ at the end of statements.

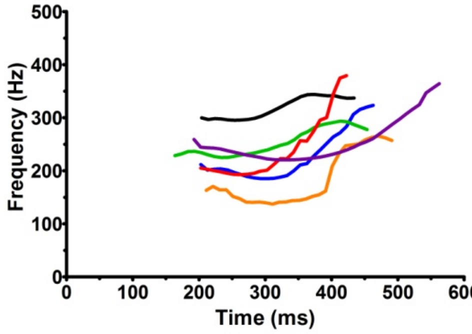

Figure B3.
Syllable /si/ at the end of questions.

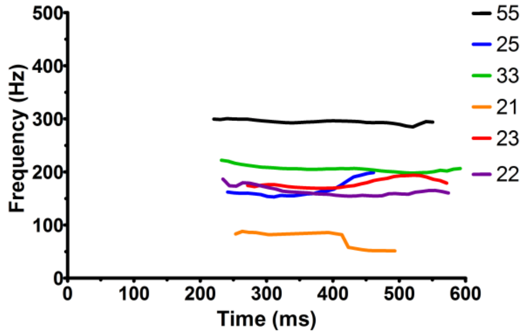

Figure B4.
Syllable /si/ at the end of statements.

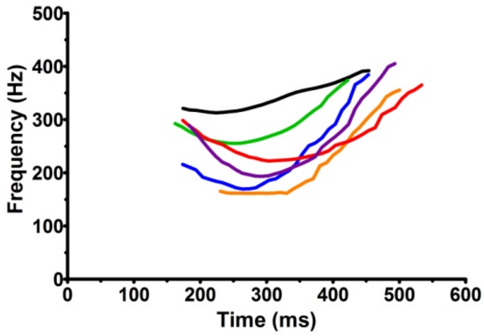

Figure B5.
Syllable /søy/ at the end of questions

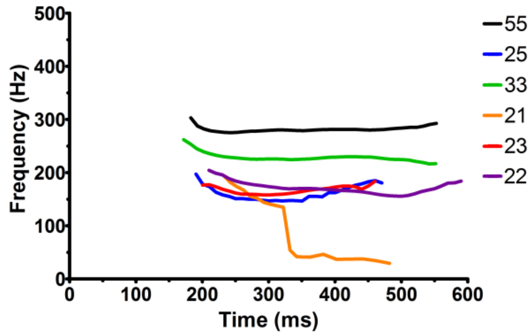

Figure B6.
Syllable /søy/ at the end of statements.

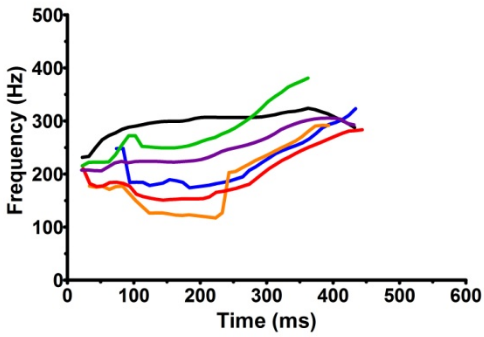

Figure B7.
Syllable / jɐn / at the end of questions.

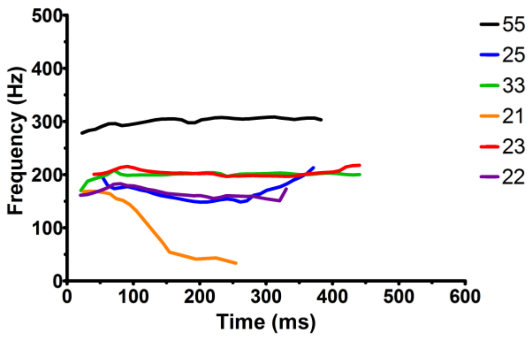

Figure B8.
Syllable / jɐn / at the end of statements.

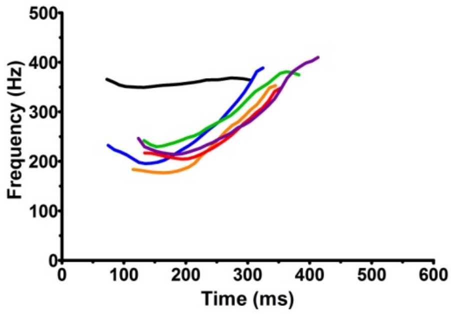

Figure B9.
Syllable /fu/ in a compound at the end of questions.

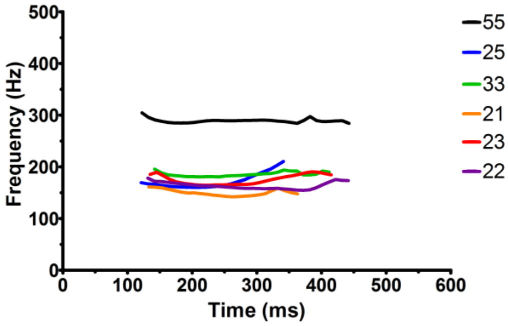

Figure B10.
Syllable /fu/ in a compound at the end of statements.

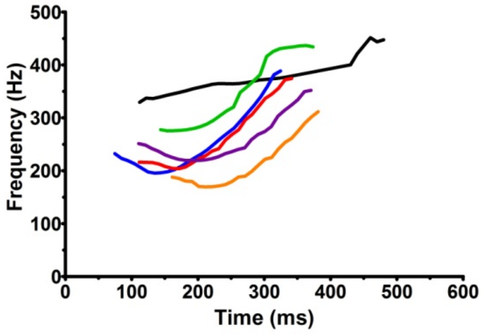

Figure B11.
Syllable /si/ in a compound at the end of questions.

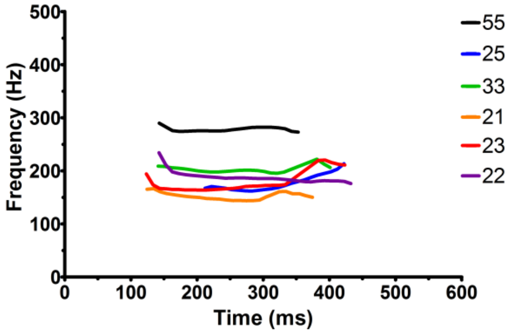

Figure B12.
Syllable /si/ in a compound at the end of statements.

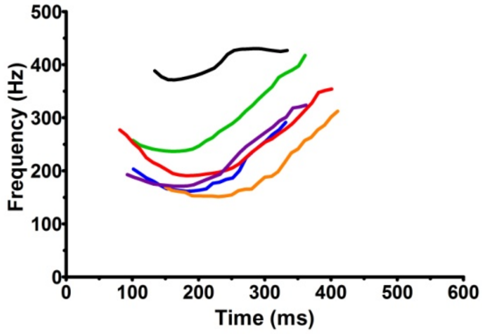

Figure B13.
Syllable /søy/ in a compound at the end of questions.

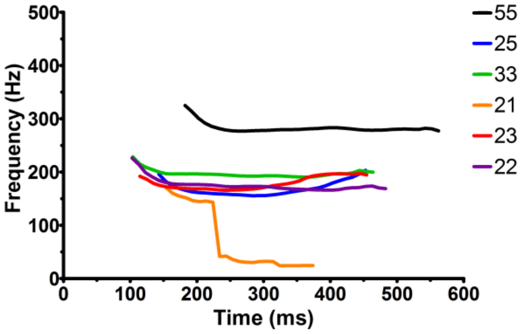

Figure B14.
Syllable /søy/ in a compound at the end of statements.

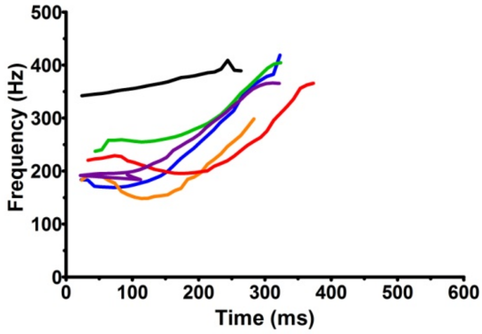

Figure B15.
Syllable /jɐn/ in a compound at the end of questions.

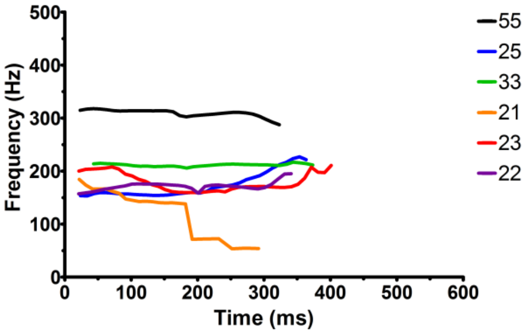

Figure B16.
Syllable /jɐn / in a compound at the end of statement.

Appendix C: Time-course analyses for Experiments 1 and 2 in Chapter 2

Table C1

Experiment 1: F values of the Main Effects of Intonation (I) for the Midline Analysis and the Lateral Analysis of low-tone words and Interactions with Electrodes (E) and Hemisphere (H) for the different time windows.

Time window (ms)	Midline		Lateral			
	I	I*E	I	I*H	I*E	I*H*E
0-50	<1	<1	<1	<1	<1	<1
50-100	<1	1.13	<1	<1	6.40 **	2.04
100-150	<1	<1	<1	2.82	<1	<1
150-200	<1	<1	<1	3.96	<1	2.35
200-250	<1	5.95 *	<1	9.33 **	2.09	2.82 *
250-300	5.18 *	<1	4.09	1.40	<1	2.79 *
300-350	<1	2.26	<1	3.19	1.33	2.76 *
350-400	2.10	<1	2.19	<1	1.21	1.88
400-450	<1	<1	<1	<1	1.38	2.62 *
450-500	1.61	1.30	1.37	<1	2.16	2.97 *
500-550	2.66	6.43 *	2.31	1.00	4.06 **	3.90 *
550-600	<1	5.86 *	<1	3.08	2.48	4.79 **
600-650	<1	8.15 **	<1	1.57	3.62 *	7.64 ***
650-700	<1	5.79 *	<1	3.41	2.17	2.77
700-750	<1	1.31	<1	1.04	4.86 **	3.01 *
750-800	<1	<1	<1	1.62	2.43	2.17
800-850	<1	<1	<1	<1	1.99	3.16 *
850-900	<1	1.13	<1	<1	2.50	2.87
900-950	<1	<1	<1	<1	1.87	4.42 *
950-1000	<1	<1	<1	1.03	3.30 *	2.62

* $p < .05$.

**$p < .01$.

***$p < .001$.

Table C2

Experiment 1: F values of the Main Effects of Intonation (I) for the Midline Analysis and the Lateral Analysis of high-mid-tone words and Interactions with Electrodes (E) and Hemisphere (H) for the different time windows.

Time window (ms)	Midline		Lateral				
	I	I*E	I	I*H	I*E	I*H*E	
0-50	<1	<1	<1	1.02	<1	1.77	
50-100	<1	1.16	<1	1.48	1.88	2.95	*
100-150	<1	<1	<1	2.26	<1	<1	
150-200	<1	<1	<1	3.49	1.42	1.56	
200-250	<1	<1	<1	2.47	1.13	1.85	
250-300	<1	<1	<1	1.90	1.32	4.34	**
300-350	<1	<1	<1	1.70	1.42	4.44	**
350-400	1.90	<1	<1	<1	2.24	2.40	
400-450	<1	<1	<1	<1	2.39	2.32	
450-500	<1	<1	<1	<1	1.82	4.64	**
500-550	<1	<1	<1	<1	1.76	3.66	*
550-600	<1	<1	<1	<1	1.16	4.20	*
600-650	<1	<1	<1	<1	2.80	5.26	**
650-700	<1	<1	<1	<1	2.09	2.24	
700-750	<1	<1	<1	<1	2.87	3.45	*
750-800	<1	<1	<1	2.48	2.51	2.38	
800-850	<1	<1	<1	<1	1.48	2.09	
850-900	<1	<1	<1	1.70	1.09	2.41	
900-950	<1	<1	<1	<1	2.36	3.55	*
950-1000	<1	<1	<1	<1	2.23	1.90	

* $p < .05$.

**$p < .01$.

Table C3

Experiment 2: F values of the Main Effects of Intonation (I) for the Midline Analysis and the Lateral Analysis of low-tone words and Interactions with Electrodes (E) and Hemisphere (H) for the different time windows.

Time window (ms)	Midline				Lateral							
	I		I*E		I		I*H		I*E		I*H*E	
0-50	<2		3.90		2.16		<1		<2		<1	
50-100	6.15	*	<2		9.08	**	<1		<1		<1	
100-150	<1		4.68	*	<2		<2		3.57	*	<2	
150-200	<1		2.60		<1		<1		8.47	***	<2	
200-250	<2		3.72		<1		<1		5.83	**	<2	
250-300	4.83	*	4.50	*	<2		<1		9.55	***	<1	
300-350	<2		2.99		<1		<1		4.43	*	2.81	*
350-400	<1		<2		<1		<1		2.36		<1	
400-450	<1		2.14		<1		<1		2.31		<1	
450-500	<2		<1		<2		<1		2.27		<2	
500-550	<1		<2		<1		<1		3.83	*	<2	
550-600	<2		<1		<1		<1		<2		<1	
600-650	3.84		<1		<2		<1		3.89	*	<1	
650-700	<2		<2		<1		<1		2.71		<1	
700-750	<1		<1		<1		<1		<2		<1	
750-800	5.63	*	<1		<1		<1		2.90		<1	
800-850	<1		<2		<1		<2		<1		3.02	*
850-900	<2		5.20	*	<1		<1		<2		<1	
900-950	<2		2.61		<1		<1		2.61		<1	
950-1000	<2		<1		<1		<1		<2		<1	

*$p < .05$.
**$p < .01$.
***$p < .001$.

Table C4

Experiment 2: F values of the Main Effects of Intonation (I) for the Midline Analysis and the Lateral Analysis of high-mid-tone words and Interactions with Electrodes (E) and Hemisphere (H) for the different time windows.

Time window (ms)	Midline				Lateral					
	I		I*E		I	I*H		I*E		I*H*E
0-50	<1		<2		<1	4.33		<2		<1
50-100	<1		<1		<1	2.76		<1		<1
100-150	2.06		<1		<2	<1		<1		<1
150-200	<1		3.18		<1	<1		5.40	***	<1
200-250	5.71	*	3.44		2.22	<1		4.71	**	<1
250-300	2.60	*	4.27	*	<2	<1		3.39	*	<2
300-350	<1		3.96	*	<1	<1		3.36	*	<1
350-400	2.26		<1		<2	<2		<2		<2
400-450	<2		<2		<1	3.74		<2		<2
450-500	<1		3.67		<1	3.60		<1		<2
500-550	<1		2.29		<1	<1		<1		<2
550-600	<1		<2		<1	5.15	*	<1		<2
600-650	<1		<2		<1	4.83	*	<2		<2
650-700	<1		<2		<1	3.73		<1		<2
700-750	2.36		<2		<2	3.18		<1		<1
750-800	<1		2.08		<1	3.42		<1		<2
800-850	<2		<2		2.50	3.78		<2		<1
850-900	5.05	*	<2		4.35	2.65		2.11		<1
900-950	3.03		<1		3.91	3.42		<2		<2
950-1000	<1		<2		<2	2.00		<1		<1

* $p < .05$.
**$p < .01$.
***$p < .001$.

Appendix D: Experimental sentence stimuli used in Chapters 3 and 5

The original experimental stimuli in Chinese are listed in Tables D1-D16. The English translation can be found in Tables D17-D36. Two notes about the Tables: First, in Tables D1-D16, some Cantonese words only have a spoken form, and these words are transcribed in Jyutping. Second, the English translations in D17-D36 only provide a general approximation to the actual meaning in Cantonese.

Table D1

Sentence items #1-#25 in the pro-laa1 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
1	你借番嚟嗰本小說就過期 laa3。	你還咗本小說 laa1!
2	有冇攪錯 aa3，你咁大個人啲字仲係歪嚟歪斜 gaa3。	你練好啲書法 laa1!
3	你個斜孭袋穿哂窿，好核突 aa3。	你買過個 laa1!
4	依家做秘書中文同英文都要識打，但係你唔識打中文 wo3。	你學中文輸入法 laa1!
5	我得一份薯條唔夠食 aa3，反正你都去開麥當勞 lok3。	你買多個巨無霸 laa1!
6	可能香港嘅教育制度唔啱佢 ze1。	你畀佢去英國 laa1!
7	宜家做時裝批發好好搵 aa3。如果你想賺大錢嘅話，	你轉行搞時裝批發 laa1!
8	條褲太長 laa3，我唔啱著 aa3。	你幫我改短條褲 laa1!
9	你今次錄音好多走音 laa3，想幫你執都執唔到，	你再錄過 laa1!
10	其實劉督察頭先同你講個番說話眞係冇錯 gaa3，你唔好嬲佢 laa3。	你見番劉督察 laa1!
11	既然你咁覺得學大師話齋斷咗六根會清靜啲嘅話，	你改信佛教 laa1!
12	既然你哋都有足夠證據證明嗰個人係俾葉繼歡殺 lo3。咁依家，	你哋正式起訴佢謀殺 laa1!
13	啲證據顯示佢冇預謀 ge3，	改判誤殺 laa1!
14	你整嗰碟荔芋炆鴨未攞出去已經俾人食哂 laa3。出面少咗碟餸，我哋好難交待 gaa3。	你整多碟荔芋炆鴨 laa1!
15	大埔嗰邊啲樓價又平咗咁多，加上你兩公婆都喺嗰頭番工 ge2，唔好諗咁多 laa3。	你哋搬番去大埔 laa1!
16	上次你都係因爲病咗所以先做唔哂份卷 ze1maa3。如果唔係嘅話份卷點會難倒你 aa1，	你重新考過個試 laa1!
17	佢哋今次份通識報告眞係寫得好好 aa3，既然佢哋又咁有興趣 lok3，	你就俾佢哋參加今屆常識百搭 laa1!
18	呢兩日啲冷氣有浸臭味 wo3，一定係有污糟嘢係個水塔度 laa3。	你搵人洗乾淨個水塔 laa1!
19	瑤瑤未嚟過巴黎，依家咁難得嚟到。	你帶佢去巴黎鐵塔 laa1!
20	厨房啲垃圾多成咁，好鬼死臭 aa3。	你倒咗啲垃圾 laa1!
21	杜拜呢家冇啖好食，留喺度餓餓死 gaa3zaa3。	你離開杜拜 laa1!
22	阿妹星期六要做伴娘。	你俾佢整水晶甲 laa1!
23	局長，再咁落去會出事 gaa3。	你叫啲保安後退 laa1!
24	今日喺呢個商場可以憑收據換現金券，乜你喺佢哋度買完嘢冇攞收據咩? 咁，	你同佢哋攞番張收據 laa1!
25	大學就嚟放假 laa3，趁住依家仲咁多人番緊學。	你開始搵人去做你個研究 laa1!

Table D2

Sentence items #26-#50 in the pro-laa1 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
26	反正佢哋喺度拍戲又唔會影響你啲伙計做嘢 ge2。	你畀佢哋喺度拍 laa1!
27	我頭先唔記得攞番好個煲蓋 aa3。	你幫我攞番好個煲蓋 laa1!
28	你都成個月冇見過世伯 laa3，佢好掛住你 gaa3。	你去探世伯 laa1!
29	嘉士伯依家買一送一 aa3。	你改飲嘉士伯 laa1!
30	佢今次話明考春秋戰國 gaa3。	你睇晒成本戰國策 laa1!
31	你都番咗工成三個月 lok3，點可以到依家都唔知自己應該做乜 gaa3。	你去搞清楚你嘅職責 laa1!
32	你塊畫版爛成咁。	你買過塊 laa1!
33	佢都話鍾意食酸 gaak3lo3。	你就可以落多啲醋 laa1!
34	啱啱我上嚟嗰時，下面有好多人睇人拍戲 a3。襯住依家仲咁多人，	你攞咁啲贈品去派 laa1!
35	如果你要眞正嘅奶味，	你改飲維記 laa1!
36	呢間舖睇落去唔係咁好 wo3，同埋啲租金又咁貴。	你搵過間舖 laa1!
37	今晚煲海帶綠豆沙，	你幫我買多包海帶 laa1!
38	國泰下個星期有招聘日 wo3，你又咁想做空姐，咁招聘日嗰日，	你去遞表格 laa1!
39	依家玩臉書過時 laa3，	你轉玩微博 laa1!
40	今次就係你唔着 laa3,佢都係爲你好 ze1。你做乜鬧人先得 gaa3，	你去同佢認錯 laa1!
41	睇嚟今次荷蘭都係打唔過德國 ga3laa3，趁依家仲有時間，你轉軚支持德國 laa1	你轉軚支持德國 laa1!
42	呢家啲人咁注重食物安全。	你種有機菜 laa1!
43	嗰個客出手最豪爽 ga3laa3，如果你唔夠數嘅話，	你搵番嗰個客 laa1!
44	你屋企前面條咸水喉爆咗 aa4?	你去搵渠務署 laa1!
45	今期金多寶有成五千萬 wo3，你做乜買一注咁少 aa3。	你買多注 laa1!
46	反正依家留係度都冇乜作爲 gaak3，加上強哥又咁有誠意 wo3，	你應承同佢去加拿大另起爐灶 laa1!
47	呢隻蛋糕唔係咁好食 wo3，	你整過隻 laa1!
48	我想度下我腰圍有幾多 aa3，但係屋企嗰把軟尺唔知去咗邊 aa3，	幫我買過把軟尺 laa1!
49	想配個型啲 ge3 眼鏡 aa4?	你去幫襯眼鏡八十八 laa1!
50	你呢個交通津貼就用哂 laa3。	你再申請過個交通津貼 laa1!

Table D3

Sentence items #51-#75 in the pro-laa1 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
51	寶蓮寺啲齋又貴又唔好食，反而附近大澳嗰邊啲齋又平又靚。	你哋改去大澳 laa1!
52	呢度去機場要成 2 個鐘 gaa3，你哋要 5 點去到機場 aa1maa3。依家都已經 3 點 lo3，	你哋準備出發 laa1!
53	依家個倉啲存貨得番 10 件 zaa3，可能唔夠賣 gaa3，	你哋去入貨 laa1!
54	我幫你打咗去東航 laa3，佢哋話你下一程機啱啱取消咗。不如，	你改搭國泰 laa1!
55	份報告嘅最後一部分就靠哂你 laa3，後日就要交 gaa3laa3。	趕起份報告 laa1!
56	都已經成個禮拜，小明依家仲好嬲你哋 aa3。	你哋去同小明道歉 laa1!
57	佢哋好辛苦先搵到一個同佢哋有同一個綠化概念嘅人。	你就應承幫佢哋搞綠化 laa1!
58	依個時間你坐巴士去上環真係會趕唔切 gaa3，	改搭地鐵 laa1!
59	你都好多年冇番屋企做節 lo3。今年中秋節，	你番屋企做節 laa1!
60	你啲頭髮 dam3 哂落嚟，搞到你睇落去冇嚟神氣 aa3。	你梳番起啲頭髮 laa1!
61	個抽獎結果今朝開咗 laa3，	你攞張抽獎卷去對 laa1!
62	前輩日日嚟做 gym gaa3，如果你做咗我哋會員，	你就可以見到前輩 laa1!
63	呢張枱其中一隻枱腳跛跛哋，搞到張枱成日扤嚟扤去 aa3。	你幫我整番好隻枱腳 laa1!
64	陳太個經紀同我講話香港建設真係好堅，你唔買好蝕底 gaa3，	去認購香港建設 laa1!
65	佢唔受呢套 gaa3，	你查清楚佢嘅嗜好 laa1!
66	公司盤數咁好鬼亂，如果俾人查起上嚟就大鑊 laa3，	你做好盤數 laa1!
67	稅務局都已經寄咗信俾你成 2 個月 laa3，你唔好再拖 laa3。	你去報稅 laa1!
68	房裏面啲人等到躁哂 laa3，你再唔播嘅話，啲人就走 gaa3laa3。	你開始播 laa1!
69	反正你去開鎖匙佬嗰頭 lo3，	你拎條匙去配 laa1!
70	隻機械臂又神咗 laa3。	你幫我整番好隻機械臂 laa1!
71	你呢個會計好似手腳唔係咁乾淨 wo3。	你炒咗個會計 laa1!
72	你想班老人家開開心心 ge3 話，	圍酒席加番魚翅 laa1!
73	你把鋸鈍到鋸唔到嘢 laa3。	你換過把鋸 laa1!
74	喂，你件衫後面唔見咗粒鈕 aa3。	你釘番粒鈕 laa1!
75	反正你都落開去 lok3，	幫我去街市買過舊粉葛 laa1!

Table D4

Sentence items #75-#100 in the pro-laa1 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
76	你哋唔係想去跳舞 ge2me1?依家出面個舞池冇咁多人 laa3wo3。	你同佢出去跳 laa1!
77	嚟到日本，點可以錯過日本嘅國技 gaa3，	你哋去睇相撲 laa1!
78	個客好重視我哋今次個計劃 gaa3，所以我唔該你，	你寫好個計劃概要 laa1!
79	你退咗休之後成日喺屋企無所事事，咁樣唔得 gaa3wo3。	你搵番樣精神寄托 laa1!
80	今次呢個委託啲條件聽落去眞係好好 aa3，加上你最近又冇乜單。	你接受呢個委託 laa1!
81	我哋成棚人等緊你份日誌先進行下一步 gaa3。	你寫好份日誌 laa1!
82	何生又呃咗你一次 laa3，再咁樣落去你渣都冇得淨 aa3。	你同佢終止合作 laa1!
83	你唔好爲咗一個小失敗垂頭喪氣，下次你實得 gaa3wo3。	你重新振作 laa1!
84	張契上面有好多錯字 aa3。	你幫我改好張契 laa1!
85	你呢個女配角 NG 咗好多次 laa3，咁樣落去套戲會拍唔成 gaa3wo3。	你搵過個女配角 laa1!
86	反正你哋下學期都唔夠人手，我對呢科又咁熟。	你俾呢科我教 laa1!
87	如果你喺度住得咁唔開心嘅話，	你番美國 laa1!
88	嘩，你個電話殼爛成咁，	你換過個殼 laa1!
89	你棵蘆薈睇落去就瓜柴 laa3wo3。不如，	你種過棵蘆薈 laa1!
90	你張租約就到期 laa3。你都唔想被人趕 gaa2!	你同包租婆續約 laa1!
91	你簽咗無線之後就唔哂再擔心冇工開 laa3，	你應承同佢哋簽約 laa1!
92	你之前個個女朋友都怕咗你隻腳。	你醫番好隻香港腳 laa1!
93	反正你都經過快圖美 lo3，	你攞卷菲林去曬 laa1!
94	佢難得遇到個好劇本，呢個角色非佢莫屬 gaa3，	你俾佢拍 laa1!
95	老爺最錫二少 gaa3laa3，所以，	你投靠二少 laa1!
96	你哋上到嚟無非都係想滑雪 ze1，難得天氣又咁好，	你哋出去滑雪 laa1!
97	佢點解可以咁鬼遲鈍 ga3。	你同佢開竅 laa1!
98	個秋祭有啲杰撻撻 wo3，話哂個秋祭都係你哋負責 ge2。	你哋搞掂個秋祭 laa1!
99	你老細睇落去好似唔係咁 likey wo3，如果你想佢幫你嘅話，	你氹掂你個老細 laa1!
100	你呢個辦法點都係行唔通 gaa3laa3。	你哋改變主意 laa1!

Table D5

Sentence items #1-#25 in the pro-laa4 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
1	你喺圖書館借番嚟嗰本小說呢? 今朝仲喺張凳度 gaak3,	你還咗本小說 laa4!
2	你唔係要練書法 ge2me1? 點解你咁得閒喺度打機 gaa3?	你練好啲書法 laa4!
3	你個手袋睇落去好似唔同咗 wo3。	你買過個 laa4!
4	之前你話唔學倉頡 gaak3，點解你依家猛咁煲個倉頡字表 ge2?	你學中文輸入法 laa4!
5	咦，頭先你淨係攞住一個餐 gaa3zaa3bo3，點解依家你有兩個紙袋喺手 ge2?終於，	你買多個巨無霸 laa4!
6	你個仔話佢下個學期去英國所以唔再嚟補習 laa3wo3，	你畀佢去英國 laa4!
7	之前你唔係做開玩具批發 ge2me1?點解黃師奶話你最近喺長沙灣時裝批發中心開咗檔 ge2，	你轉行搞時裝批發 laa4!
8	呢條褲上次試唔啱著 ga3wo3，依家又啱身 ge2。	你幫我改短條褲 laa4!
9	之前聽呢段嘢好多字讀錯 gaak3，點解依家再聽又啱哂 ge2?	你再錄過 laa4!
10	ei5，你點知劉督察準備退休 gaa3?	你見番劉督察 laa4!
11	咦，你唔係天主教徒嚟 ge3me1? 做乜呢排成日係佛堂見到你 ge2?	你改信佛教 laa4!
12	我見你哋喺度準備緊令狀 wo3，	你哋正式起訴佢謀殺 laa4!
13	聽完控辯雙方陳詞之後，你終於同意辯方，	改判誤殺 laa4!
14	咦，佢突然間咁開心 ge2?	你整多碟荔芋炆鴨 laa4!
15	聽講你同你老婆已經收番你哋喺大埔嗰層樓 wo3，	你哋搬番去大埔 laa4!
16	我記得你上次考急救好似肥咗佬 gaa3wo3，點解你話你依家有急救證書 ge2?	你重新考過個試 laa4!
17	你之前唔係反對佢哋參加 ge3me1!，依家...佢哋 ai1 多你幾吓，	你就俾佢哋參加今屆常識百搭 laa4!
18	今朝啲冷氣仲有浸臭味 gaak3，依家又冇咗 laa3wo3，	你搵人洗乾淨個水塔 laa4!
19	點解家穎同你出咗去番嚟之後就咁興奮 ge2?	你帶佢去巴黎鐵塔 laa4!
20	個廚房乾淨哂，一啲味都冇，	你倒咗啲垃圾 laa4!
21	我聽你個妹話你依家坐緊車 laa3wo3，	你離開杜拜 laa4!
22	點解呢排你個女猛問人邊度修甲最平 ge2?	你俾佢整水晶甲 laa4!
23	局長，啲示威者開始冷靜 laa3bo3，頭先，	你叫啲保安後退 laa4!
24	你之前唔係話冇咗張收據嘅咩? 咁你依家點樣計番條數出嚟 ga3?	你同佢哋攞番張收據 laa4!
25	我見你攞住一大疊關於你個研究嘅招紙 wo3，	你開始搵人去做你個研究 laa4!

Table D6

Sentence items #26-#50 in the pro-laa4 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
26	吓，之前你話唔畀佢哋喺度拍戲 gaak3? 點解啲攝影車嚟晒 ge2?	你畀佢哋喺度拍 laa4!
27	咦，我頭先煮麵好似冇揼煲蓋 gaa3wo3，點解依家揼咗蓋 ge2?	你幫我揼番好個煲蓋 laa4!
28	咦阿宗，伯母話你終於開口問佢老人院嘅開放時間，	你去探世伯 laa4!
29	咦，你一直話嘉士伯唔好飲 gaak3。點解依家你又嗌嘉士伯 ge2?	你改飲嘉士伯 laa4!
30	我記得你之前仲睇緊戰國策 gaak3。點解你俾咗本書阿恆睇 ge2,	你睇晒成本戰國策 laa4!
31	幾日前問你個位做乜你都答唔出，今次你答得有頭有路 wo3，	你去搞清楚你嘅職責 laa4!
32	你塊畫版唔係爛咗咩?做乜你依家有塊新 ge2?	你買過塊 laa4!
33	你真係以爲呢味餸叫糖醋排骨，咁喺煮嗰陣時，	你就可以落多啲醋 laa4!
34	點解你枱面啲贈品少咗咁多 ge2?	你攞咁啲贈品去派 laa4!
35	點解你唔再買牛奶公司 ge2?	你改飲維記 laa4!
36	聽張太講話你冇去睇佢介紹嗰間舖 wo3，乜，	你搵過間舖 laa4!
37	點解雪櫃多咗包海帶 ge2?	你幫我買多包海帶 laa4!
38	你之前唔係已經影過護照相 ge3me1? 點解你依家又去影埋啲咁正式嘅相 ge2?	你去遞表格 laa4!
39	我記得你冇玩微博 gaak3。點解你依家猛咁問微博啲嘢 ge2?	你轉玩微博 laa4!
40	阿禮，之前你唔係覺得自己冇錯 ge3me1? 點解你依家又攞住阿思鍾意嘅 Hello Kittyge2?	你去同佢認錯 laa4!
41	之前你唔係支持開巴西 ge3me1?點解你今次買德國波衫又唔買巴西波衫 ge2?	你轉軚支持德國 laa4!
42	你諗咗咁耐終於肯抌晒啲化肥。	你種有機菜 laa4!
43	上個月你個豪客走咗搞到你唔夠數，今個月啲數又升番晒 wo3，	你搵番嗰個客 laa4!
44	你之前話等到聽日先 gaak3，點解你依家咁急要渠務署個電話 ge2?	你去搵渠務署 laa4!
45	枱面多咗張電腦投注飛 ge2!	你買多注 laa4!
46	你又話唔想辭工跟強哥走 gaak3，點解佢好興奮噉話同你訂機票 ge2?	你應承同佢去加拿大另起爐灶 laa4!
47	咦，你隻復活蛋睇落去唔同咗 wo3，	你整過隻 laa4!
48	你知道冇咗把軟尺好唔方便 le5? 你終於都去深水埗，	幫我買過把軟尺 laa4!
49	你做咩攞番晒眼鏡八十八啲優惠卷出嚟 ge2，	你去幫襯眼鏡八十八 laa4!
50	之前你唔係申請過交通津貼 ge2me1?點解你又塡過張申請表 ge2?	你再申請過個交通津貼 laa4!

Table D7

Sentence items #51-#75 in the pro-laa4 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
51	之前話唔去大澳 gaak3? 點解阿媽今朝猛咁搵蝦膏廠地址 ge2?	你哋改去大澳 laa4!
52	我見你哋揹晒背囊又着晒鞋咁,	你哋準備出發 laa4!
53	咦, 點解你哋突然間攞咁多 catalog 番嚟 ge2?	你哋去入貨 laa4!
54	你同我拗咗成日話唔搭國泰 gaak3，點解你又過嚟呢邊搞登機手續 ge2?	你改搭國泰 laa4!
55	咦，你做乜打緊機 ge2?	趕起份報告 laa4!
56	小明唔開心咗好耐 gaa3 laa3。你哋而家攞住咁多禮物去佢屋企,	你哋去同小明道歉 laa4!
57	吓，唔係 aa3 話，原本你唔係死都唔肯幫佢哋搞綠化 ge2?依家佢哋隨便氹你兩句,	你就應承幫佢哋搞綠化 laa4!
58	你成日都話唔搭地鐵，點解今次你會咁早到 ge2? 你終於肯聽我講,	改搭地鐵 laa4!
59	今日中秋節，全公司啲人一早就走晒 laa3。你而家先走 ge2,	你番屋企做節 laa4!
60	咦，點解你啲頭髮睇落去短咗咁多 ge2?	你梳番起啲頭髮 laa4!
61	咦，你點知我哋中咗獎 ga3?	你攞張抽獎卷去對 laa4!
62	你之前見唔到前輩就攞到明係佢想避你 gaa3laa1，依家你以爲你問人攞到前輩個時間表,	你就可以見到前輩 laa4!
63	咦，張枱冇再屹嚟屹去 laa3wo3,	你幫我整番好隻枱腳 laa4!
64	你之前話無興趣 gaak。 依家你終於肯聽個經紀講,	去認購香港建設 laa4!
65	咦，我見你買咗份禮物俾佢 laa3wo3,	你查清楚佢嘅嗜好 laa4!
66	咦，你做乜停晒手 aa3,	你做好盤數 laa4!
67	你成日話拖得就拖，死都唔報稅住 gaak3， 依家手裏面又攞住個稅局信封 ge2?	你去報稅 laa4!
68	我見你啱啱放咗隻碟入部機度 wo3,	你開始播 laa4!
69	你終於明白得一揪鎖匙好唔方便，所以	你拎條匙去配 laa4!
70	之前隻機械臂唔係壞咗 ge2me1，點解依家郁得番 ge?	你幫我整番好隻機械臂 laa4!
71	班 sales 一向都好唔妥個會計 gaak，點解佢哋依家咁開心 ge2? 終於,	你炒咗個會計 laa4!
72	你終於肯聽我哋班老人家 ge3 意見,	圍酒席加番魚翅 laa4!
73	咦，我記得之前用把鋸好鈍 ga3bo3，點解依家把鋸咁利 ge2?	你換過把鋸 laa4!
74	咦，你之前件衫唔係冇咗粒扣 ge2me1? 依家件衫又扣到 ge2,	你釘番粒鈕 laa4!
75	你卒之知道超市啲嘢唔掂，所以,	幫我去街市買過舊粉葛 laa4!

Table D8

Sentence items #75-#100 in the pro-laa4 match condition

Item #	Context (Chinese)	Target sentence (Chinese)
76	琴日你又話唔再同阿美跳 gaak3，點解佢去著對舞鞋 ge2？	你同佢出去跳 laa4!
77	卒之講咗咁耐，	你哋去睇相撲 laa4!
78	你點解咁得閒做其他嘢 ge2?	你寫好個計劃概要 laa4!
79	冇見你一排，你開朗咗好多 wo3，	你搵番樣精神寄托 laa4!
80	老細話你同個客啱啱簽咗約 wo3，	你接受呢個委託 laa4!
81	咦，點解你咁得閒係度執嘢 ge2?	你寫好份日誌 laa4!
82	咦，我見你間舖冇再賣何生啲嘢 laa3wo3，	你同佢終止合作 laa4!
83	琴日仲見你死死下，今日見你做嘢咁有幹勁 ge2，	你重新振作 laa4!
84	頭先陳秘書留言俾我叫我上你度攞番張契 wo3，咁即係…	你幫我改好張契 laa4!
85	我見你個女配角好似唔同咗樣 wo3，	你搵過個女配角 laa4!
86	咦，點解你依家又肯同我講下學期通識科個課程計劃 ge2?	你俾呢科我教 laa4!
87	我見你執哂啲嘢又買埋機票 wo3，	你番美國 laa4!
88	你個殼之前唔係好素 ge3me1?點解依家咁多 bling bling ge2?終於，	你換過個殼 laa4!
89	我記得上次見你棵蘆薈就死 gaa3laa3bo3，依家點解生得咁靚 ge2?	你種過棵蘆薈 laa4!
90	你唔係約滿 gaa3le3me1?點解你依家仲喺度 ge2?	你同包租婆續約 laa4!
91	我知你之前掙扎咗好耐要唔要簽無線做你經理人，依家你俾佢哋幫你接 show ge2?	你應承同佢哋簽約 laa4!
92	你做乜抌哂啲藥 ge2?	你醫番好隻香港腳 laa4!
93	點解你攞住卷菲林出去嘅?卷菲林 pek6 咗喺櫃桶底成年 laa3，	你攞卷菲林去曬 laa4!
94	之前你講過話唔俾阿芝拍呢套戲 gaak3，依家又見阿芝同林生對劇本 ge2，	你俾佢拍 laa4!
95	你之前成日話二少個人唔得，點解你又 tsi1 埋去二少到 ge2? 終於	你投靠二少 laa4!
96	你哋頭先仲話怕危險 gaak3, 做乜依家換晒雪褲 ge2，	你哋出去滑雪 laa4!
97	咦，點解你個仔醒咗咁多 ge2?	你同佢開竅 laa4!
98	喂，點解你哋坐哂喺度抖 gaa3?	你哋搞掂個秋祭 laa4!
99	你老細點解依家會改變主意應承同我哋合作 ge2?	你氹掂你個老細 laa4!
100	之前你哋咪話唔肯賣個單位俾林生 ge2，點解依家你哋又約林生出嚟傾 aa3?	你哋改變主意 laa4!

Table D9

Sentence items #1-#25 in the pro-laa1 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
1	你喺圖書館借番嚟嗰本小說呢? 今朝仲喺張凳度 gaak3,	你還咗本小說 laa1!
2	你唔係要練書法 ge2me1? 點解你咁得閒喺度打機 gaa3?	你練好啲書法 laa1!
3	你個手袋睇落去好似唔同咗 wo3。	你買過個 laa1!
4	之前你話唔學倉頡 gaak3，點解你依家猛咁煲個倉頡字表 ge2?	你學中文輸入法 laa1!
5	咦，頭先你淨係攞住一個餐 gaa3zaa3bo3，點解依家你有兩個紙袋喺手 ge2?終於，	你買多個巨無霸 laa1!
6	你個仔話佢下個學期去英國所以唔再嚟補習 laa3wo3，	你畀佢去英國 laa1!
7	之前你唔係做開玩具批發 ge2me1?點解黃師奶話你最近喺長沙灣時裝批發中心開咗檔 ge2，	你轉行搞時裝批發 laa1!
8	呢條褲上次試唔啱著 ga3wo3，依家又啱身 ge2。	你幫我改短條褲 laa1!
9	之前聽呢段嘢好多字讀錯 gaak3，點解依家再聽又啱哂 ge2?	你再錄過 laa1!
10	ei5，你點知劉督察準備退休 gaa3?	你見番劉督察 laa1!
11	咦，你唔係天主教徒嚟 ge3me1? 做乜呢排成日係佛堂見到你 ge2?	你改信佛教 laa1!
12	我見你哋喺度準備緊令狀 wo3，	你哋正式起訴佢謀殺 laa1!
13	聽完控辯雙方陳詞之後，你終於同意辯方，	改判誤殺 laa1!
14	咦，佢突然間咁開心 ge2?	你整多碟荔芋炆鴨 laa1!
15	聽講你同你老婆已經收番你哋喺大埔嗰層樓 wo3，	你哋搬番去大埔 laa1!
16	我記得你上次考急救好似肥咗佬 gaa3wo3，點解你話你依家有急救證書 ge2?	你重新考過個試 laa1!
17	你之前唔係反對佢哋參加 ge3me1!，依家...佢哋 ai1 多你幾吓，	你就俾佢哋參加今屆常識百搭 laa1!
18	今朝啲冷氣仲有浸臭味 gaak3，依家又冇咗 laa3wo3，	你搵人洗乾淨個水塔 laa1!
19	點解家穎同你出咗去番嚟之後就咁興奮 ge2?	你帶佢去巴黎鐵塔 laa1!
20	個廚房乾淨哂，一啲味都冇，	你倒咗啲垃圾 laa1!
21	我聽你個妹話你依家坐緊車 laa3wo3，	你離開杜拜 laa1!
22	點解呢排你個女猛問人邊度修甲最平 ge2?	你俾佢整水晶甲 laa1!
23	局長，啲示威者開始冷靜 laa3bo3，頭先，	你叫啲保安後退 laa1!
24	你之前唔係話冇咗張收據嘅咩? 咁你依家點樣計番條數出嚟 ga3?	你同佢哋攞番張收據 laa1!
25	我見你攞住一大疊關於你個研究嘅招紙 wo3，	你開始搵人去做你個研究 laa1!

Table D10

Sentence items #26-#50 in the pro-laa1 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
26	吓，之前你話唔畀佢哋喺度拍戲 gaak3? 點解啲攝影車嚟哂 ge2?	你畀佢哋喺度拍 laa1!
27	咦，我頭先煮麵好似冇揼煲蓋 gaa3wo3，點解依家揼咗蓋 ge2?	你幫我揼番好個煲蓋 laa1!
28	咦阿宗，伯母話你終於開口問佢老人院嘅開放時間，	你去探世伯 laa1!
29	咦，你一直話嘉士伯唔好飲 gaak3。 點解依家你又嗌嘉士伯 ge2?	你改飲嘉士伯 laa1!
30	我記得你之前仲睇緊戰國策 gaak3。點解你俾咗本書阿恆睇 ge2,	你睇哂成本戰國策 laa1!
31	幾日前問你個位做乜你都答唔出，今次你答得有頭有路 wo3，	你去搞清楚你嘅職責 laa1!
32	你塊畫版唔係爛咗咩?做乜你依家有塊新 ge2?	你買過塊 laa1!
33	你眞係以爲呢味餸叫糖醋排骨，咁喺煮嗰陣時，	你就可以落多啲醋 laa1!
34	點解你枱面啲贈品少咗咁多 ge2?	你攞咁啲贈品去派 laa1!
35	點解你唔再買牛奶公司 ge2?	你改飲維記 laa1!
36	聽張太講話你冇去睇佢介紹嗰間舖 wo3，乜，	你搵過間舖 laa1!
37	點解雪櫃多咗包海帶 ge2?	你幫我買多包海帶 laa1!
38	你之前唔係已經影過護照相 ge3me1? 點解你依家又去影埋啲咁正式嘅相 ge2?	你去遞表格 laa1!
39	我記得你冇玩微博 gaak3。點解你依家猛咁問微博啲嘢 ge2?	你轉玩微博 laa1!
40	阿禮，之前你唔係覺得自己冇錯 ge3me1? 點解你依家又攞住阿思鍾意嘅 Hello Kittyge2?	你去同佢認錯 laa1!
41	之前你唔係支持開巴西 ge3me1?點解你今次買德國波衫又唔買巴西波衫 ge2?	你轉軚支持德國 laa1!
42	你諗咗咁耐終於肯抌哂啲化肥。	你種有機菜 laa1!
43	上個月你個豪客走咗搞到你唔夠數，今個月啲數又升番哂 wo3，	你搵番嗰個客 laa1!
44	你之前話等到聽日先 gaak3，點解你依家咁急要渠務署個電話 ge2?	你去搵渠務署 laa1!
45	枱面多咗張電腦投注飛 ge2!	你買多注 laa1!
46	你又話唔想辭工跟強哥走 gaak3，點解佢好興奮噉話同你訂機票 ge2?	你應承同佢去加拿大另起爐灶 laa1!
47	咦，你隻復活蛋睇落去唔同咗 wo3，	你整過隻 laa1!
48	你知道冇咗把軟尺好唔方便 le5? 你終於都去深水埗，	幫我買過把軟尺 laa1!
49	你做咩攞番哂眼鏡八十八啲優惠卷出嚟 ge2,	你去幫襯眼鏡八十八 laa1!
50	之前你唔係申請過交通津貼 ge2me1?點解你又填過張申請表 ge2?	你再申請過個交通津貼 laa1!

Table D11

Sentence items #51-#75 in the pro-laa1 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
51	之前話唔去大澳 gaak3? 點解阿媽今朝猛咁搵蝦膏廠地址 ge2?	你哋改去大澳 laa1!
52	我見你哋揹哂背囊又着哂鞋咁,	你哋準備出發 laa1!
53	咦, 點解你哋突然間攞咁多 catalog 番嚟 ge2?	你哋去入貨 laa1!
54	你同我拗咗成日話唔搭國泰 gaak3，點解你又過嚟呢邊搞登機手續 ge2?	你改搭國泰 laa1!
55	咦，你做乜打緊機 ge2?	趕起份報告 laa1!
56	小明唔開心咗好耐 gaa3 laa3。你哋而家攞住咁多禮物去佢屋企,	你哋去同小明道歉 laa1!
57	吓，唔係 aa3 話，原本你唔係死都唔肯幫佢哋搞綠化 ge2?依家佢哋隨便氹你兩句,	你就應承幫佢哋搞綠化 laa1!
58	你成日都話唔搭地鐵，點解今次你會咁早到 ge2? 你終於肯聽我講,	改搭地鐵 laa1!
59	今日中秋節，全公司啲人一早就走晒 laa3。你而家先走 ge2,	你番屋企做節 laa1!
60	咦，點解你啲頭髮睇落去短咗咁多 ge2?	你梳番起啲頭髮 laa1!
61	咦，你點知我哋中咗獎 gaa3?	你攞張抽獎卷去對 laa1!
62	你之前見唔到前輩就攞到明係佢想避你 gaa3laa1，依家你以爲你問人攞到前輩個時間表,	你就可以見到前輩 laa1!
63	咦，張枱冇再屹嚟屹去 laa3wo3,	你幫我整番好隻枱腳 laa1!
64	你之前話無興趣 gaak。 依家你終於肯聽個經紀講,	去認購香港建設 laa1!
65	咦，我見你買咗份禮物俾佢 laa3wo3,	你查清楚佢嘅嗜好 laa1!
66	咦，你做乜停哂手 aa3,	你做好盤數 laa1!
67	你成日話拖得就拖，死都唔報稅住 gaak3， 依家手裏面又攞住個稅局信封 ge2?	你去報稅 laa1!
68	我見你啱啱放咗隻碟入部機度 wo3,	你開始播 laa1!
69	你終於明白得一揪鎖匙好唔方便，所以	你拎條匙去配 laa1!
70	之前隻機械臂唔係壞咗 ge2me1，點解依家郁得番 ge?	你幫我整番好隻機械臂 laa1!
71	班 sales 一向都好唔妥個會計 gaak，點解佢哋依家咁開心 ge2? 終於,	你炒咗個會計 laa1!
72	你終於肯聽我哋班老人家 ge3 意見,	圍酒席加番魚翅 laa1!
73	咦，我記得之前用把鋸好鈍 ga3bo3，點解依家把鋸咁利 ge2?	你換過把鋸 laa1!
74	咦，你之前件衫唔係冇咗粒扣 ge2me1? 依家件衫又扣到 ge2,	你釘番粒鈕 laa1!
75	你卒之知道超市啲嘢唔掂，所以,	幫我去街市買過舊粉葛 laa1!

Table D12

Sentence items #75-#100 in the pro-laa1 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
76	琴日你又話唔再同阿美跳 gaak3，點解佢去著對舞鞋 ge2？	你同佢出去跳 laa1!
77	卒之講咗咁耐，	你哋去睇相撲 laa1!
78	你點解咁得閒做其他嘢 ge2?	你寫好個計劃概要 laa1!
79	冇見你一排，你開朗咗好多 wo3，	你搵番樣精神寄托 laa1!
80	老細話你同個客啱啱簽咗約 wo3，	你接受呢個委託 laa1!
81	咦，點解你咁得閒係度執嘢 ge2?	你寫好份日誌 laa1!
82	咦，我見你間舖冇再賣何生啲嘢 laa3wo3，	你同佢終止合作 laa1!
83	琴日仲見你死死下，今日見你做嘢咁有幹勁 ge2，	你重新振作 laa1!
84	頭先陳秘書留言俾我叫我上你度攞番張契 wo3，咁即係…	你幫我改好張契 laa1!
85	我見你個女配角好似唔同咗樣 wo3，	你搵過個女配角 laa1!
86	咦，點解你依家又肯同我講下學期通識科個課程計劃 ge2?	你俾呢科我教 laa1!
87	我見你執哂啲嘢又買埋機票 wo3，	你番美國 laa1!
88	你個殼之前唔係好素 ge3me1?點解依家咁多 bling bling ge2?終於，	你換過個殼 laa1!
89	我記得上次見你棵蘆薈就死 gaa3laa3bo3，依家點解生得咁靚 ge2?	你種過棵蘆薈 laa1!
90	你唔係約滿 gaa3le3me1?點解你依家仲喺度 ge2?	你同包租婆續約 laa1!
91	我知你之前掙扎咗好耐要唔要簽無線做你經理人，依家你俾佢哋幫你接 show ge2?	你應承同佢哋簽約 laa1!
92	你做乜抌哂啲藥 ge2?	你醫番好隻香港腳 laa1!
93	點解你攞住卷菲林出去嘅?卷菲林 pek6 咗喺櫃桶底成年 laa3，	你攞卷菲林去曬 laa1!
94	之前你講過話唔俾阿芝拍呢套戲 gaak3，依家又見阿芝同林生對劇本 ge2，	你俾佢拍 laa1!
95	你之前成日話二少個人唔得，點解你又 tsi1 埋去二少到 ge2? 終於	你投靠二少 laa1!
96	你哋頭先仲話怕危險 gaak3, 做乜依家換哂雪褲 ge2，	你哋出去滑雪 laa1!
97	咦，點解你個仔醒咗咁多 ge2?	你同佢開竅 laa1!
98	喂，點解你哋坐哂喺度抖 gaa3?	你哋搞掂個秋祭 laa1!
99	你老細點解依家會改變主意應承同我哋合作 ge2?	你氹掂你個老細 laa1!
100	之前你哋咪話唔肯賣個單位俾林生 ge2，點解依家你哋又約林生出嚟傾 aa3?	你哋改變主意 laa1!

Table D13

Sentence items #1-#25 in the pro-laa4 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
1	你借番嚟嗰本小說就過期 laa3。	你還咗本小說 laa4!
2	有冇攪錯 aa3，你咁大個人啲字仲係歪嚟歪斜 gaa3。	你練好啲書法 laa4!
3	你個斜孭袋穿哂窿，好核突 aa3。	你買過個 laa4!
4	依家做秘書中文同英文都要識打，但係你唔識打中文 wo3。	你學中文輸入法 laa4!
5	我得一份薯條唔夠食 aa3，反正你都去開麥當勞 lok3。	你買多個巨無霸 laa4!
6	可能香港嘅教育制度唔啱佢 ze1。	你畀佢去英國 laa4!
7	宜家做時裝批發好好搵 aa3。如果你想賺大錢嘅話，	你轉行搞時裝批發 laa4!
8	條褲太長 laa3，我唔啱著 aa3。	你幫我改短條褲 laa4!
9	你今次錄音好多走音 laa3，想幫你執都執唔到，	你再錄過 laa4!
10	其實劉督察頭先同你講個番說話眞係冇錯 gaa3，你唔好嬲佢 laa3。	你見番劉督察 laa4!
11	既然你咁覺得學大師話齋斷咗六根會清靜啲嘅話，	你改信佛教 laa4!
12	既然你哋都有足夠證據證明嗰個人係俾葉繼歡殺 lo3。咁依家，	你哋正式起訴佢謀殺 laa4!
13	啲證據顯示佢冇預謀 ge3，	改判誤殺 laa4!
14	你整嗰碟荔芋炆鴨未攞出去已經俾人食哂 laa3。出面少咗碟餸，我哋好難交待 gaa3。	你整多碟荔芋炆鴨 laa4!
15	大埔嗰邊啲樓價又平咗咁多，加上你兩公婆都喺嗰頭番工 ge2，唔好諗咁多 laa3。	你哋搬番去大埔 laa4!
16	上次你都係因爲病咗所以先做唔哂份卷 ze1maa3。如果唔係嘅話份卷點會難倒你 aa1，	你重新考過個試 laa4!
17	佢哋今次份通識報告眞係寫得好好 aa3，既然佢哋又咁有興趣 lok3，	你就俾佢哋參加今屆常識百搭 laa4!
18	呢兩日啲冷氣有浸臭味 wo3，一定係有污糟嘢係個水塔度 laa3。	你搵人洗乾淨個水塔 laa4!
19	瑤瑤未嚟過巴黎，依家咁難得嚟到。	你帶佢去巴黎鐵塔 laa4!
20	厨房啲垃圾多成咁，好鬼死臭 aa3。	你倒咗啲垃圾 laa4!
21	杜拜呢家冇啖好食，留喺度餞餓死 gaa3zaa3。	你離開杜拜 laa4!
22	阿妹星期六要做伴娘。	你俾佢整水晶甲 laa4!
23	局長，再咁落去會出事 gaa3。	你叫啲保安後退 laa4!
24	今日喺呢個商場可以憑收據換現金劵，乜你喺佢哋度買完嘢冇攞收據咩? 咁，	你同佢哋攞番張收據 laa4!
25	大學就嚟放假 laa3，趁住依家仲咁多人番緊學。	你開始搵人去做你個研究 laa4!

Table D14

Sentence items #26-#50 in the pro-laa4 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
26	反正佢哋喺度拍戲又唔會影響你啲伙計做嘢 ge2。	你畀佢哋喺度拍 laa4!
27	我頭先唔記得揲番好個煲蓋 aa3。	你幫我揲番好個煲蓋 laa4!
28	你都成個月冇見過世伯 laa3，佢好掛住你 gaa3。	你去探世伯 laa4!
29	嘉士伯依家買一送一 aa3。	你改飲嘉士伯 laa4!
30	佢今次話明考春秋戰國 gaa3。	你睇哂成本戰國策 laa4!
31	你都番咗工成三個月 lok3，點可以到依家都唔知自己應該做乜 gaa3。	你去搞清楚你嘅職責 laa4!
32	你塊畫版爛成咁。	你買過塊 laa4!
33	佢都話鍾意食酸 gaak3lo3。	你就可以落多啲醋 laa4!
34	啱啱我上嚟嗰時，下面有好多人睇人拍戲 a3。襯住依家仲咁多人，	你攞咁啲贈品去派 laa4!
35	如果你要眞正嘅奶味，	你改飲維記 laa4!
36	呢間舖睇落去唔係咁好 wo3，同埋啲租金又咁貴。	你搵過間舖 laa4!
37	今晚煲海帶綠豆沙，	你幫我買多包海帶 laa4!
38	國泰下個星期有招聘日 wo3，你又咁想做空姐，咁招聘日嗰日，	你去遞表格 laa4!
39	依家玩臉書過時 laa3，	你轉玩微博 laa4!
40	今次就係你唔着 laa3,佢都係爲你好 ze1。你做乜鬧人先得 gaa3，	你去同佢認錯 laa4!
41	睇嚟今次荷蘭都係打唔過德國 ga3laa3，趁依家仲有時間，你轉軚支持德國 laa1	你轉軚支持德國 laa4!
42	呢家啲人咁注重食物安全。	你種有機菜 laa4!
43	嗰個客出手最豪爽 gaa3laa3，如果你唔夠數嘅話，	你搵番嗰個客 laa4!
44	你屋企前面條咸水喉爆咗 aa4?	你去搵渠務署 laa4!
45	今期金多寶有成五千萬 wo3，你做乜買一注咁少 aa3。	你買多注 laa4!
46	反正依家留係度都冇乜作爲 gaak3，加上強哥又咁有誠意 wo3，	你應承同佢去加拿大另起爐灶 laa4!
47	呢隻蛋糕唔係咁好食 wo3，	你整過隻 laa4!
48	我想度下我腰圍有幾多 aa3，但係屋企嗰把軟尺唔知去咗邊 aa3，	幫我買過把軟尺 laa4!
49	想配個型啲 ge3 眼鏡 aa4?	你去幫襯眼鏡八十八 laa4!
50	你呢個交通津貼就用哂 laa3。	你再申請過個交通津貼 laa4!

Table D15

Sentence items #51-#75 in the pro-laa4 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
51	寶蓮寺啲齋又貴又唔好食，反而附近大澳嗰邊啲齋又平又靚。	你哋改去大澳 laa4!
52	呢度去機場要成 2 個鐘 gaa3，你哋要 5 點去到機場 aa1maa3。依家都己經 3 點 lo3，	你哋準備出發 laa4!
53	依家個倉啲存貨得番 10 件 zaa3，可能唔夠賣 gaa3，	你哋去入貨 laa4!
54	我幫你打咗去東航 laa3，佢哋話你下一程機啱啱取消咗。不如，	你改搭國泰 laa4!
55	份報告嘅最後一部分就靠晒你 laa3，後日就要交 gaa3laa3。	趕起份報告 laa4!
56	都已經成個禮拜，小明依家仲好嬲你哋 aa3。	你哋去同小明道歉 laa4!
57	佢哋好辛苦先搵到一個同佢哋有同一個綠化概念嘅人。	你就應承幫佢哋搞綠化 laa4!
58	依個時間你坐巴士去上環真係會趕唔切 gaa3，	改搭地鐵 laa4!
59	你都好多年冇番屋企做節 lo3。今年中秋節，	你番屋企做節 laa4!
60	你啲頭髮 dam3 哂落嚟，搞到你睇落去冇嚟神氣 aa3。	你梳番起啲頭髮 laa4!
61	個抽獎結果今朝開咗 laa3，	你攞張抽獎卷去對 laa4!
62	前輩日日嚟做 gym gaa3，如果你做咗我哋會員，	你就可以見到前輩 laa4!
63	呢張枱其中一隻枱腳跛跛哋，搞到張枱成日扢嚟扢去 aa3。	你幫我整番好隻枱腳 laa4!
64	陳太個經紀同我講話香港建設真係好堅，你唔買好蝕底 gaa3，	去認購香港建設 laa4!
65	佢唔受呢套 gaa3，	你查清楚佢嘅嗜好 laa4!
66	公司盤數咁好鬼亂，如果俾人查起上嚟就大鑊 laa3，	你做好盤數 laa4!
67	稅務局都已經寄咗信俾你成 2 個月 laa3，你唔好再拖 laa3。	你去報稅 laa4!
68	房裏面啲人等到躁哂 laa3，你再唔播嘅話，啲人就走 gaa3laa3。	你開始播 laa4!
69	反正你去開鎖匙佬嗰頭 lo3，	你拎條匙去配 laa4!
70	隻機械臂又神咗 laa3。	你幫我整番好隻機械臂 laa4!
71	你呢個會計好似手腳唔係咁乾淨 wo3。	你炒咗個會計 laa4!
72	你想班老人家開開心心 ge3 話，	圍酒席加番魚翅 laa4!
73	你把鋸鈍到鋸唔到嘢 laa3。	你換過把鋸 laa4!
74	喂，你件衫後面唔見咗粒釦 aa3。	你釘番粒釦 laa4!
75	反正你都落開去 lok3，	幫我去街市買過舊粉葛 laa4!

Table D16

Sentence items #75-#100 in the pro-laa4 mismatch condition

Item #	Context (Chinese)	Target sentence (Chinese)
76	你哋唔係想去跳舞 ge2me1?依家出面個舞池冇咁多人 laa3wo3。	你同佢出去跳 laa4!
77	嚟到日本，點可以錯過日本嘅國技 gaa3，	你哋去睇相撲 laa4!
78	個客好重視我哋今次個計劃 gaa3，所以我唔該你，	你寫好個計劃概要 laa4!
79	你退咗休之後成日喺屋企無所事事，咁樣唔得 gaa3wo3。	你搵番樣精神寄托 laa4!
80	今次呢個委託啲條件聽落去真係好好 aa3，加上你最近又冇乜單。	你接受呢個委託 laa4!
81	我哋成棚人等緊你份日誌先進行下一步 gaa3。	你寫好份日誌 laa4!
82	何生又呃咗你一次 laa3，再咁樣落去你渣都冇得淨 aa3。	你同佢終止合作 laa4!
83	你唔好爲咗一個小失敗垂頭喪氣，下次你實得 gaa3wo3。	你重新振作 laa4!
84	張契上面有好多錯字 aa3。	你幫我改好張契 laa4!
85	你呢個女配角 NG 咗好多次 laa3，咁樣落去套戲會拍唔成 gaa3wo3。	你搵過個女配角 laa4!
86	反正你哋下學期都唔夠人手，我對呢科又咁熟。	你俾呢科我教 laa4!
87	如果你喺度住得咁唔開心嘅話，	你番美國 laa4!
88	嘩，你個電話殼爛成咁，	你換過個殼 laa4!
89	你棵蘆薈睇落去就瓜柴 laa3wo3。不如，	你種過棵蘆薈 laa4!
90	你張租約就到期 laa3。你都唔想被人趕 gaa2!	你同包租婆續約 laa4!
91	你簽咗無線之後就唔哂再擔心冇工開 laa3，	你應承同佢哋簽約 laa4!
92	你之前個個女朋友都怕咗你隻腳。	你醫番好隻香港腳 laa4!
93	反正你都經過快圖美 lo3，	你攞卷菲林去曬 laa4!
94	佢難得遇到個好劇本，呢個角色非佢莫屬 gaa3，	你俾佢拍 laa4!
95	老爺最錫二少 gaa3laa3，所以，	你投靠二少 laa4!
96	你哋上到嚟無非都係想滑雪 ze1，難得天氣又咁好，	你哋出去滑雪 laa4!
97	佢點解可以咁鬼遲鈍 gaa3。	你同佢開竅 laa4!
98	個秋祭有啲杰撻撻 wo3，話哂個秋祭都係你哋負責 ge2。	你哋搞掂個秋祭 laa4!
99	你老細睇落去好似唔係咁 likey wo3，如果你想佢幫你嘅話，	你氹掂你個老細 laa4!
100	你呢個辦法點都係行唔通 gaa3laa3。	你哋改變主意 laa4!

Table D17

English translation of sentence items #1-#20 in the pro-laa1 match condition

Item#	Context (English)	Target sentence (English)
1	The novel you took out from the library is due very soon.	Please return the novel!
2	This is ridiculous! How is your hand-writing so bad, at your age?	You really should practice more on your calligraphy!
3	Your messenger bag is so broken and looks completely out of shape.	You should absolutely buy another one
4	Nowadays a secretary needs to know how to type in both Chinese and English, but you don't know how to type Chinese.	You really should learn Changjie!
5	I only have one portion of hot chips but that's not enough. Since you are on your way to McDonald's,	please buy another big mac (for me)!
6	Maybe the Education system in Hong Kong simply doesn't suit him/her.	Please let him/her go to UK!
7	Nowadays it is easy to make good money from running a fashion wholesale business.	You really should switch to fashion wholesale!
8	The pants are too long and does not fit me anymore.	Please shorten the pair of pants for me!
9	You are out of tune so many times in this recording. I tried to auto-tune it for you but failed.	You really need to record it again!
10	Actually, what Sargent Lau told you just now is not wrong, please don't be mad at him.	You really should get back in touch with Sergent Lau!
11	If you believe what Master monk said about cutting out the six sources of evil will give you peace of mind,	you really should change to Buddhism instead!
12	If you all have sufficient evidence to prove that Yip Kai Foon kill that person, then,	you really should officially sue him/her for murder!
13	The evidence shows that they have no intention to do so.	Please reduce the sentence to manslaughter!
14	Your whole taro and duck stew was finished before being served. It is difficult for me to explain why the dish is no longer served.	Please make more taro and duck stew!
15	The housing price in Tai Po is much lower now and both of you are working over there. Why wait?	You should definitely move back to Tai Po!
16	Last time you can't finish the exam because you were sick. Otherwise, the exam should not be that difficult for you.	You should definitely take the exam again!
17	Their liberal-studies report is very well written, also they seem to be very interested in participating the Trivia pursuit on liberal studies	Please let them participate in this Trivia pursuit!
18	The air-conditioning has been stinking in the last two days There must be some sewage in the water tower.	You really should hire help to clean the water tower!
19	Yiu Yiu hasn't been to Paris before. Since this is her first time,	you should absolutely take her to Eiffel Tower!
20	There's too much garbage in the kitchen, and the smell is overwhelming.	Please dump the garbage!

Table D18

English translation of sentence items #21-#40 in the pro-laa1 match condition

Item#	Context (English)	Target sentence (English)
21	The economy in Dubai is not doing very well at the moment. If you are going to stay, you won't be able to make a living at all.	You really should leave Dubai!
22	Younger sister is going to be a bridesmaid this Saturday.	Please let her do gel nails!
23	Sir (Head of department), this is going to get out of control.	Please tell the security to back off!
24	Today you can get a raffle ticket with your receipt. And seriously why didn't you ask them for a receipt after your purchase just now?	You should definitely ask them for another receipt!
25	The term is going to end soon. While there are still a lot of students around,	you really should start finding participants!
26	Even if they are filming here, they won't disturb your work.	Please let them film here!
27	I forgot to put the lid back on just now.	Please put the lid back on for me!
28	Your father has not seen you for a month and he misses you dearly.	You really should visit your father!
29	There's a buy-one-get-one-free discount for Carlsberg.	You should definitely drink Carlsberg instead!
30	(S)He did say for sure that the history of the warring states will be tested in this exam.	You should absolutely finish reading Strategies of the Warring States!
31	You have been working here for three months already. How come you still don't know what you should be doing?!	You really should figure out what your responsibilities are!
32	I can't believe how terribly broken your drawing board is.	You should definitely buy another piece!
33	(S)He did say that (s)he loves sour food. If so,	you may as well add more vinegar!
34	When I came back, I saw a lot of spectators at the film site downstairs. While there is still a big crowd downstairs,	you really should start distributing the samples!
35	If you want a truly creamy tasting milk,	You should definitely drink Kowloon dairy instead!
36	This store does not really appeal to me, and besides, the rent is also too high.	You really should find another store!
37	Tonight, I am going to make the mung bean sweet soup.	Please buy me another bag of seaweed!
38	Cathay Pacific has a recruitment day next Sunday. If you would like to become an air hostess, on the recruitment day,	You definitely should hand in your form!
39	Facebook is no longer fashionable these days.	You really should switch to Weibo!
40	This time it's totally your fault. What she did is for your own good, and I don't understand why you are mad at her.	You really should apologise to her!

Table D19

English translation of sentence items #41-#60 in the pro-laa1 match condition

Item#	Context (English)	Target sentence (English)
41	I don't think Netherlands has a chance winning against Germany. While there's still time to change your mind,	you really should support Germany instead!
42	Nowadays people are very aware of food hygiene and safety. Therefore,	you really should start planting organic vegetables!
43	That was one of our biggest clients. If you haven't met your quota for this month,	you really should get in touch with that client again!
44	The sewer pipe in front of your building is broken.	Please contact the drainage service department now!
45	The jackpot of this lottery is at least $50 million. Why are you only making one bet?!	You really should make more than one bet!
46	It isn't worth your time to stay here anymore, to be honest. Also, Brother Keung and his associates really wants you to work with them.	You should definitely take up their offer about starting a business together in Canada!
47	This cake does not taste good at all.	You really should make another one!
48	I would like to measure my waist length but the measuring tap at home is nowhere to be found.	Please buy me another measuring tap!
49	You want to have a new pair of stylish-looking glasses?	You should definitely check out optical 88!
50	Your transport allowance is almost ending.	You really should reapply for the travel allowance!
51	The vegetarian restaurant at Po Lin Monastery is expensive and has bad food. In contrast, the vegetarian restaurant in nearby Tai O is cheap and has decent food.	You should absolutely go to Tai O instead!
52	It takes at least two hours to get to the airport, and it's already 3 p.m. and you have to be there at 5 p.m.	Please get ready now!
53	There are only 10 pieces left in the warehouse, and it probably won't be enough.	You really should start stocking up!
54	I have called China Eastern Airline for you, and they told me that your next flight has been cancelled.	You really should travel with Cathay Pacific instead!
55	We rely on you to finish the last part of the report, and you only have two days left.	You really should work hard and finish the report!
56	It's already been a week and Siu Ming is still very mad at you all.	You really should apologise to Siu Ming!
57	It takes them really long to find someone who shares the same vision about the environment.	Please help them with their environment-awareness campaign!
58	If you want to go to Sheung Wan at this hour, it will be too slow to go by bus.	You really should take MTR instead!
59	You haven't been home for celebrating Mid-Autumn Festival with your family. This year,	you really should go home for the festivities!
60	Your hair is now all over your face and it makes you look very dull.	You really should tie up your hair!

Table D20

English translation of sentence items #61-#80 in the pro-laa1 match condition

Item#	Context (English)	Target sentence (English)
61	The results of the draw were announced this morning.	You should definitely check your raffle ticket!
62	Our senior goes to the gym everyday. If you become a member of our gym then,	you should be able to see our senior!
63	One of the table legs is damaged and it makes the table wobbly.	Please repair the table leg for me!
64	Mrs. Chan's agent told me that the shares of HKC Holdings are going to be worth a ton, it will be such a loss if you miss this chance.	You should subscribe for the shares of HKC Holdings!
65	S(He) does not like this at all.	You really should check what his/her hobbies are!
66	The accounts of the company are a mess. It will be a disaster if the tax authority finds out about this.	Please finish the audit!
67	The tax authority sent you a notification more than 2 months ago. You shouldn't drag it anymore.	You really should declare your tax immediately!
68	People in the room are getting irritated. If you don't start playing, they will definitely leave.	Please start playing soon!
69	Since you are on your way to the key maker,	please make another key!
70	The robot arm is broken again!	Please repair the robotic arm for me!
71	Your accountant seems to be cheating money from you.	You really should fire your accountant!
72	If you want the elderly of the family to be satisfied with the banquet,	you really should add shark fin back to the menu!
73	Your saw is so blunt that it can't saw through a thing	You should use another saw!
74	Hey you, a button went missing from the back of your top!	You definitely should sew the button back!
75	Since you are on your way anyway,	please go to the market and buy me another Kudzu root!
76	I thought you guys want to go dancing, no? And now the dance floor is not as crowded.	You definitely should take him/her to the dance floor!
77	You can't miss the national sports of the country if you are here in Japan.	You absolutely should go to watch sumo wrestling!
78	Our client takes this project very seriously, So I beg you,	please finish the summary of the plan asap!
79	You have been so bored at home since your retirement and this is not good for you.	You really should find a new diversion!
80	The conditions of this offer are fantastic, and since you don't have many cases at hand,	You definitely should accept this proposal!

Table D21

English translation of sentence items #81-#100 in the pro-laa1 match condition

Item#	Context (English)	Target sentence (English)
81	We are all waiting for you to finish logging your progress in order to proceed.	Please finish logging your progress asap!
82	Mr. Ho has cheated you again. If you go on collaborating with him, you will lose everything.	You should stop collaborating with him!
83	Don't lose your faith because of a small failure, you will definitely make it next time.	Please cheer up!
84	There are a lot of typos in the contract.	Please revised the contract!
85	Your supporting actress can't act. If you would like to finish shooting on time,	you really should find another supporting actress!
86	Since you don't have enough people for the next term, and I am very familiar with the syllabus of this subject.	Please let me teach this subject!
87	If you are miserable living here,	you really should go back to the USA!
88	(Interjection) I can't believe how broken your phone case is.	You really should replace the phone case!
89	Your aloe vera looks like it can die any time soon.	You really should replant the aloe vera!
90	Your lease is almost up, and I guess you don't want to be kicked out.	You really should extend the lease with the landlady asap!
91	After you sign the contract with TVB, I am sure you will have plenty of opportunities.	You really should take the contract!
92	All your exes were not able to bear your athlete's foot.	Please get the athlete's foot treated immediately!
93	Well…since you are on your way to the photo shop,	please develop the film!
94	It's a once-in-a-lifetime opportunity for her to come across such a good script. This role has her name written all over.	Please let her take the role!
95	We all know that our boss' favourite son is the younger one.	You really should be at the side of the boss' younger son!
96	The only reason for you all to come all the way up here is to ski, and also given that the weather is unusually good.	You should definitely go skiing!
97	How on earth is it that he still doesn't understand?	Please enlighten him!
98	The autumn festival does not seem to go well. Since you all are responsible for organising the festival,	please fix the organisation of the autumn festival!
99	Your boss doesn't seem happy at all. If you want him/her to help you,	you really should convince your boss with charm!
100	It is obvious that your idea definitely won't work,	please change your mind!

Table D22

English translation of sentence items #1-#20 in the pro-laa4 match condition

Item#	Context (English)	Target sentence (English)
1	Where is the novel you borrowed from the library? I am sure it was still on the stool this morning.	You have returned the novel?
2	Shouldn't you be practicing your calligraphy? How do you have the time to play video games right now?	You have improved on your calligraphy?
3	Your bag looks quite different from the last time I saw it.	You have bought another one?
4	You said before that you were sure that you were not going to learn Changjie, why are you studying the Changjie character table very hard now?	You have finally learnt Changjie?
5	(Interjection) I am pretty sure that you were only holding one meal a while ago, why are you holding two take-away bags? Finally,	you have bought another Big Mac?
6	Your son said he is going to the UK next term and he is not going to continue with the tutoring.	You have decided to let him/her go to UK?
7	Haven't you always been a toy wholesale distributor? Why did Mrs. Wong said you recently opened a store in Cheung Sha Wan fashion wholesale centre?	You have switched to fashion wholesale?
8	I recall that this pair of pants was too long for me last time, but now surprisingly it fits.	You have shortened the pants for me?
9	There were a lot of mistakes last time I listened to the recording. How come this time the recording is completely fine without any mistakes?	You have recorded it again?
10	(Interjection) How do you know that Sargent Lau is going to retire?	You have got back in touch with Sargent Lau?
11	(Interjection) I thought you have always been a Catholic. How come I keep seeing you in the Buddhist Temple recently?	You have changed to Buddhism instead?
12	I can see that you are preparing the writs at the moment.	You have officially sued him/her for murder?
13	After listening to the testimonies of both the prosecutor and defendant, you finally agree with the defendant. And subsequently,	you have reduced the sentence to manslaughter?
14	(Interjection) Why is (s)he getting so excited all of a sudden?	You have made more taro and duck stew?
15	I heard that your wife and you have taken back the flat in Tai Po. So,	you have moved back to Tai Po?
16	I remember that you seemed to have failed the first aid training assessment last time. How come you say that you are now certified?	You have taken the exam again?
17	Didn't you strongly oppose them participating in the competition before? So now does it mean that, after they keep nagging you,	you have decided to let them participate in this Trivia pursuit?
18	This morning the air conditioning still stinks. How come the smell is gone by now?	You have finally hired help to clean the water tower?
19	How come Ka Wing got so excited after going out with you?	You have brought her to Eiffel Tower?
20	The kitchen is so clean now and the odour is gone.	You have dumped the garbage?

Table D23

English translation of sentence items #21-#40 in the pro-laa4 match condition

Item#	Context (English)	Target sentence (English)
21	I heard from your sister that you are already on your way.	You have left Dubai?
22	How come your daughter keeps asking which nail parlour is the cheapest?	You have decided to let her do gel nails?
23	Sir, the protestors indeed starts to calm down.	You have finally told the security to back off?
24	Didn't you say you didn't have the receipt? How are you going to calculate the amount?	You have got another receipt from them?
25	I think I just saw you carrying a big pile of flyers about your study.	You have started finding participants?
26	(Interjection) didn't you say you were not going to let them film here? Why is the camera van here now?	You have decided to let them film here?
27	(Interjection) I didn't cover the pot when I was cooking noodles before. Why is the pot is now covered?	You have put the lid back on for me?
28	Hey Ah Chung, your mom said you finally asked for the opening hours of the elderly home (your father is staying).	You are finally going to visit your father?
29	(Interjection) You have always said that you disliked Carlsberg. Why are you drinking it now?	You have started drinking Carlsberg instead?
30	I remember that you were reading the Strategies of the Warring States. How come you loan your book to Ah Hang now?	You have finished reading Strategies of the Warring States?
31	A few days ago, you weren't able to even answer what your position is about, and this time you answered very adequately.	You have finally figured out what your responsibilities are?
32	I thought your drawing board was broken? Do you have a new one now?	You have bought another piece?
33	You really thought, because the dish is called sweet and sour pork, so that when you cook,	you sure you can add that much more vinegar?
34	(Seriously) How come there are so few samples on your desk at the moment?	You have distributed the samples?
35	(Seriously) How come you no longer buy milk from Dairy Farm?	You have started drinking Kowloon dairy instead?
36	I heard from Mrs. Cheung that you didn't go to see the shop she recommended. So…	you have found another store?
37	How come there's another pack of sea weed in the fridge now?	You have bought me another bag of seaweed?
38	Didn't you have your passport photo taken some time ago? How come you need to take passport photos again?	You are going to hand in the application form?
39	I remember that you don't use Weibo at all. How come you keep asking us about Weibo?	You are going to switch to Weibo instead?
40	Ah Lai, I thought you didn't think you were wrong at all. How come you are now holding Ah Si's favourite, hello kitty plush toy?	You are going to apologise to her?

Table D24

English translation of sentence items #41-#60 in the pro-laa4 match condition

Item#	Context (English)	Target sentence (English)
41	Weren't you a long-time loyal supporter of Brazil? How come, this time, you are buying the team shirt of Germany instead of Brazil?	You have decided to support Germany instead?
42	After a lengthy consideration, you finally decided to get rid of all the chemical fertilisers.	You are finally starting to plant organic vegetables?
43	You didn't meet your quota last month after your important client left you. But I can see that your sales figures this month are significantly improved.	You have got in touch with that client again?
44	Didn't you say you were going to wait until tomorrow?! How come you urgently need the contact info of the drainage service department?	You are going to contact the drainage service department?
45	Why is there an extra electronic ballot on the table?	You have made make another bet?
46	Didn't you say you don't want to leave the job for Brother Keung? Why has he been very excited and said that he was booking the ticket for you too?	You have taken up their offer to start a new business in Canada?
47	(Interjection) I can see that your Easter Egg looks different right now.	You have made another one?
48	See! Obviously you finally realise how inconvenient it is to lose the measuring tape. Finally, you went to Sham Shui Po, and	(you) have finally bought another measuring tap?
49	Why are you desperately searching for all the coupons from Optical 88?	You are going to get new glasses from optical 88?
50	Haven't you just applied for a travelling allowance? How come you are filling out another application just now?	You have reapplied for the travel allowance?
51	Didn't you say you all are not going to Tai O? Why has mum been fanatically looking for the address of the shrimp paste factories?	Did you go to Tai O instead?
52	I can see that you all have put on your shoes and got your backpack.	You are really ready?
53	(Interjection) How come, all of a sudden, you brought back so many catalogues?	You have started stocking up?
54	You have been nagging me the whole time about not flying with Cathay Pacific. But how come you are checking in with them now?	Are you really travelling with Cathay Pacific instead?
55	(Interjection) Why are you playing video games right now?	You really have worked hard and finished the report?
56	Siu Ming has been very upset for a long time. Seeing you are bringing presents to his place,	you really are apologising to Siu Ming?
57	What?! I can't believe it! I thought you were absolutely not helping them with the environment-awareness campaign? Now that after they coaxed you a bit,	you really are going to help them with their campaign?
58	You always refuse to take the metro. It's surprising to see you arriving that early this morning. So you finally took up my advice, and	(you) really took the MTR instead?
59	It's mid-autumn festival today and everyone in the company have left work early already. How come you are only leaving now?	Are you really going home for the festivities?
60	(Interjection) How come your hair looks way shorter now?	You have tied up your hair?

Table D25

English translation of sentence items #61-#80 in the pro-laa4 match condition

Item#	Context (English)	Target sentence (English)
61	(Interjection) How did you know that we won the prize?!	Have you really have checked your raffle ticket?
62	Well… it is very obvious that the guy you fancy is avoiding you, and now you are trying to get hold of his schedule.	Are you sure you are going meet our senior?
63	(Interjection) The table is no longer wobbly anymore.	You have repaired the table leg for me?
64	You did say you were not interested before. But now you finally listen to the agent's advice.	You have subscribed for the shares of HKC Holdings?
65	(Interjection) I see that you bought him/her a present (that he likes).	Have you really checked what his/her hobbies are?
66	(Interjection) Why do you stop all of a sudden?	Have you really finished the audit?
67	You always procrastinate and refuse to file in your tax. How come you are holding tax receipts from the tax bureau?	Have you really declared your tax?
68	Well...I saw that you have just put the record on.	You are finally starting to play the music?
69	You finally understand that it's inconvenient only with one set of keys, so…..	you are going to make another key?
70	I thought the robot arm has been broken. How come it is moving again?	You have repaired the robotic arm for me?
71	The sales people have not been happy with the accountant. How come they are getting along so well now? Finally,	you have finally fired your (previous) accountant?
72	Finally, you have listened to what all of us, the elderly, have to say, and	you have finally added shark fin back to the menu?
73	(Interjection) I remember the saw was very blunt before. Why is it so sharp now?	You have finally replaced the saw?
74	(Interjection) I thought you lost the button of your blouse? How come you can close your blouse up properly now?	You have finally sewn the button back?
75	Finally, you know that the quality of this supermarket is appalling, and so,	you have been to the market instead to buy me another Kudzu root?
76	Yesterday, you did say you no longer dance with Ah Mei again (as a dancing partner). How come she is putting on her dancing shoes now?	Are you really taking her to the dance floor?
77	At last, after all this time,	you have finally watched sumo wrestling?
78	Why do you have so much free time to work on other stuff?	Have you really finished the summary of the plan?
79	You look way happier since we last met.	You have found a new diversion?
80	The boss said you have just signed the contract with the client.	You have finally accepted this proposal?

Table D26

English translation of sentence items #81-#100 in the pro-laa4 match condition

Item#	Context (English)	Target sentence (English)
81	(Interjection) How come you have time to tidy up the place now?	You really have finished logging your progress?
82	(Interjection) I can see that you are not selling any products from Mr. Ho anymore.	You have stopped collaborating with him?
83	You looked terrible yesterday and now you look very bright.	You have finally cheered up?
84	Ms. Chan (the secretary) left me a message just now to come to you to pick up the contract.	You have really revised the contract?
85	Your supporting actress seems to look very different now.	You have finally found another supporting actress?
86	(Interjection) Why are you finally telling me the course plan for liberal studies next term?	You have finally decided to let me teach this subject?
87	I see that you have bought a plane ticket and are packing your belongings now.	You have finally decided to go back to the USA?
88	I remember that your phone case looked very plain before. How come it looks very 'bling bling' now? So,	you have finally replaced the phone case?
89	I remember last time when I met you, your aloe vera was dead. How comes it is growing very well now?	You have replanted the aloe vera?
90	I thought your contract has ended already, no? Why are you still here?	You have extended the lease with the landlady?
91	I remember that you were unsure about whether having Jade being your manager. And now you are letting them manage your jobs?	You have finally agreed to sign the contract?
92	Why did you throw away all your medication?	You have recovered from the athlete's foot?
93	Why did you take the film? It has been forgotten in the bottom of the draw for years.	You have finally developed the film?
94	Before you said you were not letting Ah Chi take the role. How come she is practising the dialogues with Mr. Lam?	You have finally decided to let her take the role?
95	Before you said our boss' younger son is incapable, how come you are working for him now? Finally,	You have changed to the side of our boss' younger son?
96	You all said you were afraid of the risk of a ski accident. But why are you changing into ski pants now?	Are you finally going skiing?
97	(Interjection) How has your son has become so smart?	You have finally enlightened him?
98	(Interjection) Why are you all sitting down and resting?	You have finally finished organising the autumn festival?
99	Why did your boss change his/her mind and collaborate with us?	You have finally convinced your boss with charm?
100	Before you said you refuse to sell the unit to Mr. Lam. How come you are meeting with him now to discuss details?	You have finally change your mind?

Table D27

English translation of sentence items #1-#20 in the pro-laa1 mismatch condition

Item#	Context (English)	Target sentence (English)
1	Where is the novel you borrowed from the library? I am sure it was still on the stool this morning.	Please return the novel!
2	Shouldn't you be practicing your calligraphy? How do you have the time to play video games right now?	You really should practice more on your calligraphy!
3	Your bag looks quite different from the last time I saw it.	You should absolutely buy another one
4	You said before that you were sure that you were not going to learn Changjie, why are you studying the Changjie character table very hard now?	You really should learn Changjie!
5	(Interjection) I am pretty sure that you were only holding one meal a while ago, why are you holding two take-away bags? Finally,	please buy another big mac (for me)!
6	Your son said he is going to the UK next term and he is not going to continue with the tutoring.	Please let him/her go to UK!
7	Haven't you always been a toy wholesale distributor? Why did Mrs. Wong said you recently opened a store in Cheung Sha Wan fashion wholesale centre?	You really should switch to fashion wholesale!
8	I recall that this pair of pants was too long for me last time, but now surprisingly it fits.	Please shorten the pair of pants for me!
9	There were a lot of mistakes last time I listened to the recording. How come this time the recording is completely fine without any mistakes?	You really need to record it again!
10	(Interjection) How do you know that Sargent Lau is going to retire?	You really should get back in touch with Sergent Lau!
11	(Interjection) I thought you have always been a Catholic. How come I keep seeing you in the Buddhist Temple recently?	You really should change to Buddhism instead!
12	I can see that you are preparing the writs at the moment.	You really should officially sue him/her for murder!
13	After listening to the testimonies of both the prosecutor and defendant, you finally agree with the defendant. And subsequently,	please reduce the sentence to manslaughter!
14	(Interjection) Why is (s)he getting so excited all of a sudden?	Please make more taro and duck stew!
15	I heard that your wife and you have taken back the flat in Tai Po. So,	you should definitely move back to Tai Po!
16	I remember that you seemed to have failed the first aid training assessment last time. How come you say that you are now certified?	You should definitely take the exam again!
17	Didn't you strongly oppose them participating in the competition before? So now does it mean that, after they keep nagging you,	please let them participate in this Trivia pursuit!
18	This morning the air conditioning still stinks. How come the smell is gone by now?	You really should hire help to clean the water tower!
19	How come Ka Wing got so excited after going out with you?	You should absolutely take her to Eiffel Tower!
20	The kitchen is so clean now and the odour is gone.	Please dump the garbage!

Table D28

English translation of sentence items #21-#40 in the pro-laa1 mismatch condition

Item#	Context (English)	Target sentence (English)
21	I heard from your sister that you are already on your way.	You really should leave Dubai!
22	How come your daughter keeps asking which nail parlour is the cheapest?	Please let her do gel nails!
23	Sir, the protestors indeed starts to calm down.	Please tell the security to back off!
24	Didn't you say you didn't have the receipt? How are you going to calculate the amount?	You should definitely ask them for another receipt!
25	I think I just saw you carrying a big pile of flyers about your study.	You really should start finding participants!
26	(Interjection) didn't you say you were not going to let them film here? Why is the camera van here now?	Please let them film here!
27	(Interjection) I didn't cover the pot when I was cooking noodles before. Why is the pot is now covered?	Please put the lid back on for me!
28	Hey Ah Chung, your mom said you finally asked for the opening hours of the elderly home (your father is staying).	You really should visit your father!
29	(Interjection) You have always said that you disliked Carlsberg. Why are you drinking it now?	You should definitely drink Carlsberg instead!
30	I remember that you were reading the Strategies of the Warring States. How come you loan your book to Ah Hang now?	You should absolutely finish reading Strategies of the Warring States!
31	A few days ago, you weren't able to even answer what your position is about, and this time you answered very adequately.	You really should figure out what your responsibilities are!
32	I thought your drawing board was broken? Do you have a new one now?	You should definitely buy another piece!
33	You really thought, because the dish is called sweet and sour pork, so that when you cook,	you may as well add more vinegar!
34	(Seriously) How come there are so few samples on your desk at the moment?	You really should start distributing the samples!
35	(Seriously) How come you no longer buy milk from Dairy Farm?	You should definitely drink Kowloon dairy instead!
36	I heard from Mrs. Cheung that you didn't go to see the shop she recommended. So…	you really should find another store!
37	How come there's another pack of sea weed in the fridge now?	Please buy me another bag of seaweed!
38	Didn't you have your passport photo taken some time ago? How come you need to take passport photos again?	You definitely should hand in your form!
39	I remember that you don't use Weibo at all. How come you keep asking us about Weibo?	You really should switch to Weibo!
40	Ah Lai, I thought you didn't think you were wrong at all. How come you are now holding Ah Si's favourite, hello kitty plush toy?	You really should apologise to her!

Table D29

English translation of sentence items #41-#60 in the pro-laa1 mismatch condition

Item#	Context (English)	Target sentence (English)
41	Weren't you a long-time loyal supporter of Brazil? How come, this time, you are buying the team shirt of Germany instead of Brazil?	You really should support Germany instead!
42	After a lengthy consideration, you finally decided to get rid of all the chemical fertilisers.	You really should start planting organic vegetables!
43	You didn't meet your quota last month after your important client left you. But I can see that your sales figures this month are significantly improved.	You really should get in touch with that client again!
44	Didn't you say you were going to wait until tomorrow?! How come you urgently need the contact info of the drainage service department?	Please contact the drainage service department now!
45	Why is there an extra electronic ballot on the table?	You really should make more than one bet!
46	Didn't you say you don't want to leave the job for Brother Keung? Why has he been very excited and said that he was booking the ticket for you too?	You should definitely take up their offer about starting a business together in Canada!
47	(Interjection) I can see that your Easter Egg looks different right now.	You really should make another one!
48	See! Obviously you finally realise how inconvenient it is to lose the measuring tape. Finally, you went to Sham Shui Po, and	please buy me another measuring tap!
49	Why are you desperately searching for all the coupons from Optical 88?	You should definitely check out optical 88!
50	Haven't you just applied for a travelling allowance? How come you are filling out another application just now?	You really should reapply for the travel allowance!
51	Didn't you say you all are not going to Tai O? Why has mum been fanatically looking for the address of the shrimp paste factories?	You should absolutely go to Tai O instead!
52	I can see that you all have put on your shoes and got your backpack.	Please get ready now!
53	(Interjection) How come, all of a sudden, you brought back so many catalogues?	You really should start stocking up!
54	You have been nagging me the whole time about not flying with Cathay Pacific. But how come you are checking in with them now?	You really should travel with Cathay Pacific instead!
55	(Interjection) Why are you playing video games right now?	You really should work hard and finish the report!
56	Siu Ming has been very upset for a long time. Seeing you are bringing presents to his place,	you really should apologise to Siu Ming!
57	What?! I can't believe it! I thought you were absolutely not helping them with the environment-awareness campaign? Now that after they coaxed you a bit,	please help them with their environment-awareness campaign!
58	You always refuse to take the metro. It's surprising to see you arriving that early this morning. So you finally took up my advice, and	you really should take MTR instead!
59	It's mid-autumn festival today and everyone in the company have left work early already. How come you are only leaving now?	you really should go home for the festivities!
60	(Interjection) How come your hair looks way shorter now?	You really should tie up your hair!

Table D30

English translation of sentence items #61-#80 in the pro-laa1 mismatch condition

Item#	Context (English)	Target sentence (English)
61	(Interjection) How did you know that we won the prize?!	You should definitely check your raffle ticket!
62	Well… it is very obvious that the guy you fancy is avoiding you, and now you are trying to get hold of his schedule.	You should be able to see our senior!
63	(Interjection) The table is no longer wobbly anymore.	Please repair the table leg for me!
64	You did say you were not interested before. But now you finally listen to the agent's advice.	You should subscribe for the shares of HKC Holdings!
65	(Interjection) I see that you bought him a present (that he/her likes).	You really should check what his/her hobbies are!
66	(Interjection) Why do you stop all of a sudden?	Please finish the audit!
67	You always procrastinate and refuse to file in your tax. How come you are holding tax receipts from the tax bureau?	You really should declare your tax immediately!
68	Well...I saw that you have just put the record on.	Please start playing soon!
69	You finally understand that it's inconvenient only with one set of keys, so …..	please make another key!
70	I thought the robot arm has been broken. How come it is moving again?	Please repair the robotic arm for me!
71	The sales people have not been happy with the accountant. How come they are getting along so well now? Finally,	you really should fire your accountant!
72	Finally, you have listened to what all of us, the elderly, have to say, and	you really should add shark fin back to the menu!
73	(Interjection) I remember the saw was very blunt before. Why is it so sharp now?	You should use another saw!
74	(Interjection) I thought you lost the button of your blouse? How come you can close your blouse up properly now?	You definitely should sew the button back!
75	Finally, you know that the quality of this supermarket is appalling, and so,	please go to the market and buy me another Kudzu root!
76	Yesterday, you did say you no longer dance with Ah Mei again (as a dancing partner). How come she is putting on her dancing shoes now?	You definitely should take him/her to the dance floor!
77	At last, after all this time,	you absolutely should go to watch sumo wrestling!
78	Why do you have so much free time to work on other stuff?	Please finish the summary of the plan asap!
79	You look way happier since we last met.	You really should find a new diversion!
80	The boss said you have just signed the contract with the client.	You definitely should accept this proposal!

Table D31

English translation of sentence items #81-#100 in the pro-laa1 mismatch condition

Item#	Context (English)	Target sentence (English)
81	(Interjection) How come you have time to tidy up the place now?	Please finish logging your progress asap!
82	(Interjection) I can see that you are not selling any products from Mr. Ho anymore.	You should stop collaborating with him!
83	You looked terrible yesterday and now you look very bright.	Please cheer up!
84	Ms. Chan (the secretary) left me a message just now to come to you to pick up the contract.	Please revised the contract!
85	Your supporting actress seems to look very different now.	You really should find another supporting actress!
86	(Interjection) Why are you finally telling me the course plan for liberal studies next term?	Please let me teach this subject!
87	I see that you have bought a plane ticket and are packing your belongings now.	You really should go back to the USA!
88	I remember that your phone case looked very plain before. How come it looks very 'bling bling' now? So,	You really should replace the phone case!
89	I remember last time when I met you, your aloe vera was dead. How comes it is growing very well now?	You really should replant the aloe vera!
90	I thought your contract has ended already, no? Why are you still here?	You really should extend the lease with the landlady asap!
91	I remember that you were unsure about whether having Jade being your manager. And now you are letting them manage your jobs?	You really should take the contract!
92	Why did you throw away all your medication?	Please get the athlete's foot treated immediately!
93	Why did you take the film? It has been forgotten in the bottom of the draw for years.	Please develop the film!
94	Before you said you were not letting Ah Chi take the role. How come she is practising the dialogues with Mr. Lam?	Please let her take the role!
95	Before you said our boss' younger son is incapable, how come you are working for him now? Finally,	You really should be at the side of the boss' younger son!
96	You all said you were afraid of the risk of a ski accident. But why are you changing into ski pants now?	You should definitely go skiing!
97	(Interjection) How has your son has become so smart?	Please enlighten him!
98	(Interjection) Why are you all sitting down and resting?	Please fix the organisation of the autumn festival!
99	Why did your boss change his/her mind and collaborate with us?	You really should convince your boss with charm!
100	Before you said you refuse to sell the unit to Mr. Lam. How come you are meeting with him now to discuss details?	Please change your mind!

Table D32

English translation of sentence items #1-#20 in the pro-laa4 mismatch condition

Item#	Context (English)	Target sentence (English)
1	The novel you took out from the library is due very soon.	You have returned the novel?
2	This is ridiculous! How is your hand-writing so bad, at your age?	You have improved on your calligraphy?
3	Your messenger bag is so broken and looks completely out of shape.	You have bought another one?
4	Nowadays a secretary needs to know how to type in both Chinese and English, but you don't know how to type Chinese.	You have finally learnt Changjie?
5	I only have one portion of hot chips but that's not enough. Since you are on your way to McDonald's,	You have bought another Big Mac?
6	Maybe the Education system in Hong Kong simply doesn't suit him/her.	You have decided to let him/her go to UK?
7	Nowadays it is easy to make good money from running a fashion wholesale business.	You have switched to fashion wholesale?
8	The pants are too long and does not fit me anymore.	You have shortened the pants for me?
9	You are out of tune so many times in this recording. I tried to auto-tune it for you but failed.	You have recorded it again?
10	Actually, what Sargent Lau told you just now is not wrong, please don't be mad at him.	You have got back in touch with Sargent Lau?
11	If you believe what Master monk said about cutting out the six sources of evil will give you peace of mind,	you have changed to Buddhism instead?
12	If you all have sufficient evidence to prove that Yip Kai Foon kill that person, then,	you have officially sued him/her for murder?
13	The evidence shows that they have no intention to do so.	you have reduced the sentence to manslaughter?
14	Your whole taro and duck stew was finished before being served. It is difficult for me to explain why the dish is no longer served.	You have made more taro and duck stew?
15	The housing price in Tai Po is much lower now and both of you are working over there. Why wait?	You have moved back to Tai Po?
16	Last time you can't finish the exam because you were sick. Otherwise, the exam should not be that difficult for you.	You have taken the exam again?
17	Their liberal-studies report is very well written, also they seem to be very interested in participating the Trivia pursuit on liberal studies	you have decided to let them participate in this Trivia pursuit?
18	The air-conditioning has been stinking in the last two days There must be some sewage in the water tower.	You have finally hired help to clean the water tower?
19	Yiu Yiu hasn't been to Paris before. Since this is her first time,	You have brought her to Eiffel Tower?
20	There's too much garbage in the kitchen, and the smell is overwhelming.	You have dumped the garbage?

Table D33

English translation of sentence items #21-#40 in the pro-laa4 mismatch condition

Item#	Context (English)	Target sentence (English)
21	The economy in Dubai is not doing very well at the moment. If you are going to stay, you won't be able to make a living at all.	You have left Dubai?
22	Younger sister is going to be a bridesmaid this Saturday.	You have decided to let her do gel nails?
23	Sir (Head of department), this is going to get out of control.	You have finally told the security to back off?
24	Today you can get a raffle ticket with your receipt. And seriously why didn't you ask them for a receipt after your purchase just now?	You have got another receipt from them?
25	The term is going to end soon. While there are still a lot of students around,	you have started finding participants?
26	Even if they are filming here, they won't disturb your work.	You have decided to let them film here?
27	I forgot to put the lid back on just now.	You have put the lid back on for me?
28	Your father has not seen you for a month and he misses you dearly.	You are finally going to visit your father?
29	There's a buy-one-get-one-free discount for Carlsberg.	You have started drinking Carlsberg instead?
30	(S)He did say for sure that the history of the warring states will be tested in this exam.	You have finished reading Strategies of the Warring States?
31	You have been working here for three months already. How come you still don't know what you should be doing?!	You have finally figured out what your responsibilities are?
32	I can't believe how terribly broken your drawing board is.	You have bought another piece?
33	(S)He did say that (s)he loves sour food. If so,	you sure you can add that much more vinegar?
34	When I came back, I saw a lot of spectators at the film site downstairs. While there is still a big crowd downstairs,	you have distributed the samples?
35	If you want a truly creamy tasting milk,	you have started drinking Kowloon dairy instead?
36	This store does not really appeal to me, and besides, the rent is also too high.	You have found another store?
37	Tonight, I am going to make the mung bean sweet soup.	You have bought me another bag of seaweed?
38	Cathay Pacific has a recruitment day next Sunday. If you would like to become an air hostess, on the recruitment day,	you are going to hand in the application form?
39	Facebook is no longer fashionable these days.	You are going to switch to Weibo instead?
40	This time it's totally your fault. What she did is for your own good, and I don't understand why you are mad at her.	You are going to apologise to her?

Table D34

English translation of sentence items #41-#60 in the pro-laa4 mismatch condition

Item#	Context (English)	Target sentence (English)
41	I don't think Netherlands has a chance winning against Germany. While there's still time to change your mind,	you have decided to support Germany instead?
42	Nowadays people are very aware of food hygiene and safety. Therefore,	you are finally starting to plant organic vegetables?
43	That was one of our biggest clients. If you haven't met your quota for this month,	you have got in touch with that client again?
44	The sewer pipe in front of your building is broken.	You are going to contact the drainage service department?
45	The jackpot of this lottery is at least $50 million. Why are you only making one bet?!	You have made make another bet?
46	It isn't worth your time to stay here anymore, to be honest. Also, Brother Keung and his associates really wants you to work with them.	You have taken up their offer to start a new business in Canada?
47	This cake does not taste good at all.	You have made another one?
48	I would like to measure my waist length but the measuring tap at home is nowhere to be found.	You have finally bought another measuring tap?
49	You want to have a new pair of stylish-looking glasses?	You are going to get new glasses from optical 88?
50	Your transport allowance is almost ending.	You have reapplied for the travel allowance?
51	The vegetarian restaurant at Po Lin Monastery is expensive and has bad food. In contrast, the vegetarian restaurant in nearby Tai O is cheap and has decent food.	Did you go to Tai O instead?
52	It takes at least two hours to get to the airport, and it's already 3 p.m. and you have to be there at 5 p.m.	You are really ready?
53	There are only 10 pieces left in the warehouse, and it probably won't be enough.	You have started stocking up?
54	I have called China Eastern Airline for you, and they told me that your next flight has been cancelled.	Are you really travelling with Cathay Pacific instead?
55	We rely on you to finish the last part of the report, and you only have two days left.	You really have worked hard and finished the report?
56	It's already been a week and Siu Ming is still very mad at you all.	You really are apologising to Siu Ming?
57	It takes them really long to find someone who shares the same vision about the environment.	You really are going to help them with their campaign?
58	If you want to go to Sheung Wan at this hour, it will be too slow to go by bus.	You really took the MTR instead?
59	You haven't been home for celebrating Mid-Autumn Festival with your family. This year,	Are you really going home for the festivities?
60	Your hair is now all over your face and it makes you look very dull.	You have tied up your hair?

Table D35

English translation of sentence items #61-#80 in the pro-laa4 mismatch condition

Item#	Context (English)	Target sentence (English)
61	The results of the draw were announced this morning.	Have you really have checked your raffle ticket?
62	Our senior goes to the gym everyday. If you become a member of our gym then,	are you sure you are going meet our senior?
63	One of the table legs is damaged and it makes the table wobbly.	You have repaired the table leg for me?
64	Mrs. Chan's agent told me that the shares of HKC Holdings are going to be worth a ton, it will be such a loss if you miss this chance.	You have subscribed for the shares of HKC Holdings?
65	S(He) does not like this at all.	Have you really checked what his/her hobbies are?
66	The accounts of the company are a mess. It will be a disaster if the tax authority finds out about this.	Have you really finished the audit?
67	The tax authority sent you a notification more than 2 months ago. You shouldn't drag it anymore.	Have you really declared your tax?
68	People in the room are getting irritated. If you don't start playing, they will definitely leave.	You are finally starting to play the music?
69	Since you are on your way to the key maker,	you are going to make another key?
70	The robot arm is broken again!	You have repaired the robotic arm for me?
71	Your accountant seems to be cheating money from you.	You have finally fired your (previous) accountant?
72	If you want the elderly of the family to be satisfied with the banquet,	you have finally added shark fin back to the menu?
73	Your saw is so blunt that it can't saw through a thing.	You have finally replaced the saw?
74	Hey you, a button went missing from the back of your top!	You have finally sewn the button back?
75	Since you are on your way anyway,	you have been to the market instead to buy me another Kudzu root?
76	I thought you guys want to go dancing, no? And now the dance floor is not as crowded.	Are you really taking her to the dance floor?
77	You can't miss the national sports of the country if you are here in Japan.	you have finally watched sumo wrestling?
78	Our client takes this project very seriously, So I beg you,	have you really finished the summary of the plan?
79	You have been so bored at home since your retirement and this is not good for you.	You have found a new diversion?
80	The conditions of this offer are fantastic, and since you don't have many cases at hand,	you have finally accepted this proposal?

Table D36

English translation of sentence items #81-#100 in the pro-laa4 mismatch condition

Item#	Context (English)	Target sentence (English)
81	We are all waiting for you to finish logging your progress in order to proceed.	You really have finished logging your progress?
82	Mr. Ho has cheated you again. If you go on collaborating with him, you will lose everything.	You have stopped collaborating with him?
83	Don't lose your faith because of a small failure, you will definitely make it next time.	You have finally cheered up?
84	There are a lot of typos in the contract.	You have really revised the contract?
85	Your supporting actress can't act. If you would like to finish shooting on time,	you have finally found another supporting actress?
86	Since you don't have enough people for the next term, and I am very familiar with the syllabus of this subject.	You have finally decided to let me teach this subject?
87	If you are miserable living here,	you have finally decided to go back to the USA?
88	(Interjection) I can't believe how broken your phone case is.	You have finally replaced the phone case?
89	Your aloe vera looks like it can die any time soon.	You have replanted the aloe vera?
90	Your lease is almost up, and I guess you don't want to be kicked out.	You have extended the lease with the landlady?
91	After you sign the contract with TVB, I am sure you will have plenty of opportunities.	You have finally agreed to sign the contract?
92	All your exes were not able to bear your athlete's foot.	You have recovered from the athlete's foot?
93	Well…since you are on your way to the photo shop,	you have finally developed the film?
94	It's a once-in-a-lifetime opportunity for her to come across such a good script. This role has her name written all over.	You have finally decided to let her take the role?
95	We all know that our boss' favourite son is the younger one.	You have changed to the side of our boss' younger son?
96	The only reason for you all to come all the way up here is to ski, and also given that the weather is unusually good.	Are you finally going skiing?
97	How on earth is it that he still doesn't understand?	You have finally enlightened him?
98	The autumn festival does not seem to go well. Since you all are responsible for organising the festival,	you have finally finished organising the autumn festival?
99	Your boss doesn't seem happy at all. If you want him/her to help you,	you have finally convinced your boss with charm?
100	It is obvious that your idea definitely won't work,	you have finally change your mind?

Appendix E: Number of lexical entries per Cantonese syllable-plus-tone combination of all possible combinations in the Cantonese phonological system

This appendix contains the number of lexical entries per Cantonese syllable-plus-tone combination. The data are based on the Chinese syllabary Cantonese and Mandarin pronunciation dictionary by Ng (2016), which is subsequently based on the database developed by Chinese University of Hong Kong ("A Chinese Character Database: With word-formations phonologically disambiguated according to the Cantonese Dialect," n.d.). There are some notes to this Appendix. First, some characters may have more than one pronunciation, thus counted more than once in this table. Second, this appendix includes colloquial words that do not exist in the database; the number of these colloquial words are marked by "+" followed by the number. Last, the onset and rime are transcribed in Jyutping.

Table E1

Number of lexical entries of all Cantonese syllable-plus-tone combinations

Rime	Onset																			
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
aa1	11	12	7	8	6	2	8	2	7	31	7	4	8	9	11	26	28	10	15	
aa2	5	3		1		1				12	1	3	3	3	3	2	4		4	
aa3	11	9	3	3	3				3	15	2	9		7	6	12	25	10	1	
aa4	1		8	9	1			6	+1	1		10	14					12	1	+1
aa5				10				2				7	2			1				1
aa6		3		6				1				8	6			18	4			2
aai1	7	3				4	1	1	2	15		6	6	1		4	3	5		
aai2	3	4				2			1	2	2			5		1		4	14	1
aai3	8	3	4		14	10	11		5	25		5		3	1		4	5	5	
aai4			7	4				1				8	10		+1	10		6		
aai5				3			2	9					15						2	
aai6		5		3		4		2	11			9	18			5	6	2		
aau1	5	8	5	1					1	14		3	31				3	8	12	
aau2	4	3	1							15		1	10				5	5	2	
aau3	8	3	14							13	2	3	5				3	3	3	
aau4			16	16				15	1			11	5					7		
aau5				6				1				5								
aau6		3		1				7				1	6				5			
aam1	1					10	4	1		5	0		1				7	8	17	
aam2	1					4	8		2	2	0		4				7	6	3	
aam3						7	5			5	0		4				4	6	4	
aam4								15	9		0	11	13					19		
aam5							8	6	6		0		7					2		
aam6						23			9		0		3				6			
aan1	1	8	5		14	10	11		1	8			4	7		4		1	17	
aan2	1	10			4	4	16	1	+1	16						1	9	8	3	
aan3	6	1	4		9	7	5			5		3		6			9	6	11	
aan4				12	35		8	2	15			4	11			18		1	3	
aan5				6	3			4	4			2	3			6				
aan6		7		24	15	18		1	3			3	5			13	18			
aang1	3		18	2					+1	3		3	4		3		12	11	7	
aang2														1				1	5	
aang3										3					2		1	1		
aang4			9	5									2			8		11		
aang5			2	8					1											
aang6		5		2								1		3		1	1			
aap1						1														
aap2																				
aap3	2					13	22		1	30		2	5				18	5	17	1
aap4																				

Rime	Onset																			
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
aap5																				
aap6						15		10	15				17				24		2	
aat1																				
aat2																				
aat3	17	5		1	5	9	12	1		4		13		6		5	11	10	15	
aat4																				
aat5																				
aat6		2		2		8		1	11			7				4	4			
aak1	5	1	1	1		1			+1		1	3	8							
aak2																				
aak3	1	14	15	1	2					21	1	1	5	1			21	12	5	4
aak4																				
aak5																				
aak6		11			+1							4				16	27	2		
ai1	2+1	6	4	1	23	8	2			4	7	2	1	19	22	14	11	14	18	
ai2	2				2	17	4			1	5	1		21	6	30	5	4	5	
ai3	13	8	3	1	18	19	16			14	7	9		20	5	32	19	8	9	
ai4				10			35	4	10			27	13		27	25		10		
ai5			1	12			3	5	10			18	3		5	28				1
ai6		15		3	13	22	3	2	31	2		24	8	14		35	12		11	14
au1	14			1	1	4	2	1	4	21	14	13	2				43	23	26	30
au2	4		4		10	9	5	9		15		4	4				6	8	22	12
au3	2		1	1		3	3			23	22	1	2				15	17	16	3
au4			5	17	17		5	1	53		33	1	13					37		55
au5				5				12	14		3	7	3					1		20
au6		3		9	9	13		7	17	3		1	12				22		5	24
am1	16	2							+1	12	7	9	12				19	14	19	17
am2	8					7		1	1	7		5	12				3	10	13	4
am3	6					2				12		4	17				9	5	7	7
am4						1		3	10		19	5	14					23	11	21
am5							1	3	9		1		4					1		6
am6								1	1	5			11				6	1	5	10
an1		31	3	4	46	1	8			8		1		25	19	15	9	4	33	33
an2		2		1	3	2		3		16		+1	9	12	21	14	16	22		10
an3		11	5		9	2	1			10		1		3	5	9	17	12		9
an4			10	36	26		2				7	14	3		4	35		5	9	9
an5			3	30	15						1				6	16			3	1
an6		7		10	5					8		4	2	3		24	6		8	20
ang1	6	10				9			1	8			14	10			28	2	11	
ang2	1	1	1	1		2				13	3		4							
ang3						6				5	2		1				2	1	2	
ang4							10	5					13			20		8		

Rime	Onset																		
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
ang5													2							
ang6		1				6							10				4			
ap1	1					1		2	4	6	14	2	17				13	12	5	18
ap2																				
ap3										13										
ap4																				
ap5																				
ap6								6	2	3	6	28					4		4	5
at1		21	4	1	44	1			1	19	4	1	18	17		18	18	4	10	2
at2																				
at3					6															
at4																				
at5																				
at6		24		21	14	13		3		4		20	25	10		20	22		3	22
ak1	22	1		2		3						17	12				10	4	3	
ak2																				
ak3				1																
ak4																				
ak5																				
ak6				25		4			12											
e1		1		3	1	1		1	2	1	1			+1			10	7	5	
e2				2		2			1								8	7	5	
e3													+1				8	1	11	
e4									1		4							4	5	11
e5				2					1								1		2	7
e6	2																3		3	5
ei1		18	19	4	17			1	2	13	10	13		50						
ei2		18	11		19			1		18	1	18		16					1	
ei3		30	8							16	11	16		19					6	
ei4			41	36	8			11	43		64									
ei5			8	19				11	16		3									
ei6	2	22		11	4	2		8	14	24		24								
ek1									1								1			
ek2																				
ek3			1				1					3					16	5	1	
ek4																				
ek5																				
ek6			2			3			1		5						1		5	
em1													+1							
em2																				
em3																				
em4																				

Rime	Onset																			
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
em5																				
em6																				
eng1			1			3	3		1	1			1				1	2	3	
eng2		2		1		1				1							3	1	1	1
eng3		1				1	1		1	1							1		2	
eng4			2	1					2									1	2	1
eng5							1		3											
eng6		1		1		4											4			
eoi1						6	3			14	25		16				29	29	35	1
eoi2							2			21			17				15	7	11	
eoi3						7	8		3	16			7				22	22	18	
eoi4							9		32		37							32	10	3
eoi5								8	46		5		1						9	5
eoi6						13		1	25	29							32		40	15
eon1						14	4		+1								34	15	18	
eon2							3		1								12	5	6	
eon3							2										33		25	
eon4							1		38									12	17	
eon5							3		3										4	
eon6						17			20								10		6	4
eot1						3											13	6	13	
eot2																				
eot3																				
eot4																				
eot5																				
eot6								6	29										10	
ep1																				
ep2																				
ep3																				
ep4																				
ep5																				
ep6										11										
eu1																				
eu2																				
eu3																				
eu4																				
eu5																				
eu6						2														
i1				2				1	1		+1		+1			+1	79	47	54	27
i2																	58	29	9	15
i3																	40	27	19	16
i4								1										49	11	91

Rime	Onset																			
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
i5																		12	5	24
i6																	51		25	28
ik1		26	19			21	19	8	14	20	1		5	21	11		36	27	58	16
ik2																				
ik3		2															7	3	5	
ik4																				
ik5																				
ik6				15		24		8	33	2						10	33		5	52
im1						2	3	5	1	6							25	29	4	15
im2						6	4	2	1	3	+1		6				1	1	7	19
im3						11	2			1			10				5	5	3	6
im4							5	5	18		16		6					7	11	22
im5							7	1	10									2		16
im6						3		4	8	2							3		2	11
in1		14	12			10	1			19			26				27	10	17	18
in2		13	2			8	11	6	1	11			14				31	10	19	20
in3		2	4			2	2			5	1		7				16		19	12
in4			11	9			16	3	17		10							10	8	34
in5			3	18			1	5	6									2	4	19
in6		16		5		14		5	9	8							11		23	21
ing1		8	19			14	9	2	2	15	3		10	3		1	34	18	23	30
ing2		18				11	7		1	15	4			19			4	14	5	8
ing3		11	5			11	3			12			9				9	8	8	3
ing4			25	18			20	14	68		22					5		19	22	45
ing5				12			14		6				1			1				4
ing6		4		3	+1	4		7	11	6						6	11		7	3
iu1		31	15	2		20	10	2	3	12	2		31				21	15	25	12
iu2		8	4			3	3		2	16	5		1				8	4	5	21
iu3		1	12			9	10			8	14		2				12	8	4	3
iu4			7	5				21	1	38			2					16	4	3
iu5			12	12			9	7	13		2							1		14
iu6		2		5		5		2	7	5							11		16	9
m1																				
m2	1																			
m3																				
m4	3																			
m5																				
m6	1																			
ng1																				
ng2	1																			
ng3																				
ng4	15																			

Rime	Onset																		
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
ng5	8																			
ng6	18																			
o1	15	12	7	4	9	4	7	1	3	10	1	7	8	11		15		16	19	2
o2	4	2	3	1	8	13	3		7	4		2	3	11		4	6	8	6	
o3		5	2		11	4	3		3	3			0	2		2	4	9	2	
o4	1		7	9			26	11	3	3		19	8			8		16	1	
o5				3			7	3	9			2				2		1		+1
o6				3	1	10	1	4	2			3	3			2	6			
oe1													2+1							
oe2						1												+1		
oe3							1			1										
oe4										2			+1						+1	
oe5							1													
oe6																				
oek1									+1											
oek2																				
oek3						14				4	1						32	23	7	4
oek4																				
oek5																				
oek6									3		4						4			32
oeng1						+1			+1	13			4				22	35	35	11
oeng2									2				12				9	2	3	9
oeng3											2		8				15	13	1	2
oeng4								2	16		4							19	10	35
oeng5											9								2	19
oeng6										5							13		2	17
oi1	5						6			15		4	5				7	1	6	
oi2	14		1				1			3	1	10	17				4	10		
oi3	13									7	17	10					3	9		
oi4							18		13			5	6					5		
oi5							7	2					2							
oi6						20		14	9			5	4				2			
ok1	1	2	1	+1	1+1						1									
ok2																				
ok3	4	22	19	1	18		16		15	24	17	3	7	28	8	3	6	6+1	18	
ok4																				
ok5																				
ok6		20		18		6		6	21			23	15			13	20			
on1										14	6	4								
on2										10		11								
on3										9	4	7								
on4												15								

Rime	Onset																		
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
on5												5								
on6											7	24								
ong1	3	7	5	1	16	10	11		1	30	1	2	18	12		3	14	13	3	
ong2		8			25	8	15			5	1		1	3		3	1	15	12	
ong3	3	5	6		5	7	7			8	26	1	2	8	13		7	5	1	
ong4			20	27	5		30	3	23		3	2	18		4	35		8		
ong5			5	15				6	8			2	2			2				
ong6		9		6		17		1	8	1		1	9	1		4	10			
ot1		+1																		
ot2																				
ot3											8		15							
ot4																				
ot5																				
ot6													8							
ou1	2	10	5	1		12	21		3	15		3	7				7	6	17	
ou2	8	13	12	1		12	8		1	10		2	1				14	5	4	
ou3	12	11	4			11	7			5		8	5				1	24	20	
ou4			12	30			52	11	39			23	13					13		
ou5				26			1	6	27									1		
ou6		19		27		20		2	18			9	19				10			
u1					58				+1	24	2					19				
u2					33				+1	22						6				
u3					16					16						3				
u4					13											23				
u5					2				+1											
u6					21											31				
ui1		3	7	+1	14											9				
ui2				+2	5											2				
ui3		19	14		7						24					4				
ui4			9	15							16					14				
ui5			6	5												1				
ui6		14		10												13				
uk1	2	8	2	+1	19	7	3		6	36	8	2	5				48	54	39	21
uk2																				
uk3																	1	1	1	
uk4																				
uk5																				
uk6		16		20	24	20		4	50	8			12				24		16	35
un1		3	4	2	13					7						4				
un2		4	3		5					14						14				
un3		4	11							19										
un4			23	17												21				

Rime	Onset																			
	-	b	p	m	f	d	t	n	l	g	k	ng	h	gw	kw	w	z	c	s	j
un5			2	5												10				
un6		11	2	5												18				
ung1			1	1	25	13	42		1	22		22	1				50	36	13	19
ung2	1	6	1	3	5	8	7			9		5					15	3	9	23
ung3	5		4		7	6	2			7		11	4				15	6	2	1
ung4			9	20	11		42	12	29		12	22						26	2	43
ung5				4					8									1		17
ung6		1		5	7	22		1		1		7					11	4		3
ut1																				
ut2																				
ut3		7	4	3	2						17									
ut4																				
ut5																				
ut6		26		15												7				
yu1																	28	8	19	18
yu2																	11	5	5	8
yu3																	19	1	9	12
yu4																		11	13	106
yu5																		20	3	41
yu6																	4		9	40
yun1						3	3		2	12		36					25	13	17	24
yun2						1			2	8		10					15	14	5	21
yun3						5				22		14					8	12	8	3
yun4							27		13		15							39	18	79
yun5							1	4	4									4	2	15
yun6						8		3	1	6							6		6	23
yut1						+1			+1								+1			
yut2																				
yut3							6		7	1	45	9					42	11	4	6
yut4																				
yut5																				
yut6						3			6								9			39

Nederlandse samenvatting

De herkenning van gesproken woorden is uitvoerig onderzocht in niet-tonale Indo-Europese talen en hier zijn verschillende belangrijke modellen voor expliciete verwerking uit voortgekomen. Dit onderzoek ging voornamelijk over het verwerken van segmentele informatie. Onze kennis over gesproken toontalen is daarentegen nog vrij beperkt. Lexicale toon is in alle toontalen van cruciaal belang voor lexicale betekenis, en in sommige toontalen ook voor pragmatische betekenis. Bij het interpreteren van lexicale en pragmatische betekenis in alledaagse communicatie is lexicale toon echter niet de enige taalkundige factor van belang. Verbonden spraak bevat verschillende bronnen van taalkundige informatie die gelijktijdig beschikbaar komen. Een belangrijke vraag is hoe luisteraars deze verschillende soorten informatie integreren om op de juiste interpretatie uit te komen. Het hoofddoel van dit proefschrift was om te verduidelijken hoe het begrijpen van lexicale en pragmatische betekenis in het Kantonees Chinees beïnvloed wordt door lexicale toon in combinatie met twee andere taalkundige factoren, te weten context en intonatie.

In hoofdstuk 2 onderzocht ik m.b.v. twee ERP-experimenten hoe lexicale toon, intonatie en lexicale context online samenwerken tijdens de herkenning van gesproken woorden in het Kantonees Chinees. Experiment 1 onderzocht of de verwerking van twee bepaalde woordtypen, te weten woorden met een lage lexicale toon en woorden met een hoog-midden lexicale toon, verandert als er vraagintonatie toegevoegd wordt aan de zin. De resultaten van dit experiment lieten een onmiddellijke interactie zien tussen lexicale toon en intonatie: er trad een conflict op bij de verwerking van woorden met een lage lexicale toon als die aan het einde van een vraag voorkomen, waar de intonatie omhoog gaat. Dit is te zien aan de P600 en aan het feit dat de lexicale identificatie van deze woorden minder nauwkeurig is dan wanneer ze aan het einde van een bewering voorkomen. Experiment 2 liet zien dat de lexicale identificatie van woorden met een lage lexicale toon aan het einde van een vraag sterk verbetert als de semantische context op de juiste interpretatie aanstuurt, en dat het P600-effect dan verdwijnt. Deze resultaten ondersteunen de claim dat semantische context een grote rol speelt bij het ontwarren van de tonale en intonationele informatie en zodoende ook bij het oplossen van het online conflict tussen toon en intonatie. De ERP-gegevens laten echter zien dat de introductie van een semantische context de problemen met de online verwerking van woorden aan het einde van een vraag niet helemaal oplost. Dit blijkt uit het N400-effect dat optrad bij woorden met een lage lexicale toon en bij woorden met een hoog-midden lexicale toon aan het einde van een vraag. De ERP-gegevens laten dus zien dat de semantische context dan wel helpt bij de uiteindelijke lexicale identificatie, maar tegelijkertijd het verschil benadrukt tussen het akoestische signaal en de lexicale toon die op basis van de context verwacht werd.

Naast een verschil in de letterlijke betekenis kan lexicale toon in sommige toontalen ook een onderscheid aanduiden tussen verschillende typen pragmatische betekenis. In deze talen wordt pragmatische betekenis uitgedrukt door middel van partikels aan het einde van de zin, de zogenaamde zinsfinale partikels (ZFP's), die soms alleen van elkaar verschillen in hun lexicale toon. Een aantal belangrijke vragen omtrent het begrijpen van ZFP's is tot nog toe onbeantwoord gebleven. Eén van deze vragen gaat erom of de interpretatie van de pragmatische betekenis die uitgedrukt wordt door ZFP's afhangt van de discourse context en de intonatie, net zoals het geval is bij de interpretatie van lexicale betekenis. Een andere vraag die onderbelicht is gebleven, heeft te maken met de on-line verwerking van pragmatische betekenis. Deze twee vragen werden onderzocht in hoofdstukken 3 en 5.

Hoofdstuk 3 onderzocht de relatieve rol van discourse context en intonatie bij het begrijpen van pragmatische betekenis. In drie experimenten kregen luisteraars korte passages gesproken taal te horen. Ze moesten daarbij kiezen welke van vier ZFP's – laa1, laa4, laa3 and aa3, die van elkaar verschillen qua lexicale toon en/of onset – het beste aan het einde van de passage pasten. Experiment 1 en 2 onderzochten of – en zo ja, hoe – respectievelijk discourse context en intonatie de verwerking van ZFP's beïnvloeden. Zowel discourse context (Experiment 1) als intonatie (Experiment 2) bleken invloed te hebben op de keuze van ZFP's, daarom werd in Experiment 3 de combinatie van discourse context èn intonatie onderzocht. Het hoofdresultaat van Experiment 3 was dat het effect van discourse context niet versterkt wordt door een intonatie die op dezelfde interpretatie wijst. Als context en intonatie elkaar tegenspreken, wordt het effect van de discourse context daarentegen wel afgezwakt. Desalniettemin is de discourse context voor het begrijpen van pragmatische betekenis nog altijd belangrijker dan intonatie. Deze bevindingen werden geïnterpreteerd in het kader van de spreker-perspectief hypothese, die stelt dat intonatie een gevolg is van de context (en de communicatieve bedoeling) van een spreker. Zodoende zal de luisteraar, als deze zich in het perspectief van de spreker verplaatst, intonatie alleen dan als een extra bron van pragmatische informatie beschouwen als deze op een andere pragmatische betekenis wijst dan de discourse context.

Het doel van hoofdstuk 5 was om meer duidelijkheid te scheppen over welke factoren invloed uitoefenen op het begrijpen van de pragmatische betekenis die overgebracht wordt door de ZFP's. Een tweede doel van dit hoofdstuk was om het tijdsverloop van de verwerking van ZFP's te onderzoeken tijdens online spraakverwerking. Hiervoor bekeek ik de verwerking van pragmatische schendingen die veroorzaakt waren door ZFP's, met behulp van een paradigma dat vergelijkbaar is met het standaard paradigma voor semantische schendingen: Kantonese luisteraars hoorden twee typen discourse contexts die beide eindigen op dezelfde draagzin. De ene discourse context wekte bij luisteraars de verwachting dat het geluidsfragment gevolgd zou worden door het ZFP laa1, dat een verzoek uitdrukt. De andere context deed luisteraars vermoeden dat het ZFP laa4 zou volgen, dat een echovraag aangeeft. Op deze manier stuurde de context de verwachting van de luisteraar in de richting van ofwel laa1 ofwel laa4. De ZFP's die de luisteraars daadwerkelijk hoorden, pasten soms wel en soms niet bij de gewekte verwachting. In vergelijking met de passende ZFP's zorgden de niet-passende ZFP's voor een wijdverspreide positiviteit in het tijdsvenster van 318 tot 816 ms na het begin van de ZFP. Aangenomen wordt dat deze positiviteit de heranalyse weergeeft, die veroorzaakt wordt door het conflict tussen de pragmatische betekenis van de context en de daarbijbehorende verwachting enerzijds, en de pragmatische betekenis van het niet-passende ZFP anderzijds. Het vroege begin van de positiviteit duidt erop dat Kantonese luisteraars gevoelig zijn voor zowel de tonale als de pragmatische informatie van ZFP's, en dat ze de pragmatische betekenis van een uiting afleiden uit een combinatie van deze twee soorten informatie in samenhang met de context.

Samengevat beschrijft dit proefschrift een experimenteel onderzoek naar veschillende aspecten van gesproken taalverwerking in een toontaal, te weten Kantonees. De resultaten tonen aan dat er een directe interactie bestaat tussen intonatie, (lexicale en discourse) context, en het verwerken van lexicale tonen, en dat beide typen context daarin de dominante factor lijken te zijn. Daarnaast verschaffen de empirische hoofdstukken experimentele paradigma's en benaderingswijzen die in toekomstig onderzoek gebruikt kunnen worden om spraakverwerking in andere toontalen te bestuderen.

粵語概要

從非聲調印歐系語言嘅研究度，我哋瞭解到好多關於口語認字方面嘅知識，同埋研發出唔少關於口語認字過程嘅模型。可惜嘅係，呢一系列嘅研究因爲淨係用非聲調印歐系語言，所以佢哋淨係注重音節喺口語認字扮演嘅角色。因爲咁，我哋對聲調喺口語認字所扮演嘅角色，知道得小之又小。喺現有聲調語言嘅研究度，我哋知道所有嘅聲調語言都會用聲調嚟分辨唔同嘅字詞（譬如粵語用六聲嚟分辨以下六個字：夫、苦、富、符、婦、負），同埋部分嘅聲調語言用聲調嚟分辨唔同嘅語用（例如粵語會用句末助詞嚟表示發言人嘅意圖。我哋常用嘅「啦」字用唔同聲調讀出嚟會可以代表要求、澄清、或者陳述）。但係喺日常對話，除咗聲調之外，仲有其他語言因素可以同時影響我哋理解字義同埋語用。尤其係當講嘢嘅時候，聽者會同時接收到呢啲唔同嘅語言資訊。重要嘅係，到底喺咁嘅情況下，聽者嘅大腦會點樣處理多種語言因素組成嘅資訊，同埋點樣用呢啲資訊去瞭解對方講乜。爲此，本論文會探討聲調連同其他兩種語言因素資訊句調同埋語境 (包括上文下理、時間、空間、情景、對象、話語前提等)——會點樣同時影響聽者理解粵語嘅語意同語用。

喺第二章度，我會用兩個 event-related potentials（ERP；一種腦電圖分析方法）實驗去研究到底講粵語嘅聽者會唔會同時用三種語言資訊——聲調、句調、同埋語境（特別係上文）——去認字，同埋呢三種資訊會唔會喺在大腦認字嘅時候有所交集。第一個實驗測試喺聲調上面另外再加上升嘅問句句調會唔會影響聽者分別辨認低聲調嘅字（例如符、婦、負），同埋高中聲調嘅字（例如夫、苦、富）。實驗結果顯示聲調同句調嘅資訊會喺大腦認字嘅時候即時交集，同埋影響聽者分別辨認低聲調同高聲調嘅字：當聽者聽到加上上升句調嘅低聲調字，佢哋嘅大腦會顯示 P600 腦電波效應——反映聲調同句調資訊引起嘅即時衝突，同埋最終佢哋會認錯低聲調嘅字做第二調嘅字（例如將「婦」當成「苦」）。相反當聽者聽高中聲調嘅字嘅時候，佢哋冇上文嘅反應。喺第二個實驗度，我用同樣嘅實驗設計，但係我將呢啲低聲調同高聲調嘅字前面加上另一個字組成一個常用嘅單詞（例如「孕婦」、「痛苦」）。呢個新嘅設計特別係用嚟測試聽者會唔會喺認字嘅時候即時用上文語境去解決低聲調同埋問句句調所引起嘅資訊衝突同埋認字困難。實驗結果顯示語境對認字有好大嘅幫助。同埋語境可以舒緩低聲調同埋問句句調所引起嘅資訊衝突（P600 腦電波效應冇咗），但係並未能夠完全化解認字困難：因爲上文語境令到預期嘅音訊同實際嘅音訊（聲調加咗問句句調）有更大嘅差異，因此所有加咗問句句調嘅字顯示 N400 腦電波效應——反映合併資訊嘅時候有困難。

除咗字義之外，有啲聲調語言會用聲調嚟分辨唔同嘅語用。尤其係呢啲語言會用聲調去分辨唔同嘅句末助詞，同埋呢啲句末助詞所表達嘅語用。到目前爲此，冇乜人知道到底我哋點樣理解句末助詞所表達嘅語用。由此引申一個好重要嘅問題：到底語用理解會唔會好似字義理解一樣被語境同句調所影響。另外一個未解嘅謎團係到底語境同埋聲調點樣即時影響我哋大腦分

析句末助詞所表達嘅語用。本論文嘅第三章同埋第五章會分別探討呢兩個問題。

第三章會探究上文語境同埋句調喺語用理解所扮演嘅角色。喺三個實驗度，聽者會聽到唔同嘅句子或者小段落，然後要喺四個句末助詞（laa1「啦」、laa3「喇」、laa4「嗱」同 aa3「啊」）度揀一個最適合嘅句末助詞去完成嗰句句子或者小段落。實驗一同埋實驗二分別測試到底語境同句調點樣影響我理解句末助詞嘅語用。呢兩個實驗嘅結果顯示語境同句調可以影響聽者點樣揀句末助詞。而實驗三就測試咗到底語境定句調嘅影響力會大啲。實驗結果顯示如果句調同語境預測一樣嘅句末助詞，句調唔會加強語境嘅預測能力。相反嚟講，如果句調同語境預測唔同嘅句末助詞，句調會削弱語境嘅預測能力，重要嘅係語境仍然主導我哋點樣理解句末助詞所表達嘅語用。以下我會用「發言人意向嘅假設」嚟剖析呢一系列嘅研究結果。呢個假設主張句調係語境（同埋發言人嘅意圖）嘅引申。所以，如果聽者採納發言人嘅意向，佢會認爲句調係用嚟補充額外嘅資訊。但只會係喺語境同埋句調預測唔同嘅語用嘅時候先至會處理句調嘅資訊。

第五章嘅主要目的係搞清楚乜嘢語言因素會影響語用理解。第二個目的係探究大腦點樣剖析句末助詞。我用咗一個類似 ERP 實驗常用嘅語義錯誤實驗設計，只不過呢個實驗睇嘅係語用錯誤：聽者會聽到四種結尾一樣嘅小段落，唔同之處係上文語境同埋最後嘅句末助詞。呢啲段落有兩種唔同嘅上文語境——一種語境傾向句末助詞 laa1（請求），另一種語境傾向句末助詞 laa4（澄清），而最後嘅句末助詞會係符合語用預期，又或者唔符合語用預期。對比起符合語用預期嘅句末助詞，唔符合語用預期嘅句末助詞令到我哋大腦顯示一個好早開始嘅 P600 腦電波效應——表示出聽者對由上文語境同聲調交集引起嘅語用錯誤非常敏感，因此佢哋需要重新剖析佢哋自己有冇聽錯嘢？

總括嚟講，呢一篇論文用唔同嘅實驗設計去探討聲調語言——特別係粵語——嘅語言理解。研究結果顯示當粵語聽者聽嘢嘅時候，三種語言因素——上文語境、句調同埋聲調——嘅資訊會喺大腦度即時交集，同埋會俾上文語境所引導。另外本論文提供咗唔同嘅實驗計去探究其他聲調語言嘅語言理解。

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Curriculum Vitae

Carmen Kung was born on November 7, 1984 in Hong Kong. She received her B.A. (hons) with a double major in psychology and linguistics from Memorial University Newfoundland (MUN), Canada, where she developed a profound appreciation for language systems, and a never-ending curiosity about the psychology of language. At the end of the studies, and eager to learn more about psycholinguistics, she came across the Cognitive Neuroscience research master's programme offered by Donders Graduate School for Cognitive Neuroscience (DGCN) which is affliated with Max Planck Institute of Psycholinguistics.

After securing support from the Huygens Scholarship from Dutch Ministry of Education, Culture, and Science, she enrolled in this 2-year MSc. Programme in cognivie neuroscience specialised in psycholinguistics. In one of the courses taught by Dr. Dorothee Chwilla and Prof. Herbert Schriefers, who later became her thesis advisors, she was introduced to the wonders of event-related potentials (ERP) and how they can reveal the dynamics underlying various concomitant linguistc processes. This gave rise to her master's thesis, which used the interaction between context, intonation, and lexical tone in Cantonese Chinese as a testing ground of the monitoring theory of language perception.

With the support of the DGCN Toptalent grant, she furthered the research expedition on speech comprehension in Cantonese Chinese in her PhD, in which she investigated the role of context, intonation, and lexical tone in the interpretation of lexical and pragmatic meaning using EEG and other behavioural methods. Majority of this data collection was conducted in the Hong Kong Polytechnic University and the University of Hong Kong, with the help of Dr. Roxana Fung and Prof. Sam Po Law. While she was there, Carmen helped in Dr. Fung and Prof. Law's ERP project on the the near-merger in Hong Kong Cantonese tones.

From 2014 onwards, Carmen has been working as a research associate in the Child Language Lab at Macquarie University, advised by Prof. Katherine Demuth. Applying what she learned in Nijmegen, she has been using EEG and other behavioural techniques to study prosodic processing in adults and school-aged children. She also supervised projects on morphosyntactic processing in first- and second-langauge learners of English, and morphosyntactic and semantic processing in foreign-accented speech.

Publications

Kung, C., Chwilla, D., Fung, R., & Schriefers, H. (in preparation). The effects of discourse context and intonation on the comprehension of pragmatic meaning: A study on the choice of sentence-final particles in Cantonese Chinese.

Kung, C., Chwilla, D., Fung, R., & Schriefers, H. (in preparation). Tracking pragmatic-meaning computation on-line in the pragmatic violation paradigm: An ERP study on Cantonese sentence-final particles.

Dube, S., **Kung, C**., Brock, J., & Demuth, K. (2018). Perceptual salience and the processing of subject-verb agreement in 9-11-year-old English-speaking children: Evidence from ERPs. *Language Acquisition.*

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Donders Graduate School for Cognitive Neuroscience

For a successful research Institute, it is vital to train the next generation of young scientists. To achieve this goal, the Donders Institute for Brain, Cognition and Behaviour established the Donders Graduate School for Cognitive Neuroscience (DGCN), which was officially recognised as a national graduate school in 2009. The Graduate School covers training at both Master's and PhD level and provides an excellent educational context fully aligned with the research programme of the Donders Institute.

The school successfully attracts highly talented national and international students in biology, physics, psycholinguistics, psychology, behavioral science, medicine and related disciplines. Selective admission and assessment centers guarantee the enrolment of the best and most motivated students.

The DGCN tracks the career of PhD graduates carefully. More than 50% of PhD alumni show a continuation in academia with postdoc positions at top institutes worldwide, e.g. Stanford University, University of Oxford, University of Cambridge, UCL London, MPI Leipzig, Hanyang University in South Korea, NTNU Norway, University of Illinois, North Western University, Northeastern University in Boston, ETH Zürich, University of Vienna etc.Positions outside academia spread among the following sectors:

- Specialists in a medical environment, mainly in genetics, geriatrics, psychiatry and neurology,
- Specialists in a psychological environment, e.g. as specialist in neuropsychology, psychological diagnostics or therapy,
- Higher education as coordinators or lecturers.

A smaller percentage enters business as research consultants, analysts or head of research and development. Fewer graduates stay in a research environment as lab coordinators, technical support or policy advisors. Upcoming possibilities are positions in the IT sector and management position in pharmaceutical industry. In general, the PhDs graduates almost invariably continue with high-quality positions that play an important role in our knowledge economy.

For more information on the DGCN as well as past and upcoming defenses please visit: http://www.ru.nl/donders/graduate-school/phd/