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Author: Qian Li
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CHAPTER 7 CONCLUSION

This dissertation investigated the production and perception of contextual tonal variation based on data from Tianjin Mandarin. While most of the previous studies on speech variability have focused on variation at the segmental level, this dissertation complements the existing literature with data on lexical tonal variation, a suprasegmental feature of the sound system. With evidence from Tianjin Mandarin, a dialect of the Northern Mandarin family, this dissertation provides an in-depth view of how the acoustic realization of lexical tones may vary due to both the local contextual factors (Chapter 3) and the global prosodic factors (Chapter 6), and how the different types of tonal variability further affect the online perception of the lexical tones (Chapters 4 and 5).

After an introduction to the sound system of Tianjin Mandarin (Chapter 2), Chapter 3 examined the acoustic realization of two different types of local tonal variation. Specifically, a direct comparison was made of the $f_0$ variabilities introduced by two local tonal variation processes: tone sandhi and anticipatory tonal coarticulation, which was designed to address the question of how lexical tones are realized with varying $f_0$ contours in disyllabic domains without pre-exclusion of any tonal sequence claimed to involve tone sandhi processes. To further understand the nature of tone sandhi (especially the direction and possible cyclic application of tone sandhi) in Tianjin Mandarin, trisyllabic constituents were also investigated.

With the technique of Growth Curve Analysis (GCA) (Mirman, 2014), this chapter observed a range of variation in the $f_0$ realization of the four lexical tones due to different following tones. Of particular interest were two different anticipatory raising effects due to the low-falling T1 and the low-dipping T3, where T1 consistently gives rise to a greater $f_0$ rise over the preceding tones and T3 significantly raises the overall $f_0$ mean of the preceding tones. In the sequences of T3T3, T1T1 and T4T4, the raising effects have brought about major changes in the $f_0$ contour of the preceding tones so that their surface $f_0$ may not be predictable from the characteristics of the canonical tonal $f_0$ contours. Variation over the three sequences was therefore attributed to tone sandhi. Other cases are better accounted for as tonal coarticulation, as the anticipatory raising effects have not affected the $f_0$ distinctiveness of the preceding tones. Their characteristic $f_0$ contours can still be expected to accord with the canonical tonal shapes. Over trisyllabic sequences, however, the three confirmed disyllabic tone sandhi sequences were not consistently observed, counter predictions based on claims in the literature (e.g., Li & Liu, 1985; Chen, 2000; Hyman, 2007). Specifically, tone sandhi applications over T1T1 and T4T1 sequences are only possible when these disyllabic sequences are aligned to the right edge of a trisyllabic constituent; while the T3T3 sequence triggers consistent application of sandhi changes regardless of its position within a trisyllabic utterance. Furthermore, no tonal neutralization was observed over any of the sandhi processes. Rather, we argue for two different types of tone sandhi in terms of the degrees of $f_0$ resemblance between the sandhi-derived tonal contour and the tonal contour of another lexical tone within the system. To be specific, T3T3 is a near-merger sandhi case, as its sandhi output T3$_{\text{sandhi}}$T3
shows an almost merged $f_0$ contour with the lexical tonal sequence of T2T3. T1T1 and T4T1 can be classified as no-merger sandhi sequences, as their sandhi realizations have some resemblance to but remain distinctive from the contours of other lexical tones in the language.

This chapter thus presents the first empirical study to directly compare these two types of tonal variation within a well-controlled acoustic experiment. It is to be recognized that the boundary between tone sandhi and tonal coarticulation is not straight-forward, and tone sandhi and tonal coarticulation do show some commonalities as well as differences. Nevertheless, given the rich layers of tonal variation due to different tonal variation processes, our results show that it is important to first objectively observe the patterns of $f_0$ variation due to these sources, without which, any discussion upon the differences between these two variation types is unfounded. In addition, most of the previous impressionistic studies have considered tonal variation as the categorical change of tonal identity, which has created a difficult situation and unnecessary complications for theoretical accounts of tonal variability. By showing that tone sandhi does not involve the categorical change from one tone to another, this chapter has greatly simplified the claimed complex tone sandhi system in this dialect. Consequently, our results have cast serious doubts on the previous theoretical accounts of tonal alternation based on impressionistic data, and called for future theoretical works on tonal alternation based on the empirically more solid findings.

Chapter 4 further tapped into the perceptual consequences of the different tonal variability, namely, near-merger sandhi, no-merger sandhi and no sandhi tonal coarticulation. While the literature has suggested a clear contextual effect on listeners’ identification of lexical tones, the current chapter asks how a deviated tone itself is processed by a listener prior to the access to the disambiguating tonal contexts during speech recognition. To address this question, this chapter employed a word-recognition task within the Visual World Paradigm (Tanenhaus et al., 1995).

Via examining the participants’ looks to both targets and competitors within the paradigm when they heard disyllabic stimuli with different types of tonal variability (i.e., near-merger sandhi, no-merger sandhi, no sandhi tonal coarticulation), this chapter observed significant differences in the eye movement patterns as a function of different types of tonal variability. This suggests a clear effect of tonal variability on the perception of lexical tones prior to the facilitation of the neighboring tonal contexts. To be specific, tonal sequences with no sandhi tonal coarticulation was the easiest to recognize as the proportion of participants’ looks to the target increased with the fastest rate among the three tonal variability types. Both sandhi variability types showed slower increase of looks to the target compared to no sandhi, between which near-merger sandhi was more difficult to process than no-merger sandhi, reflected in the overall less proportion of looks to target in the near-merger sandhi condition.

This chapter is the first study which shows that, prior to the access of the following tonal contexts, the deviated tone itself has already exerted effects on listeners’ recognition of speech, lending further evidence for tonal perception that speech perception is an incremental process during which listeners constantly update their perceptual decisions of
the incoming speech stimuli. From a methodological perspective, while traditional perception studies on tone sandhi mainly rely on native listeners’ meta-linguistic knowledge of whether one tone is changed to another, this chapter is also the first to look into how lexical tones with different types of tone sandhi are processed online. Furthermore, this chapter, from a perceptual point of view, has suggested the necessity of differentiating tonal variability of different types that have been observed in Chapter 3.

**Chapter 5** further investigates the nature of tone sandhi perception, as a follow-up study of Chapter 4. This chapter asks whether the online processing of sandhi tones is in a similar way to that of their non-sandhi variants of the same toneme or another lexical tone which has been claimed as the sandhi output due to their f0 contour similarity. Via the same Visual World Paradigm as in Chapter 4, this chapter examined how listeners process tone sandhi targets when presented with different types of competitors, i.e., a Toneme Competitor which has toneme overlap but no f0 contour overlap with the target, a Contour Competitor with f0 contour overlap but no toneme overlap, as well as a Segmental Competitor with neither toneme nor f0 contour overlap.

Results show that in all target types, participants were sensitive to the types of competitors together presented with the targets. First, Contour Competitors and Segmental Competitors play a comparable role during the initial activation of the target. Both show greater inhibition of the target activation. Therefore, upon hearing the target word, only the underlying toneme of the target word was concurrently activated together with the segments at an earlier stage. Second, at a later stage, contour similarity between the target and the Contour Competitor generally showed a comparable facilitation effect to that of the underlying toneme overlap in the Toneme Competitor condition. This facilitation effect due to f0 contour overlap was further observed between the target and the Contour Competitor for near-merger sandhi targets.

In previous impressionistic studies, tone sandhi in many Chinese dialects has been commonly regarded as the tonal change from one lexical tone into another lexical tone within the tonal inventory, based on evidence from traditional perceptual studies using offline meta-linguistic tonal discrimination tasks. This chapter is the first study showing, with eye tracking data which reveal the dynamic processing of spoken words, that tone sandhi does not have to be the categorical change from one lexical tone to another. Rather, tonal sandhi variation is better viewed as allophonic variation of the underlying lexical tones and are stored together with the lexical toneme as allotones in the mental lexicon. Together with evidence from the acoustic data, this chapter, from a perception perspective, casts serious doubts on the claimed nature of tone sandhi as the complete tonal neutralization as proposed in the previous impressionistic literature on Tianjin tone sandhi.

**Chapter 6** examined how the f0 realization of neutral tone is affected by global prosodic factors such as prosodic structure. This chapter focused on the rising neutral tone realization before a low-falling tone and asked whether Tianjin Mandarin has a special rising neutral tone target as claimed, and how the f0 realization of neutral tone is conditioned by different prosodic boundaries.

Via investigating the acoustic realization of the so-called “rising neutral tone” in different prosodic boundary conditions and produced with different preceding discourse
contexts, this chapter first shows that in Tianjin Mandarin, the rising neutral tone \( f_0 \) contour before T1 does not need to be treated as a special tonal target. Rather, this chapter argues that the raising effect is due to the anticipatory raising effect brought about by the following T1, which is consistent with the general raising effect of T1 towards the preceding lexical full tones as observed in Chapter 3. By increasing the number of neutral tone syllables, a mid-low tonal neutral tone target emerges, which is of a similar nature to that of the neutral tone in Standard Chinese. Furthermore, the results of this chapter suggest an interesting effect of prosodic boundaries on neutral tone \( f_0 \) realization. Specifically, the raising effect due to the following T1 can be blocked by a high-level prosodic boundary (i.e., a Subject-Predicate boundary) compared to a low-level boundary (i.e., a below-NP boundary). Last but not least, the present chapter observed an interaction of prosodic boundary and focus, where the effect of boundary was more clearly observed in Pre-Focus condition compared to the On-Focus condition despite the independent implementation of the two effects, arguing further that focus and prosodic boundary are two independent mechanisms that can interact to determine the phonetic implementation of lexical tones.

Previous studies have shown that, prosodic boundaries play an important role in conditioning the realization of segments and lexical full tones. This chapter provides the first set of data on how neutral tone realization is affected by different prosodic boundaries. Previous impressionistic studies propose that Tianjin Mandarin has a special rising neutral tone target when the neutral tone is followed by a lexical low-falling tone (Wang & Jiang, 1997; Wang, 2002; Lu & Wang, 2012), challenging our current understanding of neutral tone based on data from Standard Chinese (Chen & Xu, 2006). Results of this chapter suggest that this is not the case. While Tianjin Mandarin and Standard Chinese do differ in terms of the lexical full tone system, where the low-falling tone (T1) is present in Tianjin Mandarin but absent in Standard Chinese, the neutral tone realization in Tianjin Mandarin exhibits the similar mid-low neutral tone target as observed in Standard Chinese. It is the different lexical tone inventories between the two Mandarin varieties that give rise to different neutral tone realization.

In conclusion, with data from well-controlled experiments, this dissertation has demonstrated a rather complex structure of tonal variability in Tianjin Mandarin as well as the perceptual consequences of tonal variability in speech recognition. Several further implications can be made.

First, while most of the previous impressionistic studies have considered tonal variability as the categorical change of tonal identity, by considering multiple factors that might affect the realization of lexical tones in connected speech, this dissertation shows that tonal variation might not be as simple as the lexical tonal identity change. This has cast serious doubts on conclusions made on tonal variability in previous impressionistic studies. On the one hand, this dissertation demonstrates that careful experimental examination of tonal realization can reveal phenomena that have never been reported with impressionistic observations, e.g., the anticipatory raising of a following low-falling tone, which can shed light on theoretically important questions. On the other hand, our results show that some of the variability described in the literature as due to special tonal representations or tonal
alternation processes could already be well explained by taking into account multiple factors that affect tonal realization. All of these new findings call for revisiting of the theoretical accounts on tonal alternation based on solid empirical evidence.

Second, in previous studies on tonal variability, much research effort has been made to understand how tones are varied in Standard Chinese. This dissertation demonstrates different yet interesting tonal variability patterns in Tianjin Mandarin. It is to be noted that Tianjin Mandarin is very similar to Standard Chinese not only in terms of the number of lexical tones, but also in terms of the phonemic and the phonotactic systems. Yet the two dialects show very different patterns of tonal variability and surface f0 realizations. This study thus exemplifies that to gain better insight into the nature of tonal variability cross-linguistically, future studies on different dialects/languages are in great need.

Third, the present dissertation is based on data elicited from a generation that is born in the 1980s. It is possible that what have been reported in the impressionistic studies could be observed in speakers of an older generation. It is therefore important to collect data from older generations in the future to make cross-generation comparisons, results of which would certainly have great implications on language changes.

Last but not least, findings of the present dissertation will also serve as a great testing ground for further work in psycho/neuro-linguistic research to investigate the cognitive and neural mechanisms of lexical tones and speech variability in both production and perception.