An experimental analysis of tone sandhi in the Harbin dialect —focusing on some irregular disyllabic words

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1. Introduction and Background

In this section, I firstly introduce the Harbin dialect that is the focus of this present study and explain the citation tones and tone sandhi in the Harbin dialect. Then, the studies related to tone and tone sandhi with regards to the Harbin dialect are introduced and the aims and significance of this present study are stressed. Finally, the research questions and hypotheses are illustrated and explained.

1.1 Tone system in the Harbin dialect

Harbin is the provincial capital of the Heilongjiang Province, situated at the north-east of China, as can be seen from Figure 1.1. The Harbin dialect belongs to the group of North-eastern Chinese dialect (Yuan, 2001). As a dialect really similar to standard Chinese, the two share a large part of monosyllabic tones and pitch contours. For monosyllabic tones, tone classes and pitch contours are almost identical, only slightly lower than Mandarin in pitch (Shi & Huang, 2007). However, the Harbin dialect has features that make it a representative dialect of the north-eastern part of China: the special pattern of tone sandhi.

Figure 1.1 Map of Chinese dialect with Harbin in the black circle (from Chinese Academy of Social Sciences and Australian Academy of the Humanities, 1990: A2)

In the following part, I introduce the citation tones and tone sandhi in the Harbin dialect. Firstly, the concept of citation tone needs to be explained. Citation tone refers to the tone that occurs when the tone-bearing syllable is pronounced in isolation; this is often the tone

marked in dictionary entries. In most cases, the citation tone is identical to the tone in use (Chen, 1993).

There are in total four tones in the Harbin dialect. The pitch values are indicated by the familiar tone digital representations which were first introduced in Chao's (1930) study, in which the tonal space is idealized as a five point vertical scale, with 5 standing for the highest pitch and 1 for the lowest. The pitch value of each citation tone in the Harbin dialect can be seen in Table 1.1 and the pitch contour for each tone is shown in Figure 1.2.

Table 1.1 The pitch value of each citation tone in the Harbin dialect (Shi & Huang, 2007)

Abbreviation	Tone Type	Pitch value
T1	HH (High level)	44
T2	LH (Rising)	24
T3	HLH (Falling-rising)	313
T4	HL (Falling)	51
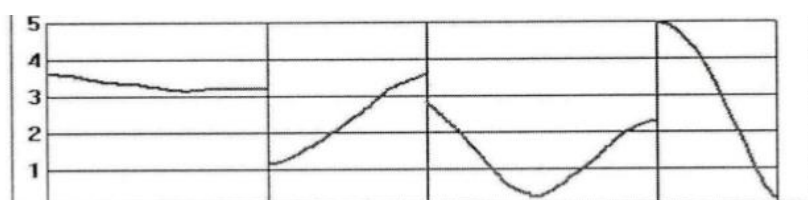
Figure 1.2 The pitch contour for each citation tone in the Harbin dialect (T1 to T4 from left to right) (Ye, 2013: 5)

According to Lin & Wang (2013), the pitch values for the four citation tones of standard Chinese in 5-point scale are 55, 35, 214, and 51. Therefore, the pitch values for monosyllabic words in the Harbin dialect are similar to the ones in standard Chinese, but the Harbin dialect has lower absolute pitch values compared to standard Mandarin.

Although citation tone is usually applied to the tone in use, in connected speech, complex and intricate sandhi processes may occur, which often drastically alter the phonetic shape of the citation tone. In such case, the concept of tone sandhi comes into sight and needs to be illustrated. Tone sandhi is the change of tone that occurs when different tones come together in a word or phrase. The tone resulting from the sandhi processes is called a sandhi tone, which is widely recognized as the result of phonologically conditioned tonal modification, and it occurs only in connected speech or in juxtaposition to other tone-bearing syllables but not in isolation.

Usually, tone sandhi has a feature of regularity, which is always applicable to a specific language or dialect in a specific period (Lin & Wang, 2013). There are two kinds of tone

sandhi in the Harbin dialect, constant tone sandhi and free tone sandhi. For constant tone sandhi, as long as the condition matches, the tone sandhi inevitably applies. For example, when a T3 syllable is followed by another T3 syllable in a disyllabic word in the Harbin dialect, the first syllable has to change to T2. For free tone sandhi, although the condition of tone sandhi exists, the tone sandhi is not necessarily present and depends solely on personal habits and contexts. Age, gender, education background, and social status can influence the use of free tone sandhi. Tone sandhi in the Harbin dialect is generally free tone sandhi while constant tone sandhi are mostly identical to constant sandhi rules in standard Chinese.

Tone sandhi can apply in disyllabic words, trisyllabic words, and even four syllabic words. However, all types of tone sandhi are based on the disyllabic tone sandhi. There are in total three different kinds of tone sandhi for disyllabic words in the Harbin dialect: tone sandhi in the first syllable, tone sandhi in the second syllable, and tone sandhi in both syllables. Tone sandhi in both syllables in the Harbin dialect is always triggered by the tone sandhi in the second syllable in the first place, and then the sandhi tone triggers the first syllable to undertake another tone sandhi rule.   **except the one you just mentioned?**

Two special types of tone that can cause tone sandhi are neutral tone and rhotic ending. Neutral tone is different in pitch value, duration, and intensity from other tones. The pitch contour of neutral tone depends on the pitch value of its preceding syllable. When the neutral tone (T0) appears after T1, T2, and T4, its pitch contour is always falling; when T0 appears after T3, its pitch contour keeps flat, is slightly rising or is slightly falling. Also, the neutral tone syllable is often short in duration, therefore the pitch contour of neutral tone is not always complete.   **how is the above not sandhi?**

There are two kinds of neutral tones. The first kind of neutral tone can be morpheme suffixes. These suffixes lose their tones under certain circumstances. As tone sandhi does not apply in morpheme suffixes and their adjacent syllables, this kind of neutral tone is not the focus of this present study. The other kind of neutral tone is that the syllable originally bear tone, however, when it appears in word, due to the restriction of stressed and unstressed syllables in a word as well as other various historical reasons, the unstressed syllable changes to neutral tone and the neutral tone in return influences the tone sandhi of its preceding syllable. Tone sandhi caused by the neutral tone in disyllabic words in the Harbin dialect is the one under focus in this present study.

I don't understand

compare 3.4

Apart from neutral tone, rhotic ending, also called *Erhua* sound, is another tone type that is worth mentioning in the Harbin dialect as it can also trigger tone sandhi in disyllabic words in the Harbin dialect. Although the rhotic ending is still written as an independent character, it is actually always combined with its preceding syllable, forming one syllable and is not pronounced as an independent syllable. The major acoustic feature of rhotic ending in the Harbin dialect is the sharp decrease of F3. The closer F3 gets to F2, the more retroflection one can perceive in audio impression.

1.2 Research background and significance

In this sub-section, I firstly illustrate the previous studies on tone and tone sandhi of disyllabic words in the Harbin dialect and discuss the limitations of these studies. Then, based on previous studies, I state the research gap in tone sandhi studies of the Harbin dialect and express the aim and significance of the present study.

1.2.1 Previous studies on tone sandhi in the Harbin dialect

Chinese, as a typical tonal language, includes many different dialects with differences and variation, which makes Chinese tonal systems rather complicated. Although many studies pay much attention to tone sandhi in different dialects, studies about Northern dialects are rare, due to the similarity of these dialects with standard Chinese. Studies on the Harbin dialect either went no further than a phonetic analysis of monosyllabic tones in isolation with incomplete disyllabic phonetic analysis, or paid more attention to the comparison between the Harbin dialect and its surrounding dialects or standard Mandarin.

Shi and Huang (2007), for the first time, provided a systematic discussion and gave a detailed description on the basic features of monosyllabic tones in the Harbin dialect based on a phonetic experiment with 58 native speakers. Shi and Huang (2007) focused only on monosyllabic tones in isolation and provided a sociophonetic analysis, including the pitch differences caused by speakers' gender, family language background and age, and did not look into tone sandhi in multi-syllabic words.

Ye (2013) compared the differences in tone sandhi systems between the Harbin dialect & standard Chinese, and the Harbin dialect & its surrounding dialects, for both regular disyllabic tonal sandhi and irregular disyllabic tonal sandhi. For the regular disyllabic tonal sandhi analysis, only one participant was recruited for each dialect which made Ye's results lack of reliability. For the irregular disyllabic tonal sandhi analysis, the analysis was not

based on phonetic experimental results but merely explanations based upon theoretical inferences.

Wang (2017) mentioned in her study of phonetic features of the Harbin dialect that when a disyllabic word ends with T0, the speaker of the Harbin dialect tends to change the tone of the first syllable to T2.
Wang (2017) also discussed the rhotic ending in the Harbin dialect. When a disyllabic word ends with rhotic ending and its first syllable is not T3, the second syllable, together with the retroflex final, tends to change to T3 (Wang, 2017). However, Wang's study is mainly based on questionnaires collected from speakers of the Harbin dialect and discussion of theoretical statements, lacking of phonetic experimental evidence.

1.2.2 Research aim and significance

Not many studies have been done on the irregular tone sandhi in the Harbin dialect from the phonetic perspective and even less a comprehensive analysis from a phonology point of view. Based on Ye (2013), Wang (2017), and Shi & Huang's (2007) studies, focusing on irregular disyllabic tonal sandhi, this paper outlines and analyses the features of some irregular disyllabic tonal sandhi in the Harbin dialect. Based on phonetic experimental analysis, this paper aims to provide further phonetic and first-hand evidence for irregular disyllabic tonal sandhi based on the conclusions of Ye (2013) and Wang (2017) and some methods introduced by Shi and Huang (2007). Neogrammarians suggest that there are always specific constraints and regularities inside irregular tone sandhi (Xu, 2011). Irregular tone sandhi could be the link to synchronic or diachronic shift. The existing studies only focus on one or a few irregular tone sandhi, while this paper aims to provide more explanation for various types of irregular tone sandhi, as well as primary experimental evidence. Also, as languages are dynamic and studies on the Harbin dialect are quite out of date, I would like to see if any changes happened in the Harbin dialect in this decade.

1.3 Research questions and hypotheses

In this section, I state the research questions and hypotheses of this paper. Considering the previous section, this thesis is an exploratory study and the main research question is:

What are the features and restrictions (environment) of some irregular disyllabic tonal sandhi of the Harbin dialect?

To be more specific, what are the phonetic features of disyllabic tone sandhi in the following cases:

a. numbers with T1 (*yi1* 'one', *san1* 'three', *qi1* 'seven', *ba1* 'eight') that appear before classifiers with different tones

b. different kinds of adverbs (*bie2* 'do not', *mei2* 'not', *hai2* 'still', *dou1* 'both/all') that are combined with verbs with different tones

c. locative preposition (*zai4* 'be/at') that is followed by syllables with different tones denoting places

d. neutral tone that appears at the end of words

e. the second syllable that appears with a retroflex final (*Erhua* suffix)

For each sub-question, as a native speaker of the Harbin dialect, based on my personal knowledge and previous theoretical studies, for each word categories, I have come up with the following hypotheses:

yi1 'one' is a special morpheme with its own special tone sandhi rules in the Harbin dialect. The citation tone of *yi1* is T1. It changes to T2 when it is followed by T4, and it changes to T4 when it is followed by other tones (Lin and Wang, 2013). It only retains its citation tone when it is used as monosyllable.

In terms of other numbers with T1, the tone sandhi from T1 to T2 when followed by T4 can contribute to making the natural focus, numbers, in the disyllabic words more prominent, enhancing the comparison between the stressed syllable and unstressed syllable. Therefore,

a) I expect numbers with T1 to change to T2 when the following classifiers are T4 and keep unchanged (except *yi1*) when the following tones are non-T4. I expect number *yi1* to change to T4 when followed by non-T4.

Adverbs *bie2*, *mei2*, and *hai2* have two functions, one as adverbs, the other as verbs. When the syllables *bie2*, *mei2*, and *hai2* are used as verbs, in the verb-and-object configuration, the objects are the natural focus and <mark>the verbs are not stressed, therefore, the tone sandhi does not apply</mark>. However, while *bie2*, *mei2* and *hai2* are used as adverbs, in the adverbial-verb configuration, the adverbs are the natural focus and stressed and tone sandhi applies. The citation tone of adverbs (*bie2*, *mei2*, and, *hai2*) is the rising tone, and it changes to T4 when followed by T1, T2, and T3 (Ye, 2013).

formulated differently from yi1, but exactly the same pattern?

The adverb *dou1* has a rather different tone sandhi pattern but the cause of tone sandhi is similar to the previous three adverbs. The adverb *dou1* also has two functions, as adverb or noun. The citation tone of *dou1* is T1 and it changes to T2 when it is used as adverb. According to the explanation above,

b) I expect adverbs of T2 (*bie2, mei2, hai2*) to change to T4 when followed by non-T4 verbs. I expect adverbs of T1 (*dou1*) change to T2 no matter which type of tone is followed.

Tone sandhi of *zai4* is mainly influenced by the act of keeping the tones of its ancient synonyms (Ye, 2013). The tone of *zai4*'s ancient synonym is T3. Therefore,

c) I expect locative preposition of T4 (*zai4*) to change to T3 when followed all types of tones.

According to Wang (2017), there is a high frequency of replacing the first syllable in T1 with T2 in disyllabic words in the Harbin dialect, resulting from the second syllable being the neutral tone. Therefore,

d) I expect the syllables before neutral tones in disyllabic words to change to T2.

When a disyllabic word ends with rhotic ending and its first syllable is not T3, the second syllable, together with the retroflex final, tends to change to T3 (Wang, 2017). Therefore,

e) I expect the second syllable with retroflex final to change to T3 when the first syllable is not T3.

This thesis is divided into 6 sections. The research background, significance, research question and hypotheses of irregular disyllabic tonal sandhi in the Harbin dialect are introduced in Section 1. The second section explores the methodology applied and the detailed description of the phonetic experiment and the analytical process are given. Section 3 outlines the results collected from experiments. Section 4 discusses the results in Section 3 and offers some explanation for tone sandhi in the Harbin dialect. Section 5 involves the phonological analysis of irregular disyllabic tonal sandhi in the Harbin dialect within the framework of Optimality Theory. The final Section is the conclusion and the limitations of this present study are illustrated.

2. Methodology

In this section, wordlist materials, participants, data collection and data analysis for the phonetic experiment of tone sandhi in the Harbin dialect are stated and explained.

2.1 Materials

The wordlist material for this study is mainly chosen from the studies by Ye (2013), Wang (2017) and the phonetic corpus of the *Chinese dialects and Dialect Survey* (Zhan, 1991) . There are in total 57 words, divided into 5 groups, namely, disyllabic words starting with numbers, disyllabic words starting with adverbs, disyllabic words starting with locative preposition, disyllabic words with neutral tone as the second syllable and disyllabic words with retroflex suffix. Some words without tone sandhi are also included in the wordlist to make the tonal system complete. The complete wordlists are given below. The gaps in the wordlists are marked with '-', indicating that no example of disyllabic words can be found with these specific tone combinations in the Harbin dialect. Wordlist of disyllabic words with numbers in T1 is shown in Table 2.1; wordlist of adverbs is shown in Table 2.2; wordlist of preposition is shown in Table 2.3; wordlist of neutral tone is shown in Table 2.4; wordlist of rhotic ending is shown in Table 2.5.

Table 2.1 Tone sandhi of disyllabic words of numbers with T1

Number (T1)	+T1	+T2	+T3	+T4
yi1 **'one'**	+*dui1* 'pile'	+*tiao2* 'pair'	+*ben3* 'clf for books'	+*jian4* 'article'
san1 **'three'**	+*zhi1* 'clf for animals'	+*tou2* 'clf for animals'	+*duo3* 'ear'	+*bian4* 'times'
qi1 **'seven'**	+*zhang1* 'slice'	+*jie2* 'block'	+*chi3* 'foot'	+*ci4* 'times'
ba1 **'eight'**	+*jin1* 'half kilo'	+*ping2* 'bottle'	+*mu3* 'area'	+*pian4* 'slice'

Table 2.2 Tone sandhi of disyllabic words of adverbs

Adverbs	+T1	+T2	+T3	+T4
mei2 **'not'**	+*reng1* 'throw'	+*lai2* 'come'	+*mai3* 'buy'	+*dong4* 'move'
bie2 **'do not'**	+*ku1* 'cry'	+*ti2* 'remind'	+*zheng3* 'do'	+*kan4* 'see'
hai2 **'still'**	+*chi1* 'eat'	+*xing2* 'allow'	+*mai3* 'buy'	+*yao4* 'want'
dou1 **'all/both'**	+*shuo1* 'say'	+*lai2* 'come'	+*pao3* 'run'	+*qu4* 'go'

Table 2.3 Tone sandhi of disyllabic words of locative preposition (No examples can be found for the combination of zai4 *followed by T2)*

Preposition	+T1	+T2	+T3	+T4
zai4 **'at/in'**	+*jia1* 'home'	-	+*na3* 'where'	+*zhe4* 'here'

Table 2.4 Tone sandhi of disyllabic words of neutral tones (the gaps in the words list indicates that no examples can be found in these tone combination and are marked with '-')

T1	+T0(T1)	**la1** +*la1* 'drop'
		dao1 +*gu1* 'whisper'
	+T0(T2)	**gou1** +*lou2* 'stoop'
	+T0(T3)	**duo1** +*zan3* 'when'
	+T0(T4)	**pu1** +*ke4* 'poker'
		gan1 +*jing4* 'tidy'
T2	+T0(T1)	-
	+T0(T2)	*shi2*+*tou2* 'stone'
	+T0(T3)	*he2*+*zi3* 'box'
	+T0(T4)	-
T3	+T0(T1)	-
	+T0(T2)	**gu3** +*tou2* 'bone'
	+T0(T3)	**shang3** +*wu3* 'noon'
	+T0(T4)	**da3** +*ban4* 'dress up'
		zhu3 +*yi4* 'idea'
T4	+T0(T1)	-
	+T0(T2)	**ge4** +*ren2* 'oneself'
	+T0(T3)	*dui4*+*wu3* 'team'
	+T0(T4)	**zuo4** +*liao4* 'seasoning'

Note: The tone in the backets after T0 is the original tone of the syllable.

Table 2.5 Tone sandhi of disyllabic words with rhotic final (the gaps in the words list indicates that no examples can be found in these tone combination and are marked with '-')

T1	+T1r	-
	+T2r	*gen1*+ **qian2r** 'near'
	+T3r	-
	+T4r	*yi4*+ **hui4r** 'a while'
T4	**+T1r**	*ban4*+ **la1r** 'half'
	+T2r	-
	+T3r	*hao4*+*ma3r* 'number'
	+T4r	*zi4*+ **ge4r** 'oneself'
		jing4+ **yi4r** 'on purpose'
		yang4+ **shi4r** 'style'

2.2 Participants

In my experimental study, 6 female speakers participated. All participants have an education background of junior college or lower and are in their 30s or 40s. All of them were born, grew up and are still living in Harbin. None of them has been away from Harbin for more than 1 week. Four of them are employees of companies and two of them are accountants. Their speech can be regarded as representative of the Harbin dialect. They have no knowledge about phonetics or phonology.

2.3 Data recording

57 words written in Chinese characters are presented on paper. Contexts with dialectal words are given for each word for reference. An example of word and its explanation in the wordlist is shown in Table 2.6. The recording process was conducted in an office room with minor noise. All the words were required to be read at least twice and were recorded to a recording software with a line-in microphone. The recording of each participant was completed in a single session.

Table 2.6 An example of word and its explanation for participants

word:	context:
ge4+ren2 'oneself'	These work are all done by **myself.**

2.4 Data processing

In the following sub-sections, I introduce the criteria applied in setting boundaries for tone bearing units during tone annotation in textgrid files. The principles and approaches used in editing pitch files are illustrated and explained. Examples for some incorrect pitch types and correction methods are also given for better understanding.

2.4.1 Tone bearing units annotation in textgrid files

In terms of F0 extraction in phonetic experimental analysis, it is difficult to extract pitch value or accurate tone contours in connected speech compared to monosyllables, as in connected words, a tone is always influenced by the final pitch value of its previous tone or the starting pitch value of its following tone. It is critical to choose the measuring boundaries of each tone. Therefore, it is important to bring in the concepts of pre-onset and post-offset. Lin (1965) firstly put forward the concepts of pre-onset and post-offset and tone-bearing parts of tones in Mandarin Chinese and suggested that the basic tonal contour is mainly related to the syllabic vowel and its adjacent transition. Wu and Lin (1989) also pointed out that the pre-onset and post-offset occupy a very small part of the contour and they are not easy to be perceived by ear, therefore, they can be neglected in study. Only the part between both ends, namely, the tone-bearing unit, is important for tone perception (Wu & Lin, 1989).

TBU as a phonetic concept?

Spectrograms show that sometimes there are pre-onset and post-offset at both ends of the syllable, which is caused by the change of the state of the vocal cords when starting or stopping the articulation of speech sounds (Shi, 1990). Some examples of pre-onset and post-offset in disyllabic words are shown in Figure 2.1, marked with red circles.
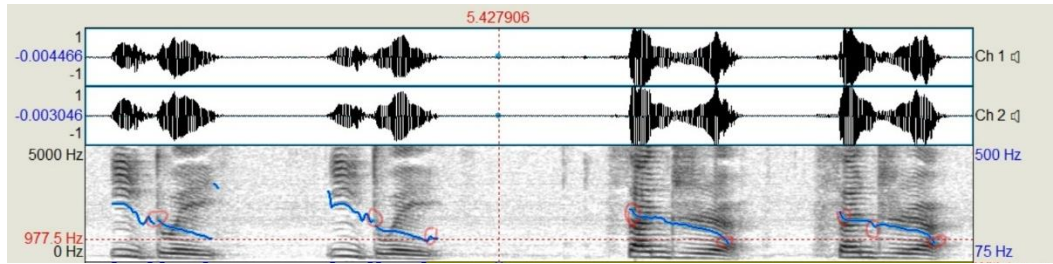
Figure 2.1 Pre-onset and post-offset of 4 disyllabic words, marked with red circles

Following the line proposed by previous scholars, pre-onset and post-offset is not included in the tone bearing units in this present study. The curves at both ends of tone contours are excluded but the nasal coda and vocalic endings are still kept, and the tone-bearing unit is the focus of this paper.

The audiofiles were analysed and segmented with the phonetic software Praat (Boersma & Weenink, 2005). Four criteria are set to annotate the tone more accurately: clear formants; steady intensity curves; automatic measured pitch values; clear pattern of spectrum for consonants are excluded.

With these judgements for tone bearing units, all the recordings were annotated in three different tiers. The first and second tier are the tone tiers, with the first tier annotating the words with tone sandhi and the second tier annotating the words without tone sandhi. The auditory tone number for each syllable is preserved on the annotation. Consonants in the onset position are not segmented in this research. The third tier is the word tier, indicating the word boundaries for each character in each disyllabic word. Taking Figure 2.2 as an example, because tone sandhi applies to *yi1+dui1*, which result in *yi4+dui1*, *yi4+dui1* is annotated in tier 1. As no tone sandhi applies to *san1+zhi1*, the combination is annotated in tier 2. The full word combination is showed in tier 3.
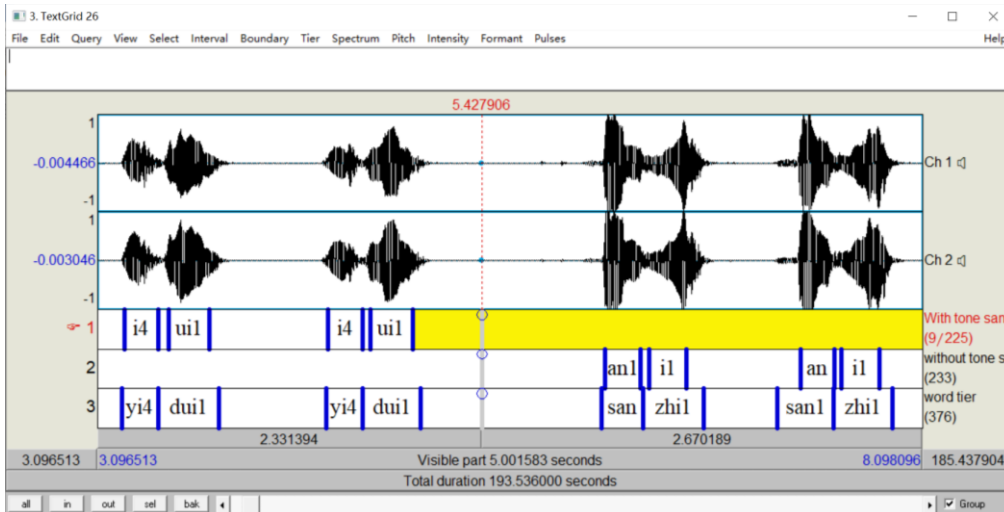
Figure 2.2 Print screen of annotation interface of four disyllabic words with three tiers

2.4.2 F0 values editing in pitch files

By using the function of periodicity, pitch file can be automatically generated in Praat. In terms of parameter setting, both pitch floor and pitch ceiling were initially set with default values. If the pitch values and curves are not neat with many extremely high or low value points, then pitch floor and ceiling were adjusted to exclude the departing values until most pitch values and curves were consistent.

Although parameter resetting can exclude some extreme points, the automatically generated F0 data still needs further inspection and correction. Errors in automatic data extraction mainly happen at the beginning and the end position of F0 segments as well as in position where the F0 value is low or the periodicity is not clear. An example for an error in ending position can be seen in Figure 2.3 and an example for the error when there is extreme low F0 with creaky voice can be seen in Figure 2.4.
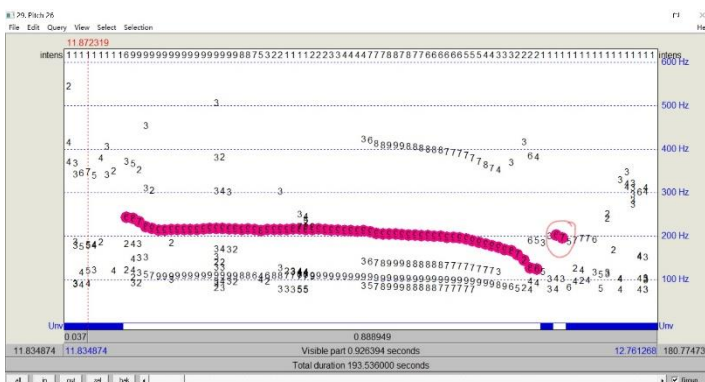
Figure 2.3 an example of pitch file with error pitch values in the final position with the error points marked in a red circle
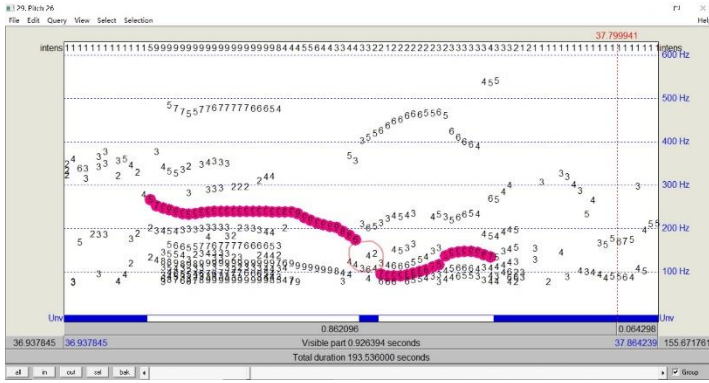
Figure 2.4 an example of pitch file with error pitch values in extracting low pitch values of creaky voice. (The value points that should be added are marked in a red circle)

Two principles are followed during F0 correction: the velocity changing of vocal cord vibration is nearly smooth, so the sharply increase or decrease in a short time could be an error F0 value; the alternating of voiced and voiceless usually cannot finish in a short amount of time, therefore, transient voiced or voiceless segment (<millisecond) can be incorrect F0 values (Ladefoged, 2003). I have applied three approaches to get rid of these error pitch values: deleting the scatter points that are far from a neat pitch curve; adding points to form a complete smooth pitch curve; moving incorrect F0 values to the ones more reasonable. For example, as can be seen in Figure 2.5[1], it is highly unlikely for a F0 value to have a 100Hz increase in this short amount of time from position 1 to next point. Therefore, the point in position 3 is more accurate.
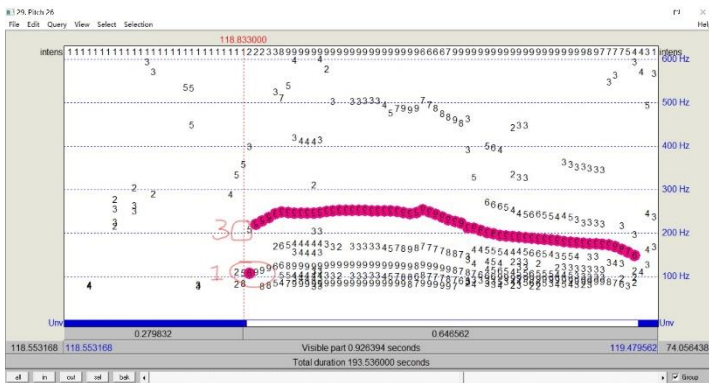
Figure 2.5 An example when moving point is necessary to make the F0 value more accurate

2.5 Data analysis: F0-normalization

In order to make it possible to compare each tonal F0 contour, for each tone-bearing syllable interval, 10 uniformly-spaced F0 values are measured, labelled F01-F010. For each participant, there can be individual differences during pronunciation due to influences caused

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[1] The numbers showed in pitch file interface is the possibility of the point at the same time to be chosen as the generated pitch value. Therefore, the higher (9) the number is, the more likely it is chosen.

by instant emotions, recording contexts, and individual psychological states, which could possibly cause big differences in values detected. Even for the same participant, the two pronunciations for the same word can be different. Therefore, F0-normalization can make the data comparable. For each tone, there are more than one set of values from F01 to F010. For each point of pitch value measurement, like F01, the mean pitch value is extracted. A set of mean pitch value from F01 to F010 is generated for each disyllabic word and pitch value for each word is compared by the 10 unit points. The pitch value at a certain time point of a specific tone refers to the mean pitch of all the samples of that specific tone at that certain time point.

Fundamental frequency is the most important factor in determining the pitch value of tone. However, the subjective perception of the pitch is not in direct proportion with F0 value. Shi (2007) states that the psychological unit of pitch is associated with the logarithm of F0, that is to say, by representing F0 in the form of common logarithm, the pitch value of any point of a tone contour can be obtained with the following equation (from Shi, 2007: 42):

$$T = \left[(\log x - \log min) \Big/ (\log max - \log min) \right] * 5$$

'T' refers to the pitch value of a specific point of a contour in the Five-point scale; 'x' refers to the F0 value at any point of a tone; 'max' represents the maximal F0 value of all the extracted F0 values for the speaker and 'min' indicates the minimal F0 value of all the extracted F0 values for the speaker. With this equation, the pitch value for each participant is normalized into a 5-point scale despite of individual differences.

3. Experimental Results

This section is divided into five parts, including the results of the tone sandhi of disyllabic words involving numbers (Section 3.1), adverbs (Section 3.2), prepositions (Section 3.3), neutral tones (Section 3.4) and rhotic ending (Section 3.5). Several examples are given to explain the general pattern of all contours. Tone sandhi does not always apply systematically. Therefore, examples with and without tone sandhi are given to illustrate different variations during tone sandhi realizations.

3.1 Number words

In this sub-section, I illustrate the general results of the tone sandhi system of disyllabic words involving numbers (T1) as the first syllable. The mean pitch values (in Hz) and normalized F0 values (in T-value on a 5-point-scale) of the six participants for tone sandhi

with numbers in disyllabic words are shown in Appendix 1a. The complete pitch contours of number (T1)+X in disyllabic words are shown in Appendix 2a.

The frequency of tone sandhi for each disyllabic word combination with a number as the first syllable is shown in Table 3.1. From Table 3.1 we can see that tone sandhi for *yi1*+X and *san1*+T4 are stable and likely to be fixed while tone sandhi with *qi1*+T4 and *ba1*+T4 are flexible. All the tone sandhi happens on the first syllable, with one exception, *qi1*+T2, where the tone change does not happen on the number *qi1* but the classifier *jie2*. For *qi1*, *ba1* and *san1* with other tones, no tone sandhi applies.

Table 3.1 frequency of tone sandhi for each combination with numbers (for all participants)

combination	*yi1*	*san1*	*qi1*	*ba1*
+T1	100%	0%	0%	0%
+T2	100%	0%	66.67%	0%
+T3	100%	0%	0%	0%
+T4	100%	100%	83.33%	83.33%
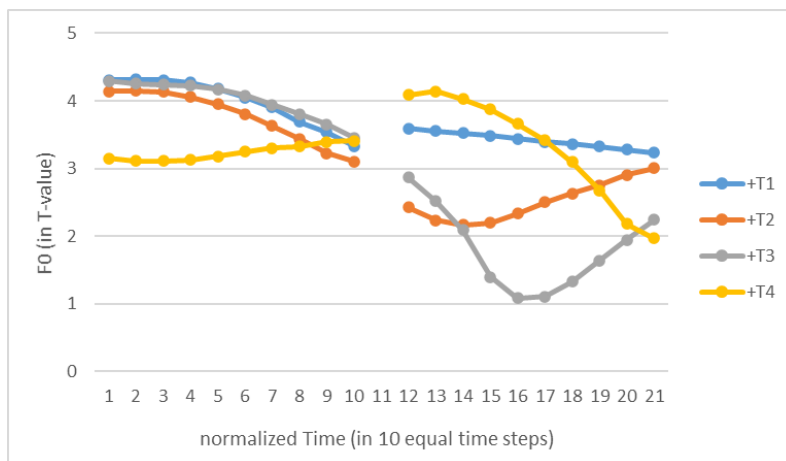
Figure 3.1 F0 contours (in T-value of 5-point scale) of yi1 *'one' + following syllable X*

In Figure 3.1, we can see the F0 contour of *yi1* 'one' + X. For all six speakers, tone sandhi always applies. When the following tones are T1, T2, and T3, *yi1* shows a falling pattern instead of its high-level citation tone. The falling contour is flat and slopes gently down compared to the citation falling tone. When the second syllable is T4, the falling tone, *yi1* shows a slightly-rising contour in the final part of the syllable. The second syllables keep their citation tones for all word combinations in this group.
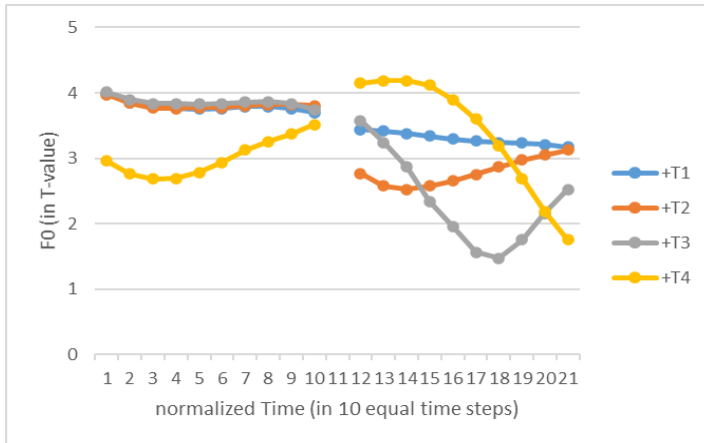
Figure 3.2 F0 contours (in T-value of 5-point scale) of san1 *'three' + following syllable X*

From Figure 3.2 we can see the F0 contour of *san1* 'three' + X. For all six speakers, tone sandhi only applies when *san1* is followed by T4. When the following tones are T1, T2, and T3, tone sandhi does not apply and *san1* keeps its high-level citation tone. The high-level tone contour is not completely flat but goes slightly downwards to the end. However, when the second syllable is the falling tone, *san1* shows a rising contour in the final part of the syllable like *yi1*. The second syllables keep their citation tones. A similar pattern can be discovered in disyllabic words starting with *qi1* 'seven' and *ba1* 'eight', see Appendix 2a.
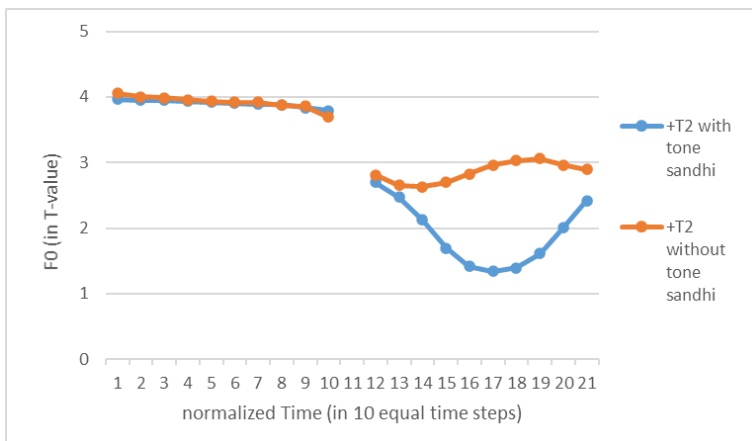
Figure 3.3 F0 contours (in T-value of 5-point scale) of qi1 *'seven' +* jie2 *'block' with and without tone sandhi*

The use of tone sandhi is flexible. For example, for *qi1* 'seven' + *jie2* 'block', as we can see in Figure 3.3, the second syllable can be pronounced with or without tone sandhi. Four out of six speakers apply the tone sandhi and change the tone of the second syllable from T2 to T3 while the first syllable *qi1* keeps its citation tone. The citation tone of the second syllable *jie2* shows a rising contour while the sandhi tone of the second syllable shows a falling-rising contour.
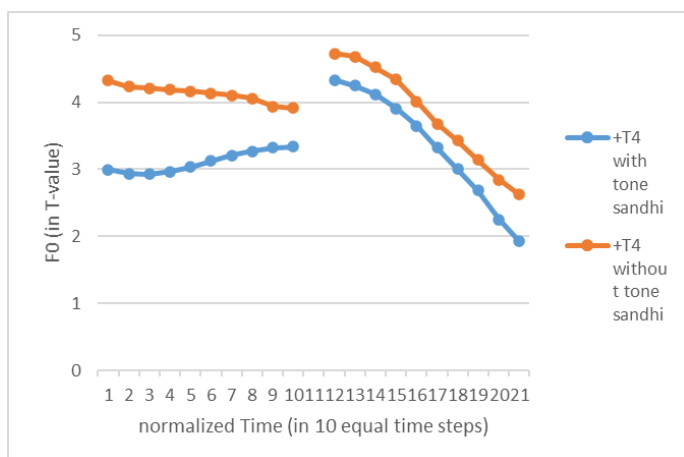
Figure 3.4 F0 contours (in T-value of 5-point scale) of qi1 *'seven' +* ci4 *'times' with and without tone sandhi*

The flexible use of tone sandhi can also happen on the first syllable. For example, for *qi1* 'seven' + *ci4* 'times', as seen in Figure 3.4, the first syllable can be pronounced with or without tone sandhi. Five out of six participants pronounce the word with tone sandhi. The F0 pattern for citation tone of *qi1* is a high-level tone with a downward end, while the F0 pattern with tone sandhi shows an opposite slightly-rising contour. A similar pattern also can be found in the combination of *ba1* 'eight' + *pian4* 'slice', see Appendix 2a.

3.2 Adverbs

The results of tone sandhi of disyllabic words involving different types of adverbs as the first syllable are illustrated in this part. Four adverbs are discussed: two negative adverbs *bie2* 'do not' and *mei2* 'not', a modal adverb *hai2* 'still', and a scope adverb *dou1* 'both/all'[2]. The mean pitch values (in Hz) and normalized F0 values of the six participants for tone sandhi with adverbs in disyllabic words are shown in Appendix 1b. The complete pitch contours of adverbs +X in disyllabic words are shown in Appendix 2b.

The frequency of tone sandhi for each disyllabic word combination with an adverb as the first syllable is shown in Table 3.2. The flexible use of tone sandhi in this word type is common and most word combinations can be pronounced with or without tone sandhi. The tone sandhi for the four adverbs can be divided into 2 groups: *bie2*, *mei2* and *hai2* as one group with T2 as their citation tones; *dou1* as the other group with T1 as its citation tone. From Table 3.2 we can see that for *bie2*, *mei2* and *hai2*, the use of tone sandhi is flexible except when the three adverbs are followed by T4, in which case, tone sandhi does not apply. In terms of *dou1*, tone sandhi applies to all four word combinations. The use of tone sandhi for *dou1* in general is

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[2] The four adverbs discussed have more than one meaning or function. Only the meaning given are considered in this thesis.

more frequent than for the other three adverbs, as in all four combinations, no less than half of the participants chose to apply tone sandhi in disyllabic words starting with *dou1*. All tone sandhi applies on the first syllable.

Table 3.2 frequency of tone sandhi for each combination with adverbs (for all participants)

combination	*bie2*	*mei2*	*hai2*	*dou1*
+T1	66.67%	50%	66.67%	66.67%
+T2	33.33%	33.33%	16.67%	66.67%
+T3	50%	16.67%	66.67%	50%
+T4	0%	0%	0%	83.33%
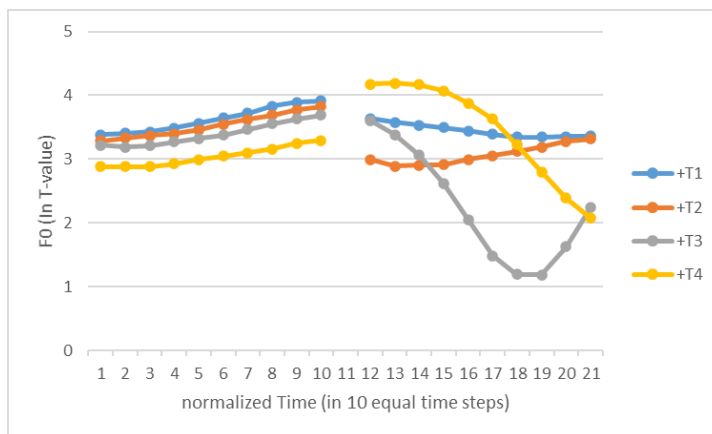
Figure 3.5 F0 contours (in T-value of 5-point scale) of bie2 *'do not' + following syllable X with <u>no</u> tone sandhi*
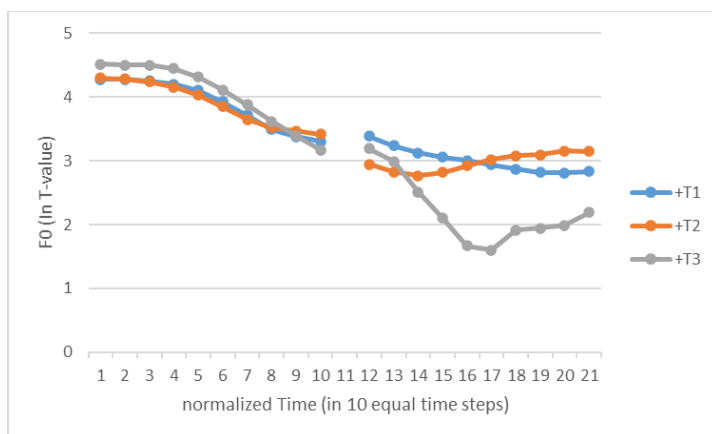
Figure 3.6 F0 contours (in T-value of 5-point scale) of bie2 *'do not' + following syllable X <u>with</u> tone sandhi*

In Figure 3.5, we see *bie2* 'do not' + X F0 contour without tone sandhi. For all four combinations, there are participants choosing to keep the citation tones of the disyllabic words with *bie2* being realized with its citation rising tone. The F0 contour with tone sandhi of *bie2* + X can be seen in Figure 3.6. None of the six participants applies tone sandhi when *bie2* is followed by T4. When the following tones are T1, T2, and T3, some participants change the original rising citation tone of *bie2* to an opposite falling tone. The magnitude of

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the decline of the falling tone contour is not as big as the citation falling tone. The second syllables in all combinations keep their citation tones. A similar pattern and tone sandhi distribution also can be found in disyllabic words starting with *mei2* 'not' and *hai2* 'still', see Appendix 2b.
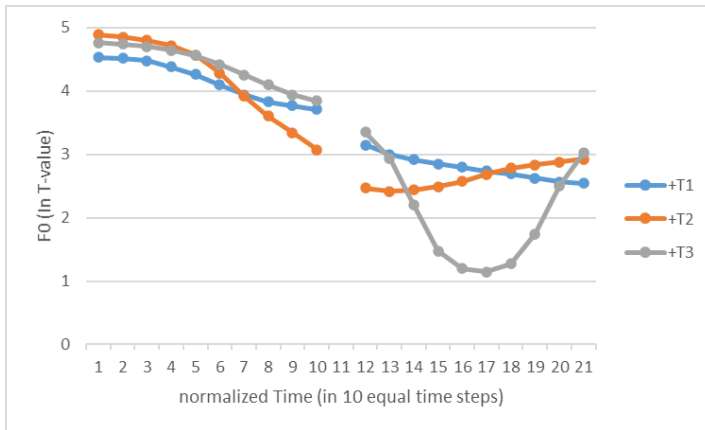
different from yi1 after all?

compare Figure 3.1

Figure 3.7 F0 contours (in T-value of 5-point scale) of hai2 *'still' + following syllable X* <u>with</u> *tone sandhi*

Although a similar F0 pattern is shared by *bie2*, *mei2*, and *hai2* when pronounced with and without tone sandhi, in terms of F0 pattern with tone sandhi, the combination *hai2+X* shows a higher F0 in T-value compared to the other two, as can be seen in Figures 3.6 and 3.7. The F0 in T-value of *hai2+X* with tone sandhi is half a degree unit higher than the F0 values of *bie2* and *mei2*.
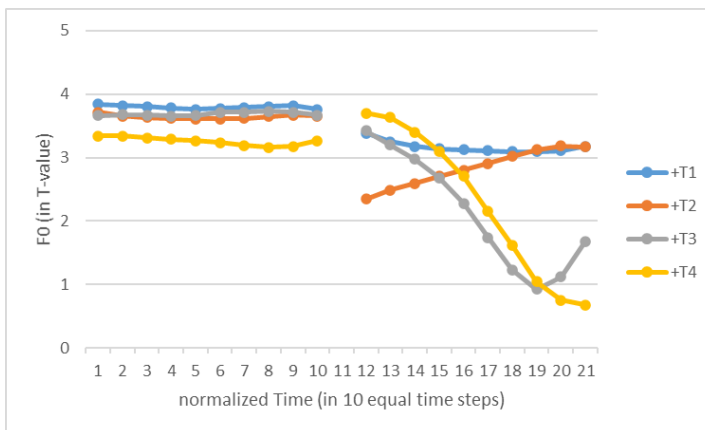
Figure 3.8 F0 contours (in T-value of 5-point scale) of dou1 *'both/all' + following syllable X with* <u>no</u> *tone sandhi*
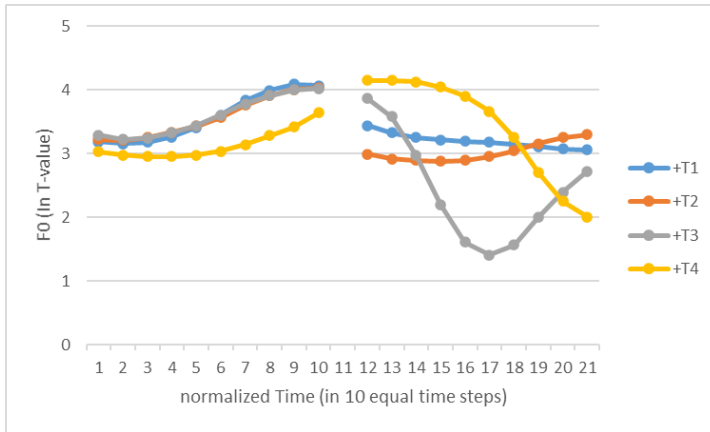
Figure 3.9 F0 contours (in T-value of 5-point scale) of dou1 *'both/all' + following syllable X* <u>*with*</u> *tone sandhi*

The F0 contour of *dou1* 'both/all' + X without tone sandhi can be seen in Figure 3.8. Some participants keep the citation tones of the disyllabic words for all four combinations and *dou1* keeps its high-level citation tone, showing a nearly-flat high-level tone contour. Figure 3.9 indicates the F0 contour of *dou1* + X with tone sandhi. Tone sandhi can apply to all four combinations. The F0 pattern with tone sandhi, as seen in Figure 3.9, shows an obviously rising contour rather than the original high-level tone. When *dou1* is followed by T4, the rising magnitude of *dou1* +T4 combination is not as big as the other three combinations. The second syllables in all combinations keep their citation tones.

3.3 Preposition

The results of tone sandhi of disyllabic words involving the locative preposition *zai4* 'at/in' as the first syllable are illustrated in this part. The mean pitch values (in Hz) and normalized F0 values of the six participants for tone sandhi with *zai4* in disyllabic words are shown in Appendix 1c.

The frequency of tone sandhi for each disyllabic word combination with *zai4* as the first syllable is shown in Table 3.3. As there is no disyllabic word combination starting with *zai4* and followed by T2, there are in total three combinations. The use of tone sandhi is flexible for all word combinations. Tone sandhi applies more frequently when *zai4* is followed by T3 than followed by T1 and T4. All tone sandhi applies on the first syllable.

Table 3.3 frequency of tone sandhi for each combination with locative preposition zai4 *(for all participants)*

combination	*zai4*
+T1	33.33%
+T3	66.67%
+T4	33.33%
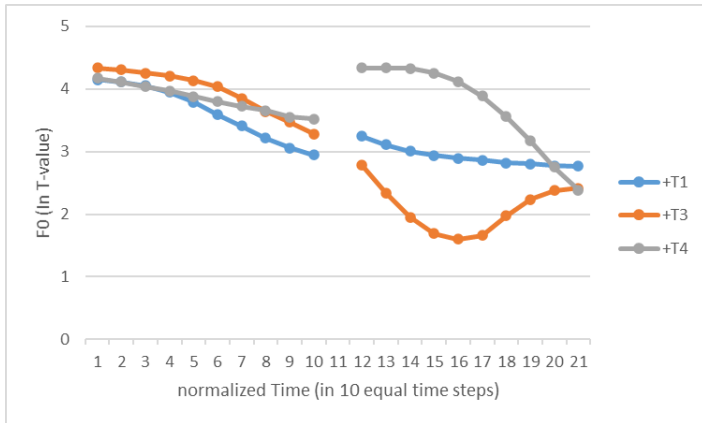
Figure 3.10 F0 contours (in T-value of 5-point scale) of zai4 *'at/in' + following syllable X with <u>no</u> tone sandhi*
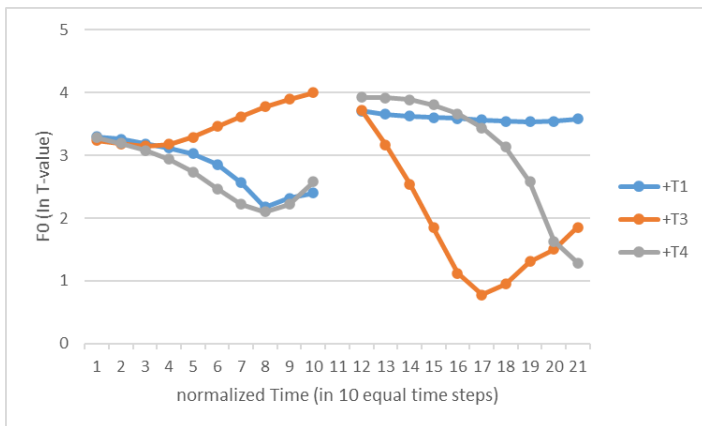
Figure 3.11 F0 contours (in T-value of 5-point scale) of zai4 *'at/in' + following syllable X <u>with</u> tone sandhi*

The F0 contour of *zai4* 'at/in' + X without tone sandhi is shown in Figure 3.10. The citation tones of the disyllabic words are kept and *zai4* shows a slightly-falling tone contour. As can be seen in Figure 3.11, when *zai4* is followed by T1 or T4, the falling citation tone contour of *zai4* changes to falling-rising tone with a short rising at the end of the first syllable; while *zai4* is followed by T3, *zai4* is pronounced as a rising tone. The second syllables in all combinations keep their citation tones.

3.4 Neutral tone as the second syllable

In this part, I illustrate the general results of tone sandhi of disyllabic words with neutral tones. The mean pitch values (in Hz) and normalized F0 values (in T-value on a 5-point-scale) of the six participants for tone sandhi with neutral tone as the second syllable in disyllabic words are shown in Appendix 1d.

The frequency of tone sandhi for each disyllabic word combination involving neutral tone as the second syllable is shown in Table 3.4. The tone in the backets after T0 is the original tone of the syllable when the syllable is not realized as neutral tone. From Table 3.4 we can see

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that, no tone sandhi applies when the first syllable is T2 or the combination is T4+T0(3). Tone sandhi for T1+T0(1), T1+T0(2), and T4+T0(4) are stable as all six speakers applied tone sandhi in these three word combinations. For the other six word combinations, tone sandhi is flexible. All tone sandhi applies on the first syllable. Generally, tone sandhi applies more frequently when the first syllable is T1 and when the original citation tone of the neutral tone is T4.[3]

Table 3.4 frequency of tone sandhi for each combination with neutral tone as finals (for all participants) (the gaps in the words list are marked with '-', indicating that this combination did not occur)

combination	T1	T2	T3	T4
+T0(1)	100%	-	-	-
+T0(2)	100%	0%	50%	16.66%
+T0(3)	33.33%	0%	66.66%	0%
+T0(4)	75%	-	75%	100%
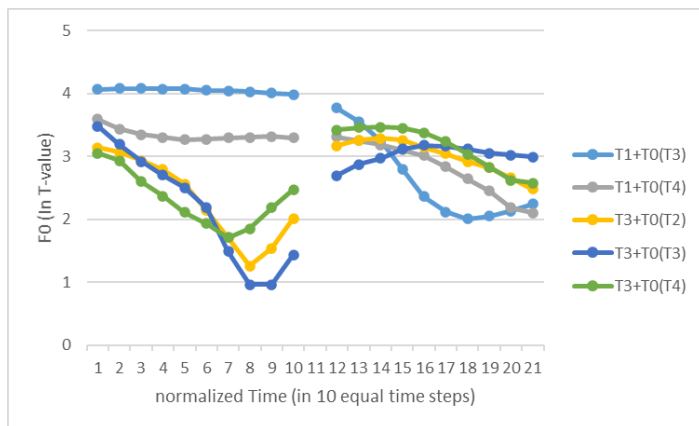
Figure 3.12 F0 contours (in T-value of 5-point scale) of starting syllable T1/T3 + T0 with no tone sandhi
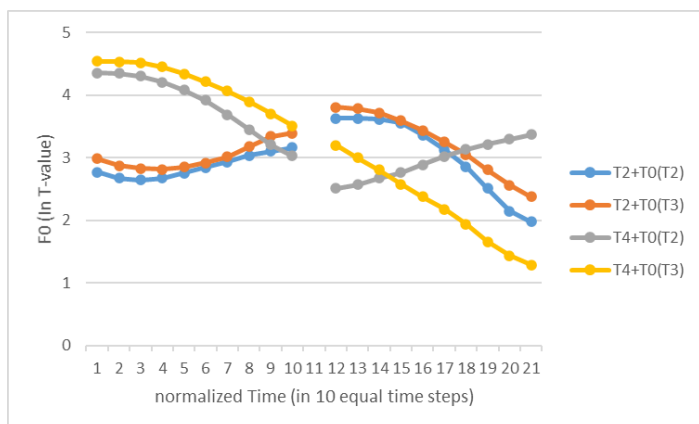
Figure 3.13 F0 contours (in T-value of 5-point scale) of starting syllable T2/T4 + T0 with no tone sandhi

Nine word combinations are pronounced without tone sandhi. Disyllabic words involving neutral tone and starting with T1 and T3 are shown in Figure 3.12 and the others are shown in

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[3] This tendency can be influence by the asymmetric number of words for each word combinations.

Figure 3.13. As can be seen from Figures 3.12 and 3.13 for the X + T0 F0 contour without tone sandhi, the first syllables keep their original citation tones. In word combination T1+T0(3), the second syllable T0(3) keeps its original falling-rising citation tone contour rather than a rising or level tone contour as other neutral tones.
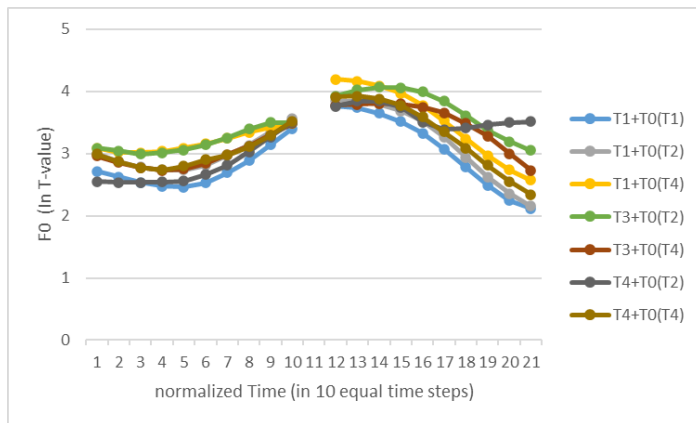
explain why all of this is sandhi, e.g. T3+T0(4)

Figure 3.14 F0 contours (in T-value of 5-point scale) of starting syllable X + T0 _with_ *tone sandhi*
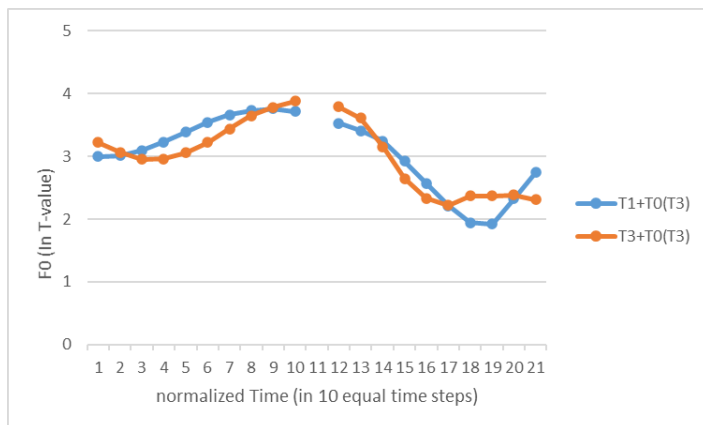
Figure 3.15 F0 contours (in T-value of 5-point scale) of starting syllable X + T0 _with_ tone sandhi

Nine word combinations apply tone sandhi. As the neutral tone can be divided into two different types according to its original citation tone, word combinations with T0(1/2/4) as the second syllable are shown in Figure 3.14 and word combinations with T0(3) as the second syllable are shown in Figure 3.15. From Figures 3.14 and 3.15 we can see that when the following syllable is T0, the first syllable changes to T2. The F0 contour for neutral tone originating from T3 does not show a level-tone or rising tone as expected but showing its original falling-rising tone contour.
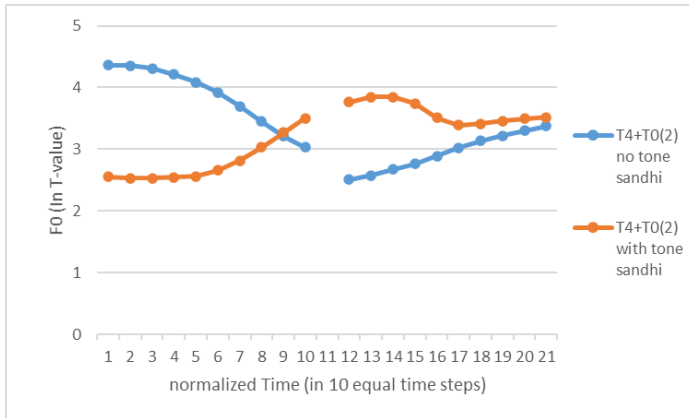
Figure 3.16 F0 contours (in T-value of 5-point scale) T4+T0(2) with and without tone sandhi

The use of neutral tone is mostly flexible, in other words, one can choose whether to apply neutral tone or not in some disyllabic words. For example, in Figure 3.16, when the neutral tone applies, the first syllable changes to T2 and second neutral tone shows a slightly-falling tone contour. However, when the neutral tone does not apply, the first syllable keeps its citation falling contour and the second syllable keeps its citation rising tone rather than showing a falling contour as neutral tone.

3.5 Retroflex final

In this part, I illustrate the general results of the tone sandhi system of disyllabic words involving rhotic ending. The mean pitch values (in Hz) and normalized F0 values (in T-value on a 5-point-scale) of the six participants for tone sandhi with rhotic endings in disyllabic words are shown in Appendix 1e.

The frequency of tone sandhi for each disyllabic word combination involving retroflex finals is shown in Table 3.5. From Table 3.5 we can see that the first syllable can only be T1 or T4. No participants apply tone sandhi to word combination T4+T3r. All six participants apply tone sandhi for T4 +T1r. For the other three word combinations, words can be pronounced with or without tone sandhi and the frequency of applying tone sandhi is generally high with more than half of the participants choosing to apply tone sandhi in each word combination. All the tone sandhi applies on the second syllable, with one exception, T1+T4r (*yi1+hui4r* 'a while'), where the tone change applies on both syllables.

Table 3.5 frequency of tone sandhi for each combination with retroflex finals (for all participants) (the gaps in the words list are marked with '-', indicating that this combination did not occur)

combination	T1	T4
+T1r	-	100%
+T2r	66.67%	-
+T3r	-	0%
+T4r	66.67%	78%
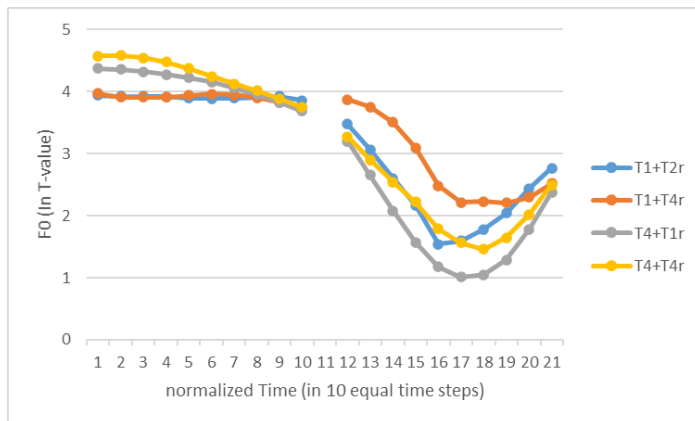
Figure 3.17 F0 contours (in T-value of 5-point scale) of starting syllable T1/T4 + Txr <u>with</u> tone sandhi
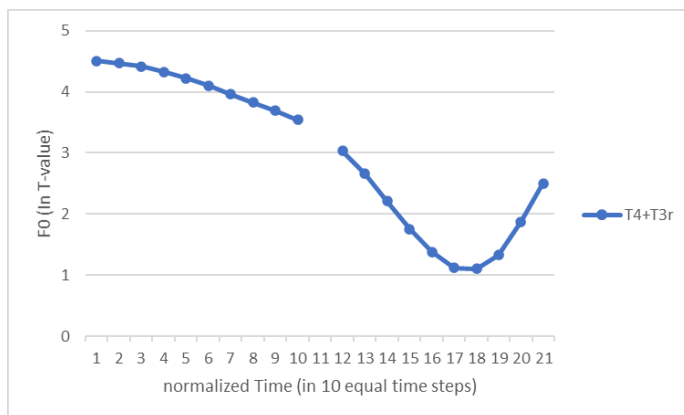
Figure 3.18 F0 contours (in T-value of 5-point scale) of T4 + T3r with <u>no</u> tone sandhi

Four word combinations apply tone sandhi. From Figure 3.17 we can see that the second syllable of T1/T4+Txr shows a falling-rising contour rather than its original citation tone when followed by rhotic ending. The falling magnitude of T4 of the first syllable is not as big as the citation falling tone. We can see from the F0 contour of T4+T3r without tone sandhi in Figure 3.18 that both syllables keep their citation tones with the first syllable showing a falling tone contour and the second syllable showing a falling-rising contour.
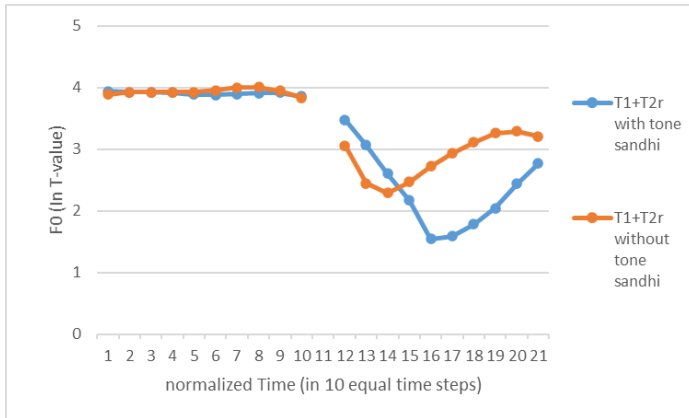
*Figure 3.19 F0 contours (in T-value of 5-point scale) T1+T2r (*gen1+qian*2r 'nearby') with and without tone sandhi*

In the following paragraphs, the F0 pattern of the word combination with and without tone sandhi in contrast pairs are explained. F0 contour of T1+T2r with and without tone sandhi is illustrated in Figure 3.19 and we can see that the second syllable shows a falling-rising contour in both conditions. However, the falling part of *qian2r* without tone sandhi is short and the falling magnitude is smaller than for the pattern with tone sandhi. Therefore, the F0 pattern of *qian2r* without tone sandhi is generally a rising contour while the F0 pattern of *qian2r* with tone sandhi shows a clear falling-rising contour. The first syllable always keeps its high-level citation tone.
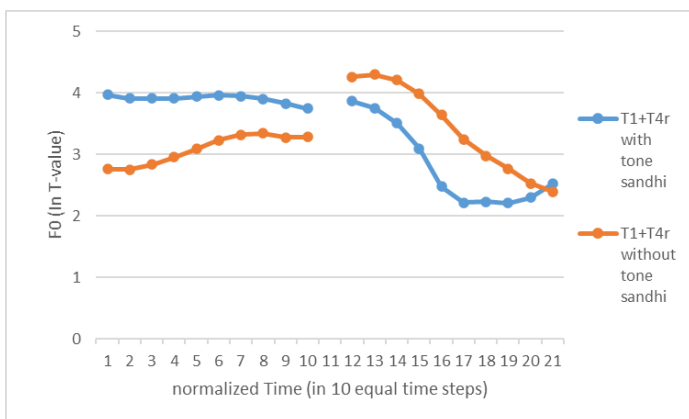
Figure 3.20 F0 contours (in T-value of 5-point scale) T1+T4r with and without tone sandhi

From Figure 3.20 for T1+T4r, we see that if tone sandhi applies to the second syllable, it applies to both syllables. Tone change of the first syllable *yi1* 'one' depends on whether tone sandhi applies to the second syllable *hui4r* 'while'. When tone sandhi does not apply to the second syllable, and it keeps its original falling citation tone, the first syllable *yi1*, which is the same syllable mentioned above in Section 3.1, changes from high-level citation tone to the rising tone. When tone sandhi applies to the second syllable, *hui4r*, and *hui4r* changes to

the falling-rising tone, the first syllable *yi1* changes to a nearly-flat high-level tone with a falling ending.
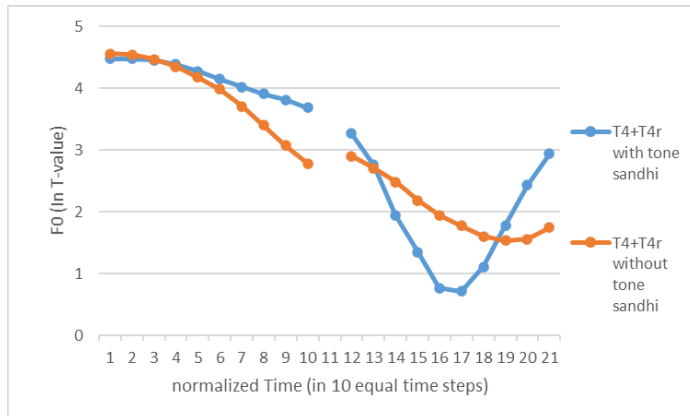
Figure 3.21 F0 contours (in T-value of 5-point scale) T4+T4r with and without tone sandhi

The F0 contour of T4+T4r with and without tone sandhi is shown in Figure 3.21. When tone sandhi does not apply, the F0 pattern of *shi4r* shows a falling tone with a slightly-rising ending; when tone sandhi applies, the F0 pattern of the second syllable shows a clear falling-rising tone contour. The first syllable keeps its falling citation tone in both conditions. A similar pattern can also be found in other words in word combination T4+T4r.

3.6 Summary of the result section

From the results described above, I provide the following summary of irregular tone sandhi in disyllabic words in the Harbin dialect:

(1a) Number words in T1:

       yi1: T1 → T4 / __{T1,T2,T3}

       yi1, san1, qi1, ba1: T1 → T2 / __T4

(1b) Adverbs:

       bie2, mei2, hai2: T2 → T4 / __{T1,T2,T3}

       dou1: T1 → T2 / __{T1,T2,T3,T4}

(1c) Preposition:

       zai4: T4 → T3 / __{T1,T3,T4}

(1d) Neutral tone:

       Tx → T2 / __T0

(1e) Rhotic ending:

$$\text{Txr} \rightarrow \text{T3r} / \{\text{T1},\text{T4}\}\_\_$$

As all the irregular disyllabic tonal sandhi rules above are either applicable to specific words or flexible in use, the rules cannot be generalized to all word combinations.

4. Discussion

This section provides explanations for different types of tone sandhi in the Harbin dialect. Most tone sandhi is consistent with the hypotheses posted in Section 1.3, but the frequency of the tone sandhi among different participants shows that tone sandhi in the Harbin dialect can be rather flexible. The only constant tone sandhi in this thesis is the tone sandhi of *yi1*. Some tone sandhi also shows similar features in tone contour. To be more specific, tone sandhi of some words with neutral tones, numbers, and adverbs shares an identical tone change pattern — from T1 to T2.

In this section, I discuss the tone sandhi pattern of different word types according to the causes. Tone sandhi in the Harbin dialect can be divided into two groups, ancient tone factor and non-ancient tone factor. Tone sandhi caused by ancient tone keeps the ancient tone rather than its citation tone used nowadays. Tone sandhi caused by non-ancient tones is mostly influenced by the word stress change caused by syllable structure. In the following paragraphs, I discuss the tone sandhi processes and causes in the Harbin dialect of the two types separately.

4.1 OCP

In order to better explain the changing processes and causes of tone sandhi in the Harbin dialect, the Obligatory Contour Principle[4] (OCP) needs to be explained. McCarthy (1986) suggests that OCP can act on any autosegmental tier including tonal tier. The OCP indicates that for tone languages, sequences of identical adjacent tones should not occur in succession (Leben, 1973). In addition, in consistency with Myers (1997) and Yip (2002)'s points of view, OCP in this present study is treated as a constraint with universal significance and can be violated. The OCP is violated in the following circumstances in disyllabic words, the tone combination T1.T1, T2.T2, T3.T3, and T4.T4.

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[4] Referred as OCP in the following. The brackets after OCP indicates the identical tones discussed. For example, OCP (HL) refers to fact that the two falling tones cannot be adjacent.

The constraint OCP(HLH), namely *T3.T3, can never be violated in disyllabic words in the Harbin dialect and the combination T3.T3 should always change to T2.T3. The other three OCP constraint cannot be violated only in specific conditions. The constraint OCP(HL) is applied when the tone combination before tone sandhi is not T4.T4. To be more specific, if the citation tone combination of a disyllabic word is two adjacent falling tones, the constraint OCP(HL) does not apply; if the citation tone combination of a disyllabic word is not T4.T4, OCP(HL) plays a role and prevents a non T4.T4 changing to T4.T4. OCP(HH) and OCP(LH) is not the focus of the words analysed in this present study, therefore, the two are not discussed further. The function of OCP as a constraint in phonological analysis is illustrated in Section 5 when applying Optimality Theory.

4.2 Ancient tone factor

The preposition *zai4* is influenced by its ancient tones. Tone sandhi of preposition *zai4* results from the act of keeping the tones of ancient synonyms. The ancient synonyms of locative prepositions *zai4* have the falling-rising citation tone. Within the same word category expressing the same meanings, *zai4* is assimilated by its ancient synonyms and changes its citation falling tone to the falling-rising tone.

However, a point that needs further clarification is when tone sandhi applies with the following syllable being T3. According to OCP(HLH) mentioned in Section 4.1, two falling-rising tones cannot be adjacent. If tone sandhi applies to *zai4* and the following syllable is T3, the output would be two adjacent falling-rising tones. Instead, a second stage of tone sandhi applies, namely, changing the first syllable to T2. Therefore, the complete phonological expression of tone sandhi rules for *zai4* is as follows in (a) (No examples can be found for the combination of *zai4* followed by T2):

(a)   R1: T4 → T3 / __{T1,T3,T4}   **as if zai3**
         R2: T3 → T2 / __T3

The sequence of R1 and R2 is fixed, which means that R2 cannot apply if R1 does not apply.

4.3 Non-ancient tone factor

Tone sandhi of other word types is mainly caused by the word stress change of syllable structure. Tone sandhi in this group applies to the stressed syllable of the disyllabic word to enhance the focused part. I divide the following explanation into two parts in accord with the cause of tone sandhi: word stress and syllable unification. Tone sandhi of number words,

words with neutral tone endings, and adverb-verb disyllabic words is mainly related to word stress while tone sandhi of words with rhotic ending mainly results from syllable unification.

4.3.1 Word stress

Word stress is a common contributing factor of tone sandhi in this study. Three word types that change tones due to word stress are disyllabic words with neutral tones in Section 4.3.1.1, adverbs in Section 4.3.1.2, and numbers in Section 4.3.1.3. The tone sandhi process behind each word type is generally similar but with some minor differences. In this part, I separately explain the reasons and processes of each tone sandhi in detail with examples.

4.3.1.1 T0 ending

The change of word stress exerts an influence on the tone sandhi of words with neutral tone. The words with neutral tone are mostly a coordinate structure, which means that the stress on both syllables should be identical. However, during the formation of disyllabic words, due to the tendency of semantic left-loading, and the prosodic rhythm of 'strong-weak' pattern, the first syllable becomes the head of the expression. At the meantime, the grammaticalization of the second syllable satisfies the expression both semantically and prosodically, resulting in the tone of the second syllable being neutral. After the 'strong-weak' pattern finally formalized in disyllabic words, the tone sandhi of the first syllable benefits the differentiation between neutral tone and non-neutral tone acoustically, which further enhances the comparison between stressed and unstressed syllable.

From the perspective of tone contour, neutral tone in the Harbin dialect has a falling feature in most circumstances. Therefore, if the first syllable changes to half falling-rising, or falling tone, the tone change violates the OCP (HL), as discussed in Section 4.1. In addition, pacing is an important factor that should not be ignored in oral expression. According to Shi and Huang (2007), level tone has the longest duration among the four tone types. In addition, from level tone to rising tone, the final part of the first syllable is enhanced rather than weakened. Tone change from level tone to rising tone can highlight the first syllable and at the same time decrease the total duration of the disyllabic word, which as a result form a more fluent expression. Therefore, the rising tone T2 is the best candidate of tone sandhi of words with neutral tone. Some disyllabic words in this word type like *ge4+ren2* (T4+T0(2)) can be pronounced with its citation tones T4+T2 without neutral tone nor tone sandhi, as can be seen in Figure 3.16 in Section 3.4. Only when the second syllable changes to neutral tone,

it is possible for the first syllable to apply tone sandhi. Therefore, the final phonological expression of tone sandhi rules for words with neutral endings is given in (b):

(b)   R1: Tx → T0 / Tx__ (ordinate structure)

        R2: Tx → T2 / __T0

The sequence of R1 and R2 is fixed, which indicates the necessity of application of R1 in order to apply R2.

4.3.1.2 Adverbs

Similar to words with neutral tone, tone sandhi of adverbs also results from word stress on the first syllable. However, rather than the 'strong-weak' prosodic pattern of disyllabic words, functioning as the natural focus of semantic word structure is the main reason why the first adverb syllable applies tone sandhi. The analogy effect within the same word categories also exerts some influence on tone sandhi of some adverbs.

Tone sandhi of the two negative adverbs mainly results from the stress on the syllable that is in natural focus. The adverbs *bie2* and *mei2* have two functions, one as adverbs, the other as verbs. When the two syllables are used as verbs, the tone sandhi of the adverbs does not apply because in the verb-and-object configuration, the objects are the natural focus and the verbs are not stressed; while in the adverbial-verb configuration, the adverbs are the natural focus and tone sandhi applies. According to Zhou (1972: 87), the falling tone can function as stressing the syllable that bears the focus, which explains the reason why the two negative adverbs change from their citation tones to the falling tone.

Although *hai2* can only act as an adverb, the analogy tone sandhi effect takes effect. This analogy effect states that due to the same function and usage, the tone sandhi pattern of syllables in the same word category tends to be identical. *bie2*, *mei2* and *hai2* are all high-frequency adverbs in use, therefore, the tone sandhi of *bie2* and *mei2* exerts an influence on the use of *hai2*. Under the influence of the negative adverbs, the adverb *hai2* applies tone sandhi and changes to the falling tone in disyllabic word constructions.

Tone sandhi of adverbs *bie2*, *mei2*, and *hai2* does not apply when the second syllable is T4 so that the constraint OCP(HL) is not violated. Therefore, the phonological expression of tone sandhi rule for adverbs *bie2*, *mei2* and *hai2* is as follows:

(c)   T2 → T4 / __¬T4

The adverb *dou1* has a rather different tone sandhi pattern compared to the previous three adverbs but the cause of tone sandhi is quite similar. The adverb *dou1* has two functions, as adverb or as noun. Tone sandhi only applies when it is used as an adverb, as the adverb is the natural focus in the adverbial-verb configuration. As the falling tone can bear the focus of disyllabic words, *dou1* should apply the tone sandhi and change from T1 to T4. However, constrained by OCP(HL), if the second syllable is T4, the first syllable cannot change from ¬T4 to T4. Alternatively, similar to the tone sandhi of words with neutral tones, because the second syllable shows a falling feature, the stressed first syllable changing to the rising tone is the best choice. This tone change from T1 to T2 analogizes to other circumstances when *dou1* is followed by other tones. Therefore, the final phonological expression of tone sandhi rule for *dou1* is written as follows:

(d)   T1 → T2 / __Tx

4.3.1.3 Number words

Tone sandhi of numbers with T1 in disyllabic words is due to the stress adding to numbers. Number disyllabic words are subordinate structures and the number is the natural focus. The tone sandhi can contribute to making the natural focus, numbers, in the disyllabic words more prominent, enhancing the comparison between the stressed syllable and unstressed syllable. Similar to tone sandhi of words with neutral tones and the adverb *dou1*, the rising tone can better enhance the stress on numbers when the second syllable shows a falling feature. The stressed number syllable in number disyllabic words applies tone sandhi when followed by T4, where it changes from high-level citation tone to the rising tone. The phonological expression of tone sandhi rule for number words is as follows:

(e)   T1 → T2 / __T4

One special case is the word combination with *yi1*. All tone sandhi of number *yi1* in the Harbin dialect is constant. The tone sandhi rule for *yi1* is identical to the rule for other numbers with high-level citation tone when followed by T4, as in (e). Tone sandhi also applies when *yi1* is followed by T1, T2, and T3. A possible reason is that the falling tone can promote the stress on the number compared to level tone, like some adverbs explained above in Section 4.3.1.2 (c). Therefore, a supplementary phonological expression of tone sandhi rule for *yi1* is added:

(f)   T1 → T4 / __¬T4

4.3.2 Word unification

Tone sandhi of words with rhotic endings is flexible, resulting from the unification of two final syllables. As mentioned in Section 1.1, rhotic ending appeared as an independent syllable originally, which indicates that words with rhotic ending in the wordlist in this thesis are originally trisyllabic words rather than disyllabic words. However, to decrease the word duration for more fluent speech, the rhotic ending used now is unified with its preceding syllable and appears as one syllable in disyllabic words. As discussed above, the pattern of word stress in disyllabic words is 'strong-weak' so the second syllable is weakened with low pitch value, while the retroflex final bears high pitch value. Therefore, the combination of low pitch value and high pitch value finally formalizes a falling-rising tone.

One condition to realize this tone sandhi is that the first syllable is non-T3. Due to the constraint OCP (HLH), if the first syllable is T3, the tone sandhi is not likely to apply, as the output of tone sandhi would be T3.T3. Therefore, when a disyllabic word ends with rhotic ending and its first syllable is not T3, the second syllable applies tone sandhi and changes the final syllable citation tone to the falling-rising tone. Therefore, the phonological expression of tone sandhi rule for words with rhotic ending is as follows:

(g)   Tx → T3 / ¬T3__-r

Tone sandhi of words with rhotic ending also appears unexpectedly in one number word, *qi1+jie2*. Some participants add rhotic ending to the second syllable so the tone sandhi of rhotic ending applies to this word combination and the second syllable changes to the falling-rising tone. This example shows that the tone sandhi of words with rhotic ending can be generalized probably not only within some dialectal words, but to a larger vocabulary set.

The number syllable *yi1* is involved in one word combination with rhotic ending. In *yi1+hui4r*, the tone sandhi of *yi1* applies according to whether *hui4r* applies tone sandhi. This is an example where both syllables in a disyllabic word apply tone sandhi. The phonological rules of *yi1+hui4r* are as follows in Table 4.1:

Table 4.1 Tone sandhi rules of yi1+hui4r

yi1+hui4r:	Rule set A:	Rule set B:
	R1: T4 → T3 / __-r	R3: T1 → T2 / __T4
	R2: T1 → T4 / __¬T4	
Output:	*yi4+hui3r*	*yi2+hui4r*

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The sequence of R1 and R2 is fixed. The application of R2 relies on whether R1 applies. If R1 applies, then R2 applies. If R3 applies then R1 and R2 cannot apply.

4.4 General summary of irregular disyllabic tonal sandhi in the Harbin dialect

i. The high-level tone tends to change to the rising tone when followed by the falling tone when the high-level tone needs to be stressed. (T1 → T2 / __T4)

ii. The rising tone tends to change to the falling tone when followed by non-falling tone. When the high level tone needs to be stressed. (T2 → T4 / __¬T4)

iii. The rhotic ending tends to combine with its former syllable, forming a falling rising tone.

iv. The tone change from falling tone to falling-rising tone is influenced by ancient tones.

5. Phonological analysis within the framework of OT

In the following paragraphs, I apply Optimality Theory to describe the tone sandhi in the Harbin dialect from a phonological perspective. The tone sandhi process of disyllabic words with numbers, adverbs, and neutral tones are included and explained through different rankings. The preposition *zai4* is not included as the main reason of its tone sandhi is its ancient tones and tone sandhi of words with rhotic ending are not discussed in detail due to the straightforward tone sandhi rule. In aspects of numbers, as words with number *yi1* are special and apply constant tone sandhi, I exclude it from the following OT analysis as well.

Optimality theory is a model of phonology that relates the underlying forms and surface forms formally. Rather than a sequence of explicit processes which describes the change performed on a representation as in classical generative phonology, OT applies an algorithm that selects a surface representation from a wide set of candidates on the basis of a method of determining the best candidate satisfying a ranked set of constraints (Prince & Smolensky, 1993). Optimality theory suggests that phonological constraints are ranked and violable, a surface form is considered to be most harmonic or optimal in the sense that it minimally violates the high ranked constraints with respect to the other potential forms (Ma, 2003). As OT has been proved effective in several dialectal tone sandhi studies in Chinese (Ma, 2003; Shi, 2009; Xu, 2011; Ye, 2013, etc), I apply it to illustrate and explain the tone sandhi process of irregular disyllabic words in the Harbin dialect. In the following paragraph, I introduce several constraints that can be used in this present study.

5.1 Constraints

Both markedness and faithfulness constraints that are applicable in irregular disyllabic tonal sandhi in the Harbin dialect are included. Some constraints are drawn from other dialectal studies in Chinese, and the other constraints are generated on the basis of results of Section 3 and Section 4.

Faithfulness constraints 1&2 are drawn from Xu's study (2011) on the Zhucheng dialect; constraints 3&4 are extracted from Ye's study (2013) on the Harbin dialect; constraints 5-7 are created according to the analysis in discussion section, which is specific to the irregular disyllabic tonal sandhi studies in the Harbin dialect in this present study.

1. RIGHT IDENT   Faithfulness constraint (Xu, 2011: 33)

This constraint enforces the tonal retention on the right syllable of the full disyllabic sequences, namely the right syllable keeps unchanged in disyllabic sequences. Any tonal modification or change on the right edge in disyllabic sequences violates this constraint.

2. IDENT   Faithfulness constraint (Xu, 2011: 33)

This constraint requires that all the tonal features in the input have identical correspondents in the output and all the tonal features in the output have identical correspondents in the input. This is a strict faithfulness constraint and any change is considered as a violation.

3. Tx / Tx __¬HL   Faithfulness constraint (Ye, 2013: 46)

This constraint requires that the first syllable keeps its citation tone when followed by non-falling tone. In other words, in disyllabic words, if the second syllable is non-falling tone, the first syllable keeps unchanged. For example, if the original tone combination is T1+T2, combination T2+T2 is seen as a violation of this constraint.

4. OCP (HL) (*T4.T4)   Markedness constraint (Ye, 2013: 46)

This constraint requires that the two falling tones cannot be adjacent. As mentioned in Section 4.1, if the citation tone combination of a disyllabic word is not two adjacent falling tones, the tone combination of the word cannot change to two adjacent falling tones. For example, if the original tone combination is T2+T4, the output T4+T4 is considered as a violation of this constraint.

5. S=HL (Stress (natural focus) = HL) Markedness constraint

This constraint is specific to the irregular disyllabic tonal sandhi in the Harbin dialect, which requires that the first syllable bearing focus stress applies tone sandhi and changes its citation tone to the falling tone.

6. S=LH (Stress (prosodic stress) = LH) Markedness constraint

This constraint is also specific to irregular disyllabic tonal sandhi in the Harbin dialect, which requires that the first syllable bearing prosodic stress changes its citation tone to the rising tone.

7. Tx → T3 / ¬T3__-r Markedness constraint

This constraint is generalized from the results discussed above in Section 4.3.2 (g), which is specific to disyllabic words with rhotic ending in the Harbin dialect. This is the only constraint that related to the tone change of the second syllable.

5.2 OT evaluation of disyllabic words with numbers, adverbs, and neutral tones

According to the constraints and results analysed above, I come up with the following OT expression for disyllabic words with numbers, adverbs, and neutral endings. One special word combination *qi1+jie2* in number words is discussed separately due to its tone sandhi related to rhotic ending. As all the tone sandhi discussed in the following is flexible and optional, both the one with tone sandhi and the one without tone sandhi are acceptable. The optimal candidates considered below are the ones with tone sandhi, if applicable.

Notation:

1) **Bold**: the candidate in the first line of OT tableau is the original tone combination without tone sandhi.
2) *: violation of a constraint
3) !: the crucial failure of suboptimal candidate or fatal violation of the relevant constraint.
4) ☞: the optimal candidate.
5) A>>B: constraint A dominates constraint B.

From *Tableau* 1, we can see the constraint ranking for tone sandhi in disyllabic words with numbers when followed by the falling tone can correctly show the optimal candidate with tone sandhi. As the tone sandhi in the Harbin dialect is flexible, the candidate without tone

sandhi is the second optimal candidate after the one with tone sandhi. The ranking of the last two constraints determines whether the tone sandhi is applied.

*Tableau 1 OT evaluation of tone sandhi in disyllabic words with numbers (*san1, qi1, ba1+*T4)*

Input: T1+T4	Tx / Tx __¬HL	RIGHT IDENT	S=LH	IDENT
T1+T4			*!	
☞ T2+T4				*
T3+T4			*!	*
T4+T4			*!	*
T2+T1		*!		*
T1+T2		*!	*	*

From *Tableau* 2, it can be seen that the same ranking also works for evaluating the tone combination of disyllabic words with numbers when followed by the non-falling tone.

*Tableau 2 OT evaluation of tone sandhi in disyllabic words with numbers (*san1, qi1, ba1+¬*T4)*

Input: T1+T2	Tx / Tx __¬HL	RIGHT IDENT	S=LH	IDENT
☞ **T1+T2**			*	
T2+T2	*!			*
T3+T2	*!		*	*
T4+T2	*!		*	*
T2+T4	*!	*		*
T1+T4		*!	*	*

From *Tableau* 3, we can see the constraint ranking for tone sandhi in disyllabic words with adverbs when followed by the non-falling tones can correctly show the optimal candidate with tone sandhi. Similar with number words, the candidate without tone sandhi is the second optimal candidate, and the ranking of the last two constraints determines the application of tone sandhi. The same ranking also works when adverbs are followed by the falling tone, as can be seen from *Tableau 4*.

*Tableau 3 OT evaluation of tone sandhi in disyllabic words with adverbs (*bie2, mei2, hai2+¬*T4)*

Input: T2+T1	RIGHT IDENT	OCP(HL)	S=HL	IDENT
T2+T1			*!	
☞ T4+T1				*
T3+T1			*!	*
T1+T1			*!	*
T2+T4	*!		*	*
T4+T2	*!			*

*Tableau 4 OT evaluation of tone sandhi in disyllabic words with adverbs (*bie2, mei2, hai2+*T4)*

Input: T2+T4	RIGHT IDENT	OCP(HL)	S=HL	IDENT
☞**T2+T4**			*	
T4+T4		*!		*
T1+T4			*	*!
T3+T4			*	*!

T2+T1	*!			*	*
T4+T2	*!				*

As shown in *Tableau* 5, *dou1* changes from T1 to T2 when followed by T4. This tone change from T1 to T2 analogizes to other circumstances when *dou1* are followed by other tones. Therefore, the other three circumstances are not considered in OT analysis here.

The tone sandhi of disyllabic words with the four adverbs is also discussed with the application of OT in previous studies. Ye (2013) differentiates the different tone sandhi process between *bie2*, *mei2*, & *hai2* and *dou1* with different rankings of constraint 3 and 4. However, I find it more effective to add one more constraint (S=LH) related to stress. The constraint S=LH does not influence the ranking of all constraints and it successfully illustrates the optimal candidates of disyllabic words with different adverbs.

*Tableau 5 OT evaluation of tone sandhi in disyllabic words with adverbs (*dou1+*T4)*

Input: T1+T4	RIGHT IDENT	OCP(HL)	S=HL	S=LH	IDENT
T1+T4			*	*!	
☞T2+T4			*		*
T4+T4		*!		*	*
T2+T1	*!				*
T1+T2	*!			*	*

From *Tableau* 6, we can see that the constraint ranking for numbers also work for disyllable words with neutral tones. The ranking of the last two constraints determines the use of tone sandhi.

Tableau 6 OT evaluation of tone sandhi in disyllabic words with neutral tones (taking gan1+jing0 *as an example)*

Input: T1+T0	Tx / Tx __¬HL	RIGHT IDENT	S=LH	IDENT
T1+T0			*!	
☞T2+T0				*
T3+T0			*!	*
T4+T0			*!	*
T1+T2		*!		*
T2+T1		*!	*	*

The tone sandhi process of the special case in word combination *qi1+jie2r* with number *qi1* is illustrated in *Tableau* 7. By adding one more high-ranked constraint related to rhotic endings, the tone sandhi process of *qi1+jie2r* can be well-explained with OT. If the rhotic ending is not applied, the deletion of the first constraint exerts no impact on predicting the

optimal candidate as shown in *Tableau* 2. The universality of the rhotic constraint is still questionable and needs further evidence so this constraint is not included in the final ranking.

*Tableau 7 OT evaluation of tone sandhi in disyllabic words with number (*qi1+jie2r*)*

Input: T1+T2	Tx → HLH / ¬HLH__-r	Tx / Tx __¬HL	RIGHT IDENT	S=LH	IDENT
T1+T2r	*!				
☞T1+T3r			*	*	*
T1+T4r	*!		*	*	*
T2+T3r		*!	*	*	*
T2+T2r	*!	*			*

To sum up, OT can give us a unified and reasonable analysis and explanation of some irregular disyllabic tonal sandhi in the Harbin dialect. Six constraints are involved in the tone sandhi of disyllabic words with numbers, adverbs, and neutral tones in the Harbin dialect. The ranking of all these constraints can be described as: Tx / Tx __¬HL >> RIGHT IDENT >> OCP(HL) >> S=HL >> S=LH >> IDENT.

6. Conclusions

In this section, the major findings of the present study and suggestions for future research are given. The objective of this research is to explore and analyse some irregular disyllabic tonal sandhi in the Harbin dialect. Based on phonetic experimental analysis, this paper provides first-hand phonetic evidence including tone sandhi of disyllabic words with numbers, adverbs, neutral tones, preposition, and rhotic ending in the Harbin dialect. The causes of tone sandhi are also discussed and OT is applied to provide a general explanation for the tone sandhi process of some irregular disyllabic tonal sandhi in the Harbin dialect.

Tone sandhi involved in the present study except disyllabic words with number *yi1* is flexible. The application of tone sandhi is unsystematic and mainly due to individual differences. Most tone sandhi applies to the first syllable except the tone sandhi related to rhotic ending.

The experimental results are basically in consistency with hypotheses.

Disyllabic words with number *yi1* apply tone sandhi and change citation tone of the first syllable from T1 to T4 when followed by non-T4. Disyllabic words with numbers with T1 including *yi1* apply tone sandhi when followed by T4 by changing the high-level citation tone of the first syllable to T2.

Tone sandhi of adverbs *bie2*, *mei2* and *hai2* applies when the second syllable is not T4. The rising citation tone of adverbs (T2) changes to T4 when followed by T1, T2, and T3. Tone sandhi of adverb *dou1* applies no matter which tone type is followed and the citation T1 of the first syllable changes to T2, similar to the tone sandhi of numbers.

Preposition *zai4* applies tone sandhi and changes the citation tone from T4 to T3 when followed by T1, T3, and T4. If the following syllable is T3, the preposition *zai4* undergoes a two-step tone sandhi, from T4 to T3 and then from T3 to T2, to avoid the violation of OCP(HLH).

Tone sandhi of words with neutral tones applies when the second syllable is T0. The first syllable changes from its citation tone to T2. The first syllable of majority of words is the high-level tone, which shares similar tone sandhi pattern with disyllabic words of numbers and adverbs *dou1*.

Tone sandhi of disyllabic words with rhotic ending applies the tone change on the second syllable when the first syllable is not T3. The second syllable changes to T3 when followed by rhotic ending.

In aspects of contributing factors of tone sandhi, word stress plays a significant role in tone sandhi of irregular disyllabic tonal sandhi in the Harbin dialect. In some disyllabic words, the first syllable acts as the natural focus being stressed. In order to enhance the difference between the stressed and unstressed syllable, tone sandhi applies to the first stressed syllable, and the main tone change feature is the first syllable changing to the rising tone. Word combinations with numbers as the first syllable and words with neutral tones as the second syllable are involved in this type of tone sandhi.

Also influenced by word stress, the first syllable in adverbial-verb configuration bears not only the natural focus of the disyllabic prosodic word but also the semantic focus of the word phrase, for example, the words with adverbs (T2). The first syllable is stressed by changing its citation tone to the falling tone.

Syllable unification is the cause of tone sandhi related to words with rhotic ending. The original independent syllable rhotic ending combines with its preceding syllable, forming one single syllable. The low pitch preceding syllable and the high pitch rhotic suffix form the falling-rising second syllable when tone sandhi applies.

Apart from word stress and syllable unification, some tone sandhi results from influence of ancient tone. As the ancient synonyms of preposition *zai4* have the falling-rising citation

tone, the preposition *zai4* is influenced by the citation tone of these synonyms and changes to the falling-rising tone when tone sandhi applies.

The phonological analysis with OT not only illustrates the different tone sandhi processes of different word types, but also supports the explanability of Optimality Theory in tone sandhi of the Harbin dialect. Within the OT framework, six constraints in the Harbin dialect can be shown in the following ranking:

Tx / Tx __¬HL >> RIGHT IDENT >> OCP(HL) >> S=HL >> S=LH >> IDENT.

This present study contains several limitations and further research is needed to provide a more complete tone sandhi pattern of the Harbin dialect.
Firstly, the study of tone sandhi in the Harbin dialect is still in the preliminary stage. This study includes only five types of irregular disyllabic tonal sandhi in the Harbin dialect. Future research can focus on the other irregular or regular disyllabic or trisyllabic tonal sandhi. Moreover, the experiments in this study are conducted by recording participants reading a wordlist. Although the contexts of each word are given in the wordlist, it is still difficult for participants to pronounce the word with tone sandhi by reading the written forms. Future research can look into conducting the phonetic experiment with the use of dialect in sentences or in natural conversation.

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8. Appendices

Appendix 1: F0 values (in Hz and in T-value) of each participant for tone sandhi with numbers in disyllabic words

1a: Number words

Table 8.1 mean F0 values (in Hz) of participant 1 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	317	318	312	297.5	281.5	258.5	243.5	225	212	192.5	218	216	213	209.5	207.5	204.5	201.5	199	198	200.5
yi1 +T2	i1	yi1 'one'	tiao2	100%	278.5	279	270	253.5	232	208	185.5	162.5	132.5	123.5	141.5	135	132	135.5	143.5	150	157.5	160	163	163.5
yi1 +T3	i1	yi1 'one'	ben3	100%	277.5	280	276.5	268	257	244.5	230.5	215	203	192	154.5	147.5	135.5	117	102.5	98.5	110.5	137	165	179
yi1 +T4	i1	yi1 'one'	jian4	100%	174.5	172	171	171	172	175	181.5	191	202	204.5	264.5	282	282	273	257	238.5	215	185.5	152.5	124.5
san1 +T1	an1	san1 'three'	zhi1	0%	262	254	247	246	246.5	247.5	247	247	245	243.5	207	206.5	200	197	195	194	192	191.5	192.5	189
san1 +T2	an2	san1 'three'	tou2	0%	244.5	232.5	227	230.5	230.5	232	231	230	228.5	226.5	145.5	141.5	144.5	153.5	161.5	168.5	173.5	179	182.5	180
san1 +T3	an3	san1 'three'	duo3	0%	238.5	228	229	231	230	231	231	227.5	229	223.5	193.5	174	162	150	132.5	116.5	120	147.5	176.5	192.5
san1 +T4	an1	san1 'three'	bian4	100%	154.5	143.5	136	131.5	136	145	166.5	176	190	197	261	265	263.5	255	236.5	215	187	164.5	135	104.5
qi1 +T1	i1	qi1 'seven'	zhang1	0%	267.5	269.5	264.5	257.5	254.5	251.5	248.5	247	244.5	237.5	195.5	185	178.5	175	173	171	170	171	173.5	172.5
qi1 +T2	i1	qi1 'seven'	jie2	100%	249.5	252	253	252	250.5	250.5	249.5	247.5	238.5	235.5	183	180.5	170.5	153.5	136	120.5	105	99	104	131.5
qi1 +T3	i1	qi1 'seven'	chi3	0%	273	274	271	268.5	268	266	264	262.5	260.5	252	190	178.5	167	147	121.5	102	91.5	90	127	182
qi1 +T4	i1	qi1 'seven'	ci4	100%	170	166.5	165	166.5	169.5	178.5	189	200	206	203.5	300.5	292	273	249.5	228.5	206	181	160	126.5	102.5
ba1 +T1	a1	ba1 'eight'	jin1	0%	215.5	216.5	213	209	204.5	201	200	198.5	199	199	179.5	177	167.5	165	163	161	159.5	159	160	
ba1 +T2	a1	ba1 'eight'	ping2	0%	231.5	229	230	229.5	226	224	223	222.5	224	224.5	158	155.5	156.5	159.5	163	166.5	172	177	185	187.5
ba1 +T3	a1	ba1 'eight'	mu3	0%	237	241.5	241	237.5	234.5	232.5	232	231.5	232.5	230.5	230.5	207	193	170	150	131	115.5	94	80.5	111
ba1 +T4	a1	ba1 'eight'	pian4	100%	148.5	148	142.5	136.5	133.5	131.5	134	144	162	179	279	278.5	264	246.5	228.5	210.5	191	160	133.5	112

Table 8.2 mean F0 values (in Hz) of participant 2 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	196.5	193	190.5	189	187.5	185	182	177	169	160	164.5	158	153	149	144	139	136	132	128.5	123.5
yi1 +T2	i1	yi1 'one'	tiao2	100%	176	175.5	169	163.5	158.5	152	144	139	131.5	139	99	94.5	94	97	105	116.5	124	131.5	139	143
yi1 +T3	i1	yi1 'one'	ben3	100%	211	206	202.5	199	193.5	187	178.5	169	160.5	149.5	129.5	124.5	116	103	90	87	92	100.5	108	116
yi1 +T4	i1	yi1 'one'	jian4	100%	144	145	145.5	145	145	147	147.5	149	151	153.5	192	192.5	185	175.5	163.5	153	140	126	115.5	113
san1 +T1	an1	san1 'three'	zhi1	0%	176.5	169.5	165.5	162	160	159.5	162	162	161	154.5	143.5	143.5	143	141.5	139	136	133	130	125.5	121.5
san1 +T2	an2	san1 'three'	tou2	0%	169.5	161.5	156	153	153	151.5	153.5	153	154	154	110.5	102	101.5	106	112	117	121	126.5	132	136.5
san1 +T3	an3	san1 'three'	duo3	0%	169	162	155	154.5	154	153	156	159	157.5	152	158	144.5	132	119	105	90	82.5	84.5	99.5	121
san1 +T4	an1	san1 'three'	bian4	100%	121	116.5	120.5	121.5	127.5	133	138.5	143	146.5	152.5	179	178.5	177.5	174.5	163.5	149.5	135	116	103.5	94
qi1 +T1	i1	qi1 'seven'	zhang1	0%	162.5	162	162	161	159	158	155.5	154	153.5	153	146	142.5	140.5	137.5	136	134	133	131.5	132	132.5
qi1 +T2	i1	qi1 'seven'	jie2	100%	164.5	161.5	160	159	157	154.5	152.5	154	155	154.5	141.5	133.5	122.5	114	111.5	116	125	139.5	158.5	161.5
qi1 +T3	i1	qi1 'seven'	chi3	0%	177.5	171.5	169.5	168	166	164.5	163	161	159	158.5	138	129	115	100.5	89	81.5	79	86	110.5	126
qi1 +T4	i1	qi1 'seven'	ci4	100%	139	135.5	135	137	140.5	144.5	147	149.5	150.5	150.5	195.5	192	183	171.5	159.5	145	132.5	118	103.5	97
ba1 +T1	a1	ba1 'eight'	jin1	0%	164	161.5	158	156	154	151	148.5	148.5	149.5	143	134.5	135	132	129.5	129	128.5	127	129	126.5	128
ba1 +T2	a1	ba1 'eight'	ping2	0%	156	156	151.5	150.5	150.5	147	144	143	144.5	143	97.5	98.5	103	109	113	116.5	122	126.5	133	138
ba1 +T3	a1	ba1 'eight'	mu3	0%	162.5	162	160.5	159	158	154.5	151.5	150	150.5	148	147.5	144	137	129.5	112.5	80	83	103	124.5	138
ba1 +T4	a1	ba1 'eight'	pian4	100%	108.5	109	111	111.5	110	105.5	104	105	108.5	116	201	204.5	201.5	191.5	176.5	156.5	133	113	99	87.5

Table 8.3 mean F0 values (in Hz) of participant 3 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	285.5	287	287.5	285	276	260.5	247	222	221.5	228	208.5	201.5	201	201.5	199	197	194	187.5	181	172.5
yi1 +T2	i1	yi1 'one'	tiao2	100%	280.5	280	280.5	276	266.5	252	231.5	214	207.5	210.5	177.5	166.5	166.5	168	172	178	180.5	178.5	171.5	162.5
yi1 +T3	i1	yi1 'one'	ben3	100%	277	271	270	265.5	257.5	240	223	215.5	207	193.5	186	167.5	142	90	100.5	127	150	150.5	142	136.5
yi1 +T4	i1	yi1 'one'	jian4	100%	188	193.5	197	198.5	202	210	212	210.5	214.5	216.5	300	300.5	279.5	271	255.5	241	223.5	199	153	133
san1 +T1	an1	san1 'three'	zhi1	0%	256	239.5	233.5	233	232	231.5	232	228.5	223.5	228	212	209.5	207	202.5	199	195	193.5	191.5	185	178.5
san1 +T2	an2	san1 'three'	tou2	0%	262	246	233.5	233.5	236.5	237	241	242	242	235.5	190	179.5	168.5	166	168.5	175.5	183.5	190.5	192	178.5
san1 +T3	an3	san1 'three'	duo3	0%	273	259	248.5	249.5	251	250.5	254	252.5	243.5	229	223.5	201	172.5	110.5	112	110.5	114	123	132.5	138.5
san1 +T4	an1	san1 'three'	bian4	100%	209	187.5	175.5	174.5	175	185.5	195.5	205.5	212.5	213.5	294.5	296.5	306	306.5	287	257	218	182.5	148.5	122.5
qi1 +T1	i1	qi1 'seven'	zhang1	0%	251	241	235	232.5	233.5	234.5	229.5	228	226.5	219.5	228	219	210.5	206.5	204	200	198.5	198.5	199	186
qi1 +T2	i1	qi1 'seven'	jie2	0%	267.5	260.5	258.5	254	250.5	250.5	252	250.5	248.5	233	179.5	170	166.5	168.5	174	182	184.5	185.5	172	164
qi1 +T3	i1	qi1 'seven'	chi3	0%	274.5	265.5	261	257	255.5	257	262	268	271	259	182.5	169	132.5	101.5	92.5	123	140	160.5	156.5	159
qi1 +T4	i1	qi1 'seven'	ci4	100%	270.5	263	261	259	257	255	252.5	248.5	239	237.5	308.5	304	289	272	245	220	203	185	168	156.5
ba1 +T1	a1	ba1 'eight'	jin1	0%	221	214	211.5	209	209	210.5	209.5	208.5	208.5	209	210	208	203	201	198.5	196.5	194	190	184	173
ba1 +T2	a1	ba1 'eight'	ping2	0%	241	231	222.5	222	221.5	221.5	222.5	221.5	221.5	221.5	178.5	173	167	169.5	172	174	172.5	169	164.5	158
ba1 +T3	a1	ba1 'eight'	mu3	0%	255.5	245.5	236	238	239.5	240.5	241	239.5	239	236.5	218	201.5	176.5	131.5	91	91.5	108.5	131	142	137
ba1 +T4	a1	ba1 'eight'	pian4	0%	243.5	232	225	225.5	225	224.5	224	226	224.5	224.5	294.5	283.5	264	250.5	242	233.5	225	210.5	173	164.5

Table 8.4 mean F0 values (in Hz) of participant 4 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	258	266.5	271.5	269.5	259.5	246.5	225.5	196.5	180	145	228	228.5	224.5	224.5	223.5	222.5	223	220.5	215	213
yi1 +T2	i1	yi1 'one'	tiao2	100%	255	265.5	275.5	280	279.5	275	270	265.5	253	233.5	169.5	156.5	155.5	159	166	174.5	181	190.5	204	220.5
yi1 +T3	i1	yi1 'one'	ben3	100%	271.5	263.5	267	272.5	275	275	265	251	229.5	217.5	180	169	151	112.5	100.5	107	116.5	124.5	134.5	155.5
yi1 +T4	i1	yi1 'one'	jian4	100%	206	185	182	184.5	191.5	198	203	200.5	208.5	206.5	267	271.5	269.5	249.5	226.5	201	174	150	132.5	136
san1 +T1	an1	san1 'three'	zhi1	0%	250	243	236	237	237.5	240.5	243.5	244	242.5	236	220	222	223	222	220.5	220.5	220.5	221	219	216.5
san1 +T2	an2	san1 'three'	tou2	0%	266.5	256.5	251.5	251	251	255	259	259.5	257	255.5	171.5	158	161	165.5	171.5	179	187	193	202.5	222
san1 +T3	an3	san1 'three'	duo3	0%	263	257	253.5	252	249.5	254	254.5	253	249.5	241.5	225	201.5	179.5	165	147.5	137.5	143.5	160	180.5	188
san1 +T4	an1	san1 'three'	bian4	100%	185.5	172	168	172.5	186	198	211.5	220.5	221	227	272	281	282	271.5	247.5	218.5	190	168.5	149.5	131.5
qi1 +T1	i1	qi1 'seven'	zhang1	0%	251.5	249.5	248.5	247.5	248	248	248	243	241.5	232	227.5	216.5	211.5	211	211	211.5	211	211	212.5	216.5
qi1 +T2	i1	qi1 'seven'	jie2	0%	270	268.5	268	268	267	265	262.5	257	256	245	179.5	170.5	171.5	177.5	186.5	195.5	201	204	206.5	207.5
qi1 +T3	i1	qi1 'seven'	chi3	0%																				
qi1 +T4	i1	qi1 'seven'	ci4	100%	197	191.5	192.5	197	204	211.5	216	215.5	214.5	217	310.5	299	285.5	259	226.5	192.5	167.5	154.5	147	138.5
ba1 +T1	a1	ba1 'eight'	jin1	0%	243	236.5	234	232	232.5	234.5	231.5	232	234.5	234	225.5	229.5	228.5	228.5	226.5	225.5	222	222	222.5	
ba1 +T2	a1	ba1 'eight'	ping2	0%	252.5	243	239.5	239.5	242	246	245	243	243.5	243	186.5	175.5	175	175.5	181.5	191	201.5	208	210	212
ba1 +T3	a1	ba1 'eight'	mu3	0%	252	243.5	239.5	237.5	237	237.5	240	242.5	241.5	242.5	236	223.5	205.5	186	160.5	129.5	107.5	89.5	85	94
ba1 +T4	a1	ba1 'eight'	pian4	100%	168.5	170	169	170.5	176	184.5	197	203	201	211	287.5	289.5	280	265	246	221.5	196	174	159.5	159

Table 8.5 mean F0 values (in Hz) of participant 5 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	258.5	261	266.5	268.5	268	264	258.5	254.5	244	236.5	228.5	226.5	223	219.5	219	218	216	216.5	217	216
yi1 +T2	i1	yi1 'one'	tiao2	100%	261	260	257	252	248.5	242	232.5	224	208.5	202	193	179.5	167	163.5	168	175.5	184	188.5	193.5	200
yi1 +T3	i1	yi1 'one'	ben3	100%	259	263	263.5	269	268.5	265	259	253	242	218	184	164	148.5	126	100.5	82	77	81	89	101
yi1 +T4	i1	yi1 'one'	jian4	100%	188	191	192	193.5	196	200	202	201	197	193.5	260.5	265	251	238	223.5	204.5	183.5	159.5	141	130.5
san1 +T1	an1	san1 'three'	zhi1	0%	241	234.5	235	235.5	234.5	235	238.5	239.5	237.5	234.5	222	217.5	217	216.5	213.5	211.5	211.5	215.5	219	218.5
san1 +T2	an2	san1 'three'	tou2	0%	240	235	232	233.5	235.5	235.5	239.5	243.5	246	247	186.5	182.5	172.5	171.5	170.5	174	180.5	189	194.5	204
san1 +T3	an3	san1 'three'	duo3	0%	245	239	235.5	236.5	237	238.5	241	242.5	241.5	239	224	212	198.5	183	169	133	108	112.5	127	137
san1 +T4	an1	san1 'three'	bian4	100%	187	178.5	175	176.5	180.5	189.5	198.5	203	206	224	250.5	252	251	245	229.5	212	189	160.5	143	126
qi1 +T1	i1	qi1 'seven'	zhang1	0%	250	246	245.5	245	244.5	244.5	245	245	243.5	242.5	221	212.5	208.5	209.5	210.5	210.5	210.5	211	212	215
qi1 +T2	i1	qi1 'seven'	jie2	100%	236	236.5	236.5	236	236	235.5	235.5	235.5	233.5	226.5	125	120.5	110	99	92	87.5	88.5	94.5	103	115
qi1 +T3	i1	qi1 'seven'	chi3	0%	262	264	263	261.5	261	260.5	260	259.5	257.5	260.5	212.5	200.5	183	160.5	134.5	108	102.5	123.5	189.5	211
qi1 +T4	i1	qi1 'seven'	ci4	100%	184.5	186	189.5	192	194	196	202.5	206.5	207.5	200	265.5	260	253.5	239	219.5	197.5	178.5	158	128	109
ba1 +T1	a1	ba1 'eight'	jin1	0%	226.5	228	227.5	226	224.5	223.5	224.5	227.5	229.5	226.5	219.5	221	221	220.5	219	220	219	218.5	218	219.5
ba1 +T2	a1	ba1 'eight'	ping2	0%	220.5	223.5	224	223.5	223	223	223	224	227.5	226	179	175	173	173	177	182	189.5	195	200.5	199.5
ba1 +T3	a1	ba1 'eight'	mu3	0%	222	227	224	222	220	218	219	221	222	221	222	222	217	212	206	190	173	90	80	107
ba1 +T4	a1	ba1 'eight'	pian4	100%	156.5	156.5	158.5	161	163.5	166	169	175	183	186	242	242.5	243	238.5	225.5	209.5	192	164	138	130.5

Table 8.6 mean F0 values (in Hz) of participant 6 for tone sandhi with numbers in disyllabic words

combination	TBU	1st syllable	2nd syllable	frequency of tone sandhi (X out of six)	syllable 1										syllable 2									
					F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	i1	yi1 'one'	dui1	100%	258.5	255	252	248	240.5	233	223.5	215	206.5	201.5	207	212	217	216.5	212	209.5	210.5	214	217	218.5
yi1 +T2	i2	yi1 'one'	tiao2	100%	248	245.5	241	235	229.5	221.5	214	206	200	195.5	125.5	119.5	117.5	116.5	118	121	123.5	132.5	151.5	164.5
yi1 +T3	i3	yi1 'one'	ben3	100%	255.5	251.5	250.5	249.5	248	245.5	242	239	236.5	234.5	172	133.5	105.5	93	86.5	88.5	94.5	109	131.5	152
yi1 +T4	i4	yi1 'one'	jian4	100%	194	191.5	192	193	196	199.5	201.5	202.5	207.5	211	197.5	197	192.5	186.5	178.5	169	157.5	139.5	123	122
san1 +T1	an1	san1 'three'	zhi1	0%	233.5	224.5	221	220	218.5	219	221	222	222	225	203	198.5	194.5	191	188.5	188.5	188.5	189.5	193.5	198.5
san1 +T2	an2	san1 'three'	tou2	0%	238.5	234.5	233	233	233	231.5	232	233.5	234.5	234	183	172	170	167	166	165.5	168	169	169.5	176
san1 +T3	an3	san1 'three'	duo3	0%	250	244.5	243.5	243.5	243	241.5	240.5	241	242.5	240	225	194.5	162.5	136	107	95.5	99	108	117.5	141
san1 +T4	an1	san1 'three'	bian4	100%	187.5	181	177.5	177	175.5	177.5	182	190	200	214	245.5	247	245.5	240	230.5	218	198	167.5	139.5	135
qi1 +T1	i1	qi1 'seven'	zhang1	0%	239.5	233	230	227.5	226	225	224	222	220.5	220	215.5	205	200	198	196.5	196.5	196	196.5	198	204
qi1 +T2	i1	qi1 'seven'	jie2	100%	247.5	246	246	245.5	245.5	246	246	243	239	237	159.5	138	117	94	83	84.5	91	101.5	122	141.5
qi1 +T3	i1	qi1 'seven'	chi3	0%	254.5	250	247.5	246	246	246.5	247	246	243.5	243	90	80	77	78.5	80.5	85.5	95.5	117.5	130.5	149
qi1 +T4	i1	qi1 'seven'	ci4	100%	177	172.5	170	170.5	172.5	174	175.5	177	185.5	193.5	246.5	241	236	232	226.5	220	211.5	202	194	188.5
ba1 +T1	a1	ba1 'eight'	jin1	0%	223	222	220.5	219.5	219	219.5	221.5	222	221.5	220.5	197.5	193	191.5	189.5	188.5	189.5	188	189.5	191	195.5
ba1 +T2	a1	ba1 'eight'	ping2	0%	240	238	238	238	239.5	241	242	243	243.5	241.5	183	174	166.5	163.5	163.5	163.5	164.5	164.5	166	
ba1 +T3	a1	ba1 'eight'	mu3	0%	239.5	239	239.5	239	239	239.5	242	245	244.5	241.5	234.5	172.5	163	149.5	135	78.5	79	96	132	145
ba1 +T4	a1	ba1 'eight'	pian4	100%	167.5	165	164	164	166	166.5	167.5	171.5	180	185.5	251.5	242.5	233.5	222	208	181.5	164.5	157	157	157.5

Table 8.7 mean F0 values (in T-value, 5-scale measurement) of all participant for tone sandhi with numbers in disyllabic words

	participants	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
yi1 +T1	1037	4.660591	4.669587	4.615182	4.47926	4.321367	4.077917	3.907179	3.681495	3.511513	3.235922	3.591225	3.564901	3.524954	3.477632	3.450234	3.408639	3.366429	3.330771	3.316382	3.352219
	1043	4.139475	4.069366	4.018506	3.987669	3.956586	3.904224	3.840447	3.731779	3.551358	3.337881	3.44608	3.288812	3.16337	3.060028	2.926878	2.789023	2.703908	2.587454	2.482625	2.327807
	26	4.486685	4.502904	4.508292	4.481259	4.381939	4.203041	4.03833	3.708035	3.701056	3.790579	3.513846	3.408145	3.400455	3.408145	3.369502	3.338237	3.290739	3.185256	3.07605	2.927171
	29	3.680506	3.779172	3.835751	3.813246	3.698152	3.541713	3.270681	2.851669	2.584557	1.926551	3.304242	3.310909	3.257153	3.257153	3.243564	3.229915	3.236747	3.20243	3.125543	3.097096
	30	4.05019	4.080357	4.145719	4.169153	4.163311	4.116178	4.05019	4.001311	3.869255	3.771402	3.663545	3.63593	3.587179	3.537596	3.530448	3.516104	3.487216	3.494463	3.501693	3.487216
	332	4.840483	4.790523	4.747152	4.688513	4.575971	4.459863	4.307306	4.165208	4.017377	3.927548	4.02624	4.113711	4.199142	4.190688	4.113711	4.070236	4.087688	4.148122	4.199142	4.224388
yi1 +T1	Average	4.309655	4.315318	4.311767	4.26985	4.182887	4.050489	3.902356	3.689916	3.539211	3.331647	3.590863	3.553745	3.522042	3.48854	3.439056	3.392026	3.362121	3.324749	3.283573	3.235983
yi1 +T2	1037	4.290765	4.295888	4.022035	4.02213	3.768999	3.457108	3.130126	2.752036	2.169107	1.9682	2.356805	2.222494	2.158308	2.233053	2.396892	2.523421	2.662774	2.707754	2.760811	2.769559
	1043	3.709678	3.69858	3.65387	3.551358	3.422294	3.301137	3.13779	2.926878	2.80303	2.631533	1.465231	1.28376	1.263066	1.385618	1.694763	2.100189	2.343568	2.57265	2.789023	2.899694
	26	4.431997	4.426475	4.431997	4.381939	4.273523	4.10036	3.837733	3.594436	3.498965	3.543395	3.015612	2.817594	2.817594	2.845354	2.918186	3.024318	3.067488	3.033001	2.909175	2.742326
	29	3.644905	3.767729	3.880269	3.929586	3.924146	3.87474	3.818888	3.767729	3.620937	3.376797	2.401757	2.158865	2.139353	2.207105	2.338246	2.490248	2.601569	2.757278	2.965685	3.20243
	30	4.080357	4.068325	4.03195	3.97037	3.926533	3.843458	3.717937	3.601203	3.376452	3.277184	3.134331	2.907047	2.680809	2.614422	2.699521	2.836412	2.984654	3.060386	3.14244	3.245997
	332	4.688513	4.651382	4.583582	4.491186	4.404394	4.274364	4.148122	4.008491	3.900164	3.816763	2.192305	2.012767	1.950912	1.919588	1.966474	2.058483	2.133431	2.391222	2.882321	3.184029
yi1 +T2	Average	4.141036	4.151396	4.130651	4.057762	3.953315	3.808528	3.631766	3.441796	3.228109	3.102312	2.427674	2.233755	2.16834	2.200857	2.33568	2.505512	2.632247	2.753715	2.908243	3.007339
yi1 +T3	1037	4.280491	4.306107	4.270179	4.180999	4.061295	3.918884	3.750472	3.551647	3.387612	3.228493	2.607846	2.475417	2.233053	1.813775	1.435871	1.32218	1.650522	2.264498	2.795642	3.028249
	1043	4.417203	4.323651	4.256804	4.188791	4.079459	3.946169	3.764699	3.551358	3.350052	3.073097	2.512865	2.359266	2.08341	1.619743	1.093434	0.961187	1.179172	1.523893	1.804655	2.08341
	26	4.393133	4.325352	4.313909	4.261887	4.167188	3.949344	3.721946	3.616056	3.491497	3.282751	3.160394	2.836128	2.324932	0.913454	1.255007	1.979381	2.494576	2.504876	2.324932	2.202663
	29	3.835751	3.744713	3.784878	3.846942	3.87474	3.87474	3.761991	3.569728	3.324201	3.160733	2.584705	2.392765	2.049967	1.154076	0.810741	1.001504	1.260423	1.46258	1.697744	2.139353
	30	4.056247	4.104283	4.110236	4.174984	4.169153	4.128028	4.056247	3.982783	3.843458	3.516104	2.984654	2.623993	2.312815	1.79784	1.089099	0.451460	0.254272	0.413004	0.708215	1.104654
	332	4.797702	4.739873	4.725272	4.710613	4.688513	4.651382	4.598758	4.553042	4.514505	4.483381	3.347422	2.418777	1.556108	1.09393	0.828393	0.912165	1.152568	1.675717	2.363458	2.894397
yi1 +T3	Average	4.296754	4.25733	4.243546	4.227369	4.173391	4.078091	3.942352	3.808611	3.651888	3.457426	2.866314	2.517724	2.093381	1.398803	1.085425	1.104647	1.331922	1.640761	1.949108	2.242121
yi1 +T4	1037	2.955528	2.914313	2.897659	2.897659	2.914313	2.9637	3.067864	3.213579	3.373507	3.408639	4.143453	4.326435	4.326435	4.233795	4.061295	3.84792	3.551647	3.130126	2.570631	1.991234
	1043	2.926878	2.953875	2.967303	2.953875	2.953875	3.007313	3.020558	3.060028	3.112041	3.176097	4.049102	4.059247	3.904224	3.69858	3.422294	3.16337	2.816986	2.405984	2.06656	1.981197
	26	3.193499	3.282751	3.338237	3.361715	3.415816	3.536034	3.565373	3.543395	3.601659	3.630386	4.640024	4.645178	4.420943	4.325352	4.143054	3.962214	3.728878	3.369502	2.555869	2.122263
	29	2.995382	2.668104	2.618339	2.659866	2.773215	2.874817	2.950728	2.913009	3.0321	3.002761	3.784878	3.835751	3.813246	3.578534	3.24815	2.92059	2.481513	2.029742	1.652142	1.731503
	30	3.052061	3.101682	3.118049	3.14244	3.182676	3.245947	3.277184	3.26163	3.198626	3.14244	4.074347	4.128028	3.957908	3.791219	3.594199	3.315737	2.976125	2.536789	2.15038	1.907827
	332	3.788536	3.741002	3.750558	3.769596	3.826124	3.890991	3.927548	3.945601	4.035082	4.096383	3.854065	3.844775	3.76009	3.644043	3.483366	3.282937	3.024663	2.579895	2.118564	2.088647
yi1 +T4	Average	3.151981	3.110288	3.115024	3.130859	3.17767	3.253142	3.301542	3.322888	3.392169	3.409451	4.090978	4.139902	4.030474	3.878587	3.664726	3.415461	3.096636	2.67534	2.18559	1.970445
san1 +T1	1037	4.116329	4.027758	3.94794	3.936353	3.942153	3.953716	3.94794	3.94794	3.924719	3.907179	3.443344	3.436436	3.345088	3.301921	3.272776	3.258091	3.228493	3.221046	3.235922	3.183513
	1043	3.720744	3.562882	3.469722	3.38634	3.337881	3.325671	3.38634	3.38634	3.362186	3.201428	2.91331	2.91331	2.899694	2.858559	2.789023	2.703908	2.616895	2.527897	2.394073	2.264117
	26	4.149105	3.942889	3.864359	3.857724	3.844411	3.837733	3.844411	3.79736	3.728878	3.608866	3.565373	3.528655	3.491497	3.423468	3.369502	3.306653	3.282751	3.250593	3.143708	3.033001
	29	3.584628	3.498184	3.409213	3.422083	3.424898	3.466706	3.504441	3.510685	3.491915	3.409213	3.19552	3.223067	3.236747	3.223067	3.20243	3.20243	3.209325	3.181653	3.146706	3.523284
	30	3.83048	3.744784	3.75146	3.758121	3.744784	3.75146	3.797796	3.810911	3.784627	3.744784	3.573093	3.508907	3.501693	3.494463	3.450728	3.421228	3.421228	3.479952	3.530448	3.523284
	332	4.467719	4.323667	4.266082	4.249461	4.224388	4.232765	4.266082	4.282627	4.282627	4.33182	3.954729	3.872574	3.797969	3.73142	3.683135	3.683135	3.683135	3.702525	3.779078	3.872574
san1 +T1	Average	3.978167	3.850027	3.784796	3.768347	3.753686	3.761342	3.791168	3.762492	3.700548		3.440895	3.413825	3.378781	3.338816	3.294599	3.262574	3.239156	3.210214	3.170533	
san1 +T2	1037	3.918884	3.775148	3.706771	3.750472	3.750472	3.768999	3.756661	3.74427	3.725582	3.700473	2.436425	2.356805	2.416727	2.589299	2.734405	2.855594	2.939113	3.028249	3.083557	3.044161
	1043	3.562882	3.374282	3.239118	3.16337	3.16337	3.124937	3.167097	3.16337	3.188783	3.188783	1.893925	1.581685	1.562516	1.731739	1.946522	2.24803	2.421433	2.587454	2.718224	
	26	4.220812	4.025773	3.864359	3.864359	3.903873	3.910409	3.962214	3.97503	3.97503	3.890757	3.226253	3.050292	2.854552	2.808285	2.854552	2.980538	3.11851	3.234387	3.258664	3.033001
	29	3.779172	3.662758	3.602837	3.59678	3.59678	3.644905	3.692281	3.698152	3.698152	3.650867	2.437462	2.187901	2.245154	2.329064	2.437462	2.567748	2.700834	2.796964	2.943221	3.223067
	30	3.817447	3.75146	3.71119	3.731389	3.758121	3.758121	3.810911	3.862826	3.894841	3.907556	3.026953	2.958998	2.782371	2.764148	2.745819	2.809508	2.92446	3.068689	3.158597	3.308064
	332	4.545367	4.483381	4.459863	4.459863	4.459863	4.43174	4.467719	4.482983	4.475558		3.574612	3.347422	3.304558	3.239307	3.217296	3.204261	3.261187	3.289963	3.293763	3.411045
san1 +T2	Average	3.974094	3.845467	3.764023	3.761039	3.77208	3.773927	3.807044	3.818561	3.822717	3.802333	2.765938	2.580517	2.527646	2.576974	2.656009	2.756087	2.865356	2.97211	3.054209	3.126365
san1 +T3	1037	3.84792	3.719325	3.731825	3.756661	3.74427	3.756661	3.756661	3.713055	3.731825	3.66239	3.25072	2.947333	2.743234	2.523421	2.169107	1.801543	1.886087	2.475417	2.988077	3.235922
	1043	3.551358	3.38634	3.214032	3.201428	3.188783	3.16337	3.239118	3.313424	3.273648	3.13779	3.288812	2.9404	2.587454	2.183014	1.694763	1.093434	0.75401	0.84745	1.484883	2.283924
	26	4.348111	4.185166	4.05707	4.0695	4.088053	4.081881	4.124829	4.106496	3.994156	3.804125	3.728878	3.400455	2.927171	1.548613	1.590347	1.548613	1.645131	1.880325	2.110605	2.247685
	29	3.738931	3.668685	3.649947	3.608882	3.578534	3.623043	3.620937	3.578534	3.479337	3.80436	3.263925	2.928153	2.576238	2.319854	1.978584	1.764891	1.894898	2.226189	2.593149	2.717068
	30	3.882074	3.80436	3.758121	3.771402	3.778022	3.797796	3.83048	3.849927	3.836976	3.80436	3.601203	3.428629	3.222401	2.967574	2.718123	2.467303	2.229319	2.157685	2.191146	2.060178
	332	4.71795	4.636423	4.621403	4.621403	4.621403	4.61387	4.583582	4.605322	4.568344		4.33182	3.797969	3.139199	2.486772	1.607848	1.191146	1.323057	1.64194	1.950912	2.619091
san1 +T3	Average	4.014391	3.90005	3.8349	3.838213	3.831922	3.837305	3.860998	3.86457	3.837377	3.742724	3.57756	3.24049	2.86595	2.338208	1.959795	1.561155	1.469645	1.752326	2.158374	2.521329
san1 +T4	1037	2.607846	2.396892	2.243573	2.147469	2.243573	2.426593	2.82149	2.979975	3.198586	3.301921	4.105406	4.148847	4.132634	4.038981	3.823868	3.551647	3.153129	2.786974	2.222494	1.491067
	1043	2.24803	2.100189	2.231878	2.264117	2.452149	2.616895	2.774965	2.899694	2.994022	3.150601	3.77561	3.764699	3.742783	3.676289	3.422294	3.073097	2.675119	2.280137	2.019579	1.263066
	26	3.521259	3.185256	2.980538	2.962851	2.971707	3.152063	3.314579	3.468986	3.572664	3.587196	4.582751	4.6037	4.701317	4.706371	4.502904	4.161172	3.651757	3.101596	2.463468	1.867717
	29	2.67632	2.446324	2.3747	2.452159	2.684513	2.874817	3.075584	3.209325	3.290862		3.841352	3.940438	3.951251	3.835751	3.554036	3.174696	2.749279	2.019579	1.629083	
	30	3.035345	2.889537	2.82747	2.854221	2.92446	3.07697	3.222401	3.292662	3.338643	3.601203	3.951658	3.97037	3.957908	3.882074	3.677232	3.428629	3.068689	2.556378	2.194525	1.79784
	332	3.663641	3.534338	3.462777	3.452439	3.421249	3.46477	3.712182	3.900164	4.148122		4.651382	4.673706	4.651382	4.568344	4.420328	4.215992	3.853263	3.250263	2.579895	2.459725
san1 +T4	Average	2.95874	2.758756	2.686823	2.689376	2.782942	2.935019	3.127258	3.259322	3.368901	3.513317	4.15136	4.183627	4.189546	4.117968	3.900111	3.600872	3.19355	2.693728	2.186433	1.751416
qi1 +T1	1037	4.175666	4.196941	4.143453	4.066846	4.033375	3.999507	3.965233	3.94794	3.918884	3.83592	3.28009	3.122417	3.02026	2.9637	2.930871	2.897659	2.880907	2.897659	2.939113	2.922604
	1043	3.398361	3.38634	3.362186	3.313424	3.288812	3.226595	3.188783	3.167097	3.16337		2.980685	2.886031	2.830893	2.746698	2.703908	2.646116	2.616895	2.587454	2.602203	
	26	4.088053	3.962214	3.884179	3.851074	3.864359	3.877586	3.810876	3.790579	3.770149	3.672981	3.790579	3.665922	3.543395	3.484012	3.446311	3.385017	3.361715	3.361715	3.369502	3.160394
	30	3.945396	3.894841	3.888464	3.882074	3.875671	3.875671	3.882074	3.882074	3.862826	3.849927	3.558942	3.436013	3.376452	3.391448	3.406374	3.406374	3.406374	3.41381	3.428629	3.472672
	332	4.560701	4.459863	4.41237	4.373124	4.348402	4.33182	4.315496	4.282627	4.275667	4.249461	4.173721	3.990659	3.900164	3.863331	3.835462	3.835462	3.826124	3.835462	3.863331	3.972738
qi1 +T1	Average	3.961836	3.913122	3.880186	3.848089	3.832513	3.822263	3.793409	3.765031	3.744179	3.68814	3.513596	3.374625	3.291125	3.252928	3.231884	3.207702	3.193399	3.191613	3.212995	3.212886
qi1 +T2 ts	1037	3.976703	4.00518	4.016491	4.00518	3.988128	3.988128	3.976703	3.953716	3.84792	3.811766	3.091371	3.052084	2.889295	2.589299	2.243573	1.897963	1.5047	1.336642	1.477368	2.147469
	1043	3.44608	3.374282	3.337881	3.313424	3.264044	3.201428	3.150601	3.188783	3.201428		2.858559	2.631533	2.296092	2.015567	1.890588	2.08341	2.374901	2.80303	3.301137	3.374282
	30	3.764769	3.771402	3.771402	3.764769	3.764769	3.758121	3.758121	3.731389	3.63599		1.772865	1.65795	1.372197	1.041966	0.812124	0.65494	0.690557	0.896159	1.166113	1.511523
	332	4.681117	4.658838	4.658838	4.651382	4.658838	4.658838	4.658838	4.641347	4.553042	4.522245	3.070908	2.540275	1.935283	1.133126	0.677021	0.742948	1.014256	1.414454	2.088647	2.632064
qi1 +T2 ts	Average	3.967167	3.952426	3.946153	3.933689	3.917081	3.901629	3.886066	3.878623	3.836596	3.792857	2.698426	2.47046	2.123217	1.69499	1.415447	1.344744	1.396103	1.612571	2.008316	2.416334
qi1 +T2	1037	4.285116	4.203041	4.179185	4.124829	4.081814	4.081814	4.10036	4.081881	4.057594	3.857724	3.050292	2.881984	2.817594	2.854552	2.953969	3.091314	3.102346	3.135332	3.152063	2.918186
	29	3.818888	3.80193	3.796257	3.796257	3.784878	3.761991	3.733139	3.668685	3.658818	3.523134	2.576238	2.419662	2.437462	2.542133	2.692685	2.836139	2.92059	2.965685	3.002761	3.017466
qi1 +T2	Average	4.052002	4.002485	3.987721	3.960543	3.933379	3.921936	3.91675	3.875283	3.856944	3.690429	2.813265	2.650823	2.627528	2.698342	2.823327	2.964622	3.027961	3.058874	2.960473	2.894116
qi1 +T3	1037	4.233795	4.244238	4.212793	4.186323	4.180999	4.09993	3.410346	4.09993	4.07963	3.075721	3.198586	3.02026	2.830054	2.465719	1.921568	1.421907	1.111631	1.064421	2.048018	3.075721
	1043	3.742783	3.608641	3.562882	3.528207	3.481489	3.44608	3.410346	3.362186	3.313424	3.301137	2.760857	2.497774	2.049636	1.523893	1.049848	0.706437	0.584904	0.916089	1.893925	2.405984
	26	4.365071	4.261887	4.208976	4.161172	4.143054	4.161172	4.220812	4.290896	3.523456	4.185166	3.101596	2.863723	2.110605	1.285653	0.99828	1.880325	2.281027	2.703995	2.625877	2.674931
	30	4.78333	4.71795	4.681117	4.658838	4.658838	4.658838	4.67963	4.658838	4.617287	4.61387	0.97376	0.542104	0.402020	0.472736	0.564938	0.785778	1.191146	1.950912	2.335482	2.821341
qi1 +T3	Average	4.243464	4.189779	4.15401	4.124179	4.108947	4.101497	4.102248	4.099197	4.07963	4.03594	2.694162	2.435537	2.07198	1.660876	1.307414	1.221827	1.263914	1.674089	2.396054	2.878357
qi1 +T4 ts	1037	2.880907	2.82149	2.795642	2.82149	2.872494	3.02026	3.183513	3.345088	3.429512	3.394638	4.507918	4.425963	4.233795	3.976703	3.725582	3.429512	3.059985	2.707754	2.036751	1.435873
	1043	2.789023	2.68954	2.732487	2.732487	2.9404	3.007313	3.073097	3.073097	3.099101		4.119572	4.049102	3.861822	3.608641	3.325671	2.789068	2.602203	2.150094	1.638634	1.385618
	29	2.859405	2.773215	2.789068	2.859405	2.965685	3.075584	3.139668	3.132614	3.118456	3.153727	4.244305	4.129428	3.988797	3.692281	3.28415	2.789068	2.365627	2.119715	1.968248	1.786948
	332	2.99316	3.018539	3.04978	3.150529	3.28806	3.389791	3.421249	3.452439	3.624339	3.779078	4.66628	4.583582	4.506748	4.4441	4.356172	4.249461	4.105057	3.936631	3.788536	3.683135
qi1 +T4 ts	Average	2.994987	2.932169	2.928272	2.96935	3.053532	3.269896	3.269896	3.321358	3.334509	3.334509	4.334402	4.25218	4.116027	3.905217	3.645834	3.325697	3.006082	2.684273	2.255874	1.92703
qi1 +T4		4.319636	4.232604	4.208976	4.185166	4.161172	4.136991	4.106496	4.05707	3.93642	3.916933	4.726502	4.681021	4.524399	4.336752	4.013165	3.680024	3.431101	3.143708	2.845354	2.625877
qi1 +T4	Average	4.319636	4.232604	4.208976	4.185166	4.161172	4.136991	4.106496	4.05707	3.93642	3.916933	4.726502	4.681021	4.524399	4.336752	4.013165	3.680024	3.431101	3.143708	2.845354	2.625877
ba1 +T1	1037	3.558282	3.571505	3.524954	3.470807	3.408639	3.359333	3.345088	3.323586	3.330771	3.330771	3.036216	2.914313	2.838593	2.795642	2.743234	2.760811	2.725549	2.698814	2.689847	2.707754
	1043	3.434205	3.374282	3.288812	3.239118	3.188783	3.112041	3.046916	3.046916	3.073097	2.899694	2.660645	2.675119	2.587454	2.512865	2.497774	2.482625	2.436821	2.497774	2.421433	2.497774
	26	3.694061	3.594436	3.558064	3.521259	3.521259	3.493444	3.48634	3.513846	3.521259		3.536034	3.506414	3.431101	3.400455	3.361715	3.330371	3.290739	3.345254	3.126932	2.936129
	29	3.498184	3.415655	3.383307	3.35718	3.350613	3.389805	3.350613	3.35718	3.389805	3.383307	3.270681	3.324201	3.310909	3.304242	3.277423	3.284115	3.270681	3.223067	3.223067	3.229915
	30	3.63599	3.656679	3.649798	3.629064	3.608191	3.594199	3.587179	3.587179	3.677232	3.63599	3.537596	3.558942	3.558942	3.551843	3.530448	3.544728	3.530448	3.516104	3.516104	3.537596
	332	4.299098	4.282627	4.257781	4.241122	4.232765	4.241122	4.274364	4.282627	4.274364	4.257781	3.854065	3.769596	3.741002	3.702525	3.683135	3.702525	3.673401	3.702525	3.73142	3.816763
ba1 +T1	Average	3.686637	3.649197	3.610453	3.576425	3.551708	3.528992	3.518683	3.528992	3.50447	3.5048	3.315873	3.291333	3.244667	3.211262	3.182288	3.184202	3.154607	3.145286	3.118134	3.120873
ba1 +T2	1037	3.762837	3.731825	3.74427	3.730054	3.694161	3.668773	3.655993	3.649582	3.668773	3.675141	2.671827	2.626273	2.644582	2.698814	2.760811	2.82149	2.914313	2.996157	3.122417	3.160755
	1043	3.239118	3.239118	3.124937	3.099103	3.099103	3.007313	2.926878	2.899694	2.9404	2.899694	1.405674	1.44548	1.619743	1.840609	1.981197	2.100189	2.280137	2.421433	2.616895	2.760857
	26	3.962214	3.83104	3.714998	3.708035	3.701056	3.701056	3.701056	3.701056	3.701056		3.03001	2.936129	2.826875	2.872867	2.918186	2.953969	3.031104	3.160394	3.250593	3.163370
	29	3.614916	3.498184	3.454024	3.454024	3.485632	3.535533	3.523134	3.498184	3.504441	3.498184	2.692685	2.507641	2.498957	2.507641	2.609966	2.765257	2.928153	3.024791	3.05392	3.082772
	30	3.551843	3.594199	3.601203	3.594199	3.587179	3.587179	3.587179	3.587179	3.587179		2.898304	2.82747	2.791443	2.791443	2.863087	2.950399	3.07697	3.166643	3.253823	3.238152
	332	4.568344	4.537676	4.537676	4.537676	4.560701	4.583582	4.598758	4.61387	4.621403	4.591178	3.574612	3.389791	3.228318	3.161683	3.161683	3.161683	3.161683	3.184029	3.184029	3.217296
ba1 +T2	Average	3.783212	3.738674	3.696185	3.688515	3.687972	3.685377	3.67972	3.680792	3.683921	3.665719	2.712684	2.622131	2.601653	2.645509	2.715822	2.792164	2.881404	2.942796	3.001879	3.019206
ba1 +T3	1037	3.8299	3.83623	3.877703	3.83592	3.799612	3.775148	3.768999	3.762837	3.775148	3.750472	3.750472	3.443344	3.243331	2.980907	2.523421	2.136588	1.776921	1.188621	0.745809	1.663156
	1043	3.398361	3.38634	3.350052	3.313424	3.288812	3.201428	3.124937	3.086122	3.099103	3.03376	3.020558	2.926878	2.732487	2.512865	1.963898	0.633973	0.777581	1.619743	2.359266	2.760857
	26	4.143054	4.019475	3.897322	3.92314	3.821394	3.841294	3.841294	3.479337	3.93642	3.903873	3.651757	3.408145	2.998125	2.087156	0.947656	0.964616	1.492078	2.075362	2.452932	2.21398
	29	3.608882	3.504441	3.454024	3.428498	3.422083	3.428498	3.460372	3.491915	3.479337	3.491915	3.409213	3.243564	2.987985	2.684513	2.235686	1.582432	1.015695	0.457899	0.300874	0.607219
	30	3.573093	3.544271	3.558064	3.551843	3.57093	3.57093	3.573093	3.573093	3.558942		3.601203	3.35806	3.150458	2.833618	2.459725	0.472736	0.496005	1.210283	2.377366	2.721611
	332	4.560701	4.553042	4.560701	4.553042	4.553042	4.560701	4.598758	4.64391	4.636423	4.591178	4.483381	3.35806	3.150458	2.833618	2.459725	0.472736	0.496005	1.210283	2.377366	2.721611
ba1 +T3	Average	3.852332	3.831637	3.790167	3.775528	3.755828	3.763913	3.760837	3.768999	3.762837	3.72169	3.648079	3.233516	3.102346	2.737948	2.244838	1.39162	1.215858	1.413719	1.875436	
ba1 +T4 ts	1037	2.494716	2.485083	2.376919	2.254055	2.190582	2.147469	2.201259	2.406827	2.743234	3.028249	4.295888	4.290765	4.138049	3.942153	3.725582	3.491232	3.213579	2.707754	2.190582	1.689032
	1043	1.822673	1.840609	1.911536	1.929068	1.876234	1.713295	1.657433	1.694763	1.822673	2.08341	4.227801	4.295143	4.237493	4.03893	3.720744	3.251601	2.616895	1.981197	1.465231	0.983542
	29	2.383746	2.410722	2.392765	2.516301	2.659866	2.874817	2.92059	3.06838			4.010045	4.031147	3.929586	3.761991	3.535533	3.216204	2.843783	2.518942	2.623993	2.207105
	30	2.477275	2.477275	2.517076	2.566127	2.614422	2.661985	2.718123	2.82747	2.967574	3.018539	3.843458	3.849927	3.856383	3.791796	3.622122	3.391448	3.118049	2.623993	2.082973	1.907827
	332	3.250263	3.195152	3.172873	3.217296	3.230426	3.253823	3.253823	3.624339			4.739813	4.603222	4.467719	4.283902	3.544448	3.184029	3.161683	2.82747	2.561493	2.193692
ba1 +T4 ts	Average	2.485735	2.481768	2.474234	2.468357	2.482967	2.482186	2.537297	2.643308	2.793621	2.964583	4.223414	4.214661	4.125846	3.964699	3.729576	3.378987	2.995293	2.561493	2.193692	1.962434
ba1 +T4	26	3.994156	3.844411	3.749582	3.756453	3.749582	3.742696	3.735795	3.763308	3.742696	3.742696	4.582751	4.464926	4.24435	4.081881	3.97503	3.864359	3.749582	3.543395	2.936129	2.780189
ba1 +T4	Average	3.994156	3.844411	3.749582	3.756453	3.749582	3.742696	3.735795	3.763308	3.742696	3.742696	4.582751	4.464926	4.24435	4.081881	3.97503	3.864359	3.749582	3.543395	2.936129	2.780189

1b: Adverbs

Table 8.8 mean F0 values (in Hz) of participant 1 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	190	195	202.5	210	216	220.5	225	228	227.5	223	204.5	202.5	200	198.5	195	191.5	188.5	188.5	186.5	179
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	185	193	199	205	212	220.5	227.5	230.5	236.5	232.5	174	165	168.5	171.5	176.5	182	187	194	197.5	197.5
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	181.5	182.5	187	195.5	204.5	210	219	230.5	239	239.5	215	200	182	165	156	147	140	133	135.5	143.5
bie2+T4	ie2	bie2 'do not'	kan4 'see'	163.5	156.5	154	157.5	163.5	166.5	170.5	180	194.5	196	270	267	262	249	229.5	208.5	177	155	131.5	108
mei2+T1	ei2	mei2 'not'	reng1 'throw'	179	182.5	189	196.5	207	214.5	226	238	245	243.5	217	209.5	204.5	202	200.5	198	197	198	196	194
mei2+T2	ei2	mei2 'not'	lai2 'come'	180	178.5	182.5	190.5	200	210	221	231	237.5	237.5	170.5	157	158.5	167	176	180.5	182.5	182.5	184	183.5
mei2+T3	ei2	mei2 'not'	mai3 'buy'	173.5	175	179	189.5	200	214.5	228	243.5	255	258	238	216	184.5	154.5	129	111	100	93.5	96.5	123.5
mei2+T4	ei2	mei2 'not'	dong4 'move'	186	182.5	182	182.5	185.5	191.5	198	205.5	216	225	312	315.5	308.5	289.5	257.5	226.5	196	171.5	142.5	126.5
hai2+T1	ai2	hai2 'still'	chi1 'eat'	175.5	174	176	179.5	187	196.5	204	214.5	216	213	192	186.5	182.5	180	181.5	179.5	175.5	174	173.5	176
hai2+T2	ai2	hai2 'still'	xing2 'allow'	163.5	162.5	164	168	175	184	193.5	201.5	207.5	206.5	154.5	146.5	148	152	157.5	164	168.5	171	175	180.5
hai2+T3	ai2	hai2 'still'	mai3 'buy'	186.5	185.5	187	194	207	219.5	237	253	267.5	271.5	185.5	179.5	166.5	147	124.5	102.5	87	86.5	109.5	145
hai2+T4	ai2	hai2 'still'	yao4 'want'	154.5	148	144.5	142	144.5	151	163.5	179	194.5	199.5	302	300	286	265	236	212.5	190.5	168	149	131
dou1+T1	ou1	dou1 'all'	shuo1 'say'	249	248.5	249	250	248.5	250.5	251.5	254	257	252.5	213	207	200.5	199	198.5	197	195.5	196.5	195.5	193
dou1+T2	ou1	dou1 'all'	lai2 'come'	238	239	239.5	240.5	244	246.5	247	250	251.5	246.5	160.5	158	159.5	163.5	169.5	176.5	187	196	201.5	201
dou1+T3	ou1	dou1 'all'	pao3 'run'	241	238.5	237.5	237	241.5	247.5	247.5	243	241	242	212	194.5	180	159.5	137	116	92.5	78	78	101
dou1+T4	ou1	dou1 'all'	qu4 'go'	145	147.5	149	149	151	157	167.5	180	194.5	215.5	247.5	245	241	230.5	212	189.5	164.5	138.5	113.5	97.5

Table 8.9 mean F0 values (in Hz) of participant 2 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	186.5	183	182	180.5	179	176.5	174	170.5	166.5	164	167.5	157	148.5	144	142.5	140	139	141	143.5	145.5
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	146	147	147.5	146.5	148	150.5	151	153.5	155	157.5	123	119.5	121.5	123.5	128	130.5	136.5	141.5	150	155.5
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	157.5	155	154	153.5	151.5	151.5	153.5	154.5	156	156.5	159	150.5	139.5	125.5	106.5	89	79	80.5	100.5	130.5
bie2+T4	ie2	bie2 'do not'	kan4 'see'	128	129.5	129	129.5	131.5	131.5	131.5	131	132.5	132.5	175	175	176.5	178	174.5	166.5	154.5	133.5	113	92.5
mei2+T1	ei2	mei2 'not'	reng1 'throw'	176.5	176	176.5	173.5	170.5	167.5	161.5	151	145	144.5	137	134.5	131	129	131.5	133.5	136	137	139	140.5
mei2+T2	ei2	mei2 'not'	lai2 'come'	140.5	142	143.5	147	150.5	154.5	158	160.5	161	159	116.5	113.5	121	127	129.5	132.5	137.5	139.5	145	150.5
mei2+T3	ei2	mei2 'not'	mai3 'buy'	145.5	145.5	144	146	149	153.5	157.5	162	164.5	164	159.5	148	138.5	129	113.5	93	82	85	99.5	117.5
mei2+T4	ei2	mei2 'not'	dong4 'move'	143	142.5	143	144.5	144.5	143	144	146.5	152.5		195.5	193.5	188	182.5	172.5	156.5	142.5	129.5	115.5	106
hai2+T1	ai2	hai2 'still'	chi1 'eat'	207.5	210.5	208.5	202.5	197	190	182	175.5	171	169	157	146	142	139.5	135	130	126	124.5	123	122.5
hai2+T2	ai2	hai2 'still'	xing2 'allow'	141	140.5	142	144	147	150	153	157	159.5	161	105	116	122.5	128	128	129.5	133	137.5	146.5	156.5
hai2+T3	ai2	hai2 'still'	mai3 'buy'	174.5	176.5	177	178.5	179.5	180	179.5	178	179.5	181	152.5	141.5	126.5	107.5	88	79	75	78	99.5	128
hai2+T4	ai2	hai2 'still'	yao4 'want'	131.5	131.5	133.5	134.5	137	140	141	141.5	143.5	146	210	198.5	182.5	164.5	145	132	118	110.5	106.5	107
dou1+T1	ou1	dou1 'all'	shuo1 'say'	176	174.5	172.5	170	169	169.5	170	170.5	170	167	156	149	146.5	144.5	144	143.5	143	144.5	151	
dou1+T2	ou1	dou1 'all'	lai2 'come'	170.5	165	163	161	158.5	157.5	158	159	160	161	113	123	128.5	134	137	140.5	142.5	145	147	146
dou1+T3	ou1	dou1 'all'	pao3 'run'	160.5	163	161.5	159	157	160.5	162.5	165	166	163	156.5	149	138.5	127.5	111.5	96	93	97.5	111.5	128.5
dou1+T4	ou1	dou1 'all'	qu4 'go'	160	160	159	158	157	156	154	153	153.5	157	175.5	172.5	162.5	150.5	136	118	103	89	82.5	81

Table 8.10 mean F0 values (in Hz) of participant 3 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	308	318.5	312.5	311	300.5	275.5	243.5	210.5	196.5	192	207	195	189	187	184	179.5	174.5	167.5	161	157
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	216	220.5	226.5	232.5	236.5	244.5	252.5	254	252.5	253	199	193.5	192.5	194	202	210	213	209.5	202	192.5
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	318.5	317.5	318.5	311.5	295.5	269	242.5	214.5	198.5	184.5	205.5	181.5	128.5	101	86	102.5	153.5	164.5	158.5	153.5
bie2+T4	ie2	bie2 'do not'	kan4 'see'	182	187	187.5	194	200	209.5	218.5	225.5	224	227.5	292.5	298	298.5	275.5	245	219	196.5	177.5	161.5	147
mei2+T1	ei2	mei2 'not'	reng1 'throw'	195.5	185.5	189	205.5	220.5	236.5	253.5	260	261.5	256.5	220.5	202	194	191	186	181.5	175	170	167.5	164
mei2+T2	ei2	mei2 'not'	lai2 'come'	192	189.5	196.5	207.5	216.5	233.5	253	260	262.5	257	192	168.5	163.5	166.5	171	174	177.5	177.5	175.5	169.5
mei2+T3	ei2	mei2 'not'	mai3 'buy'	210.5	211	218.5	226.5	237	256.5	270	278.5	282.5	280	220.5	184.5	159.5	127	98	90.5	115.5	141.5	162	156.5
mei2+T4	ei2	mei2 'not'	dong4 'move'	181.5	175.5	176	179	185	193.5	202.5	209	216	232	299	302	307	301	282.5	256.5	222.5	189.5	168.5	161.5
hai2+T1	ai2	hai2 'still'	chi1 'eat'	313	313	308.5	294	276	254	239	231.5	230	221.5	201	188.5	183	179	176.5	171.5	171.5	159.5	149	144.5
hai2+T2	ai2	hai2 'still'	xing2 'allow'	201	207	212	221	232	241.5	250.5	257	260	253	202.5	186	182.5	184.5	186.5	185.5	184	182.5	179	170.5
hai2+T3	ai2	hai2 'still'	mai3 'buy'	323	328.5	329	322.5	312	294.5	276.5	262.5	253.5	250	201.5	167	115.5	77	73.5	77	82	97.5	127	143
hai2+T4	ai2	hai2 'still'	yao4 'want'	202	196.5	189.5	191	195.5	206.5	218	221.5	220.5	218	336.5	335	329	316	292.5	261	237	212.5	188	181
dou1+T1	ou1	dou1 'all'	shuo1 'say'	220.5	204	198.5	203	215	237.5	269	283	295	290.5	204.5	196.5	190	188	187	186	181.5	175.5	167	160
dou1+T2	ou1	dou1 'all'	lai2 'come'	213	209	209	214	220	232.5	262	277	283	276	172	175	175.5	173.5	177.5	188	199	208.5	207	199
dou1+T3	ou1	dou1 'all'	pao3 'run'	213.5	205	205.5	211	220.5	236	257	274.5	284.5	288.5	242	208	163	119	92.5	81.5	93.5	127.5	141.5	142.5
dou1+T4	ou1	dou1 'all'	qu4 'go'	191.5	183.5	178	178.5	179	182	187.5	196.5	207	220.5	280	284	284.5	280	270	255	233.5	203.5	170.5	159

Table 8.11 mean F0 values (in Hz) of participant 4 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	292.5	289.5	288.5	282	271	253	238.5	228	232	226.5	210.5	195	187	182.5	178	172	165.5	160	164	165.5
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	307.5	305.5	306.5	304	296	283	270	263	263	261.5	183	173	170.5	174.5	182	189.5	193.5	192	193.5	191.5
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	320.5	317.5	319.5	315.5	303	288.5	272	254.5	227	204.5	201.5	193.5	179	166	156	157.5	173.5	171.5	169	171
bie2+T4	ie2	bie2 'do not'	kan4 'see'	195.5	193.5	196	199.5	205.5	211.5	215.5	214	216	223.5	276.5	286.5	295	290	275.5	256	240.5	228	215.5	223
mei2+T1	ei2	mei2 'not'	reng1 'throw'	312.5	311	308	303.5	295.5	284.5	271.5	254.5	237	222	209	203	195.5	191.5	188.5	185	183.5	181	179	183
mei2+T2	ei2	mei2 'not'	lai2 'come'	331	327	320.5	313	305	292	277	258.5	239	216	175	169.5	161	161.5	164.5	168	171.5	176	182	192.5
mei2+T3	ei2	mei2 'not'	mai3 'buy'	322.5	328	324	320	312	298.5	281	262.5	246	227	201.5	183	164.5	148	141	133	138.5	144.5	150	158.5
mei2+T4	ei2	mei2 'not'	dong4 'move'	191.5	192.5	196	203	211.5	218	224.5	225.5	223	240.5	301	311	314.5	305.5	286.5	262	234.5	213.5	194	189.5
hai2+T1	ai2	hai2 'still'	chi1 'eat'	368	363	356	347.5	336	323.5	313	305	301.5	300.5	228.5	223	218	216	214	211.5	209	206	204	202
hai2+T2	ai2	hai2 'still'	xing2 'allow'	384	379.5	372.5	362.5	345.5	314.5	279	251.5	231	211.5	173.5	170.5	171.5	174.5	179.5	186	192	195.5	198.5	201.5
hai2+T3	ai2	hai2 'still'	mai3 'buy'	382	382	378	371	359.5	346.5	327.5	307.5	283.5	267	215	189.5	175	161	162.5	171	188	209.5	240.5	250
hai2+T4	ai2	hai2 'still'	yao4 'want'	188.5	184	180	180	186.5	202	218	224	228	228.5	350	352	348	339	317.5	270.5	245	218.5	201	205.5
dou1+T1	ou1	dou1 'all'	shuo1 'say'	200	195.5	196	202.5	214	230	245	258.5	264	256.5	225	208	201	198.5	196.5	195	193.5	191.5	189	190
dou1+T2	ou1	dou1 'all'	lai2 'come'	191	186.5	190.5	202	217	233.5	246.5	256	256.5	252	176	173	174.5	174.5	173.5	178.5	185.5	191	193.5	189.5
dou1+T3	ou1	dou1 'all'	pao3 'run'	204	200	205.5	215	227	243.5	256.5	263	269	265.5	262	244.5	229.5	207	180.5	156.5	138.5	135.5	145	157
dou1+T4	ou1	dou1 'all'	qu4 'go'	203.5	198.5	199	202.5	208.5	215.5	223.5	233	243	255	292	296.5	298	295.5	286	274.5	260.5	246	230	216.5

Table 8.12 mean F0 values (in Hz) of participant 5 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	286	288.5	287	279.5	267	253	236	219	206.5	199.5	215	219.5	220.5	217	214	211.5	211	208.5	205	209
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	287.5	286	277.5	265.5	251.5	233.5	215.5	204	197	191.5	201	196	192	194	199	203.5	207	211	217.5	218
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	286	286.5	283.5	278.5	269	255	239.5	225.5	219	210	196	189	182	167.5	138	108	89	86.5	95	117.5
bie2+T4	ie2	bie2 'do not'	kan4 'see'	177	177	178.5	180.5	182.5	185	188	193.5	202.5	200	252.5	253.5	249	243	231.5	218	203	187.5	165	151
mei2+T1	ei2	mei2 'not'	reng1 'throw'	273.5	274	269	260.5	252	234.5	220.5	212.5	207.5	203	208	207.5	205	205.5	205.5	205.5	205	206.5	208.5	213.5
mei2+T2	ei2	mei2 'not'	lai2 'come'	278.5	277.5	270.5	258.5	241.5	219	203.5	191.5	183	175	158.5	155.5	154	158.5	166.5	173	179.5	186.5	190.5	196.5
mei2+T3	ei2	mei2 'not'	mai3 'buy'	202	204	206	212	219.5	230	235.5	244.5	250.5	250.5	243	230.5	219	206.5	188.5	140.5	114	107.5	125.5	160
mei2+T4	ei2	mei2 'not'	dong4 'move'	194.5	197.5	197.5	196.5	198	201	207	213	215.5	224	270	270.5	267	258.5	247	229.5	207.5	186	169	155
hai2+T1	ai2	hai2 'still'	chi1 'eat'	274	268.5	267	263	256	246	233	223.5	217.5	213	164	161.5	158	153.5	153	152.5	153.5	156.5	159	161
hai2+T2	ai2	hai2 'still'	xing2 'allow'	186.5	187.5	189	192	197.5	204	210.5	216.5	221	226	201.5	189.5	183	182.5	184.5	187.5	189	190	194.5	202
hai2+T3	ai2	hai2 'still'	mai3 'buy'	289	281.5	273.5	270	265	256	246	237.5	230	230	234.5	218.5	162	119.5	100	87	86	104.5	143	159.5
hai2+T4	ai2	hai2 'still'	yao4 'want'	180	179	178.5	179	178.5	180.5	183	184	181.5	183	271.5	264	260	253	237.5	219	203	190	181	159.5
dou1+T1	ou1	dou1 'all'	shuo1 'say'	195	196	199.5	208	218.5	227.5	241	252.5	256	258	222.5	218.5	213	209.5	209	209.5	209.5	209	211	214.5
dou1+T2	ou1	dou1 'all'	lai2 'come'	192	197	204.5	209	214.5	220.5	229	241	250.5	252	188.5	185	181.5	180.5	183.5	186.5	190.5	195	198.5	202
dou1+T3	ou1	dou1 'all'	pao3 'run'	236	236.5	239	241	241	241	238.5	240.5	237	232	217.5	201.5	191	178.5	165.5	138.5	109	89.5	91	102.5
dou1+T4	ou1	dou1 'all'	qu4 'go'	187.5	187	186	184	184.5	186	193.5	206	209	227.5	256.5	253.5	250	242	232	217.5	200.5	181.5	152.5	137.5

Table 8.13 mean F0 values (in Hz) of participant 6 for tone sandhi with adverbs in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1	ie2	bie2 'do not'	ku1 'cry'	182.5	181	178	178.5	182.5	187.5	192.5	202	209.5	215.5	198	193	190	187.5	185	182	180	180	182	189
bie2+T2	ie2	bie2 'do not'	ti2 'remind'	175	173	171.5	171.5	173.5	178	182	189	203	213.5	171.5	169	166	162	161	159.5	158	161.5	170	177.5
bie2+T3	ie2	bie2 'do not'	zheng3 'do'	170.5	168.5	169.5	172.5	176	180.5	184.5	190.5	194.5	203	203	190	170.5	143.5	112	89	83	84	93.5	112.5
bie2+T4	ie2	bie2 'do not'	kan4 'see'	167.5	169	169.5	169.5	169	168	169	171.5	177.5	184	250.5	246	238	230	220.5	203.5	160	126	110	107.5
mei2+T1	ei2	mei2 'not'	reng1 'throw'	176	174.5	174.5	177.5	182	187	195.5	205.5	212	213	194	190	186.5	182.5	180.5	179	177	176.5	178.5	181
mei2+T2	ei2	mei2 'not'	lai2 'come'	174.5	171.5	171.5	173.5	176.5	180.5	188	195.5	201.5	206	183.5	175	170	168.5	167	167.5	168.5	171	172	178
mei2+T3	ei2	mei2 'not'	mai3 'buy'	178.5	175.5	172.5	171.5	174.5	178.5	183.5	193	202	210	210.5	183.5	153.5	115.5	96	88.5	91.5	102.5	115.5	119.5
mei2+T4	ei2	mei2 'not'	dong4 'move'	172	168.5	167	166.5	168.5	170	174.5	182	187.5	203.5	240	236	234	230.5	224.5	216	206.5	198	190	182.5
hai2+T1	ai2	hai2 'still'	chi1 'eat'	182.5	177.5	173	171.5	173	177.5	183.5	195	207	218.5	186.5	183.5	180	177.5	176	173.5	170.5	168	167	172
hai2+T2	ai2	hai2 'still'	xing2 'allow'	194	184.5	175	174	177.5	183.5	190	198.5	210	216	142.5	130	124.5	122	122.5	127	136	155.5	160	161
hai2+T3	ai2	hai2 'still'	mai3 'buy'	263	259	256.5	252	245.5	235.5	225.5	215.5	205.5	197	162	143.5	121	106.5	95	93	94.5	105.5	132.5	186
hai2+T4	ai2	hai2 'still'	yao4 'want'	195.5	189.5	184.5	183	182.5	180.5	179	178.5	180.5	190.5	259.5	255.5	248.5	240.5	230	215	194.5	170	149.5	133.5
dou1+T1	ou1	dou1 'all'	shuo1 'say'	156	163.5	169	170	174	180.5	189.5	198	206.5	206.5	177.5	176.5	176	174.5	173.5	172	171	170	171	171
dou1+T2	ou1	dou1 'all'	lai2 'come'	176	176	175	175.5	176.5	179.5	185	193.5	204	215	177.5	167	164	163	161	158	158.5	164	178.5	195.5
dou1+T3	ou1	dou1 'all'	pao3 'run'	170.5	170	169.5	170.5	172	175.5	180.5	185.5	190	194	200.5	190.5	150	112.5	96.5	103	115	128.5	154	187.5
dou1+T4	ou1	dou1 'all'	qu4 'go'	177	174	171.5	170	169.5	170	170.5	172	177.5	187.5	221.5	221.5	217.5	211.5	205.5	184.5	142	99.5	88.5	87

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Table 8.14 mean F0 values (in T-value, 5-scale measurement) of all participant for tone sandhi with adverbs in disyllabic words

participants	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
bie2+T1* 1037	3.198586	3.272776	3.380568	3.48444	3.564901	3.623793	3.681495	3.719325	3.713055	3.655993	3.408639	3.380568	3.345088	3.323586	3.272776	3.221046	3.175947	3.175947	3.145481	3.028249
332	3.564585	3.534338	3.473086	3.483366	3.564585	3.663641	3.76009	3.936631	4.070236	4.173721	3.863331	3.769596	3.712182	3.663641	3.614448	3.554531	3.514035	3.514035	3.554531	3.692843
Average	3.381585	3.403557	3.426827	3.483903	3.564743	3.643717	3.720792	3.827978	3.891646	3.914857	3.635985	3.575082	3.528635	3.493613	3.443612	3.387788	3.344991	3.344991	3.350006	3.360546
bie2+T1 1043	3.935725	3.861822	3.840447	3.808163	3.77561	3.720744	3.665095	3.585829	3.493221	3.434205	3.51658	3.264004	3.046916	2.926878	2.886031	2.816986	2.789023	2.844751	2.91331	2.967303
26	4.721482	4.825242	4.766377	4.751484	4.645178	4.376326	3.994156	3.543395	3.330371	3.258664	3.491497	3.306653	3.209919	3.176991	3.126932	3.050292	2.962851	2.836128	2.713622	2.635751
29	4.062527	4.031147	4.020614	3.951251	3.83014	3.620937	3.441288	3.304242	3.35718	3.28415	3.061158	2.828345	2.700834	2.62669	2.550695	2.446324	2.329064	2.226189	2.30135	2.329064
30	4.367056	4.394334	4.377996	4.295	4.151594	3.982783	3.764769	3.530448	3.346241	3.238152	3.472672	3.537596	3.551843	3.501693	3.458059	3.421228	3.41381	3.376452	3.323391	3.383959
Average	4.271697	4.278136	4.251358	4.201474	4.100631	3.925198	3.716327	3.490978	3.381753	3.303792	3.385477	3.234159	3.127378	3.058063	3.005429	2.933708	2.873687	2.82008	2.812918	2.829019
bie2+T2* 1037	3.122417	3.243331	3.330771	3.415614	3.511513	3.623793	3.713055	3.750472	3.823868	3.775148	2.947333	2.795642	2.855594	2.905998	2.988077	3.075721	3.153129	3.258091	3.309161	3.309161
1043	2.980685	3.007313	3.020558	2.994022	3.03376	3.099103	3.112041	3.176097	3.214032	3.276448	2.311981	2.19937	2.264117	2.327807	2.467417	2.542872	2.718224	2.858559	3.086122	3.226595
26	3.623229	3.68705	3.770149	3.851074	3.903873	4.006842	4.106496	4.124829	4.106496	4.112619	3.369502	3.282751	3.266714	3.290739	3.415816	3.536034	3.579938	3.528655	3.415816	3.266714
332	3.410793	3.368668	3.336753	3.336753	3.379244	3.473086	3.554531	3.692843	3.954729	4.13955	3.336753	3.282937	3.217296	3.127905	3.105212	3.070908	3.036279	3.116576	3.304558	3.462777
Average	3.284281	3.32659	3.364558	3.399366	3.457097	3.550706	3.621531	3.68606	3.774781	3.825941	2.991392	2.890175	2.90093	2.913112	2.994131	3.056384	3.121892	3.190471	3.278914	3.316312
bie2+T2 29	4.214752	4.19489	4.204837	4.179908	4.098733	3.962025	3.818888	3.738931	3.738931	3.721521	2.635018	2.463969	2.490248	2.618339	2.743258	2.80484	2.781152	2.80484	2.773215	
30	4.383451	4.367056	4.272491	4.133936	3.964145	3.731389	3.479952	3.308064	3.198626	3.109876	3.26163	3.182676	3.118049	3.150529	3.230286	3.300373	3.353821	3.41381	3.508907	3.516104
Average	4.299102	4.280973	4.238664	4.156922	4.031439	3.846707	3.64942	3.523498	3.468779	3.415699	2.948324	2.823323	2.820388	2.924313	3.020815	3.079331	3.097481	3.156873	3.144659	
bie2+T3* 1037	3.067864	3.083557	3.153129	3.28009	3.408639	3.48444	3.604297	3.750472	3.853902	3.859871	3.551647	3.345088	3.075721	2.795642	2.635442	2.465719	2.326366	2.179864	2.233053	2.396892
1043	3.276448	3.214032	3.188783	3.176097	3.124937	3.124937	3.176097	3.201428	3.239118	3.251601	3.313424	3.099103	2.890473	1.750096	1.049848	0.584904	0.658277	1.523893	2.542872	
332	3.315321	3.272078	3.293763	3.35806	3.431675	3.524201	3.604529	3.721814	3.797969	3.954729	3.954729	3.712182	3.315321	2.683502	1.775221	0.932812	0.677021	0.720912	1.11358	1.791546
Average	3.219878	3.189889	3.211892	3.271416	3.32175	3.377859	3.461641	3.557905	3.63033	3.688734	3.60626	3.385458	3.064691	2.623206	2.053586	1.482793	1.196097	1.186351	1.623509	2.24377
bie2+T3 26	4.825242	4.815509	4.825242	4.756456	4.593244	4.302424	3.981419	3.601659	3.361715	3.135332	3.468986	3.084589	2.015724	1.270368	0.727338	1.315998	2.565968	2.780189	2.665182	2.565968
29	4.34079	4.312164	4.331278	4.29293	4.169879	4.020614	3.841352	3.638931	3.290862	2.973137	2.928153	2.80484	2.567748	2.338246	2.149125	2.178253	2.472754	2.437462	2.392765	2.428575
30	4.367056	4.37253	4.339537	4.283765	4.174984	4.007463	3.810911	3.622122	3.530448	3.39892	3.182676	3.068689	2.950399	2.690179	2.082973	1.314686	0.708215	0.618913	0.912698	1.578929
Average	4.511029	4.500068	4.498686	4.444384	4.312702	4.110167	3.877894	3.620904	3.394342	3.169129	3.193272	2.986039	2.51129	2.099598	1.668279	1.602979	1.915646	1.945521	1.990215	2.191157
bie2+T4* 1037	2.769559	2.644582	2.598588	2.662774	2.769559	2.82149	2.889295	3.044161	3.265443	3.287385	4.202235	4.170322	4.116329	3.970974	3.738054	3.463966	2.996157	2.617074	2.147469	1.585161
1043	2.467417	2.512865	2.497774	2.512865	2.57265	2.57265	2.57265	2.55779	2.602203	2.602203	3.48745	3.68745	3.720744	3.753756	3.676289	3.493221	3.201428	2.631533	1.981197	1.200315
26	3.093104	3.176991	3.185256	3.290739	3.385017	3.528655	3.658848	3.756453	3.735795	3.783784	4.561659	4.61932	4.624509	4.376326	4.013165	3.665922	3.330371	3.015612	2.72322	2.432044
29	2.836139	2.80484	2.843914	2.89779	2.987985	3.001642	3.052061	3.14244	3.249593	3.245997	3.891298	3.999439	4.088432	4.035999	3.880269	3.656818	3.466706	3.304242	3.132614	3.236747
30	2.863087	2.863087	2.889537	2.92446	2.958998	3.001642	3.052061	3.14244	3.284923	3.245997	3.976583	3.988971	3.932833	3.856383	3.704427	3.516104	3.292662	3.043714	2.643046	2.365142
332	3.250263	3.282937	3.293763	3.293763	3.282937	3.261187	3.282937	3.336753	3.462777	3.594584	4.725272	4.658838	4.537676	4.41237	4.257781	3.963744	3.082378	2.206877	1.709186	1.624933
Average	2.879928	2.880883	2.884805	2.930398	2.992858	3.043535	3.098067	3.158158	3.24847	3.29292	4.174083	4.18739	4.170087	4.067701	3.878331	3.626629	3.228284	2.803175	2.389455	2.074057
mei2+T1* 1037	3.028249	3.083557	3.183513	3.294662	3.443344	3.544997	3.694161	3.841926	3.924719	3.907179	3.578093	3.477452	3.352219	3.316382	3.301921	3.316382	3.287385	3.258091		
26	3.314579	3.152063	3.209919	3.468986	3.68705	3.903873	4.11873	4.197094	4.2149	4.155145	3.68705	3.415816	3.290739	3.242501	3.160394	3.084589	2.971707	2.881984	2.836128	2.770766
332	3.431675	3.400307	3.400307	3.462777	3.554531	3.653855	3.816763	3.999586	4.113711	4.130957	3.788536	3.712182	3.644063	3.564585	3.524201	3.493618	3.454239	3.442072	3.483366	3.534338
Average	3.258168	3.211975	3.26458	3.408809	3.561641	3.700908	3.876551	4.012869	4.084443	4.064427	3.68456	3.53521	3.447807	3.393531	3.345605	3.298196	3.242022	3.213479	3.202293	3.187732
mei2+T1 1043	3.720744	3.709678	3.720744	3.65387	3.585829	3.51658	3.374282	3.112041	2.953875	2.9404	2.732487	2.660645	2.575757	2.57265	2.631533	2.703908	2.732487	2.732487	2.703908	2.830893
29	4.263848	4.249202	4.219698	4.174897	4.093587	3.978116	3.835751	3.638931	3.422083	3.223067	3.03939	2.950728	2.836139	2.773215	2.725153	2.668104	2.643323	2.601569	2.567748	2.635018
30	4.226983	4.232708	4.174984	4.074347	3.97037	3.744784	3.551843	3.436013	3.361383	3.292662	3.046934	2.900918	2.905773	2.867339	2.876276	2.876888	2.892753	2.893432	2.911074	2.972213
Average	4.070525	4.063863	4.038475	3.967705	3.883262	3.746493	3.587292	3.395662	3.24578	3.152043	3.046934	2.990918	2.905773	2.867339	2.876276	2.876888	2.892753	2.893432	2.911074	2.972213
mei2+T2* 1037	3.044161	3.02026	3.083557	3.206092	3.345088	3.48444	3.630262	3.756661	3.83592	3.83592	2.889295	2.653692	2.680851	2.830054	2.979975	3.052084	3.083557	3.083557	3.106936	3.099164
1043	2.830893	2.872319	2.91331	3.007313	3.099103	3.201428	3.288812	3.350052	3.362186	3.313424	2.100189	1.99842	2.24803	2.436821	2.512865	2.602203	2.746698	2.80303	2.953875	3.099103
26	3.258664	3.218097	3.330371	3.498965	3.630386	3.864359	4.112619	4.197094	4.226714	4.161172	3.258664	2.854552	2.761315	2.817594	2.900138	2.953969	3.015612	3.015612	2.980528	2.817594
332	3.400307	3.336753	3.336753	3.379244	3.442072	3.524201	3.673401	3.816763	3.927548	4.008493	3.584611	3.410793	3.304558	3.272078	3.239307	3.250263	3.272078	3.326053	3.347422	3.473086
Average	3.133506	3.111857	3.165998	3.272903	3.379162	3.518607	3.676273	3.780143	3.838092	3.829752	2.95819	2.729364	2.748689	2.839137	2.908071	2.96463	3.029486	3.057063	3.097193	3.13605
mei2+T2 29	4.438913	4.401905	4.34079	4.268714	4.189904	4.057319	3.896797	3.686399	3.447662	3.139668	2.498957	2.401757	2.245154	2.254592	2.310616	2.3747	2.437462	2.516301	2.618339	2.789068
30	4.283765	4.272491	4.192413	4.05019	3.836976	3.530448	3.300373	3.109876	2.967574	2.82747	2.517076	2.457183	2.426802	2.575269	2.671411	2.791443	2.90707	3.026953	3.093466	3.190661
Average	4.361339	4.337198	4.266602	4.159452	4.01344	3.793884	3.598585	3.398138	3.207618	2.983569	2.508016	2.42947	2.335978	2.385834	2.491014	2.583071	2.672255	2.771627	2.855903	2.989865
mei2+T3* 1037	2.939113	2.9637	3.028249	3.191059	3.345088	3.544997	3.719325	3.907179	4.038981	4.072387	3.841926	3.564901	3.114487	2.092647	1.663416	1.365347	1.173388	1.26359	1.9682	
1043	2.967303	2.967303	2.926878	2.980685	3.060028	3.176097	3.276448	3.38634	3.44608	3.434205	3.325671	3.03376	2.774965	2.497774	1.99842	1.221345	0.730296	0.870464	1.484883	2.11353
26	3.543395	3.550738	3.658848	3.770149	3.910409	4.155145	4.313909	4.409849	4.453988	4.426475	3.68705	3.153392	2.686449	1.979381	1.770137	0.930602	1.685592	2.314014	2.712788	2.627803
30	3.277184	3.308064	3.338643	3.428629	3.537596	3.684053	3.758121	3.875671	3.951658	3.951658	3.856383	3.690859	3.530448	3.346241	3.060386	2.139245	1.484149	1.300141	1.785378	2.546599
332	3.483366	3.421249	3.35806	3.336753	3.400307	3.483366	3.584611	3.769596	3.936631	4.078972	4.087688	3.845641	3.290386	1.887995	1.210283	0.912165	1.034337	1.450384	1.887995	2.012767
Average	3.242072	3.242211	3.262136	3.341455	3.450686	3.608732	3.730483	3.869727	3.965468	3.992739	3.759744	3.401892	3.007027	2.463847	1.907755	1.373355	1.259944	1.421678	1.830927	2.257395
mei2+T3 29	4.359726	4.411199	4.37385	4.336038	4.258974	4.124334	3.940438	3.733139	3.535533	3.290862	2.928153	2.635018	2.310616	1.988884	1.841402	1.663607	1.786948	1.916036	2.029742	2.197518
Average	4.359726	4.411199	4.37385	4.336038	4.258974	4.124334	3.940438	3.733139	3.535533	3.290862	2.928153	2.635018	2.310616	1.988884	1.841402	1.663607	1.786948	1.916036	2.029742	2.197518
mei2+T4* 1037	3.177814	3.083557	3.075721	3.083557	3.130126	3.221046	3.316382	3.422571	3.564901	3.681495	4.615182	4.647044	4.582961	4.401404	4.066846	3.700473	3.287385	2.905998	2.879184	2.905998
1043	2.899694	2.886031	2.899694	2.9404	2.9404	2.899694	2.899694	2.926878	2.994022	3.150601	4.119572	4.079459	3.966974	3.851149	3.631321	3.251601	2.886031	2.512865	2.06656	1.731739
26	3.084589	2.980538	2.989344	3.041659	3.143708	3.282751	3.423468	3.521259	3.623229	3.844411	4.629689	4.66059	4.711416	4.650324	4.453988	4.155145	3.74498	3.218097	2.845512	2.741258
29	2.773215	2.789068	2.843914	2.950728	3.075584	3.167722	3.257153	3.270681	3.236747	3.466706	4.149721	4.249202	4.283267	4.19489	3.999439	3.727336	3.389805	3.104233	2.812695	2.741258
30	3.158597	3.206571	3.206571	3.190661	3.214496	3.26163	3.353821	3.443379	3.499952	3.601203	4.186614	4.192413	4.151594	4.05019	3.907556	3.677232	3.361383	3.018539	2.718123	2.447089
332	3.347422	3.272078	3.239307	3.228318	3.272078	3.304558	3.400307	3.554531	3.663641	3.963744	4.568344	4.50674	4.475558	4.420328	4.323667	4.182214	4.017377	3.863331	3.712182	3.564585
Average	3.06688	3.036307	3.042425	3.072554	3.129399	3.189567	3.275138	3.35655	3.427082	3.618027	4.378187	4.389343	4.361962	4.26138	4.063803	3.782333	3.44283	3.103844	2.756839	2.540774
hai2+T1* 1037	2.971849	2.947333	2.979975	3.036216	3.153129	3.294662	3.401647	3.544997	3.564901	3.524954	3.228493	3.145481	3.083557	3.041161	3.067864	3.036216	2.971849	2.947333	2.939113	2.979975
332	3.564585	3.462777	3.368668	3.336753	3.368668	3.462777	3.584611	3.807378	4.02624	4.224388	3.644043	3.564585	3.514035	3.462777	3.431675	3.379244	3.315321	3.261187	3.239307	3.163699
Average	3.268217	3.205055	3.174321	3.186485	3.260898	3.37872	3.493129	3.676188	3.79557	3.874671	3.436268	3.365046	3.298796	3.253469	3.249769	3.20773	3.143585	3.10426	3.08921	3.163699
hai2+T1 1043	4.351953	4.407948	4.370708	4.256804	4.149388	4.008254	3.840447	3.69858	3.597252	3.551358	3.264044	2.980685	2.872319	2.80303	2.675119	2.527994	2.405984	2.359266	2.31158	2.359266
26	4.771325	4.771325	4.726502	4.577492	4.381939	4.124829	3.93642	3.837733	3.817612	3.701056	3.400455	3.20172	3.110064	3.041659	2.989344	2.962851	2.909175	2.684649	2.473872	2.378951
29	4.761455	4.719814	4.660544	4.586986	4.484549	4.369149	4.268714	4.189904	4.154773	4.14466	3.310909	3.236747	3.167723	3.111353	3.075584	3.03939	2.995382	2.965685	2.935696	
30	4.232708	4.169153	4.151594	4.104283	4.01973	3.894841	3.724671	3.594199	3.508907	3.443379	2.623993	2.575846	2.507173	2.416609	2.406383	2.396123	2.416609	2.477275	2.526948	2.566127
Average	4.52936	4.51706	4.477337	4.381391	4.259268	3.942563	3.830104	3.769636	3.710113	3.14985	2.998749	2.91412	2.79555	2.74016	2.69279	2.629143	2.565629			
hai2+T2* 1037	2.769559	2.752036	2.77828	2.847106	2.9637	3.106936	3.25072	3.366429	3.450234	3.436436	2.607846	2.455988	2.485083	2.561252	2.662774	2.77828	2.855594	2.897659	2.9637	3.052084
1043	2.844751	2.830893	2.872319	2.926878	3.007313	3.086122	3.16337	3.264044	3.325671	3.362186	1.694763	2.08341	2.296092	2.467417	2.467417	2.512865	2.616895	2.746698	2.994221	3.212621
26	3.400455	3.491497	3.565373	3.694061	3.844411	3.968629	4.081881	4.161172	4.197094	4.112619	3.423468	3.160394	3.101596	3.135332	3.168704	3.152063	3.126932	3.101596	3.041659	2.891074
30	3.026953	3.043714	3.068689	3.118049	3.206571	3.308064	3.406374	3.494463	3.558942	3.609069	3.269417	3.07697	2.96776	2.99316	3.043714	3.068689	3.085229	3.158773	3.023704	3.105212
332	3.788536	3.604529	3.410793	3.389791	3.462777	3.584611	3.712182	3.872574	4.078972	4.182214	2.657873	2.321413	2.162987	2.088647	2.103636	2.235849	2.486772	2.977828	3.082378	3.105212
Average	3.160051	3.144534	3.139091	3.195177	3.296954	3.410872	3.522906	3.631737	3.722183	3.744504	2.730673	2.619635	2.602666	2.642329	2.679138	2.744554	2.830977	2.961802	3.008711	3.128153
hai2+T2 29	4.891001	4.85512	4.79845	4.715619	4.569416	4.283267	3.918696	3.602837	3.344031	3.075584	2.472754	2.419662	2.437462	2.490248	2.576238	2.684513	2.781152	2.836139	2.882494	2.928153
Average	4.891001	4.85512	4.79845	4.715619	4.569416	4.283267	3.918696	3.602837	3.344031	3.075584	2.472754	2.419662	2.437462	2.490248	2.576238	2.684513	2.781152	2.836139	2.882494	2.928153
hai2+T3* 1037	3.145481	3.130126	3.153129	3.258091	3.443344	3.61081	3.8299	4.016491	4.175966	4.218058	3.130126	3.036216	2.82149	2.465719	1.991234	1.435873	0.967592	0.95113	1.624556	2.426593
1043	3.676289	3.720744	3.731779	3.764699	3.786492	3.797343	3.786492	3.818954	3.818954	3.959516	2.721433	1.786553	1.005769	0.584904	0.382213	0.150601	0.85318	1.55472	1.484883	2.447005
Average	3.410885	3.425435	3.442454	3.511395	3.614918	3.704076	3.808196	3.885124	3.98191	4.018506	3.140363	2.947388	2.621462	2.126136	1.498502	1.010389	0.674903	0.74317	1.55472	2.447005
hai2+T3 26	4.868668	4.920929	4.925637	4.863873	4.761421	4.582751	4.387541	4.226714	4.11873	4.075697	3.408145	2.826875	1.685592	0.430586	0.286596	0.430586	0.625318	1.161205	1.979381	2.346653
29	4.875106	4.875106	4.843065	4.786168	4.690323	4.578214	4.40655	4.229127	3.967398	3.784878	3.152485	2.741258	2.498957	2.265154	2.273382	2.428575	2.717068	3.046664	3.466706	3.584628
30	4.999762	4.317348	4.226983	4.18644	4.128028	4.01973	3.894841	3.784677	3.684053	3.640053	3.744784	3.523284	2.585534	1.63183	1.073467	0.604978	0.87046	1.211428	1.947572	2.836139
332	4.903732	4.847565	4.812018	4.747152	4.651382	4.498976	4.339955	4.173721	3.999586	3.844775	3.127905	2.683502	2.058483	1.590682	1.171908	1.09393	1.152568	1.556108	2.391222	3.634204
Average	4.761817	4.740237	4.701926	4.645952	4.557788	4.419918	4.257223	4.099953	3.942442	3.847351	3.351594	2.94373	2.207142	1.474563	1.201338	1.147517	1.273924	1.748351	2.449245	3.025568
hai2+T4* 1037	2.607846	2.485083	2.416727	2.36368	2.416727	2.542399	2.769559	3.028249	3.265443	3.337938	4.522139	4.503161	4.366663	4.148847	3.817823	3.518241	3.206092	2.847106	2.504316	2.136588
26	2.57265	2.57265	2.631533	2.660645	2.732487	2.816986	2.844751	2.858559	2.91331	2.980685	4.398671	4.178978	3.851149	3.44608	2.953875	2.587414	2.150094	1.893925	1.750096	1.768367
26	3.415816	3.330371	3.218097	3.242501	3.314579	3.484012	3.651757	3.701056	3.68705	3.651757	4.995404	4.981576	4.925637	4.800851	4.561659	4.208976	3.910409	3.572664	3.193499	3.07605
29	2.725153	2.651606	2.584705	2.584705	2.692685	2.935696	3.167722	3.308064	3.304242	3.310909	4.608806	4.6215	4.591362	4.511606	4.312164	3.825419	3.523134	3.174696	2.92929	2.987985
30	2.915766	2.898304	2.889537	2.898304	2.889537	2.92446	2.965574	2.984654	2.941777	2.967574	4.203979	4.116178	4.068325	3.982783	3.784627	3.530448	3.292662	3.085229	2.91331	2.536789
332	3.816763	3.702525	3.604529	3.574612	3.564585	3.524201	3.493618	3.483366	3.524201	3.721814	4.854633	4.797702	4.698591	4.575971	4.41237	4.163528	3.79756	3.304558	2.831618	2.418477
Average	3.088999	2.94009	2.890855	2.887941	2.9351	3.037959	3.149163	3.217709	3.27267	3.328446	4.597272	4.533957	4.416505	4.244356	3.973753	3.639141	3.313394	2.979696	2.689208	2.487426
dou1+T1* 1037	3.970974	3.965233	3.970974	3.982422	3.965233	3.988128	3.999507	4.027758	4.061295	4.010841	3.380236	3.324662	3.33077	3.323586	3.324662	3.324662	3.328009	3.294662		
1043	3.709678	3.676289	3.631321	3.574372	3.551358	3.562882	3.574372	3.585829	3.574372	3.504918	3.239118	3.060028	2.994022	2.9404	2.926878	2.91331	2.91331	2.899694	2.9404	3.112041
Average	3.840326	3.820761	3.801148	3.778397	3.758296	3.775505	3.78694	3.806794	3.817834	3.75788	3.382036	3.251686	3.17312	3.105023	3.09171	3.114615	3.127999	3.14533		
dou1+T1 26	3.68705	3.446311	3.361715	3.431101	3.608866	3.916933	4.302424	4.459462	4.588002	4.540423	3.453888	3.330371	3.226253	3.193499	3.176991	3.160394	3.084589	2.980538	2.826875	2.694337
29	2.905409	2.836139	2.843914	2.943221	3.111353	3.330826	3.523134	3.686399	3.750483	3.662758	2.923756	2.920959	2.882894	2.851669	2.828345	2.804840	2.804840	2.773215	2.733212	2.694337
30	3.166643	3.182676	3.238152	3.368926	3.523284	3.649798	3.83048	3.976583	4.01973	4.044122	3.580144	3.523284	3.450728	3.391448	3.383959	3.391448	3.383959	3.41381	3.465374	
332	2.989593	3.161683	3.282937	3.304558	3.389791	3.524201	3.702525	3.863331	4.017377	4.017377	3.462777	3.442072	3.415321	3.379244	3.347422	3.304558	3.326053	3.362053	3.058761	
Average	3.187174	3.156702	3.181679	3.261952	3.408323	3.605439	3.839641	3.996444	4.093898	4.06617	3.440183	3.33013	3.257311	3.216937	3.197966	3.181902	3.151733	3.110568	3.074988	3.058761
dou1+T2* 1037	3.841926	3.853902	3.859871	3.871771	3.913038	3.942153	3.94794	3.982422	3.999507	3.942153	2.716665	2.671827	2.698814	2.789259	2.872494	2.987157	3.130126	3.287385	3.346239	
1043	3.585829	3.457919	3.410346	3.362186	3.301137	3.276448	3.288812	3.313424	3.337881	3.362186	1.981197	2.311981	2.482625	2.646116	2.732487	2.830893	2.886031	2.953875	3.007313	2.980685
Average	3.713878	3.65591	3.635108	3.616979	3.607087	3.6093	3.618376	3.647923	3.668694	3.65217	2.348931	2.491904	2.59072	2.647687	2.731657	2.802491	2.909485	3.01958	3.12823	3.170009
dou1+T2 29	3.579938	3.521259	3.521259	3.594436	3.680024	3.851074	4.220812	4.393133	4.459462	4.381939	2.918186	2.971707	2.980538	2.945062	3.015612	3.193499	3.369502	3.513846	3.491497	3.369502
29	2.765257	2.692685	2.752278	2.935696	3.153727	3.376797	3.541713	3.645838	3.662758	3.608882	2.516301	2.463969	2.490248	2.472754	2.559233	2.702525	2.76522	2.765257	2.76522	2.761258
30	3.118049	3.198626	3.315737	3.383959	3.465374	3.551843	3.670396	3.83048	3.951658	3.97037	3.060386	3.001642	2.941777	2.92446	2.976125	3.026953	3.093466	3.166643	3.222401	3.277184
332	3.483675	3.431675	3.410793	3.442072	3.420729	3.50384	3.614448	3.778022	3.712182	4.165208	4.127877	3.154058	3.105212	3.002473	3.172873	3.172873	4.483466	3.172873		
Average	3.22373	3.211061	3.251267	3.333835	3.435299	3.570889	3.761842	3.914877	4.011654	4.0316	2.989412	2.919156	2.896359	2.877557	2.892426	2.953991	3.046787	3.154655	3.250526	3.301177
dou1+T3* 1037	3.877703	3.84792	3.83592	3.8299	3.863623	3.953716	3.901308	3.877703	3.889512	3.511513	3.516913	3.264161	2.698814	1.142677	0.655702	0.653737	1.382762			
1043	3.350052	3.410346	3.374282	3.313424	3.264044	3.350052	3.398361	3.457919	3.481489	3.410346	3.251601	3.060028	2.774965	2.452149	1.929068	1.345193	1.221345	1.405674	1.929068	2.482625
Average	3.664175	3.676556	3.671521	3.657935	3.659382	3.711416	3.716625	3.727732	3.712405	3.670355	3.424007	3.198296	2.973163	2.680167	2.28203	1.74292	1.235865	0.92905	1.12088	1.675751
dou1+T3 26	3.587196	3.461446	3.468986	3.550738	3.68705	3.897322	4.161172	4.365071	4.475824	4.519039	3.905	3.506414	2.751835	1.777984	0.998206	0.606387	1.031543	1.991543	2.314814	2.335811
29	2.965685	2.905409	2.987985	3.125543	3.290862	3.504441	3.662758	3.758931	3.807593	3.767729	3.727336	3.516916	3.324001	0.970122	2.595349	2.158865	1.786948	1.720292	1.926551	2.168575
332	3.283673	3.304558	3.293763	3.315321	3.347422	3.421249	3.524201	3.624339	3.712182	3.788536	3.909315	3.721814	2.845853	1.791546	1.022329	1.468218	1.872995	2.342306	3.168575	
Average	3.289401	3.223804	3.250245	3.330534	3.441778	3.60767	3.78271	3.909447	3.998533	4.025101	3.87056	3.581715	2.973964	2.193221	1.60691	1.411157	1.563529	1.996905	2.394289	2.722676
dou1+T4* 1043	3.337881	3.337881	3.313424	3.288812	3.264044	3.239118	3.188783	3.16337	3.176097	3.264044	3.500793	3.581715	3.398361	3.099103	2.703908	2.150094	1.619743	1.049848	0.75401	0.682432
Average	3.337881	3.337881	3.313424	3.288812	3.264044	3.239118	3.188783	3.16337	3.176097	3.264044	3.500793	3.581715	3.398361	3.099103	2.703908	2.150094	1.619743	1.049848	0.75401	0.682432
dou1+T4 1037	2.426593	2.475417	2.504316	2.504316	2.542399	2.653692	2.838593	3.044161	3.265443	3.558282	3.953716	3.924719	3.877703	3.750472	3.511513	3.191059	2.786974	2.29956	1.727031	1.293036
26	3.250593	3.11851	3.024318	3.033001	3.041659	3.093104	3.185256	3.303371	3.491497	3.68705	4.426475	4.475824	4.313909	4.131999	3.709859	3.535533	3.330826	3.146706		
29	2.958216	2.882494	2.890151	2.943221	3.0321	3.132614	3.243564	3.370272	4.498184	3.644905	4.057319	4.103871	4.119231	4.093587	3.994123	3.869201	3.709859	3.535533	3.330826	3.146706
30	3.043714	3.035345	3.018539	2.984654	3.018539	3.14244	3.389897	3.883959	3.97037	4.058001	3.968971	3.711119	3.508907	3.253823	2.947777	2.674633	2.775869	3.058001		
332	3.452439	3.389791	3.336753	3.304558	3.293763	3.304558	3.315321	3.347422	3.462777	3.663641	4.274364	4.274364	4.207577	4.105057	3.999586	3.604529	2.644991	1.341519	0.912165	0.849516
Average	3.026311	2.980311	2.954816	2.95395	2.980616	3.040501	3.145035	3.286174	3.420372	3.640735	4.14744	4.152461	4.125146	4.04381	3.906064	3.662137	3.252001	2.710629	2.251444	2.007157

1c: Preposition

Table 8.15 mean F0 values (in Hz) of participant 1 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	286.5	273	263	251	234.5	213	199.5	190.5	184.5	179	196	187	182.5	180	178	176	173	173	174	176
zai4+T3	ai4	zai4 'in/at'	na3 'where'	277	273.5	267.5	262.5	255.5	245.5	230	218	207	196	159.5	127.5	108.5	100	103.5	117	144	153.5	159	161.5
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	250.5	242	233	224	214.5	207.5	202.5	197	189	189.5	246	249.5	252	247	236	220	196.5	173.5	151.5	127

Table 8.16 mean F0 values (in Hz) of participant 2 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	170.5	171.5	170	165.5	159	152	145.5	138	130	121.5	150.5	144.5	139	137	136.5	135.5	131.5	131.5	130	135
zai4+T3	ai4	zai4 'in/at'	na3 'where'	136	136.5	133.5	133.5	137.5	144.5	152	160.5	165.5	172	180.5	165	152	141.5	122.5	98	78.5	70.5	76.5	93.5
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	195.5	192	187.5	183.5	179.5	177	173	168	162.5	157.5	205	200	199	193	183.5	167.5	149	133	116	100.5

Table 8.17 mean F0 values (in Hz) of participant 3 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	294.5	296.5	295.5	287	272	253.5	230.5	210.5	202	200.5	202.5	189	182.5	175.5	175.5	173	170	166	160	151.5
zai4+T3	ai4	zai4 'in/at'	na3 'where'	204	197	197	203	215	234.5	252.5	270.5	285	295	240.5	201	150.5	113	84.5	81.5	104	140	144	137.5
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	283	280.5	278	274.5	267.5	260.5	254	252	245.5	243.5	313	309	305.5	299.5	289	275.5	255.5	224.5	189.5	168

Table 8.18 mean F0 values (in Hz) of participant 4 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	291	286	279.5	271.5	261.5	249	243	231.5	217.5	212.5	218.5	216.5	210.5	203.5	197	197	200	200	201.5	199.5
zai4+T3	ai4	zai4 'in/at'	na3 'where'	326	324.5	320	315.5	309	300	283	259	243	226.5	197.5	182.5	164.5	149	136.5	126.5	128	143	152	153.5
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	298	293	288.5	284.5	277.5	268.5	262.5	259.5	251.5	253.5	320.5	328.5	329	324	312	289.5	263.5	234.5	217	216

Table 8.19 mean F0 values (in Hz) of participant 5 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	193	192	187.5	183.5	175	160	136	106	110.5	112	223.5	219	217	215.5	216	214.5	216	214	213	220.5
zai4+T3	ai4	zai4 'in/at'	na3 'where'	194	191	190.5	193.5	201.5	212.5	222.5	233.5	240	246.5	220	194.5	170	140	105	95	117.5	146	148	152.5
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	185.5	180.5	173.5	164	147	127.5	113.5	110.5	116	134	233	233	229.5	222.5	210.5	194	179.5	150.5	95.5	87.5

Table 8.20 mean F0 values (in Hz) of participant 6 for tone sandhi with preposition in disyllabic words

combination	TBU	1st syllable	2nd syllable	syllable 1										syllable 2									
				F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1	ai4	zai4 'in/at'	jia1 'home'	177.5	174.5	171	168	166.5	163.5	160.5	160.5	167.5	173	195.5	193.5	191.5	191	188.5	187.5	186	185.5	186	184.5
zai4+T3	ai4	zai4 'in/at'	na3 'where'	187	183	180.5	179.5	181	184	186	189.5	194.5	198.5	183	142	112.5	85.5	73.5	72.5	75	80	88	105
zai4+T4	ai4	zai4 'in/at'	zhe4 'here'	182	177.5	172.5	167.5	164.5	161	155	149	152	163.5	212.5	212	211	207	201	191	172.5	148.5	130.5	116.5

Table 8.21 mean F0 values (in T-value, 5-scale measurement) of all participant for tone sandhi with preposition in disyllabic words

combination	participants	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
zai4+T1*	1037	4.371652	4.233795	4.127209	3.993823	3.799612	3.524954	3.337938	3.206092	3.114687	3.028249	3.287385	3.153129	3.083557	3.044161	3.012248	2.979975	2.930871	2.930871	2.947333	2.979975
	1043	3.585829	3.608641	3.574372	3.469722	3.313424	3.13779	2.967303	2.760857	2.527897	2.264117	3.099103	2.9404	2.789023	2.732487	2.718224	2.68954	2.57265	2.57265	2.527897	2.675119
	26	4.582751	4.6037	4.593244	4.502904	4.336752	4.11873	3.824333	3.543395	3.415816	3.392745	3.423468	3.209919	3.101596	3.033001	2.980538	2.936129	2.881984	2.808285	2.694337	2.525374
	29	4.046877	3.994123	3.924146	3.835751	3.721521	3.572428	3.498184	3.350613	3.160733	3.089942	3.174696	3.146706	3.061158	2.958216	2.859405	2.859405	2.905409	2.905409	2.928153	2.89779
	Average	4.146777	4.110065	4.054743	3.95055	3.792827	3.588475	3.40694	3.215239	3.054783	2.943763	3.246163	3.112538	3.008833	2.941966	2.892604	2.866262	2.822728	2.804304	2.77443	2.769564
zai4+T1	30	3.134331	3.118049	3.043714	2.976125	2.82747	2.546599	2.037216	1.256099	1.386412	1.428673	3.594199	3.530448	3.501693	3.479952	3.487216	3.465374	3.458059	3.443379	3.458059	3.551843
	332	3.462777	3.400307	3.326053	3.261187	3.228318	3.161683	3.093813	3.093813	3.050263	3.368668	3.816763	3.779078	3.741002	3.73142	3.683135	3.663641	3.634204	3.624339	3.634204	3.604529
	Average	3.298554	3.259178	3.184883	3.118656	3.027894	2.854141	2.565514	2.174956	2.318338	2.39867	3.705481	3.654763	3.621347	3.605686	3.585175	3.564507	3.546132	3.533859	3.546132	3.578186
zai4+T3*	1037	4.27534	4.239021	4.175666	4.121774	4.044576	3.930542	3.74427	3.591225	3.443344	3.287385	2.698814	2.059241	1.598353	1.365347	1.463603	1.813775	2.406827	2.589299	2.689847	2.734405
	29	4.392582	4.378544	4.336038	4.29293	4.229564	4.139591	3.962025	3.528207	3.398361	3.28415	2.867121	2.62669	2.310616	2.009382	1.742673	1.511089	1.54697	1.884274	2.070059	2.09995
	Average	4.333961	4.308783	4.255852	4.207352	4.13707	4.035067	3.853148	3.641753	3.470764	3.285768	2.782967	2.342966	1.954485	1.687365	1.603138	1.662432	1.976898	2.236787	2.379953	2.417178
zai4+T3	1043	2.703908	2.718224	2.631533	2.631533	2.746698	2.9404	3.13779	3.350052	3.469722	3.619998	3.808163	3.457919	3.13779	2.858559	2.296092	1.425628	0.560136	0.140843	0.459462	1.242261
	26	3.446311	3.338237	3.338237	3.431101	3.608866	3.877586	4.106496	4.319636	4.481259	4.588002	3.955785	3.400455	2.504876	1.61786	0.718275	0.606387	1.360966	2.281027	2.368222	2.225256
	30	3.150529	3.101682	3.093466	3.14244	3.269417	3.436013	3.580144	3.731389	3.817447	3.901205	3.544728	3.158597	2.736614	2.128071	1.22639	0.912698	1.578929	2.2596	2.302244	2.396123
	332	3.653855	3.574612	3.524201	3.50384	3.534338	3.594584	3.634204	3.702525	3.797969	3.872574	3.574612	2.644991	1.791546	0.785778	0.231541	0.181337	0.30558	0.542104	0.891401	1.538698
	Average	3.238651	3.183189	3.146859	3.177229	3.28983	3.462146	3.614658	3.775901	3.891599	3.995445	3.720822	3.16549	2.542707	1.847567	1.118074	0.781512	0.951403	1.305893	1.505332	1.850584
zai4+T4*	1037	3.988128	3.88953	3.781284	3.668773	3.544997	3.450234	3.380568	3.301921	3.183513	3.191059	3.936353	3.976703	4.00518	3.94794	3.817823	3.617309	3.294662	2.939113	2.551841	2.048018
	1043	4.119572	4.049102	3.956586	3.872466	3.786492	3.731779	3.642612	3.528207	3.398361	3.276448	4.304669	4.208345	4.188791	4.069366	3.872466	3.51658	3.060028	2.616895	2.08341	1.523893
	26	4.459462	4.431997	4.404287	4.365071	4.285116	4.203041	4.124829	4.10036	4.019475	3.994156	4.771325	4.731515	4.696256	4.634861	4.524399	4.376326	4.143054	3.742696	3.218097	2.845354
	29	4.119231	4.067726	4.020614	3.978116	3.902286	3.80193	3.733139	3.698152	3.602887	3.626947	4.34079	4.415835	4.420465	4.37385	4.258974	4.031147	3.744713	3.389805	3.153727	3.139668
	Average	4.171598	4.109589	4.040693	3.971106	3.879723	3.796746	3.720287	3.65716	3.551047	3.522153	4.338284	4.3331	4.327673	4.256504	4.118415	3.88534	3.560614	3.172127	2.751769	2.389233
zai4+T4	30	3.010102	2.92446	2.800489	2.623993	2.280994	1.834933	1.470371	1.386412	1.538659	1.990781	3.724671	3.724671	3.677232	3.580144	3.406374	3.150529	2.907047	2.354746	0.929151	0.65494
	332	3.554531	3.462777	3.35806	3.250263	3.184029	3.105212	2.966024	2.821341	2.894397	3.161683	4.122344	4.113711	4.096383	4.02624	3.918443	3.73142	3.35806	2.809022	2.335482	1.919588
	Average	3.282316	3.193619	3.079274	2.937128	2.732512	2.470073	2.218198	2.103876	2.216528	2.576232	3.923507	3.919191	3.886807	3.803192	3.662408	3.440975	3.132554	2.581884	1.632317	1.287264

1d: neutral tones

Table 8.22 mean F0 values (in Hz) of participant 1 for tone sandhi with neutral tones as the second syllable in disyllabic words

			syllable 1										syllable 2									
	combination	word	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	135.5	128	122	119	120	127.5	141	157.5	178.5	198.5	218.5	215.5	207.5	197	183.5	169.5	154.5	137	123.5	120
		dao1+*gu1* 'whisper'	128	118	119	122	129	141	160	177	186	192.5	206	204	198	187	174.5	162.5	151.5	140	130	122.5
	+T0(T2)	*gou1*+*lou2* 'stoop'	167	162.5	157.5	155.5	156	157	161	169	182.5	203.5	235	238.5	236	228.5	218	205.5	190	175	153	136.5
	+T0(T3)	*duo1*+*zan3* 'when'	246.5	250.5	254.5	256	255	254.5	255	253.5	251	247.5	223.5	214	194.5	172.5	148.5	124	98.5	89.5	108.5	137.5
	+T0(T4)	*pu1*+*ke4* 'poker'	156.5	155	155.5	159	165	173.5	184	196	202	204	245	243	235.5	222	206	186.5	165	146	130.5	119.5
		gan1+*jing4* 'tidy'	221.5	212.5	209.5	208	205	204	205	205.5	207	205.5	202.5	193.5	181	172	163	153	145	138.5	130.5	125.5
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	146	141.5	137.5	137.5	143	151	159	167	173	176.5	201.5	198	197.5	191.5	180	164.5	149	134	123.5	113
	+T0(T3)	*he2*+*zi3* * 'box'	160.5	151.5	147.5	149	154.5	160.5	171	185	198.5	205	225.5	221.5	214.5	203.5	189.5	175.5	159	137	115.5	98.5
T3	+T0(T2)	*gu3*+*tou2* 'bone'	176.5	172.5	164	157.5	151.5	143	130.5	123.5	138	154.5	207	211.5	213	208	199	187.5	171.5	159	141	123
	+T0(T3)	*shang3*+*wu3* 'noon'	213	197	178.5	163.5	150.5	136.5	101	82.5	97.5	132.5	180.5	184	188	190.5	191	191	188	181.5	172.5	165.5
	+T0(T4)	*da3*+*ban4* 'dress up'	106	110	115.5	123.5	135.5	145.5	155.5	166	172	175	215.5	216	211	205	197	187	172	154	131	104.5
		zhu3+*yi4* 'idea'	155	150	147	143.5	145	151	159	169	181	194	224.5	225	225	220.5	210	195.5	174	158	144.5	131
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	299.5	298.5	292	278.5	264.5	248.5	225.5	209.5	196	182	154	152.5	157.5	165.5	172.5	189	200	205	206.5	205.5
	+T0(T3)	*dui4*+*wu3* * 'team'	300.5	297	287	269.5	246.5	229.5	213.5	197	181.5	168.5	148	140.5	133.5	128	123.5	120	114.5	109	102	92
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	169.5	157	148	141	149	159	163.5	167	173	195	232	232	223	205.5	187.5	164	145.5	130.5	121	120

Table 8.23 mean F0 values (in Hz) of participant 2 for tone sandhi with neutral tones as the second syllable in disyllabic words

			syllable 1										syllable 2									
	combination	word	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	110	108.5	106.5	104.5	105	110	120.5	128	134	146	171	171	166	160	151	141	127	111	97	90.5
		dao1+*gu1* 'whisper'	92	91.5	91.5	96	120.5	137	146	152	158.5		165	163	160	154.5	146	135	121.5	106	91.5	83
	+T0(T2)	*gou1*+*lou2* 'stoop'	133.5	127.5	125.5	125.5	127.5	135	144	151	158.5	166	182.5	175	166	156	145.5	129	110.5	99.5	92	88
	+T0(T3)	*duo1*+*zan3* 'when'	183	180.5	177.5	177	176.5	176	175	173	175	173.5	168	164	157	150.5	141.5	130.5	113.5	100.5	93	90.5
	+T0(T4)	*pu1*+*ke4* 'poker'	164.5	164.5	164.5	165.5	167.5	169	171	172	171.5	172	194.5	194	189	180	169	155.5	130	115.5	100.5	
		gan1+*jing4* 'tidy'	169	161	155	152.5	151.5	152.5	153.5	154	154.5	153.5	156	156.5	159	158.5	157	150.5	141.5	132.5	121	119.5
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	130	123	122	125.5	130.5	135	141	149	152.5	154.5	165.5	161.5	159	150.5	128	110	98	91	87.5	83
	+T0(T3)	*he2*+*zi3* * 'box'	138	136.5	139.5	141.5	144	150.5	156.5	164	169.5	169	191.5	186	179.5	170	158.5	142.5	127	111	97	90.5
T3	+T0(T2)	*gu3*+*tou2* 'bone'	162.5	154	144.5	136	120.5	95.5	81	75.5	84	95.5	142	147.5	148.5	144.5	137.5	134	133.5	135.5	138	141.5
	+T0(T3)	*shang3*+*wu3* 'noon'	164	150	140	133.5	128.5	117	102	90.5	80	81.5	124	134	138.5	148	152	151	149.5	148	151.5	154
	+T0(T4)	*da3*+*ban4* 'dress up'	108	103.5	99.5	99.5	103.5	109	117.5	126	134.5	138	154.5	153.5	152	148	141	131	115	100.5	91.5	84.5
		zhu3+*yi4* 'idea'	134.5	128	122.5	119.5	120	125	134	142.5	148	152.5	164.5	165	162.5	157.5	151	143	134.5	123.5	111	105
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	211.5	204.5	195.5	187.5	179.5	171.5	155.5	140.5	130.5	123	93.5	106.5	118.5	127	137.5	140.5	145.5	150	154.5	158
	+T0(T3)	*dui4*+*wu3* * 'team'	230.5	227	221.5	214.5	205	195.5	186	177	169.5	163	151.5	146.5	139.5	134.5	129	120	111.5	99	87	81.5
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	140.5	135.5	129	125.5	125	127.5	130	135.5	142	157.5	173.5	169	158.5	145.5	134.5	126.5	118.5	112.5	107	101.5

Table 8.24 mean F0 values (in Hz) of participant 31 for tone sandhi with neutral tones as the second syllable in disyllabic words

			syllable 1										syllable 2									
	combination	word	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	181	175	172	171.5	172	173.5	179	184.5	196.5	212	248.5	243	237	230.5	222.5	213.5	207.5	207	205	203
		dao1+*gu1* 'whisper'	184.5	180	166	155.5	158.5	171.5	181	191.5	204	224.5	266	266	260	250.5	238	221	198.5	177	169	162
	+T0(T2)	*gou1*+*lou2* 'stoop'	214	195	181	170.5	166.5	168.5	179	188	204	220	235.5	246	255	254	248	237.5	221	197.5	167.5	138
	+T0(T3)	*duo1*+*zan3* 'when'	263.5	272.5	275	275.5	275.5	270	270	269	258.5	257.5	245.5	209.5	170	117	83	81	109	152	159	153
	+T0(T4)	*pu1*+*ke4* 'poker'	192	184	183.5	186	189.5	195	206.5	217.5	231.5	245.5	301.5	304.5	291	280.5	263	241	210	186	161	148.5
		gan1+*jing4* 'tidy'	185.5	170.5	145.5	135.5	135.5	151.5	172.5	187	200.5	202	238	252.5	253.5	247.5	236	223	202.5	176.5	133.5	110
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	175.5	167.5	164	164	168	170	172	173.5	178.5	193.5	228	227.5	219.5	219.5	212.5	198	183	153.5	125.5	120.5
	+T0(T3)	*he2*+*zi3* * 'box'	182.5	172	171	172	178	177.5	180	185.5	198	201.5	235.5	234	226.5	214.5	203.5	192	177	159	140	125.5
T3	+T0(T2)	*gu3*+*tou2* 'bone'	182.5	176.5	171	173	178	185.5	197.5	210	220.5	215	256	260.5	261.5	257	250	243	234	218	200.5	186.5
	+T0(T3)	*shang3*+*wu3* 'noon'	194.5	184.5	179.5	180	192	207	226	240	250	255	218.5	183	118.5	81	71.5	80	104.5	115.5	117	107
	+T0(T4)	*da3*+*ban4* 'dress up'	196.5	193.5	183.5	169	151.5	138.5	142	153.5	158	159	210	213	216.5	220	221	217	208.5	199.5	189	181
		zhu3+*yi4* 'idea'	190.5	182	177.5	177.5	180.5	189.5	201.5	209.5	222	239.5	260	261	267	270	269	261.5	238.5	218	186.5	166
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	275.5	290	302	304	300.5	285	265.5	244.5	222	206.5	169.5	163.5	163.5	165.5	171	176	181.5	183	182	178
	+T0(T3)	*dui4*+*wu3* * 'team'	301	305	307.5	305.5	296.5	280.5	263	247.5	235.5	223	195.5	186	176	169	166.5	162	146.5	134	121.5	111
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	186.5	175.5	169	168	175.5	183.5	187	198.5	213	219	255	267.5	274.5	274.5	263	247.5	226	197	161.5	135

Table 8.25 mean F0 values (in Hz) of participant 4 for tone sandhi with neutral tones as the second syllable in disyllabic words

			syllable 1										syllable 2									
	combination	word	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	179	175	169	165	167	175	186.5	200.5	226.5	243	259.5	260.5	254.5	244.5	227	210	197.5	186	172.5	170.5
		dao1+*gu1* 'whisper'	180.5	170.5	166.5	167.5	183.5	198.5	210	222	229	245	255.5	258.5	254.5	244.5	231.5	217	200	187.5	180.5	184.5
	+T0(T2)	*gou1*+*lou2* 'stoop'	178.5	173.5	171	173	174.5	181	191.5	205.5	221	237	264.5	265	259	245.5	228.5	206.5	186	175	171	168
	+T0(T3)	*duo1*+*zan3* 'when'	196.5	198	207	221.5	241	259.5	272	274.5	271.5	267	241	227.5	216	192	162.5	136	126	134.5	169.5	205.5
	+T0(T4)	*pu1*+*ke4* 'poker'	193	191.5	194	198	203	207.5	211	211.5	208	205	289	288	280.5	268.5	252	235.5	221.5	211.5	206.5	205.5
		gan1+*jing4* 'tidy'	160.5	159.5	157	144.5	136	158	179.5	199	213	217	256	263.5	265	260.5	245.5	227.5	205.5	188	178.5	183.5
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	178	180.5	184	191.5	198.5	207	211.5	216.5	215.5	214	252.5	258	257.5	254	245	232	215	201	187	174
	+T0(T3)	*he2*+*zi3* * 'box'	183	177.5	170	164.5	163	166.5	173	194	211	216	253	259	255	244	232	223.5	215	208	208	211
T3	+T0(T2)	*gu3*+*tou2* 'bone'	178	179.5	180	183	187	193	201	212	215.5	215.5	260	267	267.5	264	253.5	235	214	195	190.5	190
	+T0(T3)	*shang3*+*wu3* 'noon'	195.5	186.5	176.5	178.5	186.5	200.5	215.5	233.5	246	255.5	259.5	248.5	224	182	152.5	133.5	144	153	167.5	172
	+T0(T4)	*da3*+*ban4* 'dress up'	188.5	179	142	130.5	119	124.5	139	152	162	186	236	241	240	234.5	223	208.5	193	188	191	191
		zhu3+*yi4* 'idea'	187	183.5	182	182	185.5	191.5	202	215.5	230.5	245.5	259	266.5	270.5	274.5	278.5	279.5	274	262	243	220
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	178	177	177	177.5	178.5	184.5	194	208.5	225.5	243.5	265	272.5	272.5	263.5	244	234.5	236	240	243	244.5
	+T0(T3)	*dui4*+*wu3* * 'team'	332.5	330	337	337.5	335.5	329	315	292.5	262.5	234.5	216	191	176	162.5	146.5	133	122	117.5	118.5	119.5
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	184.5	180	178.5	181	186.5	193.5	200.5	208	221.5	239	263.5	268.5	275.5	284.5	265	248.5	225.5	207.5	202.5	203

Table 8.26 mean F0 values (in Hz) of participant 5 for tone sandhi with neutral tones as the second syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	187	185	180	173	165.5	161.5	162	170	187	206.5	227.5	225.5	219	208	198.5	186	168.5	151.5	141	129
		dao1+*gu1* 'whisper'	188.5	176	164.5	155.5	152.5	160.5	175	189	199	198	238	240	240.5	234.5	225.5	214.5	193	162	145	141
	+T0(T2)	*gou1*+*lou2* 'stoop'	185	183.5	181	179.5	177.5	179.5	187	204	219	228	235	229.5	224.5	216.5	205	188.5	168.5	154.5	149.5	146.5
	+T0(T3)	*duo1*+*zan3* 'when'	194	194	196	199.5	203.5	209	216	223.5	229.5	227.5	223	218.5	206.5	189	177	167.5	152.5	141	145.5	157.5
	+T0(T4)	*pu1*+*ke4* 'poker'	195	192.5	189	186.5	186	186.5	188	193	201	214	242	237	237.5	233	223	208.5	192	179.5	173.5	164
		gan1+*jing4* 'tidy'	171.5	162	162	165.5	159.5	148.5	137.5	139.5	146	147	225.5	234	236	230.5	218.5	205.5	190.5	183	173	167
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	171.5	165.5	163	163	165.5	170.5	178	185	190.5	192	212.5	216.5	221.5	222	216	206.5	190.5	160	133	127
	+T0(T3)	*he2*+*zi3* * 'box'	186	183.5	181.5	180	181.5	184	189	196	199.5	203.5	220.5	221	220.5	219.5	218	215	210.5	202	194	188
T3	+T0(T2)	*gu3*+*tou2* 'bone'	186.5	190	190.5	186	179.5	168.5	149.5	111	115.5	139	196.5	200	203.5	208.5	208	205	199	190.5	177	164.5
	+T0(T3)	*shang3*+*wu3* 'noon'	195	185.5	181	182	183.5	189.5	201.5	214.5	223	228.5	229	226	219.5	210.5	198.5	185.5	170.5	155	156	155.5
	+T0(T4)	*da3*+*ban4* 'dress up'	190.5	182	174	165.5	156.5	138.5	98	95	120	137	205.5	204.5	204.5	203	197.5	188	174	152.5	130	129.5
		zhu3+*yi4* 'idea'	191	190.5	185	180	179.5	180.5	181.5	182.5	189.5	201	221	223.5	228	232	233.5	233	227	217.5	204	186
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	253	259.5	257.5	248.5	232	217.5	207	192	173	165.5	173	175	171	168	170	179	185	196.5	203.5	212.5
	+T0(T3)	*dui4*+*wu3* 'team'	268	275	277.5	275	270.5	264	255.5	244.5	233.5	221.5	209	199	186.5	177.5	169.5	161.5	150.5	137	129	127
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	178	173.5	171	168.5	167.5	171	176	183.5	196.5	210.5	244.5	242	240.5	234.5	224.5	208.5	191.5	174	156	136.5

Table 8.27 mean F0 values (in Hz) of participant 6 for tone sandhi with neutral tones as the second syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	178.5	173.5	171	169	167	165	168.5	174	181	188.5	207	204	198.5	190.5	181	159.5	140	126.5	121	119
		dao1+*gu1* 'whisper'	174.5	165	161.5	161.5	161.5	162	167.5	173.5	178	185	208	207	206.5	203.5	198	193	186.5	175.5	164.5	159.5
	+T0(T2)	*gou1*+*lou2* 'stoop'	173	169.5	165	162.5	162.5	164.5	169.5	172.5	178	190.5	207	210	209	205.5	198.5	190.5	177	157.5	147.5	148
	+T0(T3)	*duo1*+*zan3* 'when'	218	217	215.5	214	214.5	214	214	214.5	214.5	215	198.5	190	182	177.5	176	172.5	165.5	160.5	158	158.5
	+T0(T4)	*pu1*+*ke4* 'poker'	184	178.5	176.5	176.5	177.5	178.5	181	183	184	183.5	236.5	233	228.5	220.5	207.5	193.5	180.5	167.5	159	153
		gan1+*jing4* 'tidy'	181	173.5	173	170.5	168.5	170	173.5	184	195	198.5	217.5	215	209.5	203	197.5	187	173.5	154.5	147	148
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	172.5	169.5	168.5	167	166	166	166	168	168.5	169	212.5	213	214	213.5	211	207	199.5	189	171.5	167.5
	+T0(T3)	*he2*+*zi3* * 'box'	189.5	182	177	174.5	172	172.5	172.5	174	179	181.5	208	207.5	205.5	201.5	195	189.5	186	188.5	192.5	194
T3	+T0(T2)	*gu3*+*tou2* 'bone'	185	182	178.5	177.5	177	178	179.5	182.5	188.5	191.5	201	210	216.5	221.5	221	213.5	197.5	186	176	166.5
	+T0(T3)	*shang3*+*wu3* 'noon'	184	175	170	168.5	170	175	184	195	201.5	209.5	212.5	212.5	209.5	204	196	186.5	177	168	155	151.5
	+T0(T4)	*da3*+*ban4* 'dress up'	127	125	122	122	123.5	126.5	133.5	148.5	169.5	198	213	211	207	203	197	192	186.5	180	177	176.5
		zhu3+*yi4* 'idea'	176.5	170	167.5	166.5	167	167	169.5	172.5	182	193.5	211	208	206	204.5	201.5	201	197	194.5	188	180
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	236	228	222	217	212.5	207	202	196	190.5	186.5	158.5	155	157.5	160	163	166.5	168.5	169.5	177	189.5
	+T0(T3)	*dui4*+*wu3* * 'team'	250	247	245	242	238.5	234	230.5	226	220	213	192.5	181.5	171	146	130	118.5	112	101.5	96	95
	+T0(T4)	*zuo4*+*liao4* 'seasoning'	181.5	181.5	179.5	180	182	184.5	186	193.5	202.5	209	222.5	222.5	220.5	217	211	201	195	184.5	180	176

Table 8.28 mean F0 values (in T-value, 5-scale measurement) of all participant for tone sandhi with neutral tones as the second syllable in disyllabic words

1st syllable	2nd syllable	word	participants	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T0(T1)	*la1*+*la1* 'drop'	1037	2.233053	2.07042	1.933297	1.862186	1.886087	2.059241	2.346695	2.662774	3.02026	3.323586	3.597768	3.558282	3.450234	3.301921	3.099164	2.872494	2.607846	2.264498	1.9682	1.886087
T1	+T0(T1)		1043	1.876234	1.822673	1.750096	1.676143	1.694763	1.876234	2.231878	2.467417	2.646116	2.980685	3.597252	3.597252	3.481489	3.337881	3.112041	2.844751	2.438621	1.911536	1.385618	1.115046
T1	+T0(T1)		26	3.07605	2.971707	2.918186	2.909175	2.918186	2.945062	3.041659	3.135332	3.330371	3.565373	4.05707	3.987794	3.910409	3.824833	3.714998	3.587196	3.498965	3.491497	3.461446	3.431101
T1	+T0(T1)		29	2.567748	2.498957	2.392765	2.319854	2.356528	2.498957	2.692685	2.913009	3.28415	3.498184	3.698152	3.709859	3.638931	3.516916	3.290862	3.05392	2.867121	2.684513	2.455159	2.419662
T1	+T0(T1)		30	3.035345	3.001642	2.915766	2.791443	2.65253	2.575846	2.585534	2.736614	3.035345	3.346241	3.649798	3.622122	3.530448	3.368926	3.222401	3.018539	2.708836	2.375503	2.15038	1.871593
T1	+T0(T1)		332	3.483366	3.379244	3.326053	3.282937	3.239307	3.195152	3.272078	3.389791	3.534338	3.683135	4.02624	3.972738	3.872574	3.721814	3.534338	3.070908	2.593007	2.221392	2.058483	1.997401
T1	+T0(T1)	*la1*+*la1* 'drop' Average		2.711966	2.624107	2.53936	2.473623	2.4579	2.525082	2.695088	2.884156	3.141763	3.399534	3.771047	3.741341	3.647348	3.511965	3.328968	3.074635	2.785433	2.49149	2.246548	2.120148
T1	+T0(T1)	*dao1*+*gu1* 'whisper'	1037	2.07042	1.838083	1.862186	1.933297	2.092647	2.346695	2.707754	2.996157	3.137814	3.235922	3.429512	3.401647	3.316382	3.153129	2.955528	2.752036	2.551841	2.326366	2.114702	1.944979
T1	+T0(T1)		1043	1.179172	1.157914	1.157914	1.157914	1.345193	2.231878	2.732487	2.980685	3.13779	3.301137	3.457919	3.410346	3.337881	3.201428	2.980685	2.675119	2.264117	1.731739	1.157914	0.777581
T1	+T0(T1)		26	3.135332	3.058902	2.808285	2.606036	2.665182	2.909175	3.07605	3.250593	3.446311	3.742696	4.267711	4.267711	4.197094	4.081881	3.923442	3.694061	3.361715	3.00688	2.863723	2.732788
T1	+T0(T1)		29	2.593149	2.419662	2.347401	2.365627	2.643323	2.882494	3.05392	3.223067	3.317563	3.523134	3.650867	3.686399	3.638931	3.516916	3.350613	3.153727	2.905409	2.708962	2.593149	2.659866
T1	+T0(T1)		30	3.060386	2.845329	2.633534	2.457183	2.396123	2.556378	2.82747	3.068689	3.230286	3.214496	3.791219	3.817447	3.82397	3.744784	3.622122	3.465374	3.134331	2.585534	2.238058	2.15038
T1	+T0(T1)		332	3.400307	3.195152	3.116576	3.116576	3.116576	3.127905	3.250263	3.379244	3.473086	3.614448	4.043902	4.02624	4.017377	3.963744	3.863331	3.769596	3.644043	3.421249	3.184029	3.070908
T1	+T0(T1)	*dao1*+*gu1* 'whisper' Average		2.573127	2.419174	2.320982	2.272772	2.376508	2.675754	2.941324	3.149739	3.290475	3.438639	3.773522	3.768298	3.721939	3.610314	3.449287	3.251652	2.976909	2.630122	2.358596	2.22275
T1	+T0(T2)	*gou1*+*lou2* 'stoop'	1037	2.830054	2.752036	2.662774	2.626273	2.635442	2.653692	2.725549	2.864057	3.083557	3.394638	3.805695	3.84792	3.817823	3.725582	3.591225	3.422571	3.198586	2.9637	2.579981	2.254055
T1	+T0(T2)		1043	2.631533	2.452149	2.390473	2.390473	2.452149	2.675119	2.926878	3.112041	3.301137	3.481489	3.851149	3.68745	3.481489	3.239118	2.967303	2.497774	1.893925	1.484883	1.179172	1.005769
T1	+T0(T2)		26	3.594436	3.306653	3.07605	2.891074	2.817594	2.854552	3.041659	3.193499	3.446311	3.680024	3.890757	4.025773	4.136991	4.124829	4.050836	3.916933	3.694061	3.346083	2.836128	2.236491
T1	+T0(T2)		29	2.559233	2.472754	2.428575	2.463969	2.490248	2.601569	2.773215	2.987985	3.209325	3.422083	3.756243	3.761991	3.692281	3.52934	3.310909	3.002761	2.684513	2.498957	2.428575	2.3747
T1	+T0(T2)		30	3.001642	2.976125	2.93313	2.907047	2.871929	2.907047	3.035345	3.308064	3.530448	3.656679	3.75146	3.677232	3.608191	3.494463	3.323391	3.060386	2.708836	2.436962	2.33385	2.270315
T1	+T0(T2)		332	3.368668	3.293763	3.195152	3.139199	3.139199	3.184029	3.293763	3.35806	3.473086	3.721814	4.02624	4.078972	4.061479	3.999586	3.872574	3.721814	3.452439	3.024663	2.78426	2.796662
T1	+T0(T2)	*gou1*+*lou2* 'stoop' Average		2.997594	2.87558	2.781026	2.736339	2.734427	2.812668	2.966068	3.137284	3.340644	3.559455	3.846924	3.846556	3.799709	3.685486	3.519373	3.270373	2.938727	2.625875	2.356994	2.156332
T1	+T0(T3)	*duo1*+*zan3* 'when'*	1037	3.942153	3.988128	4.033375	4.05016	4.038981	4.033375	4.038981	4.02213	3.993823	3.953716	3.66239	3.538332	3.265443	2.922604	2.494716	1.97974	1.32218	1.048509	1.598353	2.274903
T1	+T0(T3)		1043	3.861822	3.808163	3.742783	3.731779	3.720744	3.709678	3.68745	3.642612	3.68745	3.65387	3.528207	3.434205	3.264044	3.099103	2.858559	2.542872	1.99842	1.523893	1.221345	1.115046
T1	+T0(T3)		26	4.238483	4.342437	4.370704	4.376326	4.376326	4.313909	4.302424	4.179185	4.167188	4.004284	4.019475	3.528655	2.881984	1.725531	0.662837	0.58734	1.506309	2.535573	2.674931	2.555869
T1	+T0(T3)		332	4.215992	4.199142	4.173721	4.148122	4.156675	4.148122	4.148122	4.156675	4.156675	4.165208	3.872574	3.712182	3.554531	3.462777	3.431675	3.35806	3.20624	3.093833	3.036279	3.047858
T1	+T0(T3)	*duo1*+*zan3* 'when'* Average		4.064612	4.084468	4.080146	4.076597	4.073182	4.051271	4.047116	4.03096	4.004284	3.984996	3.770662	3.553343	3.2415	2.552802	2.361947	2.117003	2.008287	2.050447	2.132727	2.248419
T1	+T0(T3)	*duo1*+*zan3* 'when'	29	2.851669	2.874817	3.010122	3.216204	3.473028	3.698152	3.841352	3.869201	3.835751	3.784878	3.473028	3.297559	3.139668	2.781152	2.273382	1.731503	1.499034	1.697744	2.401757	2.987985
T1	+T0(T3)		30	3.150529	3.150529	3.182676	3.238152	3.300373	3.383959	3.487216	3.594199	3.677232	3.649798	3.587179	3.523284	3.464291	3.068689	2.690179	2.396123	2.15038	2.248847	2.497239	
T1	+T0(T3)	*duo1*+*zan3* 'when' Average		3.001099	3.012673	3.096399	3.227178	3.3867	3.541055	3.664284	3.7317	3.756491	3.717338	3.530104	3.410422	3.242955	2.92492	2.568235	2.210841	1.947578	1.924062	2.325302	2.742612
T1	+T0(T4)	*pu1*+*ke4* 'poker'*	1043	3.44608	3.44608	3.44608	3.469722	3.51658	3.551358	3.597252	3.619998	3.608641	3.619998	4.099567	4.089526	3.987669	3.797343	3.551358	3.226595	2.858559	2.527897	2.06656	1.523893
T1	+T0(T4)	*pu1*+*ke4* 'poker'* Average		3.44608	3.44608	3.44608	3.469722	3.51658	3.551358	3.597252	3.619998	3.608641	3.619998	4.099567	4.089526	3.987669	3.797343	3.551358	3.226595	2.858559	2.527897	2.06656	1.523893
T1	+T0(T4)	*pu1*+*ke4* 'poker'	1037	2.644582	2.617074	2.626273	2.689847	2.795642	2.939113	3.106936	3.287385	3.373507	3.401647	3.924719	3.901308	3.811766	3.643157	3.429512	3.145481	2.795642	2.446223	2.125666	1.874162
T1	+T0(T4)		26	3.258664	3.126932	3.11851	3.160394	3.218097	3.306653	3.484012	3.644649	3.837733	4.017475	4.655461	4.686107	4.545746	4.431997	4.232604	3.962214	3.160394	2.713622	2.463468	
T1	+T0(T4)		29	2.796964	2.773215	2.812695	2.874817	2.950728	3.017466	3.06838	3.075584	3.024791	2.98057	4.025885	4.015334	3.935017	3.80193	3.608882	3.402757	3.216204	3.075584	3.002761	2.987985
T1	+T0(T4)		30	3.166034	3.1262	3.068689	3.026953	3.018539	3.026953	3.052061	3.134331	3.26163	3.458059	3.843458	3.778022	3.784627	3.724671	3.587179	3.376452	3.118049	2.907047	2.800489	2.623993
T1	+T0(T4)		332	3.594584	3.483366	3.442072	3.442072	3.467777	3.483366	3.534338	3.574612	3.594584	3.584611	4.514505	4.459863	4.38839	4.267721	4.035082	3.779078	3.245603	3.059401	2.918428	
T1	+T0(T4)	*pu1*+*ke4* 'poker' Average		3.092287	3.025358	3.013648	3.038817	3.089157	3.15471	3.249145	3.343312	3.418449	3.488873	4.192806	4.168127	4.093109	3.971907	3.778652	3.533197	3.238026	2.967902	2.740388	2.573607
T1	+T0(T4)	*gan1*+*jing4* 'tidy'*	1037	3.636717	3.518241	3.477632	3.457108	3.415614	3.401647	3.415614	3.422571	3.443344	3.422571	3.380568	3.25072	3.059985	2.914313	2.760811	2.579981	2.426593	2.2956	2.125666	2.014083
T1	+T0(T4)		1043	3.551358	3.362186	3.214032	3.150601	3.124937	3.150601	3.176097	3.188783	3.201428	3.176097	3.239118	3.251601	3.313424	3.301137	3.264044	3.099103	2.998521	2.24803	2.19937	
T1	+T0(T4)	*gan1*+*jing4* 'tidy'* Average		3.594037	3.440213	3.345832	3.303855	3.270275	3.276124	3.295855	3.305677	3.322386	3.299334	3.309843	3.251161	3.186704	3.107725	3.012428	2.839542	2.642576	2.448901	2.186848	2.106726
T1	+T0(T4)	*gan1*+*jing4* 'tidy'	26	3.152063	2.891074	2.400298	2.179904	2.179904	2.525374	2.927171	3.176991	3.2747	3.411976	3.923442	4.106496	4.11873	4.044589	3.897322	3.721946	3.423468	2.998125	2.133877	1.534576
T1	+T0(T4)		29	2.235686	2.216662	2.168575	1.916036	1.731503	2.187901	2.576238	2.890151	3.097096	3.153727	3.656818	3.744713	3.761991	3.709859	3.52934	3.297559	2.987985	2.717068	2.559233	2.643323
T1	+T0(T4)		30	2.764148	2.585534	2.585534	2.65253	2.536789	2.312815	2.071596	2.116857	2.2596	2.280994	3.622122	3.738094	3.764769	3.690859	3.523284	3.313101	3.093466	2.967574	2.791443	2.680809
T1	+T0(T4)		332	3.534338	3.379244	3.368668	3.315321	3.272078	3.304558	3.379244	3.594584	3.807378	3.872574	4.207577	4.165208	4.070236	3.954729	3.854065	3.653855	3.379244	2.954183	2.771815	2.796662
T1	+T0(T4)	*gan1*+*jing4* 'tidy' Average		2.921559	2.768129	2.630769	2.515948	2.430068	2.582662	2.738562	2.944646	3.139205	3.180778	3.85249	3.938628	3.928931	3.850009	3.701003	3.501097	3.221041	2.909237	2.564092	2.413843
T2	+T0(T2)	*shi2*+*tou2* * 'stone'	1037	2.446223	2.356805	2.274903	2.239622	2.386923	2.542399	2.689847	2.830054	2.930871	2.988077	3.366429	3.316382	3.309011	3.221046	3.044161	2.786974	2.504316	2.201259	1.9682	1.714421
T2	+T0(T2)		1043	2.527897	2.311981	2.280137	2.390473	2.542872	2.675119	2.844751	3.060028	3.150601	3.201428	3.469722	3.374282	3.313424	3.099103	2.467417	1.876234	1.425628	1.136539	0.983542	0.777581
T2	+T0(T2)		26	2.980538	2.836128	2.770766	2.770766	2.845354	2.881984	2.918186	2.945062	3.033001	3.28271	3.790579	3.783784	3.672981	3.672981	3.572664	3.353909	2.565968	1.942605	1.816766	
T2	+T0(T2)		29	2.550695	2.593149	2.651606	2.773215	2.882494	3.010122	3.075584	3.146706	3.132614	3.111353	3.614916	3.680506	3.674601	3.632945	3.523134	3.35718	3.125543	2.92059	2.700834	2.481513
T2	+T0(T2)		30	2.764148	2.65253	2.604822	2.604822	2.65253	2.745819	2.880745	3.001642	3.093466	3.118049	3.436013	3.494463	3.566571	3.531372	3.487216	3.346241	3.093466	2.546599	1.967573	1.822617
T2	+T0(T2)		332	3.35806	3.293763	3.272078	3.239307	3.217296	3.217296	3.217296	3.261187	3.272078	3.282937	4.122344	4.130957	4.148122	4.13955	4.096383	4.02624	3.890991	3.692843	3.336753	3.250263
T2	+T0(T2)	*shi2*+*tou2* * 'stone' Average		2.77126	2.674059	2.642385	2.675581	2.754578	2.845457	2.937735	3.04078	3.102105	3.164099	3.633334	3.630062	3.614052	3.556453	3.365162	3.124463	2.858335	2.510633	2.149873	1.977193
T2	+T0(T3)	*he2*+*zi3* * 'box'	1037	2.716665	2.551841	2.475417	2.504316	2.607846	2.716665	2.897659	3.122417	3.323586	3.415614	3.687835	3.636717	3.544997	3.394638	3.191059	2.971849	2.689847	2.264498	1.776921	1.32218
T2	+T0(T3)		1043	2.760857	2.718224	2.80303	2.858559	2.926878	3.099103	3.251601	3.434205	3.562882	3.551358	4.03893	3.925253	3.786492	3.574372	3.301137	2.886031	2.434821	1.911536	1.385618	1.115046
T2	+T0(T3)		26	3.101596	2.918186	2.900138	2.918186	3.024318	3.015612	3.058902	3.152063	3.353909	3.408145	3.890757	3.870979	3.770149	3.601659	3.438715	3.258664	3.00688	2.674931	2.281027	1.942605
T2	+T0(T3)		29	2.635018	2.542133	2.410722	2.310616	2.282733	2.347401	2.463969	2.812695	3.06838	3.139462	3.620937	3.692281	3.644905	3.510685	3.35718	3.243564	3.024791	3.06838		
T2	+T0(T3)		30	3.018539	2.976125	2.941777	2.915766	2.941777	2.984654	3.068689	3.182676	3.238152	3.300373	3.551843	3.558942	3.551843	3.537596	3.516104	3.472672	3.406374	3.277184	3.150529	3.052061
T2	+T0(T3)		332	3.702525	3.554531	3.452439	3.440037	3.347422	3.35806	3.35806	3.389791	3.493618	3.544448	4.043902	4.035082	3.999586	3.927548	3.807378	3.702525	3.634204	3.483135	3.76009	3.788536
T2	+T0(T3)	*he2*+*zi3* * 'box' Average		2.9892	2.87684	2.830587	2.817958	2.855162	2.920249	3.01648	3.182308	3.340088	3.393268	3.805701	3.786542	3.716329	3.591083	3.435262	3.255884	3.049945	2.806013	2.563163	2.381468
T3	+T0(T2)	*gu3*+*tou2* 'bone'*	1037	2.988077	2.922604	2.77828	2.662774	2.551841	2.386923	2.125666	1.9682	2.28527	2.607846	3.443344	3.504769	3.524954	3.457108	3.330771	3.160755	2.905898	2.689847	2.346695	1.956613
T3	+T0(T2)		1043	3.398361	3.188783	2.9404	2.70308	2.313878	1.324823	0.682432	0.408133	0.824299	1.324823	2.872319	3.020558	3.046916	2.9404	2.746698	2.646116	2.633123	2.68954	2.760857	2.858559
T3	+T0(T2)		30	3.026953	3.085229	3.093466	3.018539	2.907047	2.708836	2.33385	1.400562	1.52512	2.105603	3.190061	3.245997	3.30373	3.376452	3.368926	3.323391	3.230286	3.093466	2.863087	2.633534
T3	+T0(T2)	*gu3*+*tou2* 'bone'* Average		3.137797	3.065539	2.937382	2.79574	2.563589	2.140194	1.713983	1.258965	1.544896	2.012773	3.168775	3.257108	3.297987	3.148798	3.043421	2.922606	2.824284	2.656	2.482902	
T3	+T0(T2)	*gu3*+*tou2* 'bone'	26	3.101596	2.998125	2.900138	2.936129	3.024318	3.152063	3.346083	3.536034	3.68705	3.608866	4.149105	4.203041	4.2149	4.161172	4.075697	3.987794	3.807979	3.651757	3.392745	3.168704
T3	+T0(T2)		29	2.550695	2.576258	2.584705	2.63018	2.700834	2.796964	2.920929	3.082772	3.132614	3.13214	3.704011	3.784878	3.790572	3.750483	3.626947	3.396288	3.11353	2.828345	2.757278	2.749279
T3	+T0(T2)		332	3.614448	3.554531	3.483366	3.462777	3.452439	3.473086	3.50384	3.564585	3.683135	3.741002	3.918443	4.078972	4.190688	4.274364	4.266082	4.13955	3.854065	3.634204	3.431675	3.228318
T3	+T0(T2)	*gu3*+*tou2* 'bone' Average		3.088913	3.042964	2.989403	3.011308	3.059197	3.140704	3.256838	3.394463	3.500933	3.494161	3.923853	4.022297	4.065387	4.062006	3.989575	3.841211	3.612132	3.371435	3.1939	3.048767
T3	+T0(T3)	*shang3*+*wu3* 'noon'*	1037	3.524954	3.301921	3.02026	2.769559	2.532926	2.254051	1.993367	1.815902	1.929036	2.343048	3.106936	3.168361	3.060022	3.213579	3.163531	3.067864	2.922604	2.804284		
T3	+T0(T3)		1043	3.434205	3.086122	2.816986	2.631533	2.482625	2.116895	1.581685	1.115046	0.633973	0.706437	2.343568	2.646116	2.774965	3.03376	3.13779	3.112041	3.073097	3.03376	3.124937	3.188783
T3	+T0(T3)	*shang3*+*wu3* 'noon'* Average		3.479579	3.194021	2.918623	2.700546	2.507775	2.185475	1.787726	1.465474	1.281505	1.524743	2.697826	2.876526	2.971663	3.175684	3.16281	3.120729	3.050812	3.02377	2.996534	
T3	+T0(T3)	*shang3*+*wu3* 'noon'	26	3.298706	3.135332	3.050292	3.058902	3.258664	3.491497	3.763308	3.949344	4.075697	4.136991	3.658848	3.110064	1.764961	0.58734	0.201205	0.548889	1.375811	1.685592	1.725531	1.448988
T3	+T0(T3)		29	2.836139	2.692685	2.524936	2.559233	2.692685	2.913009	3.132614	3.376797	3.535533	3.650867	3.698152	3.56631	3.250366	2.618339	2.080055	1.675029	1.905486	2.090019	2.365627	2.446324
T3	+T0(T3)		30	3.166043	3.010102	2.93313	2.939299	2.976125	3.076107	3.269417	3.446573	3.587179	3.663545	3.670396	3.629064	3.373596	3.406374	3.222401	3.010102	2.745819	2.447089	2.621545	2.457183
T3	+T0(T3)		332	3.594584	3.410793	3.304558	3.272078	3.304558	3.410793	3.594584	3.807378	3.927548	4.070236	4.122344	4.122344	4.070236	3.972738	3.826124	3.644043	3.452439	3.261187	2.966024	2.882321
T3	+T0(T3)	*shang3*+*wu3* 'noon' Average		3.224018	3.062228	2.953229	2.901301	2.953008	3.223067	3.439981	3.649723	3.781489	3.88041	3.787435	3.606945	3.15579	2.646198	2.332446	2.219516	2.369889	2.370972	2.381107	2.308704
T3	+T0(T4)	*da3*+*ban4* 'dress up'*	26	3.330371	3.282751	3.11851	2.863723	2.525374	2.247685	2.324932	2.565968	2.655403	2.674931	3.536034	3.579938	3.680024	3.694061	3.637526	3.513846	3.377269	3.218097	3.07605	
T3	+T0(T4)		29	2.725153	2.567748	2.862913	1.605847	1.325051	1.46258	1.797917	2.070059	2.264002	2.684513	3.409213	3.473028	3.460372	3.389805	3.26747	2.796964	2.717068	2.765257	2.765257	
T3	+T0(T4)		30	3.093466	2.950399	2.809508	2.65253	2.477275	2.094308	1.010146	0.912698	1.644917	2.06178	3.130563	3.315737	3.315737	3.205571	3.052091	2.806511	2.351895	1.895795	1.883717	
T3	+T0(T4)	*da3*+*ban4* 'dress up'* Average		3.049663	2.933633	2.596977	2.374033	2.109233	1.934858	1.710998	1.849575	2.188107	2.473207	3.425424	3.456234	3.468831	3.454164	3.379127	3.240562	3.040106	2.830154	2.626383	2.575008
T3	+T0(T4)	*da3*+*ban4* 'dress up'	1037	1.531773	1.637569	1.776921	1.9682	2.253253	2.436425	2.626273	2.8129	2.914313	2.9637	3.558282	3.564901	3.498009	3.153129	2.914313	2.598588	2.316588	1.491067		
T3	+T0(T4)		1043	1.804655	1.638634	1.484883	1.484883	1.638634	1.840609	2.13353	2.405984	2.660645	2.760857	3.201428	3.176097	3.13779	3.03376	2.844751	2.55779	2.049636	1.523893	1.157914	0.84745
T3	+T0(T4)		332	2.235849	2.177675	2.088647	2.088647	2.133431	2.221392	2.418777	2.809002	3.293763	3.863331	4.130957	4.096383	4.02624	3.954729	3.844775	3.750558	3.644043	3.514035	3.452439	3.442072
T3	+T0(T4)	*da3*+*ban4* 'dress up' Average		1.857426	1.817959	1.783484	1.847243	2.001706	2.166142	2.39286	2.675969	2.95624	3.195963	3.630222	3.61246	3.554013	3.468034	3.330482	3.153825	2.869331	2.54505	2.24898	1.926863
T3	+T0(T4)	*zhu3*+*yi4* 'idea'	1037	2.617074	2.523421	2.465719	2.396892	2.426593	2.542399	2.689847	2.864057	3.059985	3.258091	3.675141	3.681495	3.681495	3.623793	3.48444	3.28009	2.947333	2.671827	2.416727	2.136588
T3	+T0(T4)		1043	2.660645	2.467417	2.296092	2.19917	2.215658	2.374901	2.646116	2.886031	3.13779	3.150601	3.44608	3.457919	3.398361	3.270149	2.899694	2.646116	2.327807	1.911536	1.694763	
T3	+T0(T4)		26	3.234387	3.093104	3.015612	3.015612	3.067488	3.218097	3.408145	3.528655	3.708035	3.942889	4.197094	4.208976	4.279325	4.313909	4.302424	4.2149	3.929938	3.651757	3.168704	2.808285
T3	+T0(T4)		29	2.700834	2.643323	2.618339	2.67632	2.773215	2.935696	3.132614	3.337436	3.29334	3.692281	3.779172	3.824519	3.863651	3.727336	3.489174	3.19552				
T3	+T0(T4)		30	3.101682	3.093466	3.001642	2.915766	2.907047	2.92446	2.941777	2.958998	3.07697	3.26163	3.558942	3.594199	3.656679	3.71119	3.731389	3.724671	3.642902	3.508907	3.308064	3.018539
T3	+T0(T4)		332	3.442072	3.304558	3.250263	3.228318	3.239307	3.239307	3.291791	3.354531	3.554531	3.75778	3.927548	3.918443	3.981709	3.927548	3.918443	3.927548	3.850065	3.617443	3.514035	3.514035
T3	+T0(T4)	*zhu3*+*yi4* 'idea' Average		2.959449	2.854215	2.774611	2.72905	2.755402	2.845396	2.985891	3.121403	3.295119	3.486938	3.777653	3.794277	3.808145	3.796042	3.74518	3.660324	3.48154	3.280934	2.996103	2.727955
T4	+T0(T2)	*ge4*+*ren2* 'oneself'*	1037	4.498397	4.488845	4.425964	4.290765	4.143453	3.965233	3.687835	3.477632	3.287385	3.075721	2.598588	2.570361	2.662774	2.804284	2.922604	3.183513	3.345088	3.415614	3.436436	3.422571
T4	+T0(T2)		1043	4.426436	4.295143	4.119572	3.956586	3.786492	3.608641	3.226595	2.830893	2.542872	2.311981	1.242261	1.750096	2.166589	2.436821	2.746698	2.830893	2.967303	3.086122	3.201428	3.288812
T4	+T0(T2)		26	4.376326	4.535091	4.66059	4.681021	4.645178	4.481259	4.261887	4.006842	3.785035	3.484012	2.278667	2.761315	2.763315	2.798948	2.900138	2.889364	3.093104	3.024318		
T4	+T0(T2)		30	3.982783	4.062292	4.038042	3.926533	3.71119	3.508907	3.353821	3.118049	2.791443	2.65253	2.791443	2.82747	2.754997	2.699521	2.736614	2.898304	3.001642	3.190661	3.300373	3.436013
T4	+T0(T2)		332	4.506748	4.380362	4.282627	4.199142	4.122344	4.02624	3.936631	3.824204	3.721814	3.644049	2.908754	2.966024	3.024663	3.150458	3.203138	3.272078	3.393763	3.454204	3.702525	
T4	+T0(T2)	*ge4*+*ren2* 'oneself'* Average		4.358138	4.352346	4.305359	4.210809	4.081731	3.918056	3.693354	3.451908	3.21031	3.033657	2.510603	2.575107	2.674068	2.764391	2.891302	3.026075	3.13414	3.219245	3.296756	3.374848
T4	+T0(T2)	*ge4*+*ren2* 'oneself'	29	2.550695	2.533547	2.533547	2.542133	2.559233	2.659866	2.812695	3.0321	3.270681	3.50444	3.761991	3.846942	3.846942	3.744713	3.510685	3.389805	3.409213	3.460372	3.498184	3.516916
T4	+T0(T2)	*ge4*+*ren2* 'oneself' Average		2.550695	2.533547	2.533547	2.542133	2.559233	2.659866	2.812695	3.0321	3.270681	3.50444	3.761991	3.846942	3.846942	3.744713	3.510685	3.389805	3.409213	3.460372	3.498184	3.516916
T4	+T0(T3)	*dui4*+*wu3** 'team'	1037	4.507918	4.474456	4.376633	4.196941	3.942153	3.738054	3.53165	3.301921	3.067864	2.855594	2.485083	2.336549	2.190582	2.07042	1.9682	1.886087	1.752085	1.611485	1.421907	1.127196
T4	+T0(T3)		1043	4.762016	4.702328	4.606649	4.481379	4.340446	4.119572	3.925253	3.714916	3.481379	3.150601	2.343407	2.994022	2.80303	2.660645	2.497774	2.215546	1.929068	1.45531	0.961187	0.706437
T4	+T0(T3)		26	4.650324	4.691186	4.716453	4.696256	4.6037	4.431997	4.232604	4.044589	3.890757	3.721946	3.314579	3.160394	2.989344	2.863723	2.817594	2.732788	2.421498	2.145448	1.842346	1.562587
T4	+T0(T3)		29	4.452675	4.429703	4.493594	4.498107	4.480016	4.420465	4.288102	4.062842	3.73339	3.488591	2.860168	2.765257	2.563421	1.957877	1.563041	1.602021	2.071596	2.533611	1.337813	
T4	+T0(T3)		30	4.163311	4.244126	4.272491	4.242164	4.192413	4.116178	4.013603	3.857571	3.731389	3.566025	3.383959	3.230286	3.026953	2.871929	2.727382	2.575846	2.354746	2.060178	1.871592	1.822617
T4	+T0(T3)		332	4.71795	4.67974	4.64391	4.588327	4.57	4.475558	4.420328	4.348072	4.245691	4.200328	2.794796	2.792191	2.727599	2.642213	2.567573	2.479149	2.321413	1.98971	1.775221	1.171908
T4	+T0(T3)	*dui4*+*wu3** 'team' Average		4.542366	4.53517	4.518288	4.452594	4.34472	4.216914	4.06859	3.894093	3.705915	3.512445	3.201386	3.005159	2.80871	2.581149	2.381707	2.175993	1.938909	1.663872	1.436592	1.288093
T4	+T0(T4)	*zuo4*+*liao4* 'seasoning'	1037	2.872494	2.653692	2.485083	2.346695	2.504316	2.689847	2.769559	2.830054	2.930871	3.272776	3.768999	3.768999	3.655993	3.422571	3.160755	2.77828	2.436425	2.125666	1.90979	1.886087
T4	+T0(T4)		1043	2.830893	2.68954	2.497774	2.390473	2.374901	2.452149	2.527897	2.660645	2.872319	3.054018	3.551358	3.551358	3.301137	2.967303	2.660645	2.421433	2.166183	1.963898	1.760873	1.562516
T4	+T0(T4)		26	3.168704	2.980538	2.863723	2.845354	2.980538	3.11851	3.176991	3.361715	3.579938	3.665922	4.136991	4.285116	4.365071	4.365071	4.232604	4.044589	3.763308	3.338237	2.72322	2.168461
T4	+T0(T4)		29	2.659866	2.584705	2.559233	2.601569	2.692685	2.80484	2.913009	3.024791	3.216204	3.447662	3.744713	3.80193	3.880269	3.978116	3.761991	3.56631	3.270681	3.017466	2.943221	2.950728
T4	+T0(T4)		30	2.889299	2.808509	2.754997	2.708836	2.643957	2.754997	2.904145	3.093466	3.28163	3.476123	3.843458	3.843458	3.976123	3.748984	3.608191	3.390572	3.190061	3.018539		
T4	+T0(T4)		332	3.544448	3.544448	3.50384	3.514035	3.554531	3.604529	3.634204	3.779078	3.945691	4.061479	4.290872	4.290872	4.257781	4.199142	4.096383	3.918443	3.807378	3.604529	3.514035	3.431675
T4	+T0(T4)	*zuo4*+*liao4* 'seasoning' Average		2.992859	2.875569	2.777442	2.734494	2.799525	2.904145	2.977831	3.110218	3.289281	3.521777	3.911853	3.923622	3.880704	3.779498	3.586761	3.350918	3.092376	2.809884	2.554313	2.341364

1e: Rhotic endings

Table 8.29 mean F0 values (in Hz) of participant 1 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	241.5	241	242	243	245.5	249.5	250	251	246.5	241	233	183.5	134	97.5	68	64.5	67	77	90.5	109.5
T1	+T4r	yi4+hui4r 'a while'	154	158.5	163.5	170	175	181.5	186.5	189	188.5	187	265	268.5	262	251.5	235	216	193	174.5	153	139.5
T4	+T1r	ban4+la1r 'half'	286	285.5	284	280.5	274.5	265.5	254.5	243	231.5	223	186.5	169	153	134	112	91	78	72.5	85	117
T4	+T3r	hao4+ma3r* 'number'	282	273.5	263.5	254	243.5	232.5	221.5	212	204	196	155.5	140	132.5	120	106.5	92.5	90	98.5	119.5	177.5
T4	+T4r	zi4+ge4r 'oneself'	275.5	283.5	286.5	285	278.5	266	250.5	233	220.5	210.5	176	168.5	156.5	136.5	113	105.5	128	158	169.5	170.5
T4	+T4r	jing4+yi4r 'on purpose'	301	306	300.5	292	284	274	265.5	256.5	248	236.5	198	176.5	155.5	140	129.5	127.5	120	122	125	130
T4	+T4r	yang4+shi4r 'style'	297	296	286	273.5	256	236.5	216	198	183.5	170.5	162.5	160.5	154	147	139.5	130.5	122	114	105	100

Table 8.30 mean F0 values (in Hz) of participant 2 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	188	188.5	188.5	188	190	191	191	191.5	190.5	187.5	164.5	153.5	139	119.5	92	89	96	108.5	138	153.5
T1	+T4r	yi4+hui4r 'a while'	195	193	194	193	195	195	194	193	192	189	164	154	142	125	87	86	103	123	149	162
T4	+T1r	ban4+la1r 'half'	231.5	228	225	216.5	209.5	203	196.5	190	182.5	173	147	135	123.5	109	93.5	84.5	89	103	124	146
T4	+T3r	hao4+ma3r* 'number'	227.5	222.5	216.5	210.5	204	197	190	181.5	172	161.5	128.5	122.5	113.5	101.5	93	83.5	80	86	104	134.5
T4	+T4r	zi4+ge4r 'oneself'	228	222.5	218.5	213	205.5	196.5	187	177	164	151.5	146.5	143.5	131	112.5	91.5	82	84	93	109	142
T4	+T4r	jing4+yi4r 'on purpose'	230.5	229.5	223	215	208.5	203.5	199	196	191.5	185.5	156	148	139	127	108.5	92	81	78.5	100	132.5
T4	+T4r	yang4+shi4r 'style'	232	227.5	222.5	213.5	203	193	177.5	159	134	110.5	137.5	129	116.5	101.5	91.5	85.5	82	82	86.5	101

Table 8.31 mean F0 values (in Hz) of participant 3 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	266	273	278	278	277	275.5	273	267.5	257	244	190	152	111	88	76	101	121	114	117.5	
T1	+T4r	yi4+hui4r 'a while'	291.5	290	289	287.5	283.5	277	268	255.5	242.5	230	206.5	187.5	162.5	125.5	97.5	110	156.5	165.5	160.5	155.5
T4	+T1r	ban4+la1r 'half'	255.5	256.5	257	258.5	260.5	264.5	268	269	266	256	212.5	170.5	123.5	85	74	88.5	114.5	136.5	161.5	206
T4	+T3r	hao4+ma3r* 'number'	316.5	322	320	310	299.5	288	272	258.5	247	236	200.5	178	142	101.5	89.5	97.5	114.5	126.5	158.5	166.5
T4	+T4r	zi4+ge4r 'oneself'	297.5	293.5	290	282	272	260.5	248.5	236	226.5	216	184.5	145.5	102	79.5	72.5	82.5	97	105	123.5	138
T4	+T4r	jing4+yi4r 'on purpose'	293	288.5	285	278	267	251.5	241	237	236.5	232	174.5	140	113	95.5	85	86	91.5	103	126.5	156.5
T4	+T4r	yang4+shi4r 'style'	315	315.5	311.5	302	286	271	259.5	249.5	242	232	191.5	160	133	101.5	77.5	71	76	93.5	127.5	161.5

Table 8.32 mean F0 values (in Hz) of participant 4 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	276	279.5	279.5	280	279.5	282.5	287	287.5	282	271.5	210.5	172	163.5	173.5	188.5	202	214	225	227	221
T1	+T4r	yi4+hui4r 'a while'	201.5	194.5	199.5	208.5	222	234.5	242.5	243	233.5	237	324	328	316.5	284	242	202	188	179.5	174	174
T4	+T1r	ban4+la1r 'half'	329.5	326.5	323	318.5	312.5	298	278.5	258.5	240	224.5	205	152.5	134	124	115	119.5	131	155.5	179.5	193
T4	+T3r	hao4+ma3r* 'number'	342	340	333.5	327.5	318.5	304	281.5	259	242	227.5	220.5	200.5	174	154	135	122	125.5	135	146.5	156
T4	+T4r	zi4+ge4r 'oneself'	356.5	361.5	363.5	360	350	332	299	269.5	245.5	226.5	200.5	196.5	193.5	176.5	171.5	192	218	231.5	238.5	243.5
T4	+T4r	jing4+yi4r 'on purpose'	351.5	353.5	357.5	357	349	333.5	312.5	284	260.5	241	239	210	188.5	175.5	161	161.5	189	213.5	220	227
T4	+T4r	yang4+shi4r 'style'	330	334	330	322	309	294	271	250	242	248.5	221.5	201	190	177	167.5	164	156	155.5	160	165

Table 8.33 mean F0 values (in Hz) of participant 5 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	192	191.5	189.5	185	173.5	165.5	166.5	170	186	187.5	192.5	181	175.5	175	181	191	199	207	214.5	214
T1	+T4r	yi4+hui4r 'a while'	331	309.5	297.5	278	270.5	266	260	253	245	233.5	248	244	219.5	197	172.5	150.5	137	120.5	112.5	117
T4	+T1r	ban4+la1r 'half'	272.5	274	270	265.5	261.5	256.5	248.5	240	231.5	221	210.5	194.5	180.5	163.5	146	122.5	94	83.5	92.5	107
T4	+T3r	hao4+ma3r* 'number'	256.5	260	262	255	245.5	237.5	230.5	227	222.5	214	182.5	165.5	137.5	129.5	122	119	108.5	103.5	109	118
T4	+T4r	zi4+ge4r 'oneself'	258.5	260	260.5	260.5	260.5	260	256.5	247.5	237	231	189.5	179.5	172	160	128	106	119.5	154.5	167.5	172
T4	+T4r	jing4+yi4r 'on purpose'	290	295	293.5	288	277	267	259	253.5	240	228.5	210.5	193.5	182.5	170.5	135.5	116	98.5	107	112	128
T4	+T4r	yang4+shi4r 'style'	276.5	281	280.5	277.5	267	255.5	247.5	241	234.5	224	198.5	191.5	183.5	159.5	121.5	109	115	131	145.5	156.5

Table 8.34 mean F0 values (in Hz) of participant 6 for tone sandhi with rhotic endings syllable in disyllabic words

combination		word	syllable 1										syllable 2									
			F01	F02	F03	F04	F05	F06	F07	F08	F09	F010	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1	+T2r	gen1+qian2r 'near'	237.5	223.5	222.5	222.5	223	224	225.5	229	232	232.5	219.5	218.5	202	174.5	111.5	92.5	88.5	100	133	174
T1	+T4r	yi4+hui4r 'a while'	255.5	251	249	248.5	248.5	247	243	239	235.5	228	198	189	177.5	160.5	143.5	118.5	93.5	89	104	147
T4	+T1r	ban4+la1r 'half'	223	221.5	220	217.5	215	212	209	206	202	197.5	159.5	128	92.5	80.5	75.5	73.5	78	85.5	99	117
T4	+T3r	hao4+ma3r* 'number'	242.5	235.5	231.5	227.5	223	218	214	210	206	202.5	181.5	145.5	127	113	96	81	78	87.5	111.5	147.5
T4	+T4r	zi4+ge4r 'oneself'	255	246	242	238	234.5	230	228.5	228.5	227.5	226	192.5	181.5	158.5	122.5	95	87.5	104.5	131	156.5	168
T4	+T4r	jing4+yi4r 'on purpose'	236	226.5	220.5	217.5	215.5	214	212	211	209.5	209	228	215	192	170.5	151.5	125	101.5	88.5	80.5	80.5
T4	+T4r	yang4+shi4r 'style'	228	225.5	223.5	219	216	211.5	204	196.5	191	185.5	171.5	135.5	84	73.5	72	81.5	102	132.5	159	185.5

Table 8.35 mean F0 values (in T-value, 5-scale measurement) of all participant for tone sandhi with rhotic ending in disyllabic words

	participant	F01	F02	F03	F04	F05	F06	F07	F08	F09	F010		F01	F02	F03	F04	F05	F06	F07	F08	F09	F010
T1+T2r	1037	3.883623	3.877703	3.88953	3.901308	3.930542	3.976703	3.982422	3.993823	3.942153	3.877703		3.781284	3.099164	2.201259	1.293036	0.263833	0.112906	0.221519	0.618847	1.080244	1.624556
	1043	3.966974	3.977335	3.977335	3.966974	4.008254	4.028731	4.028731	4.03893	4.018506	3.956586		3.44608	3.176097	2.789023	2.19937	1.179172	1.049848	1.345193	1.822673	2.760857	3.176097
	26	4.267711	4.348111	4.404287	4.404287	4.393133	4.376326	4.348111	4.285116	4.161172	4.000506		3.226253	2.535573	1.562587	0.843896	0.390125	1.270368	1.867717	1.829582	1.645131	1.738731
	29	3.885789	3.924146	3.924146	3.929586	3.924146	3.956643	4.004747	4.010045	3.951251	3.835751		3.061158	2.446324	2.292056	2.472754	2.725153	2.935696	3.111353	3.263925	3.290862	3.209325
	30	3.118049	3.109876	3.07697	3.001642	2.800489	2.65253	2.671411	2.736614	3.018539	3.043714		3.1262	2.93313	2.836412	2.82747	2.93313	3.101682	3.230286	3.353821	3.465374	3.458059
	332	4.529968	4.307306	4.290872	4.290872	4.299098	4.315496	4.339955	4.396401	4.4441	4.45199		4.241122	4.224388	3.936631	3.400307	1.758824	1.074173	0.912165	1.35989	2.405025	3.389791
T1+T2r	Average	3.942019	3.924079	3.92719	3.915778	3.89261	3.884405	3.895896	3.910155	3.92262	3.861042		3.480349	3.069113	2.602995	2.172805	1.541706	1.590779	1.781372	2.041456	2.441249	2.766093
T1+T2r*	29	3.885789	3.924146	3.924146	3.929586	3.924146	3.956643	4.004747	4.010045	3.951251	3.835751		3.061158	2.446324	2.292056	2.472754	2.725153	2.935696	3.111353	3.263925	3.290862	3.209325
T1+T2r*	Average	3.885789	3.924146	3.924146	3.929586	3.924146	3.956643	4.004747	4.010045	3.951251	3.835751		3.061158	2.446324	2.292056	2.472754	2.725153	2.935696	3.111353	3.263925	3.290862	3.209325
T1+T2r?	30	3.118049	3.109876	3.07697	3.001642	2.800489	2.65253	2.671411	2.736614	3.018539	3.043714		3.1262	2.93313	2.836412	2.82747	2.93313	3.101682	3.230286	3.353821	3.465374	3.458059
T1+T2r?	Average	3.118049	3.109876	3.07697	3.001642	2.800489	2.65253	2.671411	2.736614	3.018539	3.043714		3.1262	2.93313	2.836412	2.82747	2.93313	3.101682	3.230286	3.353821	3.465374	3.458059
T1+T4r	1037	2.598588	2.680851	2.769559	2.880907	2.9637	3.067864	3.145481	3.183513	3.175947	3.153129		4.148847	4.186323	4.116329	3.999507	3.805695	3.564901	3.243331	2.955528	2.579981	2.316148
	1043	4.109582	4.069366	4.089526	4.069366	4.109582	4.109582	4.089526	4.069366	4.049102	3.987669		3.434205	3.188783	2.872319	2.374901	0.961187	0.916089	1.619743	2.311981	3.060028	3.38634
	26	4.551059	4.535091	4.524399	4.508292	4.464926	4.393133	4.290896	4.143054	3.981419	3.817612		3.484012	3.185256	2.742326	1.942605	1.161205	1.534576	2.625877	2.798948	2.703995	2.606036
	29	2.928153	2.82053	2.89779	3.0321	3.223067	3.389805	3.491915	3.498184	3.376797	3.422083		4.37385	4.411199	4.302562	3.972762	3.485632	2.935696	2.717068	2.576238	2.481513	2.481513
	30	4.82506	4.614559	4.490617	4.278133	4.192413	4.139833	4.068325	3.982783	3.882074	3.731389		3.92022	3.869255	3.537596	3.198626	2.782371	2.354746	2.060178	1.65795	1.442634	1.565563
	332	4.797702	4.73258	4.703261	4.695895	4.695895	4.673706	4.61387	4.553042	4.498976	4.380362		3.863331	3.692843	3.462777	3.093813	2.683502	1.98197	1.11358	0.932812	1.503627	2.771815
T1+T4r	Average	3.968357	3.90883	3.912525	3.910782	3.941597	3.96232	3.950002	3.90499	3.827386	3.748707		3.870744	3.75561	3.505652	3.097036	2.479932	2.214663	2.229963	2.205576	2.295296	2.521236
T1+T4r*	1037	2.598588	2.680851	2.769559	2.880907	2.9637	3.067864	3.145481	3.183513	3.175947	3.153129		4.148847	4.186323	4.116329	3.999507	3.805695	3.564901	3.243331	2.955528	2.579981	2.316148
	29	2.928153	2.82053	2.89779	3.0321	3.223067	3.389805	3.491915	3.498184	3.376797	3.422083		4.37385	4.411199	4.302562	3.972762	3.485632	2.935696	2.717068	2.576238	2.481513	2.481513
T1+T4r*	Average	2.76337	2.75069	2.833674	2.956503	3.093384	3.228834	3.318698	3.340849	3.276372	3.287606		4.261349	4.298761	4.209445	3.986135	3.645664	3.250298	2.980199	2.765883	2.530747	2.39883
T4+T1r	1037	4.366663	4.361666	4.34662	4.311202	4.249445	4.154231	4.033375	3.901308	3.762837	3.655993		3.145481	2.864057	2.579981	2.201259	1.689032	1.095981	0.655702	0.446853	0.901167	1.813775
	1043	4.778903	4.719475	4.624221	4.517583	4.389372	4.266424	4.139475	4.008254	3.851149	3.642612		3.007313	2.675119	2.327807	1.840609	1.242261	0.84745	1.049848	1.619743	2.343568	2.980685
	26	4.143054	4.155145	4.161172	4.179185	4.203041	4.250207	4.290896	4.302424	4.267711	4.149105		3.572664	2.891074	1.892882	0.736536	0.30758	0.861432	1.658677	2.202663	2.72322	3.476508
	29	4.425087	4.397247	4.364441	4.321736	4.263848	4.119231	3.913236	3.686399	3.460372	3.257153		2.987985	2.080055	1.686408	1.450331	1.220977	1.337813	1.617487	2.139353	2.576238	2.796964
	30	4.215502	4.232708	4.186614	4.133936	4.086356	4.025846	3.926533	3.817447	3.704427	3.558942		3.406374	3.158597	2.92446	2.614422	2.2596	1.709544	0.879531	0.508279	0.829112	1.285529
	332	4.299098	4.274364	4.249461	4.207577	4.165208	4.113711	4.061479	4.008493	3.936631	3.854065		3.070908	2.264593	1.074173	0.564938	0.329932	0.231541	0.449318	0.785778	1.323057	1.935283
T4+T1r	Average	4.371385	4.356767	4.322088	4.278537	4.226212	4.154942	4.060832	3.954054	3.830521	3.686312		3.198454	2.655582	2.080952	1.568016	1.174897	1.01396	1.05176	1.283778	1.782727	2.381458
T4+T3r*	1037	4.326435	4.239021	4.132634	4.027758	3.907179	3.775148	3.636717	3.511513	3.401647	3.287385		2.626273	2.326366	2.169107	1.886087	1.545214	1.142677	1.064421	1.32218	1.874162	3.004214
	1043	4.710911	4.624221	4.517583	4.407948	4.285593	4.149388	4.008254	3.829715	3.619998	3.374282		2.482625	2.296092	1.99842	1.562516	1.221345	0.80101	0.633973	0.916089	1.657433	2.660645
	26	4.85907	4.85907	4.839785	4.741516	4.634861	4.51367	4.336752	4.179185	4.03833	3.897322		3.392745	3.024318	2.324932	1.285653	0.896211	1.161205	1.658677	1.967171	2.665182	2.817594
	29	4.538424	4.520571	4.461816	4.406555	4.321736	4.179908	3.945849	3.692281	3.485632	3.297559		3.20243	2.913009	2.481513	2.109849	1.709039	1.400836	1.486931	1.709039	1.957877	2.149125
	30	4.025846	4.068325	4.092343	4.007463	3.888464	3.784627	3.690859	3.642902	3.580144	3.458059		2.958998	2.65253	2.071596	1.883717	1.696725	1.618688	1.329163	1.181291	1.343573	1.592239
	332	4.606322	4.498976	4.436193	4.372316	4.299098	4.215992	4.148122	4.078972	4.008493	3.945691		3.544448	2.734227	2.235849	1.807798	1.210283	0.58763	0.449318	0.870518	1.758824	2.78426
T4+T3r*	Average	4.50228	4.468364	4.413392	4.327259	4.222822	4.103122	3.961092	3.822428	3.68904	3.543383		3.034587	2.657757	2.213569	1.755936	1.379803	1.118674	1.103747	1.327715	1.876175	2.501346
T4+T4r	1037	4.259831	4.341587	4.371652	4.356659	4.290765	4.159605	3.988128	3.781284	3.623793	3.491232		2.979975	2.855594	2.644582	2.254055	1.714421	1.518268	2.07042	2.671827	2.872494	2.889295
	1043	4.719475	4.624221	4.553454	4.454004	4.314172	4.139475	3.946169	3.731779	3.434205	3.124937		2.994022	2.91331	2.55779	1.963898	1.157914	0.730296	0.824299	1.221345	1.840609	2.872319
	26	4.614122	4.572223	4.535091	4.448505	4.336752	4.05707	3.897322	3.770149	3.623229			3.135332	2.400298	1.300863	0.529483	0.244195	0.644134	1.145291	1.390586	1.892882	2.236491
	29	4.664816	4.70721	4.724004	4.694554	4.608806	4.448095	4.129428	3.813246	3.52934	3.28415		2.913009	2.851669	2.80484	2.524936	2.437462	2.781152	3.167722	3.350613	3.441288	3.504441
	30	4.05019	4.068325	4.074347	4.074347	4.074347	4.38839	4.38839	4.372316	4.348072			3.07697	2.90047	2.773273	2.546599	1.8472	1.256099	1.63183	2.436962	2.690179	2.773273
T4+T4r	Average	4.516493	4.495401	4.476218	4.427624	4.35137	4.238485	4.089172	3.920986	3.751304	3.594879		3.143233	2.912061	2.521534	1.987101	1.42885	1.300078	1.726794	2.236805	2.623129	2.922834
T4+T4r	1037	4.512666	4.559721	4.507918	4.425963	4.34662	4.244238	4.154231	4.055733	3.95948	3.823868		3.316382	2.988077	2.626273	2.326366	2.103696	2.059241	1.886087	1.933297	2.002681	2.114702
	1043	4.762016	4.745055	4.632977	4.490462	4.370708	4.276021	4.188791	4.129536	4.03893	3.914752		3.239118	3.03376	2.789023	2.436821	1.822673	1.179172	0.682432	0.560136	1.504437	2.602203
	26	4.566946	4.519039	4.481448	4.407248	4.279325	4.094213	3.962214	3.910409	3.903873	3.844411		2.962851	2.281027	1.61786	1.097053	0.736536	0.772738	0.964616	1.33106	1.967171	2.625877
	29	4.621823	4.639093	4.673342	4.669082	4.600096	4.461816	4.263848	3.972762	3.709859	3.473028		3.447662	3.05392	2.725153	2.507641	2.245154	2.254592	2.733216	3.104233	3.19552	3.290862
	30	4.410588	4.464167	4.448189	4.388897	4.266839	4.151594	4.056247	3.988971	3.817447	3.663545		3.406374	3.14244	2.958998	2.745819	2.025671	1.538659	1.026096	1.285529	1.428673	1.8472
T4+T4r	Average	4.574808	4.585415	4.548737	4.475738	4.372718	4.245576	4.125066	4.011482	3.885918	3.743921		3.274477	2.899845	2.543461	2.22274	1.786746	1.560881	1.458489	1.642851	2.019696	2.496169
T4+T4r*	332	4.506748	4.356172	4.257781	4.207577	4.173721	4.148122	4.113711	4.096383	4.070236	4.061479		4.380362	4.165208	3.750558	3.315321	2.882321	2.177675	1.414454	0.912165	0.564938	0.564938
T4+T4r*	Average	4.506748	4.356172	4.257781	4.207577	4.173721	4.148122	4.113711	4.096383	4.070236	4.061479		4.380362	4.165208	3.750558	3.315321	2.882321	2.177675	1.414454	0.912165	0.564938	0.564938
T4+T4r	26	4.79104	4.795949	4.756656	4.66059	4.492101	4.325352	4.191136	4.0695	3.97503	3.844411		3.250593	2.694337	2.122263	1.285653	0.45062	0.179484	0.390125	1.031543	1.031543	2.72322
	30	4.261176	4.311775	4.306193	4.272491	4.151594	4.013603	3.913895	3.83048	3.744784	3.601203		3.222401	3.109876	2.976125	2.536789	1.683853	1.343573	1.511523	1.919813	2.248847	2.477275
	332	4.380362	4.339955	4.307306	4.232765	4.182214	4.105057	3.972738	3.835462	3.73142	3.624339		3.336753	2.473274	0.720912	0.231541	0.155974	0.610183	1.432463	2.391222	3.059401	3.624339
T4+T4r	Average	4.477526	4.48256	4.456652	4.388615	4.275303	4.148004	4.025923	3.91114	3.817078	3.689984		3.269916	2.759162	1.939767	1.351327	0.763482	0.71108	1.11137	1.780859	2.433264	2.941611
T4+T4r*	1037	4.474456	4.464823	4.366663	4.239021	4.05016	3.823868	3.564901	3.316382	3.099164	2.889295		2.752036	2.716665	2.598588	2.465719	2.316148	2.125666	1.933297	1.739585	1.5047	1.365347
	1043	4.787319	4.710911	4.624221	4.463151	4.266424	4.069366	3.842783	3.313424	2.646116	1.893925		2.746698	2.497774	2.109289	1.75262	1.157914	0.893343	0.730296	0.732926	0.938703	1.543252
	29	4.429703	4.466376	4.429703	4.355003	4.229564	4.078097	3.83014	3.584628	3.485632	3.56631		3.216204	2.92059	2.749279	2.533547	2.365627	2.30135	2.149125	2.139353	2.226189	2.319854
T4+T4r*	Average	4.563826	4.54737	4.473529	4.352392	4.182049	3.990444	3.712608	3.404811	3.076971	2.783177		2.904979	2.711677	2.482685	2.18726	1.946563	1.773453	1.60424	1.536412	1.556531	1.742818

Appendix 2: F0 contours
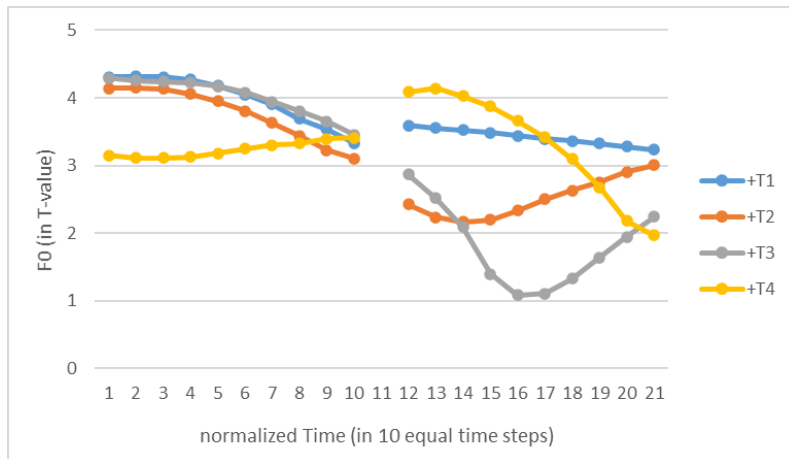
<u>2a: F0 contours for number words</u>

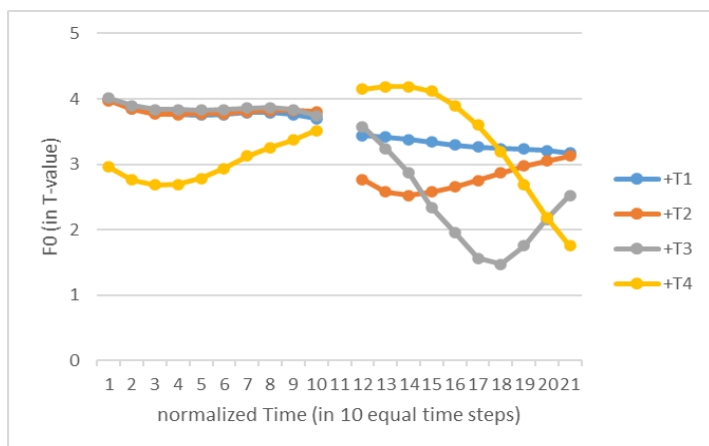*Figure 8.1 F0 contours (in T-value of 5-point scale) of* yi1 *'one' + following syllable X*

Figure 8.2 F0 contours (in T-value of 5-point scale) of san1 *'three' + following syllable X*
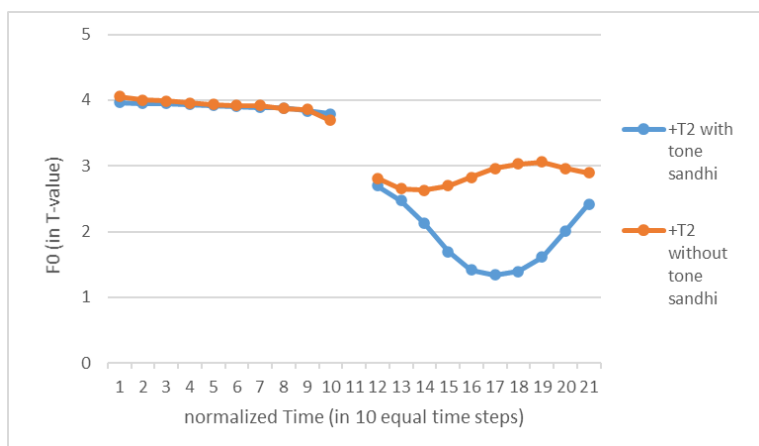

Figure 8.3 F0 contours (in T-value of 5-point scale) of qi1 *'seven' +* jie2 *'block' with and without tone sandhi*
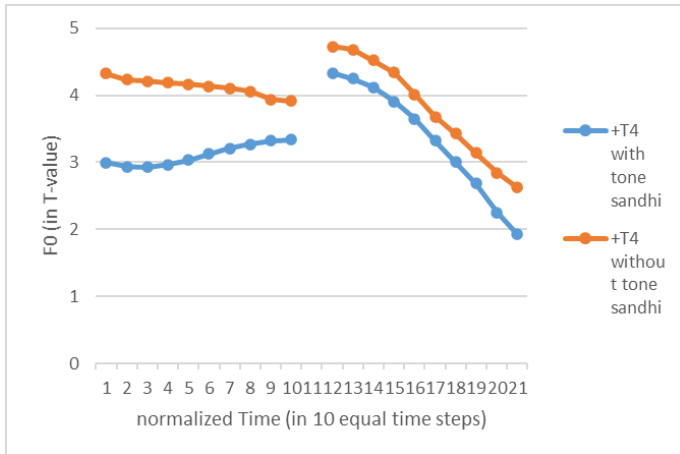
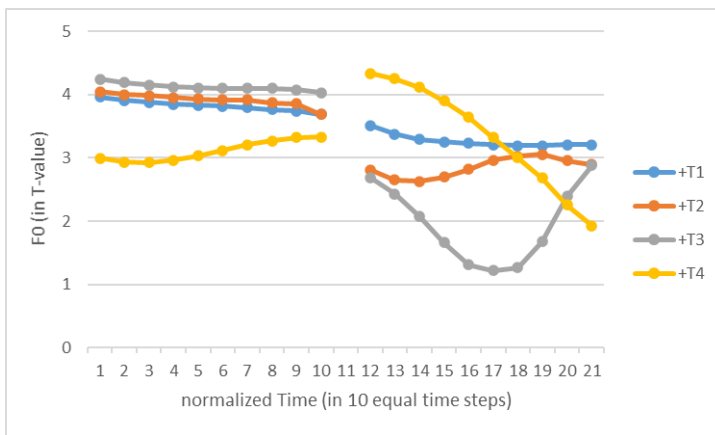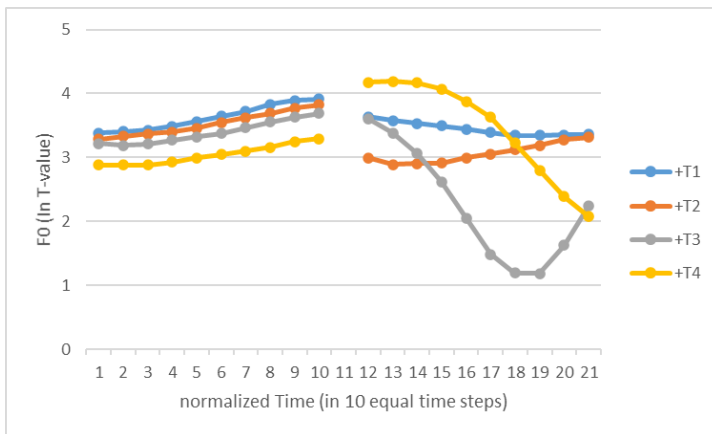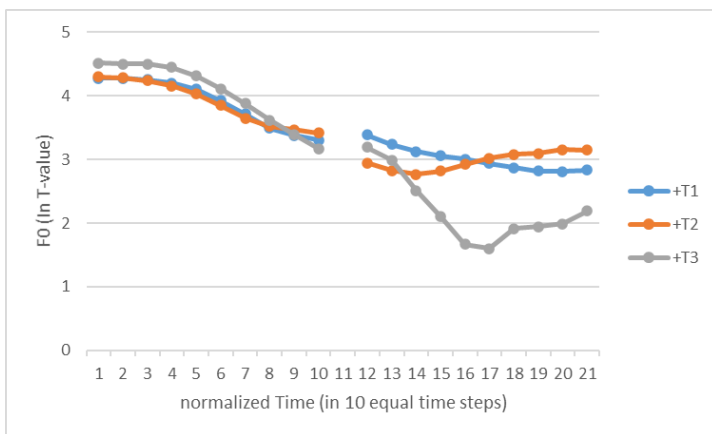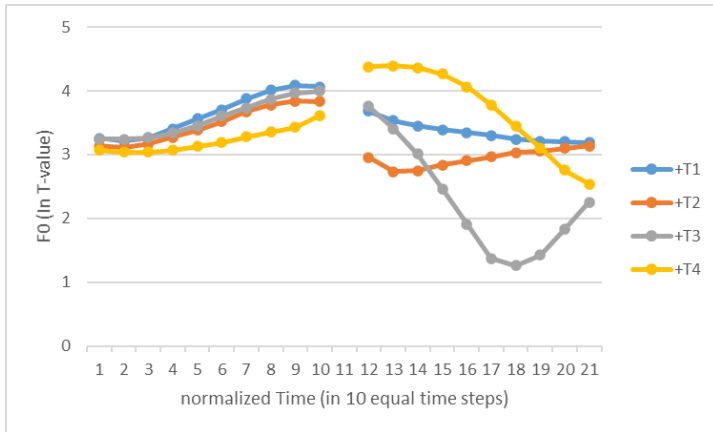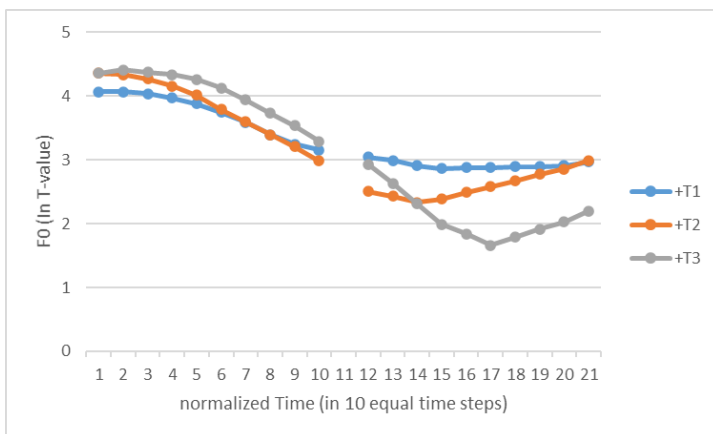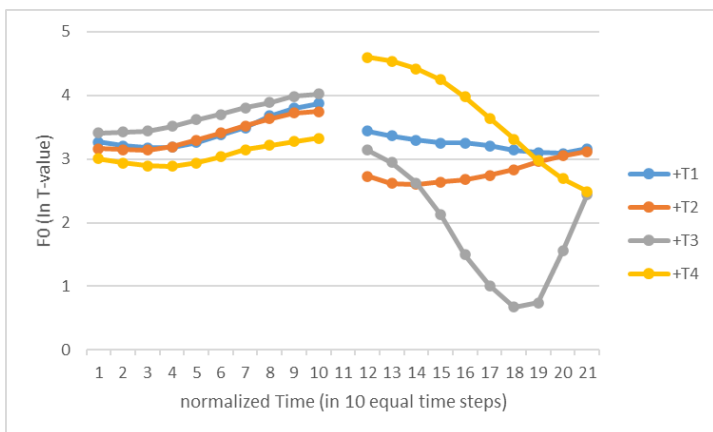*Figure 8.4 F0 contours (in T-value of 5-point scale) of* qi1 *'seven'* + ci4 *'times' with and without tone sandhi*

Figure 8.5 F0 contours (in T-value) of qi1 *'seven' + following syllable X*
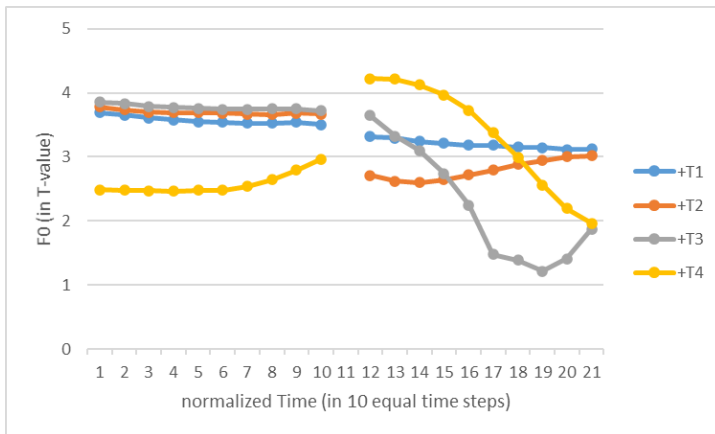
Figure 8.6 F0 contours (in T-value) of ba1 *'eight' + following syllable X*
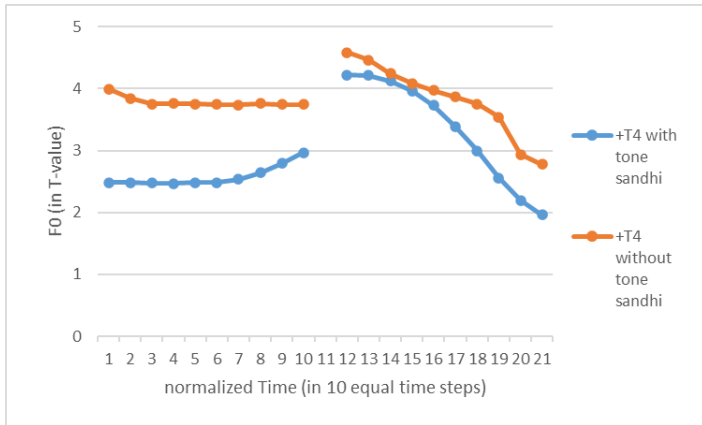
Figure 8.7 F0 contours (in T-value) of ba1 *'eight'* + pian4 *'slice/piece' with and without tone sandhi*

2b: F0 contours for adverbs

Figure 8.8 F0 contours (in T-value of 5-point scale) of bie2 *'do not' + following syllable X with no tone sandhi*
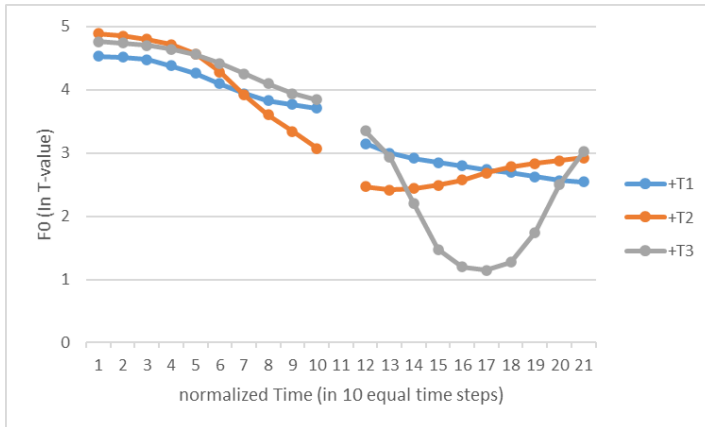

Figure 8.9 F0 contours (in T-value of 5-point scale) of bie2 *'do not' + following syllable X with tone sandhi*
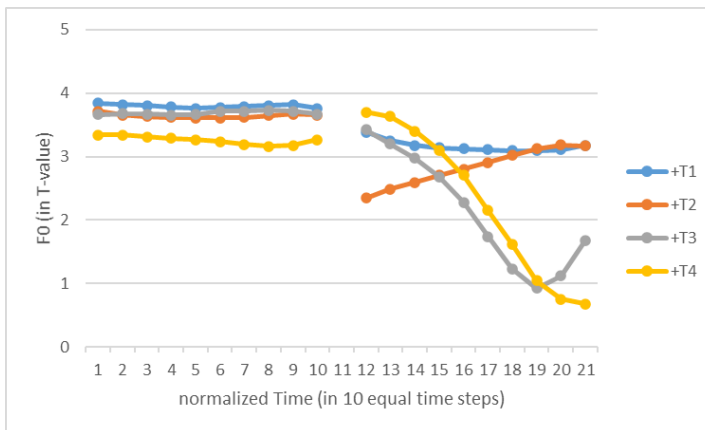
Figure 8.10 F0 contours (in T-value of 5-point scale) of mei2 *'not' + following syllable X with <u>no</u> tone sandhi*

Figure 8.11 F0 contours (in T-value of 5-point scale) of mei2 *'not' + following syllable X <u>with</u> tone sandhi*

Figure 8.12 F0 contours (in T-value of 5-point scale) of hai2 *'still' + following syllable X with <u>no</u> tone sandhi*

Figure 8.13 F0 contours (in T-value of 5-point scale) of hai2 *'still' + following syllable X* _with_ *tone sandhi*

Figure 8.14 F0 contours (in T-value of 5-point scale) of dou1 *'both/all' + following syllable X with* _no_ *tone sandhi*
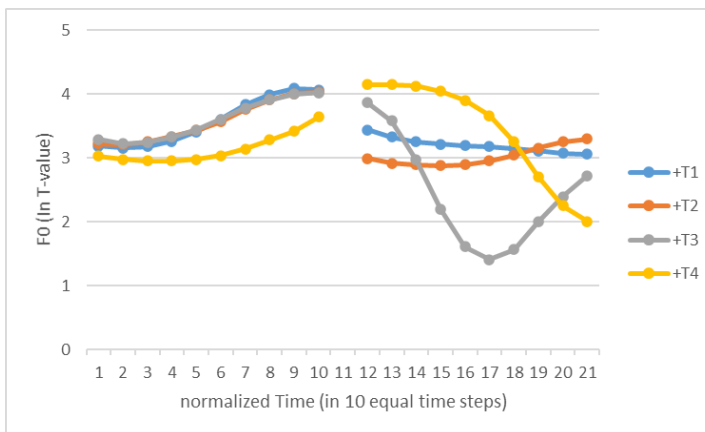

Figure 8.15 F0 contours (in T-value of 5-point scale) of dou1 *'both/all' + following syllable X* _with_ *tone sandhi*