

## **Frequency of Taiwanese Tone Sandhi in a Spoken Corpus with Some Implications\***

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Taiwanese, a variety of Southern Min, is a dialect spoken in Taiwan with a pervasive tone sandhi system. To speak Taiwanese fluently and appropriately, one has to frequently apply Taiwanese tone sandhi. While it is common knowledge that tone sandhi is pervasive in spoken Taiwanese, there are no studies reporting on the rate of Taiwanese tone sandhi in spoken corpora in any genre. This paper attempts to determine the average tone sandhi rates of L1 Taiwanese dominant speakers and L1 Taiwanese L2 Mandarin bilinguals by analyzing a spoken corpus. Our study shows that the two groups do not reveal any significant differences in their tone sandhi application rate. On average, out of every 100 syllables, approximately 67 syllables have undergone tone sandhi. Regarding the application rates of individual tone sandhi rules, all speakers show a consistency as to which rules are most common and which are not. Consequently, one implication of our study is that L2 Mandarin fluency does not impact L1 Taiwanese tone sandhi frequency. Other implications help make clear the specific nature of the Taiwanese tone sandhi system.

Key words: Taiwanese tone sandhi, frequency, Taiwanese corpus, sociolinguistic variations

### **1. Introduction**

Taiwanese Southern Min, also known as Amoy, Xiamen, Hoklo, and Hokkian, is a variety of the Southern Min dialect spoken in Taiwan. This dialect is well-known for the complex nature of its tone sandhi system. Taiwanese tone sandhi is pervasive, involving all seven Taiwanese tones (rising, high-level, mid-level, low-level, falling, high-abrupt and low-abrupt). A tone, regardless of its type, must undergo tone change when it occurs in a sandhi position. Using the sentence in (1), we illustrate the pervasive nature of Taiwanese tone sandhi. The syllables and tones occurring in sandhi positions are bold-faced. The seven Taiwanese tones, five non-entering tones on syllables ending in a sonorant (i.e., a vowel or nasal consonant) as well as two entering tones on stop-ending syllables, are represented by  $R_n$  (a rising non-entering tone),  $M_n$  (a mid-level non-entering tone),  $L_n$  (a low-level non-entering tone),  $F_n$  (a falling non-entering tone),  $H_n$  (a high-level non-entering tone),  $L_e$  (a low-abrupt entering tone), and  $H_e$  (a high-abrupt entering tone).

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(1) An example showing the pervasive nature of Taiwanese tone sandhi

**/gua be? sek-sai siao-lian su-ki/**

I want know young driver

‘I want to know young drivers.’

Underlying tone: **/F<sub>n</sub> L<sub>e</sub> H<sub>e</sub>-M<sub>n</sub> L<sub>n</sub>-R<sub>n</sub> H<sub>n</sub>-H<sub>n</sub>/**

Surfacing tone: **[H<sub>n</sub> H<sub>e</sub> L<sub>e</sub>-L<sub>n</sub> F<sub>n</sub>-M<sub>n</sub> M<sub>n</sub>-H<sub>n</sub>]**

As exemplified in (1), Taiwanese tone sandhi is pervasive in that it involves all the Taiwanese tones and that tone changes take place in almost all utterances longer than one syllable. Except for the last syllable, all the other syllables, which are in the sandhi context, must undergo tone changes. Without such tone changes, speech production can be unintelligible or ambiguous. Take the two-syllable phrase /sio k<sup>hi</sup>/ with /k<sup>hi</sup>/ carrying L<sub>n</sub> for instance. /sio k<sup>hi</sup>/ can mean ‘stingy,’ ‘hot air,’ or ‘burned,’ depending on the surfacing tone of the first syllable. Suppose that a person says ‘It is all hot air’ when an air conditioner breaks down. Then every syllable except the last one in the sentence should undergo tone sandhi, as shown in (2a). Without utilizing tone sandhi, the intended meaning conveyed in (2a) would be lost, and the sentence may become difficult to understand, as in (2b).

(2) a. Tone sandhi applied to the sentence: **/loŋ si sio k<sup>hi</sup>/**

all be hot air

Conveyed meaning: ‘It is all hot air.’

Underlying tone: **/F<sub>n</sub> M<sub>n</sub> H<sub>n</sub> L<sub>n</sub>/**

Surfacing tone: **[H<sub>n</sub> L<sub>n</sub> M<sub>n</sub> L<sub>n</sub>]**

b. Absence of tone sandhi in the sentence: **/loŋ si sio k<sup>hi</sup>/**

all be hot air

Possible meanings: ‘XXX stingy/burned.’

Underlying tone: **/F<sub>n</sub> M<sub>n</sub> H<sub>n</sub> L<sub>n</sub>/**

Surfacing tone: **[F<sub>n</sub> M<sub>n</sub> H<sub>n</sub> L<sub>n</sub>]**

Although the application of tone sandhi in Taiwanese occurs often and is mandatory, the extent to which tone sandhi is required in fluent speech remains unknown. Note that in this paper, the term, *tone sandhi application*, is limited to referring to the number of syllables in a sentence that are subject to tone sandhi change. Utterances with the same number of syllables might require different degrees of tone sandhi application. Compare the rates of tone sandhi application in the three sentences in (3), all of which are composed of eight syllables. Syllables and tones in sandhi environments are bold-faced.

## (3) Utterances with different rates of tone sandhi application

- a. /**gua bo siū-be? bue un-toŋ** k<sup>h</sup>o/  
 I not want buy sport pants  
 ‘I don’t want to buy sport pants.’  
 Underlying tone: /**F<sub>n</sub> R<sub>n</sub> M<sub>n</sub>-L<sub>e</sub> F<sub>n</sub> M<sub>n</sub>-M<sub>n</sub> L<sub>n</sub>**/  
 Surfacing tone: [**H<sub>n</sub> M<sub>n</sub> L<sub>n</sub>-H<sub>e</sub> H<sub>n</sub> L<sub>n</sub>-L<sub>n</sub> L<sub>n</sub>**]  
 Tone sandhi application rate: 87.5%
- b. /**hak-siəŋ ai ka ai bat to-li**/  
 student need teach need know moral  
 ‘Students need to be taught and know morals.’  
 Underlying tone: /**H<sub>e</sub>-H<sub>n</sub> L<sub>n</sub> L<sub>n</sub> L<sub>n</sub> L<sub>e</sub> M<sub>n</sub>-F<sub>n</sub>**/  
 Surfacing tone: [**L<sub>e</sub>-H<sub>n</sub> F<sub>n</sub> L<sub>n</sub> F<sub>n</sub> H<sub>e</sub> L<sub>n</sub>-F<sub>n</sub>**]  
 Tone sandhi application rate: 62.5%
- c. /yi goŋ t<sup>h</sup>iā bo be hiau bo mŋ/  
 he dumb listen not not understand not ask  
 ‘He was dumb, didn’t understand, and didn’t ask.’  
 Underlying tone: /**M<sub>n</sub> M<sub>n</sub> H<sub>n</sub> R<sub>n</sub> R<sub>n</sub> F<sub>n</sub> R<sub>n</sub> M<sub>n</sub>**/  
 Surfacing tone: [**M<sub>n</sub> M<sub>n</sub> M<sub>n</sub> R<sub>n</sub> M<sub>n</sub> F<sub>n</sub> M<sub>n</sub> M<sub>n</sub>**]  
 Tone sandhi application rate: 37.5%

As shown by the examples in (3), the application rate of tone sandhi can vary, depending on the syntactic structure of an utterance. Sometimes the rate of utilizing tone sandhi is high, as in (3a), and is sometimes low, as in (3c). According to Lin (1994), Taiwanese tone sandhi is determined by lexical government. The more phrases in a sentence that are not lexically governed, the lower the rate of tone sandhi application. An overview description of Taiwanese tone sandhi will be presented in the next section.

It should be apparent that as a general principle, when speaking Taiwanese appropriately one has to do tone sandhi often and correctly. Given that tone sandhi is frequent in Taiwanese and that the length of an utterance does not always serve as a good sandhi application rate indicator, as the example sentences in (3) show, one can ask the question ‘How often does a fluent Taiwanese speaker utilize tone sandhi rules in general?’ As of now, no studies have been conducted on the frequency of Taiwanese tone sandhi in natural speech. The only Taiwanese spoken corpus available in the literature, constructed by Tsay & Myers (2005), does not provide frequency information on Taiwanese tone sandhi. Their corpus provides data on the frequency of each Taiwanese tone, but because their corpus does not distinguish sandhi tones from citation tones it does not indicate how frequent the tones in sandhi contexts are nor the

frequency of the various tone sandhi rules. Therefore, the main purpose of this paper is to fill this gap by constructing a small Taiwanese spoken corpus of natural unrehearsed speech. Despite its small size, this corpus is the first and only one in the field that has documented unscripted narratives. It can thus serve as a basis for future comparisons across different genres of speech. The statistical analyses of data taken from the corpus indicate that the results are significant and can be validated.

The corpus data examined in this study were produced by 11 first language (L1) Taiwanese speakers who learned Mandarin as their second language (L2). Six of the speakers were older and Taiwanese-dominant. The other five were younger and balanced in Taiwanese and Mandarin. The rationale for dividing the participants into two separate groups was to examine whether the differences in age and L2 fluency would cause a difference in tone sandhi application rates. Research has shown that early bilingual speakers who are fluent in both L1 and L2 can display phonetic differences from monolingual speakers (e.g., Flege & Eefting 1988, Kehoe, Lleó & Rakow 2004). There is no research indicating whether L2 fluency plays a role in L1 tone sandhi application, although Zhang & Liu (2011) suggest that part of the changing nature of the tone sandhi pattern among younger speakers in Tianjin Chinese may be due to the influence of Standard Chinese (Mandarin).

The remainder of this paper is organized as follows. Section 2 serves as background by reviewing the tones and tone sandhi of Taiwanese. Section 3 introduces the corpus, including the speakers who provided the speech data, the methods of data collection, and how the data were coded and analyzed to calculate the frequency of Taiwanese tone sandhi. Section 4 presents the findings. Section 5 concludes by summarizing the study and offering some implications and directions for future research.

## 2. Taiwanese tones and tone sandhi

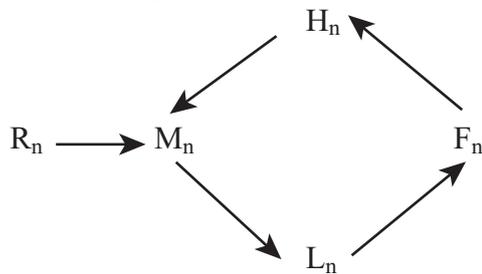
Linguists working on Taiwanese generally agree that the language has seven distinct underlying lexical tones (Chao 1930, Cheng 1968, 1979, Chung 1996, Chen 2000)—five non-entering tones (rising, high-level, mid-level, low-level, and falling) and two entering tones (high-abrupt and low-abrupt) (Tsay 1989). Non-entering tones occur in non-checked syllables, which end either in a vowel or a sonorant coda (i.e., a nasal consonant). However, entering tones are shorter in length and are used in syllables that end in an obstruent.<sup>1</sup> In this study, we use,  $R_n$ ,  $H_n$ ,  $M_n$ ,  $L_n$ ,  $F_n$ ,  $H_e$ , and

<sup>1</sup> The consonants, /p, t, k, ʔ/, are the only obstruents that can end a syllable in Taiwanese. There is some disagreement among Taiwanese phonologists as to the precise pitch of the two entering tones as well as to the pitch range of the non-entering tones, given the 5-point pitch scale (Chao 1930, 1968)

$L_e$ , to refer to Taiwanese tones. Subscripted letters,  $n$  and  $e$ , denote the tonal types, non-entering or entering respectively. For example,  $H_n$  refers to the non-entering high-level tone while  $H_e$  represents the entering high-abrupt tone. We also limit our use of the term *Taiwanese* to *Inland Taiwanese*, as opposed to *Coastal Taiwanese*, given that the speech data were produced by Inland Taiwanese speakers.<sup>2</sup>

Both non-entering tones and entering tones are involved in Taiwanese tone sandhi with separate sets of tone sandhi rules. Every tone, regardless of its tonal type, undergoes tone change in a sandhi environment. Whether a tone-occurring context requires tone sandhi or not is mainly determined by its syntactic position in an utterance (Chen 1987, Lin 1994). When occurring in a nonfinal position of a phrase, a tone must be subject to tone sandhi and surface with its sandhi form. In this paper, the nonfinal position of a phrase is termed *sandhi environment/context*. The sandhi form of a tone is derived by following the tone change rules, as shown in (4) and (5). Given that the coda in a syllable makes a difference when determining the sandhi tones for  $L_e$ , the coda consonants are subscripted.<sup>3</sup>  $L_{e(p/t/k)}$  and  $L_{e(?)}$  stand for an entering low tone on a syllable ending with /p/, /t/, or /k/ and an entering low tone on a syllable ending with /ʔ/, respectively.

(4) Non-entering tone sandhi rules (Chao 1930, Cheng 1968, 1979, Hsieh 1976, Chen 1987, Chung 1996)



commonly used to transcribe tone in Chinese languages. Because of this disagreement, we refer to the Taiwanese tones by their relative height (high, mid, low) or contour (rising, falling) and not by reference to numbers on the 5-point pitch scale.

<sup>2</sup> Both Inland Taiwanese and Coastal Taiwanese are considered subdialects of Taiwanese. One of the main differences that distinguishes the two subdialects is their disparity in tone sandhi rules involving the  $R_n$  and  $F_n$  tones. According to Hsieh (1976) and Wang (1993), in a sandhi position,  $R_n$  becomes  $M_n$  in Inland Taiwanese whereas  $R_n$  changes to  $L_n$  in Coastal Taiwanese. As for the sandhi rule for  $F_n$ , Hsieh states that Inland Taiwanese speakers abide by  $F_n \rightarrow H_n$  while Coastal Taiwanese speakers follow  $F_n \rightarrow M_n$ . In Wang, on the other hand, Coastal Taiwanese speakers adhere to  $F_n \rightarrow R_n$ .

<sup>3</sup> Traditionally, the sandhi tones of the two entering tones,  $H_e$  and  $L_e$ , are described as interchanging with each other ( $H_e \rightarrow L_e$ ,  $L_e \rightarrow H_e$ ). That is, the sandhi tone for  $H_e$  is  $L_e$ , and the sandhi tone for  $L_e$  is  $H_e$  (Chao 1930, Cheng 1979, Chung 1996). Nonetheless, Chen (2000) proposed a slightly different set of sandhi rules for the entering tones, based on the coda ending of a checked syllable. When a checked syllable ending with /ʔ/ carries the underlying low abrupt entering tone  $L_e$ , the surfacing sandhi counterpart is  $F_n$  ( $L_{e(?)}$   $\rightarrow$   $F_n$ ). Otherwise, the sandhi tone of  $L_e$  is  $H_e$  ( $L_{e(p/t/k)}$   $\rightarrow$   $H_e$ ). With regard to the sandhi tone for  $H_e$ , there is no difference between the transcription of Chen (2000) and that of Chao (1930), Cheng (1979), and Chung (1996).

(5) Entering tone sandhi rules (Chao 1930, Cheng 1968, 1979, Hsieh 1976, Chung 1996, Chen 2000)

- a.  $H_e \rightarrow L_e$
- b.  $L_{e(p/t/k)} \rightarrow H_e$
- c.  $L_{e(?)}$   $\rightarrow H_e$  or  $F_n$

As illustrated in (4), the non-entering tones in Taiwanese follow a tone circle with respect to their change to sandhi tones (Chen 1987). This circle is like a chain, by which an underlying tone is looking for another underlying tone to serve as its sandhi tone to surface. For example, a syllable with the underlying tone  $L_n$  would undergo this tone circle to derive its sandhi tone  $F_n$ , while a syllable with the underlying tone  $F_n$  surfaces as  $H_n$  in a sandhi context, and so on. With respect to the entering tones, the sandhi tone for  $H_e$  is consistently  $L_e$ , as seen in (5a). However, the sandhi form for the underlying tone  $L_e$  might be either  $H_e$  or  $F_n$  depending on the coda ending of a checked syllable. When a syllable with the underlying tone  $L_e$  ends with /p/, /t/, or /k/, the surfacing sandhi counterpart is always  $H_e$ . On the other hand, a /ʔ/-ending syllable with the  $L_e$  tone has two sandhi variants,  $H_e$  and  $F_n$ . With the examples in (6), we demonstrate how tone sandhi functions in Taiwanese. The syllable and tone in a sandhi environment are bold-faced.

(6) Taiwanese tone sandhi examples

- a. Tone sandhi involving the non-entering tone sandhi rule:  $F_n \rightarrow H_n$

/**ho**    si/  
 good    time  
 ‘auspicious time’

Underlying tone: / **$F_n$**      $R_n$ /  
 Surfacing tone: [ **$H_n$**      $R_n$ ]

- b. Tone sandhi involving the entering tone sandhi rule:  $H_e \rightarrow L_e$

/**sik**    tsju/  
 familiar hand  
 ‘experienced’

Underlying tone: / **$H_e$**      $F_n$ /  
 Surfacing tone: [ **$L_e$**      $F_n$ ]

c. Tone sandhi involving the entering tone sandhi rule:  $L_{e(p/t/k)} \rightarrow H_e$

/sik boŋ/

color blind

‘color blind’

Underlying tone: /L<sub>e</sub> R<sub>n</sub>/

Surfacing tone: [H<sub>e</sub> R<sub>n</sub>]

d. Tone sandhi involving the entering tone sandhi rule:  $L_{e(?)}$   $\rightarrow$  H<sub>e</sub>

/be? kwã/

want see

‘...want to see.’

Underlying tone: /L<sub>e</sub> L<sub>n</sub>/

Surfacing tone: [H<sub>e</sub> L<sub>n</sub>]

e. Tone sandhi involving the entering tone sandhi rule:  $L_{e(?)}$   $\rightarrow$  F<sub>n</sub>

/pe? swã/

climb mountain

‘mountain climbing’

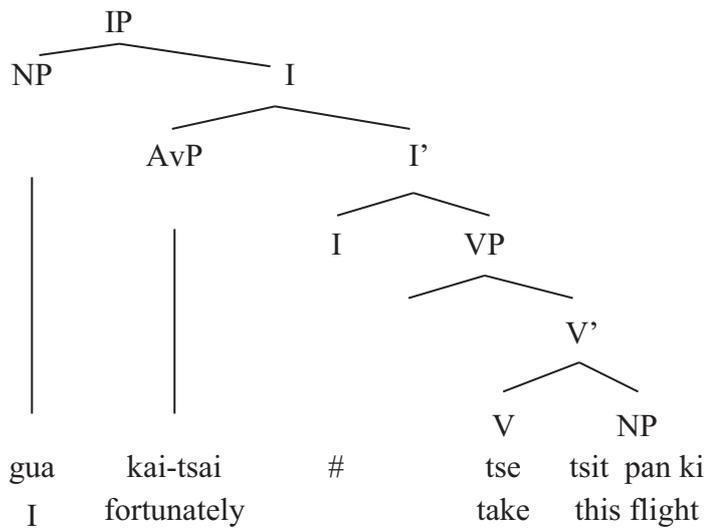
Underlying tone: /L<sub>e</sub> H<sub>n</sub>/

Surfacing tone: [F<sub>n</sub> H<sub>n</sub>]

As shown by the examples in (6), a tone is subject to tone sandhi when it occurs in a sandhi environment. If a tone in a sandhi environment does not surface with its sandhi tone, the speech production might be unintelligible.

With such a tone sandhi system, Taiwanese tone sandhi is applied extensively in speech, given that natural speech is almost always longer than two syllables. When utterances are longer than two syllables, a certain type of partitioning is necessary so that longer sentences can be divided into phrase groups for tone sandhi application. The phrase groups in a sentence are called tone groups or tone sandhi domains. According to Lin (1994), the Taiwanese tone sandhi domain is determined by lexical government. A tone group boundary forms at the right edge of a phrase when it is not lexically governed, as illustrated by Lin’s example in (7). The symbol # marks the boundary between two tone groups.

(7) Lin's (1994) example demonstrating tone groups in Taiwanese



A tone boundary is inserted after the adverb phrase *kai-tsai* because it is not lexically governed by V. Although *kai-tsai* is governed by I, this type of government is non-lexical. In a tone group, only the last syllable can preserve its underlying citation tone, the syllables preceding the last one must be subject to tone sandhi. Therefore, in (7) the syllables, except for /tsai/ and /ki/, have to surface with their sandhi tones. Lin's government-theoretic approach provides a unified account of tonal phrasing in Taiwanese, which represents a fluent Taiwanese speaker's grammar of tone sandhi.<sup>4</sup>

Having reviewed Taiwanese tones, in the next section we turn to the introduction of the spoken corpus. The speakers' backgrounds and methods of data collection will also be presented.

### 3. Speech data

The speech data analyzed in this paper are from 11 fluent Taiwanese speakers. The speakers are homogeneous in their language background (Taiwanese as L1 and Mandarin as L2), use Taiwanese for daily functions, and are fluent in Taiwanese. In

<sup>4</sup> We are aware that it is sometimes suggested that prosodic hierarchy may play a role in tone sandhi grouping in addition to the government-theoretic account. However, it is important to keep in mind that tone sandhi in Taiwanese applies in the domain determined by the lexical government regardless of speech rate. While speech rate may affect prosodic grouping it does not affect the syntactic grouping in the relevant sense. A different issue that we do not discuss in this paper concerns neutral tone, as in the phrase /ao lit/ with the specific meaning 'the day after tomorrow.' In /ao lit/, the morpheme /ao/ is realized in its citation tone since the morpheme /lit/ in this context has a neutral tone. Syllables with neutral tones may be considered as prosodically weak (see Cheng 1973, Du 1988). Since syllables with neutral tones do not participate in tone sandhi, we do not consider them in the current paper.

order to reduce the effect of dialectal differences in Taiwanese, the speakers chosen were all born and raised in the Taipei area, including Taipei City and New Taipei City. According to Hsieh (1976), participants in a study such as this should speak the subdialect of Taiwanese—Inland Taiwanese, given that Inland Taiwanese is spoken in Taipei. The speakers differ in age and in L2 Mandarin fluency. The subjects' ages correlate with their Mandarin fluency. The older participants, aged over 50, all speak Mandarin with a heavy Taiwanese accent whereas the younger speakers, aged between 32 to 40 years old, do not. Details of the speakers and the methods of data collection are given in the following subsections.

### 3.1 Speaker groups

The 11 Taiwanese speakers were divided into two groups based on their ages and L2 Mandarin fluency—six speakers in the Taiwanese-dominant group and five speakers in the Taiwanese-Mandarin bilingual group. The six Taiwanese-dominant participants, in their 50s and 60s, speak Taiwanese and Mandarin as their L1 and L2, respectively. Mandarin was learned in elementary school when they were approximately 7 years old. Based on the older participants' self-reports, they did not switch to speaking Mandarin after starting school. Taiwanese has always been their main medium for daily communication. They all claimed to be Taiwanese-dominant and were able to communicate in Mandarin though with a Taiwanese-influenced accent. All of the Taiwanese-dominant speakers met the following criteria.

#### (8) Criteria for the Taiwanese-dominant group

- a. Taiwanese is the speakers' L1.
- b. Before going to school, they had very little or no exposure to Mandarin. The language spoken at home was Taiwanese.
- c. Mandarin was learned in school (around or after five years old).
- d. Taiwanese is their dominant language. They speak Taiwanese at work and use Taiwanese for daily functions.
- e. They do not speak Mandarin often, only when talking to people who speak Mandarin to them or do not speak Taiwanese.
- f. They live in Taipei.
- g. They grew up and had never left Taipei before they were 18. If the participants had left Taipei for school, work, or the military, they still spoke Taiwanese most of the time.
- h. They are more than 50 years old.

In Table 1, we show relevant background details of the Taiwanese-dominant speakers. Among them, TW1 and TW6 had been retired for a couple of years when the data were collected.

**Table 1. Background details of the Taiwanese-dominant group**

Participant Code	Sex	Age	Education	(Former) Occupation
TW1	Male	68	Elementary School	Restaurant Owner
TW 2	Male	54	High School	House Remodeler
TW 3	Male	59	High School	Car Parts Supplier
TW 4	Female	61	Elementary School	Tailor
TW 5	Female	61	Elementary School	Housewife
TW 6	Female	60	Elementary School	Lottery Retailer

Like the Taiwanese-dominant speakers, the bilingual group speak Taiwanese as L1 and learned Mandarin as L2 at school. They also continued to use Taiwanese after having massive exposure to Mandarin in school. Unlike the Taiwanese-dominant speakers, the bilingual speakers have native fluency in both Mandarin and Taiwanese. When asked about their dominant language, all of the bilingual participants were uncertain and their first reaction was a puzzled look. They then stressed their native fluency in both languages. When told that they had to select either Taiwanese or Mandarin as their dominant language, two chose Taiwanese, two chose Mandarin, and the other refused and insisted on being dominant in both languages. The standard we abided by in selecting qualified bilingual speakers was based on the criteria given in (9). In Table 2, we present the background details of each bilingual speaker.

(9) Criteria for the bilingual group

- a. Taiwanese is the bilingual speakers’ L1.
- b. Before going to school, they had very little or no exposure to Mandarin. The language spoken at home was Taiwanese.
- c. Mandarin was learned in school (around or after five years old).
- d. Taiwanese and/or Mandarin are/is the dominant language(s). They mostly speak Taiwanese at work and use both Taiwanese and Mandarin for daily functions.
- e. They are fluent in both Taiwanese and Mandarin and have no difficulty expressing themselves in either language.
- f. They live in Taipei.

- g. They grew up and had never left Taipei before they were 18. If the participants had left Taipei for school, work, or the military, they still spoke Taiwanese most of the time.
- h. The age range is between 28 to 40 years old.

**Table 2. Background details of the bilingual group**

Participant Code	Sex	Age	Education	Occupation	Language Dominance
BL1	Male	40	Middle School	Security Window Installer	Taiwanese
BL2	Male	34	High School	Truck Driver	Mandarin
BL3	Male	33	High School	Factory Owner	Taiwanese
BL4	Female	40	High School	Receptionist	Both
BL5	Female	31	Vocational 2-year college	Foreman	Mandarin

### 3.2 Methods of data collection

The speech data were collected from two tasks—film retelling and storytelling. These tasks constituted short, spoken, and unscripted narratives. The purpose of utilizing two separate tasks was to increase the variety of vocabulary. The speakers did the film retell task first and then the story telling task.

For the film retell task, the speakers watched an excerpt, *Alone and Hungry* (approximately 11 minutes), from the silent movie *Modern Times*. Before the movie was played, the speakers were told that they would be asked to retell the film based on their own interpretation and that they could only use Taiwanese. Thus, they needed to pay attention to the film and try to remember as much as possible. The speakers spent approximately three to four minutes retelling the movie excerpt.

The second task was story telling. The speakers were asked to tell eight short stories (Byrne 1989) one after another. Each story was presented through four small pictures on a piece of paper. The speakers were reminded again that they should use only Taiwanese, that there was no correct or preferred way of telling the stories, and that they should tell their stories based on their understanding of the pictures. This task took the speakers approximately six minutes to complete.

### 3.3 Data coding and analyses

The data were transcribed word by word by the first author of this paper with relevant information coded. Each syllable spoken was transcribed even if it was a repetition of the previous one caused by hesitation or self-correction. Each syllable

was coded with information regarding its underlying tone, surfacing tone, context of tone occurrence (sandhi or non-sandhi), syllable type (checked or non-checked), and approximate meaning in Mandarin. The underlying tone and syllable type of each syllable were determined by consulting an online Taiwanese dictionary compiled with data provided by R. Cheng.<sup>5</sup> The surfacing tones in the corpus were transcribed based on the first author’s tone judgment and the pitch plots of all the speakers’ production as shown by the phonetic software *Audacity*.<sup>6</sup> To guarantee the reliability of the tone transcription, intra- and inter-transcriber reliability was verified in a subset of data (TW1’s speech data, a total of 1,219 syllables accounting for 12.6% of the data) in terms of percent agreement (McHugh 2012) by following Yang’s (2016) procedure. To obtain percent agreement, a matrix was created with the rows representing the syllables produced by TW1 and the columns representing the two transcribers and the agreement. The cells in the matrix contained the tones transcribed by the two raters and the number of ratings that were in agreement. A score of “1” was assigned when the two tone transcriptions of the syllable agreed, and a score of “0” was assigned when they did not. Percent agreement was obtained by dividing the total agreement score by the total number of syllables. An example of percent agreement is presented in Table 3. R. Cheng’s online Taiwanese dictionary was consulted for the syllable transcription and approximate translation in Mandarin Chinese.

**Table 3. Example of percent agreement for inter-transcriber reliability**

Syllable	Meaning	Transcriber 1	Transcriber 2	Agreement
i	he (他)	M <sub>n</sub>	M <sub>n</sub>	1
leng-	additionally (另)	L <sub>n</sub>	L <sub>n</sub>	1
goa	additionally (外)	L <sub>n</sub>	L <sub>n</sub>	1
khi	go (去)	H <sub>n</sub>	H <sub>n</sub>	1
chhan-	restaurant (餐)	M <sub>n</sub>	M <sub>n</sub>	1
thia <sup>n</sup>	restaurant (廳)	M <sub>n</sub>	H <sub>n</sub>	0
chiah	eat (吃)	L <sub>e</sub>	L <sub>e</sub>	1
mih-	stuff (物)	L <sub>n</sub>	L <sub>n</sub>	1
kia <sup>n</sup>	stuff (件)	M <sub>n</sub>	M <sub>n</sub>	1
				8/9

The percent agreement in Table 3 is 88.9%. According to McHugh (2012), 80% agreement is the minimum acceptable interrater agreement.

<sup>5</sup> Publicly accessible at <http://210.240.194.97/iug/Ungian/soannteng/chil/Taihoa.asp>.

<sup>6</sup> Publicly available at <http://audacityteam.org>.

For intra-transcriber reliability, the first author transcribed TW1's data for the second time in 2017, there being a six-year interval between the first and second transcriptions. The tone transcription agreement rate between the two transcriptions was 98.2%. To deal with tone transcription discrepancies, the first author listened to the file again and determined the final transcription. For inter-transcriber reliability checking, another transcriber, fluent in Taiwanese with a Ph.D. in linguistics, was hired to transcribe the same subset of data. The inter-transcriber percent agreement rate was 94.7%. The two transcribers then discussed the tone discrepancies and reached a consensus.

With the transcript, the transcribed surfacing tones were compared to the underlying tones. A match usually indicated that the context of tone occurrence was non-sandhi. On the other hand, a tone mismatch was generally suggestive of a sandhi environment. The transcribed surfacing tones were verified as to whether they were produced as a result of tone sandhi. Take, /ho/, meaning 'good,' for instance. The mismatch between its underlying tone  $F_n$  and surfacing tone  $H_n$  indicates a sandhi context as well as a result of sandhi application. However, discrepancies from the traditional tone sandhi grammar were observed. These were caused either by slips of the tongue or exceptions to tone sandhi. Slips of the tongue occurred when the speakers over- or under-applied tone sandhi and they then immediately self-corrected themselves. Discrepancies belonging to slips of the tongue were marked and confirmed by two other native speakers of Taiwanese who did not participate in the study. The two consultants, in their 50s and 60s, also met the criteria for the Taiwanese-dominant group as listed in (8).

Given numerous pieces of information associated with a syllable, the first author used Microsoft Excel to transcribe the data. Transcribed data in an Excel file were then sorted based on tone-occurring contexts—sandhi and non-sandhi environments. With data stored in Excel, it is possible to calculate the proportion of the number of sandhi contexts to the number of non-sandhi environments in each single speaker's speech data. For example, if a speaker produced a total of 1,500 syllables with 1,200 syllables in sandhi environments and 300 in non-sandhi contexts, the proportion of sandhi and non-sandhi environments would be 1,200:300. This would show that his/her average rate of employing tone sandhi in natural speech was 80%. A rate of 80% means that on average for every one hundred syllables, 80 syllables are subject to tone sandhi and should be pronounced with sandhi tones.

In addition to tone transcription, the average length of utterance by each speaker was calculated. An utterance is a natural unit of speech that can be separated from another by pause and breath (Crookes 1990). Note that the average length of utterance examined in this paper is different from the mean length of utterance (hereafter

MLU). MLU refers to the average number of morphemes per utterance (Gabig 2013) while the average length of utterance focuses on the number of syllables involved in an utterance. We calculated the average length of utterance and then randomly selected three utterances with the average length from each speaker's data to examine the number of tone sandhi groups involved in an utterance. By so doing, we hoped to gain more insight into the Taiwanese syntactic-phonological systems of the two speaker groups, specifically to see whether one group produced longer utterances and created more tone groups in them. In addition, the relationship between the average length of utterance and the number of tone sandhi groups could either support or deviate from the method discussed in the previous paragraph regarding how the sandhi application rate was calculated. The number of utterances was calculated by the first author based on natural pauses. A second listener, an MA linguistics student from Taiwan, was hired to calculate the number of utterances produced by each speaker. The first author and the listener then compared their numbers and how they had marked natural pauses. Regarding discrepancies, the first author and the listener discussed them and decided on a final number.

In general, longer utterances may generate more sandhi environments and entail a more complex syntactic system. The calculation of each participant's average length of utterance could, to some extent, shed light on the impact of L2 Mandarin fluency on the bilingual speakers' syntactic-phonological system in Taiwanese. After obtaining the average length of utterance, we randomly selected three utterances of average length from each speaker's data and calculated the number of tone sandhi groups in each one.

## **4. Findings**

### **4.1 Tone sandhi application rate, average utterance length, and tone sandhi group**

Examining the spoken corpus, we observed that the 6 Taiwanese-dominant participants created a total of 2,072 non-sandhi contexts and 4,305 sandhi contexts for tones. The 5 bilingual speakers produced 1,108 non-sandhi environments and 2,176 sandhi environments. The speech production of the Taiwanese-dominant speakers and Taiwanese-Mandarin bilinguals most of the time showed the syntax-governed grammar. However, not every syllable in the sandhi environment was pronounced with the expected sandhi tone, due to exceptions or slips of the tongue. We address these discrepancies in Section 4.2 where the use frequency of each tone sandhi rule is presented.

With 4,305 syllables in the sandhi context and 2,072 syllables in the non-sandhi context in the data of the Taiwanese-dominant speakers, proportion of employing the sandhi tone is 67.5%. The Taiwanese-Mandarin bilinguals demonstrated a similar rate, at 66.3% (2,176 syllables in the sandhi environment and 1,108 in the non-sandhi environment). Table 4 summarizes the proportions of non-sandhi and sandhi contexts of the two speaker groups.

**Table 4. Tone occurring context (non-sandhi and sandhi) information of the Taiwanese-dominant and bilingual groups**

Group	# of non-sandhi contexts	# of sandhi contexts	Total
Taiwanese-dominant	2,072 (32.5%)	4,305 (67.5%)	6,377
Bilingual	1,108 (33.4%)	2,176 (66.3%)	3,284

In order to investigate whether there was a significant difference between the Taiwanese-dominant and the bilingual groups on their rates of tone sandhi application, an independent samples *t* test was conducted. The results showed that there was no significant difference in the tone sandhi application rates between the two speaker groups ( $t(4.67) = 0.46, p = 0.67$ ). Given that the groups did not differ in tone sandhi application rate at a significant level, it is plausible to claim that in natural narrative speech, Taiwanese speakers apply the Taiwanese tone sandhi to approximately 67% of their total production.

The six Taiwanese-dominant speakers and the five bilingual speakers were also found to produce about the same length of utterance in their speech. On average, the Taiwanese-dominant group produced 9.54 syllables per utterance, and the bilingual group produced 9.91. An independent samples *t* test was conducted to compare the average utterance lengths of the two groups. There was no significant difference in utterance length ( $t(9) = -0.59, p = 0.57$ ). We further investigated whether the two groups demonstrated similar syntactic tone sandhi grouping. Given that utterance lengths vary to a great extent, 10-syllable utterances were selected as the baseline in order to obtain an estimated average number of tone sandhi groups in an utterance. We randomly selected three 10-syllable utterances from each speaker and calculated the number of tone sandhi groups in each utterance. In an utterance with 10 syllables, the Taiwanese-dominant speakers created an average of three tone sandhi groups, and the bilingual speakers produced 2.93. An independent-samples *t* test revealed that the sandhi group difference between the two groups was not significant ( $t(31) = 0.2, p = 0.85$ ).

In short, the data show that there are approximately three sandhi groups in an utterance of 10 syllables. That means seven out of the ten syllables should surface with sandhi tones, meaning the sandhi application rate is 70%. The findings on the average utterance length and tone sandhi group further lend support to our claim that approximately two thirds of the syllables in natural narratives are subject to tone sandhi. Since the bilingual speakers did not significantly differ from the Taiwanese-dominant speakers in their tone sandhi application rate, average utterance length, and number of tone sandhi groups, we conclude that L2 Mandarin fluency does not seem to impact overall L1 Taiwanese tone sandhi frequency and that the Taiwanese-Mandarin bilinguals may have a similar Taiwanese syntax system as the Taiwanese-dominant speakers.<sup>7</sup> We encourage further studies to verify our claim by analyzing and comparing the syntactic structures of natural narratives produced by Taiwanese-dominant and bilingual speakers.

#### **4.2 Cases of tone discrepancies that do not conform to sandhi rules**

In our speech data, we found tone discrepancies in which the speakers were expected to produce the expected sandhi tones but did not. As discussed previously, these discrepancies were either exceptions or slips of the tongue. According to Poulisse's definition (1999:92), slips of the tongue are 'accidental,' 'unintended,' and 'non-habitual' errors. They are errors that would not have occurred if the speaker had been more careful but are repairable by the speaker if the speaker's attention is drawn to the error. We consider that tone discrepancies accounted for less than 5% as slips of the tongue. Thus, our discussion of tone discrepancies is limited to those cases that make up more than 5% of the data. A non-entering tone matrix in Table 5 shows the speakers' tone distribution based on the underlying tonal category and the surfacing tone sandhi category. The matrix in Table 6 demonstrates the participants' entering tone sandhi pattern. Expected tone sandhi production, based on the tone sandhi rules presented in Tables 5 and 6, is represented by the shaded cells. To compare whether the two groups show different sandhi patterns, the cells include numbers that represent both the Taiwanese-dominant and bilingual speakers' tokens of tone production and their percentages in the group's overall production. The Taiwanese-dominant speakers' production is presented in the left half of the cell before the slash, with the bilinguals' data shown on the right.

<sup>7</sup> This does not preclude that there may be differences in segmental phonology between the two groups, especially given the difference in coda phonotactics between Taiwanese and Mandarin. We leave this matter for future research.

**Table 5. Non-entering tone matrix of the participants in the sandhi context**

Surfacing Underlying	H <sub>n</sub>	R <sub>n</sub>	M <sub>n</sub>	L <sub>n</sub>	F <sub>n</sub>	Total
H <sub>n</sub>	0/1 0%/0.4%		535/249 100%/99.6%			535/250
R <sub>n</sub>	3/2 0.4%/0.6%		275/114 33.8%/33.2%	535/227 65.8%/66.2%		813/343
M <sub>n</sub>			10/6 1.2%/1.4%	836/407 98.7%/98.1%	1/2 0.1%/0.5%	847/415
L <sub>n</sub>	69/63 18.1%/25.5%		2/0 0.5%/0%	3/2 0.8%/0.8%	3.7/182 80.6%/73.7%	381/247
F <sub>n</sub>	770/422 92.5%/91.9%		1/0 0.1%/0%	1/1 0.1%/0.2%	60/36 7.2%/7.8%	832/459
Total						3,408/1,714

Note: In the cells where #<sub>T</sub>/#<sub>B</sub> and #<sub>T</sub>%/#<sub>B</sub>% are available, #<sub>T</sub> refers to the number of tokens of tone production produced by the Taiwanese-dominant group. #<sub>T</sub>% stands for the percentage of the Taiwanese-dominant speakers' overall tone production for that particular tone sandhi category. The bilingual speakers' tone production and distribution can be found in #<sub>B</sub> and #<sub>B</sub>%.

**Table 6. Entering tone matrix of the participants in the sandhi context**

Surfacing Underlying	H <sub>n</sub>	R <sub>n</sub>	M <sub>n</sub>	L <sub>n</sub>	F <sub>n</sub>	H <sub>e</sub>	L <sub>e</sub>	Total
H <sub>e(p/t/k)</sub>			12/8 3.5%/3.7%		0/1 0%/0.4%		333/209 96.5%/95.9%	345/218
L <sub>e(p/t/k)</sub>			1/0 0.2%/0%		5/1 1.1%/0.5%	434/194 98.6%/98.5%	0/2 0%/1%	440/197
L <sub>e(?)</sub>			2/0 1.7%/0%		34/19 30.4%/40.4%	76/28 67.9%/59.6%		112/47
Total								897/462

Note: In the cells where #<sub>T</sub>/#<sub>B</sub> and #<sub>T</sub>%/#<sub>B</sub>% are available, #<sub>T</sub> refers to the number of tokens of tone production produced by the Taiwanese-dominant group. #<sub>T</sub>% stands for the percentage of the Taiwanese-dominant speakers' overall tone production for that particular tone sandhi category. The bilingual speakers' tone production and distribution can be found in #<sub>B</sub> and #<sub>B</sub>%.

The tone matrixes in Tables 5 and 6, which demonstrate tone distribution across all the sandhi types, show that the sandhi patterns of the bilingual speakers are very similar to those of the Taiwanese-dominant speakers. With regard to non-entering tone sandhi, both groups deviated from the traditional sandhi grammar in three situations—R<sub>n</sub>→L<sub>n</sub> (instead of the orthodox R<sub>n</sub>→M<sub>n</sub>), L<sub>n</sub>→H<sub>n</sub> (instead of the orthodox L<sub>n</sub>→F<sub>n</sub>) and F<sub>n</sub>→F<sub>n</sub> (instead of the orthodox F<sub>n</sub>→H<sub>n</sub>). As for entering tone

sandhi, the two groups most of the time followed the traditional sandhi rules. We discuss these three tone sandhi exceptions in the following subsections.

#### 4.2.1 Tone sandhi exception 1: $R_n \rightarrow L_n$

When encountering the  $R_n \rightarrow M_n$  sandhi type, both the Taiwanese-dominant and bilingual groups' preferred surfacing sandhi tone is the low tone  $L_n$ . The proportion of  $M_n$  to  $L_n$  ( $M_n:L_n$ ) in the  $R_n \rightarrow M_n$  sandhi is 1:1.94 for the Taiwanese-dominant group and 1:2 for the bilingual group. This means that for both groups, the chance of utilizing the low tone  $L_n$  instead of the sandhi  $R_n$  is twice as much as using the mid tone  $M_n$ . Given that the focus of this article is on the Taiwanese tonal systems as a whole, we do not address specific phonological, phonetic, or semantic environments where a low tone is favored over a mid tone. It is sufficient to note that the production of the sandhi tone for  $R_n$  in every fluent speaker of Taiwanese varies. Considering the participants' extensive use of the  $R_n \rightarrow L_n$  sandhi rule, we revise the traditional  $R_n \rightarrow M_n$  to  $R_n \rightarrow M_n/L_n$  to reflect their actual speech.<sup>8</sup>

#### 4.2.2 Tone sandhi exception 2: $L_n \rightarrow H_n$

With respect to the aberrant sandhi type,  $L_n \rightarrow H_n$ , there are three situations in which the non-entering low tone does not follow standard tone sandhi, where it surfaces with its orthodox sandhi tone  $F_n$ , and instead the surfacing tone is  $H_n$ . The first situation has to do with the morpheme /k<sup>h</sup>i/ 'go.' The citation tone of /k<sup>h</sup>i/ is a low tone. However, when /k<sup>h</sup>i/ 'go' is used as a linking verb (i.e., usually in the environment of another verb) or is followed by a noun phrase in the sandhi context, the surfacing form is consistently  $H_n$ , which is not derived from the Taiwanese tone sandhi circle. The examples in (10a) and (10b) show the usage of /k<sup>h</sup>i/ in final and nonfinal positions when it is not used as a linking verb or is not followed by a noun phrase. The pronunciation of the examples in (10) was confirmed by one of the Taiwanese-dominant speakers (TW5) and the two informants.

<sup>8</sup> An interesting question that we do not investigate here is whether a single lexical item with  $R_n$  as citation tone varies in the individual speaker as to whether its sandhi tone is  $M_n$  or  $L_n$ .

(10) k<sup>hi</sup> ‘go’ (Citation tone: L<sub>n</sub>)

a. Final position: /kwe **k<sup>hi</sup>**/  
 pass go  
 ‘past’

Surfacing tone: [F<sub>n</sub> **L<sub>n</sub>**]

b. Nonfinal position: /**k<sup>hi</sup>** hyoŋ/  
 go direction  
 ‘whereabouts’

Surfacing tone: [**F<sub>n</sub>** L<sub>n</sub>]

However, all of the Taiwanese-dominant and bilingual speakers realized /k<sup>hi</sup>/ (Taiwanese-dominant group: 58 tokens; bilingual group: 56 tokens) with a high tone in the sandhi context when it was used as a linking verb or was followed by a noun phrase. This is exemplified in (11).

(11) k<sup>hi</sup> ‘go’ in a nonfinal position

/zau <b>k<sup>hi</sup></b> k <sup>hi</sup> -k <sup>he</sup>	<b>k<sup>hi</sup></b> kwan tsui-k <sup>hi</sup> /
run go tooth-department go see mouth-tooth	
‘go to see a dentist’	

Underlying tone: /F<sub>n</sub> **L<sub>n</sub>** F<sub>n</sub>-H<sub>n</sub>                      **L<sub>n</sub>** L<sub>n</sub> L<sub>n</sub>-F<sub>n</sub>/

Surfacing tone: [H<sub>n</sub> **H<sub>n</sub>** H<sub>n</sub>-H<sub>n</sub> #                      **H<sub>n</sub>** F<sub>n</sub> F<sub>n</sub>-F<sub>n</sub>]

As seen in (11), when /k<sup>hi</sup>/ ‘go’ is used as a linking verb or is followed by a noun phrase in a nonfinal position, the surfacing form is consistently H<sub>n</sub>, which is not derived from the Taiwanese tone sandhi circle. We consider this to be a lexical exception to the standard Taiwanese tone sandhi rules.

The second exception involves the morpheme /ki/ ‘remember’ in the compound /be-ki/ ‘forget’ (Taiwanese-dominant group: 7 tokens; bilingual group: 6 tokens), which we also consider a lexical exception. Based on the online Taiwanese dictionary, Tai-wen/Hua-wen Xian Ding Zi Dian, the underlying tone of the morpheme /ki/, meaning ‘remember’, is a low tone, as demonstrated in (12a) with /ki/ in the final position. In a nonfinal context, the tone on /ki/ should undergo tone sandhi and become F<sub>n</sub>, as shown in (12b). Both examples have been confirmed by TW5 and the two informants in terms of pronunciation.

(12) ki ‘remember’ (Citation tone: L<sub>n</sub>)

- a. Final position: /be            **ki**/  
    not            remember  
    ‘forget’
- Surfacing tone: [L<sub>n</sub>            **L<sub>n</sub>**]
- b. Nonfinal position: /**ki**            ti/  
    remember keep  
    ‘memory’
- Surfacing tone: [**F<sub>n</sub>**            R<sub>n</sub>]

When the verb in (12a) is followed by an object or another verb, the context for /ki/ is shifted to nonfinal. Nevertheless, the surfacing tone of /ki/ is not its canonical falling tone but a high tone, as observed in the speech data of the Taiwanese-dominant group. The Taiwanese-dominant speakers produced seven tokens of /be-ki/, and the tone on /ki/ was consistently H<sub>n</sub>, such as the example in (13) produced by TW4.

(13) ki ‘remember’ in a nonfinal position by TW 4

- /be-**ki**            e<sup>9</sup> kuan/  
    not-remember    ∅    carry  
    ‘forget to carry’
- Underlying tone: /M<sub>n</sub>-L<sub>n</sub>            ∅    M<sub>n</sub>/
- Surfacing tone: [L<sub>n</sub>-**H<sub>n</sub>**            H<sub>n</sub> M<sub>n</sub>]

In (13), /ki/ was pronounced with a high tone. We regard the high tone on /ki/ ‘remember’ in the verb /be-ki/ ‘forget’ in a nonfinal position as an exception to the sandhi rule L<sub>n</sub>→F<sub>n</sub>

The last exception concerns the morpheme /zu/ ‘pour’ in the compound /zu-yi/ ‘attention’ (Taiwanese-dominant group: 3 tokens; bilingual group: 1 token). The online Taiwanese dictionary indicates that the citation tone of the morpheme /zu/ ‘pour’ is the low tone L<sub>n</sub>. Two examples showing the usage of the citation tone and sandhi tone of /zu/ are presented in (14).

<sup>9</sup> /e/ is an interjection marker inserted to make the whole sentence sound smoother. According to the two informants, the use of /e/ in (12) is optional. The omission of /e/ in (12) does not change the surfacing tone of its preceding syllable /ki/.

(14) zu ‘pour’ (Citation tone:  $L_n$ )

- a. Final position: /zwan      **zu**/  
concentrate pour  
‘focused’  
Surfacing tone: [ $M_n$        $L_n$ ]
- b. Nonfinal position: /**zu**      yi/  
pour      attention  
‘pay attention to’  
Surfacing tone: [ $F_n$        $L_n$ ]

When the example in (14b) appears in a sentence-final position, the tone on /zu/ shifts to  $H_n$ , as seen in (15a). This was produced by TW5 and TW6 in the data collection tasks. After consulting TW5 and the two informants, we found that the sandhi tone /zu/ in the verb /zu-yi/ was preserved with the presence of an object. This is shown in (15b).

(15) zu-yi ‘pay attention to’

- a. Nonfinal position: /yi      bo      **zu-yi**/  
he      not pay.attention  
‘He didn’t pay attention.’  
Underlying tone: / $M_n$        $R_n$        $L_n-L_n$  /  
Surfacing tone: [ $M_n \#$        $L_n$        $H_n-L_n$ ]
- b. Nonfinal position: /yi      bo      **zu-yi**      an-zuan/  
he      not pay.attention safety  
‘He didn’t pay attention to safety.’  
Underlying tone: / $M_n$        $R_n$        $L_n-L_n$        $H_n-R_n$  /  
Surfacing tone: [ $M_n \#$        $L_n$        $F_n-F_n$        $M_n-R_n$ ]

These three exceptions explain away virtually all the tokens indicated in Table 5 of an underlying  $L_n$  surfacing as  $H_n$  in a nonfinal position produced by the Taiwanese-dominant and bilingual speakers, respectively.

#### 4.2.3 Tone sandhi exception 3: $F_n \rightarrow F_n$

The third tone sandhi exception concerns the falling non-entering tone,  $F_n$ . There were a total of 96 tokens with  $F_n$  which resist tone sandhi in a nonfinal position (Taiwanese-dominant group: 60 tokens; bilingual group: 36 tokens). Among the 96 tokens, 89 tokens belong to the same morpheme /kiəŋ/ ‘police’ in a nonfinal position,

as in /kiəŋ-tsait/ ‘policeman’ (Taiwanese-dominant group: 55 tokens; bilingual group: 34 tokens). According to the same online dictionary, the underlying tone of /kiəŋ/ is a falling tone, as shown in (16a). When /kiəŋ/ is used in a nonfinal position, the expected surfacing tone should be  $H_n$ , as in (16b).

(16) kiəŋ ‘police’ (Citation tone:  $F_n$ )

- a.                            /gi-**kiəŋ**/  
                                   volunteer-police  
                                   ‘neighborhood watch volunteer’  
 Underlying tone: / $M_n$ - **$F_n$** /  
 Surfacing tone:    [ $L_n$ - **$F_n$** ]
- b.                            /**kiəŋ**-tsait/  
                                   police-examine  
                                   ‘policeman’  
 Underlying tone: / **$F_n$** - $L_e$ /  
 Surfacing tone:    [ **$H_n$** - $L_e$ ]

However, all the speakers in the study consistently produced  $F_n$  for /kiəŋ/ in the phrase /kiəŋ-tsait/, and this does not reflect the grammar indicated in the dictionary. Such a deviation from the standard norm suggests two possibilities. On the one hand, it is possible that some Taiwanese language speakers use  $L_n$  as the underlying tone for /kiəŋ/, which would explain why 89 tokens of /kiəŋ/ in /kiəŋ-tsait/ was pronounced with  $F_n$ . On the other hand, it is possible that the use of /kiəŋ/ ‘police’ in a nonfinal context has been exempt from or has never undergone tone sandhi. That is, it is invariant tone. To figure out what the citation and sandhi tones for /kiəŋ/ are, we asked five Taiwanese speakers (TW5, BL1, the two informants, and another bilingual speaker who met the criteria in (9) but did not participate in the study) to pronounce the phrases in (17)–(18). Tone variation was observed. In (17)–(18), IF1 and IF2 stand for the two informants, and IF3 for the bilingual speaker.

(17) kiəŋ ‘police’ in a final position

- a.                            /gi-**kiəŋ**/  
                                   volunteer-police  
                                   ‘neighborhood watch volunteer’  
 TW5’s surfacing tone: [ $L_n$ - **$L_n$** ]  
 BL1’s surfacing tone:  [ $L_n$ - **$F_n$** ]  
 IF1’s surfacing tone:  [ $L_n$ - **$F_n$** ]  
 IF2’s surfacing tone:  [ $L_n$ - **$L_n$** ]  
 IF3’s surfacing tone:  [ $L_n$ - **$F_n$** ]

- b. /lu-kiəŋ/  
 woman-police  
 ‘policewoman’
- TW5’s surfacing tone: [H<sub>n</sub>-L<sub>n</sub>]  
 BL1’s surfacing tone: [H<sub>n</sub>-F<sub>n</sub>]  
 IF1’s surfacing tone: [H<sub>n</sub>-F<sub>n</sub>]  
 IF2’s surfacing tone: [H<sub>n</sub>-L<sub>n</sub>]  
 IF3’s surfacing tone: [H<sub>n</sub>-F<sub>n</sub>]
- (18) kiəŋ ‘police’ in a nonfinal position
- a. /kiəŋ-ko/  
 police-tell  
 ‘to warn’
- TW5’s surfacing tone: [F<sub>n</sub>-L<sub>n</sub>]  
 BL1’s surfacing tone: [F<sub>n</sub>-L<sub>n</sub>]  
 IF1’s surfacing tone: [F<sub>n</sub>-L<sub>n</sub>]  
 IF2’s surfacing tone: [F<sub>n</sub>-L<sub>n</sub>]  
 IF3’s surfacing tone: [F<sub>n</sub>-L<sub>n</sub>]
- b. /kiəŋ-hoŋ/  
 police-party/side  
 ‘police’
- TW5’s surfacing tone: [F<sub>n</sub>-H<sub>n</sub>]  
 BL1’s surfacing tone: [F<sub>n</sub>-H<sub>n</sub>]  
 IF1’s surfacing tone: [H<sub>n</sub>-H<sub>n</sub>]  
 IF2’s surfacing tone: [H<sub>n</sub>-H<sub>n</sub>]  
 IF3’s surfacing tone: [F<sub>n</sub>-H<sub>n</sub>]

As shown in (17)–(18), only TW5 demonstrated consistent tone sandhi behavior. Her underlying and sandhi tones for /kiəŋ/ were L<sub>n</sub> and F<sub>n</sub>, respectively. Her tone realizations were not those prescribed but still abided by the standard tone sandhi rule. BL1 and IF3 were also consistent in that they used F<sub>n</sub> for /kiəŋ/ in both final and nonfinal positions. This shows that /kiəŋ/ is exempt from tone sandhi in their system. For them, the tone on /kiəŋ/ is invariant. IF1’s language behavior was more similar to BL1 and IF3 whereas IF2’s pronunciation of /kiəŋ/ was closer to TW5’s, except for the phrase in (18b). IF1 and IF2 both realized /kiəŋ/ with H<sub>n</sub>, unlike the other speakers who all used F<sub>n</sub>. To sum up, our prediction regarding the tone for /kiəŋ/ ‘police’ was supported by TW5, BL1, and IF3. TW5’s production shows that the underlying tone for /kiəŋ/ can also be L<sub>n</sub>, which is different from the standard pronunciation given by the dictionary. In the grammar of BL1 and IF3, the citation tone of /kiəŋ/ is the same

as its sandhi tone, and this morpheme is a lexical exception to tone sandhi. As for IF1 and IF2, it could be that for some speakers it is indeterminant whether the tone for /kiəŋ/ is underlyingly  $L_n$  or  $F_n$ .

### 4.3 Use frequency of individual tone sandhi rules

With the exceptions and slips of the tongue removed from the data, Table 7 presents the numbers of syllables as well as the use frequency for each tone sandhi rule.

**Table 7. Use frequency for individual tone sandhi rules<sup>10</sup>**

		Group	
		Taiwanese-dominant	Bilingual
Non-entering tone sandhi rules	$H_n \rightarrow M_n$	535 (13%)	249 (12.1%)
	$R_n \rightarrow M_n/L_n$	810 (19.6%)	341 (16.6%)
	$M_n \rightarrow L_n$	836 (20.2%)	407 (19.8%)
	$L_n \rightarrow F_n$	307 (7.4%)	182 (8.9%)
	$F_n \rightarrow H_n$	770 (18.6%)	422 (20.6%)
Entering tone sandhi rules	$H_e \rightarrow L_e$	333 (8%)	209 (10.2%)
	$L_{e(p/t/k)} \rightarrow H_e$	434 (10.5%)	194 (9.5%)
	$L_{e(?) } \rightarrow H_e/F_n$	110 (2.7%)	47 (2.3%)
Total	4,135 (100%)	2,051 (100%)	

As shown in Table 7, despite minor differences in the percentages of sandhi rule utilization, the Taiwanese-dominant speakers and Taiwanese-Mandarin bilinguals did not differ much. Both groups show that the three most frequently used tone sandhi

<sup>10</sup> It should be pointed out that the sandhi rules affecting entering tones have lower frequency rates than those affecting non-entering tones because fewer syllables end in obstruents than in sonorants.

rules are  $F_n \rightarrow H_n$ ,  $M_n \rightarrow L_n$ , and  $R_n \rightarrow M_n/L_n$ . If all the tone sandhi rules are considered together, each of the three most frequent rules are applied approximately 19% of the time. The fourth most occurring sandhi rule is  $H_n \rightarrow M_n$  with an average application rate of 12.5%. The sandhi rules,  $L_{e(p/t/k)} \rightarrow H_e$ ,  $L_n \rightarrow F_n$ , and  $H_e \rightarrow L_e$ , are the next three most frequently used rules with an average frequency of about 9% each. The least used sandhi rule is  $L_{e(?) \rightarrow H_e/F_n}$ , with approximately 2.5% of use in speech. To investigate if the two speaker groups differed in sandhi rule application, independent-samples t-tests were conducted. The results showed that there were no significant differences between the Taiwanese-dominant speakers and bilingual speakers in terms of sandhi rule application.

To recapitulate, both the Taiwanese-dominant speakers and the Taiwanese-Mandarin bilinguals demonstrate significant similar frequencies of applying overall tone sandhi and individual sandhi rules. On average, Taiwanese fluent speakers utilize tone sandhi in two thirds of their speech. In terms of using individual sandhi rules, both speaker groups showed the frequency ranking illustrated in (19). Rules with similar frequency percentages are grouped together in parentheses without ranking.

- (19) Frequency of using individual tone sandhi rules (from the most frequently used to the least used)
- $(F_n \rightarrow H_n, M_n \rightarrow L_n, R_n \rightarrow M_n/L_n)$ : approximately 19% each >  $H_n \rightarrow M_n$ : approximately 12.5% >  $(L_{e(p/t/k)} \rightarrow H_e, L_n \rightarrow F_n, H_e \rightarrow L_e)$ : approximately 9% each >  $L_{e(?) \rightarrow H_e/F_n}$ : approximately 2.5%

## 5. Conclusion and implications

This study has provided important frequency information regarding Taiwanese tone sandhi. It is known that while speaking Taiwanese, it is necessary to perform tone sandhi very frequently; otherwise, the speech output can be unintelligible. It has been suggested that the application of tone sandhi in Taiwanese occurs often and is required. However, the extent to which tone sandhi is required in fluent speech was previously unknown. Moreover, we know of no previous study undertaken to investigate whether L2 Mandarin fluency affects L1 Taiwanese tone sandhi performance. In order to fill these gaps, speech data provided by Taiwanese-dominant speakers and Taiwanese-Mandarin bilinguals were coded and analyzed. In the corpus, each Taiwanese syllable is specified with its tone occurring environment information—final position where tone sandhi is not applicable and nonfinal position where it is mandatory. In addition, each speaker's average number of utterances and

number of tone groups in a 10-syllable utterance were calculated to see whether the Mandarin fluency of the bilingual group had impacted their L1 Taiwanese utterance length and syntax. This method of analysis has provided the answers to the questions concerning how often a fluent speaker utilizes Taiwanese tone sandhi, the frequency of each tone sandhi rule, and whether L2 influences L1 sandhi behavior.

Based on the speech data, we found that the Taiwanese-dominant speakers applied tone sandhi to approximately 67% of their speech in a narrative context. The Taiwanese-Mandarin bilinguals' data yielded a 66% tone sandhi application rate, which is not significantly different. Our examination of the two groups' average length of utterances and number of tone groups in a 10-syllable utterance also lent support to this claim. On average the participants produced 10 syllables in an utterance, and there were approximately three tone groups embedded in a 10-syllable utterance. In conclusion, this study shows that in everyday spoken Taiwanese, a speaker has to consistently apply the Taiwanese tone sandhi to approximately two-thirds of their total production, at least in narrative contexts. The bilingual speakers also revealed a similar frequency pattern of sandhi rules as the Taiwanese-dominant speakers. The sandhi rules,  $F_n \rightarrow H_n$ ,  $M_n \rightarrow L_n$ , and  $R_n \rightarrow M_n/L_n$ , were the most frequently used whereas the  $L_{e(?) \rightarrow H_e/F_n}$  sandhi was the least utilized. The bilinguals' use frequency of the sandhi rules is not significantly different from that of the Taiwanese-dominant speakers'. The similarity in the overall tone sandhi application rate between the two speaker groups, regarding the average number of utterances and the average number of tone groups in a 10-syllable utterance, suggests that L2 fluency does not seem to have an effect on L1 tone sandhi application<sup>11</sup> and that the two speaker groups may have a similar Taiwanese syntax system. We encourage future studies to look into and compare the syntactic complexity between Taiwanese-dominant and Taiwanese-Mandarin bilingual speakers to verify this claim.

Another implication of our study is that it makes clear the degree of variation within the Taiwanese tone sandhi system. There are two notable cases of variation in tone sandhi: the variation with the rising tone  $R_n$  and that found with a low entering tone  $L_e$ . Although traditional analyses state that  $R_n$  has  $M_n$  as its sandhi tone in Inland Taiwanese, our data show that approximately two-thirds of the time its sandhi tone is the low tone ( $L_n$ ). Noteworthy is the observation that every speaker shows variation. This suggests an ongoing change is in progress. With respect to the tone sandhi rule for the low entering tone ( $L_e$ ), the traditional view is that the sandhi tone for  $L_e$  is  $H_e$ . Chen (2000), however, maintains that it is  $F_n$  if the syllable ends in a glottal stop. Our study clearly shows that there is variation when the  $L_e$  syllable ends in a glottal stop.

<sup>11</sup> This claim does not entail that other aspects of Taiwanese phonology are unaffected by L2 Mandarin.

While there are instances of the sandhi tone for such syllables being  $F_n$  as Chen (2000) maintains, still in the majority of cases  $L_e$  syllables ending in glottal stop have  $H_e$  as their sandhi tone. Again, all speakers show this variation and this may be reflective of a change in progress. The factors that determine these instances of sandhi variation are in need of further study.

As a final observation regarding the Taiwanese tone sandhi system, our study has documented that certain morphemes can be exceptions to the tone sandhi circle. We found that in actual speech, the lexical item /kiəŋ/ ‘police’ shows tone variation. Some speakers follow the Taiwanese sandhi system, using  $L_n$ , a citation tone different from what the dictionary prescribes, in a non-sandhi position and  $F_n$  in a sandhi environment while others consistently utilize  $F_n$  regardless of the tone context. Also, the morpheme /k<sup>h</sup>i/ ‘go’ has a different sandhi tone when used as a linking verb or is followed by a noun phrase. The sandhi tones for /ki/ in /be-ki/ ‘forget’ and /zu/ in /zu-yi/ ‘pay attention’ shift, depending on the presence or absence of the object in a sentence. The fact that specific morphemes can be exceptions to the tone sandhi circle may have consequences for whether tone sandhi is best understood as reflecting a productive rule, is a lexical storage of related allomorphs, or is perhaps both. Detailed discussion of this is beyond the scope of the current paper, though see Zhang, Lai & Turnbull-Sailor (2006) for experimental evidence.

To conclude, as we have discussed, Taiwanese tone sandhi frequency information was not available prior to this study. Given that obtaining such information requires not only compiling a spoken corpus but also its detailed transcription, with annotation for the tone occurring contexts (sandhi or non-sandhi) and tone types (entering tone or non-entering tone), such a corpus, as far as we are aware, did not previously exist. The compilation of such a corpus is not only time consuming, but requires an intimate understanding of Taiwanese tonal phonology and morphosyntax in order to distinguish a sandhi context from a non-sandhi context. We understand the limitation that the first author was the only transcriber for all of the tone data for this study. Nonetheless, by selecting a subset of the speech data and conducting an intra- and inter-transcriber reliability check as described in Section 3.3, we have greatly increased the reliability of our tagging. The Taiwanese spoken corpus of Tsay & Myers (2005), while providing frequency information, does not distinguish between citation and sandhi tones. Consequently, it does not contain data on which tone sandhi rules are more frequent. The results of our study, though relatively small in size, provide an important baseline which can be used as reference for future studies. Such studies should examine other genres of spoken Taiwanese, other dialects of Taiwanese and other Chinese languages with extensive tone sandhi systems to see how they compare with the sandhi rates reported in this study.

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