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First Language Taiwanese Tonal Attrition: Revisiting First Language Attrition Hypotheses and Their Relevance

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Abstract

Most first language (L1) attrition research focuses on syntactic and morphological deterioration in environments where L1 'attriters' rarely have contact with their L1, such as immigrants. There is no study on L1 attrition in tones and in contexts where L1 can still be often heard. This study examines this attrition type in Taiwan, where the attriters cannot speak their L1 Taiwanese fluently and have become L2-Mandarin dominant after five years old. This study investigates L1 attriters' Taiwanese tonal system by evaluating tonal attrition hypotheses based on four of the six L1 attrition proposals in the literature. The data in this study are composed of natural speech provided by 10 L1 Taiwanese attriters, 6 older L1 Taiwanese non-attriters, and 5 younger L1-Taiwanese L2-Mandarin bilinguals. The participants performed a film retell and a story-telling task. The results indicate that Taiwanese tone sandhi is so ingrained in the attriters' phonology that the attriters are still capable of accurately performing tone sandhi (approximately 90% accurate). Although the attriters have become L2 Mandarin dominant, L2 interference is not observed. Given these findings, the L1 Taiwanese tonal attrition hypotheses referencing L2, such as the simplification hypotheses, cannot account for the attriters' system. Rather, attrition hypotheses referencing L1 acquisition, such as the threshold hypothesis, are more successful at accounting for the attriters' tonal system. There is still a larger question as to why the complex Taiwanese tone sandhi system is so well maintained in light of the presence of the competing dominant L2 Mandarin tonal system. Perhaps it is because the Taiwanese system is so complex. Tone sandhi interacts with the syntax, the semantics, the morphology and even the segmental phonology of the language. If the complexity was learned before the onset of massive exposure to Mandarin, then we can revise slightly the threshold hypothesis by saying complicated structures that are learned well are unlikely to attrite.

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Yufen Chang*

1 Introduction

In the field of first language (hereafter L1) attrition, Bardovi-Harlig and Stringer (2010) articulate six hypotheses including the simplification hypothesis, the interference hypothesis, the markedness hypothesis, the regression hypothesis, the threshold hypothesis, and the dormant hypothesis. These hypotheses have been mostly utilized in explaining or predicting syntactic attrition (e.g. Silva-Corvalan 1991, Håkansson 1995, Keijzer 2007) and morphological attrition (e.g. Altenberg 1991, Keijzer 2007, Schmid 2002). For example, Altenberg (1991) used the interference account to explain L1 morphological attrition of two L1 German speakers who had lived in the US for over 40 years. Her findings support the interference hypotheses, which states that attrition arises in conditions where L1 and second language (hereafter L2) bear similarities. Few such studies, though, have examined L1 tonal attrition. It is unclear if the L1 attrition hypotheses proposed in the literature would be relevant to predicting the attrition patterns in tones. This paper focuses on tonal attrition by examining speech data produced by 10 L1 Taiwanese attriters who learned Mandarin as their L2 and have become L2-Mandarin dominant after five years old. The particular focus of tonal attrition under investigation is the attrition of the Taiwanese tone sandhi circle. The attrition patterns of the L1 Taiwanese attriters will be hypothesized based on four of the six L1 attrition hypotheses— the simplification hypothesis, the interference hypothesis, the markedness hypothesis, and the threshold hypothesis. The regression hypothesis is relevant to the attrition type of this study. However, due to the unavailability of research on the acquisitional order of Taiwanese tone sandhi in the literature, verifying the regression hypothesis is unlikely. The explanation and its claim will be provided in a later section. The dormant hypothesis is not applicable to this study since it concerns cases in which attriters have no memory and no contact with their L1.The L1 Taiwanese attriters of this study still have contact with Taiwanese. Their attrition in Taiwanese was caused by ceased or reduced use of the language, not by being cut off from the language. As a result, the dormant hypothesis does not fit the Taiwanese context and will not be considered. The results of the data will be helpful in determining the extent to which the four L1 attrition hypotheses are relevant to tonal attrition.

The remainder of this paper is organized as follows. As background for this study, Section 2 reviews tones and tone sandhi of Taiwanese and Mandarin. Section 3presents the fiveL1 attrition hypotheses as well as the application of these hypotheses to predicting L1 Taiwanese tonal attrition for subsequent verification. Section 4 proceeds to present the methods of data collection and analysis. Section 5 shows the results of the study. Section 6 concludes the study.

2 Tones and Tone Sandhi

2.1 Taiwanese

Most linguists agree that there are seven distinct underlying lexical tones in Taiwanese (Chao 1930, Chen 2000, Chung 1996)— five non-entering tones (rising, high-level, mid-level, low-level, and falling) and two entering tones (high-abrupt and low-abrupt) (Tsay 1989, 2001). Non-entering tones occur in non-checked syllables, which end either in a vowel or a sonorant coda (i.e. a nasal consonant). On the other hand, entering tones are shorter in length and are used in syllables that end in an obstruent /p/, /t/, /k/, or /ʔ/. Each tone, regardless of its tonal type, is subject to tone change in a sandhi environment. Whether a tone-occurring context requires tone sandhi or not depends on its syntactic position in an utterance (Chen 1987, Lin 1994). When occurring in 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*. Take the phrase

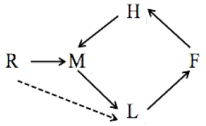
*I would like to thank Prof. Stuart Davis for his comments.

in (1) for instance. The word /ho/, occurring in a sandhi environment, must undergo sandhi and surface with its sandhi tone. For the sake of simplicity, I use, *R*, *M*, *L*, *F*, and *H*, to refer to the rising, mid-level, low-level, falling, and high-level tones, respectively.

(1) Taiwanese tone sandhi example:	/ho	lan/	'good person'
	good	person	
Underlying tone:	/F	R/	
Surfacing tone:	[H	R]	

The sandhi form of a tone, depending on its tonal type (non-entering/entering), is derived by two separate sets of tone sandhi rules. The sandhi rules for the non-entering tones are referred to as the Taiwanese tone sandhi circle (Chen 1987), as in (2). Given that the focus of this paper is on the attrition of the Taiwanese tone sandhi circle, the entering tone sandhi rules are not presented.

(2) Taiwanese tone sandhi circle [1](Chang 2012, Chao 1930, Chen 1987, Chung 1996)



The Taiwanese tone circle is like a chain, by which a tone is looking for another tone to serve as its sandhi tone to surface. For example, a syllable with the underlying high-level tone *H* would undergo this tone circle to derive its sandhi tone *M*, while a syllable with an underlying tone *M* surfaces as L in a sandhi context, and so on.

When a sentence is longer than two syllables, whether a tone on a syllable undergoes tone sandhi is determined by its syntactic position in a phrase. In short, if a phrase is lexically governed, all the syllables, except the rightmost one, in the phrase must be uttered with their sandhi tones (see Lin 1994 for a detailed syntactic analysis of Taiwanese tone sandhi). Otherwise, the speech production can be unintelligible or ambiguous.

2.2 Mandarin

In Mandarin, a syllable can be associated with four lexical tones— a high-level tone (Tone 1), a rising tone (Tone 2), a falling-rising tone (Tone 3), and a falling tone (Tone 4) (Li 1999, Li and Thompson 1981). Among the four tones, Tone 3 has another variant similar to a low-level tone, in which the rising from low pitch to high pitch is not produced. The reduced Tone 3 usually occurs in the pre-pausal positions and is regarded as a low tone due to the omission of the rise (Speer, Shih, and Slowiaczek 1989).

Like Taiwanese, Mandarin is also a language with tone sandhi. In Mandarin, however, tone sandhi is applied only when a Tone 3 syllable is followed by another Tone 3 syllable. The first syllable of the disyllable has to surface with Tone 2, as illustrated in (3).

(3) Mandarin tone sandhi: Tone 3 → Tone 2 / ____ Tone 3

Despite the tone change on the first syllable, the meaning of the disyllable remains unchanged, as the example in (4) shows.

(4) Mandarin tone sandhi example:	/ lao	ma /	'old horse'
	old	horse	
Underlying tone:	/ Tone3	Tone3 /	
Surfacing tone:	[Tone2	Tone3]	

[1] The dashed line indicates a tone sandhi variation found in Chang (2012). She found that Taiwanese speakers prefer *L* (the new sandhi tone for *R*, with approximately 64% of usage) over *M* (the traditional sandhi tone for *R*, with approximately 36% of usage) as the sandhi tone for *R*. To be clear, the same speaker will use both R→*M* and *R*→*L*.

The syllable /lao/, in (4), with Tone 3 means 'old.' With Tone 2, the meaning shifts to 'tight.' Even with the application of Mandarin tone sandhi, the phrase in (4) still means 'old' horse, instead of 'tight' horse. The tone change due to Mandarin tone sandhi seldom causes ambiguity.

After this brief introduction of Taiwanese and Mandarin tones and tone sandhi, it is apparent that Taiwanese tone sandhi functions in a more complex way that Mandarin. To begin with, the tone sandhi mechanism is syntax-based in Taiwanese (Lin 1994) and prosody-based in Mandarin (Shih 1986). Furthermore, in Taiwanese, all sentences must be operated on tone sandhi before being uttered whereas Mandarin tone sandhi is very limited in that only adjoined Tone 3 syllables are eligible for tone sandhi. As for surfacing sandhi tones, in the repertoire of sandhi counterparts in Taiwanese, all of the underlying tone qualities, except the rising tone *R*, can surface in the utterances. Nonetheless, in Mandarin, Tone 2 (a rising tone) is the only legitimate sandhi tone. With the tone sandhi differences between Taiwanese and Mandarin laid out, the next section will present the five L1 attrition hypotheses and their predictions of L1 Taiwanese tonal attrition patterns.

3 L1 Attrition Hypotheses and Their Predictions of L1 Taiwanese Tonal Attrition

3.1 Simplification Hypothesis and Predictions

The simplification hypothesis suggests that L1 grammar becomes simplified after extensive contact with L2. Simpler L2 rules encroach on the L1 system to replace more complex L1 rules (Seliger 1991). Complexity of a linguistic item can be measured through its frequency of use (Andersen 1982) and cognitive load (Silva-Corvalan 1991, Slobin 1977). Previous studies on phonological attrition of L1 contrastive features employ the notion of frequency of use in making predictions (Andersen 1982, Bullock and Gerfen 2004a, 2004b). Phonological features that are frequently used in L1 or that are shared by both L1 and L2 are more likely to be better preserved. With the same method, hypotheses of Taiwanese tone sandhi attrition are formulated through an examination of tone frequency as well as a comparison of Taiwanese and Mandarin tonal systems.

The only information available concerning the frequency of Taiwanese tone usage is from a Taiwanese spoken corpus constructed by Tsay and Myers (2005), as shown in (5) with the most frequently used tone placed on the left and least on the right.

(5) Token Frequency of Taiwanese tones (cited from Zhang et al. 2006, 2009):
H > *R* > *M* > *F* > *L*

According to Andersen's (1982) proposal, the frequency of use correlates with attrition— the more frequently a linguistic item is used, the less attrition it suffers. If Andersen's account holds true, it is likely that the tonal attrition degree in Taiwanese might show the mirror image of the ranking in (5). Note that Taiwanese is a language highly involved with tone sandhi. However, the tone use frequency in (5) is a merger of both underlying tones and sandhi tones. J. Myers (personal communication, February 6, 2012) suggested using the tone frequency in (5) to represent sandhi tone frequencies. Following this rationale, I must delete the rising tone *R* from (5), given that *R* is not a legitimate sandhi tone. Then the tone use frequency ranking becomes *H*>*M*>*F*>*L*, which is gained after tone sandhi rules are applied. For instance, the reason why *H* is the most frequent sandhi tone is because the sandhi rule *F*→*H* is used the most often. In (6), I show the use frequency of Taiwanese sandhi rules based on (5). The symbol '>' indicates that the sandhi rule placed before '>' is more frequent than that after the symbol.

(6) Frequency of uses of Taiwanese sandhi rules:
F→*H* > *H*→*M*, *R*→*M*[2] > *L*→*F* > *M*→*L*

As mentioned before, based on Andersen's theory, the tonal attrition degree in Taiwanese may

[2] *R*→*M* is considered the standard tone sandhi rule in a lot of work (e.g. Chen 2000). Given that the variation between *R*→*M* and *R*→*L* was not noted until Chang (2012), I abide by *R*→*M* when referring to Tsay and Myers' (2005) corpus data.

show the reversed order of the frequency ranking, as seen in (7). The sandhi rule on the left is hypothesized to reveal more attrition than that on the right. The bracketed tone sandhi rules mean a hypothesized similar degree of attrition.

(7) Hypothesized Attrition Degree in Tone Sandhi based on Tsay and Myers' (2005) Corpus:
$M \rightarrow L \;>\; L \rightarrow F \;>\; (H \rightarrow M\,,\, R \rightarrow M) \;>\; F \rightarrow H$

According to the simplification hypothesis, another source of simplified L1 stems from simpler rules in L2 or from getting rid of rules that only exist in L1. Compared with Taiwanese, Mandarin tone sandhi is not complicated, involving only two adjacent low-tone syllables. In accordance with the simplification hypothesis, attriters' Taiwanese tone sandhi system might be simplified to the extent that tone sandhi is completely absent. It is also possible that attriters may use Mandarin tone sandhi rule in speaking Taiwanese, dispreferring two adjacent low-tone syllables and changing the tone on the first syllable to a rising tone. I outline in (8) the hypothesized tone sandhi differences between Taiwanese and Mandarin under the simplification hypothesis.

(8) Hypothesized tone attrition in tone sandhi based on tone sandhi differences:
a. Complete absence of Taiwanese tone sandhi
b. Application of Mandarin tone sandhi to Taiwanese: $L \rightarrow R /$ _____ L

3.2 Interference Hypothesis and Predictions

The interference hypothesis states that L1 attrition is caused by the intrusion of the dominant language L2, resulting in L2 borrowing, L1 extension or reduction of function, L1 overgeneralization, or L1 loss (Silva-Corvalan 1991). Interference from L2 is caused when there is a mismatch of forms or functions between L1 and L2. In terms of tonal inventories of Taiwanese and Mandarin, the Taiwanese mid level tone does not have a corresponding similar tone in Mandarin. Therefore, the mid level tone is likely to be lost in attriters' Taiwanese speech. In addition to the mismatch of tonal inventories, Mandarin tone sandhi does not have an equivalent sandhi rule in Taiwanese. Conversely, Taiwanese tone sandhi rules are completely absent in Mandarin. According to Silva-Corvalan (1991), a form present in L2 but absent in L1 might result in L2 borrowing whereas an item missing in L2 but existing in L1 might cause L1 loss. Based on the incompatibility of tone sandhi in Taiwanese and Mandarin, it is possible that attriters might have transferred L2 Mandarin tone sandhi rule to L1 Taiwanese and have lost the ability to operate Taiwanese tone sandhi. In (9), I encapsulate the likely tonal attrition patterns caused by L2 external interference.

(9) Hypothesized tonal attrition patterns caused by interference
a. The Taiwanese mid level tone, M_n, is missing.
b. Transfer Mandarin tone sandhi to Taiwanese speech.
c. Taiwanese tone sandhi is absent.

3.3 Markedness Hypothesis and Predictions

The markedness hypothesis is concerned with the relationship between markedness and L1 attrition. According to Seliger and Vago (1991), L1 attrition is most likely to happen when L1 contains marked linguistic rules or items while the corresponding L2 rules or items are unmarked or considered less marked. The consequence is L2 unmarked linguistic items taking the place of L1 marked ones. Viewing tone sandhi as a whole in Taiwanese and Mandarin, the Taiwanese tone sandhi system is far more marked than Mandarin tone sandhi. Mandarin tone sandhi is a result of the obligatory contour principle effect (OCP, Goldsmith 1976), which states the disperference of two adjacent identical tones. On the other hand, Taiwanese tone sandhi is mandatory and unconnected to the OCP. Up to now, no consensus has been reached as to how Taiwanese tone sandhi functions (e.g. Anderson 1978, Barrie 2006, Schuh 1978, Tsay and Myers 1996, Wang 1967). Given the marked nature of Taiwanese tone sandhi, to the extreme extent, attriters might have lost the capability to operate Taiwanese tone sandhi. Thus, underlying citation tones might be constantly used in nonfinal position. In (10), I recapitulate the prediction of Taiwanese tone sandhi

attrition based on the markedness hypothesis to the extreme degree.

(10) Hypothesized tone attrition in tone sandhi based on the markedness hypothesis: Absence of Taiwanese tone sandhi

3.4 Regression Hypothesis and Predictions

The regression hypothesis suggests that the attrition pattern is in the reverse order of the acquisition pattern— "first in, last out" (Bardovi-Harlig and Stringer 2010). What is learned earlier is more resistant to L2 intrusion whereas what is learned last is vulnerable to attrition. Thus, predictions of attrition patterns founded on the regression hypothesis require an established order of acquisition. However, in the literature of L1 acquisition of Taiwanese tone sandhi, there has not been an established acquisitional order. Consequently, no prediction of tonal attrition patterns can be proposed based on the regression hypothesis.

3.5 Threshold Hypothesis and Predictions

The threshold hypothesis states that what is learned best is least subject to language loss (Bardovi-Harlig and Stringer 2010, Berko-Gleason 1982, Jordens, de Bot, Van Os, and Schumans 1986). Therefore, hypotheses grounded on the threshold hypothesis would necessitate an evaluation of what linguistic item is learned the best. The accuracy rates of uses of investigated linguistic items serve as an appropriate indicator. In the literature of L1 Taiwanese tonal acquisition, Hsu (1989)[3] reports the percentages of accurate tone sandhi uses, as shown in Table 1.

Tone sandhi type	*F → H/R/M*[4]	*L → F*	*H → M*	*M → L*	*R → M/L*[5]
Average accuracy rate	95%	89.5%	89.5%	80.5%	79.5%

Table 1: The accuracy rates for tone sandhi rules in Hsu (1989)

In accordance with the threshold hypothesis, the least attrited tone sandhi should be *F→H/R/M* whereas the most deteriorated sandhi might be *R→M/L*. For the sake of consistency in tone sandhi rules, Hsu's tone sandhi rules are modified to fit the standard tone sandhi rules that have been proposed in the literature. With this criterion and modification, I show in (11) the predicted degrees of attrition in tone sandhi under the threshold hypothesis. For tone sandhi rules with the same accuracy rates, they are grouped in brackets to show hypothesized similar degrees of attrition.

(11) Hypothesized attrition degree in tone sandhi based on Hsu (1989):
R→M/L > *M→L* > (*H→M*, *L→F*) > *F→H*

In this section, I have proposed a number of hypotheses concerning L1 Taiwanese attrition of tone sandhi within the framework of the four L1 attrition proposals. Some proposals have produced similar or identical predictions while some do not. In (12), I summarize the hypotheses of this study with reference information. This study will attempt to test the hypotheses shown in (12) for Taiwanese tone sandhi attrition.

(12) Hypotheses of L1 Taiwanese tone sandhi attrition
a. Complete absence of Taiwanese tone sandhi (based on the simplification hypothesis, the interference hypothesis, and the markedness hypothesis)
b. Attrition degree: *M→L* > *L→F* > (*H→M*, *R→M*) > *F→H*

[3]In Hsu (1989),she kept track of one child's Taiwanese development for one and a half years. For the data analysis, she took into consideration of three subdialects— the inland dialect (the child's caretaker), a coastal dialect that had not been noted in the literature (the child's grandmother), and the coastal dialect (Hsu, the investigator). These were the dialects the child participant had exposure to.

[4] F→H: the inland dialect; F →R: a coastal dialect not noted yet; F →M: the coastal dialect

[5] R→M: the inland dialect; R→L: the coastal dialect

(based on the simplification hypothesis and Tsay and Myers 2005)
c. Attrition degree: (*R*→*M/L*, *M*→*L*) > (*H*→*M*, *L*→*F*) > *F*→*H*
(based on the threshold hypothesis and Hsu 1989)
d. Application of Mandarin tone sandhi to Taiwanese: *L* → *R* / _____ *L*
(based on the simplification hypothesis and the interference hypothesis)
e. The Taiwanese mid level tone, M, is missing (based on the interference hypothesis).

With the hypotheses of L1 Taiwanese tonal attrition laid out, this study now proceeds to methods of data collection and analysis of the data.

4 Methods of Data Collection and Analysis

4.1 Participants

A total of 21 subjects participated in this study. All of the 21 participants belong to one of the three groups—the L1 Taiwanese non-attriter group (hereafter NA group, six speakers, more than 50 years old), the L1 Taiwanese L2 Mandarin bilingual group (hereafter BL group, five speakers, less than 40 years old), and the L1 Taiwanese attriter group (hereafter ATT group, 10 speakers, less than 40 years old).Although the focus of this paper is on the attrited Taiwanese tone sandhi system, the inclusion of the NA group and the BL group in data collection is crucial in that their speech production serves as a baseline for determining attriters' tonal attrition. Participants within the same group are more homogeneous in terms of language dominance and socioeconomic background than participants across groups. The age of the BL group is similar to that of the ATT group. All of the participants learned Mandarin as their L2 and have no difficulty communicating in L2 Mandarin. However, only the BL and ATT groups have native fluency in Mandarin. In order to reduce the effect of dialectal differences in Taiwanese, the participants all grew up in the Taipei area, including Taipei City and New Taipei City.

4.2 Tasks for Data Collection

The data of this study were collected from two tasks— film retell and storytelling. The purpose of utilizing two separate tasks in data collection was to increase vocabulary variety. The first task was film retell. The speakers watched an excerpt, *Alone and Hungry* (about 11 minutes), from a 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 pictures on a piece of paper, each of which was composed of four small pictures. 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 the stories based on their understandings of the pictures. This task took the speakers approximately six minutes to complete.

4.3 Analysis

All data collected from the two tasks were transcribed to serve as the bases for phonological analyses of attrited and non-attrited Taiwanese tonal systems. Each syllable said by the participants was transcribed even if the syllable was a repetition of the previous one caused by hesitation or self-correction. Each syllable was coded with information regarding its underlying citation tone, surfacing tone, context of occurrence (sandhi or non-sandhi), underlying syllable type (checked or non-checked), and approximate meaning in Mandarin. Given numerous pieces of information associated with a syllable, I used Microsoft Excel to transcribe the data.

Transcribed data in an Excel file were then sorted based on different categories, such as underlying tone or context of occurrence. With data stored in Excel, it is possible to calculate the attriters' accuracy rate for each sandhi rule. For example, to calculate the accuracy rate of the san-

dhi rule *L*→*F*, I sorted the data in this order— the category 'context' first, then the category 'Underlying tone,' and the category 'Surfacing tone.' The sorting results are then shown in a pivot table, as the example in Table 2 shows.

Sandhi (context)	
F (underlying)	138
F (surfacing)	10
H (surfacing)	125
L (surfacing)	3

Table 2: An example of sorted data in an Excel pivot table

The pivot table shows that the participant produced a total of 138sandhi environments, in which the underlying tone is the falling tone *F*. Given these 138 tokens were produced in the sandhi environment, tone sandhi must be mandatorily performed— the underlying tone *F* should surface as *H* (*F*→*H*).There are125 instances of the expected sandhi rule being applied. The other 13 instances are considered aberrant, meaning that the tone sandhi was not performed (*F*→*F*: 10 tokens) or the surfacing sandhi tone was not the standard one (*F*→*L*: 3 tokens). The example in Table 2 shows that the tone sandhi accuracy rate for *F*→*H* is 90.5%.

5 Results[6]

The attriters produced a total of 5,797 tokens of non-entering tones in the sandhi environment, the non-attriters 3,285 tokens, and the bilinguals 1,617.In Table 3, I show the three speaker groups' tone accuracy rates for the sandhi type involved in the Taiwanese tone sandhi circle.

	H→*M*	*R*→*M/L*	*M*→*L*	*L*→*F*	*F*→*H*
Attriter	90.4%	86.2%	91.2%	85.5%	93.3%
Non-attriter	100%	99.6%	98.7%	98%	99.1%
Bilingual	99.6%	99.4%	98.1%	98.9%	99.3%

Table 3: Accuracy rates for the Taiwanese tone sandhi circle

A mixed ANOVA was conducted to assess whether there were Sandhi Type (*H*→*M*, *R*→*M/L*, *M*→*L*, *L*→*F*, and *F*→*H*) and Speaker Group differences in accuracy rates. Results indicated a significant main effect of Speaker Group ($F(2, 18)= 65.09$, $p<.001$) but not of Sandhi Type ($F(1.87, 33.68)= 1.41$, $p=.26$). Subsequent post-hoc analyses revealed that the attriters significantly had lower accuracy rates for tone sandhi than the non-attriters and bilinguals (*H*→*M*, *R*→*M/L*, and *M*→*L*: $p<.001$; *L*→*F*: $p<.005$; *F*→*H*: $p<.05$). There was not a significant difference between the non-attriters and bilinguals in terms of their uses of non-entering tone sandhi. Based on the results of the mixed ANOVA, the attriters significantly performed tone sandhi less correctly than the non-attriters and bilinguals.

Despite the fact that the attriters' Taiwanese tone sandhi performance is not as good as the non-attriters' and bilinguals', Taiwanese tone sandhi remains at the attriters' disposal. They could apply tone sandhi correctly on average 89.5% of the time. Therefore, the hypothesis in (12a), which predicts absence of Taiwanese tone sandhi, is rejected. The data in Table 3 also prove wrong the prediction in (12e), which states that attriters would be missing Taiwanese mid level tone. The attriters could still change the high tone and the rising tone to the mid tone in sandhi context, even though the mid tone does not exist in the Mandarin tonal category.

[6]The token numbers reported here do not include exceptions found in the speakers' data (123 tokens from the NA group; 97 tokens from the BL group;195 tokens from the ATT group).Due to the length limitation, the exceptions are not discussed in this paper. Please see Chang (2012) for the morphemes considered tone sandhi exceptions.

Based on the interference hypothesis and the simplification hypothesis, the simple Mandarin tone sandhi rule, *L→R*/__*L*, should appear in the attriters' Taiwanese tonal data, as shown in the prediction in (12d). Nonetheless, the findings of this study show that the interference from the Mandarin tone sandhi is very minimal. If the Mandarin tone sandhi rule does play a role in simplifying the Taiwanese tone sandhi, we would observe a lot of non-entering mid tone (*M*) errors in the sandhi required environment, in which the sandhi tone of *M* becomes *R* (instead of its orthodox sandhi tone *L*) in order to avoid two adjacent low tones. The results of the attriters' sandhi performance reveal that the attriters' chance of the incorrect sandhi type, *M→R*, is only 0.6%, as seen in the table below with expected tone sandhi production reflected in shaded cells. Consequently, I reject the hypothesis stated in (12d).

Surfacing / Underlying	*H*	*R*	*M*	*L*	*F*	Total
H	77(7.8%)	3(0.3%)	891(90.4%)	15(1.5%)		986
R	89(6.2%)	105(7.4%)	853(60.2%)	369(26%)	1(0.2%)	1,417
M	21(1.1%)	10(0.6%)	98(5.4%)	1642(91.2%)	31(1.7%)	1,802
L	20(3.8%)		6(1.1%)	50(9.6%)	448(85.5%)	524
F	997(93.3%)		7(0.7%)	11(1%)	53(5%)	1,068
Total						5,797

Table 4: Tone matrix of the ATT group in sandhi environment

Up to now, the results have shown that three of the five predictions in (12) are inaccurate. Those predictions are all grounded on the differences between L1 and L2, such as transferring the simpler L2 Mandarin tone sandhi to L1 Taiwanese. On the other hand, the other two predictions in (12b-c) are L1-based without involving L2. The hypothesis in (12b), based on the simplification hypothesis and the corpus data of Tsay and Myers (2005), suggests that more frequently used sandhi would be better retained. The prediction in (12c), formulated within the framework of the threshold hypothesis and the L1 acquisitional findings of Hsu (1989), holds that better learned sandhi is less subject to attrition. In (13), I present the actual and the hypothesized tone sandhi attrition degree in (12b-c). The accuracy rates of this study and of Hsu are shown in the brackets. The sandhi rules placed on the left mean that they might be more decayed than those on the right. The sandhi rules whose accuracy rates differ within 2% are grouped together.

(13) Comparison of hypothesized and actual tone sandhi attrition degrees
  a. Actual tone sandhi attrition degree:
    (*R→M/L*: 86.2%, *L→F*: 85.5%) > (*H→M*: 90.4%, *M→L*: 91.2%) > *F→H*: 93.3%
  b. Prediction in (12b)(based on the simplification hypothesis and Tsay and Myers 2005):
    M→L > *L→F* > (*H→M*, *R→M*) > *F→H*
  c. Prediction in (12c)(based on the threshold hypothesis and Hsu 1989):
    (*R→M/L*: 79.5%, *M→L*: 80.5%) > (*H→M*: 89.5%, *L→F*: 89.5%) > *F→H*: 95%

First, let us divide the attrition levels into three degrees— severe, moderate, and slight. As shown in (12a), the *F→H* sandhi is slightly attrited, *H→M* and *M→L* demonstrate moderate attrition, and *R→M/L* and *L→F* are severely decayed. The simplification hypothesis only successfully predicts the attrition ranking of three sandhi types— *L→F* (severe) >*H→M* (moderate) >*F→H* (slight). The actual attrition degrees of the other two sandhi rules, *R→M/L* and *M→L*, are different from the hypothesis. According to the hypothesis in (13b), *R→M/L* should be slightly attrited and *M→L* severely eroded. However, the actual attrition levels for *R→M/L* and *M→L* are severe and moderate, respectively. With respect to the prediction in (13c), the results confirm the attrition order of four sandhi rules predicted by the threshold hypothesis—*R→M/L*> (*M→L*, *H→M*) >*F→H*. As for the other sandhi type (*L→F*), the hypothesis of this study and the actual results are different. The *L→F* sandhi is more attrited than what the threshold hypothesis predicts.

In summary, we have seen that the L1-based hypotheses, (12b-c), have produced some accurate attrition rankings. On the contrary, the L2-based hypotheses, (12a) and (12d-e), lack strength in predicting L1 tonal attrition.

6 Conclusions

In this paper, I have revisited the hypotheses of L1 Taiwanese tone sandhi attrition, which were proposed on the basis of the four L1 attrition proposals. I did not find conclusive evidence supporting any of the four L1 attrition proposals. However, I found that in terms of L1 tonal attrition, L1 attrition proposals drawing on L1 only, such as the threshold hypothesis, are of more strength than those stressing differences between L1 and L2, such as the interference hypothesis. The hypotheses which employ learnability or frequency of use in predicting attrition patterns are at least partially confirmed by our results.

Based on the results of this study, it seems plausible to conclude that there should be two separate tonal systems operating in the L1 Taiwanese attriters' phonology. Despite not using Taiwanese in everyday life, the attriters are still capable of switching to the Taiwanese tonal system from the Mandarin system when speaking Taiwanese. What could account for their attrition is neither the Taiwanese tones nor the complicated Taiwanese tone sandhi, but the deteriorated operating mechanism of tonal groups. This also explains why L2 Mandarin interference does not take effect in L1 Taiwanese tonal attrition and why L1-based hypotheses are more powerful than L2-based hypotheses in predicting L1 tonal attrition.

There is still a larger question as to why the complex Taiwanese tone sandhi system is so well maintained in light of the presence of the competing tonal system from the dominant Mandarin language. Perhaps it is because the Taiwanese system is so complex. Tone sandhi interacts with the syntax, the semantics, the morphology and even the segmental phonology of the language. If the complexity was learned by the time the attriters were five years old (before the onset of massive exposure to Mandarin), then I can revise slightly the threshold hypothesis by positing complicated structures that are learned well are unlikely to attrite. Perhaps, then, if the Taiwanese tonal system were not so complex, it would more readily undergo attrition.

An area that can be pursued in the future is the acquisitional order of the Taiwanese tone sandhi rules. Unlike the acquisition of Taiwanese tones and the learnability of tone sandhi rules, which have been documented and investigated in the L1 acquisition literature, the acquisitional order of tone sandhi has not been examined in detail. A thorough examination will be able to further our understanding of L1 Taiwanese acquisition and make possible the verification of the regression hypothesis.

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