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## Neutralization of Short Tones in Taiwanese

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### ABSTRACT

This paper is an acoustic study of neutralization of short tones in Taiwanese. The results show that the two short tones were completely neutralized in juncture position. Since long tones in Taiwanese show complete neutralization in context position, the bidirectionality of tone alternation in Taiwanese Tone Sandhi poses a problem for rule-based approaches, while it is consistent with the hypothesis that both juncture and context tones are listed in the lexicon, instead of one being derived from the other. Moreover, in order to account for the difference between Taiwanese Tone Sandhi and Mandarin Tone Sandhi (which has been proven acoustically to be incomplete neutralization), the Naturalness Hypothesis is proposed, which claims that if the neutralization is phonetically unnatural, then the neutralization is more likely to be lexicalized and show complete neutralization.

### 1. INTRODUCTION

This paper is concerned with the neutralization of short tones in Taiwanese. Although it has been observed in the literature that in some dialects of Taiwanese, the two short tones, which are distinct in context position, are neutralized in juncture position (Chang 1972, Yang 1991, Kuo 1996), this observation has not been tested in the laboratory. The primary goal of this study is to test by acoustic data whether the neutralization of short tones in Taiwanese is complete neutralization. A production experiment was conducted to verify the neutralization of short tones in Taiwanese.

The results of the acoustic study of Taiwanese short tones confirm the complete neutralization. Two theoretical issues arise after this observation is confirmed. First is an issue of bidirectional tone alternation. It has been proven that two of the long tones in Taiwanese are completely neutralized in context position based on acoustic data (Tsay and Charles-Luce, in preparation). That is, long tones alternate from juncture form to context form, which is the opposite direction of short tone alternation. This phenomenon is more consistent with the hypothesis that both juncture and context tones are listed in the lexicon (Hsieh 1975, Wang 1995, Tsay and Myers 1996) and, by contrast, is a problem for rule-based approaches.

Second, if tone alternation in Taiwanese (called Taiwanese Tone Sandhi) gives complete neutralization, what causes the difference between Taiwanese Tone Sandhi and Mandarin Tone Sandhi which has been claimed to be incomplete neutralization (Zee 1980, Peng 1996)? To answer this question, we propose the Naturalness Hypothesis which claims that if the neutralization is phonetically unnatural, i.e., not physiologically or acoustically motivated, then the neutralization is more likely to be lexicalized and show complete neutralization.

## 2. TAIWANESE TONE SANDHI

Taiwanese has seven lexically distinctive tones: five long tones and two short tones. Each tone is realized as one of two forms depending on syntactic environment. One form appears in isolation or at the end of an XP (in juncture position); the other elsewhere (in context position) (Chen 1987, Lin 1994). This tone alternation is called Taiwanese Tone Sandhi

Long tone alternation between juncture and context position can be summarized as follows:  $H \leftrightarrow M$ ,  $LH \leftrightarrow M$ ,  $M \leftrightarrow L$ ,  $L \leftrightarrow HL$ ,  $HL \leftrightarrow H$  (H, M, and L stand for high, mid, and low tones). As can be seen, H and LH in juncture position are neutralized to M in context position. Examples are given in Figure 1 below (where tones are in superscript).

Figure 1 Neutralization of long tones in Taiwanese

Character	Juncture	Context	Gloss
詩	[si <sup>H</sup> ]	[si <sup>M</sup> ]	"poem"
時	[si <sup>LH</sup> ]	[si <sup>M</sup> ]	"time"

This neutralization has been proven to be complete neutralization based on acoustic data (Tsay and Charles-Luce, in preparation).

Short tones only appear with syllables ending with an unreleased obstruent (p, t, k, or ?). They are called "Yin Ru" (陰入) and "Yang Ru" (陽入), and have been described in the literature as follows (Cheng 1973, Zhang 1983). (Note that some sources, e.g., Cheng 1968, Hsieh 1976, Chen 1987, give M or ML, instead of L, for Yin Ru tone in juncture position. However, this variation does not affect the neutralization issue.)

Figure 2 The contrast of Yin Ru and Yang Ru tones

	Character	Juncture	Context	Gloss
Yin Ru	督	[tɔk <sup>L</sup> ]	[tɔk <sup>H</sup> ]	"supervise"
Yang Ru	獨	[tɔk <sup>H</sup> ]	[tɔk <sup>L</sup> ]	"alone"

It has also been observed that in some dialects of Taiwanese these two tones are neutralized in juncture position, a direction opposite of long tone neutralization (Chang 1972, Yang 1991, Kuo 1996). However, the neutralization of short tones has not been tested in the laboratory. Hence a

production experiment was conducted to verify the neutralization of short tones in Taiwanese. That is, the pitch contours of the short tones in juncture position should not be significantly different.

### 3. EXPERIMENT

#### 3.1. Experimental design

The purpose of the experiment was to verify the neutralization of short tones in Taiwanese. Ten minimal pairs of monosyllabic morphemes which contrasted only in tone, i.e., Yin Ru vs. Yang Ru, were chosen as target syllables. Each of these twenty target syllables (written in Chinese characters) showed up in two bisyllabic words where the target syllable is either in juncture position or in context position, as the examples shown in Table 1 below.

Table 1 Examples

Syllable	Yin Ru Tone		Yang Ru Tone	
	Juncture	Context	Juncture	Context
tək	[kam tək <sup>L</sup> ] 監督 “supervise”	[tək <sup>H</sup> hak] 督學 “supervisor”	[kə tək <sup>H</sup> ] 孤獨 “alone”	[tək <sup>L</sup> lip] 獨立 “independent”

Thus ten minimal pairs made up ten sets of target words, each set containing four bisyllabic words as given in Table 2.

Table 2 Target syllables (in bold) in juncture and context positions

	Yin Ru Tone		Yang Ru Tone	
	Juncture	Context	Juncture	Context
kiək	秋菊	菊花	郵局	局長
sit	得失	失禮	事實	實在
kut	大骨	骨頭	路滑	滑倒
pe?	大伯	伯公	黑白	白色
cio?	要借	借車	溪石	石頭
tək	監督	督學	孤獨	獨立
cip	固執	執照	收集	集會
ap	氣壓	壓力	大盒	盒子
chio?	一尺	尺半	涼蓆	蓆子
cia?	一隻	五隻豬	好吃	吃飯

These bisyllabic words were then embedded in a sentence frame 我讀 \_\_\_ 三遍 [gua tak \_\_\_ sā pian] “I read \_\_\_ three times”. These forty target sentences and forty filler sentences made up the complete reading list. Sentences were displayed in random order in Chinese characters on a computer

screen one sentence at a time. Six male speakers from the Chia-Yi area of Taiwan, aged between 18 and 30, were asked to read these sentences in a sound-proof room into a microphone which was connected to a SONY tape recorder. The whole list was repeated three times.

### 3.2 Measurements

Among the ten sets of words, five sets were not measured for various reasons -- subjects used different lexical items or didn't know how to say them (in the case of 一隻, 大盒, 督學, 涼蓆, 執照) or the syllable following the target syllable was onsetless and caused segmentation problems (in the case of 盒子). Therefore, only five sets of words, i.e., [kiok], [sit], [kut], [pe?], [cio?], were analyzed. For each sentence, only the bisyllabic word was digitized with Kay's Computerized Speech Lab 4300B. The beginning, middle, and end points of the F0 contour of each target syllable were measured. Each data point was obtained by averaging the three repetitions of each subject.

### 3.3 Results

For each set of words, a paired two-tailed t-test was performed to compare the Yin Ru and Yang Ru tones in juncture position, as well as in context position. The results showed that the F0 values of the beginning, middle, and end points were not significantly different between the two contrastive target syllables in juncture position ( $p > .09$ ), although they are significantly different in context position ( $p < .05$ ). The following table gives the mean F0 values and p values at the middle point of the target syllables in juncture position.

Table 3 Mean F0 values (in Hz) and p values at the middle point of the target syllables in juncture and context positions

	n	Juncture			Context		
		Yin Ru	Yang Ru	p	Yin Ru	Yang Ru	p
kiok	5	112.5	113.3	0.867	130.5	103.5	0.0002
sit	5	110.5	123.5	0.196	132	103.8	0.0004
kut	5	110.3	113.8	0.222	135.7	104.8	0.0005
pe?	5	104	105.5	0.091	128.3	99.5	0.0000
cio?	5	109.2	110.2	0.702	128.2	100.3	0.0001

That is to say, there was complete neutralization between Yin Ru and Yang Ru tones in juncture position, although they were distinct in context position.

## 4. DISCUSSION

There are interesting theoretical consequences of this finding. First of all, we confirm that short tones in Taiwanese do neutralize completely in juncture position. Since short tone neutralization happens in juncture position, the direction of tone alternation has to be from context to juncture, which is opposite

of long tone neutralization mentioned above. That is, Taiwanese Tone Sandhi has tone alternation in both directions: from context form to juncture form (short tones) and from juncture form to context form (long tones).

The bidirectionality of tone alternation in Taiwanese Tone Sandhi poses a problem for rule-based approaches in the study of Taiwanese Tone Sandhi, e.g., Wang (1967), Cheng (1968, 1973), Yip (1980), Tsay (1994). However, it is consistent with the hypothesis that Taiwanese Tone Sandhi is a lexical pattern arising by allomorph selection (Hsieh 1975, Wang 1995, Tsay and Myers 1996). That is, both juncture and context forms are listed in the mental lexicon, instead of one being derived from the other.

Another intriguing phenomenon lies in the contrast between Taiwanese Tone Sandhi and Mandarin Tone Sandhi. In Mandarin, Tone 3 (a L tone) changes into Tone 2 (a LH tone) when followed by another Tone 3 syllable. This tone sandhi has been proven acoustically to be incomplete neutralization, i.e., the derived LH (changed Tone 3) is not identical to the underlying LH (Tone 2) (Zee 1980, Peng 1996). Why is there a difference in neutralization between these two languages? Before we answer this question, let us compare the characteristics of tone sandhi in these two languages.

Taiwanese Tone Sandhi is phonetically unnatural. First of all, it is insensitive to neighboring tones. Also, tone alternation is very dissimilar among tones. For example, long tone alternation is as follows:  $H \leftrightarrow M$ ,  $LH \leftrightarrow M$ ,  $M \leftrightarrow L$ ,  $L \leftrightarrow HL$ ,  $HL \leftrightarrow H$ . It is impossible to describe the alternation with fewer than three rules. (See detailed discussion in Tsay and Myers 1996.) Moreover, productivity experiments show that Taiwanese Tone Sandhi is only semi-productive (Hsieh 1975, 1976, Wang 1995). Both linguistic and psycholinguistic evidence suggests that Taiwanese Tone Sandhi is a lexicalized pattern which might have had a phonetic motivation in an earlier stage but is not necessarily phonetically grounded anymore.

By contrast, Mandarin Tone Sandhi is phonetically natural. As mentioned above, in Mandarin a L tone becomes a LH tone when followed by another L tone, or, put differently, it inserts a H tone between two L tones. That is, tone sandhi is triggered by the following tone. Moreover, the insertion of H tone between two L tones is dissimilation which is phonetically very natural and commonly found in tone languages (Hyman and Schuh 1974).

Therefore, tone sandhi patterns in these two languages seem to support the Naturalness Hypothesis: Taiwanese Tone Sandhi is phonetically unnatural, hence it shows complete neutralization and tones change into other tones that already exist in the system. By contrast, Mandarin Tone Sandhi is phonetically natural and it shows incomplete neutralization.

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