Processes In The Production Of Taiwanese Tone Sandhi: An Acoustic Phonetic Study

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1 INTRODUCTION

This study concerns the on-line production processes of tone alternation in Taiwanese (South Min Chinese), using acoustic-phonetic experimental method.

1.1 Taiwanese tone sandhi

Taiwanese has seven lexical tones: Yinping, Yangping, Yinshang, Yinqu, Yangqu, Yinru, and Yangru. Each of these tones has two alternative forms, one appearing in juncture position, the other in context position, a phenomenon called Taiwanese tone sandhi. Juncture tones are found utterance-finally and context tones are found word-internally (as within compounds or reduplicated forms). A summary of this tone alternation is given below based on the dialect of Chiayi County in Taiwan. (Underlined tones are short tones.)

Table 1 Tone alternation in Taiwanese

Tone category	Juncture position	Context position	Example
Yin Ping	H	M	詩
Yang Ping	LM	M	時
Yin Shang	HL	H	死
Yin Qu	L	HL	四
Yang Qu	M	L	寺
Yin Ru	M	H	色
Yang Ru	H	L	熟

1.2 Allomorph selection hypothesis

Many studies have been trying to capture this tone alternation by phonological rules (e.g. Wang 1967, Yip 1980, Tsay 1994). However, this tone alternation has typical lexical properties such as semi-productivity (e.g. Hsieh 1975, Wang 1995), phonetic insensitivity, and idiosyncrasies. Recently, it has been proposed that the production of the tone sandhi alternations in actual speech does not involve on-line change of one tone category into another, but rather the selection of allomorphs (juncture or context) appropriate to the environment (see Tsay and Myers 1996 for detailed discussion).

We focus on categoricality since it is a classic diagnostics of lexicon-internal phonology (in the case of Taiwanese tone sandhi described above) as opposed to postlexical phonology (in the case of third-tone sandhi in Mandarin which has been shown to be gradient in production by Zee 1980, Peng 2000).

1.3 Goals of this study

A previous study by Tsay, Charles-Luce and Guo (1999) has confirmed that the alternation between juncture and context tones was categorical, as indicated by the neutralization of the F0's of juncture and context forms. However, this study only tested neutralization within words (i.e. compounds). In the current study, we further explored (i) the lexical effect in word-final, but phrase-internal position (Experiment 1); (ii) the effect of the pragmatic context (listener absent vs. present) (Experiment 2)

2 EXPERIMENT 1

Tsay, Charles-Luce, and Guo (1999) found that Yinping (e.g.***詩***報"***poetry*** journal") and Yangping (e.g.***時***報"***times*** newspaper") are indeed neutralized in context position as a mid level tone M, suggesting that tone sandhi is a lexical process. However, since these context positions were always within words, a critic could charge that in such a case tone sandhi is of course lexical, since compounds are likely at least sometimes to be retrieved as wholes rather than always compounded on-line. Thus this experiment aimed to strengthen the argument by putting Yinping and Yangping into positions that produce context tones, and yet are word-final.

2.1 Method

Subjects: 10 native speakers of Taiwanese (average around 30 years of age)
Materials: Subjects were presented with pairs of written sentences containing Yinping and Yangping tones that are neutralized as M in context position word-finally, but preceding various syntactic boundaries. Examples are given below.
1a. Yinping ***kuan***^{H} "donate" preceding an NP (surfaces as ***kuan***^{M})
伊 要 ***捐*** 土地 起(蓋)學校
kuan^{M} tʰ ɔ te
he want ***donate*** land (for) building school
1b. Yangping ***kuan***^{LM} "high" preceding an NP (surfaces as ***kuan***^{M})
我 要 ***懸(高)*** 椅仔 較好坐
kuan^{M} i-a
I want high chair better sitting
Procedure: Subjects were asked to read the sentences aloud in Taiwanese. The recordings were made with a Sharp Mini-Disc Player in a sound-treated room and analyzed with the Computerized Speech Lab (Kay Elemetrics).

2.2 Results and discussion

F0 was measured at two positions within the syllable. As expected, no significant effects were found by subject at either measuring point (beginning: 125 Hz vs. 126 Hz, $t(9)=-0.12$, $p=0.91$; end: 118 Hz vs. 119 Hz, $t(9)=-0.10$, $p=0.92$). Since context tones here were phrase-internal but not word-internal, the apparently lexical nature of Taiwanese tone sandhi cannot be explained away by claiming that it merely describes a lexical pattern found across words stored in the lexicon. Instead, it appears that it is both lexical (as indicated by the complete tonal neutralization that it causes) and phrasal. This is consistent with the hypothesis of Tsay and Myers (1996), who suggested that speakers apply tone sandhi by selecting juncture vs. context allomorphs from memory and placing them in the correct environments in the syntactic structure. That is, while the generation of a particular tonal allomorph does not occur on-line, its selection does.

3 EXPERIMENT 2

This experiment tests the prediction that tone sandhi, as a fundamentally lexical process, cannot be modified/controlled on-line by pragmatic context (listener absent vs. present), unlike the results of Charles-Luce (1993, 1997) for postlexical processes.

3.1 Method

Subjects: 30 native speakers of Taiwanese (average around 20 years old).
Materials: Twenty written experimental sentences were given to subjects to read aloud in Taiwanese: five pairs containing sequences that involved the neutralization of context Yinping and juncture Yangqu (both realized as M), and five pairs containing sentences that involved the neutralization of Yinping and Yangping tones in context position (both realized as M). In the

former case, disambiguation is possible through the postlexical process of syllable duration (juncture tones tend to be longer than context tones due to phrase-final lengthening), but in the latter case, disambiguation would require varying pitch itself (which we hypothesize to be impossible, since the tone sandhi allomorphs are simply stored in the mental lexicon). Forty-eight fillers were included. Examples of these two types of neutralization are given below.

Type I: Can be disambiguated by syllable duration (Yinping ***ti***^{H} 'pig' in context form ***ti***^{M} vs. juncture Yangqu ***ti***^{M} "chopsticks")

2a. 這 是 ***豬***肉 及 碗
ce si ***ti***^{M} bah kap u)a)
this is ***pig***-meat and bowl

2b. 這 是 ***筷 ,*** 肉 及 碗
ce si ***ti***^{M} bah kap u)a)
this is ***chopsticks***, meat, and bowl

Type II: Cannot be disambiguated by syllable duration (context Yinping ***kun***^{H} "army" vs. context Yangping ***kun***^{LM} "group", both neutralized as M)

3a. 伊愛參加 ***軍***隊 的活動
kun^{M} tui
army team
"He loves to participate in army activities."

3b. 伊愛參加 ***群***隊 的活動
kun^{M} tui
group team.
"He loves to participate in group activities."

Procedure: Subjects were asked to read each of these four types of sentences aloud in two different conditions: alone in a room first, then in the presence of an attentive listener who was (ostensibly) trying to transcribe the subject's words. The recordings were made the same way above.

3.2 Results and discussion

The acoustic measures of F0 (in three positions within the syllable) and syllable duration were made on the digitized recordings. Statistical analyses (two-way ANOVA by subject) were conducted for duration and F0 for both across position (2a vs. 2b in examples above) and within position (3a vs. 3b).

Duration across position: A significant main effect of Tone Condition was found ($F(1,26)=22.686$, $p<0.01$). That is, juncture tone duration was significantly longer than context tone duration regardless of whether listener was absent or present. There was no significant main effect of Listener Presence ($p=0.16$) and no interaction ($p=0.58$). This is consistent with what has been found in previous studies.

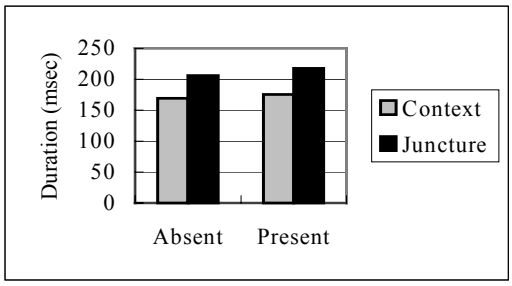

Figure 1 Duration across position

F0 across position: We found no significant main effects for the Tone factor at the three_

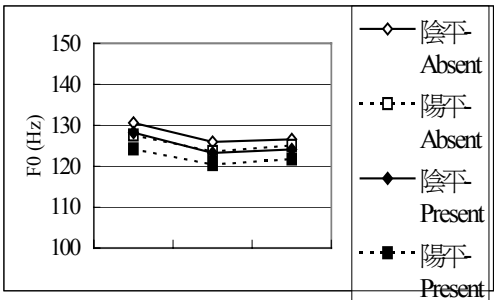

Figure 2 F0 across position

measurement points (p>0.1), no main effects of Listener Presence (except for the end point where marginal significance was found (F(1,26)=5.1, p<0.05), and no interactions (minimum p-value over 0.26). This indicates that there was no speaker control of the tone sandhi as predicted.

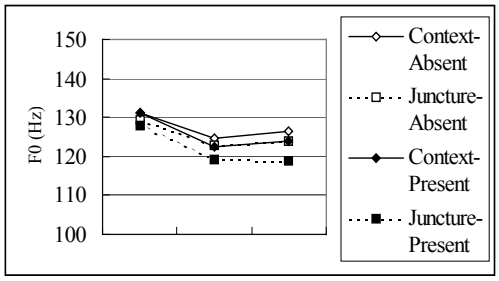

Figure 3 Duration within position

Duration within position: Significant main effects were found for Tone Condition (F(1,26)=7.07, p<0.05) and Listener Presence (F(1,26)=7.26, p<0.05); and there was interaction (p<0.01). The interaction suggests that the speakers were trying to disambiguate the pairs by controlling the duration.

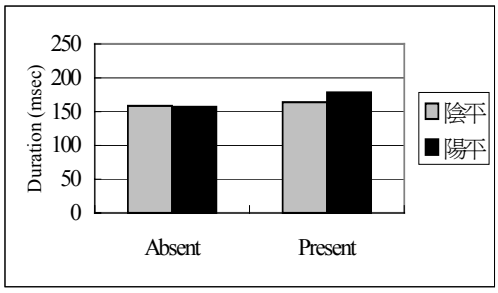

Figure 4 F0 within position

F0 within position: There were significant main effects of Tone Condition at the three measurement points (F(1,26)=20.596, p<0.01; F(1,26)=15.260, p<0.01; F(1,26) =10.417, p<0.01). There were also main effects of Listener Presence (p<0.05), but no tone-listener interaction. (minimum p-value over 0.47). This seems to indicate there was no speaker control of tone.

4 CONCLUSION

The results of Experiment 1 were very straightforward: Tone neutralization occurs at word-final position within a phrase. This is consistent with the allomorph hypothesis of Tsay and Myers (1996) that speakers apply tone sandhi by selecting juncture vs. context allomorphs from memory and placing them in the correct environments in the syntactic structure. In other words, while the generation of tonal allomorph does not occur on-line, the selection of

allomorph does occur on-line as indicated by the tone neutralization in word-final position within a phrase which is concatenated on-line.

In Experiment 2, we manipulated a pragmatic factor (listener absent vs. listener present) both across position (context vs. juncture) and within position (in context).

First, for neutralization across position, duration is an important factor distinguishing the articulation of juncture and context tones. The lack of significant differences in F0 is consistent with the allomorph hypothesis that the allomorphs of Taiwanese tone sandhi are lexically distinct forms that are retrieved from memory rather than generated during speech production planning.

We had hoped to find further evidence for this control by finding an interaction for durations between the tone categories and the presence/absence of a listener, but the lack of such a finding does not argue against our basic hypotheses. The crucial finding is that it seems to be impossible for speakers to control F0 enough to distinguish context Yinping and juncture Yangqu by that variable alone.

Second, for neutralization in context position, it is not surprising that speakers were not able to use duration to distinguish these tones, since both occur in the same prosodic position. The significant differences in F0 within position seem to support the nonlexical 'tone sandhi rules.' However, it should be pointed out that both context Yinping and context Yangping have the same slope that cannot be explained by the nonlexical hypothesis. This is a puzzle that needs further investigation.

Since there has been very little research about the on-line processing of Taiwanese, especially tone sandhi, all that we learn will greatly improve our understanding of this language, as well as provide new challenges to psycholinguistic models based primarily on English.

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