

行政院國家科學委員會專題研究計畫 成果報告

界線前後台閩語鼻音、塞音發音形式 2/2

計畫類別：個別型計畫

計畫編號：NSC91-2411-H-009-017-

執行期間：91年08月01日至92年07月31日

執行單位：國立交通大學外國語文學系

計畫主持人：潘荷仙

計畫參與人員：李宜興、張業承、謝瓊羽、蘇怡如、蔡欣芸

報告類型：完整報告

處理方式：本計畫可公開查詢

中 華 民 國 92 年 10 月 28 日

行政院國家科學委員會補助專題研究計畫 [√] 成 果 報 告
期中進度報告

界限前後台閩語鼻音、塞音發音形式

計畫類別：個別型計畫

計畫編號：NSC 91 - 2411 - H - 009 - 017 -

執行期間： 2002 年 8 月 1 日至 2003 年 7 月 31 日

計畫主持人：潘荷仙

計畫參與人員：李宜興、張業承、謝瓊羽、蘇怡如、蔡欣芸

成果報告類型(依經費核定清單規定繳交)：完整報告

處理方式：除產學合作研究計畫、提升產業技術及人才培育研究計畫、列管計畫及下列情形者外，得立即公開查詢

Prosodic Hierarchy and Nasalization in Taiwanese

Ho-hsien Pan

† National Chiao Tung University, Taiwan

E-mail: hhpan@faculty.nctu.edu.tw

ABSTRACT

This study investigated nasalization process from final nasal to initial voiced stops across intermediate phrase boundary, word boundary, tone group boundary, and syllabic boundary in Taiwanese. The degree of nasalization was investigated with nasal airflow data collected from four native Taiwanese speakers producing sentences with final nasal at the end of second syllable and initial voiced stops at the third syllable. Results revealed duration of final nasal and initial stop across ip boundary was the longest, but undistinguishable across tone group, word, and syllable boundary. No final lengthening was observed on final nasals, /m, n, ŋ/ across ip, tone group, word, and syllable boundaries. The duration of /mb, nl, ŋg/ deducting the duration of final /m, n, N/ showed that the duration of /b, l, g/ plus optional pauses intervening between final nasals and initial voiced stops was the longest across ip boundary, but were undistinguishable among tone group, word, and syllable boundaries. The amplitude and latency of peak nasal airflow and peak velocity both showed that the peak latency and peak velocity across tone group boundary was the latest in time, and shortest in time across syllable boundary. Duration of exhaling nasal airflow showed a trend of the prosodic hierarchy of ip, tone group, word, and syllable boundaries, ranking from the strongest to the weakest. Duration of vowel in syllable preceding /mb, nl, ŋg/ was the longest across ip, and the shortest across syllable boundary. The duration of vowel nuclei preceding /mb, nl, ŋg/ intermediate between ip and syllable boundaries and were indistinguishable between each other. However, the duration of vowel following /mb, nl, ŋg/ indicated a increase of initial lengthening across ip, tone group boundaries and was the strong across word boundaries.

Key Words: Taiwanese, Prosodic Hierarchy, Nasal Airflow, Nasalization, final nasal, initial voiced stops

1. INTRODUCTION

The influence of phonological structure extends into low-level articulatory activities. The signature of prosodic hierarchy on segmental articulation can be found in lingual gesture [3-5], labial movement [6,7], glottalization [12], glottal opening [9], and jaw movement [11, 13]. Among these studies on different articulators, the movement of velum was not as well investigated. Nasalization that involves the downward movement of velum within the

domain of a word can be found in languages such as English, French, Hindi, Bengali, Sundanese, and Italian [1, 10, 14, 15]. However, the spreading of nasality from nasal to oral segment across word boundary was reported in few languages such as Taiwanese [8].

This study investigate the extent of nasalization from final nasal to initial voiced stops across prosodic boundaries of different strength, e.g. intermediate phrase, word, tone group, and syllabic boundaries, in Taiwanese. Taiwanese is a tone language with seven lexical tones. There are two different surface tonal values for each syllable, i.e. juncture and context tonal values. According to tone sandhi rules, a syllable surfaces with juncture tone at the end of tone group, and with context tone value in initial or medial position of a tone group. The tonal value is determined by tone sandhi rule that has a recursive nature, that is [55]and [51] -> [33] -> [31] -> [53] -> [55]. For example the syllable /kun 55/ 'king' which carries tone [55] at juncture position would carries tone [33] at context position, while the syllable /kun 33/ 'near' that carries tone [33] in juncture position turns to tone [31] in context position. Due to the recursive nature of tone sandhi rule, the surface form [kun 33] means 'near' if it is at the juncture position. However, in context position the surface form [kun 33] means 'king'. In other words, both surface tonal values and the location of a syllable in a tonal group are essential during lexical processing. Therefore, the location of tonal group boundary is a very important cue in Taiwanese lexical processing. The domain of a tone group is prosodically determined in Taiwanese. Tone group boundary is an important and unique prosodic boundary in Taiwanese. This study investigated the ranking of tone group boundary in prosodic hierarchy by studying the degree of nasalization across boundaries of various strengths.

2. METHODS

Four male native Taiwanese speakers, i.e. CYS, HFY, HYH, and LYK, participated in the experiments. They were students at the National Chiao Tung University at the time of data collection.

Corpus discussed here was part of the larger database consisted of sentences with vowel and final nasal positioned at the end of second syllable followed by initial voiced stops, and voiceless stops at the beginning of third syllable across prosodic boundaries. Example of corpus was shown in Table 1. According to Ding [2] alveolar lateral, /l/, has a stop-like quality, therefore it is included as one of voiced stops. Data discussed here included final

vowels and final nasals, /m, n, ŋ/, in the second syllable and initial voiced stops, /b, l, g/, at the third syllable across intermediate phrase, tone group, word, and syllabic boundaries. The intermediate phrase boundary was placed at the end of a vocative phrase, while tone group boundary was placed within a compound word.

Recording of nasal airflow was conducted with MS100-A2 airflow system manufactured by Glottal Enterprise, and a nasal airflow mask, model P0789, by Hans Rudolph Inc. A TEV microphone was placed 30 cm in front of the subject's mouth. Both nasal airflow and acoustical data were picked up simultaneously and recorded onto a PC.

Recording was conducted at a sound treated room in the phonetic lab at Naitonal Chiao Tung University. To control the speed at which subject produce each sentence, A metronome was used to provide reference speed. Subject wore headphone to hear the beat, and were instructed to produce the first two syllables following the beats. Two speeds were used, i.e. 144 and 200 beats per minute. During the recording subjects produced randomized sentences from a list. After production of one sentence subject paused for a few seconds to allow an experimenter to save the acoustical and airflow data with CspeechSP software. Both acoustical and airflow data were then transformed into .wav format and then analyzed with multi-speech by Kay Elemetrics.

Spectrographs were generated from the acoustical data and then aligned with the trace of nasal airflow in time. By using spectrographic cues, the time at the offset of second vowel and the onset of third vowel were determined. The amplitude of nasal airflow at the offset of the second vowel, and onset of the third vowel was then taken, along with the peak and valley of nasal airflow in between the two vowels. 144 sentences (4 final segments * 3 initial segments * 4 prosodic boundaries * 3 repetitions) were analyzed for each subject. Peak velocity and its latency relative to the onset of the first vowel was also taken. The time of exhaling nasal airflow was also measured. Duration of vowel in syllables preceding and following /mb, nl, ŋg/ was also measured (Figure 1).

As shown in the upper panel of Figure 1, there were two nasal peaks and a valley between the offset of the second vowel and onset of third vowel, that is during final nasal and initial voiced stop across ip (intermediate phrase) boundary. The first nasal peak was reached during the production of final nasal, then the subject inhaled resulting in the valley observed in the trace of nasal airflow. After the valley, the nasal airflow peaked again during the production of initial voiced stop following intermediate phrase boundary. In the lower panel of figure 1, the nasal airflow peaked once and remained exhaling through the final nasal and initial voiced stop.

3. RESULTS

Figure 2 showed the duration of final nasal and initial

voiced stop across intermediate phrase, word, tone group, and syllable boundary. The same pattern of duration with respect to strength of prosodic boundary. The duration of final nasal and initial voiced stop was the longest across ip boundary. The duration of final nasal and initial voiced stop across tone group, word, and syllable boundaries was indistinctive, as shown in figure 2.

Duration of final nasals, in ___ # /p, t, k/ contexts, preceding intermediate phrase, tone group, word, and syllable boundaries was undistinguishable as shown in figure 3. The duration of final nasals did not vary according to the hierarchical strength of following boundaries.

Since the duration of final nasal remain constant before different prosodic boundaries, the duration variation of final nasal plus initial voiceless stop located between offset of second vowel and onset of third vowel were mainly due to the duration of occasional pause and initial stops, as shown in Figure 4. Duration of initial voiced stops, /b, l, g/ plus preceding pause (observed only across ip boundary) was the longest across ip boundary and was undistinguishable across tone group, word and syllable boundaries which does not have intervening pause between final nasals and homorganic initial voiced stops.

Results of amplitude and latency for peak nasal airflow were shown in Figure 5. In terms of peak latency, the order from the latest to the earliest was ip, tone group, word, and syllable boundaries. In terms of peak amplitude, peak across ip and tone group boundaries were both the highest. The amplitude of peak across syllable boundary was the second highest, while the peak amplitude across word boundary was the lowest.

Peak velocity and its latency relative to the onset of first vowel of the sentence revealed that the peak velocity of nasal airflow across ip boundary was the highest followed by tone group boundary that in turn was higher than that across word boundary. The peak velocity across syllable boundary was the lowest. As far as latency for peak velocity was concerned, latency for peak velocity of nasal airflow across tone group boundary was the latest, followed by latency across word boundary, and finally peak latency across syllable boundary which was the earliest, as shown in figure 6.

If we disregard the data point of ip in both figure 5 and 6 which were read with a pause between final nasals and initial voiced stops and paid attention only to peak velocity and latency across tone group, word, and syllable boundaries which were read without pause in between, it was found that the time for peak latency and peak velocity was the latest across tone group boundary, the second latest across word boundary and the earliest across syllable boundary.

The duration of exhaling (positive) nasal airflow between the offset of second vowel and onset of the first vowel was shown in figure 7. There is a trend for duration of exhaling nasal airflow was the longest across ip boundary, followed

by tone group boundary, and then word boundary. The duration of exhaling nasal airflow across syllable boundary was the shortest.

The duration of vowel in syllables preceding /mb, nl, ŋg/ (Figure 8) and /mp, nt, ŋk/ (Figure 9) was the longest across ip boundary and a trend for the duration across syllable boundary to be the shortest. As for the duration following /mb, nl, ŋg/ (Figure 10), and /mp, nt, ŋk/ (Figure 11), it was the longest across word boundary.

4. DISCUSSIONS

The influence of prosodic strength for hierarchical boundaries extended into low level articulatory activities, such as the lowering of velum, which is involved in the production of nasal and nasalization of oral segments. Though the investigation of amplitude and temporal factors for nasality across intermediate phrase, word, syllabic and tone group boundaries in Taiwanese, the study contributed to the line of study on prosodic influence and articulation.

Results of this study showed that though a hierarchical relationship could not be found in single measurement. However, nasal airflow across different boundaries has its own unique trait which surfaced on the different measurement to mark the boundary. As shown in Table 3. the duration of /mb, nl, ŋg/ was the longest across ip boundary, but undistinguishable across tone group, word and syllable boundaries. Inhaling nasal airflow (pause) were observed across ip boundary but not across tone group, word and syllable boundary. Duration of final nasal was not an effective measurement in distinguishing ip, tone group, word, or syllable boundaries. Duration of /mb, nl, Ng/ excluding duration of final nasals was the longest across ip boundary and were undistinguishable across tone group, word and syllable boundaries, since pauses contributed to the measurement of /mb, nl, Ng/ excluding duration of final nasal, but did not contribute to the duration across tone group, word and syllable boundaries.

If we disregard the peak latency and peak velocity across ip boundary which were consisted of pauses, and compare peak velocity and latency of /mb, nl, Ng/ that was not consisted of pauses across tone group, word and syllable boundaries, it is observed that the time for peak latency and peak velocity was the latest across tone group boundary, intermediate across word boundary, and the shortest across syllable boundary.

Duration of vowel preceding /mb, nl, Ng/ was the longest across ip boundary. This suggests for the strongest final lengthening effect across ip boundary. While the duration of vowel following /mb, nl, Ng/ was the longest across word boundary. It was suggested that initial lengthening marked syllables following word boundary.

Different boundaries are signaled by different measurements, according to the nasal airflow data collected here. It is proposed that ip with the longest duration across

/mb, nl, Ng/, longest in duration of exhaling nasal nasal flow and longest in vowel duration preceding /mb, nl, Ng/ was the strongest prosodic boundary among the four boundaries studied. Similarly, syllable boundary with the earliest peak latency and velocity and without any other measuring to mark it was the weakest among the four boundaries studied. It is hard to distinguish the prosodic hierarchy between tone group and word boundaries, since one is marked by latest peak latency and peak velocity, while the other was marked by strongest initial lengthening. It is proposed that word and tone group boundary intermediate between ip and syllable boundary. However, further studies are necessary to distinguish the two.

REFERENCES

- [1] A. C. Cohn, "Phonetic and phonological rules of naslailzaiton", UCLA Working Papers in Phonetics 97, Ph.D. Dissertation University of California, Los Angeles, 1990.
- [2] B. Ting, "Taiwan Yu-ian Yuan-liou" Taipei: Student Publisher, 1985.
- [3] C. Fougeron and P.A. Keating, "Variations in velic and lingual articulation depending on prosodic position: Results for two French speakers", *UCLA Working Papers in Phonetics*, **92**, pp. 88-96, 1996.
- [4] C. Fougeron and P.A. Keating, "Articulatory strengthening at edges of prosodic domains", *Journal of Acoustical Society of America*, **106** (6), pp. 3728-3740, 1997.
- [5] D. Byrd, "A phrase window framework for articulatory timing", *Phonology*, **13**, pp. 139-169, 1996.
- [6] D. Byrd and E. Saltzman, "Intragestural dynamics of multiple prosodic boundaries", *Journal of Phonetics*, **26**, 173-200, 1998
- [7] D. Byrd, A. Kaun, S. Narayanan, E. Saltzman, "Phrasal signatures in articulation". In *Acquisition and the lexicon: Papers in laboratory Phonology V* (M. Broe and J. Pierrehumbert, editors), pp. 70-88. Cambridge, UK:Cambridge University Press, 2000.
- [8] H. Pan, "The voicing contrast of Taiwanese (Amoy) initial stops: Data from adults and children", Ph.D. Dissertation, The Ohio State University, 1994.
- [9] J. Pierrehumbert and D.Talkin, "Lenition of /h/ and glottal stop", In *Papers in Laboratory Phonology II: Gesture, Segment, Prosody* (G. Docherty and D.R. Ladd, editors), pp. 90-117, Cambridge, UK: Cambridge University Press. 1992.
- [10]J. J. Ohala and M. Ohala, "Speech perception and lexical representation: the role of vowel nasalization in Hindi and English " In *Phonology and Phonetic Evidence: Papers in Laboratory Phonology IV*, pp. 41-60. Cambridge, UK: Cambridge University Press, 2000.
- [11]K. de Jong, "The supra-glottal articulation of prominenece in English: Linguistic stress as localized hyper-articulation", *Journal of Acoustical Society of America*, **97**(1), 491-504, 1995.
- [12]L. Dilley, S. Shattuck-Hufnagel, & M. Ostendorf, "Glottalization of word-initial vowels as a function of prosodic structure". *Journal of Phonetics*,**24**, pp. 423-444, 1996.
- [13]M. E. Beckman, J. Edwards, and J. Fletcher, "Prosodic structure and tempo in a sonority model of articulatory dynamics", In *Papers in Laboratory Phonology II: Gesture, Segment, Prosody* (G. Docherty & D. R. Ladd, editors), pp. 68-86. Cambridge, UK: Cambridge University Press. 1992.
- [14] P. Ladefoged and I. Maddieson, "The Sounds of the the World's Languages", Oxford, UK: Blackwell Publisher, 1996.
- [15]P. Maturi, "The perception of consonantal nasality in Italian: Conditioning factors", In *Proceedings of the XIIIth International Congress of Phonetic Sciences*, Aix-en-Provence, **5**, 50-53, 1991

Table 1. Example of Corpus.

Final nasal of second Syllable	Initial voiced stops of third Syllable	Example
/m/ #	#/b/	/tsa him ba sīū kioŋ bo/ ‘It is too scary to eat bear meat.’
	#/l/	/si sam la təŋ lai a/ ‘Sam-la came back.’
	#/g/	/fīā im gak tsin kwai lok/ ‘Listening to music is enjoyable.’
/n/#	#/b/	/be hwan be təŋ lai a/ ‘(I) bought corn (back).’
	#/l/	/be tsan le təŋ lai a/ ‘(I) bought snail (back).’
	#/g/	/k ^h i dwan gai gī tʃi tou/ ‘Play on the side of cliff.’
/ŋ/#	#/b/	/tsia t ^h aŋ ba sīū kioŋ bo/ ‘It is scary to eat worm meant.’
	#/l/	/tsia p ^h aŋ la sīū kioŋ bo/ ‘It is scary to eat bee wax.’
	#/g/	/hi gaŋ gaŋ i di k ^h waŋ/ ‘He kept on staring mindlessly.’

Vowel#	#/b/	/be a ba mī lai a/ ‘(I) bought duck noodle (back).’
	#/l/	/k ^h i p ^h a la təŋ lai a/ ‘(I) came back from hunting.’
	#/g/	/an ka gak təŋ lai a/ ‘(I) came back from jail.’

Table 3. Summary of results

	ip	Tone group	Word	Syllable
Duration of /mb, nl, ŋg/	longest			
Inhaling nasal airflow (pause)	Yes	No	No	No
Duration of /m, n, ŋ/				
Duration of pause and /b, l, g/	longest			
Time of peak latency		latest	Intermediate	earliest
Time of peak velocity		latest	Intermediate	earliest
Duration of exhaling airflow	longest			
Duration of vowel preceding /mb, nl, ŋg/	longest			
Duration of vowel following /mb, nl, ŋg/			longest	

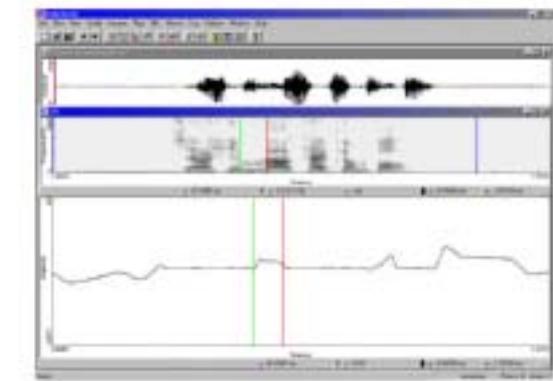
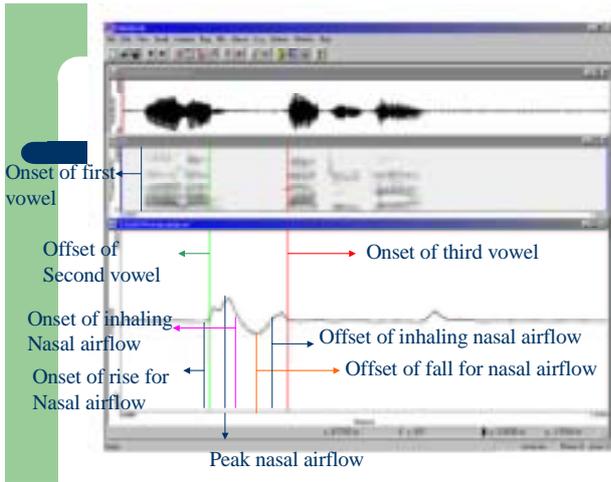


Figure 1. Waveform, spectrogram and trace of nasal airflow across intermediate phrase boundary (upper panel) and word boundary (lower panel).

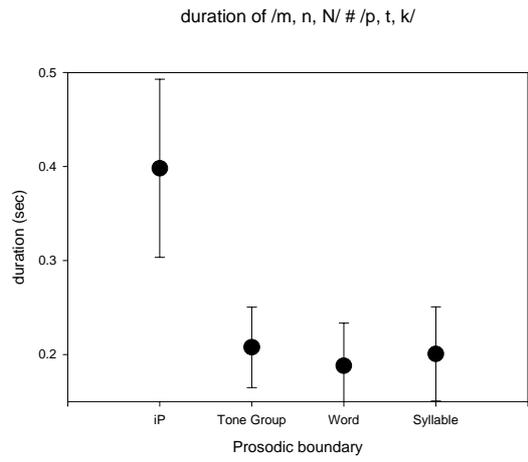


Figure 2. Duration of final nasal and initial voiced stops across ip, tone group, word, and syllable boundaries.

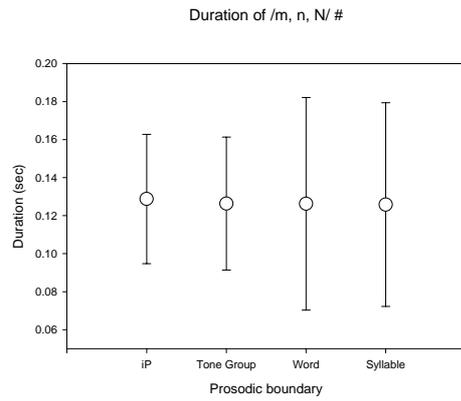


Figure 3. Duration of final stops before prosodic boundaries

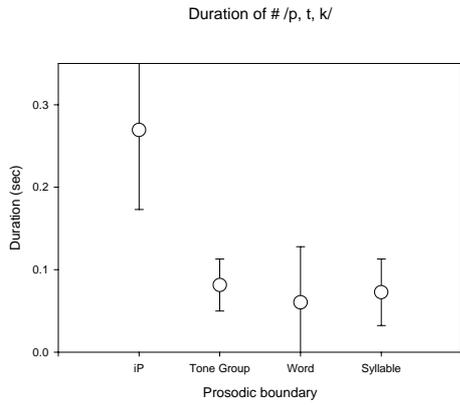


Figure 4. Duration of optional pause and initial stop

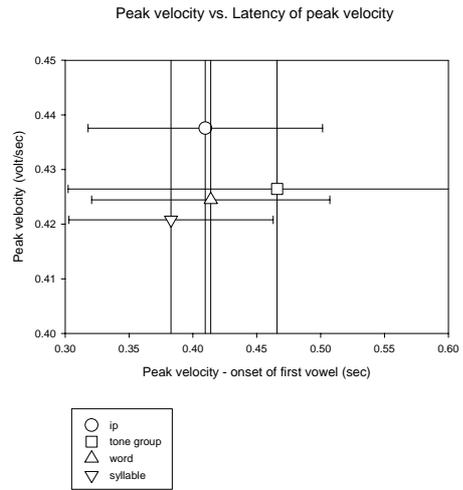


Figure 6. Peak velocity and its latency

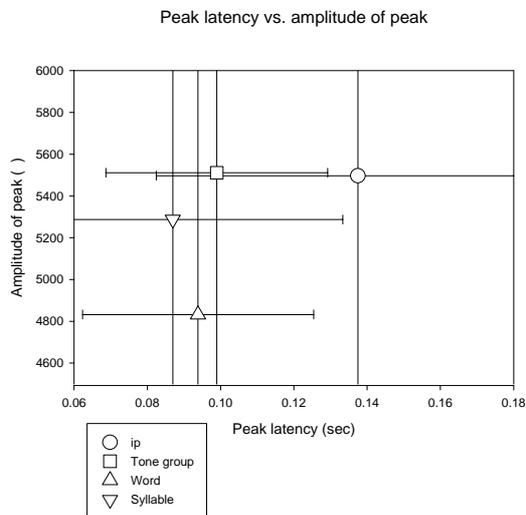


Figure 5. Time and amplitude of peak nasal airflow between onset of final nasal and offset of initial stop across ip, tone group, word, and syllable boundaries.

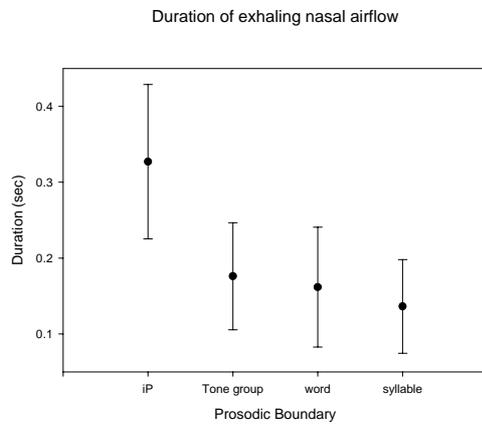
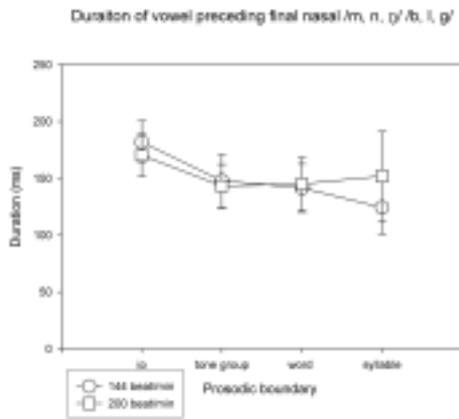
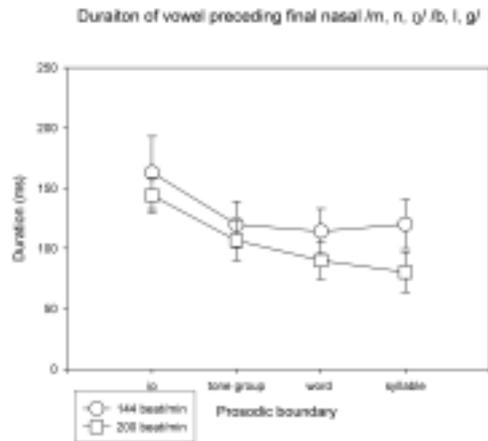


Figure 7. Duration of exhaling nasal airflow across ip, tone group, word, and syllable boundary

Subject: CYS



Subject: LYK



Subject: HFY

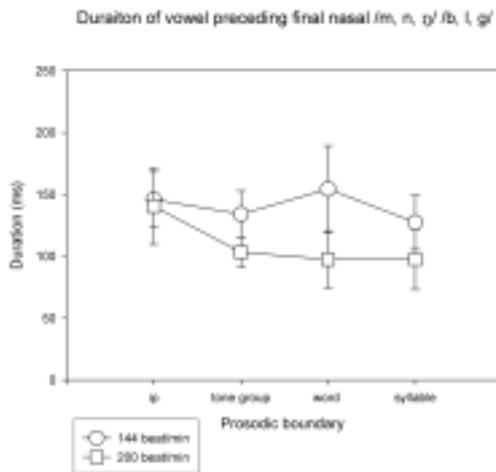
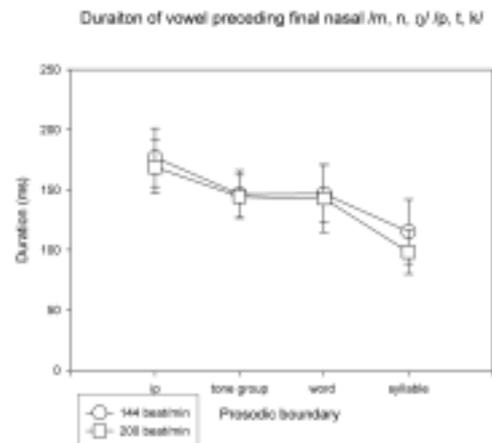
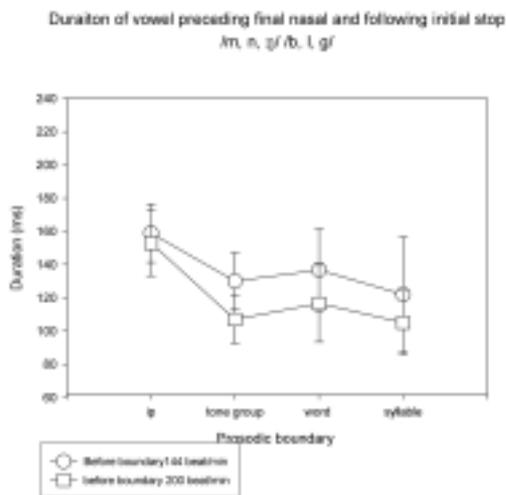


Figure 8. Duration of vowel in syllable preceding /m, n, ɱ/ /b, l, g/

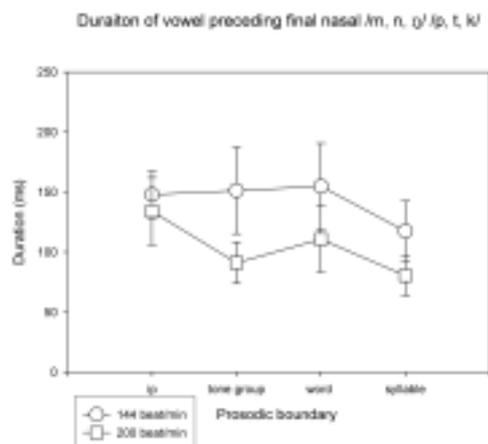
Subject: CYS



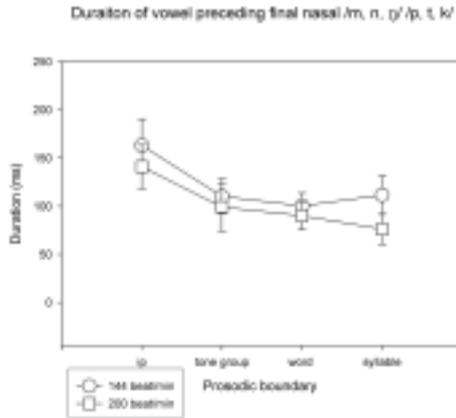
Subject: HYH



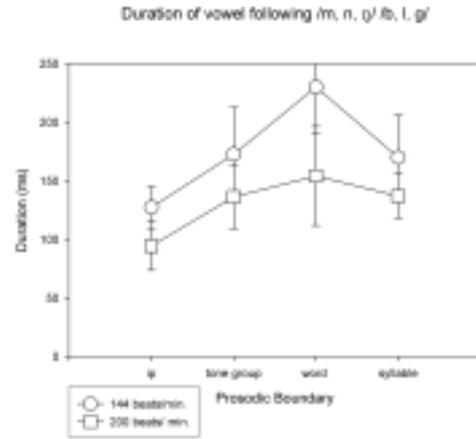
Subject: HFY



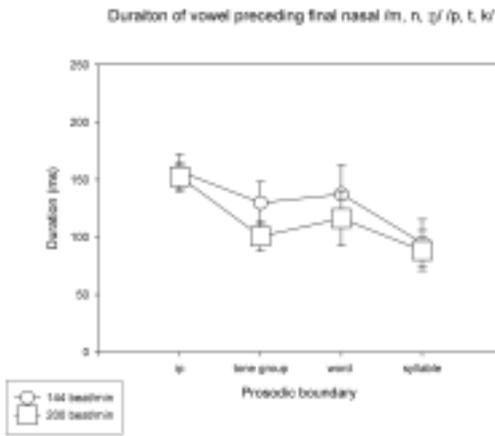
Subject: HYH



Subject: HFY



Subject: LYK



Subject: HYH

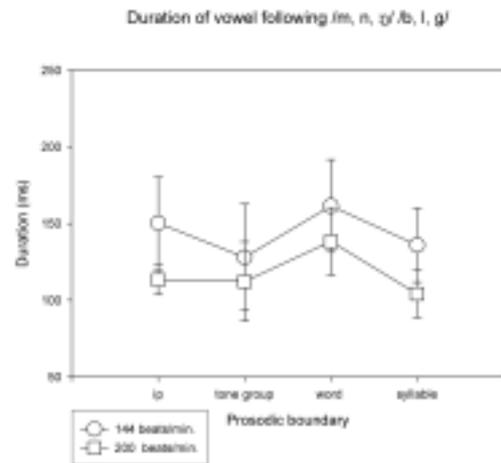


Figure 9. Duration of vowel in syllable preceding /m, n, ŋ/

/p, t, k/

Subject: LYK

Subject: CYS

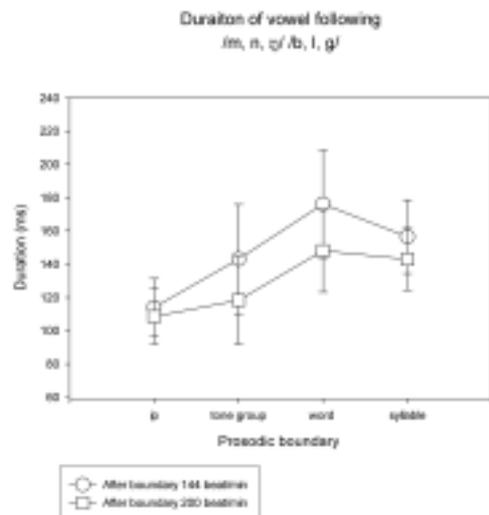
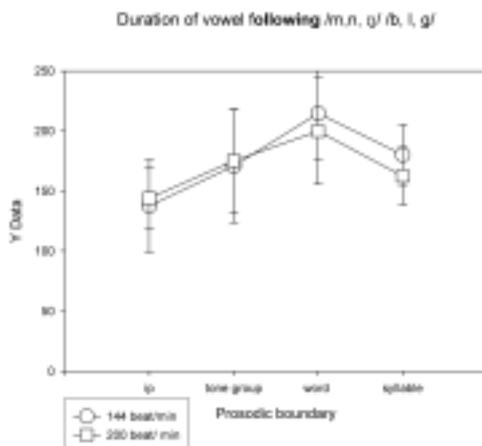


Figure 10. Duration of vowel in syllable following /m, n, ŋ/

Subject: LYK

/b, l, g/

Subject: CYS

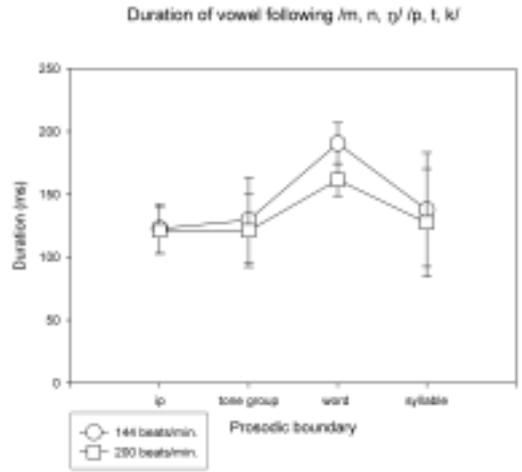
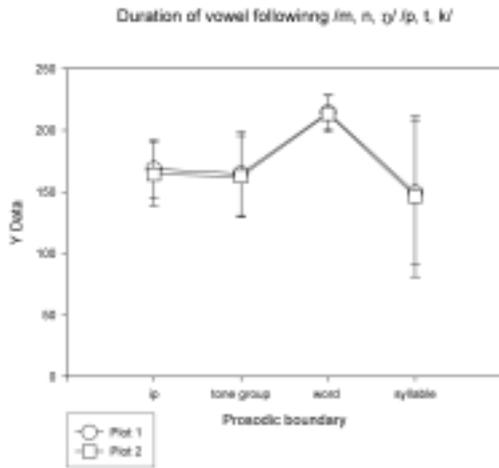
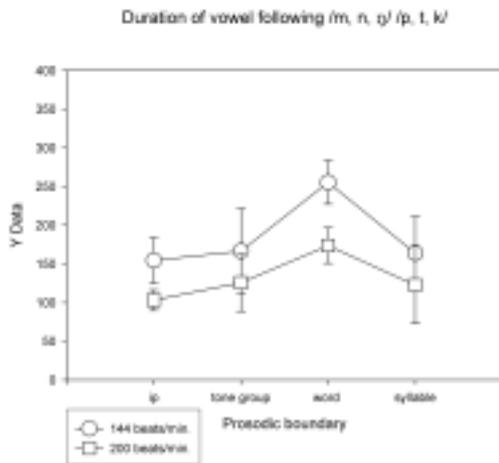


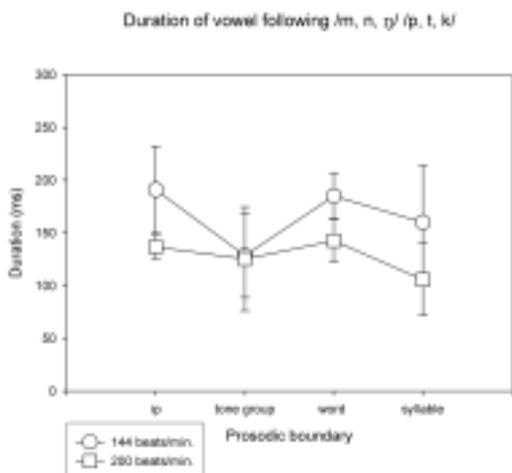
Figure 11. Duration of vowel in syllable following /m, n, ŋ/

/p, t, k/

Subject: HFY



Subject: HYH



計畫成果自評

本計畫未在同一丈量值上發現台閩語口語韻律結構之強度關係，但在鼻氣流丈量過程中已尋找到每一強度不同之口語韻律界限在不同丈量值上之所產生之影響。另外台閩語變調界限，從實驗結果看來，應屬口語韻律界限之一員。實驗目的初步說來已達成。在學術應用上，可將所尋得之聲學量變化用於語音合成上，增加口語自然度，另亦將各丈量值輔助應用於語音辨識中斷詞，找出各上下音節間構詞、段落等關係。增加辨識之準確度。

本結果已發表在 Lab Phon, 及 International Congress of Phonetic Science 中，未來當盡力與期刊發表工作。