Gender, Bilingualism and Vowel Inventory in Taiwan Mandarin [1]

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1. Introduction

Although the phonological system of Taiwan Mandarin (TM) is usually considered to be essentially the same as that of Beijing Mandarin (BM), the fact that its development since being introduced in Taiwan in 1945 has been strongly influenced by Taiwan Southern Min (TSM) (Kubler, 1985), has insured that the phonetic details of TM vowels differ from those of BM. Despite this fact, little research has been carried out to determine the degree of phonetic divergence between these two Mandarin systems.

Additionally, because the phonological system of Southern Min differs significantly from that of TM's key superstratum influence (BM), there is every reason to expect that TM might also differ from BM at the phonological level as well, and not just at the phonetic level. But again, empirical study investigating this possibility is quite limited.

Another issue of relevance to this particular study is the tendency among most linguists to assume a degree of homogeneity among speakers that simply isn't there, overlooking differences in usage within individuals and across individuals. Shen (1997) notes that for a long time, linguists, (especially those in Chinese linguistics), "have been using idiolects in their theoretical thinking and reasoning about languages". Thus, classic descriptive works in Chinese, e.g., Chao (1968), Li & Thompson (1982), Yuan (1960), Beijing University (2005), as well as very important recent works in Chinese acoustic phonetics, e.g. Lin (2001), Shi and Deng (2006), Wu (2004), Zee & Lee (2001) (which serves as the BM acoustical reference in this work), all have relied on data gleaned from a single speaker or a very small handful of speakers to draw their broad generalizations from. Only occasionally do phonetic studies exceed that standard sampling size of 1-4, e.g., Wang (2006). Likewise, the possibility that variation in pronunciation might exist and correlate with traditional sociolinguistic variables such as age, gender, and level of education is taken into consideration only very infrequently, e.g., Lin and Wang (1985), Wang (2006). The present study of vowel pronunciation in TM, with a sampling of 17 speakers [2], seeks to investigate if any variation in vowel pronunciation can be observed, and if so, whether it is possible to correlate this variation with any particular sociolinguistic variable or set of variables.

To find answers to the above questions we carried out a study using data collected in Taiwan in 2003 to acoustically analyze the six cardinal vowels of TM, /ɑ/, /ɤ/, /u/, /i/, /y/ and /ɚ/, together with two diphthongs involving the mid vowel /ɤ/, /uɤ/ and /ɤu/, two syllables involving the low vowel /ɑ/, /iɑ/and /iɑ/, and the two syllables /ʧiɤ/ and /ʧiɑn/, where phonemic overlap may be occurring between the two vowels /ɤ/ and /ɑ/. The results of this analysis were then compared with existing acoustic data for BM (Zee & Lee 2001), "a spectral analysis study of the vowels and syllabic approximants in Beijing Mandarin. It presents: (i) the average F1, F2, F3 values for the resonant sounds, (ii) the vowel ellipses for the resonant sounds, showing their relative positions in the F1/F2 plane, (iii) the vowel diagrams, showing the F-patterns of the first three formant frequencies of the resonant sounds, (iv) the formant trajectories for the rhotic schwa, showing that the vowel in the V syllables is actually a sequence of a plain schwa and a rhotic schwa, and (v) the diagrams of the average vowel positions for the vowels followed by a nasal ending, showing that the effect of the nasal ending on the F1 and F2 of the vowel sounds varies according to vowel type and nasal type."

2. Methodology

To collect our data we prepared a set of Powerpoint slides, with each slide designed to contain a single Chinese character whose pronunciation has come from among the set of target syllables discussed immediately above. To ensure that tone variation would not play a role in influencing vowel quality, every character selected for use in this study represented a morpheme pronounced in the fourth tone. In certain cases, however, no fourth tone morpheme existed for a particular syllable, so in which case tone 1 was used instead.

The purpose for working with individual written characters rather than connected speech was to avoid the phonetic influence of the co-articulation of surrounding speech sounds, which naturally 'corrupts' the purity of an isolated, idealized pronunciation. Likewise, the very act of requesting someone to correctly pronounce a written character is itself a highly formal event, which naturally leads subjects to pronounce each syllable as carefully as possible, thus giving us direct or near-direct access to his/her intuition of what the 'correct' pronunciation ought to be.

The procedure, then, was for subjects to be shown individual Powerpoint slides, one at a time, and as each slide was displayed, for the subject to read it out loud, with the pronunciation then recorded digitally onto the computer. That digital data was then subject to acoustic analysis via the acoustic software package Praat (Version 4.4.2)[3].

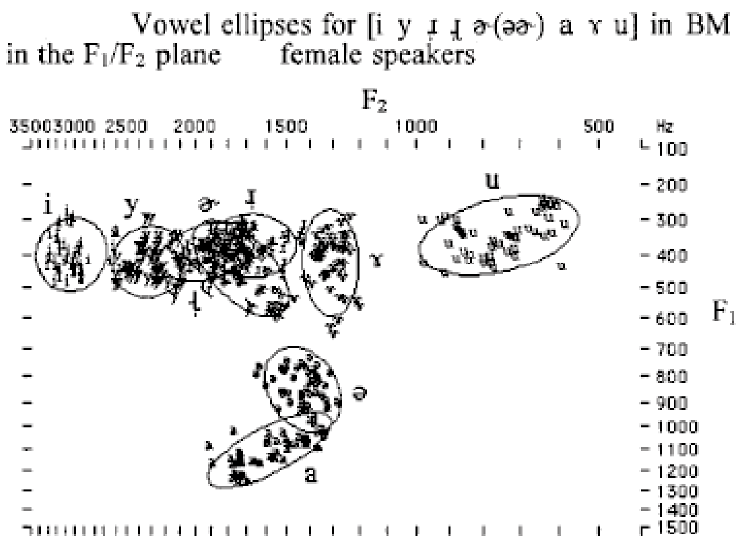
Altogether 17 university students in Taiwan, ranging in age from 19 to 22, were recruited for the current study, 8 females and 9 males. All were native speakers of TM and all but three were bilingual in both TM and TSM.

As far as the spectral analysis of the TM data is concerned, in the case of monophthongs, F1 and F2 were obtained by sampling the mid points of each vowel. In the analysis of /ɑiɤ/ vs /ʧiɑn/, and /ʧiɤ/ vs. /ɤ/ vs. /ɤu/, because we were only interested in comparing the phonetic qualities of the main vowel /ɤ/ with the phonetic qualities of the main vowel /ɑ/, we ignored both the onglide /i/ and offglide /u/ altogether[4]. For the /ɤ/ in /ʧiɤ/ and the /ɑ/ in /ʧiɑn/, sampling of /ɤ/ and /ɑ/ was carried out at the midpoint of each of their respective concentrations of acoustical intensity. In the case of /ɤu/, because the main vowel /ɤ/ occupies a point prior to the mid point of the spectrogram, as shown by a flat line, the mid point of that flat line was sampled.

3. Results

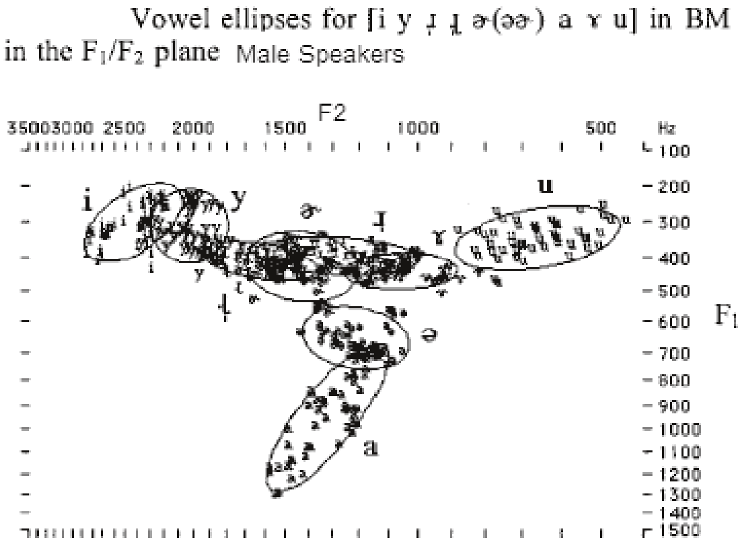
Data for the BM and TM cardinal vowels are shown in Figures 1-4 below:

Fig. 1:



Lee & Zee (2001:644)

Fig. 2:



Lee & Zee (2001:644)

Fig. 3: Vowel and diphthong ellipsis for in TM in the F1/F2 Plane. Female Speakers.

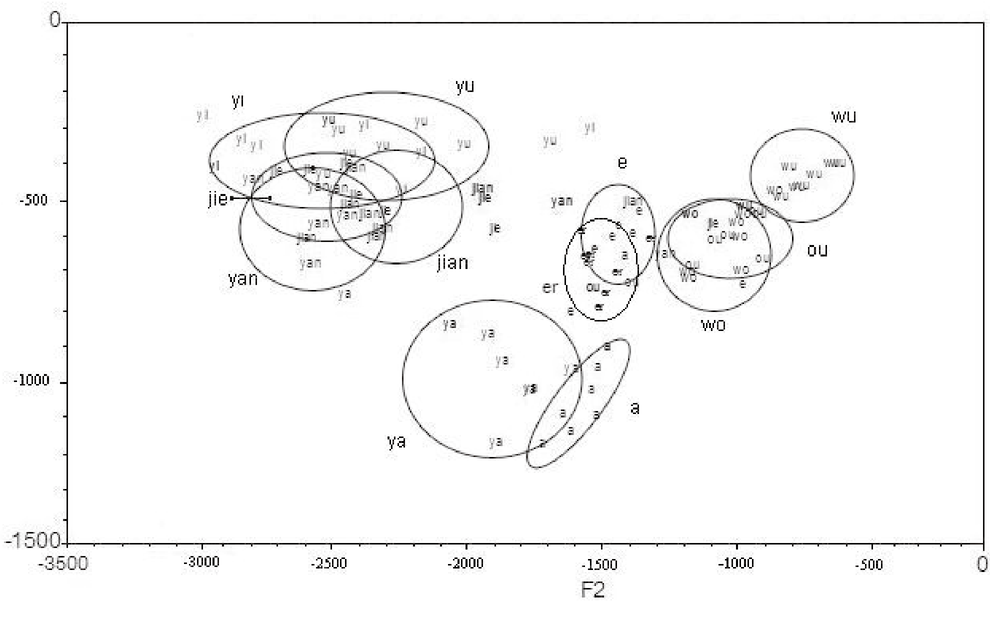
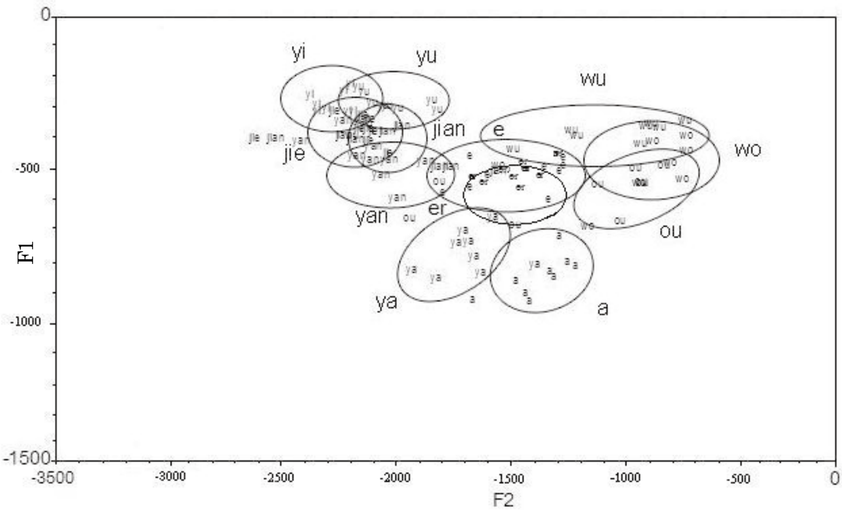


Fig. 4: Vowel and diphthong ellipsis for in TM in the F1/F2 Plane. Male Speakers.



Note: In the TM data, all IPA symbols have been displayed in Hanyu Pinyin, the key being:

yi = /i/	yu = /y/	wu = /u/	ou = /ɤu/
jie = /ʧiɤ/	jian = /ʧiɑn/	yan = /iɑn/	wo = /uɤ/
ya = /iɑ/	a= /ɑ/	e= /ɤ/	er = /ɚ/

Examining Figures 1-4, some very striking facts are revealed. Both in the case of male speakers and in the case of female speakers, the total acoustical space occupied by the Beijing vowel system is greater in surface area than that occupied by the Taiwan vowel system. BM vowels are dispersed over a wider area, with more space separating each from the others, while TM vowels are compressed into a much smaller space, thus shrinking, and in sometimes possibly eliminating, the acoustic boundaries between one vowel and another. Two examples of this trend in TM toward the merging of vowels include the case of /i/ and /y/ frequently overlapping/merging regardless of gender, as well as the case of significant overlapping among /u/, /ɤu/ and /uɤ/ within the speech of male speakers, but significantly not so for female speakers. These tendencies will be addressed in greater detail in the discussion and conclusion section below.

The average values for F1 and F2, and the standard deviation, are presented in Tables 1-4 below for BM male and female speech, versus TM male and female speech:

Table 1: Average F1 and F2 values (Hz) and their standard deviations (s.d.) of the vowels /i/, /y/, /ɤ/, /u/ and /ɑ/ in BM, male speakers.

Vowel	F1		F2	
	MEAN	SD	MEAN	SD
/i/	300.42	56.33	2443.08	206.60
/y/	310.10	52.83	2030.64	127.64
/ɤ/	441.40	27.15	1059.34	92.41
/u/	345.16	46.86	661.32	108.11
/ɑ/	956.98	157.23	1328.26	125.47

Table 2: Average F1 and F2 values (Hz) and their standard deviations (s.d.) of the vowels /i/, /y/, /ɤ/, /u/ and /ɑ/ in BM, female speakers.

Vowel	F1		F2	
	MEAN	SD	MEAN	SD
/i/	401.24	55.41	3036.76	185.03
/y/	423.84	54.54	2327.36	141.18
/ɤ/	426.52	83.18	1314.42	57.93
/u/	345.02	59.72	758.68	111.73
/ɑ/	1104.04	85.90	1593.64	153.91

Lee & Zee (2001:644)

Table 3: Average F1 and F2 values (Hz) and their standard deviations (s.d.) of the vowels /i/, /y/, /ɤ/, /u/, /ɑ/, /ɚ/, /iɑ/, /iɑn/, /uɤ/, /ɤu/, /ʧiɤ/ and /ʧiɑn/ in TM, Male

Vowel	F1		F2	
	MEAN	SD	MEAN	SD
/i/	284	35	2244	103
/y/	293	37	2015	130
/ɤ/	531	52	1437	220
/u/	389	32	1110	470
/ɑ/	875	69	1336	146
/ɚ/	543	35	1420	143
/iɑ/	795	70	1655	157
/iɑn/	474	72	2095	158
/uɤ/	509	91	955	345
/ɤu/	590	78	1175	431
/ʧiɤ/	380	45	2197	185
/ʧiɑn/	428	65	2007	299

Table 4: Average F1 and F2 values (Hz) and their standard deviations (s.d) of the vowels /i/, /y/, /ɤ/, /u/, /ɑ/, /ɚ/, /iɑ/, /iɑn/, /uɤ/, /ɤu/, /ʧiɤ/ and /ʧiɑn/ in TM, Female

Vowel	F1		F2	
	MEAN	SD	MEAN	SD
/i/	351	70	2484	512
/y/	341	51	2258	306
/ɤ/	647	97	1350	196
/u/	453	47	699	115
/ɑ/	1036	175	1521	103
/ɚ/	726	167	1486	108
/iɑ/	978	133	1895	263
/iɑn/	551	91	2279	555
/uɤ/	617	92	984	125
/ɤu/	651	83	1063	242
/ʧiɤ/	496	72	2157	543
/ʧiɑn/	539	71	2210	401

From the data above it appears that BM male speakers pronounce /i/, /y/ with a slightly higher F1 than do TM males, and pronounce /ɑ/ with a much higher F1 than do TM males, but pronounce /ɤ/

with a substantially lower F1 value than do TM males and pronounce /u/ with a slightly lower F1 value than their TM male counterparts.

As for the F2 value of these vowels, with the exception of those containing /a/, BM males show higher F2 values than do TM males, but with /y/ being only slightly higher and /ɑ/ being almost the same (but lower than in TM).

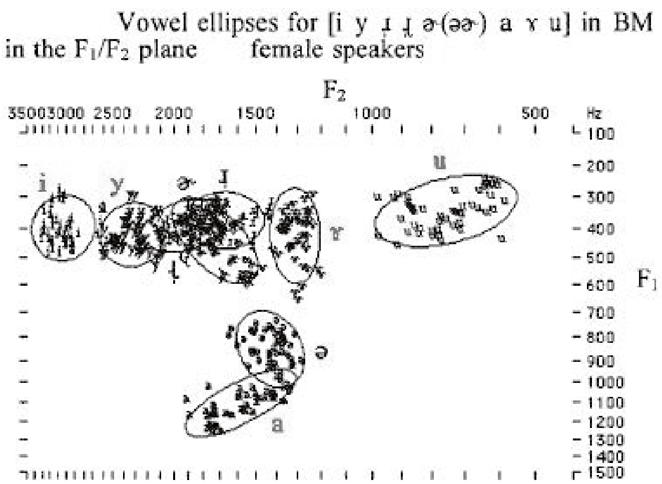
In the case of female pronunciation of cardinal vowels, once again it appears that F1 values for /i/, /y/ and [ɑ] are higher for BM speakers than for TM speakers, but much lower in the case of /ɤ/ and /u/. With the F2s, all are higher except /ɤ/.

Generalizing this, it appears the BM sample has higher F1 frequencies for /i/, /y/ and /ɑ/ and lower frequencies for /ɤ/ and /u/ than the TM sample. With F2 frequencies, however, the pattern is not so clear cut, /i/, /y/ and /u/ being higher in the BM sample, and with /ɑ/ and /ɤ/ being variable. This will be addressed in more detail below in the discussion and conclusion section.

The vowel ellipses of each of the cardinal vowels for both BM and TM are shown in Figures 5-8 below.

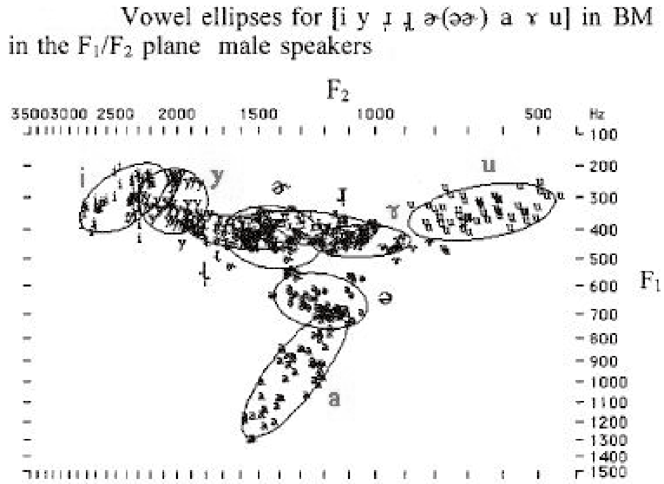
Note: In the BM charts, refer only to /i/, /y/, /ɤ/, /u/ and /ɑ/.

Fig. 5:



Lee & Zee (2001:644)

Fig. 6:



Lee & Zee (2001:644)

Fig. 7: Vowel ellipses for /i/, /y/, /ɤ/, /u/ and /ɑ/ in TM in the F1/F2 plane. Female Speakers.

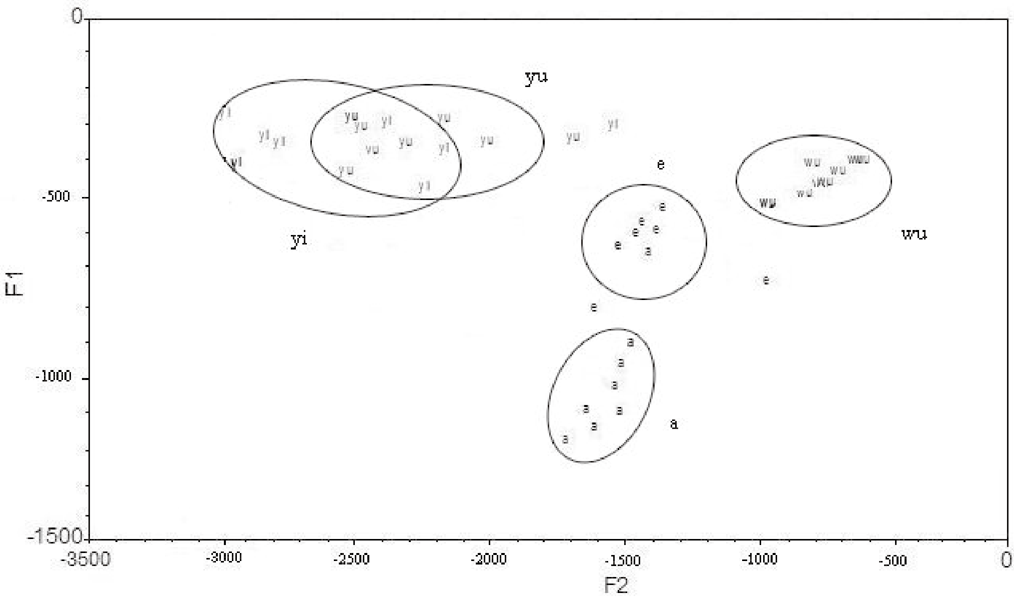
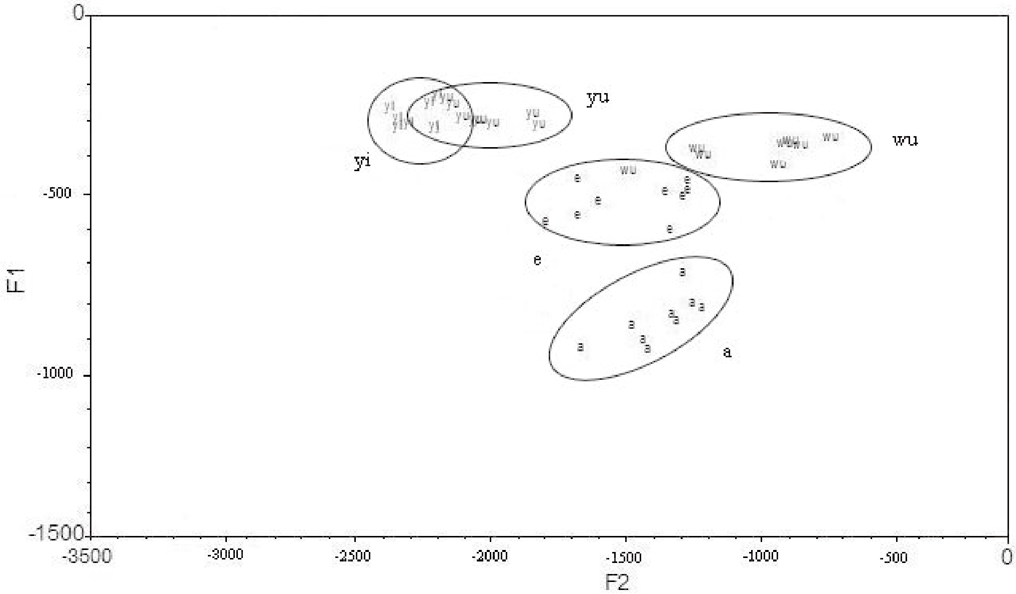


Fig. 8: Vowel ellipses for /i/, /y/, /ɤ/, /u/ and /ɑ/ in TM in the F1/F2 plane. Male Speakers.



Key: yi = /i/ yu = /y/ wu = /u/ a= /ɑ/ e= /ɤ/

Notable in the above figures is the overlap between /y/ and /i/, especially in the case of the TM data compared to the BM data, their closeness explained by the fact that /i/ and /y/ are both high front vowels that differ only on the point of rounding. However, it is also worth noting that TSM does not distinguish these two vowels, instead having only /i/. The implications of this will also be addressed and discussed in the conclusion section below.

Given the lower F1 value of /ɤ/ in TM in comparison to its value in BM, there exists the real possibility in TM that /ɤ/ might be partially encroaching upon /ɚ/, which in BM is located clearly above /ɤ/ on the vowel chart. The actual degree of merger between /ɤ/ and /ɚ/ in our data is shown in Figures 9 and 10.

Fig. 9: Vowel ellipses for /ɤ/ vs. /ɚ/ in TM in the F1/F2 plane. Female Speakers.

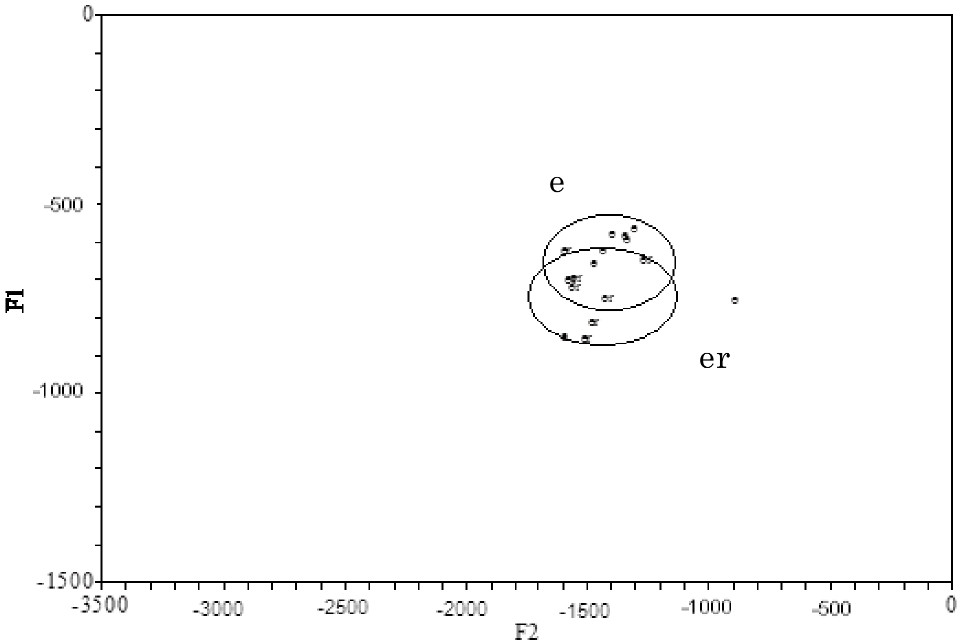
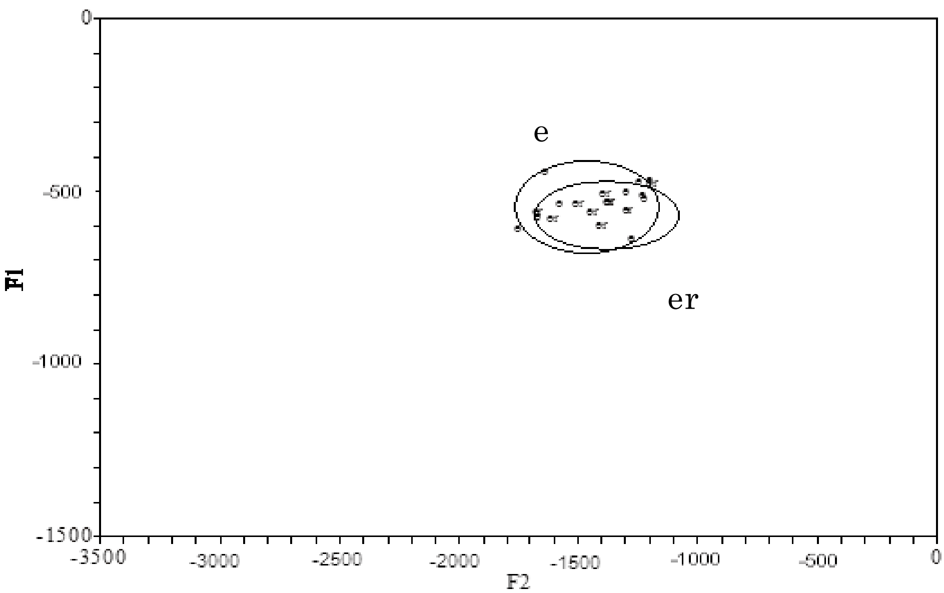


Fig. 10: Vowel ellipses for /ɤ/ vs. /ɚ/ in TM in the F1/F2 plane. Male Speakers.



Key: e = /ɤ/ er = /ɚ/

While these two vowels do not overlap in BM, in TM it is evident in both the male and female data that there is phonetic overlap. This is yet another example of the consequences of the smaller acoustic space occupied by the vowel system in TM, noted above, where vowels are much more squeezed together than they are in BM, thus resulting in a trend toward vowel overlap for certain vowels.

Using a T-statistical test, it was found that in the results for males, there is no significance suggesting overlap in the F1 data, and for the F2 data the significance of overlap falls just under the 90% confidence level. The female data however, shows that at F1, there is a very significant phonetic overlap for F1 (at 99% confidence), and significant at a 95% confidence level for F2 phonetic overlap. This demonstrates that TM does not make such a clear cut distinction between /ɤ/ and /ɚ/.

Another vowel that was acoustically investigated for allophonic variation in TM was /ɑ/, which was investigated both as monophthong /ɑ/ and as a main vowel in the syllable /iɑ/, as well as the main vowel in a similar syllable /iɑn/. The results of this analysis are shown in Figures 11 and 12 below.

Fig. 11: Vowel ellipses for /iɑ/ vs. /ɑ/ vs. /iɑn/ in TM in the F1/F2 plane. Female Speakers.

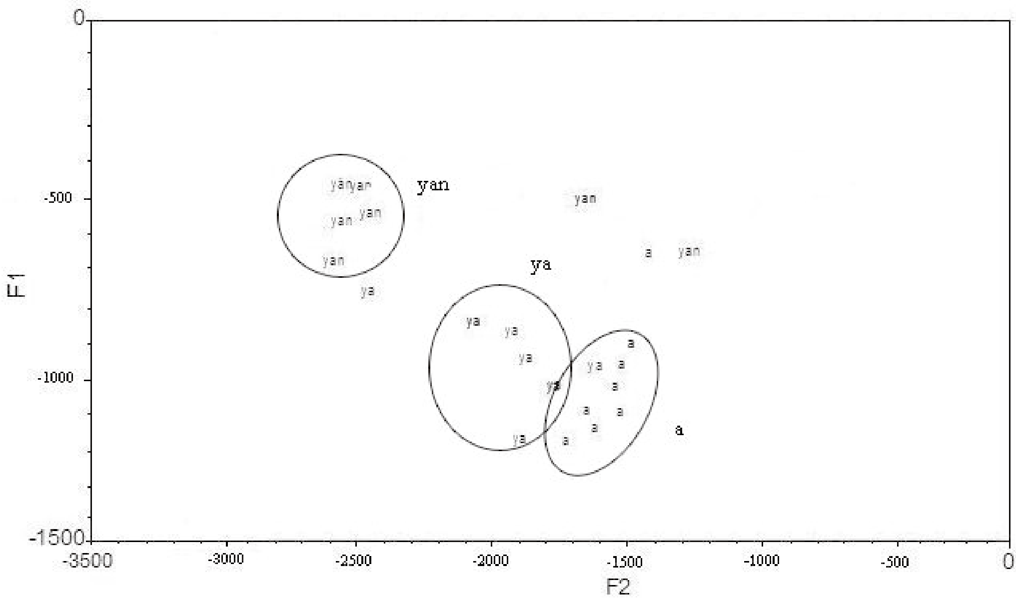
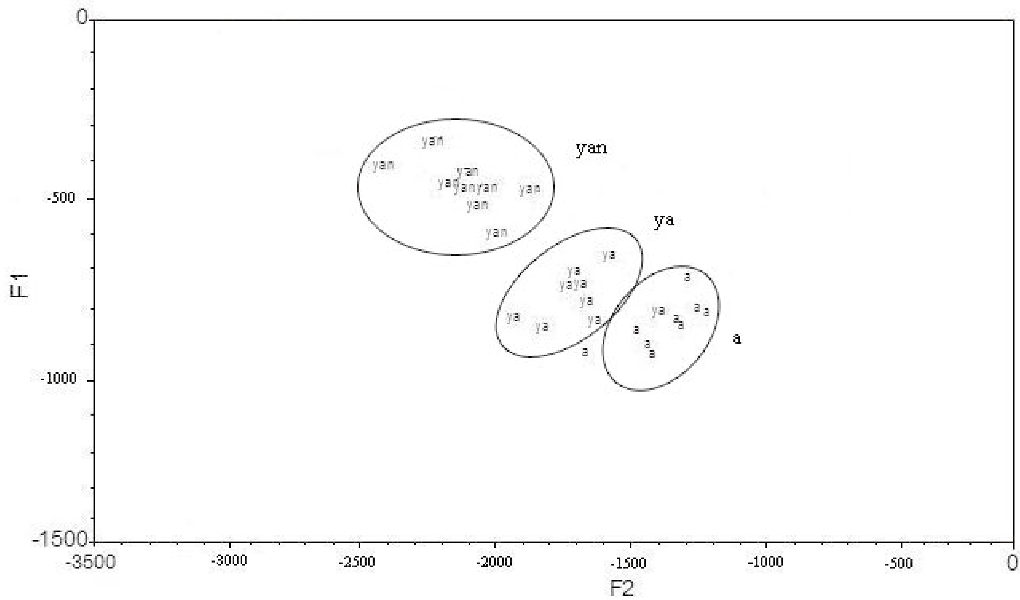


Fig. 12: Vowel ellipses for /iɑ/ vs. /ɑ/ vs. /iɑn/ in TM in the F1/F2 plane. Male Speakers.



Key: yan = /iɑn/ ya = /iɑ/ a= /ɑ/

As can be seen in the above figures, depending on the environment, /ɑ/ changes in frequency, increasing its F2 values while its F1 value decreases if /i/ (/iɑ/) serves as an onglide. This phenomenon is even more evident if /iɑ/ is further immediately followed by /n/, i.e. /iɑn/. This holds true for both male and females. As /ɑ/ slowly changes it position depending on its environment, it could be interpreted phonetically as different vowels, since its F1 and F2 values have altered significantly from its base. But because these different sounds exist in complementary distribution with one another, they are merely allophones of one another.

Another vowel that we chose to investigate for allophonic variation was /ɤ/, which we looked at as a monophthong /ɤ/, as a main vowel both in the diphthong /ɤu/ and in the syllable /ʧiɤ/. The results of this analysis are shown in Figures 13 and 14 below:

Fig. 13: Vowel ellipses for /ʧiɤ/ vs. /ɤ/ vs. /ɤu/ in TM in the F1/F2 plane. Female Speakers.

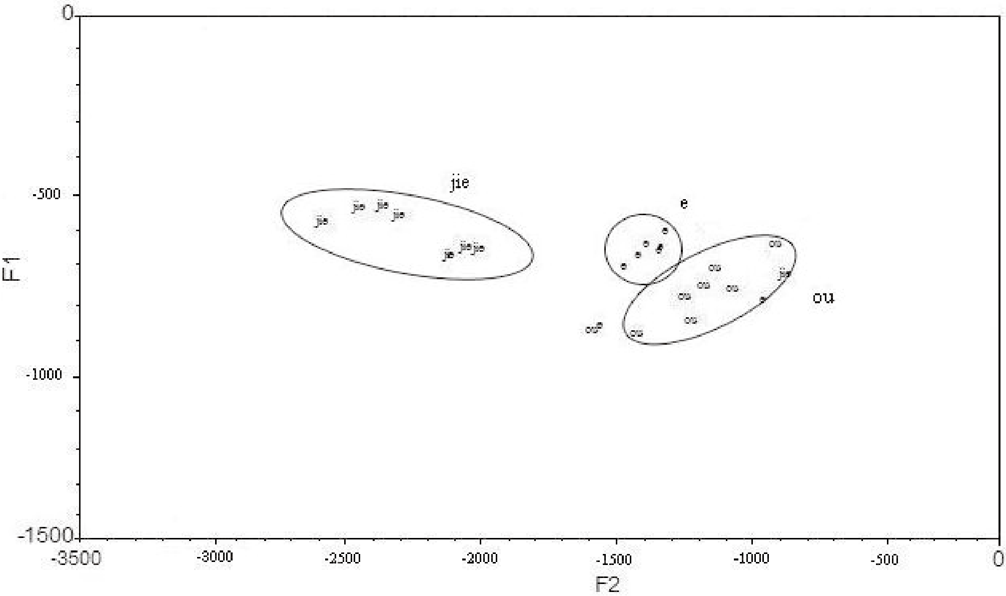
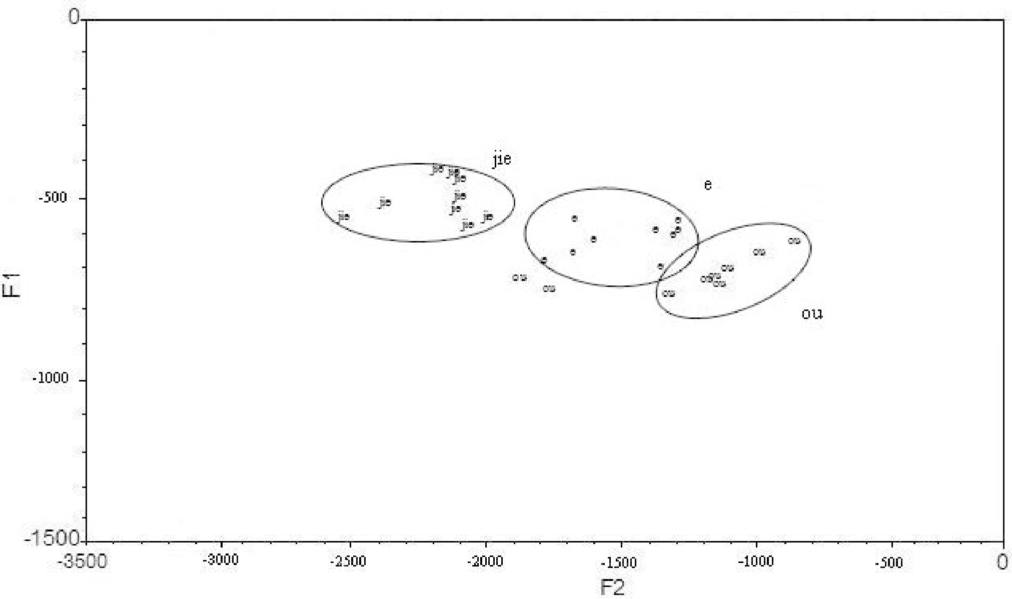


Fig. 14: Vowel ellipses for /ʧiɤ/ vs. /ɤ/ vs. /ɤu/ in TM in the F1/F2 plane. Male Speakers.

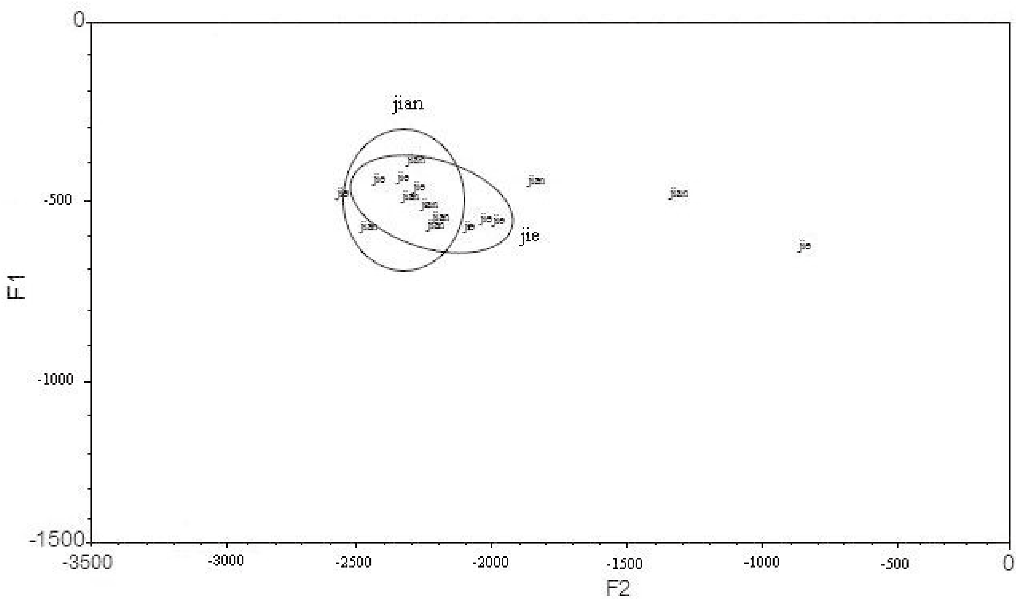


Key: ou = /ɤu/ jie = /ʧiɤ/ e = /ɤ/

For both male and female speakers /ɤ/ occupies a roughly middle position in the charts, its F2 frequency almost doubles when preceded by /i/ in /ʧiɤ/, while its F1 frequency stays around the same level. If /ɤ/ is followed by a /u/ in /ɤu/, its F1 frequency increases somewhat, with a decrease in F2 frequency. With /ɤ/ occupying such different positions on the charts, is it still the same vowel? With such different F1 and F2 frequencies, it could be transcribed phonetically as a different vowel when occurring in different environments.

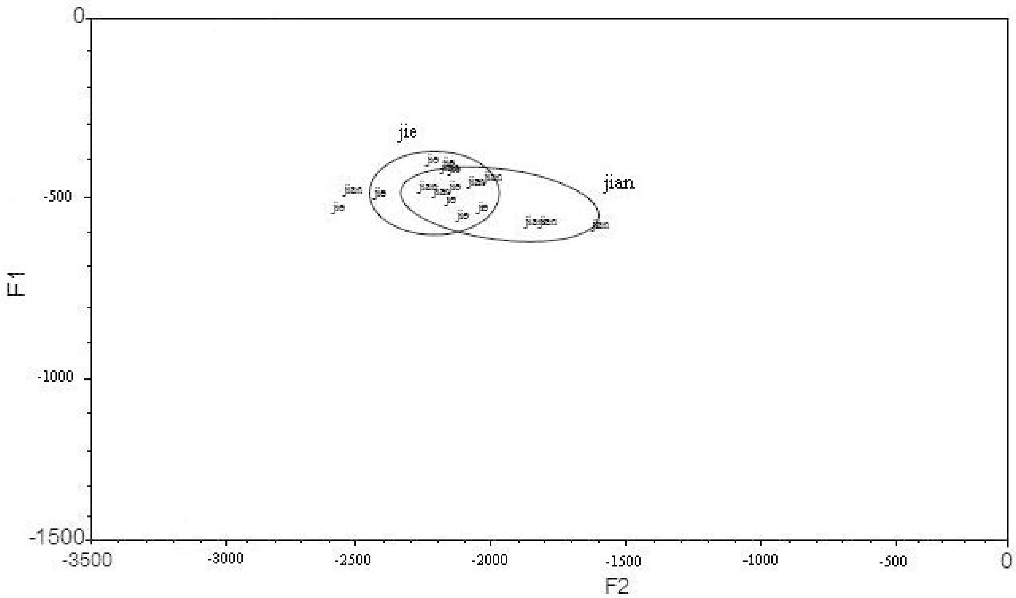
Finally, given the phonetic realization of /ɑ/ in the syllable /iɑn/ as shown in Figures 11 and 12 above, as well as the phonetic realization of /ɤ/ in the syllable /ʧiɤ/, we also chose to investigate the possibility of phonetic overlap in TM between /ɑ/ and /ɤ/ in such syllable pairs as /ʧiɤ/ and /ʧiɑn/. The results of this comparison are shown in Figures 15 and 16:

Fig. 15: Vowel ellipses for /ʧiɤ/ vs. /ʧiɑn/ in TM in the F1/F2 plane. Female Speakers.



While /ɤ/ and /ɑ/ do not overlap when pronounced in isolation, it is evident from Figures 13 and 14 that in their environments there is phonetic overlap. Here the pronunciation of /ɑ/ has been affected by the nasal /n/ by increasing its F2 and decreasing its F1 even more than what /i/ does to /ɑ/ when they are in a diphthong /iɑ/ (refer to Fig. 9, 10 for /iɑ/ position on the charts). At first observation, it appears that the two vowels /ɤ/ and /ɑ/ have almost the same F1 and F2 frequencies, but it cannot be deduced from the chart alone. Therefore a T statistics test was used to test their significance. It reveals that the F1 and F2 overlap of the two vowels are insignificant for female speakers. However for male speakers the F1 overlap is significant at 90% confidence level, and F2 is at the 95% confidence level. If 90% and 95% confidence level is accepted for overlap, the /ɑ/ in /ʧiɑn/ could be transcribed as another vowel. The implication of this virtual phonological merger/overlap for male speakers but not for female speakers will be addressed below.

Fig. 16: Vowel ellipses for /ʧiɤ/ vs /ʧiɑn/ in TM in the F1/F2 plane. Male Speakers.



Key: jie = /ʧiɤ/ jian = /ʧiɑn/

4. Discussion & Conclusions

An acoustical comparison of BM and TM cardinal vowels reveals that the pronunciations of the vowels differ with regard to their respective target values. BM has higher F1 frequencies for /i/, /y/ and /a/ and lower frequencies for /ɤ/ and /u/ than TM. With the F2 frequencies, /i/, /y/ and /u/ are higher in BM than in TM. These differences in F1 and F2 frequencies between TM and BM have thus created a situation in TM whereby the same number of vowels that are found in BM end up being squeezed into a total acoustic space in TM significantly smaller than what is found in BM. A consequence of this condensed vowel space in TM is that some vowels end up encroaching on other vowels, sometimes bordering on phonetic merger, and sometimes even possibly phonemic merger.

At times these vowel overlaps/mergers are gender-blind, as we observe in the case of TM /i/ and /y/, shown in Figures 7 & 8 above. This trend is arguably the result of influence from TSM, the major substratum contributor to the development of TM[6], which itself does not maintain a rounded/unrounded distinction for high, front vowels, maintaining just the unrounded /i/.

At other times TM vowel overlaps/mergers are more advanced/more extreme in male pronunciation than in female pronunciation. The clearest example of this gender correlated difference in pronunciation, as shown in Figures 3 and 4, is for /u/, /ɤu/ and /uɤ/ to be pushed one on top of the other in male speech in the form of a common unrounded monophthong [ʊ], but remain clearly separated out from one another in female speech. One wonders whether the 'derounding' of /u/ in male speakers is at all related to the lack of rounding in high, front vowels, though there is little evidence to suggest that these two cases of 'derounding' are related.

A second example of gender correlated difference in pronunciation in TM involves the overlap/-merger of /ɤ/ and /ɚ/, which is much more pronounced in male speech than it is in female speech. This can be seen in Figures 9 and 10, where we find that there is significant overlap among female speakers and virtual merger for male speakers.

We can see, then, that there appear to be real consequences in TM when the full vowel inventory of BM is squeezed into a total TM acoustic space that is much smaller than what is found in BM. As the acoustic space is reduced it appears that the total vocalic inventory in TM is likewise reduced. The first casualty of this trend is /y/, whose demise among speakers of both genders is further supported by its total absence in the phonemic inventory of TSM, the major substratum influence on the development of TM. Two other mergers that seem to have been triggered by trying to squeeze 'too many' vowels into too small a total acoustic space in TM are the merging of /ɤ/ and /ɚ/ and the merging of /ɤu/, /uɤ/ and /u/ into a single unrounded monophthong [ʊ]. These two mergers appear to be so advanced in male TM speech that we might be able to claim that they are essentially complete there, while they have not yet reached the same degree of completion in female TM speech. At any rate, the trend is sufficiently clear for TM: adequately reduce the total acoustic vowel space for a set of vowels and the total quantity of these vowels will likewise be reduced. And the leaders in this particular instance of vowel inventory reduction appear to be males. All of the above observations about vowel space, vowel merger and the role of gender in leading or lagging receives a degree of cross-linguistic support from Heffernan (2007), whose investigation of vowel mergers among the *Atlas of North American English* speakers concludes that "men do lead mergers, and that speakers with a less dispersed vowel system show more instances of mergers regardless of sex."

Notes

1 The authors would like to thank the anonymous reviewers for their very useful critical feedback which has improved the quality of the paper considerably. Any and all remaining shortcomings and errors, however, are the sole responsibility of the authors. This research is partially supported by the Grant-in-Aid for Scientific Research for the Japan Society for the Promotion of Science (No.17401012). All correspondences concerning this paper should be sent to: Robert Sanders, School of Asian Studies. University of Auckland, New Zealand, and/or Satoshi Uehara,

Graduate School of International Cultural Studies, Tohoku University, Japan.

2 That this study makes use of 17 subjects should in no way imply that this somehow represents a casual sampling of the speech community. First, the quantity of subjects interviewed by us vastly outnumber the standard 1-4 speakers that regularly underlie most descriptive studies in Chinese linguistics, including acoustic descriptive studies. For example, Zee (2002), reporting the effect of fast speech on the temporal organization of syllable production in Hong Kong Chinese, notes "The list was recorded by three native speakers of HKC who were all college students. However, in this presentation only data from one speaker is reported...." (p.724). Also, our speakers were required to make multiple pronunciations (roughly 10 per vowel) of the targeted vowels, unlike many studies that rely on single tokens to draw their conclusions.

3 Praat, developed at the University of Amsterdam's Institute of Institute of Phonetic Sciences, is one of the most commonly used acoustical analysis software programs in world and is freely downloadable from the Praat homepage: http://www.fon.hum.uva.nl/praat/

4 As evidence that /ɤ/ and /ɑ/ are indeed treated as the main vowels in their respective syllables, the rules of Hanyu Pinyin require that the tone mark be placed above those vowels only.

5 The reason for using Hanyu Pinyin, as opposed to IPA, is that the former is a common term of reference for the Mandarin sound system among Chinese linguists and it approximates the Mandarin phonemic inventory. We can only speculate that because Zee and Lee presented their paper at an international phonetics conference, the use of IPA by them was more appropriate for that context.

6 There are arguable reasons for us to point to TSM as the only significant substratum influence on the pronunciation of TM today and at the same time discount the any possible significant substratum influence from Hakka on the pronunciation of TM speakers belonging to the particular age group we investigated. First, there is the question of relative population size. According to Hsiao (2004) the ethnic population breakdown in Taiwan currently stands at approximately 70% Southern Min, 15% Hakka, 13% 'Mainlander' and 2% Aboriginal. Additionally, as Yeh et al. (2004) document in detail, ethnic identity in Taiwan does not always directly correspond to language use. They found that young Southern Min people (the age group of our own study) "were even less proficient in their native language than the middle-aged and old…The same pattern was also found among Hakka, with an even sharper drop in Hakka proficiency among young people." In other words, young people today are all fluent in Mandarin, while a very large number are much less fluent, if at all fluent, in their so-called 'native' language/dialect. Furthermore, preliminary results of an ongoing acoustical study at Nankai University of TM vowel pronunciation by university-aged monolinguals (6 in total so far), proficient TSM native speakers (4 in total so far) and proficient Hakka native speakers (4 in total so far) fail to reveal any significant differences in vowel pronunciation among these three groups (personal communication).

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