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Differences of tone realization between younger and older speakers of Nanjing dialect

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This article investigates differences of tone representation between younger and older speakers of Nanjing dialect, spoken in the city of Nanjing, China. Nineteen native speakers, divided into two groups according to their ages, were recruited and recorded reading monosyllabic and disyllabic words. After vowel segmentation and extraction of F0 points, statistical analysis was performed on the slope, maximum, minimum and mean values of tones to explore age differences. The result shows that for single tones, tone one and four have differences between these two groups. For disyllabic combinations, there are three combinations that have the most differences and nine other combinations that differ to some extent. The article also proves the loss of one tone sandhi process in the younger group, which may be due to the influence of standard Mandarin.

1. Introduction

Nanjing dialect is spoken in the city of Nanjing, located along the east coast of China. According to the Bureau of Statistics (2004), it has a population of 5.72 million. The Atlas of *Chinese Dialects* divides the dialects spoken in Jiangsu Province into three groups: Zhongyuan Mandarins, Jianghuai Dialects and Wu Dialects. Nanjing dialect belongs to the Hongchao subgroup within Jianghuai dialects. Liu (1995) defines the Nanjing dialect in a general and a specific sense. In the specific sense, Nanjing dialect refers to the dialect spoken in the Nanjing City, which consists of six districts (Qinhuai, Baixia, Jianye, Xuanwu, Gulou, Xiaguan) within the city and four districts in suburbs (Yuhuaitai, Qixia, Pukou, Dachang). The general definition of Nanjing dialect also includes the dialect spoken in Jiangning, Jiangpu and Luhe Counties.

Nanjing dialect has five basic tones and five tone sandhi rules, which are reported in Sun (2003). Using a scale for tone values of one (lowest) to five (highest), the basic tones

have the following values: T1(31), T2(13), T3(22), T4(44), T5(55). The tone value of T1 (31) is falling tone and T2 (13) is rising, while T3, T4, and T5 are level tones. The specific value of each tone varies according to different reports. For example T2 is recorded as 24 or 13, and T3 is recorded as 22, 212 and 11 in Liu (1995, 1997). Combining tones leads to tone sandhi rules, which according to Sun (2003) are as follows: T1→T4/_T1 (31→44/_31), T5→T4/_T5 (55→44/_55), T3→T2/_T1(22→13/_31), T3→T1/_T3(22→31/_22), T2→T3/_T5(13→22/_55). Both Song (2006) and Liu (1995) reported phonetic production differences among different ages. Liu (1995) provides a detailed description for different age groups, noting differences in both basic tone values and in tone sandhi rules. This present paper proves that there are differences in basic tone production within different age groups, in addition to the tone sandhi production mentioned in Song (2006).

Liu (1995) investigated the use of the dialect among residents in Nanjing and divided them into four groups based on their ages: the first group of age 0-25(now 15-40), the second group of age 22-55 (now 37-70), the third group of age 55-80 (now 70-95) and the fourth group of age 80 and above (now 95 and above, and rare). There are more differences between the first two and the last two groups. Liu proceeded to group the first two groups together as the new dialect group and the last two groups as the old dialect group. The differences he proposed are mainly about consonants and vowels. For example, the oldest (4th) group has diphthongs [ae], [□o], while the youngest (1st) group pronounces those two diphthongs as monophthongs [□], [□]. The third and fourth groups pronounce the consonants as [ts], [ts'], [s] before high vowels [i], [y], while the first and second groups pronounce them as [t□], [t□'],[□].

As for tone differences, Liu (1995) noticed a difference in the T1. The old dialect has the tone value 31 while the new dialect has the value 41. In addition, the sandhi rule for T1+T1 has the value of 33+31 for the old dialect and 44+41 for the new dialect. For the old dialect, Liu (1995) proposed slightly different tone values from Sun (2003). Liu also described the sandhi rules for the old (the third and fourth group) and new dialect (the first and second group) as in Table-1.The old dialect creates new tone values such as 33, 12 and 42 while the new dialect does not. The new dialect is also influenced by the standard dialect, namely, Mandarin.

In this paper, the goal is to investigate the tone differences between two age groups (24~29, 35~63), which are counted as speakers of the new dialect in Liu's research. With fifteen years of development of this dialect, there might be new differences between these two groups. It is also worth investigating the influence from standard Mandarin, to explain some phonetic differences such as the changes in sandhi rules.

Table-1 Liu's sandhi rules for older and newer Nanjing dialects

Old Dialect	New Dialect
T1(31)→33/_T1(31)	T1→T4/_T1 (41→44/_41)
T2(24)→T3(11)/_T5(5)	T2→T3/_T5(13→22/_55)
T3(11)→12/_T1(31)	T3→T2/_T1 (11→24/_41)
T3(11)→12/_T3(11)	T3→T2/_T3 (11→24/_11)
T4(44)→42/_T5(5)	T4→T1/_T5 (44→41/_55)
T5(5)→3/_T5(5)	T5(5)→T3/_T5(5)

The five monosyllabic tones in Nanjing dialect have a mapping relationship with four Mandarin tones, though some words have no correspondents in Mandarin Chinese. This mapping relationship, summarized in Table 2, is calculated using the dictionary by Liu (1995). The total number of tones represents monosyllabic vocabulary words which have a certain tone value. For example, for Nanjing T1, there are 401 monosyllabic words, within which 334 words have a mapping word of T1 in Mandarin. Tone values in brackets are cited from Sun (2003).

Table-2 Mapping relationship between Nanjing and Mandarin tones

Nanjing Tones	Mandarin Tones (number of mapping tones /total tones)
31 (T1)	55 334/401
13 (T2)	35 314/338
22 (T3)	214 260/290
44 (T4)	51 473/495
55 (T5)	55 96/289 35 81/289 214 24/289 51 93/289

This goal of the current paper is to explore differences in tone realization between two age groups. Specifically, single tones in isolation and disyllabic tone combinations will be examined, and the differences will be analyzed both phonetically and phonologically to reveal the development of tone realization within different age groups.

2. Methodology

Nineteen native speakers of Nanjing dialect were recruited and recorded reading monosyllables and disyllables (25 combinations of tones) in a sentence frame. The pitch was measured at twenty sample points from each segmented vowel. The participants are

divided into two groups according to their ages: the younger group (24~29) and the older group (35~63). The younger group consists of eight people and the older group consists of eleven people; all have lived in Nanjing for most of their lives.

Eleven samples of each monosyllabic tone and five samples of each disyllabic tone combination were segmented, and twenty F0 value points of each sample were extracted automatically by a Praat script[1]. In total, there are 5795 stimuli in this project, including 1045 monosyllabic tones (11 samples*5 tones*19 participants) and 4750 disyllabic tones (5 samples*2*25combinations*19 participants). The next step was to normalize the extracted data.

As for normalization, there are some common formulas adopted by researchers. In the article by Deng et al. (2008), they use the following formula to transfer F0 values to a tone value on the 1-5 scale: T=[(lgx-lgmin)/(lgmax-lgmin)]*5, in which x means F0 in the point that you want to transfer into the 5 scale tone value, Min means the minimum F0 value across the tone and Max means the maximum F0 value across the tone. Rose (1987) compared two normalization methods: Z-Score and Fraction of Range, and argued that the Z-Score method is more appropriate. He also proposed a Z-score normalization method using the long term F0 mean and standard deviation (Rose, 1991). All the data in this paper were normalized by Rose's Z score (Rose 1987), after deleting the first and last point of each sample. The mean value is calculated from all samples of a certain tone by each speaker. To lessen the influence of the initial consonants, 20% of the tone from the initial point is deleted, following Sarmah and Wiltshire (2010). The mean of the normalized sample points are calculated to represent each tone within the two groups. Regression analysis was applied to the data to evaluate the slope of the tone. The maximum point and mean of each tone by each speaker are also calculated in order to evaluate the frequency range. Statistic analysis compares the slope, mean values and maximum point values within the two age groups: younger (24~29) vs older (35~63).

3. Results of Monosyllabic Tones

For single tones, the mean value of slope, maximum and mean values are summarized in the Table-3. From the table, it appears that for the younger group, the height of the maximum point has the order T5, T1, T2, T4, T3 while the older group has the order T5, T2, T1, T4, T3. For the younger group, a t-test shows that T1 and T2 do not significantly differ while the maximum points of all other tones differ statistically ($p<.05$). For the older group, the maximum point of T1, T2 and T4 are not significantly different.

[1] This script was created by Byunggon Yang(http://fonetiks.info/bgyang). Jirapat Jangjamras added meanf0 and mean db on 9/11/09 and reorganize the printed line to be one line instead of two on 10/15/09.Jirapat edited some parts of the script 5/6/10 for Si Chen's analysis.

Table-3 Summary of single tone values for the two groups (younger/older)

Tone	Slope (younger/older)	Maximum (younger/older)	Mean (younger/older)	Min(younger/older)
1	-0.1093/-0.1006	0.9307/0.5458	0.1456/-0.1636	-0.6506/-0.9307
2	0.1162/0.1096	0.6347/0.6101	-0.3075/-0.1987	-0.9727/-0.9170
3	-0.0173/-0.0200	-0.9814/-1.1858	-1.3128/-1.3949	-1.5505/-1.5747
4	-0.0306/-0.0267	0.0727/0.3664	-0.1800/0.1969	-0.3997/-0.0676
5	0.0143/-0.0002	1.6242/1.6239	1.4810/1.4782	1.3258/1.2711

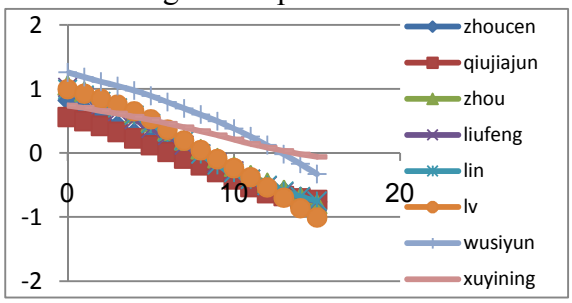
For the younger group, the height of the minimum point has the order T5, T4, T1, T2, T3, while the older group has T5, T4, T2, T1, T3. For the younger group, T4 and T1 have no significant difference and the minimum points of all other tones are statistically different. For the older group, T1, T2, T3 have the same minimum points. As for slope, both groups have the same slope for T3, T4, T5, which were reported to be level tones in previous research. Table 4 summarizes the points of similarity for each tone.

Table-4 Similarities between Younger/Older tone systems

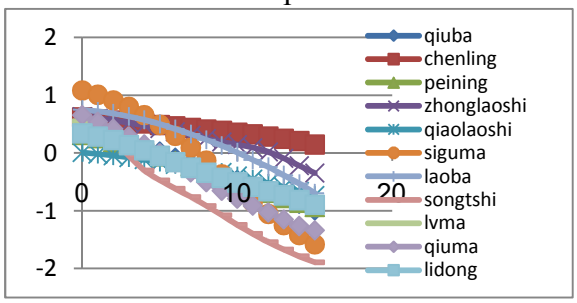
Category	Tones of the Younger Group	Tones of the Older Group
slope	T3,T4,T5	T3,T4,T5
max	T1,T2	T1,T2,T4
min	T1,T4	T1,T2,T3

The following graphs show monosyllabic tones pronounced by these two groups. The X-axis represents the sampled 15 points over time. The Y-axis represents normalized values of each sampled point. Each color represents a single speaker, whose names are written on the column to the right.

Tone 1 Younger Group

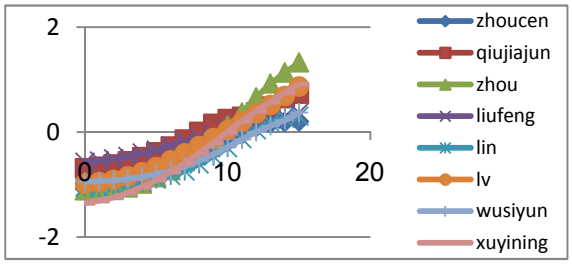


Tone 1 Older Group

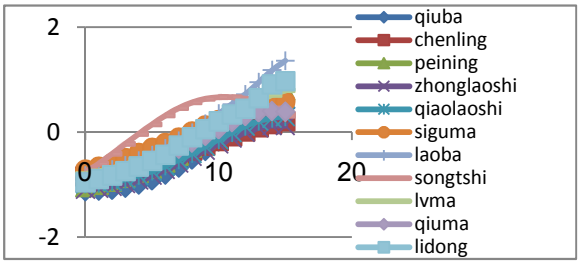


For tone one, both younger and older groups have a falling tone with similar shape. The t-test does not show a statistically significant result for the difference in the slope, although descriptively the slope of older group has a deeper slope with a difference of 0.0084 unit. The minimum point of the older group is 0.28 lower than the younger group, but it is also not statistically significant. However, there are two statistically significant differences: the younger group has a 0.309 unit higher mean than the older group, and the maximum point of the tone is higher for the younger group by 0.385 unit. These normalized differences mean that in the same scale, the younger group pronounces tone one in a higher frequency range.

Tone 2 Younger Group

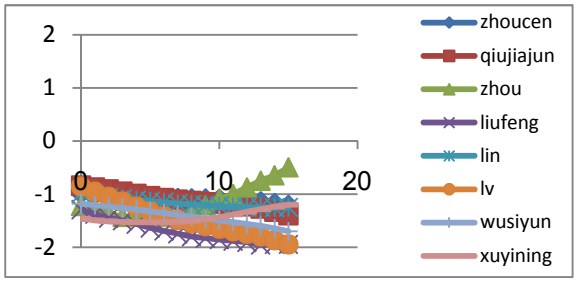


Tone 2 Older Group

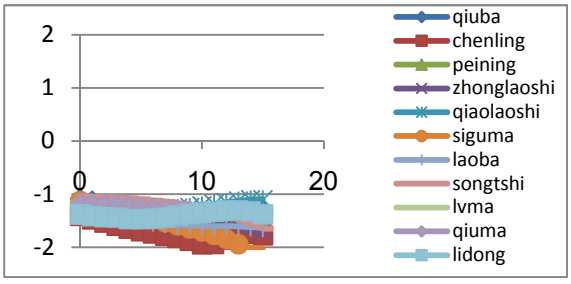


For tone two, both younger and older groups have a rising tone. The two groups do not have any statistically significant differences. Descriptively, the younger group averages a deeper slope, 0.0065 unit greater than the older group. The younger group also has a 0.024 unit lower mean, a 0.11 unit higher maximum point than older group, and a 0.05 unit higher minimum point for the younger group.

Tone 3 Younger Group



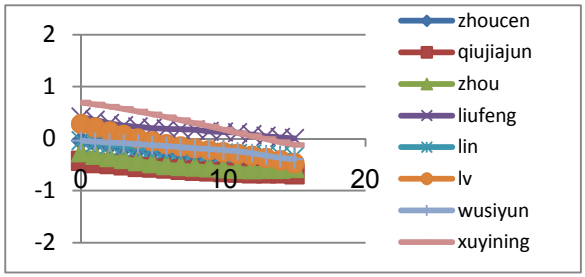
Tone 3 Older Group



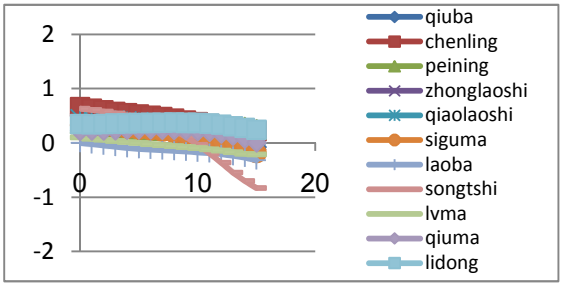
For tone three, both groups have some variation with regards to the shape of tone contours. Two out of eight speakers in the younger group, and five out of eleven speakers

in the older group, have a falling-rising tone. The remainder in both groups have a falling tone. The differences in slope, maximum and minimum points, as well as the mean, are not statistically significant. To measure the slope, we split the tone into two and measured the slope of first eight and last eight points. In the first half, the older group has a 0.0071 unit higher slope than the younger group. In the second half, younger group has a 0.01 unit higher slope. The older group has a 0.21 unit lower maximum point, 0.02 unit lower minimum point and 0.08 unit lower mean.

Tone 4 Younger Group

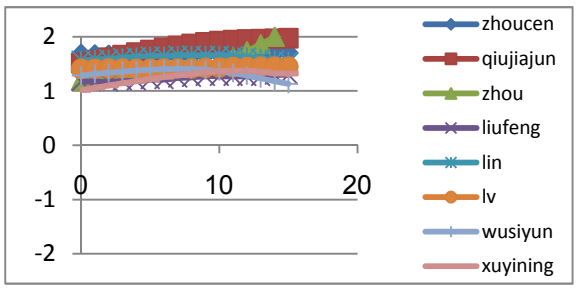


Tone 4 Older Group

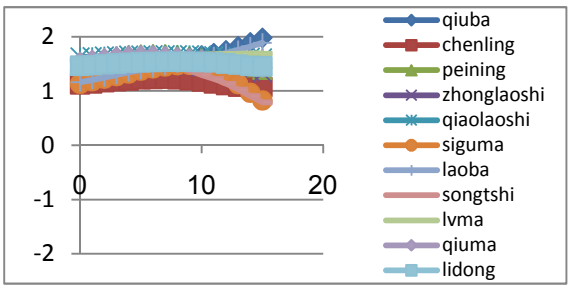


For tone four, both younger and older groups have a slightly falling tone with similar shape. There is no statistically significant result for the difference in slope, although descriptively, the slope of older group has a deeper slope with a difference of 0.0034 unit. Similarly, although the maximum point of the older group is higher than the younger group by 0.25 unit, the difference is not significant. There are two statistically significant differences, however; the younger group has a 0.38 unit lower mean than the older group, and the younger group has a .332 unit lower minimum point than the older group. These normalized differences mean that in the same scale, the younger group pronounces tone four in a lower frequency range.

Tone 5 Younger Group



Tone 5 Older Group



Similarly to tone three, tone five also varies within both groups. For the first half, all speakers have a slightly rising direction, while for the second half, three out of eight younger speakers and eight out of eleven older speakers have a falling direction; the rest of those speakers have a rising direction. This means that more speakers in the older group tend to fall in T5 than in the younger group. The comparison of the slope shows a statistically significant result, when the three speakers producing rising tone are excluded from the older group. The differences in maximum, minimum and mean value between the two groups are not statistically significant, although the maximum point of the older group is 0.0003 unit lower, the mean of the older group is 0.003 unit lower, and the minimum point of the older group is 0.06 unit lower than the younger group. The following table summarizes the differences between the two groups.

Table-5 Differences between Older/Younger speakers tones on phonetic measures (T-test significance marked by *)

Tones	Slope difference (Older vs Younger)	Max difference (Older vs Younger)	Mean difference (Older vs Younger)	Min difference (Older vs Younger)
1	deeper 0.0084	0.385 lower *	0.309 lower *	0.28 lower
2	shallower 0.0065	0.11 lower	0.024 higher	0.05 higher
3	0.0071 unit higher (first 8 points) 0.01 unit lower(last 8 points)	0.21 lower	0.08 lower	0.02 lower
4	0.0034 deeper	0.284 lower	0.38 unit higher*	0.332 higher*
5	negative/positive	0.0003 unit lower	0.003 unit lower	0.06 lower

Judging from the statistically significant differences, T1 and T4 display the most obvious differences between these two groups. For the older group, T1 has a lower maximum and mean value, while T4 has a higher mean and minimum value. The higher value of T1 for the younger group is in accordance with Liu's (1995) report.

4. Results of disyllabic Tones

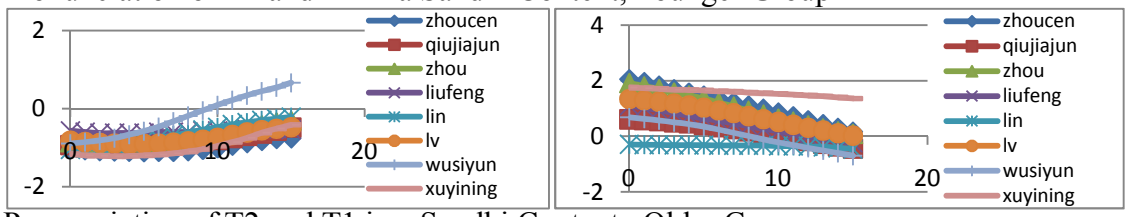
In order to test if there are any differences in disyllabic tones between these two groups, we measured the slope, the maximum and mean of tones in disyllables, and evaluated the differences with t-tests.

In 25 combinations of five basic monosyllabic tones, there are some tones showing statistically significant difference in slope, maximum and mean between the two groups. Three combinations have differences in maximum, slope and mean points. Since three combinations have so many differences, we conducted t-tests to examine the value with single tones produced by younger and older groups as well. Among the three

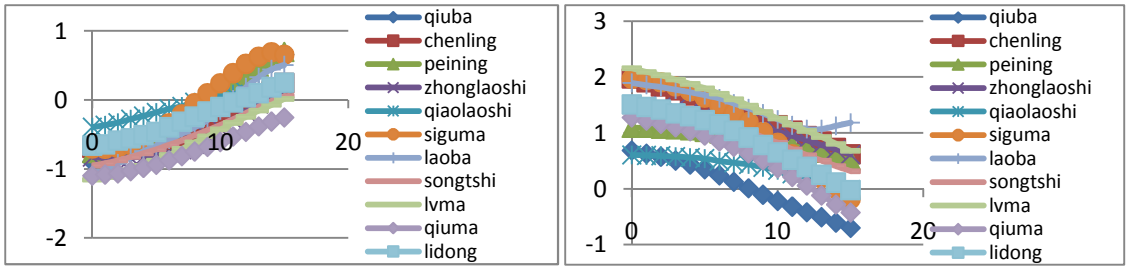
combinations, T3+T1 is mentioned in Liu's (1995) research. Liu did not find a difference between the new and old dialect with regards to this sandhi rule. There are differences now between the two groups in the current study, which both belonged to the "new" dialect according to Liu's research.

In the combination of T2+T1, the slope, maximum and mean values of T2 are all significantly different. The older group pronounces T2 with a deeper slope (0.04 unit), a higher maximum point (0.6 unit) and a higher mean value (0.35 unit). The older group has the same slope for T2 as the single tone while the younger group has a different slope with the single T2, but the same slope as the single T5. The mean value is also the same as the single T2 for the older group, but the younger group has a different mean from any single tone. The mean value for younger group is 0.41 unit lower than the single T2.

Pronunciation of T2 and T1 in a Sandhi Context, Younger Group

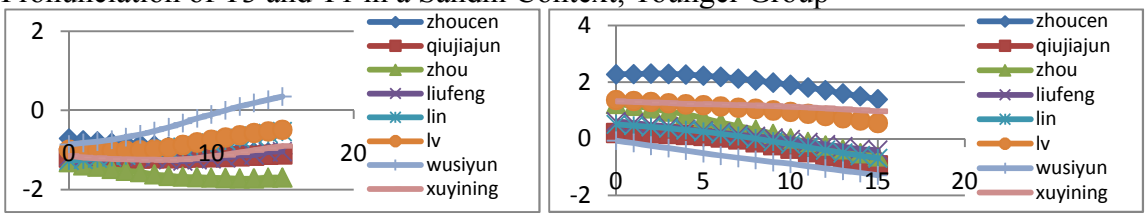


Pronunciation of T2 and T1 in a Sandhi Context , Older Group

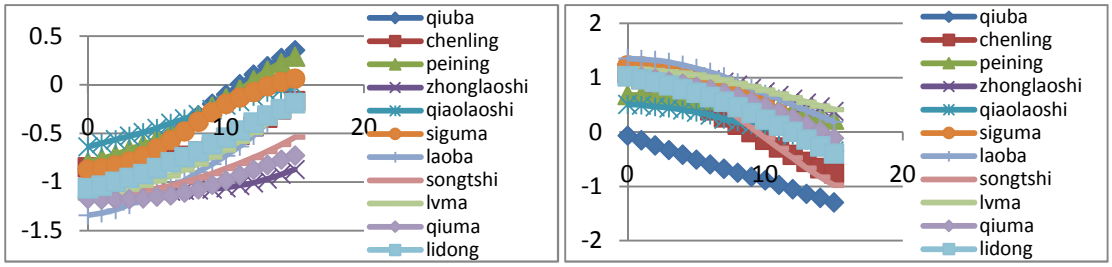


In the combination of T3+T1, the slope, maximum and mean value of T3 are all significantly different. The older group has a deeper rising slope (0.04 unit) and a higher maximum and mean value (max: 0.52 unit, mean: 0.34 unit).

Pronunciation of T3 and T1 in a Sandhi Context, Younger Group



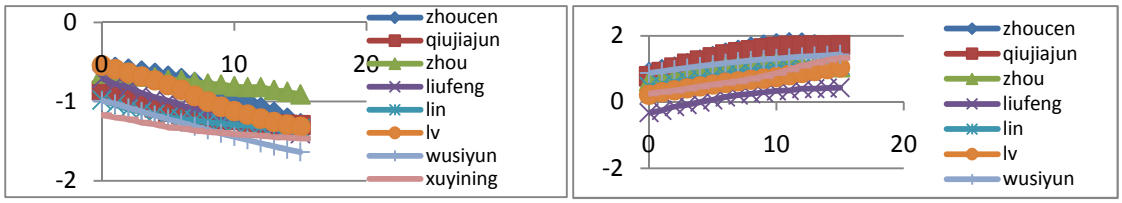
Pronunciation of T3 and T1 in a Sandhi Context, Older Group



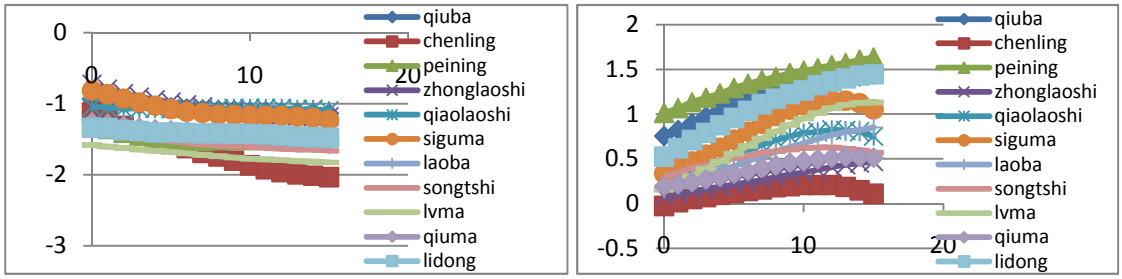
In this T3+T1combination, the younger group pronounces T3 with the same slope as the single T3, but the older group shows a difference from any single tone. The maximum and mean point of T3 pronounced by the younger speakers is statistically the same as that of the single T3. The maximum and mean point of the older group is different from any single tone (max:-0.2, mean:-0.66). Perceptually, the older group pronounces T3 in this combination similarly to T2. Since in Mandarin, there is no sandhi rule for the combination T3+T1, it is possible that the youngest group is influenced by the Mandarin dialect and has lost the sandhi rule.

In the combination of T3+T5, the slope, maximum and mean values of T3 are all significantly different. The slope of these two groups has a negative value and the older group's slope is 0.02 unit deeper than the younger group's. The younger group is 0.36 unit higher in the maximum point and 0.28 unit higher in the mean value. The slope, maximum point and the mean value of T3 are the same as the single T3 for both younger and older groups. The slopes for both groups are negative with a 0.01 unit difference.

Pronunciation of T3 and T5 in a Sandhi Context, Younger Group

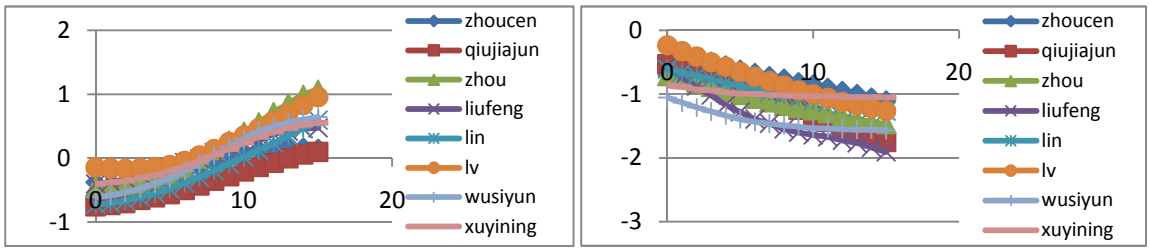


Pronunciation of T3 and T5 in a Sandhi Context, Older Group

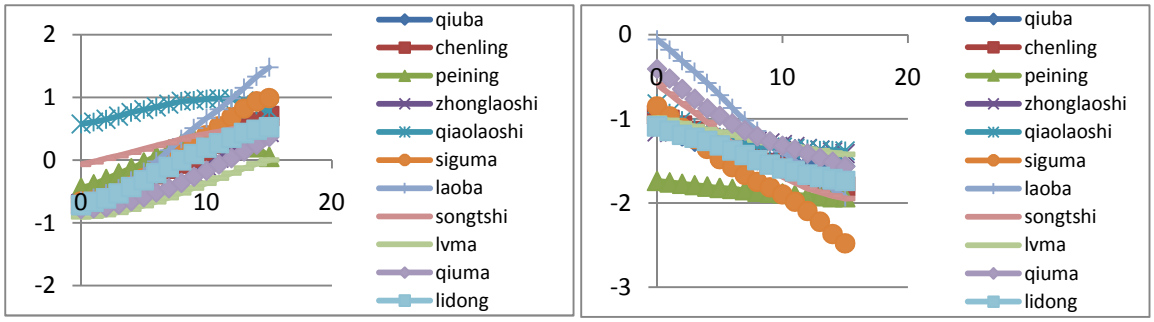


Within the four sandhi rules in Nanjing new dialect, there are two combinations which show some significant differences between the two groups in the study, namely T3+T3 and T4+T5. In T3+T3, the older group has a 0.31 lower mean value and a 0.32 lower minimum point for the second T3.

Pronunciation of T3 and T3 in a Sandhi Context, Younger Group

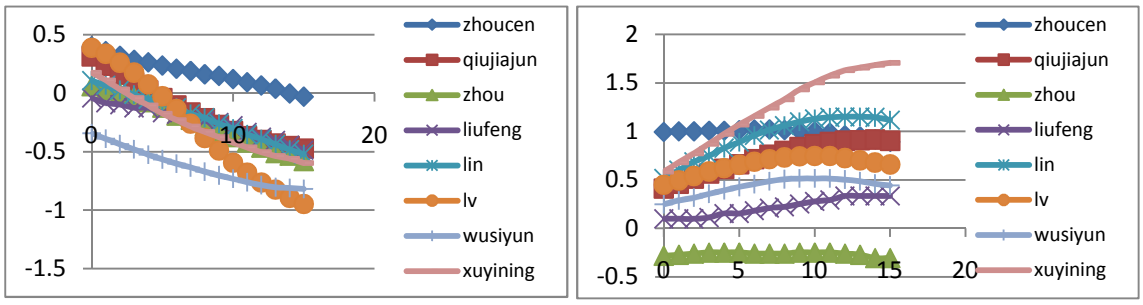


Pronunciation of T3 and T3 in a Sandhi Context, Older Group

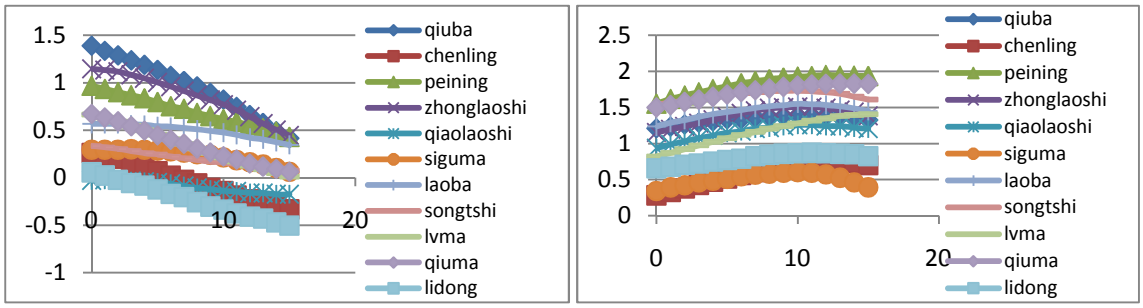


In T4+T5, both tones have significant difference in maximum and mean value. For T4, the older group has a 0.45 unit higher max point and 0.57 unit higher mean value. For T5, the older group has a 0.58 unit higher max point and 0.61 unit higher mean value.

Pronunciation of T4 and T5 in a Sandhi Context, Younger Group

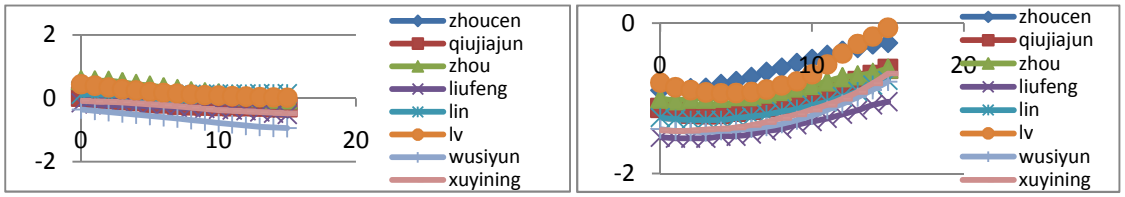


Pronunciation of T4 and T5 in a Sandhi Context, Older Group

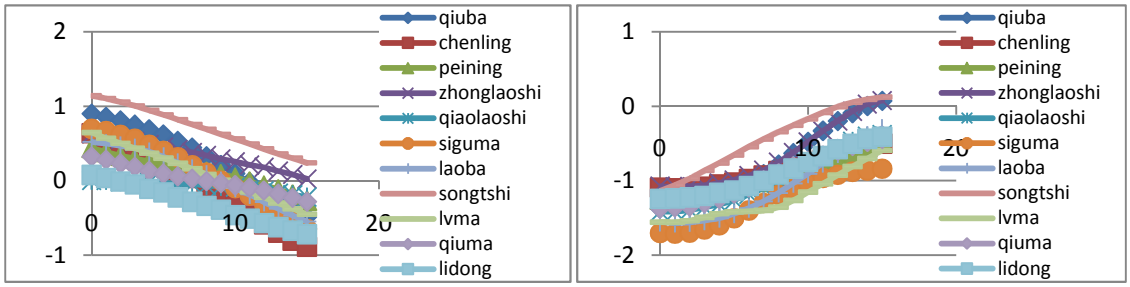


According to statistically significant results in different points, the combinations can be further divided into several categories: differences in slope and maximum, slope only, maximum and mean, minimum and mean, and also maximum and minimum. The differences of slope and maximum hold for the combination of T4+T2. Both groups have a negative slope for T4, and the older group is 0.03 unit deeper. Also, the older group has a significant higher maximum point (0.4 unit), though the older group's higher mean (0.22unit) is not significantly different.

Pronunciation of T4 and T2 in a Sandhi Context, Younger Group



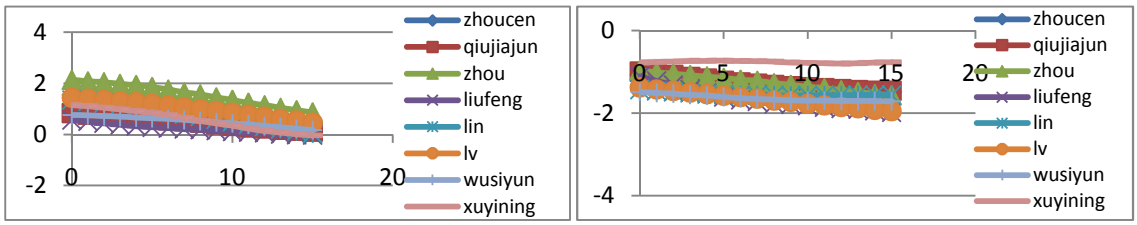
Pronunciation of T4 and T2 in a Sandhi Context, Older Group



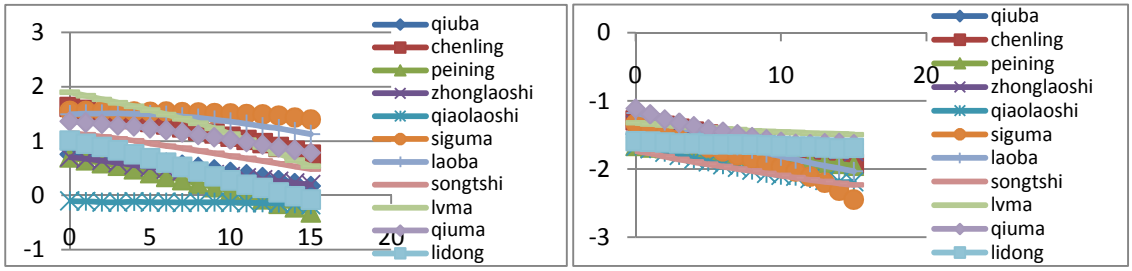
Many combinations have differences only in maximums and means: T1+T3, T2+T3, T3+T4, T4+T4, T4+T5, T5+T3. First, in T1+T3, the maximum and mean value of T3 is higher for the older group (max: 0.28 unit, mean: 0.3 unit). While the slope difference is

not statistically different, the older group pronounces T3 in this combination at a higher frequency.

Pronunciation of T1 and T3 in a Sandhi Context, Younger Group

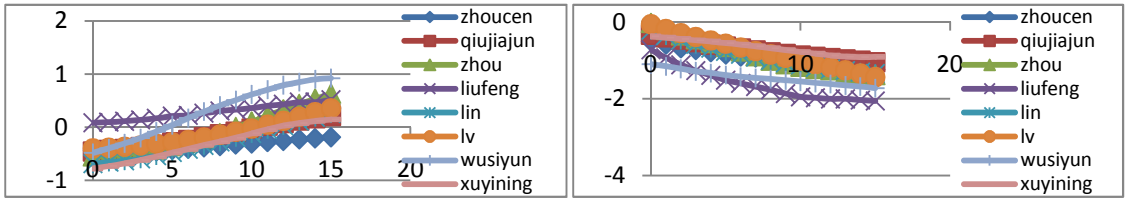


Pronunciation of T1 and T3 in a Sandhi Context, Older Group

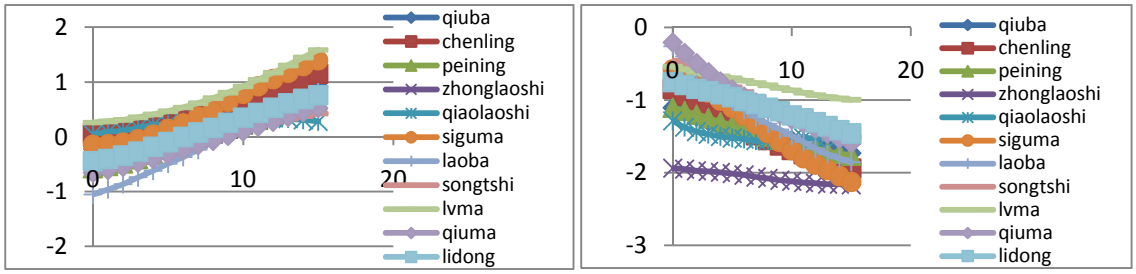


In T2+T3, the maximum and mean of T2 are significantly different between these groups, with the older group higher for both (0.48 unit higher max, 0.29 unit higher mean).

Pronunciation of T2 and T3 in a Sandhi Context, Younger Group

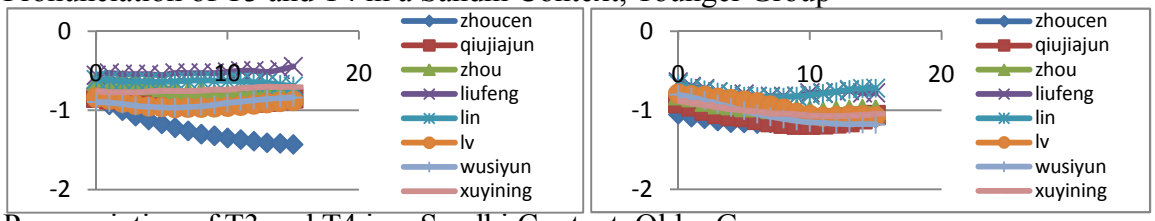


Pronunciation of T2 and T3 in a Sandhi Context, Older Group

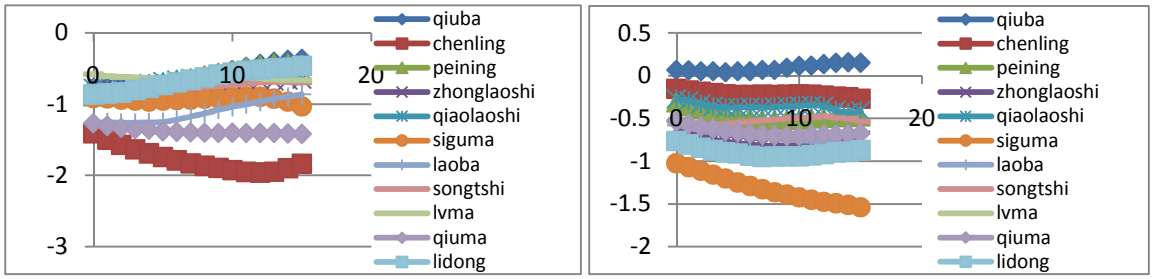


In the combination T3+T4, T4 differed between the two groups on maximum and mean value, with the older group higher for both (0.34 unit higher max, 0.36 unit higher mean).

Pronunciation of T3 and T4 in a Sandhi Context, Younger Group

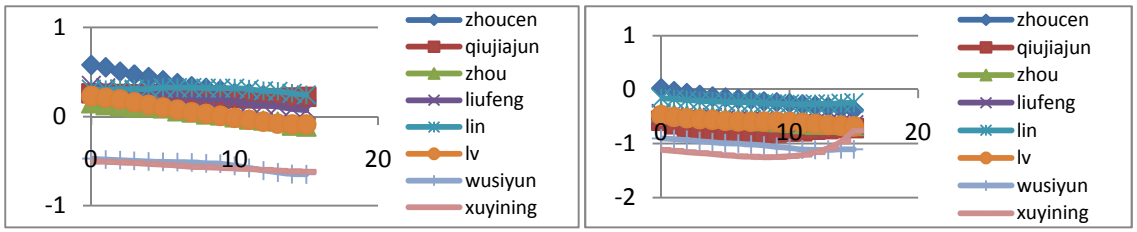


Pronunciation of T3 and T4 in a Sandhi Context, Older Group

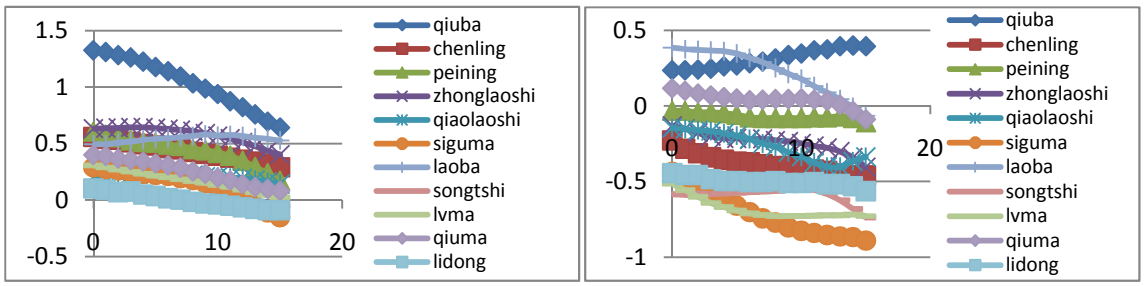


In the combination of T4+T4, the second T4 is statistically different in maximum and mean values, with the older group having higher values for both than the younger group (max: 0.33 unit, mean: 0.37 unit).

Pronunciation of T4 and T4 in a Sandhi Context, Younger Group

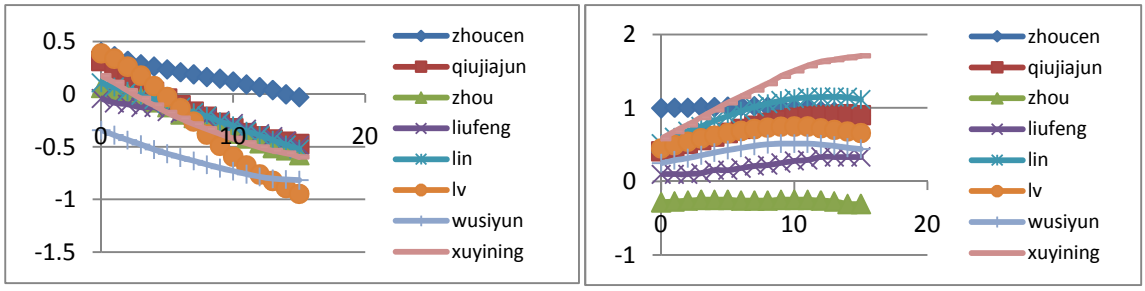


Pronunciation of T4 and T4 in a Sandhi Context, Older Group

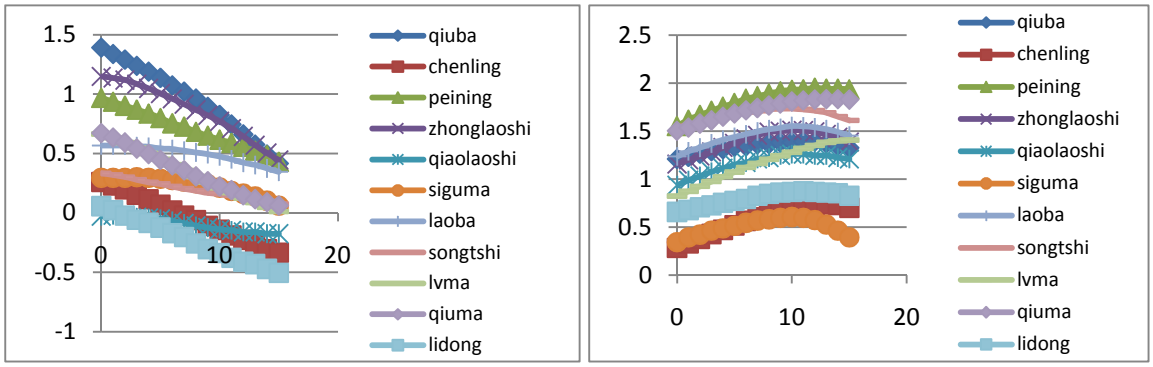


In T4+T5, both T4 and T5 are different within the two groups. The older group has a higher frequency range in general.

Pronunciation of T4 and T5 in a Sandhi Context, Younger Group

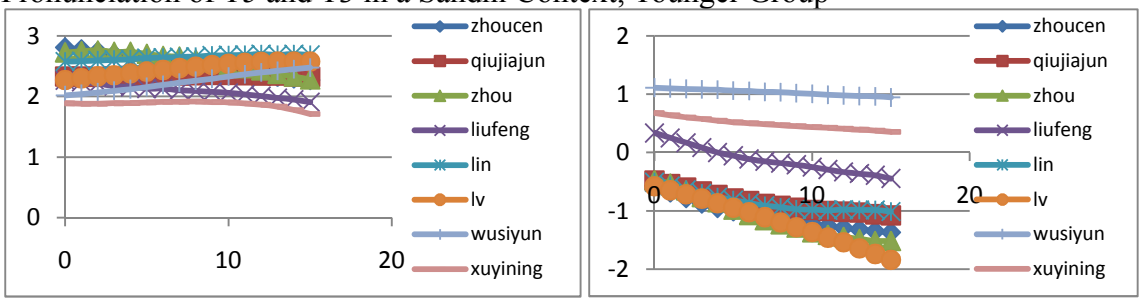


Pronunciation of T4 and T5 in a Sandhi Context, Older Group

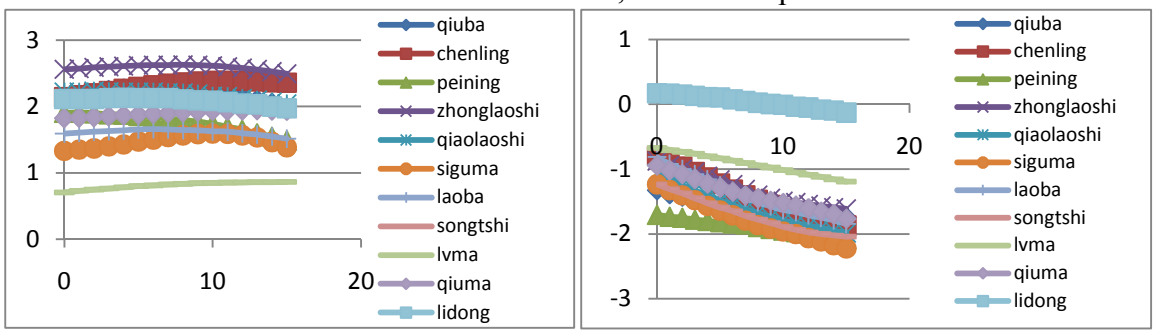


In T5+T3, T3 has a significant difference in the maximum and mean value. The younger group has a higher maximum and mean value than the older one (max: 0.89 mean: 0.9).

Pronunciation of T5 and T3 in a Sandhi Context, Younger Group

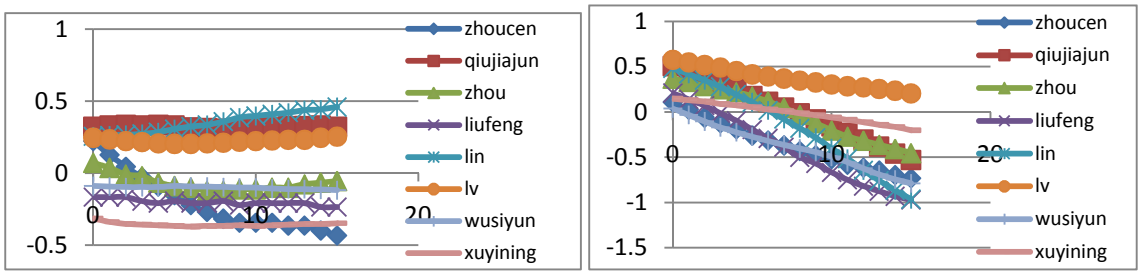


Pronunciation of T5 and T3 in a Sandhi Context, Older Group

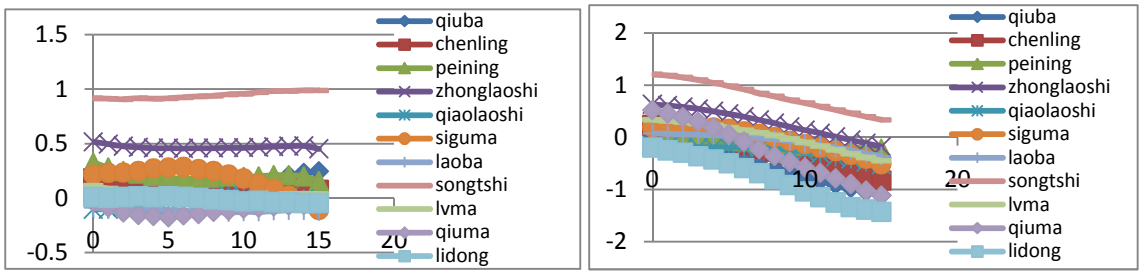


The slope of T4 is the only statistical difference for the two groups in the combination of T4+T1. They all have a positive slope and the younger group is 0.003 unit deeper, which is not a big difference in its value itself though it is statistically significant.

Pronunciation of T4 and T1 in a Sandhi Context, Younger Group



Pronunciation of T4 and T1 in a Sandhi Context, Older Group



Combinations of T1+T5, T3+T3 showed differences in minimum and mean points, while T5 + T4 differed in maximum and minimum points. The specific values are summarized in Table-6. However, since productions of T4 differed as a monotone, differences in combination are likely not due to sandhi rules, but rather to original monotonal differences.

Table-6 Differences found in tone combinations in Older/Younger speakers
(t-test significance marked by *; bold tones show a difference between groups)

	Combination	Slope difference (Older vs Younger)	Max difference (Older vs Younger)	Mean difference (Older vs Younger)	Min difference (Older vs Younger)
Slope, max & mean	**T2**+T1	positive 0.04 deeper*	0.6 higher*	0.35 higher*	0.12 higher
	T3+T1	positive 0.04 deeper*	0.52 higher*	0.34 higher*	0.30 higher
	T3+T5	negative .002 shallower*	0.36 lower*	0.28 lower*	0.14 lower
Slope & max	**T4**+T2	negative 0.03 deeper*	0.4 higher*	0.22 higher	0.08 lower
Slope only	**T4**+T1	positive 0.003 shallow*	0.135 higher	0.17 higher	0.17 higher
Max & mean	T1+**T3**	0.005 deeper	0.29 lower*	0.3 lower*	0.6 lower *
	T2+T3	0.03 deeper	0.48 higher*	0.29 higher*	0.12 higher
	T3+**T4**	0.0027shallower	0.34 higher*	0.36 higher*	0.354 higher*
	T4+**T4**	0.0023 deeper	0.33 higher*	0.37 higher*	0.35 higher*
	T4+T5	T4 0.014 shallower T5 0.009 shallower	T4 0.45 higher* T5 0.58 higher*	T4 0.57 higher* T5 0.61 higher*	T4 0.636 higher* T5 0.66 higher *
	T5+T3	T5 0.002 shallower T3 0.004 deeper	T5 0.5 lower* T3 0.89 lower*	T5 0.44 lower* T3 0.9 lower*	T5 0.4 lower* T3 0.93 lower*
Min & mean	T1+**T5**	0.002 deeper	0.42 higher	0.43 higher*	0.383 higher*
	T3+**T3**	0.004 deeper	(0.28 lower)	0.31 lower*	0.32 lower*
Max & min	**T5**+T4	0.005 deeper	0.38 lower*	0.38 lower	0.42 lower*

5. Conclusions

For monotones, there are two tones which show statistically significant differences between these two groups. For the older group, T1 has lower max and mean points and T4 has higher mean and minimal points. Other tones do have differences in max, mean, minimal points and slope, but they are not statistically different. For disyllabic tones, there are three tone combinations which show the most difference between the two groups. In these three combinations, only the first tone has some differences. In the combination T2+T1, the younger group creates a new value which has a shallower slope than the single T2, and the max point is lower than the single T2 as well. In contrast, the older group does not create a new value but remains the same. To compare the two groups, the older group has a deeper slope and higher mean and max points.

In the combination T3+T1, the younger group does not have a sandhi rule since the slope and all the points are similar to single T3. On the other hand, the older group has a sandhi rule which changes T3 to T2. To compare the two groups, the older group has a shallower slope and lower mean and max points. With the influence of the standard

Mandarin dialect, the two groups treat the sandhi rule differently. The T3 in this dialect is mapped to T3 in the standard Mandarin and the combination T3+T1 in Mandarin does not have a sandhi rule. The younger group may be more influenced by the Mandarin and has lost the sandhi rule that the older group has. In the combination T3+T5, neither of the two groups has a sandhi rule, but phonetically, the older group has a lower max and mean, and a shallower slope. The other nine combinations are also tested to be different to some extent. It is possible that the tone four in some combinations is different because the two groups have some difference for this single tone four in monosyllabic words.

Since some differences were suggestive but not significantly different, it would be productive to collect larger samples to determine if there are further real differences measured here. It is clear that the two age groups studied do have some differences in both monotones in isolation and tone combinations. In order to obtain a better statistical result, more data need to be collected for each group in the future.

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