



Neutral Tone in Changde Mandarin

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Abstract

This paper discusses the phonetics and phonology of tones in Changde Mandarin and focuses on neutral tone in disyllabic words. Acoustic realizations of both citation and neutral tones are examined in terms of fundamental frequencies (F_0), duration, and intensity. And phonetic and phonological descriptions are given on the basis of acoustic data. Acoustic data from 12 speakers show that Changde Mandarin has four lexical tones that distinguish in contour, namely level versus rising, and pitch height, namely high versus low. Neutral tone in Changde Mandarin is different from that in Beijing Mandarin or Standard Chinese. Neutral tone in Changde Mandarin is a reduced form of its citation tone, which is produced with a neutralized pitch height, and a significantly shorter duration and weaker intensity than the control.

Index Terms: Changde Mandarin, tone system, tone features, neutral tone, acoustic realization.

1. Introduction

The Mandarin dialect family is distributed widely in China and is spoken as a first language by about 1 billion people. Mandarin dialects are all tonal languages, and syllables are tone bearing units. That is, each syllable, which is usually represented by a Chinese character, bears a lexical tone that specifies lexical meaning in terms of fundamental frequency (F_0). For instance, Beijing Mandarin or Standard Chinese has four lexical tones that are transcribed as /55 35 214 51/ in terms of Chao's 5-scale tone letters [1]. An interesting and intriguing issue in Mandarin tonology is that there is a neutral tone. Chao pointed that in Beijing Mandarin, some lexical items, especially those reduplicated forms and function words including suffixes, particles, etc., are always produced with a neutral tone [2] [3]. In addition, tones become neutralized when syllables are weakened in running speech. In short, neutral tone is not only a tonal issue, but also related to stress. Neutral tones in Beijing Mandarin are studied from various perspectives including phonetics [4] [5] [6] [7] [8], phonology [9] [10] [11], syntax [3] [12] [13], and lexicology [14] [15] [16].

There is a long debate as to how neutral tone should be represented in Mandarin phonology. First, scholars disagree whether neutral tone should be treated as a purely tonal phenomenon or as an interaction with stress. Second, what is the surface phonetic realization of a neutral tone? It is true that a neutral tone syllable is toneless and its pitch is determined by its preceding tone in Beijing Mandarin. But how about in other Mandarin dialects? It has been reported that the phonetic realization of a neutral tone could be related to its citation tone in some Mandarin and Xiang dialects [17]. However, previous phonetic studies are mostly on Beijing Mandarin or Standard

Chinese. Little attention has been paid to other Mandarin dialects. This paper reports neutral tone in Changde Mandarin. Changde locates in Northwest Hunan Province, and Changde Mandarin is surrounded by Xiang dialects.

Similar to Beijing Mandarin, Changde Mandarin has four lexical tones, namely a high-level tone for T1 (*yin-ping*), a low rising tone for T2 (*yang-ping*), a low falling tone for T3 (*shang-sheng*), and a high rising tone for T4 (*qu-sheng*), which could be transcribed as /55 13 21 35/ in terms of Chao's tone letters (c.f.: [18] [19] [20]). Changde Mandarin does not have tone sandhi ([19]), but is rich in neutral tone [21]. Unlike in Beijing Mandarin, neutral tones in Changde Mandarin are not toneless. These syllables have citation tones, and neutral tones are weakened forms for the citation tones. According to the impressionistic description in [20], the neutral form is a short mid-tone for T1, T2 and T4, and is a short low-tone for T3.

This paper discusses the phonetics and phonology of tones in Changde Mandarin and focuses on neutral tones in disyllabic words. Acoustic realizations of both citation and neutral tones will be examined in terms of fundamental frequencies (F_0), duration, and intensity. Phonetic and phonological descriptions will be given on the basis of acoustic data.

2. Method

12 native speakers, 6 male and 6 female, provided speech data. All have no reported history of speech or hearing disorders. First, 5 meaningful monosyllabic words were used as the test words for each of the 4 lexical tones. Test word was placed in a carrier sentence [X, uo3 tǒu2 X kǎ3 nǐ3 t'īŋ1] (X, I read X for you to listen). Second, all the 16 possible tonal combinations were considered for neutral tones in disyllabic words. And another 16 corresponding tonal combinations without neutral tones were used as control. Table 1 shows the 32 disyllabic words. The 16-bit audio sounds were recorded through an AKG microphone directly into a laptop PC with a Lexicon I-O 22 sound card. The sampling rate is 11,025 Hz. Three repetitions were recorded.

$$D_i = 0.5 + \frac{8 * \lg f_i - 9 * \lg f_{\min} + \lg f_{\max}}{2 * (\lg f_{\max} - \lg f_{\min})} \quad (1)$$

The rime part of each target syllable was labeled as the tone-bearing unit (TBU) and annotated in Praat 6.0.29 [22]. 10 equidistant sampling points of F_0 through the entire duration were automatically extracted. Raw F_0 value was firstly transformed into logarithm, and then Revised D-value Procedure [23] was applied to rescale F_0 into 5-scale values with is comparable to Chao's tone letters. As postulated in Formula (1), $\lg f_{\min}$ and $\lg f_{\max}$ represent the minimal and maximal logarithm values respectively, within the modal-voiced pitch range of each speaker.

Table 1: *Disyllabic words with/without neutral tones.*

	T1 (0)	T2 (0)	T3 (0)	T4 (0)
T1	te11 kuan1 (cockscorn)	ciaŋ1 tshin2 (celery)	tiŋ1 tɕj3 (nail paper)	sau1 tshai4 (reap vegetable)
	te11 kuan0 (government department)	ciaŋ1 tshin0 (homesick)	tiŋ1 tɕj0 (nail)	sau1 tshai0 (vegetable)
T2	iaŋ2 tɕiaŋ1 (Yang Jiang city)	ma2 sɔŋ2 (good mahjong player)	luo2 ma3 (hinny)	ioʊ2 mɛ4 (print's ink)
	iaŋ2 tɕiaŋ0 (Jerusalem artichoke)	ma2 sɔŋ0 (hemp rope)	luo2 ma0 (Rome)	ioʊ2 mɛ0 (leaf lettuce)
T3	u3 sɿ1 (lion dance)	lau3 sɿ2 (senior surnamed Shi)	kha3 tɕ3 (paper jam)	li3 mau4 (top hat)
	u3 sɿ0 (stuntman)	lau3 sɿ0 (honest)	kha3 tɕ0 (clamp)	li3 mau0 (politeness)
T4	lau4 kuo1 (record songs)	pau4 tshau2 (revenge)	tian4 tɕj3 (store's location)	la4 ŋau4 (spicy meat)
	lau4 kuo0 (elder brother)	pau4 tshau0 (salary)	tian4 tɕj0 (store)	la4 ŋau0 (cured meat)

3. Result

3.1. Citation tone

Figure 1 shows averaged pitch curves of the four tones of Changde Mandarin. The normalized pitch height, which is in accordance with Chao's tone letters, are labeled on the ordinates, and 10 sampling pitch points are dotted along the abscissas with preserved durations. Male and female data are consistent in terms of both the pitch value and duration. First, the high-level tone (T1) is slightly rising. Second, T2 is a rising tone that starts below 2 and dips a bit before rising towards 3, and T4 is also a rising tone that starts from 2 and ends above 4. Third, T3 falls from 2 to 1.

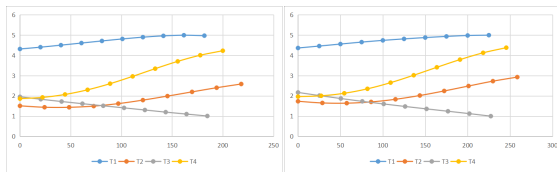


Figure 1: *Changde citation tones in male (left) and female (right) speakers.*

Table 2: *Mean durations and standard deviations in millisecond of the 4 tones in Changde Mandarin.*

	T1	T2	T3	T4
male	225 (41)	259 (51)	218 (42)	246 (50)
female	182 (68)	218 (79)	185 (69)	200 (82)

Table 2 summarizes mean durations of Changde citation tones: $T4 > T2 > T3 > T1$. Two-factor (gender*category) analysis of variance yielded a significant effect of tonal category ($F(3, 1358) = 24.803, P < 0.001$) and gender ($F(1, 1358) = 166.909, P < 0.001$), but no significant effect of interaction ($F(3, 1358) = 2.129, P > 0.095$). Post-hoc pairwise comparisons of category effect had no significance between T1 and T3 ($p=0.967$), T2 and T4 ($p=0.081$). In short, rising tones are intrinsically longer than high tone and low falling tone [24].

Changde tones distinguish with each other in contour and pitch height or register. First, it is obvious that T2 and T4 are both rising tones contrasting in height (high vs. low). Second, T1 and T3 should phonologically be treated as level tones contrasting in height (high vs. low), although the former is a bit rising and the latter is falling. It is not uncommon in languages that level tones, especially high-level and low-level tones are phonetically realized with a pitch contour that carries

information and helps improve tonal identification [25] [26] [27] [28].

The four lexical tones in Changde Mandarin are thus transcribed as /55 13 21 35/ in the present study. Please note that T1 is transcribed without phonetic detail but T3 is transcribed with phonetic detail.

3.2. Neutral tone in disyllabic words

3.2.1. Pitch

Pitch contours of disyllabic words with/without neutral tones were plotted in Figure 2. Data were classified by the tone on the first syllable. Different colors represent for different tonal combinations. Solid lines were used for Words without neutral tones and dot line for words with neutral tones. Male data were shown in left and female data in right.

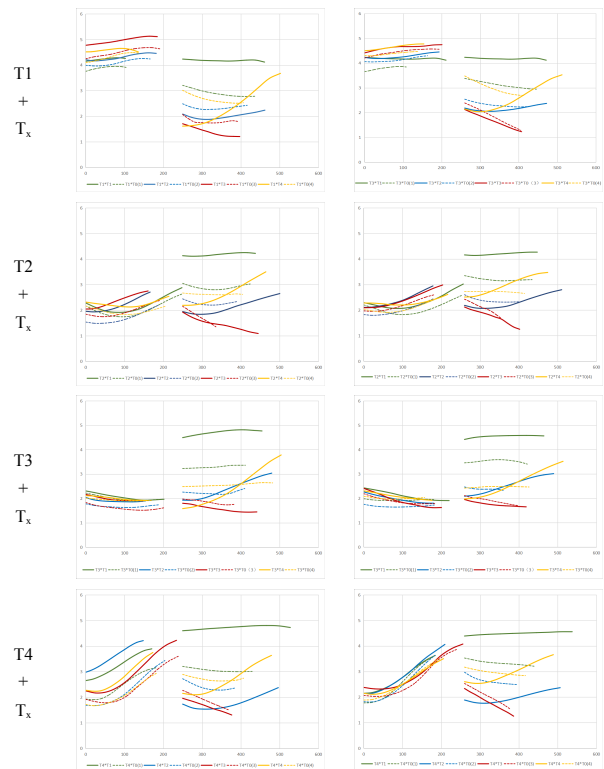


Figure 2: *Pitch curves of disyllabic words with/without neutral tones (dot line/solid line) in male (left) and female (right) speakers.*

It can be observed from comparisons between the neutral tone (NT) group and the control that pitch curves demonstrate consistent patterns across male and female speakers. First, the first syllable in a disyllable retains its pitch curve of citation form for both the NT group and the control except that the NT group could be a bit lower in pitch than the control. Second, the second syllable in a disyllable generally maintains its citation tone for the control group. That is, it is confirmed that there is no tone sandhi for disyllabic words in Changde Mandarin. Third, the tone on the second syllable is somehow weakened for the neutral group. The weakened form exhibits a tendency of leveling while retaining a pitch curve comparable

to its citation. However, the weakened form is not necessarily lower in pitch than its citation form. In fact, only the weakened form of T1 is lower than its citation form, whereas the weakened forms for all the other three tones are higher in pitch than their citation counterparts. It seems that the weakened form, i.e. the neutral tone in Changde Mandarin, tends to have a pitch value of mid-tone. The neutral tone has a pitch range between 2 and 3 in general. In addition, the weakened form has a much shorter duration than its citation counterpart.

3.2.2. Duration

Mean durations and standard deviations in millisecond for initial consonant (*I*), rime/tone (*R*), and syllable (*syl*) on first or second syllable of each disyllabic word were summarized in Table 3. Columns were arranged according to the tonal category on the first syllable of disyllables.

Table 3: Mean duration and standard deviations in millisecond for initial consonant, rime/tone, and syllable on first or second syllable in disyllabic words.

	T1		T2		T3		T4									
	1 st syl	2 nd syl	1 st syl	2 nd syl	1 st syl	2 nd syl	1 st syl	2 nd syl								
	con	NT	con	NT	con	NT	con	NT								
<i>I</i>	102	106	112	84	36	38	99	92	67	66	146	136	59	42	93	72
sd	20	16	22	19	22	31	16	16	21	21	18	18	40	14	18	15
<i>R</i>	151	150	206	163	197	209	212	139	165	186	220	153	181	201	220	148
sd	28	25	45	52	44	51	36	47	45	53	55	62	31	34	75	33
<i>syl</i>	253	256	317	247	233	247	311	231	231	252	365	289	240	243	313	220
sd	36	23	51	53	42	49	38	47	49	58	51	55	47	38	84	30
<i>I</i>	96	98	87	77	32	31	95	85	55	54	131	122	42	43	106	93
sd	22	27	18	14	7	5	19	12	14	24	21	17	28	18	24	16
<i>R</i>	190	151	205	163	215	200	199	141	190	175	212	142	215	201	237	159
sd	21	27	60	32	23	30	38	34	30	243	48	37	41	20	60	45
<i>syl</i>	286	250	292	240	247	231	294	226	244	229	343	263	256	242	343	252
sd	26	43	61	34	24	33	36	34	35	263	45	33	31	20	65	43

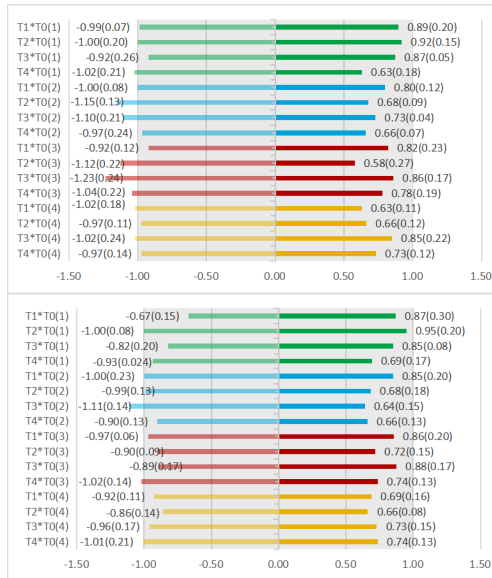


Figure 3: The NT to control ratio of duration for each syllable in disyllables in male (upper) and female (lower) speakers.

It can be seen from Table 3 that there is a general tendency of durational reduction for the NT syllables vis-à-vis the control. The reduction in duration was observed unanimously on the second syllable, i.e. the syllable of neutral tone. And a few exceptions, which is shaped in grey in Table 3, were found on the first syllable, especially in male speakers. That is, the first syllable in a disyllabic word with neutral tone is also subject to durational reduction in female speakers.

Comparison in duration was further expressed as the NT to control ratio for each syllable in disyllables, and was plotted as bar graphs in Figure 3. Duration ratio of the first syllable was expressed as negative values to the left half of axis, and duration ratio of the second syllable was expressed as positive values to the right half of axis.

It can be observed from the bar plots that the NT to control ratio for the first syllable is around or even less than -1.00 in most cases in male speakers. This means that the first syllable either has an equivalent or a longer duration in NT disyllables vis-à-vis the control. But the situation is different in female speakers. The first syllable has either an equivalent or shorter duration in NT disyllables vis-à-vis the control in most cases in female speakers. As mentioned above, the second syllable in NT disyllables, i.e. the NT syllable unanimously has a reduced duration than the control. However, the range of reduction varies. The range varies from 0.44 to 0.93 across different tonal combinations in male speakers, and from 0.40 to 0.99 in female speakers. This implies that the reduction could be tone dependent. That is, the reduction on the NT syllable could be related to its citation tone.

Table 4: Paired t-tests for durations in NT vs. control.

		Male			Female		
		t	df	p-value (double tail)	t	df	p-value (double tail)
1 st syl	<i>I</i>	0.025	233	0.980	-0.837	233	0.405
	<i>R</i>	-2.311	287	0.023	4.223	287	0.000
	<i>Syl</i>	-2.129	287	0.036	2.650	287	0.009
2 nd syl	<i>I</i>	15.169	287	0.000	5.419	287	0.000
	<i>R</i>	5.788	287	0.000	11.530	287	0.000
	<i>Syl</i>	9.971	287	0.000	12.706	287	0.000

As shown in Table 4, paired t-tests for durations pooled from all tonal combinations for the initial consonant, rime/tone, and syllable confirmed significant differences on the second syllable in disyllabic words. That is, the NT syllable is significantly shorter than control in terms of all the three measurements. Regarding the first syllable, data are not consistent across male and female speakers. T-tests show that the initial consonant on the first syllable has no significant difference in duration between a NT disyllable and the control. And durational data for rime/tone and syllable contradict with each other between male and female speakers. Suffice it to conclude that the NT syllable tends to reduce in duration in a disyllabic word, while the first syllable is not subject to reduction.

3.2.3. Intensity

Both pitch and duration data suggest a reduction effect for the NT syllable in a disyllable. It is quite naturally to further examine if there is any effect of reduction in intensity. Figure 4 shows the intensity curves in db for the first and second syllables in the 32 sampled disyllabic words. Curves were grouped according to the tonal category on the first syllable in

disyllables. Dot lines represent for the NT disyllables, while solid lines represent for the control.

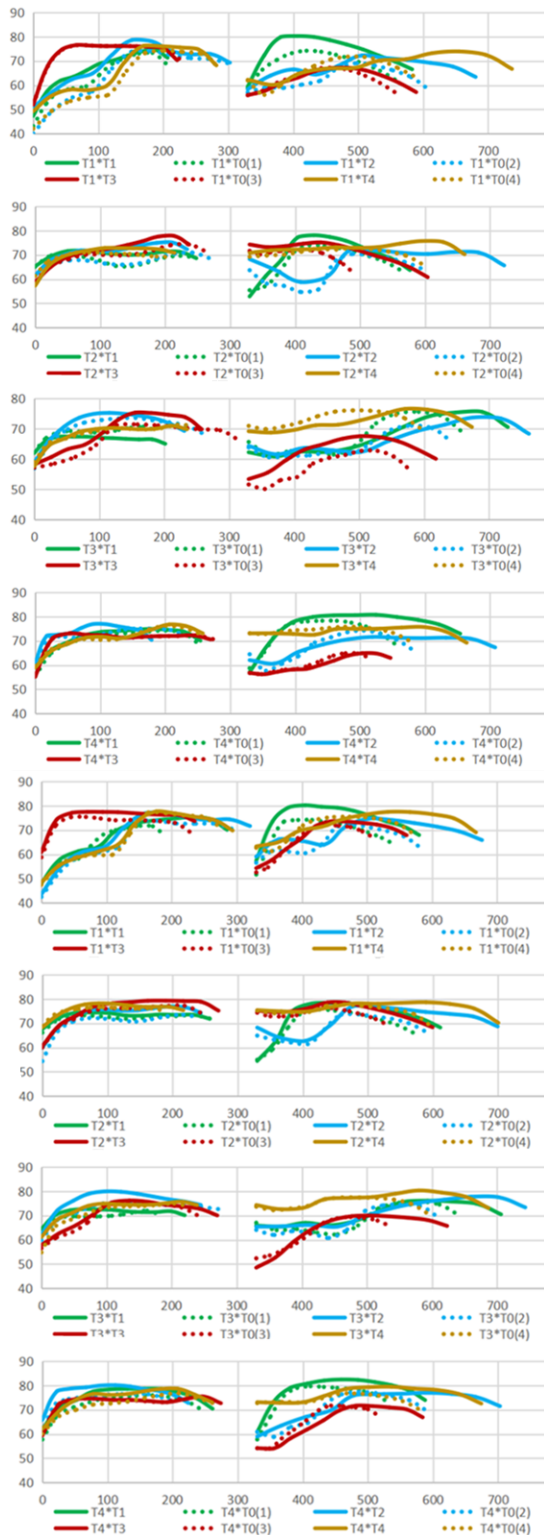


Figure 4: Intensity curves in db for disyllabic words in male (upper) and female (lower) speakers.

It can be observed from the figures that the intensity curves for syllables in the NT group are generally below those in the control. That means that both first and second syllables in NT disyllables are weaker than those in control.

Table 5: Paired *t*-tests for intensity in NT vs. control.

		Male			Female		
		t	df	p-value (double tail)	t	df	p-value (double tail)
1 st syl	I	5.366	233	0.000	8.062	233	0.000
	R	7.925	287	0.000	10.272	287	0.000
	Syl	5.106	287	0.000	13.020	287	0.000
2 nd syl	I	4.917	287	0.000	7.722	287	0.000
	R	4.102	285	0.000	8.846	287	0.000
	Syl	2.498	287	0.000	11.103	287	0.000

Mean intensities were averaged across different tonal combinations for the initial consonant, rime/tone, and syllable on the first and second syllables. Paired *t*-tests of mean intensities were summarized in Table 5 for the NT disyllables versus the control. The results show that mean intensities for NT disyllables are significantly lower than those for the control in terms of measurements on initial consonant, rime/tone, and the entire syllable. It is thus confirmed that the NT disyllables are produced with reduced intensities.

4. Discussion & Conclusion

This paper describes acoustic characteristics of tones and neutral tone in Changde Mandarin.

Fined grained phonetic details explained that Changde Mandarin distinguish level tones from rising tones, and both level and rising tones distinguish in pitch height. The level tones are phonetically complex: the high level T1 is slightly rising, while the low level T3 is a bit falling. The four lexical tones in Changde Mandarin are thus transcribed as /55 13 21 35/ in Chao's tone letters.

Neutral tone in Changde Mandarin is different from Beijing Mandarin. In Beijing Mandarin, neutral tone is toneless and it thus receives pitch assignment from the preceding tone. Neutral tone is simply a reduced form of its citation tone in Changde Mandarin. First, pitch curves are reduced for the neutral syllable. T1 is lowered, and T2, T3 and T4 are all raised. That is, the pitch values for the four citation tones are neutralized to a mid-tone 2 or 3, when they become a neutral tone. Second, neutral tone is significantly shorter than citation tone. So the neutral tone in Changde Mandarin could be transcribed as /3/ or /2/ in tone letters. Third, the intensity data confirm that the neutral tone is less stressed vis-à-vis its citation form. In fact, when a disyllabic word contains a neutral tone, both syllables (i.e. not only the neutral tone syllable itself but also the preceding syllable) are weaker than their corresponding syllables in the control.

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6. References

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