

Mandarin Learners' Tonal Patterns: An Experimental Study

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This paper introduces an experimental study of Mandarin tonal sequences produced by native English speakers. Sound recordings of learners' Mandarin have been analyzed empirically and acoustically. The conclusions are as follows: tonal variation in accented Mandarin is not correlated to the original Mandarin tones or the context of the original Mandarin tones. The pronounced Mandarin tones selectively transform to each other. The percentage of pronounced Tone 1's and Tone 3's are much higher than those of other pronounced tones in the accented Mandarin. Tonal combination patterns do exist, and there are two basic patterns. Pattern 1 is similar to the tonal combination T1T3, and Pattern 2 is similar to the tonal combination T3T1 or T3T4. The two basic patterns serve as composing elements to form two more tonal combination patterns. The speech stream contains much more Pattern 1 tonal combinations than Pattern 2 tonal combinations.

1. Purpose and methods

Patterns of pronunciation by English learners have been extensively studied, but relatively little research of this kind has been conducted for the Chinese language. Analysis of speech samples by Chinese learners found that the most noticeable feature of their accent is that the tones vary greatly in the speech stream, far more than the variation in vowels or consonants. This paper will analyze Mandarin tonal sequences produced by learners who are native English speakers.

In the Mandarin speech of most native English speakers, tones are often pronounced in unexpected forms. Native Mandarin speakers are very sensitive to these transformed tones. Even without the experience of teaching Chinese to foreigners, many of them could identify the "incorrect" tones without difficulty. Experienced Chinese instructors could immediately tell that these Mandarin speaking sounds contain typical features of English accent, and that tonal pronunciations make up a large part of the accent. However, it is hard for them to explain exactly what is different about these tones.

In order to find the reason, and to better understand the tonal phenomena in the learners' speech, the following questions are raised: How do Mandarin tones transform? Can a Mandarin tone transform to some other Mandarin tones? If yes, which tone may transform to which tone? Are there any tones that other tones "prefer to" transform into? Are there any tones that are pronounced much more than other tones? Are there any

patterned tonal combinations? If yes, what are they? To achieve more understanding of the tonal phenomena, an experiment that combines empirical analysis and instrumental analysis was conducted.

First, a group of six learners were asked to spontaneously tell stories and make recording of their story-telling. All of the learners had learned Chinese for more than one year. Each of them was asked to tell stories about their own life experiences, which they could express quite naturally and fluently at normal pace.

Then the sounds in the recordings were analyzed empirically by two listeners (include the author), both native speakers experienced in teaching Mandarin. Portions of the recordings were repeatedly played. The listeners paid special attention first to tones on each syllables one by one, and then to tones in sequences.

Afterwards, the recordings were analyzed with the Praat software package. The acoustic analysis provided pitch tracks (F0 curves), wave forms, and intensity envelopes. When tones on a sequence of two or more syllables were examined, not only the pitch tracks, but also other acoustic data are used for locating syllable boundaries, analyzing stressed pitch contours, and identifying tonal patterns.

When making judgments, such as deciding which tone was produced on a syllable, both auditory impression and acoustic data, mainly pitch tracks, were needed at the same time. The decisions were based on not only repeatedly listening to the recordings, but also carefully examining the pitch tracks. One reason for doing so is that pitch track of a tone may not be same as the image that based on the auditory impression, especially when the syllable is short. For example, the pitch track of the high level tone, Tone 1, in a very short syllable is often a sharp rising-falling curve, not a level and smooth curve.

2. Analyses and Results

2.1 Selective tonal transformation

The first step of analyzing the learners' tonal pronunciations is to examine the tones on each syllable. Portions of the recordings were played again and again; special attention was paid to tones on each syllable, and judgment was made about which tone was actually pronounced. The pitch track of the syllable was also examined to confirm, adjust, or make judgments.

When the learners spoke slowly, with more pauses and strong stresses, it was relatively easy for the listener to judge the tonal categories that they heard; also it was not too hard for them to identify the basic features of many tones. When the learners spoke faster, with less pauses and strong stresses, it was often hard for the listener to tell the features and categories of the tones. Under this kind of situation, pitch tracks provided more accurate information.

The results of the judgment show that in a relatively small percentage of the syllables, the pronounced tones keep the basic features of their original Mandarin tones. In quite a high percentage of the syllables, the tones were pronounced as other Mandarin

LIAO: MANDARIN LEARNERS' TONAL PATTERNS

tones; while in the rest of the syllables, the tones were pronounced in forms that do not belong to any Mandarin tones. These facts mean that in the learners' speaking sounds, Mandarin tones may transform to other Mandarin tones or tones with other forms.

In order to see the way that Mandarin tones transform, the times that each tone was pronounced by one learner were counted and put in Table 1. The recording is 110 seconds long, and it contains 273 syllables.

Table 1 Numbers of tones produced in one learner's speaking

Original Tones	Pronounced Tones						
	Tone 0	Tone 1	Tone 2	Tone 3	Tone 4	Other Tonal Form	Sub Total
Tone 0	10	0	1	32	0	3	46
Tone 1	3	40	2	16	1	6	68
Tone 2	2	5	5	11	1	8	32
Tone 3	0	29	1	16	5	6	57
Tone 4	1	18	2	16	19	14	70
Sub Total	16 =10+6	92 =40+52	11 =5+6	91 =16+75	26 =19+7	37	
Total	273						

In Table 1, the original tones are listed in the first column, and the pronounced tones are listed in other columns. The four basic Mandarin tones are represented by "Tone 1" to "Tone 4." The neutral tone is referred as "Tone 0," which are tones on fillers (presented as 啊), particles, and tones that should be neutralized, such as the one on the second syllable of 看看 (Tone 4 + Tone 0). The pronounced tones with pitch curves unlike those of any Mandarin tones were referred as "Other Tonal Form."

With Rows 3 to 7 and Columns 2 to 8, each number shows how many times that a Mandarin tone was pronounced as the same Mandarin tone, other Mandarin tone, or the "Other Tonal Form." For example, the number 29 at Row 6, Column 3 indicates that 29 syllables that originally carry a Tone 3 were pronounced as syllables with a Tone 1. In other words, 29 Tone 3's transformed to Tone 1's.

In the row "Sub Total," the numbers typed in the larger size are the sums of the numbers from Row 3 to Row 7 in the same column. The equalities for the numbers indicate how many tones were produced in their original form and in other forms respectively. For instance, the equality "92=40+52" shows that there are 92 syllables produced with Tone 1; among which 40 are original tone 1's, and 52 were transformed from other tones.

Based on the data shown in Table 1, it is clear that the four Mandarin tones transform among each other. Every single one of the tones may transform to other tones; and each tone may transform to every single one of the other tones. The facts that there are numbers in all slots on the rows for the four Mandarin tones in Table 1 support these conclusions.

In fact, Table 1 also shows that any one of the four Mandarin tones may transform to not just any of the other three tones, but also the tones that carry unexpected pitch curves. As for the neutral tone, it may transform to or transform from any Mandarin tone, as well. Although the limited data in Table 1 for the Learner do not fully show this point, other learners' data do support it. There are many fillers in the learners' speech that are counted as neutral tone syllables, and most of them were pronounced as Tone 3's.

A further analysis of the numbers in Table 1 will lead to some interesting phenomena about the way that Mandarin Tones transform. The numbers in the Rows for Tone 0 to Tone 4 suggest that besides keeping their original tonal forms, Tone 0 and tone 1 tend to transform more to Tone 3 rather than to other tones, Tone 3 tends to transform more to Tone 1 rather than to other tones; and Tone 4 tends to transform to both Tone 1, Tone 3 and "Other Tonal Forms." As for Tone 2, although the numbers show that it also tends to transform to Tone 3 more than other tones, the tendency is not clear, due to the much smaller total sample number.

Put the numbers for the tones together, the statistics in the row of "Sub Total" demonstrate that other tones tend to transform to Tone 1 and Tone 3. The reason is explained in the following: in each of the five equalities that is in the formula " $A = b+c$," "c" represents the number of the pronounced tones that transform from other Mandarin tones. So the five numbers 6, 52, 6, 75, and 7, that on the position of "c" in the four equalities, represent the numbers of tones transformed from other tones to Tone 0-4 respectively. Comparing these numbers, the 53 and 75 for Tone 1 and Tone 3 are significantly larger than 6, 6 and 7 for Tone 0, tone 2, and Tone 4. Therefore, the conclusion is that other tones tend to transform to Tone 1 and Tone 3.

This conclusion indicates that in the learner's speech, the Mandarin tones selectively, rather than equally or randomly, transform to each other. This means that learners prefer to pronounce Tone 1 and tone 3 much more than other tones. In fact, this point is also denoted by the significant phenomenon that Tone 1 and Tone 3 occur much more frequently than other tones. Among the 273 syllables, 92 (33%) were pronounced as Tone 1's and 91 (33%) were pronounced as Tone 3's. Put together, 183 (66%) out of 273 tones were pronounced as these two tones. In other words, two thirds of the syllables carry these two tones, and only one third of the syllables carry Tone 0, Tone 2, Tone 4, and "Other Tonal Form." No wonder experienced instructors always feel that there is something in the learners' speaking sounds that cause the auditory impression of the English accent. This uneven occurrence of the tones must contribute to the learner's accent significantly.

2.2. Patterned Tonal Combinations

Besides selective transformation and uneven occurrence of the Mandarin tones, are there any other aspects of the tones, especially Tone 1 and tone 3, that might also significantly contribute to the learner's accent? Would tonal combinations in the sound sequences demonstrate anything?

With these questions in mind, the second step of analyzing the learners' tonal pronunciations was taken, which was to examine the tonal combinations on syllables that grouped together, and special attention was paid to the pattern of pitch curves. Again, portions of recordings were analyzed empirically and acoustically.

Listening to the recordings, and observing pitch tracks, one impression was that syllables grouped together in the running speech. In normal pace, there were often two to three syllables in a group; but in faster pace, a group contained more syllables. In each group, tones combined together and sound like a tonal unit. Pitch tracks showed the tonal combinations on the grouped syllables clearly. Between groups of pitch curves, there was often a space, reflecting the pause on the boundary between groups. Among the total 273 syllables, there are 78 tonal combination groups, according for 174 (64%) syllables. This means that two thirds of the learner's speech consisted of tonal combinations.

Repeatedly listening to the recordings, the listeners could tell that the tonal accent was obvious and very familiar, which was typical of what they heard in daily instruction. This indicated that there must be some common patterns in the tonal combinations. A closer analysis of what was heard indicated that there were many tonal combinations that sounded very similar to each other.

A careful observation of the corresponding pitch tracks revealed that there were indeed common tonal patterns. The pitch curves of the tonal combinations carry two basic patterns. Pattern 1 is similar to a Tone 1 plus a Tone 3 (T1T3), and Pattern 2 is similar to a Tone 3 plus a Tone 1 or Tone 4 (T3T1 or T3T4).

In most cases, both patterns occur in disyllabic combinations, and only a few in tri-syllabic or other multi-syllabic combinations. When Pattern 1 occurs in disyllabic combinations, if listen to the two tones in the combinations one by one, the first tone sounds just like Mandarin Tone 1, and the second tone sounds exactly like a Mandarin Tone 3. However, when the tones are heard as one unit, it often happens that the pattern does not sound as natural as a typical Mandarin T1T3 combination. The main reason is that in the former, the Tone1 portion, is often much shorter than the Tone3 portion; but in the latter, the two portions are similar in length.

Although the two basic patterns may occur in tri-syllabic or other multi-syllabic groups, there are two more patterns that may occur in these groups. Pattern3 is similar to a Tone 1 plus a Tone 3 and another Tone 1 (T1T3T1) or a Tone 1 plus a Tone 3 and a Tone 4 (T1T3T4); and Pattern 4 is similar to a Tone 3 plus a Tone 1 and another Tone 3 (T3T1T3). Pattern 3 could be viewed as the extended Pattern 1, and Pattern 4 the extended Pattern 2.

LIAO: MANDARIN LEARNERS' TONAL PATTERNS

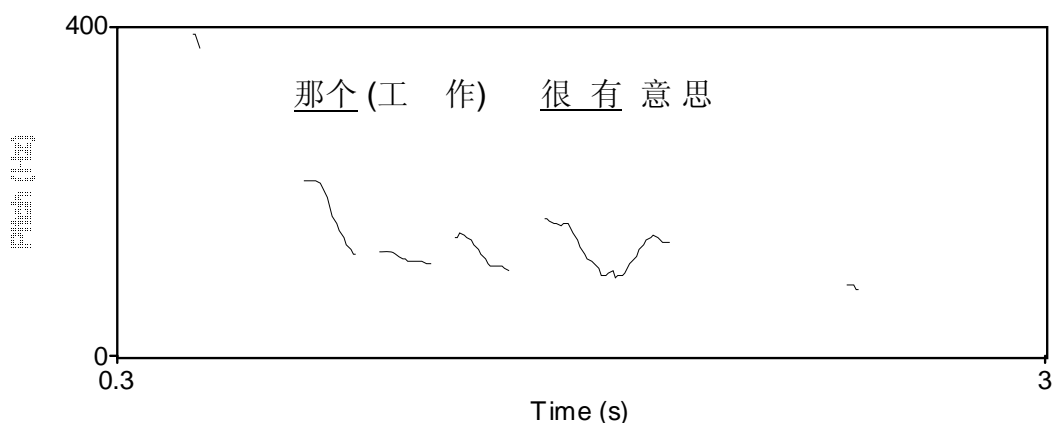
When spoken in a relatively faster pace, with more syllables grouped together, the average length for the tones become shorter. The tonal combination patterns are formed with more tonal forms that do not belong to any typical Mandarin tones, although the basic tonal combination patterns remain the same as described above.

The following are examples of pitch tracks. Patterns 1-4 are marked by underlines, round parentheses, square brackets, and brace brackets respectively in the Chinese characters.

Example 1:

<u>那个</u>	(工作)	<u>很有</u>	意思	
nage	gongzuo	henyou	yisi	
that	job	is very	interesting	
T4T0	T1T4	T3T3	T4T0	---- original tones
T1T3	(T3T4)	<u>T1T3</u>	T4T0	---- pronounced tones

“That job is very interesting.”



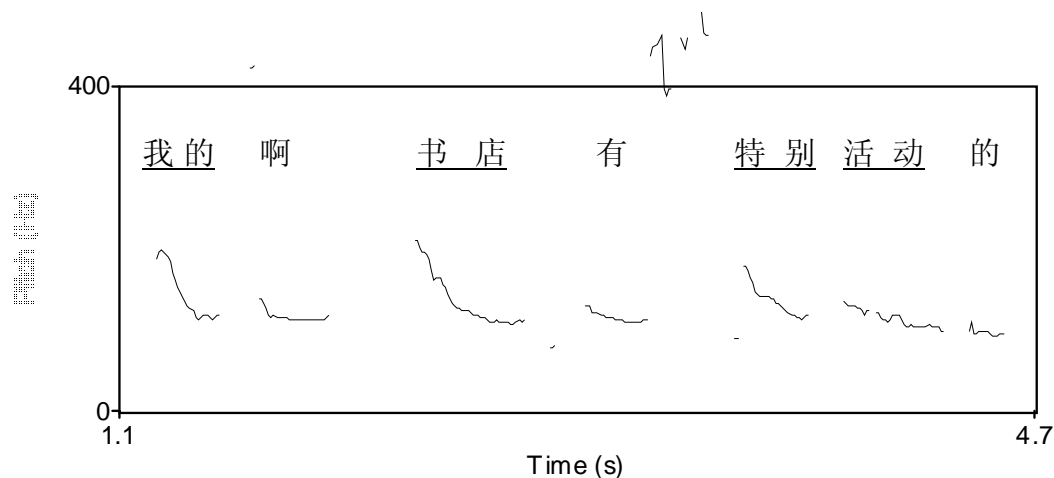
In Example 1, two groups of syllables, 那个 and 很有, carry Pattern 1 tonal combinations, and one group of syllables, 工作, carry a Pattern 2 tonal combination. Because of intonational influence, the high starting portions in the pronounced Tone 1 and Tone 4 are not the same in height, but the basic features for each tone are clear. Notice that the pitch track on the syllable 思 does not show up, for some reasons.

Example 2:

<u>我的</u>	啊	<u>书店</u>	有	<u>特别</u>	<u>活动</u>	的	
wode	a	shudian	you	tebie	huodong	de		
my	filler	bookstore	have	special	activity	particle		
T3T0	T0	T1T4	T3	T4T2	T2T4	T0		---- original tones
T1T3	T3	T1T3	T3	T1T3	T1T3	T0		---- pronounced tones

“(When) my bookstore has special activity, ...”

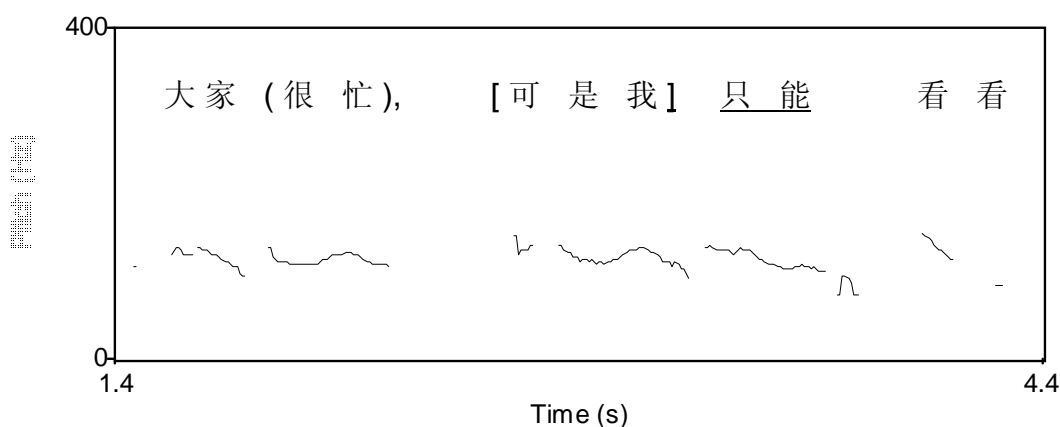
LIAO: MANDARIN LEARNERS' TONAL PATTERNS



In Example 2, four groups of syllables, 我的, 书店, 特别 and 活动, carry Pattern 1 tonal combinations. The starting portion of the tonal combination in 活动 is much lower than those in other tonal combinations, due to the resetting of pitch range, which is one type of intonational influence.

Example 3:

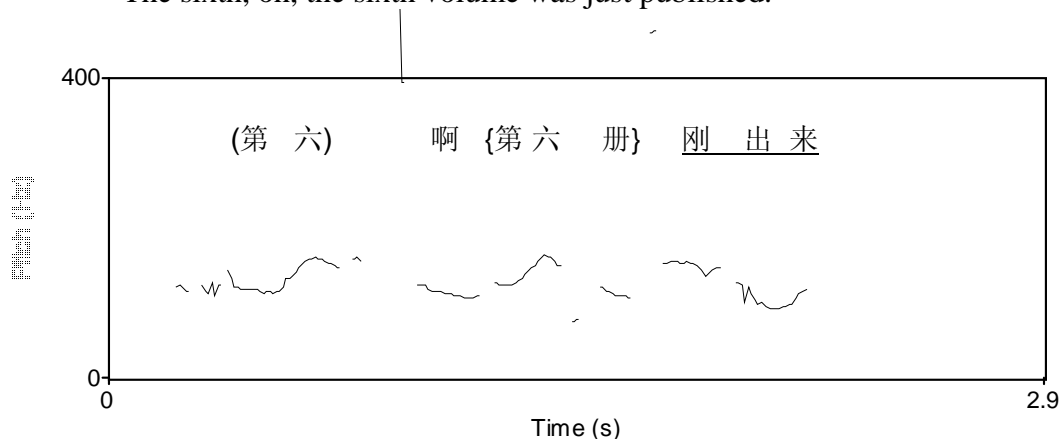
大家 (很忙), [可是我] 只能 看看
 dajia henmang keshiwo zhineng kankan
 everybody very busy but I only can watch
 T4T1 T3T2 T3T4T3 T3T2 T4T0 ---- original tones
 T1T4 T3T4 T1T3T4 T1T3 T4T0 ---- pronounced tones
 "Everybody was busy, but I could only watch."



In Example 3, two groups of syllables, 只能 and 很忙, carry a Pattern 1 and a Pattern 2 tonal combination respectively, and one group of syllables, 可是我, carry a Pattern 3 tonal combination. Although the pitch track between 可 and 是 is broken due to the interruption of the consonant in 是, the three syllables 可, 是 and 我 are in the same group according to auditory impression. In this utterance, the pitch range is relatively narrow, so the difference between higher portion and lower portion of the tones is small.

Example 4:

(第六) 啊 {第六册} 刚出来
 diliu a diliuce gangchulai
 sixth filler sixth volume just published
 T4T4 T0 T4T4T4 T1 T1T2 ---- original tones
 T3T1 T0 T3T1T3 T1 T3T2 ---- pronounced tones
 "The sixth, oh, the sixth volume was just published."



In Example 4, two groups of syllables, 刚出来 and the first 第六, carry a Pattern 1 and a Pattern 2 tonal combination respectively. One group of syllables, 第六册, carry a Pattern 4 tonal combination. Because of the interruption of the consonant in the syllable of 册, the pitch track is broken between the syllable 六 and 册. However, according to auditory impression, the two syllables belong to the same group of syllables.

The above analysis shows that the two basic patterns, Pattern 1 and Pattern 2, are both formed by combining Tone 1 and Tone 3 in different orders. Pattern 3 and 4 could be viewed as the extensions of Pattern 1 and Pattern 2. In fact, they could also be viewed as Pattern 1 and Pattern 2 combining together with a portion overlapping. For example, Pattern 3 on 可是我 in Example 3 could be viewed as 可(是我), i.e. Pattern 1 on 可是 and Pattern 2 on 是我 combine to create a single tonal unit, with one portion of each overlapping on 是. For the same reason, Pattern 4 on 第六册 in Example 4 could be viewed as (第六)册, i.e. Pattern 2 on 第六 and Pattern 1 on 六册 combine to one tonal

unit, with one portion of each overlapping on 六. This phenomenon shows that Pattern 1 and 2 are in fact the basic composing elements co-occurring in Pattern 3 and 4.

The above statistics has shown that there are total of 183 Tone 1's and Tone 3's in the recording. How many Pattern 1's and Pattern 2's are there? Among the 78 tonal combinations, only 6 are in the form of Pattern 3 and 4. Counting one Pattern 1 and one Pattern 2 in each Pattern 3 or 4 once, there are 84 total occurrences of Pattern 1 and 2. The recording is only 110 seconds long; so on average, one of the two basic patterns occurs once every 1.2 seconds. If they had equal chances to be pronounced, then each one would occur once every 2.4 seconds.

The interesting fact is that Pattern 1 is pronounced much more than Pattern 2. Among the 84 occurrence of the two patterns, Pattern 1 has 73 (87%) repetitions, while Pattern 2 has 11 repetitions (13%). In other words, during a period of less than two minutes, the learner repeated pattern 1 73 times and Pattern 2 11 times. Such a high frequency of pronouncing Pattern 1 must significantly contribute to the so called English accent. Even for Pattern 2, 11 repetitions in about two minutes are also quite frequent, enough for listeners to build an impression.

The above statistics and sample pitch tracks are all from the data of one learner. The same patterns also appear in other learners' data, although the percentages vary slightly. In general, patterned tonal combinations make up in the range of 50% to 70 % of the total syllables, and the occurrence of Pattern 1 made up about 60% to 90% of the total tonal combinations. As the occurrence of correct Mandarin tones increases, the total percentage of Pattern 1 in the speech decreases.

3. Conclusion And Discussion

The data and analysis presented in this paper leads to the following conclusions: First, to certain extent, tonal variation in accented Mandarin is not correlated to the original Mandarin tones or the context of the original Mandarin tons. The pronounced Mandarin tones selectively transform to each other, with a preference of transforming to Tone1 and Tone 3 more than to other tones, although any tone may transform to any other tones or tones with unexpected forms.

Second, the percentage of pronounced Tone 1's and Tone 3's are much higher than those of other pronounced tones in the accented Mandarin. Most of the pronounced Tone 1's and tone 3's occur in disyllabic- or multi-syllabic groups to form tonal combinations.

Third, tonal combination patterns do exist in the accented Mandarin. There are two basic patterns. Pattern 1 is similar to a Tone 1 plus a Tone 3 (T1T3), with the Tone 1 portion much shorter than the tone 3 portion. Pattern 2 is similar to a Tone 3 plus a Tone 1 or a tone 4 (T3T1 or T3T4). The two basic tonal combination patters serve as composing elements to form two more tonal combination patterns.

Fourth, the speech stream contains sequences of patterned tonal combinations. Pattern 1 occurs much more frequently than Pattern 2. For some learners, Pattern 1 may

repeat as much as 5 times more often. The occurrence of the two patterns together may reach as many as 80 times in a normal paced speech with 280 syllables in two minutes.

The basic reason that accented Mandarin tones vary in the above ways must be that the intonational system of the learners' native language, English, affects the pronunciation of the second language. The two basic tones in English are a high tone and a low tone, which causes the learners to frequently pronounce Mandarin tones in similar ways. In English, tonal change happens cross groups of syllables, but in Mandarin, patterned tonal changes often happen within each syllable, especially when the speech pace is relatively low. Also, the learners need to remember which syllable carries which tone. These all cause difficulties in pronunciation. Therefore, correctly pronounced Chinese carry a smaller number of the tonal combination patterns detailed above, while accented Chinese carry more.

REFERENCES

- LIAO, RONGRONG. 2005. Underline information and rules of Chinese intonation. *Languag pragmatic and innovation. Academic series to celebrate the 80th birthday of Professor Hu Mingyang*. Foreign Language Teaching and Research Press, Beijing, China. 137-156.
- WU, ZONG-JI. 1990. Basic patterns of intonation in Standard Chinese. *Academic series to honour the memory of Professor Wang Li*. Commercial Press, Beijing, China.
- PIERREHUMBERT, JANET B. 1980. *The Phonology and Phonetics of English Intonation*. Ph.D. dissertation, M.I.T.