The change of Standard Thai high tone: an acoustic study and a perceptual experiment

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Abstract
Standard Thai tones are divided into two categories: namely level tones (mid tone, low tone, and high tone) and contour tones (falling tone and rising tone). Thai high tone has been found to have changed its shape during the years 1908-2006 (Bradley, 1916; Abramson, 1962; Tumtavitikul, 1992; Morén and Sziga, 2006). The tone has changed its shape from mid falling (1908) to high level (1962), and mid rising (2006). This study attempts to show that high tone in Standard Thai is changing from high level to mid rising acoustically and perceptually. The participants in the study are divided into two age groups: over-sixty and under-twenty. Each age group is comprised of twenty participants of male and female. The Praat program was used to conduct an acoustic analysis and to conduct perceptual experiments. The results show that high tone shape in the over-sixty group is high level, but it is mid rising in the under-twenty group. It has also been found that the present characteristic of high tone is similar to that of rising tone. It is argued that Standard Thai high tone should be categorized as a contour tone.

1. Introduction

For many years linguists have done acoustic studies along with auditory experiments to identify tones in languages. Thai is one of the languages that has been investigated and classified as a tonal language. Based on a combination of an acoustic study and a perceptual experiment or auditory experiment (Abramson, 1962, 1975, 1978), there are five distinctive tones in Standard Thai[1]: mid tone [33], low tone [21], falling tone [43], high tone [44 or 45] and rising tone [323]. Acoustically, each Thai tone characteristic is well-defined by fundamental frequency shape (F_0; Hz). F_0 shape is identified by pitch height (at the starting point of pitch) and pitch direction (the movement of pitch). The F_0 shape and perceptual experiment are the basis for grouping Thai tones into two categories (Abramson, 1962), namely level or static tones, and contour or dynamic tones. The level tone category is comprised of mid tone, low tone, and high tone. The contour tone category is comprised of falling tone and rising tone.

During past decades, an acoustic study of Standard Thai tones, which indicates a relationship to an articulatory dimension, has developed into a long progression of studying tones of monosyllabic words to tones in connected speech (Abramson, 1962, 1975, 1979; Erickson, 1974; Hiranburana, 1972, Potisuk et al., 1994; Tingsabadh and Deeprasert, 1997). At this date, the study of Standard Thai tones in isolated monosyllables seems to be less important than in connected speech; yet it has been used as a fundamental reference for a more advanced study of experimental phonetics and phonology. However, some linguists have raised an interesting point concerning Thai tones based on their F_0 shapes in monosyllabic words. It has been noticed that F_0 of high tone in isolated monosyllable words has changed its shape from high falling (Bradley, 1916) to high level (Abramson, 1962, 1975,

1979; Erickson, 1974; Panroj, 1991; Tingsabadh and Deeprasert, 1997; Potisuk et al., 1994), and to mid rising (Abramson, 1979; Chuwarahawong, 2000; Morén and Zsiga, 2006; Panroj, 1991; Tumtavitikul, 1992; Potisuk et al., 1994; Tingsabadh and Deeprasert, 1997; Teeranon, 2002a, 2002b). And it is questioned whether high tone should be recategorized as a dynamic or contour tone (Teeranon, 2002a, 2002b). This change has been proven to exist acoustically but not auditorily. The study has two main goals; 1) to attest the change of high tone in both articulatory and auditory aspects to confirm that the change has occurred in the production and perception process of Thai speakers, and 2) to proclaim the importance of study tones in monosyllabic words.

In order to study the change in high tone, an acoustic study of Standard Thai tones and perceptual experiments were analyzed on isolated monosyllables spoken by forty participants of two generations: over sixty years old and under twenty years old[2]. There is a related chronology in studying the change in these two age groups. The over-sixty group represents the past, and the under-twenty group represents the present and the future.

2. Preliminary background

2.1 An acoustic study of the change of Standard Thai high tone

According to F_0 shape of high tone during the past century, from 1908[3] to 2007, the development of high tone is divided into three periods[4] as follows:

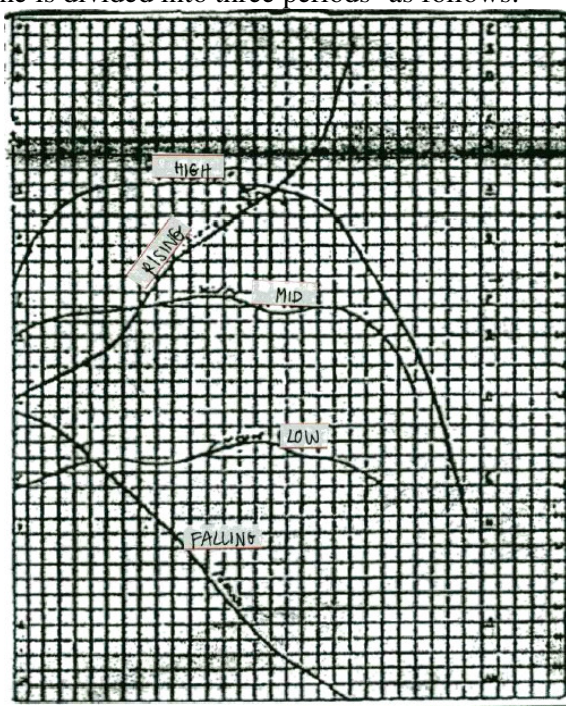


Figure 1 F_0 shapes of Standard Thai tones in the first period (Bradley, 1916)

The phonetic characteristic of Standard Thai tones first began to be recognized and recorded in 1908 by C. B. Bradley (1916). It is observed that high tone was high-falling which acts like a falling tone at the present time. For the rising tone, it begins with mid pitch before steadily increasing. As a result, when comparing high tone and rising tone, their shapes are totally different in F_0 height and direction. (see Figure 1)

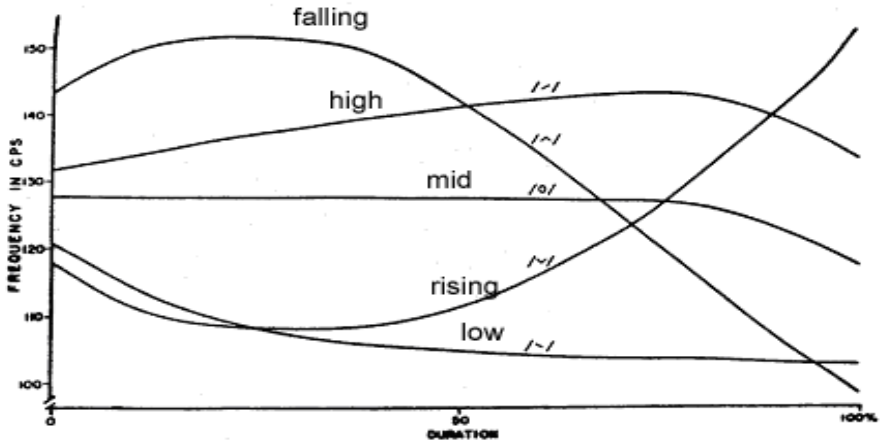


Figure 2 F_0 shapes of Standard Thai tones in the second period (Abramson, 1962)

During 1962-1975, while rising tone showed a slight change, the shape of high tone showed much greater change. In this period, rising tone begins at mid point then stays low before rising, but high tone gradually increases from high level with a slight fall at the end (Abramson, 1962, 1975; Erickson, 1974). High tone is seemingly changing from contour to level. And it is found that falling tone shape looks very much like high tone in the first period. (see Figure 2)

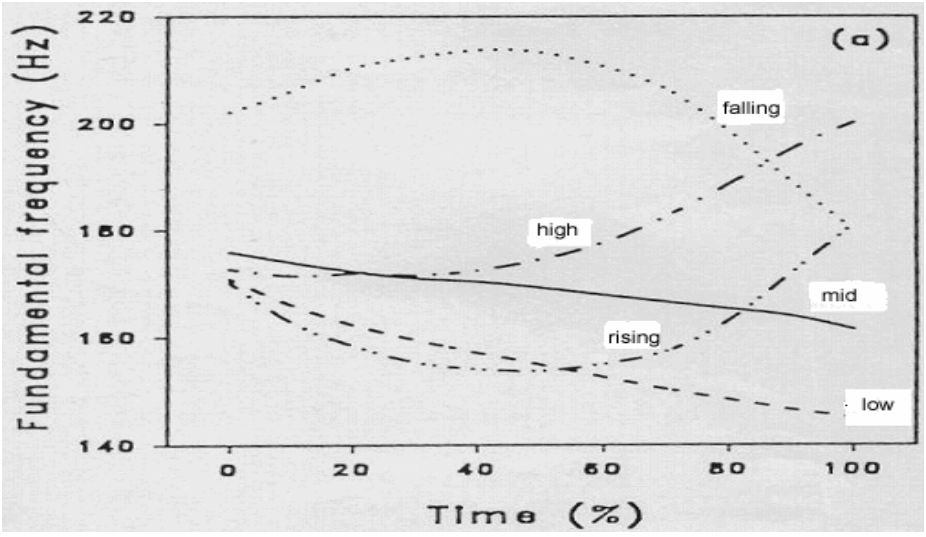


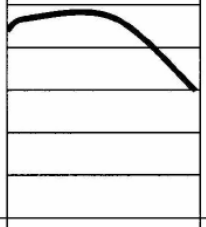
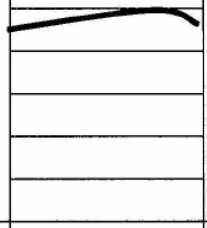
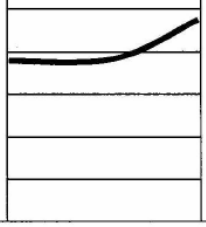
Figure 3 F_0 shapes of Standard Thai tones in the third period (Potisuk et al., 1994)

At present, high tone has been noticed to have changed its shape again from high level to mid rising (see Figure 3) (Abramson, 1979; Chuwarahawong, 2000; Morén and Zsiga, 2006; Panroj, 1991; Tumtavitikul, 1992; Potisuk et al., 1994; Tingsabadh and Deeprasert, 1997; Teeranon, 2002a, 2002b). Its shape looks like rising tone.

In order to make a comparison between high tone shapes in each period, we converted each figure and set up a table to present the change as follows.

Table 1 consists of six columns. The first column represents the period which is divided by high tone shape. The second column represents the authors and the year they conducted their researches. Some sociolinguistic factors - age and sex - are represented in the third and fourth columns. The fifth column represents the tone shapes converted from Figure 1, 2, 3 shown in previous pages. Five lines in this column were drawn using the musical bar concept. Each line represents pitch level. The lowest pitch is represented by the lowest line (or number 1 for 5-scale numerical system) and the highest line represents the highest pitch (or number 5 for 5-scale numerical system). Then pitch level in the fifth column is converted into a numerical system in the sixth column.

Table 1 The change of Standard Thai high tone

(1) Period	(2) Author	(3) Age of informants	(4) Sex of informants	(5) 5-scale tone stick system	(6) 5-scale tone numerical system
1	Bradley (1916)	-	-		442
2	Abramson (1962)	20	female		44 45
3	Potisuk et al.(1994)	22	male and female		334

In the first period, high tone is high-falling [442]. The tone shape starts from high pitch and rises before falling to a lower level of pitch. Its falling curve shows that high tone is a contour tone.

Fifty-five years later, in the second period, the tone shape is high level [44 of 45]. The tone shape starts from high pitch and rises steadily. However, its slightly falling contour at the end still remains. Its shape is becoming less contoured compared with the first period.

In the third period, high tone starts from mid pitch and levels off before rising. It is noted that this shape is similar to that of rising tone (Abramson, 1979). A comparison

between the first period and the third period high tone shape shows a total change. That is to say, high tone height has changed from high to mid, and its direction has changed from falling to rising.

2.2 A perceptual experiment of Standard Thai high tone

To this date, there are not many researches published concerning perceptual aspects of Standard Thai high tone. On one hand, some experiments were done with normal speech (Abramson, 1962, 1975, 1997). And on the other hand, some wer done with abnormal-Thai speakers (Gandour and Dardarananda, 1989; Nasanee, 2003). However, only normal speech perception tests were only mentioned in this study.

Abramson (1962, 1975) was the first to test Thai tones perception in normal speech. It was found that there are 2 types of tones in Thai, level tones and contour tones. It was found that the mid and the low tones were confused by the participants. This was later confirmed by Gandour and Dardarananda (1989) and Nasanee (2003).

In the year 1997, Abramson (1997) combines techniques of acoustic analysis and speech synthesis to investigate the tones of Standard Thai acoustically and perceptually. The two techniques were combined to revalidate and test the distinction of static and dynamic tones in Thai. The word 450ms-long-[khaa] 'to be stuck' was synthesized by using the Haskin Laboratories computer-controlled formant synthesizer. The synthesized word is ranges from 90 to 154 Hz. Then thirty-seven native speakers of Standard Thai were selected to perceive the randomized-synthesize speech over a period of month. The technique of synthesized speech was used to conduct four experiments from which the central concern and idea of this study arose. It was found that the level shape of synthesized speech indicates static tone perception. And the movement of synthesized speech, especially the onset, is a cue for dynamic tones perception. It was also noted that high tone identification by participants is improved by clear F_0 movement.

3. Language data

The language data used as the test tokens were drawn from Standard Thai belonging to the Tai-Kadai language family. The language has a repertoire of nine monopthongal vowels /i, ɨ, u, e, ə, o, ɛ, a, ɔ/ with vowel length distinctions. But all the test words contained vowel /aa/. The reason for selecting /aa/ was to avoid an effect of intrinsic pitch.

Forty participants were chosen. As language change can be affected by age, these participants were then divided into two groups: twenty participants were over sixty years old and another twenty participants were under twenty years old. Each age group is comprised of twenty participants of male and female. The changing age of participants was used to help further confirmation the claim of high tone change. It is believed that age is one of the most important factors to test the change in tones over time (Chambers, 1995; Labov, 1994). As stated before, over-sixty group represents the past and under-twenty group represents the present and the future.

Three sets of test tokens were selected for /aa/ vowel with various kinds of initial consonants as follows:

Set 1	Set 2	Set 3
khaa ‘to be stuck’	naa ‘rice field’	faa ‘a note’
khàa ‘galangal’	(nóy) nàa ‘custard apple’	fàa ‘palm (of the hand), sole (of the foot)’
khâa ‘servant, slave’	nâa ‘face’	fâa ‘scum’
kháa ‘to trade’	náa ‘aunt’	fáa ‘sky’
khǎa ‘leg’	nǎa ‘thick’	fǎa ‘pot cover’

4. Methodology

4.1 Acoustic Analysis

After preparing the appropriate test tokens (For example, all test tokens had voiceless and voiced initials to avoid context effects), the participants were asked to pronounce each test word in isolation five times. They pronounced each word with a moderate tempo. The number of total test tokens was six thousand (forty participants x two age groups x five tokens x three sets x five times). Cooledit Pro was used to segment each vocalization. The Praat program version 4.2.09 was used to analyze the F_0 of isolated words. The frequency at five points of time for each vowel was selected for measurement, at 0%, 25%, 50%, 75% and 100%. Microsoft Excel 2003 was used for analyzing and plotting graphs illustrating the overall mean ($\bar{x}$) of high tone F_0.

5.2 A Perceptual experiment

The fundamental frequency (F_0; Hz) which relates to the rate of vocal folds vibration in the larynx was used in the speech synthesis. The Praat program version 4.2.09 was used to synthesize the word [khaa] ‘to be stuck’. The duration and loudness were controlled. And pitch range in Hertz (Hz), 150-240 Hz, was drawn from the F_0 measurement in both the over-sixty group and the under-twenty group. Then the speech ranging from 150-240 Hz was synthesized into three patterns each represented by a graph as follows:

Experiment 1: Figure 4 shows simple straight contours that were used as stimulus to test static tones. The first variant was started at 150 Hz and then the remaining contours move up to 240 Hz in 5-Hz steps. There are 19 F_0 contours.

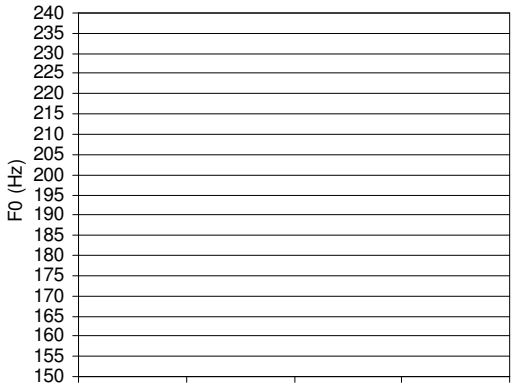


Figure 4 Nineteen simple straight contours stimulus for experimental 1 ranging from 150 to 240 Hz

Experiment 2: Figure 5 shows stimulus for this test. There are eighteen contours starting at 150 Hz and going up to endpoints ranging from 155 Hz to 240 Hz (the exception is a contour which starts at 150 Hz and ends at 150 Hz, due to its being tested in experiment 1).

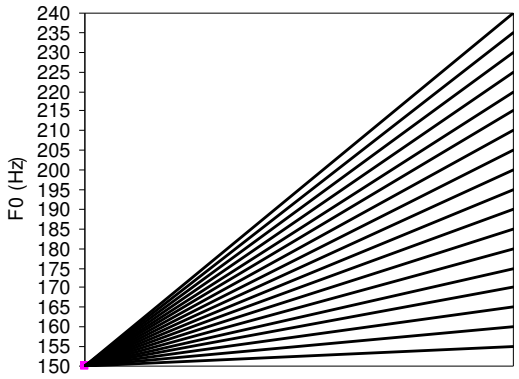


Figure 5 Eighteen contours stimulus for experiment 2 starting at 150 Hz and arriving at end points ranging from 155 to 240 Hz

Experiment 3: Figure 5 shows stimuli for this test. There are eighteen contours starting at in the middle of the pitch range, 195 Hz, and ending at points ranging from 150 Hz to 240 Hz (the exception is a contour starts at 195 Hz and ends at 195 Hz, due to its being tested in experiment 1).

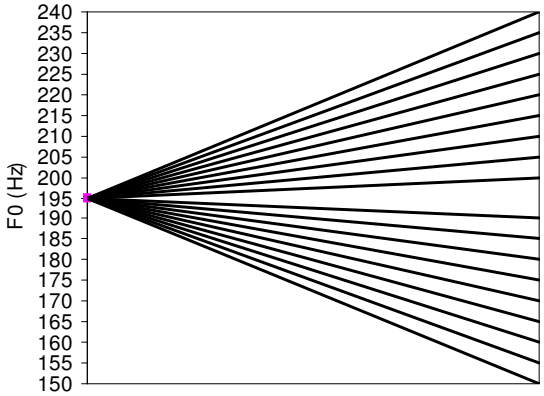


Figure 6 Eighteen contours stimulus for experiment 3 starting at 195 Hz and arriving at end points ranging from 150 to 195 Hz and 200 to 240 Hz

Forty participants of each age group were then asked to listen to each stimus and choose the answer from 5 choices, [khaa] 'to be stuck', [khàa] 'galagal', [khâa] 'value', [kháa] 'to trade', [khǎa] 'leg'.

5. Results: an acoustic study

5.1 The overall mean of Thai high tone in the over-sixty group

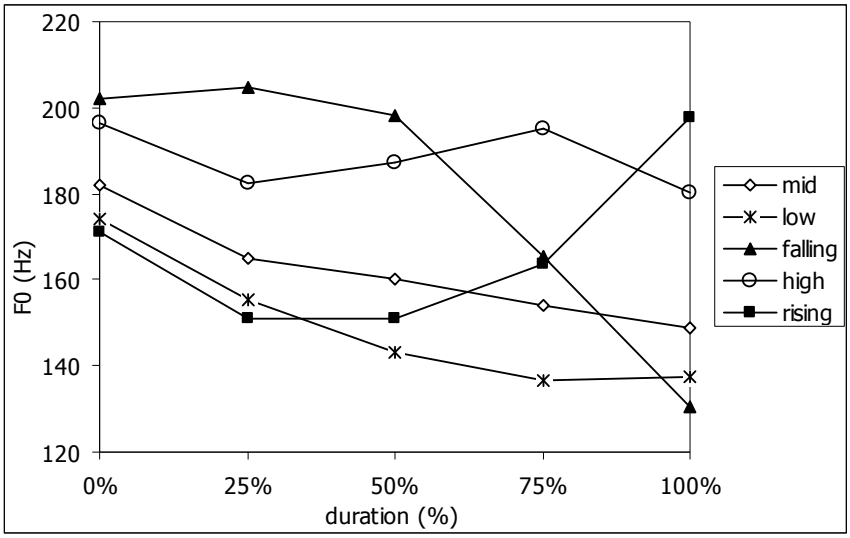


Figure 7 F_0 shapes of Thai high tone in the over-sixty group

In Figure 7, the results show that the Thai high tone among members of the over-sixty group is similar to that which was found in Abramson (1962). The high tone is consistently high level [44]. It begins with high pitch, then steadily rises before slightly falling. It is because the participants represent the second period of tone change (see Table 1). In comparison with rising tone, rising tone begins with lower pitch then slightly falls before rising.

5.2 The overall mean of Thai high tone in the under-twenty group

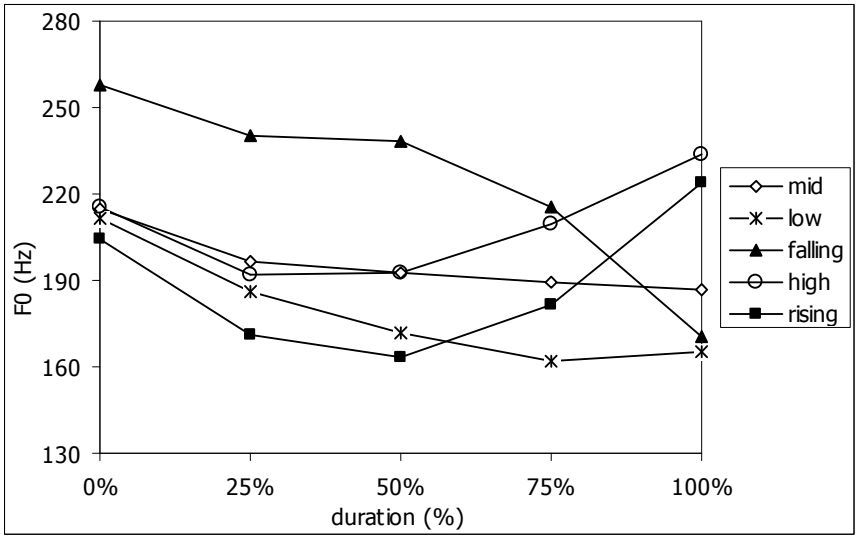


Figure 8 F_0 shapes of Standard Thai tones in the under-twenty group

As seen in Figure 8, the under-twenty high tone shape became [334] which is more similar to rising tone. And the starting point of the pitch for high tone and rising tone is lower

than that of the over-sixty group. Both tones seem to be more contoured, sharply falling and rising. This result confirms the gradual change of Thai high tone from high level [44] to mid-rising [334]. The findings support the change of high tone reported by Abramson (1979), Panroj (1991), Tumtavitikul (1992), and Teeranon (2002a, 2002b).

As all Thai tones are well-defined by F_0 shape, the shape of high tone has changed to be more contoured. This leads to the question of whether or not high tone should be placed as a contour tone instead of a level tone.

In addition, it was found that falling tone is changing. In comparison with the over-sixty group, falling tone shape in the under-twenty group levels off at higher level for half of the duration before gradually dropping (see Figure 7 and 8). This result supports the findings of Lertthana (2005) that falling tone is becoming less contoured.

6. Results: a perceptual experiment

6.1 Experiment 1: identification of straight contours in Figure 4

In experimental 1, it is hypothesized that percentage of high tone identification of the over-sixty group is greater than that of the under-twenty group as the stimulus are in static shape or level F_0.

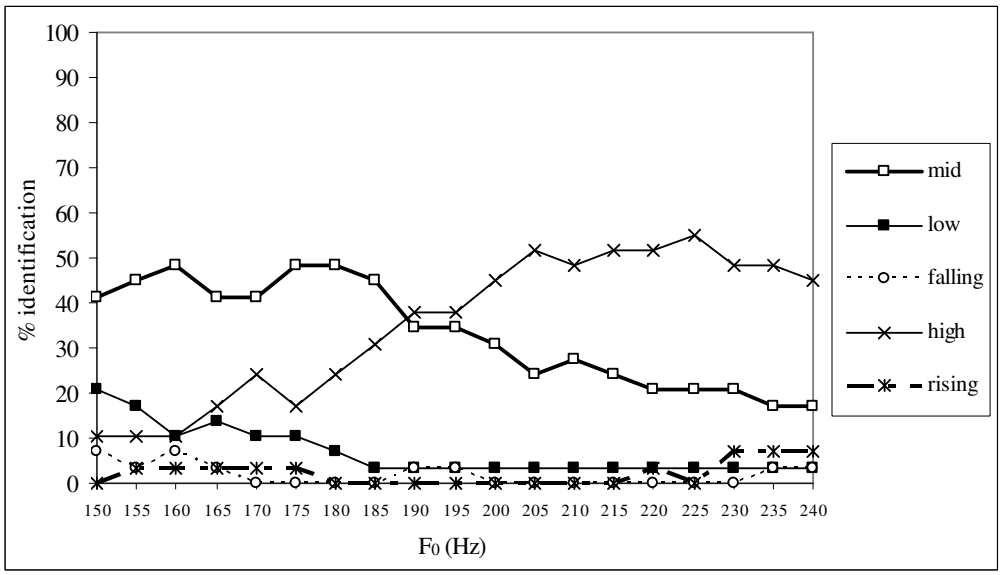


Figure 9 Identification of straight contours in Figure 4 in the over-sixty group

Figure 9 shows that in the over-sixty group, percentage of mid tone identification crashed from 50% to 20% when the F_0 straight contours were moved up to high level, while percentage of high tone identification gradually peaks to over 50%.

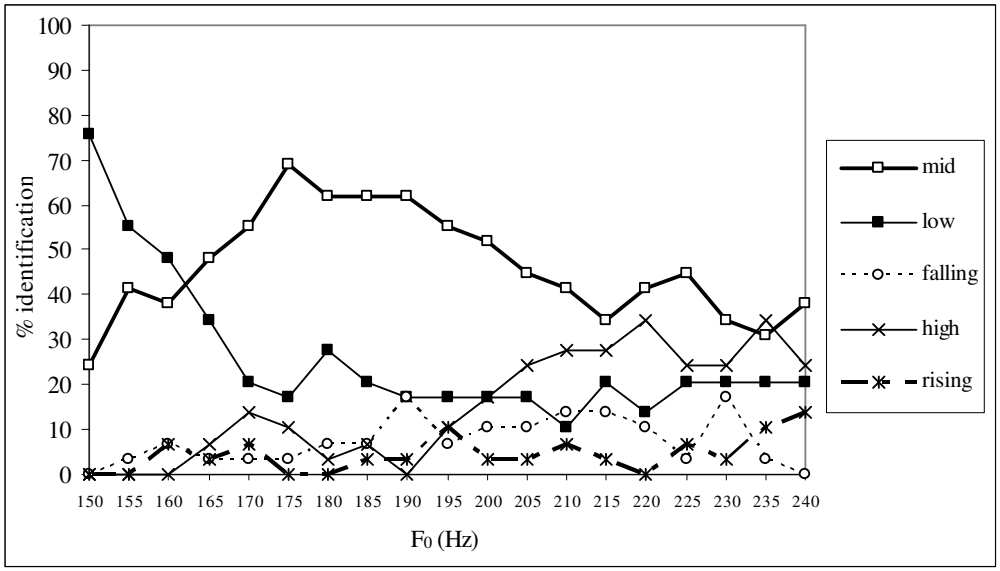


Figure 10 Identification of straight contours in Figure 4 in the under-twenty group

Figure 10 shows that low tone identification plunges from above 75% to a point around 20% when F_0 straight contours were moved up to high level. Mid tone was identified predominantly at about the middle of F_0 range.

In comparing between percentages of high tone identification in the under-twenty group with the over-sixty group, it was found that, when the F_0 straight contours were increased, percentage of high tone identification was less than in the under-twenty group. And high tone is presumably perceived more as high level tone in the over-sixty group than in the under-twenty group.

6.2 Experiment 2: identification of contours in Figure 5

In experimental 2, it is hypothesized that percentage of high tone identification of the over-sixty group is less than that of the under-twenty group because the stimuli are in dynamic shape or contour F_0.

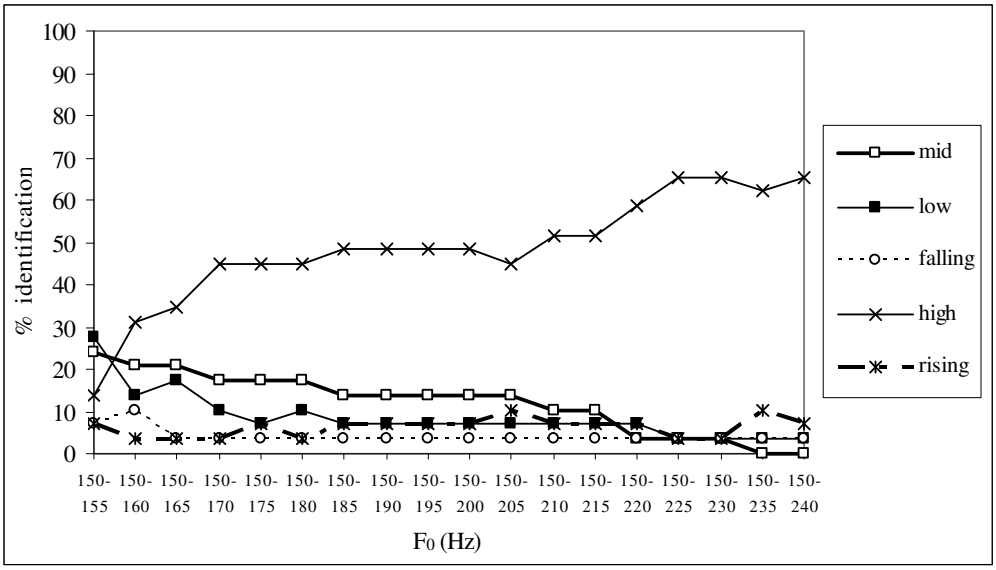


Figure 11 Identification of contours in Figure 5 in the over-sixty group

Figure 11 shows that in the over-sixty group, percentage of high tone identification gradually increases from 15% to more than 60% when the F_0 end points were increased, while the other tones identification are at the bottom line.

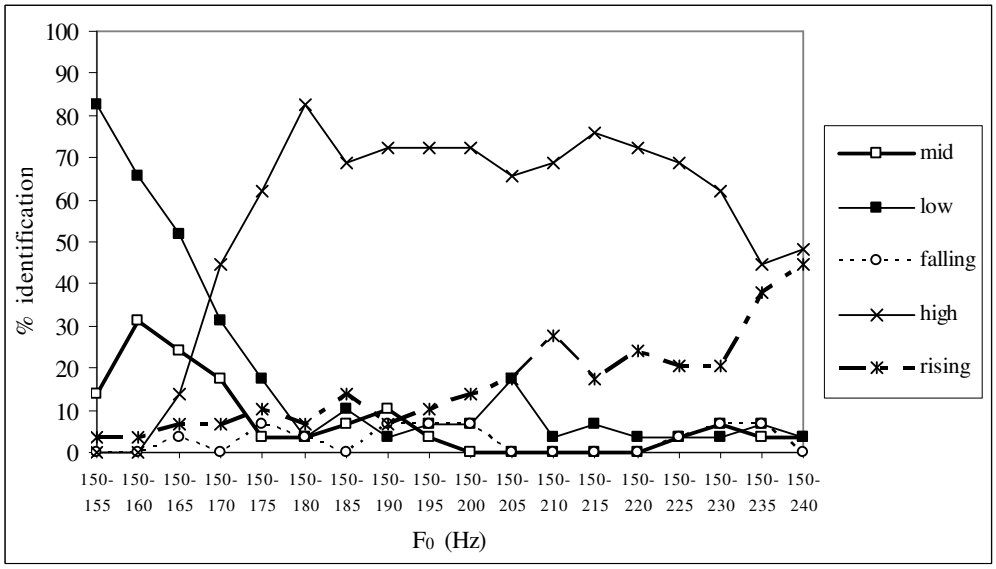


Figure 12 Identification of contours in Figure 5 in the under-twenty group

Figure 12 shows that percentage of low tone identification dramatically drops from 82% to a point below 10% when the F_0 end points were increased. High tone identification seems to peak and separating itself from the other tones identification.

In particular, percentage of high tone and rising tone identifications seem to come close when the end points of F_0 contour were increased to the highest F_0. In other words,

when the synthesized pitch is more contoured or more dynamic, the participants apparently confused high and rising tone.

In comparing percentage of high tone identification in the under-twenty group and in the over-sixty group, it was found that % of high tone identification was less in the over-sixty group. Consequently, the experiment 2 hypothesis is supported. High tone is probably perceived as contour tone in the under-twenty group than in the over-sixty group.

6.3 Experiment 3: identification of contours in Figure 6

In experimental 3, it is hypothesized that percentage of high tone identification of the over-sixty group and in the under-twenty group is low in the first half of the stimulus as they are in falling contour. However, in the second half of the stimulus, which are in rising contour shape, percentage of high tone identification in the over-sixty group is less than that of the under-twenty group.

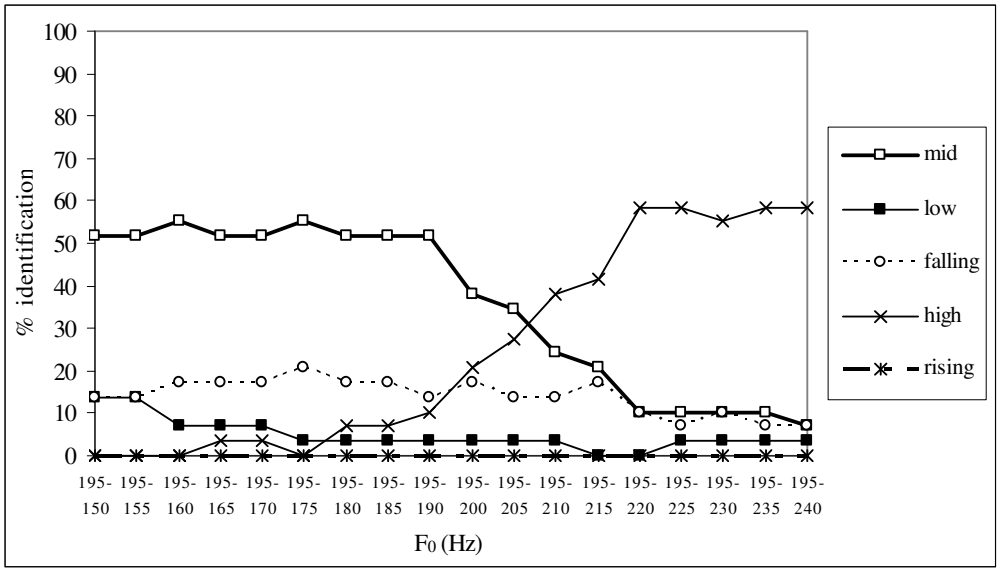


Figure 13 Identification of contours in Figure 6 in the over-sixty group

In the over-sixty group, Figure 13 shows that percentage of high tone identification in the first half of the stimulus is at the bottom line. By contrast, in the second half of the stimulus, percentage of high tone identification gradually peaks to 60%. Percentage of mid tone identification is high, amounted to 50%, in the first half of the stimulus (falling shape stimulus). Then the identifications gradually drop to a point around 10% when the F_0 contours were changed from falling shape to rising shape.

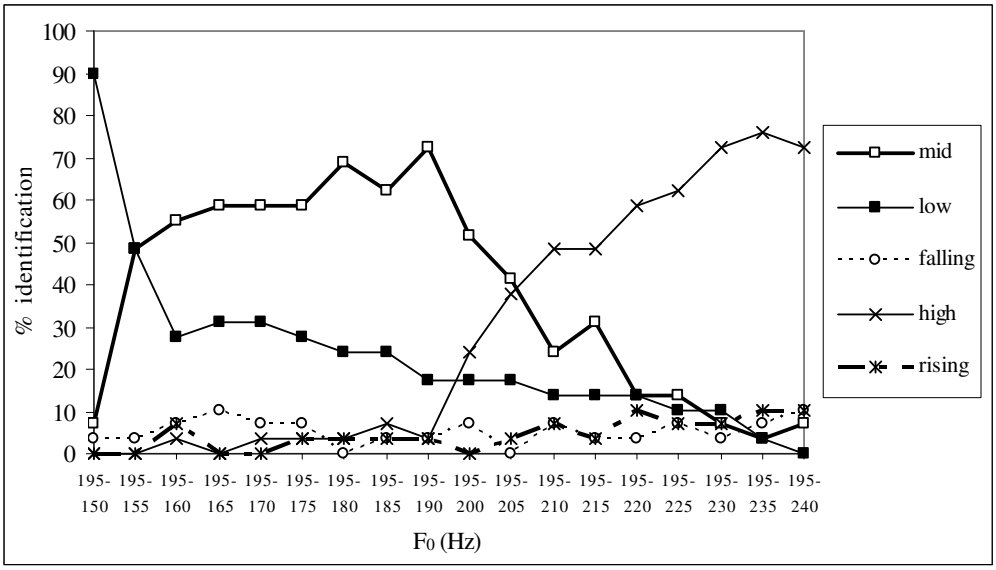


Figure 14 Identification of contours in Figure 6 in the under-twenty group

In the under-twenty group, Figure 14 shows that percentage of high tone identification in the first half of the stimulus, which are falling shape, is at the bottom line. By contrast, in the second half of the stimulus, which are rising shape, percentage of high tone identification gradually peaks at over 70%. Obviously, % of mid tone identification is high, amounted to 60%-70%, in the first half of the stimulus. Then the identification gradually drops to a point around 10% when the F_0 contours were changed from falling shape to rising shape. Besides, it is obvious that percentage of low tone identification in the first half of the stimulus plunges from 90% to a point under 20%.

In comparing between percentage of high tone identification in the under-twenty group and in the over-sixty group, it was found that percentage of high tone identification was less in the over-sixty group. Consequently, the experiment 3 hypothesis is supported. High tone is probably perceived as contour tone in the under-twenty group than in the over-sixty group.

In Experiment 2, the stimulus starts at 150 Hz and go to endpoints ranging from 155 Hz to 240 Hz. In experiment 3, the stimulus starts at 195 Hz and go to end points ranging from150 to 240 Hz. That is to say, the rising shape stimulus in experiment 2 is more contoured than experiment 1. Consequently, percentage of high tone identification in experiment 1 is higher than in experiment 2. And it is obvious that percentage of rising tone identification in experiment 1 is higher than in experiment 2.

7. Discussion and conclusion

Based on the acoustic findings, Standard Thai high tone has changed its shape from high-falling [442] to high level [44 or 45], and to mid rising contour [334]. The shape of high tone manifests itself in rising shape like rising tone. However, it is obvious that the starting point of high tone is mid but the rising tone is low (See Figure 7 and 8).

This study supports the importance of studying Thai tones in isolated words in previous work (Abramson, 1962, 1975, 1997; Erickson, 1974; Gandour, 1974), although the

study of Thai tones in connected speech has shown the rapid pace (Gandour et al., 1999, 2002; Potisuk et al., 1994; Tingsabadh and Deeprasert, 1997; Nasanee, 2003).

The perceptual experiments conducted by using "ideal" contour in Abramson's methodology (Abramson, 1997) have generated additional information on the two-generation perception. The over-sixty group, which represents the past, basically perceives high tone as a level tone (See Figure 9 and 10). On the contrary, the under-twenty group, which represents the present, seemingly perceives high tone as a contour tone (See Figure 11, 12, 13, and 14).

In comparing between Figure 12 and Figure 14, Figure 12 shows that the under-twenty group starts to become confused concerning the difference between high and rising tone when the F_0 movement (the difference of the starting point and the end point of F_0) is high. Alternatively, in Figure 14, when F_0 movement is smaller, only high tone seems to be perceived. This can be interpreted that a rapid movement of F_0 is needed for contour tone perception as stated in Abramson (1997: 9) and Pittayaporn (2007). In addition, this result also show the correspondence between F_0 shape of high tone found in an acoustic study and the perceptual experiment that the high tone shape has not manifested itself as contour as the rising tone (See Figure 9 and 10). This is due to the progressive change of Thai high tone is in progress, the so called an observable change in progress (Labov, 1994; Aitchison, 2001).

The acoustic study within the perceptual study in this study shows that high tone is arguably a contour tone and not a level tone as classified in earlier work (Abramson, 1962, 1975, 1978).

To sum up, the study shows the change of Standard Thai high tone acoustically and perceptually. It is an open question and the subject further as to whether or not the high tone in Thai should be recategorized as a member of contour tone classification. Finally, the study supports the importance of using age groups in studying language change in progress.

Acknowledgements

I would like to express my gratitude to all our participants for their cooperation. I am grateful to the Division of Research Services, Mae Fah Luang University for the research fund. And I would like to thank you Mr.Michael Hettinger for his comments on the final draft.

Notes:

1 Standard Thai is an official language spoken by educated speakers in every part of Thailand, used in news broadcasts on radio and television, taught in school, and describe in grammar books and dictionaries (Tingsabadh and Abramson, 1993). I use the term Standard Thai because it has been classified as a variety of Central Thai on the basis of tone system and one split (Gedney, 1972).

2 From now on, I refer to them as the over-sixty group and under-twenty group, respectively.

3 Though C.B. Bradley conducted the research in 1908, his paper was published in 1916.

4 Actually, there were many works concerned with Standard Thai tones done by linguists in each period. But we selected to present only one representative piece of work in each period. In addition, the rule for selection is the age of participants in the earliest periods must not exceed twenty-five. Therefore, the participants are sixty-five years old at present; in other words, they are in the same generation as our over-sixty group participants.

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