University of Pennsylvania Working Papers in Linguistics

Volume 14
Issue 1 *Proceedings of the 31st Annual Penn Linguistics Colloquium*

Article 30

April 2008

Modeling diachronic change in the Thai tonal space

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Zsiga, Elizabeth C. (2008) "Modeling diachronic change in the Thai tonal space," *University of Pennsylvania Working Papers in Linguistics*: Vol. 14 : Iss. 1 , Article 30.
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Modeling diachronic change in the Thai tonal space

Abstract

This paper investigates a diachronic change that has taken place in the production and perception of the "rising" tone in Bangkok Thai, comparing data collected in the 1960's and 1970's with data collected 2004 to 2006. Regarding production, several studies have found that the abrupt pitch rise that had characterized the rising tone in earlier studies is now curtailed, such that the pitch of the rising tone does not actually rise above the middle of the pitch range. Concomitant with the change in the production has been a change in perception. Abramson (1978) found that a steeply rising trajectory, from the bottom of the pitch range at syllable onset to the top of the pitch range at syllable offset, was identified as a lexical item with a rising tone in 90% of presentations. In a partial replication and extension of Abramson's experiment by Zsiga & Nitisaroj (2007), the same steeply rising trajectory was identified with the lexical item bearing the rising tone in only 5% of presentations; 85% of the time, this trajectory was identified with the high tone item. Zsiga & Nitisaroj found that the only tokens reliably identified as "rising" were those in which the pitch contour reached the bottom of the range at or near syllable midpoint, and that any actual rise is optional in citation form and prohibited in connected speech.

It is argued here that this change can be understood only in the context of an abstract phonological representation, specifically, an autosegmental representation in which contour tones are compositional, and the mora is the tone-bearing unit in Thai. In this representation the rising tone has two pitch targets: L associated to the first mora, H associated to the second. The diachronic change can then be modeled as phonetic reduction of the H tone associated to the second (weaker) mora, followed by a shift of attention to the L tone associated to the first mora. Viewed through the lens of an abstract phonological representation, the diachronic change can be understood as a shift in perceptual importance from one phonologically specified target to another. Without reference to such a representation, the reversal in perception of rising trajectories makes no sense. This research thus supports the importance of abstract phonological representations in constraining the targets and outcomes of diachronic change in both perception and production.

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Modeling Diachronic Change in the Thai Tonal Space

Elizabeth C. Zsiga

1 Introduction

Over the past 30 years, a surprising change has occurred in the way Thai tones, particularly the rising tone, are perceived. In this paper, this change is examined through comparing perception and production studies from the 1970's, especially Abramson (1978), along with more recent studies, particularly Zsiga and Nitisaroj (in press). Abramson (1978) synthesized varying straight-line pitch trajectories on a syllable in isolation, and asked speakers of Bangkok Thai to identify the tone they heard. Among the trajectories tested was a pitch trajectory that rose from the bottom of the pitch range at the beginning of the syllable to the top of the pitch range at the end. Not surprisingly, 90% of the time, this syllable was identified as a lexical item with a rising tone. In contrast, Zsiga and Nitisaroj (in press) found that the same synthesized pitch trajectory was identified as a rising-tone item in only 5% of presentations. Instead of a rising tone, speakers predominantly identified this token as having a high tone. A number of different tokens were identified with a lexical item usually transcribed as rising, but these tokens did not all have rising pitch trajectories. Rather, what all these "rising" tokens had in common was that the trajectory reached the bottom of the pitch range somewhere near the middle of the syllable. Pitch might or might not rise from that point. How is such a change possible, such that rising trajectories are not heard as "rising" tones, and level lows are heard as "rising"? It will be argued here that the answer lies in understanding the system of tonal contrast in Thai, and how those contrasts are represented in the minds of the speakers. Specifically, this paper will argue that the diachronic data support a compositional analysis of contour tones, in which the mora is the tone bearing unit.

2 Thai Tonal Contrasts

Thai contrasts five tones, as shown in Table 1. At least since the work of Abramson (1962), these tones have been described and transcribed by linguists as high, mid, low, falling and rising. It is worth noting however, that Thai speakers themselves do not use these labels, instead using names that correspond to military ranks.

high	mid	low	falling	rising
ná: *aunt*	na: *rice field*	nà: *custard apple*	nâ: *face*	nă: *thick*
k^há: *to trade*	k^ha: *to be stuck*	k^hà: *galangal*	k^hâ: *value*	k^hă: *leg*
láw *coop*	law *classifier for wood instr.*	làw *group*	lâw *alcohol*	lăw *to sharpen*

Table 1: Thai tonal contrasts.

Numerous linguists have addressed the question of whether "rising" and "falling" tones in Thai and other languages are compositional (that is, composed of a sequence of H and L autosegments), or unitary, where the unit of contrast is the upward or downward movement itself. At the present time, most phonologists, exemplified by Yip (2002), assume that all tones are compositional, allowing a unified cross-linguistic analysis of level and contour tone systems, and of tone and pitch accent systems. Morén and Zsiga (2006) argue that a compositional analysis provides the best explanation of certain facts about distributions and simplifications in the Thai tonal system. Phoneticians who pay careful attention to the production and perception of tone, however, do not always agree with a compositional analysis. Abramson (1979:7) states that there is "no phonetic plausibility" to the hypothesis that "rising" tones are composed of H plus L. Rather, Abramson argues that "it seems psychologically far more reasonable to suppose that the speaker of Thai stores a suitable tonal shape as part of his internal representation of each monosyllabic lexical item." Perceptual studies, beginning with Abramson's and Gandour's work in the 1970's (Abramson 1978, Gandour and Harshman 1978) and continuing today, as exemplified by work by Gandour et al. (2000) and Xu (2004), argue that listeners pay attention to movement rather than endpoints.

Whether one chooses unitary or compositional tones, one also has to answer the question: what is the tone-bearing unit (TBU) in Thai? Different linguists have suggested different prosodic units. Leben (1971) and Gandour (1973) assume the vowel is the TBU in Thai; Yip (1982) and Zhang (2002) assume the syllable. Yip (2002) discusses both the syllable and mora as possible candidates for the Thai TBU, and Morén and Zsiga (2006) argue for the mora. Following Morén and Zsiga (2006), this paper will argue that tones are compositional, and that the TBU is the mora, as shown in (1).

(1)

high	mid	low	falling	rising
H		L	H L	L H
|		|	| |	| |
μ μ	μ μ	μ μ	μ μ	μ μ

In this representation, each syllable is composed of two moras. The necessity of a bi-moraic syllable is supported by the interaction of tone and stress: only stressed syllables can carry the five-way contrast, and all stressed syllables are heavy, either CV: or CVC (see Morén and Zsiga 2006, Nitisaroj 2006 for further discussion). The mid tone has no pitch target, the high and low tones have a single pitch target aligned as far right as possible, and the falling and rising tones have a target specified for each mora.

The following sections will consider how evidence from diachronic change in Thai tone production and perception can provide insight into which tonal representation best captures the tonal contrasts of Thai.

3 Changes in Tone Production

This section considers changes in the acoustic contours of Thai tones that have taken place over several decades, comparing tone contours in citation form and connected speech as reported by Abramson (1962), Abramson (1979), Morén and Zsiga (2006) and Nitisaroj (2006). Figure 1 graphs the tones of Thai in citation form as reported by Abramson (1962). The contours represent an average over multiple repetitions by two adult male speakers. Note the shape of the rising tone: low at the beginning of the syllable and high at the end. The high tone is fairly flat, but does trend upward.

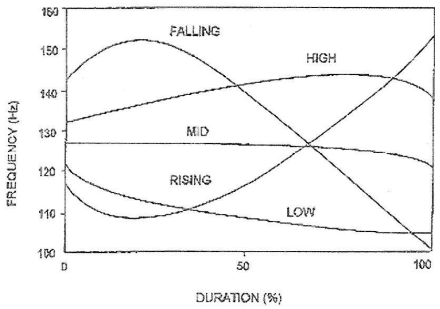

Figure 1: Thai tonal contours from Abramson (1962), Fig. 3.6.

Figure 2 shows data from approximately 15 years later (Abramson 1979), corresponding to the time for which Abramson also reports perceptual data. In Figure 2, the speaker is an adult female, and the contours again represent an average over multiple representations. Graph 2A shows tonal contours in citation form; Graph 2B shows contours in connected speech, between two mid tones. Note that, in both contexts, the rising tone stays at or near the bottom of the pitch range for some time, and the high tone has taken on a more scooped shape. (That is, the upward movement of the high tone does not begin until mid-syllable.) In citation form, however, the rising and high tones end at the same place, at the top of the pitch range. In connected speech, the rising tone ends at a point intermediate between mid and high. The lower origin of the falling tone in 2B, resulting in a rise-fall shape, can be attributed to the preceding mid-tone context.

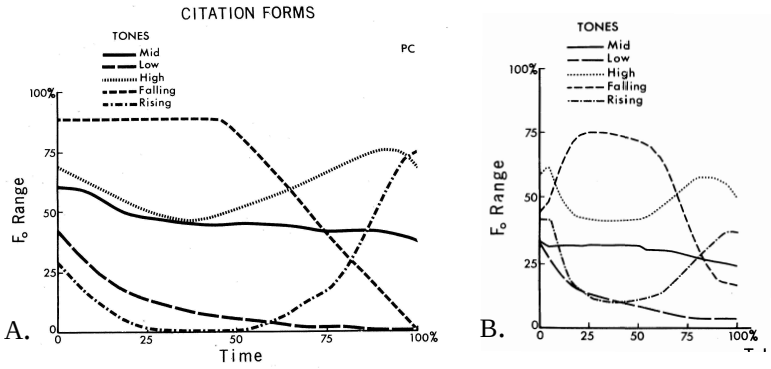

Figure 2: Thai tonal contours from Abramson (1979). A. Citation form; B. Tonal contours in connected speech between mid tones

Figure 3 graphs more recent data, citation forms in Figure 3A and connected speech in Figure 3B. Figure 3A is taken from Morén and Zsiga (2006). This graph shows a single representative token, produced by a young adult female, but the data is consistent with patterns reported for young female speakers in Bangkok by Kallayanamit (2005) and Nitisaroj (2006). Figure 3B, from Nitisaroj (2006), shows production of stressed mono-syllables between mid tones in connected speech. The contours in 3B represent an average over the productions of ten young adult speakers, both men and women (with pitch range normalized to a z-score). The contours of the high, mid, and low tones have not changed much since 1979, nor is there much difference between citation form and connected speech. These three

tones begin at a common mid origin, from which the low tone falls and the high tone scoops upward. Changes are seen in the rising and falling tones, however, both over time and according to context. In the 1979 data, the rising tone rises from low to high in citation form and from low to mid in connected speech. In the 2006 data, it rises from low to mid in citation form, and in connected speech it hardly rises at all, ending below the point where the mid tone ends. The differences in the falling tone are even more striking. In 1979, the contour is rise-fall. In 2006, in connected speech, Thai "falling" tones don't fall at all.

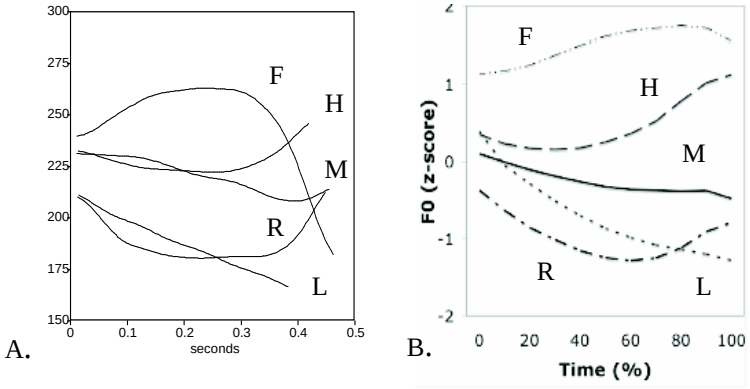

Figure 3: A. Thai tonal contours in citation form (Morén and Zsiga 2006). B. Tonal contours in connected speech between mid tones (Nitisaroj 2006).

4 Modeling the Changes in Production

How can these changes be represented? Descriptively, over time the offsets of complex tones are weakened or deleted. I would argue that this change can best be captured by the association of autosegments to moras, as shown in Table 2.

The mid tone is simply the absence of any inflection. When no pitch target is specified, there is a slow downward trend resulting from phonetic declination. (Downward movement in the absence of a target is supported for Thai with acoustic and electromyographic data in Erickson 1994.) In order to capture the mid to high movement of the high tone and the mid to low movement of the low tone, the high tone is specified as high only on the second mora, and the low tone as low only on the second mora. Thus all three "level" tones trend downward during the first half of the syllable (first

mora), and the high and low tones reach their respective pitch targets only at the end of the syllable (end of the second mora).

	high	**mid**	**low**	**falling**	**rising**
Citation form	H | μ μ	 μ μ	L | μ μ	H L | | μ μ	L H | | μ μ
Connected speech	H | μ μ	 μ μ	L | μ μ	H | μ μ	L (H) | | μ μ
Perceptual cue in both	High late in the syllable	No pitch inflection	Low late in the syllable	High early in the syllable	Low early in the syllable

Table 2: Proposed representations of Thai tonal contrasts in both citation form and connected speech.

The complex tones are specified on both moras in citation form. Contrasting with the high, mid, and low tones, the rising and falling tones reach their high and low pitch targets early in the syllable. The “falling” tone quickly rises to the top of the pitch range and the “rising” tone drops to the bottom. It is the second half of the tone (the autosegment associated to the weaker, less sonorant, mora) that that is affected by context and that has changed over time. Because the default pitch movement when there is no specification is downward, it is assumed that an H autosegment, corresponding to a high pitch target, is always present on the second mora of the rising tone, though it is phonetically weakened, especially in connected speech. (It may sometimes be completely deleted in fast speech.) The falling tone falls to the bottom of the pitch range in citation form due to the L associated to its second mora. In connected speech, however, this L is completely deleted, and the “falling” tone remains at the top of the pitch range.

This has been the diachronic change: weakening and eventual deletion of the second specification of the complex tones.

The representations in Table 2 lead to predictions about perceptual cues, as shown. The cue to the “falling” tone is that is should be high; the cue to the “rising” tone is that it should be low. These predictions are examined in the next section. Unfortunately, Abramson (1978) did not report perceptual data on a full set of falling trajectories, so the comparison across time will concentrate on change in the perception of the rising tone.

5 Changes in Tone Perception

We have a window on how Thai tone perception has changed in the last 25 to 30 years by comparing the results of perception studies published by Abramson in 1975 and 1978 with a more recent study by Zsiga and Nitisaroj.

Abramson (1975) and Zsiga and Nitisaroj (2007, experiment 1) asked Thai listeners to identify syllables produced in citation form by a Thai talker. The stimuli consisted of five-way minimal sets, as shown in Table 1. Abramson used the syllable /k^{h}a:/ and Zsiga and Nitisaroj the syllable /na:/. In both studies, Thai listeners were able to identify the naturally-produced lexical items with 98.6% accuracy. Thus, we can conclude that the five-way contrast continues to be maintained in Thai, at least in citation form.

Abramson (1978) and Zsiga and Nitisaroj (2007, experiment 2) used synthesized or digitally-altered stimuli to further test perceptual cues to the tonal contrasts. The designs of the two studies are compared in Table 3. Abramson used only straight-line trajectories across the syllable, with a 4 Hz step size. Zsiga and Nitisaroj used more varied contours, including some that were straight-line and many where pitch changed direction mid-syllable, but with a larger (20 Hz) step size. Thus, the two studies overlap in a subset of their stimuli. These common trajectories are shown in Figure 4. Note that although the pitch ranges in the two experiments are different as measured in Hz, in both cases the full range of a speaker is represented. In what follows, results for this overlapping subset are compared.

	Abramson 1978	**Zsiga & Nitisaroj 2007**
type	synthesized	pitch digitally altered on natural utterance
syllable	/k^{h}a:/	/k^{h}a:/ and /law/
context	citation	citation
voice	male	female
duration	350 ms	300 ms
manipulation	straight-line trajectories: level, from mid origin, and from low origin	onset, midpoint, and endpoint varied independently
step size	16 steps of 4 Hz; 92 to 152 Hz	5 steps of 20 Hz at each point; 170 to 250 Hz
listeners	37 college students in Bangkok	10 young adults in Bangkok

Table 3: Comparison of experimental designs in Abramson (1978) and Zsiga and Nitisaroj (2007, experiment 2).

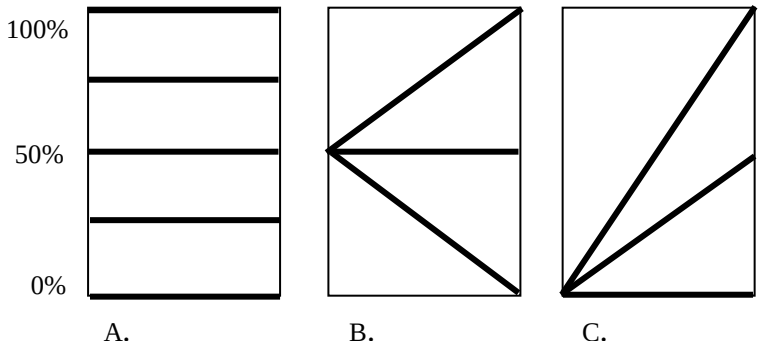

Figure 4: Pitch trajectories tested in both Abramson (1978) and Zsiga and Nitisaroj (2007). The y-axis represents the full pitch range of the subject in each case. A. Level trajectories. B. Trajectories from mid origin. C. Trajectories from low origin.

5.1 Level trajectories

Figure 5 shows the results (for all level pitch trajectories) from Abramson (1978). Low level pitch trajectories were identified as low tones, mid level as mid tones, and high level as high tones, with the pitch range about equally divided among the three tones.

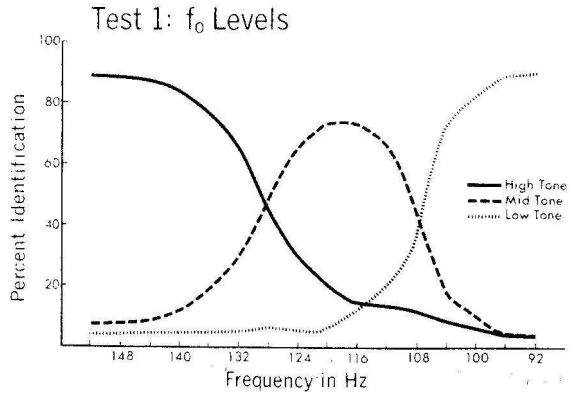

Figure 5: Identification function for level pitch trajectories, 1978. (Abramson 1978, Figure 2.)

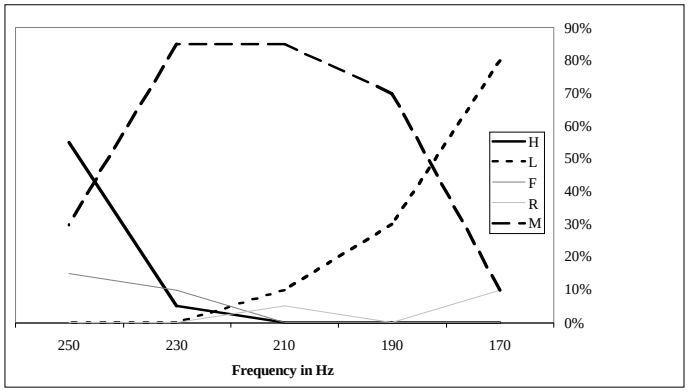

Figure 6: Identification function for level pitch trajectories, 2007 (data from Zsiga and Nitisaroj 2007).

Figure 6 graphs the results for level trajectories (see Figure 4A above) from Zsiga and Nitisaroj (in press). In this later study, Thai speakers were willing to identify very high, flat trajectories as high tones and very low, flat trajectories as low tones, but there is a much stronger tendency to identify any flat trajectory as mid. Further, a few listeners identified high level trajectories as "falling" and low level trajectories as "rising," even in citation form. Though these amounted to only 10% of responses in each case, these categories were never chosen for level trajectories in Abramson's study. Further, the identification of high pitch with falling tones and low pitch with rising tones is not accidental.

5.2 Slopes from mid origin

Results from the two studies for the slopes from mid origin (Figure 4B above) are compared in Table 4. The data are presented as a table rather than a figure because of the smaller number of data points. In general, results for these gradually-sloping trajectories are comparable across the two studies. The predominant identifications are the same, as shown by the bolded cells. Trajectories from mid to high are identified as high tones, and from mid to low are identified as low tones. The listeners in the later study, however, were more likely to identify these mid-origin trajectories as "level" high or low tones, and less likely to identify them as "dynamic" rising and falling.

Slope:	Identified as:				
	H	M	L	R	F
mid-to-high					
Abramson:	**85%**			15%	
Z&N:	**90%**			5%	5%
mid-level					
Abramson:	20%	**75%**	5%		
Z&N:		**85%**	10%	5%	
mid-to-low					
Abramson:		10%	**90%**		10%
Z&N:			**100%**		

Table 4: Identification for slopes from mid origin. Data from Abramson (1978) Figure 4 and Zsiga and Nitisaroj (2007) Table 5.

5.3 Slopes from low origin

Table 5 shows the results for trajectories that begin at the bottom of the pitch range (Figure 4C above).

Slope:	Identified as:				
	H	M	L	R	F
low-to-high					
Abramson:	**10%**			**90%**	
Z&N:	**85%**			**5%**	10%
low-to-mid					
Abramson:	**20%**	5%	10%	**65%**	
Z&N:	**60%**	25%	15%	**0%**	
low level					
Abramson:	5%	5%	**90%**		
Z&N:		10%	**80%**	10%	

Table 5: Identification for slopes from low origin. Data from Abramson (1978) Figure 4 and Zsiga and Nitisaroj (2007) Table 5.

The low level trajectories are unsurprisingly identified as low tones in both studies. The results for the rising trajectories are very different, however. In the 1978 study, a trajectory that rises from the bottom of the pitch range to the top is identified as a rising tone 90% of the time (and as a high tone 10% of the time). In the later study, this same trajectory is identified as a high tone 85% of the time, and as a rising tone only 5% of the time. Results for the low-to-mid trajectories are similar to the results for the

low-to-high trajectories, though not as strong. Again, trajectories that rise from a low origin were identified primarily as rising tones in the 1978 study and primarily as high tones in the later study.

Recall, of course, that the listeners in both studies were asked to identify lexical items, not linguistic labels. So it would be more accurate to state the results as: listeners in the 1978 study were more likely to identify a syllable with a low-to-high pitch trajectory as the word meaning “leg”, which is usually transcribed with a rising tone, and listeners in the later study were more likely to identify the same syllable as the word meaning “trade”, which is usually transcribed with a high tone.

The question then arises: If listeners didn’t identify a low-to-high rising pitch trajectory as a rising tone, what did they identify as a rising tone? Some of the trajectories most commonly identified as “rising” in citation form in the Zsiga and Nitisaroj study are shown in Figure 7.

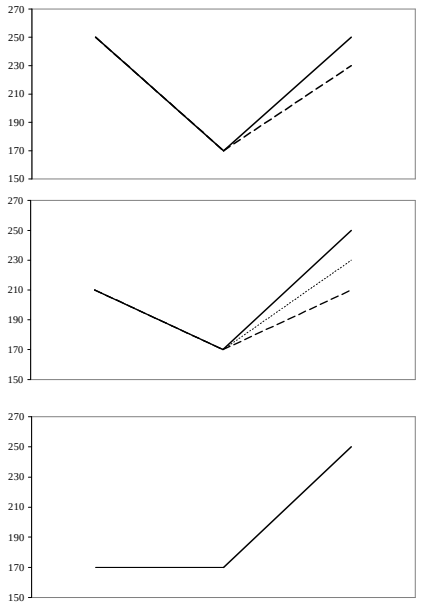

Figure 7: The trajectories most consistently identified as “rising” in Zsiga and Nitisaroj (2007). Solid = identified as rising in > 85% of presentations. Dashed = identified as rising in > 70% of presentations. Dotted = identified as rising in > 50% of presentations.

As Figure 7 shows, a variety of trajectories were heard as rising. There generally was a rise, but always confined to the second half of the syllable. The onset of the pitch movement, whether low, mid, or high, made little or no difference for tone identification. All trajectories primarily identified as rising in citation form had two points in common: a midpoint at the very bottom of the pitch range, and an endpoint above the middle of the pitch range. Any rising trajectory with a midpoint above 170 Hz, such as the trajectories in Figure 4C, were primarily identified as high tones.

We do not have data for connected speech tone perception in the 1970's. Zsiga and Nitisaroj, however, report perceptual data for connected speech. In this experiment (Zsiga and Nitisaroj, 2007, experiment 3), pitch was digitally altered on the syllables /na:/ and /law/ in a frame sentence between mid tones. In each case the syllable started at the middle of the pitch range. The midpoint and endpoint values were systematically varied in steps of 10 Hz, and then the pitch reset to mid on the following syllable. Trajectories primarily identified as rising and high are shown in Figure 8. The vertical lines indicate the beginning and end of the target syllable.

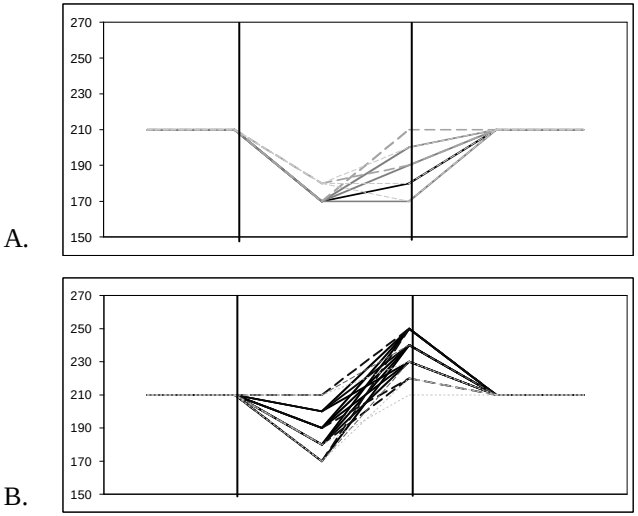

Figure 8: Pitch contours identified as rising tones (A) and high tones (B) in connected speech. Data from Zsiga and Nitisaroj (2007), experiment 3.

In order to be identified as a rising tone in connected speech, it was crucial that the pitch reach a low point at mid-syllable, and then *not* rise above the midline at the end. Any trajectories that were below the midline

during the first half of the syllable, but that did rise above the midline at the end, were identified as high.

6 Modeling the Changes in Perception

If the principal perceptual cues to tone identification are taken to be upward or downward pitch movements, this change in Thai tone perception is paradoxical. How could the cue for a rising tone change from "sharp rise" to "low" in the space of approximately 25 years? However, given the model of H and L autosegments associated to moras, such as that proposed in Table 2, the change is easy to understand. The change can be modeled as a shift in importance between two phonologically specified targets.

A plausible explanation runs as follows. Before the diachronic change begins, the rising tone is specified as high on the first mora and low on the second mora. This can be realized as a simple rise across the syllable (as in Figure 1, Abramson 1962). Phonetic factors, however, may lead to "tone delay" (Xu 1999): pitch targets are realized as late as possible in their specified domains. This stage can be seen in Figure 2A (Abramson 1979). Additional articulatory undershoot may cause weakening of the second target of complex tones, particularly in connected speech (Figure 2B).

Due to this weakening, the fall of "falling" tones and the rise of "rising" tones become less reliable cues. Thus perceptual weight shifts to the first target: early H for "falling", early L for "rising." As they lose perceptual importance, the second targets become even weaker, and may eventually be deleted, especially in casual speech (Figure 3B). Thus, the contrast eventually becomes early high vs. late high instead of falling vs. high, and early low vs. late low instead of rising vs. low, as shown in Table 2, and as evidenced in the experiments reported in Section 5.

This perceptual switch makes sense only in the context of an abstract phonological representation in which tones are autosegments associated to moras.

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