Effects of Stress on Vowel Length in Thai

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The phonetic correlates of stress vary from language to language. Some languages exploit pitch, loudness, duration, and quality. Most languages, however, make use of pitch, loudness, and duration only. Of these three cues, pitch and duration appear to be the principal phonetic correlates of stress. A major question that arises is the extent to which the relative importance of a given phonetic correlate of stress varies across languages as a function of their phonological structure.

The phonetic correlates of stress become especially interesting when one considers languages that use either pitch or duration or both to signal phonemic contrasts in their phonological systems. The idea is that the use of duration as a stress correlate would obscure phonemic vowel length contrasts. In those languages, pitch would be predicted to be the principal correlate of stress. Similarly, the use of pitch as a stress correlate would obscure phonemic tonal contrasts. As Hayes (1995) says, "stress is **parasitic**, in the sense that it invokes phonetic resources that serve other phonological ends". If phonetic resources are used up in signaling phonological distinctions, they are unavailable for signaling stress. This conceptualization of the interaction between stress and its phonetic correlates assumes that these phonological contrasts are to be preserved at all costs irrespective of stress demands at higher levels of linguistic representation. Whether or not such an assumption underlies the structural organization of languages of the world remains an empirical question.

This hypothesis has not yet been tested in a language that exhibits stress and employs both pitch and duration to signal phonemic contrasts. Thai is an interesting test case because it has five lexical tones as well as a vowel length opposition. In addition, stress has consistently been reported to be a rule-governed, phonetic characteristic of the language. Previous acoustic investigations have shown that F_0 is the primary acoustic correlate of Thai tones and that duration is the primary cue in signaling the vowel length opposition. It is incontrovertible that both pitch and duration in Thai are serving other phonological ends. It has also been demonstrated that pitch, duration, and quality are all affected by changes in stress. Therefore, we may conclude that both pitch and duration are implicated in signaling Thai stress as well as

phonemic contrasts of tone and vowel length.

Although it has been claimed that the vowel length distinction is lost in unstressed syllables, no systematic, quantitative study exists in the literature that examines the effects of stress on vowel length contrasts in Thai running speech. Thus, the primary aim of the present study is to investigate changes in vowel duration as a function of stress in running speech. Contrary to Haye's view of stress being parasitic, it is hypothesized that the vowel length contrast in Thai will be sacrificed to higher-level prosodic demands in sentence production.

Method

Five native speakers of Thai, two males, three females, participated in this study. All five were monodialectal speakers from the Bangkok metropolitan area.

Stimuli consisted of 16 pairs of syntactically ambiguous sentences (see Table 1 for example of sentence pairs; # = phrase boundary). Each member of a sentence pair (a-b; c-d) contained four syllables that were identical in segmental and tonal composition. Sentence pairs manifested four types of structural ambiguity. In sentences a) and c), target syllables occurred before a syntactic phrase boundary; in sentences b) and d), target syllables occurred before a word-internal boundary within a compound. Target syllables (/CVC/) in half of the sentence pairs contained phonologically, short vowels (a-b); in the other half, target syllables (/CVVC/) contained phonologically, long vowels (c-d).

Table 1

Sentence Stimuli

a) / **tàp # tàw** c^{h}âj máj /
'What is that black blob. Is it turtle liver?'

b) / **tàptàw** c^{h}âj máj /

'What do you call this kind of vegetable? Is it called /tàptàw/?'

c) / **c^{h}àap # c^{h}ŭaj** mâj dii /

'I won't throw anything to Chab anymore. Chab can't catch it.'

d) / **c^{h}àapc^{h}ŭaj** mâj dii /

'Son, money isn't everything. It's not good to be a shallow person.'

To evaluate the effects of stress on vowel length in target syllables, vowel length was held constant within sentence pairs. Target syllables in sentences a)

and c) were stressed, in sentences b) and d) unstressed. Within each sentence pair (a-b; c-d) , the tonal pattern on the two critical syllables was held constant to control for changes in duration that could be attributed to differences in tonal contours. Vowel quality was held constant across pairs in order to minimize concomitant, spectral differences related to stress. All but one of the nine *possible syllable-final consonants (/ p t k m n ŋ j w/) were represented in the* target syllables.

Within sentence pairs, the syntactic category of the target words or syllables was held constant. It was assumed that the two critical syllables in the (a,c) sentences all exhibit the same metrical pattern; similarly, the two critical syllables in the (b, d) sentences all exhibit the same metrical pattern.

Subjects were instructed to read target sentences preceded by one or two sentences of disambiguating context typed in Thai script on index cards. Recordings were made in a soundproof booth using a Sony ECM-66B unidirectional microphone and a Marantz PMD-420 taperecorder. A total of 160 utterances were recorded for each speaker in two sessions. Test stimuli were counterbalanced across sessions such that the a) and c) members of all pairs were assigned to the first recording session, the b) and d) members to the second session. The tape-recorded stimuli were low-pass filtered at 10 KHz and digitized at a sampling rate of 20 KHz using the Kay CSL software installed on a Gateway 2000 P5-90 microcomputer.

Syllable-final consonant clusters are prohibited in Thai. Stops, glides, and nasals are the only segments permitted to occur in coda position. Therefore, we constructed a phonetic dichotomy between rhymes ending in a nonnasal segment (short - /VS,VG/; long - /VVS,VVG/) versus those ending in a nasal segment (short - /VN/; long - /VVN/). Phonetically, /VG/ and /VVG/ are analyzed as short and long dipthongs, respectively. In common with /VS/ and /VVS/, vowel formants of /VG/ and /VVG/ extend to the end of the rhyme without any intervening nasal murmur. In constrast, vowel formants are interrupted by a nasal murmur before reaching the end of the /VN/ and /VVN/ rhymes. Acoustically, /VV/ syllables minus a coda, albeit excluded from this study, would be expected to behave like /VVG/.

To measure the durations of the vowel and nonvowel intervals of the first of the two critical syllables in a target sentence, segmentation was performed on a simultaneous display of an audio waveform and wide-band spectrogram. Vowel onset was defined as the onset of voicing that coincided with vertical striations in the second and higher formants. For nonnasal-ending syllables, vowel offset was defined as the abrupt cessation of the second and higher formants; for nasal-ending syllables, as the sudden onset of a nasal murmur. The nonvowel interval was measured from vowel offset to the beginning of the release burst of the

following affricate or stop, frication onset of the following fricative, or voicing onset of the following nasal murmur or glide.

Results

Mean vowel durations for each syllable type and stress condition show that for like syllable structures, all stressed vowels, either short or long, were significantly longer than unstressed vowels (Figure 1, top panel). Long vowels, however, were significantly longer than short vowels in stressed syllables, but not in unstressed syllables (Figure 1, bottom panels).

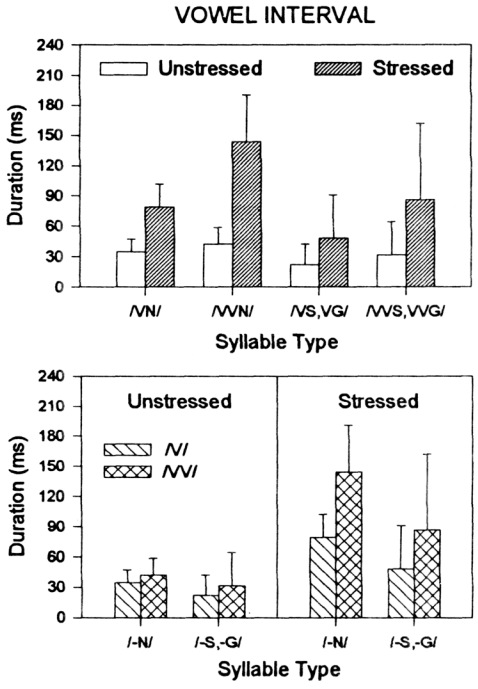

Figure 1. Mean durations of vowel intervals between (top panel) and within (bottom panels) stress conditions for each syllable type. Syllable types are represented by rhymes only; onsets are excluded: /VN/ = short vowel + nasal; /VVN/ = long vowel + nasal; /VS, VG/ = short vowel + stop or glide; /VVS, VVG/ = long vowel + stop or glide. Vowel = [-consonantal] portion of speech signal (glide is included as part of the vowel in /VG/ and /VVG/); nonvowel = [+consonantal] portion.

Mean nonvowel durations for each syllable type and stress condition show that for like syllable structures, all nonvowel durations in the stressed condition were significantly longer than those in the unstressed condition (Figure 2, top panel). Nonvowel durations of phonologically short and long syllables ending in a nasal segment were significantly different in the unstressed, but not the stressed condition (Figure 2, bottom panels). Conversely, nonvowel durations of syllables ending in a nonnasal segment were significantly different in the stressed, but not the unstressed condition.

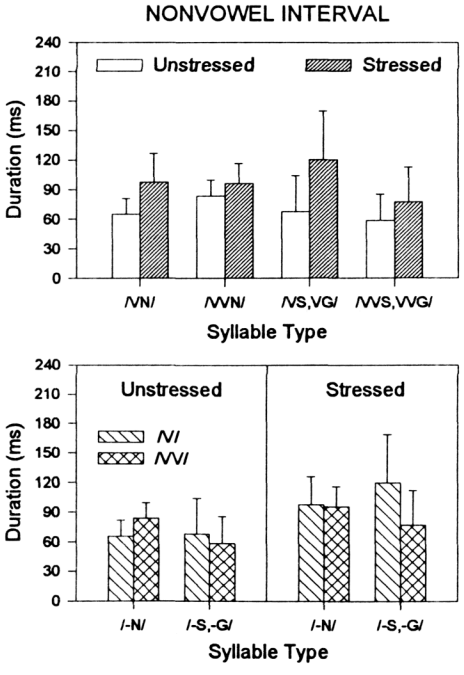

Figure 2. Mean durations of nonvowel intervals between (top panel) and within (bottom panels) stress conditions for each syllable type.

Mean vowel + nonvowel durations for each syllable type and stress condition show that the combined timing interval was significantly longer when

stressed than when unstressed irrespective of vowel length or syllable type (Figure 3, top panel). The combined timing interval for long vowel syllables ending in a nasal segment were significantly longer than those ending in a nonnasal segment in both unstressed and stressed conditions (Figure 3, bottom panels). The combined timing intervals, however, were not significantly different between nasal and nonasal syllable types containing short vowels in either stressed or unstressed conditions.

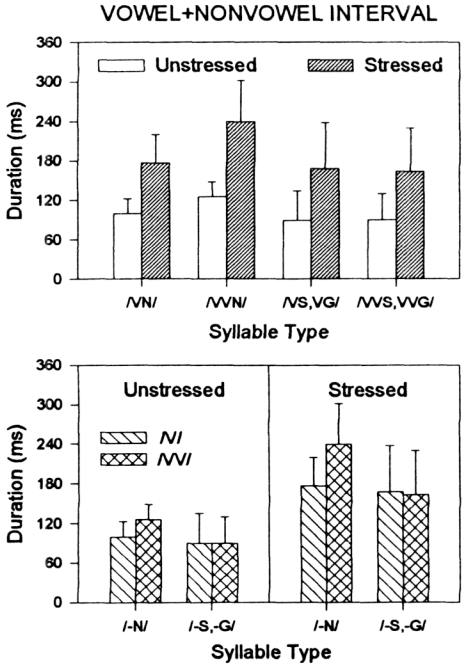

Figure 3. Mean durations of vowel + nonvowel intervals between (top panel) and within (bottom panels) stress conditions for each syllable type.

Mean duration ratios of stressed to unstressed syllables show that the vowel + nonvowel duration ratios were not significantly different for either vowel length or syllable type (Figure 4).

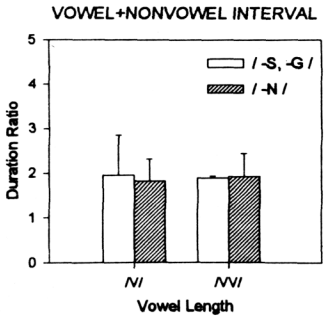

Figure 4. Mean duration ratios of stressed to unstressed syllables for vowel + nonvowel intervals between syllable types containing phonologically short (/V/) and long (/VV/) vowels.

Discussion

Our findings demonstrate unequivocally that the vowel length contrast is neutralized in unstressed syllables in Thai. This neutralization results from the use of duration to disambiguate higher-level syntactic structures. Contrary to the notion that acoustic correlates of stress vary depending on language-specific characteristics of phonological systems, both F_0 and duration emerge as dominant cues irrespective of differences in phonological systems across languages. Whereas languages may be expected to differ somewhat as far as weighting coefficients of acoustic correlates of stress are concerned, the availability of a particular correlate does not depend on whether it is being used to signal other phonological ends.

Thai presents an especially strong test of the functional load hypothesis. In Thai, both F_0 and duration are involved in signaling phonological contrasts. Yet both acoustic correlates appear to figure prominently in signaling stress. According to Shen, tonal variations at the lexical level make it highly unlikely that F_0 can be an important cue of stress in tone languages. This idea fails to take into account the possibility that despite differences in F_0 variations of lexical tones in unstressed syllables, the relationships between lexical tones will continue to behave in a lawful manner. Indeed, despite variations in F_0 contours in unstressed syllables, we have shown in an earlier study that tonal contrasts in Thai are preserved but in a reconfigured tone space. According to Berinstein and Hayes, duration would be unlikely to serve as a stress correlate in Thai because of the vowel length contrast. Their underlying assumption, similar to Shen's, is

that lexical or morphological distinctions take precedence over syntactic ones. Our findings do not support such an assumption.

On either an absolute or relative measurement scale, our findings clearly establish that the vowel length distinction is lost or neutralized in unstressed syllables in running speech, but preserved across a variety of syntactic and syllabic contexts in stressed syllables. These findings are compatible with earlier studies that have cited shorter vowel duration as a defining property of unstressed "linker", i.e. [CV] syllables, or unstressed, monosyllabic, function words such as auxiliaries, pronouns, etc. Vowel duration is an important cue for signaling stress in Thai in spite of its service to other phonological ends.

Although vowel duration is neutralized in unstressed syllables, it is possible that the length distinction has been shifted to other parts of the syllable. Regardless of vowel length or syllable type, vowel durations are indistinguishable in unstressed syllables. Nonvowel durations, however, are longer for nasal-ending syllables containing a long vowel than those containing a short vowel. It is possible that the duration of the syllable-final nasal signals the distinction between short and long vowels in unstressed nasal-ending syllables. In the case of syllables ending in a nonnasal segment, neutralization is complete. Both vowel and nonvowel intervals are indistinguishable in unstressed syllables.

Duration ratios are constant between prosodic structures in Thai regardless of absolute or relative duration differences attributable to either vowel length or syllable type. Even though long, nasal-ending syllables are longer, their ratios of stressed to unstressed conditions are indistinguishable from the other syllable types. Speakers apparently are able to maintain a contrast between prosodic structures that is relatively constant in spite of segmental variation. This finding is not unexpected in view of the suprasegmental nature of stress. However, whether or not the absolute timing intervals within prosodic structures in Thai are constant is a topic for future research.

The combined vowel + nonvowel timing intervals are significantly longer when stressed than when unstressed irrespective of vowel length or syllable type. These timing differences are correlated with differences in syntactic structures. This relationship between syntax and prosody suggests that timing may be used to resolve structural ambiguities in Thai. In this study, the timing interval for signaling a phrase boundary is considerably longer than that for a word-internal, compound boundary. Any contribution that prosody can make to resolving syntactic ambiguities will be especially helpful in spoken language understanding and in automatic speech recognition. Although syntactic structures differ in the degree to which they can be disambiguated by prosodic cues, our findings provide a point of departure for investigating other syntactic environments in Thai in which prosody alone might be used to disambiguate sentences.

References

Abramson, A. 1962 The vowels and tones of standard Thai: Acoustical measurements and experiments (Publication No. 20). Bloomington: Indiana University Research Center in Anthropology, Folklore, and Linguistics. International Journal of American Linguistics. 28 (2), Part III.

Abramson, A. 1974 Experimental phonetics in phonology: Vowel duration in Thai. Pasaa: Notes and News about Language Teaching and Linguistics in Thailand. 4 (1): 71-90.

Abramson, A. (in press) The stability of distinctive vowel length in Thai. In K. Tingsabadh & A.S. Abramson (Eds.), Essays in Tai linguistics. Bangkok: Chulalongkorn University Press.

Abramson, A., & Ren, N. 1990 Distinctive vowel length: Duration vs. spectrum in Thai. Journal of Phonetics. 18: 79-92.

Berinstein, A. 1979 A cross-linguistic study on the perception and production of stress (UCLA Working Papers in Phonetics No. 47). Los Angeles: University of California at Los Angeles, Phonetics Laboratory, Department of Linguistics.

Gandour, J. 1984 Vowel duration in Thai. Crossroads: An Interdisciplinary Journal of Southeast Asian Studies. 2: 59-64.

Hayes, B. 1995 Metrical stress theory: Principles and case studies. Chicago: University of Chicago Press.

Henderson, E. 1949 Prosodies in Siamese: A study in synthesis. Asia Major. 1: 189-215.

Hiranburana, S. 1971 The role of accent in Thai grammar. Unpublished doctoral dissertation, School of Oriental and African Studies, University of London.

Luangthongkum, T. 1977 Rhythm in standard Thai. Unpublished doctoral dissertation, University of Edinburgh.

Luksaneeyanawin, S. 1983 Intonation in Thai. Unpublished doctoral dissertation. University of Edinburgh.

Potisuk, S., Gandour, J., & Harper, M. (in press) F_0 correlates of stress in Thai. Linguistics of the Tibeto-Burman Area.

Shen, X.-N. 1993 Relative duration as a perceptual cue to stress in Mandarin. Language and Speech. 36: 415-433.

Svastikula, K. 1976 A perceptual and acoustic study of the effects of speech rate on distinctive vowel length in Thai. Unpublished doctoral dissertation, University of Connecticut.