Temporal Relations between Thai Initial Stops and Vowels: Acoustic and Perceptual Studies

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1. Introduction

This study continues a line of inquiry begun by Onsuwan and Beddor (1998), examining possible acoustic and perceptual interactions between two temporal properties in Thai, vowel duration and stop consonant voice onset time (VOT). Although previous studies (e.g., Abramson and Ren 1990; Lisker and Abramson 1970) have investigated the phonetic characteristics of these two properties, the focus of the present study is the temporal relations that hold between the two.

Thai contrasts long and short vowels. All 9 vowels /iː eː ɛː aː ɯː ɤː uː oː ɔː/ occur phonemically short and long. Thai initial stops show a 3-way contrast in voicing and aspiration (voiced, voiceless unaspirated and voiceless aspirated) in bilabial /b p pʰ/ and alveolar stops /d t tʰ/ and a 2-way contrast (voiceless unaspirated and voiceless aspirated) in velar stops /k kʰ/.

VOT and vowel length are both temporal distinctions. VOT is the time interval between obstruent release and the onset of voicing for a following vowel. Measurement of VOT and vowel duration is shown in Figure 1. In the waveform display (bottom panel), the release burst marks the beginning of VOT (marked by the first cursor). The onset of periodic pulsing marks the end of VOT as well as the onset of the vowel (marked by the second cursor). The vowel offset (marked by the third cursor) is identified by a change in the patterns of the periodic wave and by the end of energy in the lower formants shown in the wideband spectrographic display (top panel).

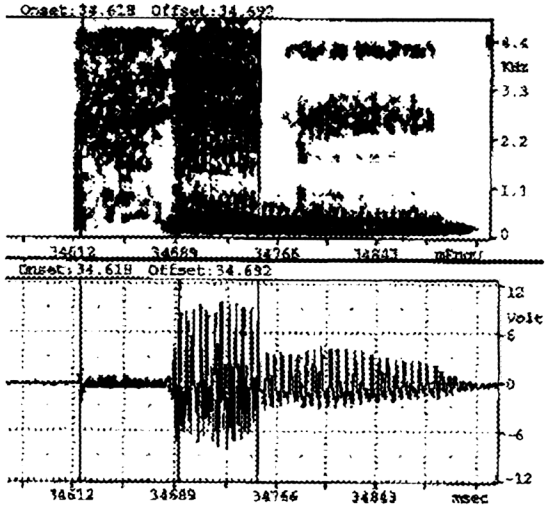

Figure 1. Wideband spectrogram (top panel) and waveform display (bottom panel) with the first cursor placed at the beginning of VOT (consonantal release burst); the second cursor at the end of VOT/vowel onset and the third cursor at the vowel offset. The word is [tʰìn] 'region' produced by a female speaker. VOT measurement is 74.7 ms. Vowel duration is 60 ms.

However, during aspiration, the vocal tract is already in the position for the vowel. Aspiration can be viewed therefore as a voiceless articulation of vowel onset. For this reason, it is possible that, although consonant laryngeal features and vowel length are phonologically independent in Thai, phonetically vowel length might influence VOT and/or vice versa.

The possible effect of phonological consonant laryngeal timing on phonetic vowel duration and of phonological vowel length on phonetic VOT is explored here in terms of acoustic measures of these temporal relations and perceptual study of the effect of these relations on listeners' judgments. The study involves 2 parts. The first part investigates possible influences of the phonological contrast between aspirated and unaspirated stops on the phonetic duration of following vowels. The

results will show that the aspirated-unaspirated contrast does affect following vowel duration both acoustically and perceptually. The second part of this study investigates whether phonological contrasts in vowel length affect phonetic voice onset time of preceding stops. The results will show that although acoustically phonological vowel length has no effect on stop VOT, Thai listeners' perception of VOT is proportional to following vowel length.

2. *Part 1:* Influences of the Phonological Contrast between Aspirated and Unaspirated Stops on the Phonetic Duration of Following Vowels

2.1 Acoustic Analysis

2.1.1 *Method*

Three native Thai speakers participated in the acoustic study. The speakers were recorded reading multiple repetitions of a list of 40 minimal or near-minimal pairs. The members of each pair began with a voiceless unaspirated or aspirated stop and differed from each other in terms of vowel length (e.g., [pān]-[pāan] 'to share-birthmark'; [pʰān]-[pʰāan] '1000-tray with pedestal'; [pàt]-[pàat] 'to brush way-to smooth and level off'; [pʰàt]-[pʰàat] 'to stir fry-briefly'; [tʰōn]-[tʰōon] 'to bear-singleton'; [kàk]-[kàak] 'to stop-garbage'). Test pairs were balanced as evenly as possible, given the constraints imposed by using real-word pairs, across 3 places of articulation (bilabial, alveolar, and velar), 5 vowels (/i e ɛ a o/) and 3 level tones (high, mid, and low).

Five repetitions of the 80 words were randomized for a total of 400 items for each speaker. Each item was read in a sentence context [ʔàan wâa...ʔìik] 'read as__again'. The recorded materials were then digitized and analyzed acoustically in terms of 2 temporal measures: VOT and vowel duration. VOT duration is measured from the release burst until the onset of periodic pulsing which also marks the onset of the vowel. Vowel duration is measured from the vowel onset until the vowel offset generally identified by the end of energy in the lower formants.

2.1.2 *Results*

The vowel duration measures are shown in Figure 2. It can be seen from this figure that the duration of long vowels was approximately twice as long as that of short vowels, and that all vowel qualities showed roughly the same relation.

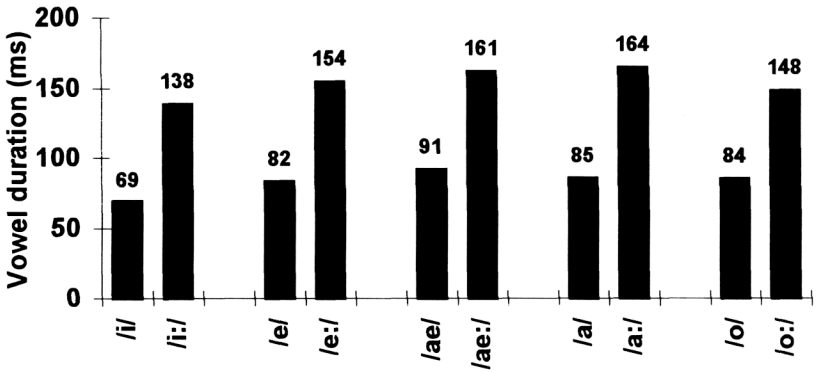

Figure 2. Duration (in ms) of long and short vowels pooled across 3 speakers and consonantal contexts[1].

The main question here however is whether the phonetic vowel duration in the context of aspirated stops differs from that in the context of unaspirated stops. Figure 3 shows that the duration of the voiced portion of both short and long vowels (the dark portion of each bar in this figure) was shorter in the context of aspirated stops than in the context of unaspirated stops. This pattern holds for all places of articulation. Short vowels were on average 21% shorter in the context of aspirated stops and long vowels were on average 9% shorter.

Alternatively, if aspiration is viewed as voiceless portion of following vowel, vowel duration would correspond to VOT plus the following voiced vocalic portion (in this figure, each entire bar would correspond to vowel duration). Therefore, the alternative account for the pattern would be that phonetic vowel duration is longer preceded by aspirated consonants than by unaspirated consonants. However, in the