Standard Khmer Vowel System: An Acoustic Study

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Abstract

Previous acoustic studies of Khmer Language (Henderson 1952, Thomas el all 1987-88, Ratree 1996, Woźnica 2009, Kirby 2014) do not concentrate on the Phnom Penh Khmer dialect as the canonical form of Khmer. This study concentrates on the description of standard Khmer vowel distinction in the specific context of the Phnom Penh dialect. Although there is no clear-cut definition of "Standard Khmer", the notion of "speaking clearly" (និយាយច្បាស់/nijiəj cbah/) may help us to define standard Khmer dialects. This study reports the results of an acoustic-phonetic analysis of the Phnom Penh Khmer dialect. The study finds that all Phnom Penh Khmer vowels are phonemically and phonetically presented in the standard Khmer vowel system.

***Keywords**: Mon-Khmer, Khmer, standard Khmer, vowel system, duration, frequency, acoustic Phonetics, Phnom Penh dialect, structure and variation.*

Introduction

Khmer is the official language of the Kingdom of Cambodia and it is one of the major languages of the Mon-Khmer subgroup of the Austroasiatic Language family (Schmidt, 1907; Henderson, 1952; Huffman, 1968; Diflorth, 1987). One dialectal variety, Surin Khmer, is spoken by around 1.3 million ethnic Khmer people in the north-eastern and eastern provinces of Thailand. Another variety called Lower Khmer is spoken by more than one million people of the Khmer ethnic group in the Mekong delta region of southern Vietnam (Minegishi, 2006). The Khmer spoken in the northern and southern parts of central Khmer have been well studied by linguists (e.g. Suwilai, 1995; Smalley, 1964-76; Jenner, 1974; Tran Van, 1974; Dhanan and Chartchai, 1978; Hoang Thi, 1978; Thomas, Dorothy & Thomas, David, 1982; Phunsap, 1984; Cummings & Thomas, David, 1984; Krissana, 1986; Thomas and Wanna, 1989; Pornpen, 1989; Ratree, 1996; Wichitkhachee, 1996; Thach, 1999; Ratree & Jongman, 2001; Kirby, 2013). Central Khmer, however, is less well known. The main information of Central Khmer comes from a number of studies, such as Aymonier (1874-75-77); Kuhn (1889); Finot (1902); Maspero (1915); Martini (1946); Henderson (1952); Gorgoniyev (1966); Huffman (1968-70); Ehrman (1972); Pinnow (1980); Headley (1998); Sakamoto (2005); Filippi & Hiep (2009); Haiman (2011) and Julien Heurdier (2016). While the Khmer dialects in Vietnam and Thailand are relatively well studied, there is only minimal information gathered about the Khmer dialect spoken in Phnom Penh, especially in terms of instrumental phonetic analysis. The studies of Khmer phonemic structure, vowels and consonants mostly describe Khmer language in the manner in which it was spoken a long time ago. The currently manner of Khmer language needs to be documented, especially the Khmer vowel system.

Method: Subjects and Materials

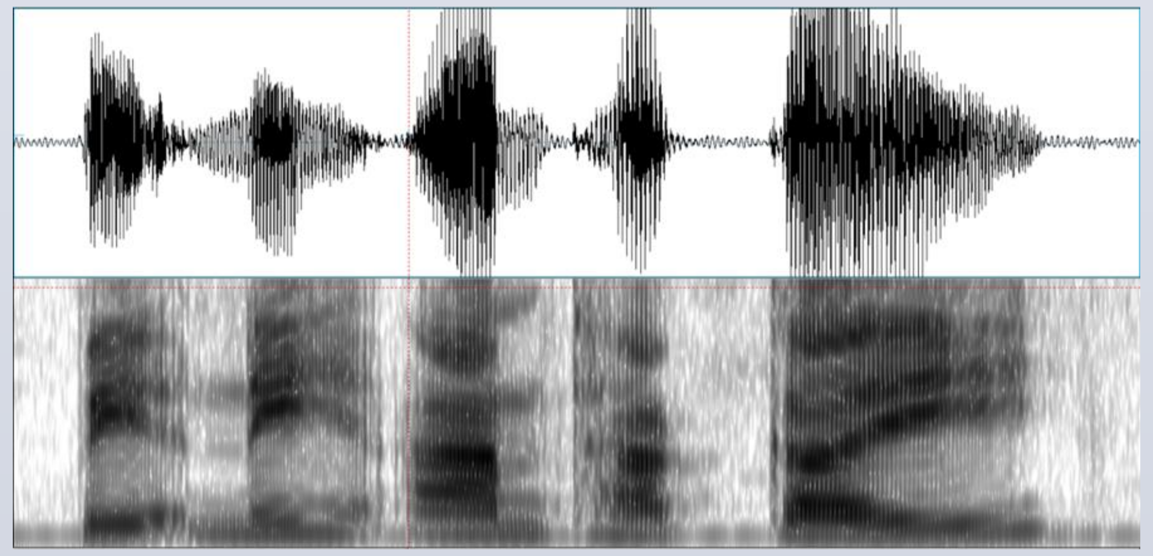
The aim of this paper is to analyse the Khmer vowel system in terms of frequency domain and duration. First, native speakers who have permanent residence in Phnom Penh were selected. They were asked to pronounce a number of words in a formal and in a casual manner. They were recorded using a computer program: Praat software with 32 bit and 44200 Hz sampling voice recording rate. The context of the recording was very important. We did everything to avoid our informants feeling uncomfortable or nervous in the recording room. Twenty-one native Khmer speakers (12 females) from different backgrounds, occupations and residences were selected for conversational observation during the first stage of the Clearly-Speak observation procedure. They were assigned to engage in formal and/or casual speech with 168 lexical items. They repeated the items 2 times each. This process was designed to determine who had clearer speech. Eventually, four Khmer native speakers (2 males and 2 females) from Phnom Penh were selected as the informants for this study. They not only had a good and clear voice but also had experience in talking naturally in front of a microphone. They ranged from 20 to 50 years old. Each had finished a Bachelor degree and/or Master degree and had been working as an administrator, educator or a news reporter. In the next step, they were recorded reading the isolated word from a word list. The next process was that they were allowed to read 61 lexical items in a formal reading manner 3 times. They used the following phrasing: ពាក្យនេះអានថា....។ [piə̆ʔ nih ʔaːn thaː …] Then they pronounced the designated word. Here, we listed 61 lexical items, including 34 vowel nucleus clusters with 21 monophthongs/ iː ĭ, iː ĭ, uː ŭ, eː e, ɛː ɛ, aː a, ɔː ɔ, oː o, ɔː ɔ, ɒː ɒ, ɜ / and 13 diphthongs /iə/: /iə/ : /uə/ : /aɛ/: /aɜ/: /aɔ/: /oa/: /ɛe/: /ou/: /ɜə/; /iə̆/, /ŭə/, /ĕa/.

Experiment

The average duration of each of the 34 standard Khmer vowels was measured by monosyllabic and polysyllabic structure. The vowel durations were measured in milliseconds (ms). The measurement for vowel duration was used for both the visual and auditory cues. The auditory cues can be interpreted differently in different studies. They are used in this study to investigate the actual duration of all vowels consisted acoustic cues on the sound spectrum unit. Further, vibration separations were defined by voice onset time (VOT) specifically used to describe consonants. The time between samples was 0.09 seconds (90 milliseconds). The potential time resolution of a recording on Praat Window is reported as 112.848980 seconds. The position and function of the words within the sentences avoid the deformation of the vowel caused by lack of sentence stress. Some vowel distribution patterns make it difficult to find words that provide an appropriate environment for the vowels that are commonly used by Khmer native speakers. The substantial variation of the Khmer native speakers' literacy skills was also a problem during the recording process. Unnatural word stress, vowel duration artifacts, or even refusal to read a word ("There is no such word") often was caused by the speakers' lack of familiarity with a lexical item. Whenever possible, such gaps in the data were filled by the vowel in question being taken from a different word and sentence instead. This is a particular issue in relation to the second of the above mentioned guidelines. Not all of the vowel samples featured in the research because Khmer sequences of the type /VA/ (vowel + approximant) are traditionally interpreted as two-phoneme sequences (Huffman 1970b; Huffman 1970a). The graph illustrating the results shows how vowel duration could be interpreted in complex word classes and sequences.

Segmentation

Our acoustic data were annotated and segmented using Praat 6.0.36.(2016) speech synthesizer and automatic alignment (new eSpeak). It was used to measure the total frequency and duration of all assets V1 and V1+V2 in the nucleus cluster, accommodated by C1 release or plosive, final consonant closure and possibly a release in transitional vocoid or syllabic rime. Our analytical data was stored and analyzed according to Source-filter Theory and it was based on the linear regressions diagram and chart on Microsoft Excel 2016. Acoustic cues and spectral combination were highlighted by observing a periodic waveform, increase in signal energy at C1 release or plosive, and a region of formant structure. In Khmer syllabic structure, the abstract element of the phonemic structure of the final consonants was always a closure consonant, unreleased, with an invisible spectrum.



/p iə̆ ʔ/ /n i h/ /ʔ aː n/ /tʰ aː/ /k ɛ j/

Figure 1: Praat speech synthesizer and automatic alignment /piə̆ʔ nih ʔaːn taː kɛj/.

Analysis

The results were analyzed by linear regressions, specifying the intercepts for subjects and items. Use of main slopes, where appropriate (where models converge), is noted. The results were displayed in chart and graph showing average frequencies, F1 and F2, and vowel duration in the Khmer vowel system based on place of articulation and acoustic characteristics by using Praat for calculating formants and Ms Excel 2016 for creating vowel bar-charts and scatter (x,y) charts.

Result

This paper displays an analysis of vowel quality according to acoustic characteristics. This study clearly reveals that both F1 and F2 represent the place of articulation of the various vowels in the Phnom Penh dialect, but also in standard Khmer language. By comparing these speakers' frequencies, F1 and F2, a diagram was created to display the articulation of Khmer vowels. However, this paper is only an outreached statistical study for determining the characteristics of Khmer vowels and its function in acoustic phonetics data. This diagram below shows the place of articulation of vowels in the vertical axis that is normally linked with high, mid-high, mid-low and low vowels, a tongue position in the vertical axis. Another explanation relies on the tongue movement along the horizontal axis and also specification of the front, central and back vowels. This diagram shows only long and short monophthongs.

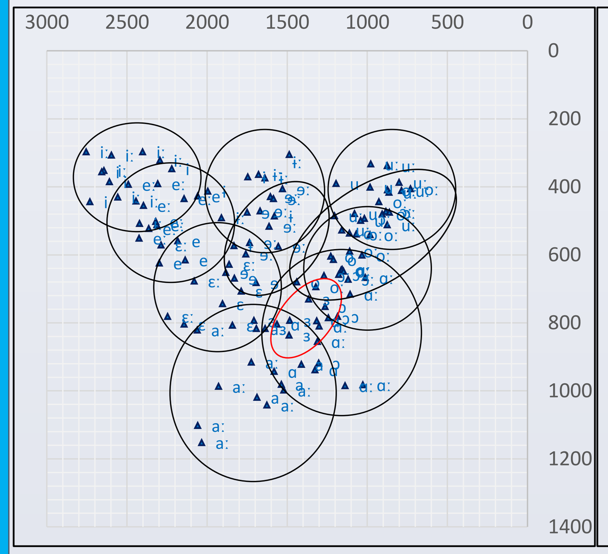


Chart 1. Area of F1 and F2 of all speakers

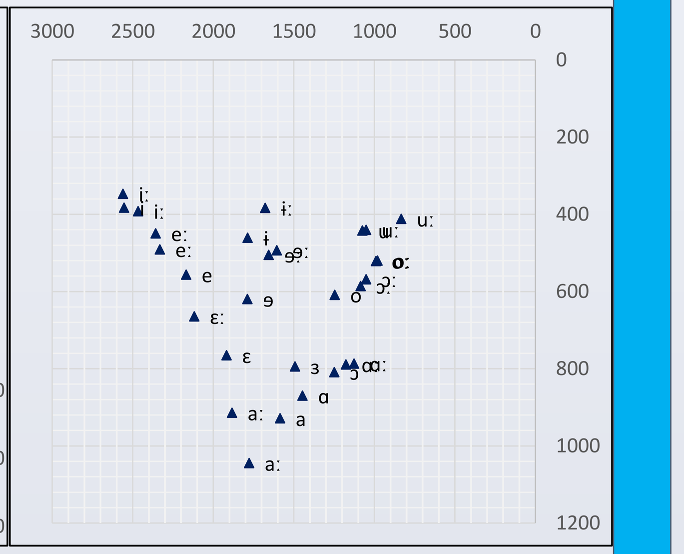


Chart 2. Average of F1 and F2 of all speakers

Chart 2 shows the average of vowel frequencies and indicates the value of the first and second frequency of all 21 monophthongs, 10 long monophthongs, and 11 short monophthongs, of the Phnom Penh dialect. According to the value found for F1, all long vowels were lower than short vowels, except the long vowel [aː] in the opened-syllabic structure. The vowel in the opened-syllable was higher than the short vowel [a] and the long vowel [aː] in closed syllable was lower than the short vowel of its counterparts. This frequency revealed that vowels in the closed syllable could be modified by the coda or final consonant. The coda or final consonant in the syllabic structure can affect the vowel nucleus. The results showed that long vowels are more closed than short vowels, except [aː]. Long vowels are definitely higher in quality. Most importantly, in term of backness, all back short vowels are further in front of their counterparts. With frontness, long vowels are more back than their counterparts. For central vowels [iː, i; ɔː, ɔ], long vowels are centralized in comparison to front and back vowel frequencies. The short vowel [a] seems to be more centralized than its counterpart is.

Chart 3. Average of Long diphthongs of all speakers

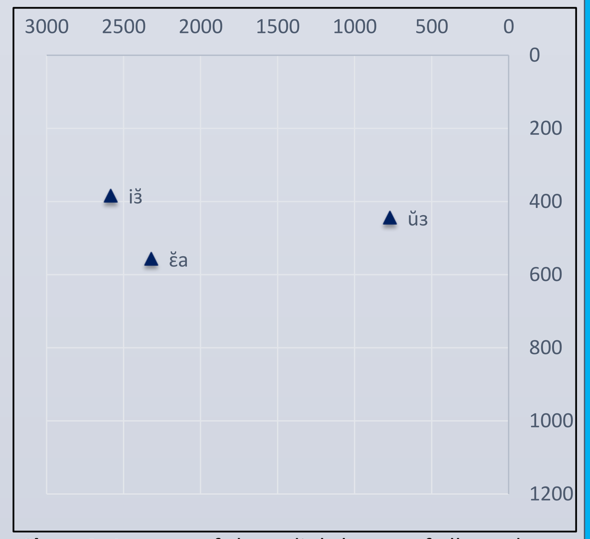


Chart 4. Average of short diphthongs of all speakers

Most diphthongs were classified by combination and the arrow pointed in the direction of the second vowel position, based on the monophthong result. The first segment of standard Khmer diphthongs was higher than the second element of its combination. The descriptive approach of vowel frequencies indicated, both in the spectrogram and sonogram, that the second vowel unit (V2) of the diphthong was influenced (2/3) by the first vowel unit (V1). Thus, the frequencies, F1 and F2, mainly represented only the first vowel unit (V1) of all diphthongs.

Result

As a result, the long monophthongs were ranked from 0.9 seconds to 0.27 seconds and short monophthongs were from 0.6 seconds to 0.11 seconds. The long monophthongs are characterized by the two main approaches, opened and closed syllabic structure. Closed syllables were usually shorter than opened syllables. The syllable illustrations were characterized simply to justify the acoustic data. If transitional elements are part of the phonological specification of the syllable, we might expect to observe an increase in the duration of nucleus clusters containing the pure vowel segment and closure syllable (C+ V1 +C). In the closure syllable, the most complicated analysis was the separation of the vibration of the vowel nucleus and the plosive consonant at the end of the word, excepting fricative and/or even nasalized consonants that can be separated by voice onset time. Both sonogram and spectrogram did not show the boundary of nucleus and coda in the standard Khmer syllabic structure.

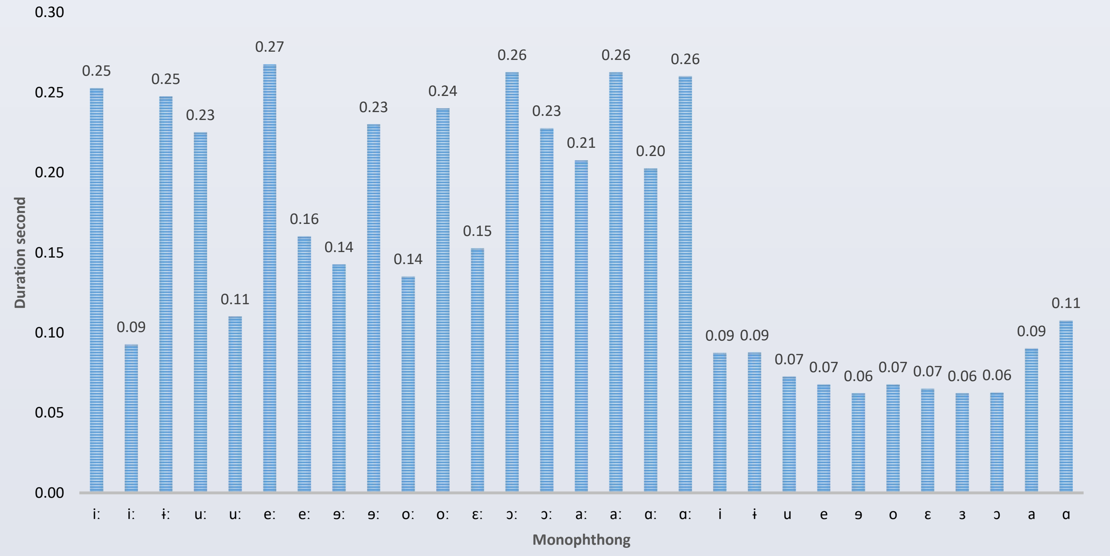


Chart 5. Average of short and long monophthongs of all speakers

Chart 5 shows vowel duration that was measured based on isolated words and sentences. The average vowel duration was recorded in seconds (Ss) and milliseconds (ms). Utilized spectrograms and waveform plots to analyse such features of the acoustic signal, as periodicity (very useful cue, taking into account the ubiquity of /V+ Fricative Consonants/ and /V+ nasal Consonants/ syllable offsets in Khmer), /V+h/ formant patterns typical of some vowel categories and sound wave amplitude dynamics. Part of the waveform envelope is schematically represented on a spectrogram and sonogram. (A) The curve at the [n|a] boundary indicates a surge of voice wave amplitude. The transition from the periodic [a] to the non-periodic [h] is also clearly visible. (B) The last impulse of [a] is relatively weak; therefore it is not counted in the vowel's duration. The vowel duration data obtained was sorted and averaged according to vowel type (long and short monophthong and long and short diphthong). The patterns thus yielded are generally accordant with Jean Michel Filippi's classification of Khmer vowels. The ratio of the average duration of short to long vowels to long and short diphthongs is 76ms: 204ms: 215ms and 130ms. The table also shows the mean duration of all types of vowels with a maximum and minimum duration classified by long and short vowels.

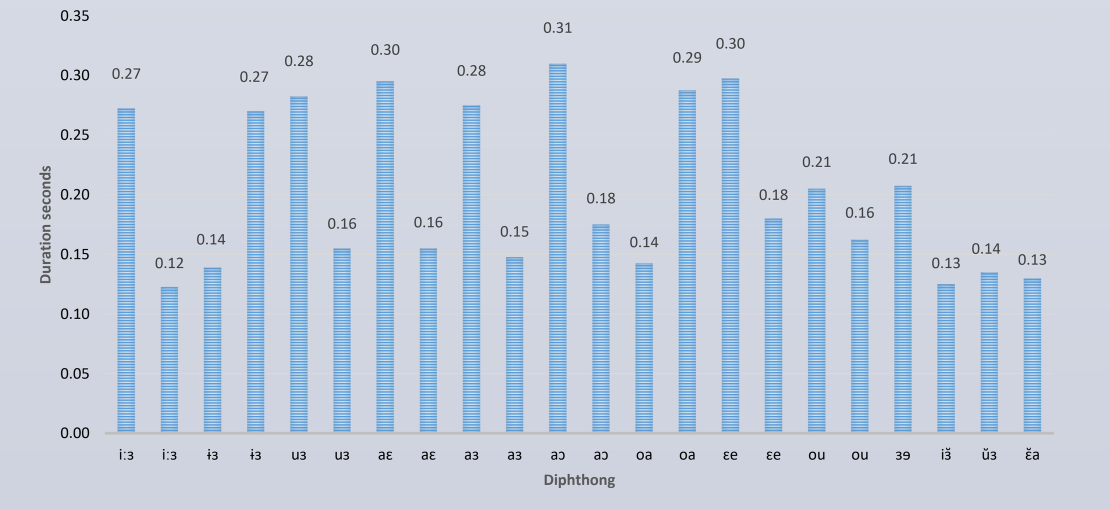


Chart 6. Average of short and long diphthongs of all speakers

General Discussion and Conclusion

The measurement of modern Khmer vowels frequencies and durations has been the aim of this work. The first experiment on the phonetics of the standard Khmer vowel system was concerned with monophthongs. Ten long monophthongs and 11 short monophthongs were recorded, stored and analysed in the computer software. There were two common problems in monophthong measurement. The main issues were the closure syllabic structure of both long and short monophthongs that completely changed the vowel duration, making it shorter than the opened syllabic structure. The long monophthong /iː/ in the word /tiː/ ("place") has a duration 0.25 seconds longer than /iː/ in the word /ciːc/ (to dig). In the closure syllabic structure, it has only 0.9 seconds duration. This shortening of duration was similar to the short monophthong /i/ in the word /kaʔpi/ (Khmer fermented paste) that has a duration of only 0.9 seconds.

The 10 long diphthongs and 3 short diphthongs were not totally modified according to what was expected from previous studies because the presentation of vowel frequencies, F1 and F2, categorised these diphthongs as the varieties of speech. The long diphthongs /iə/ in the Khmer word /tiə/ (duck) and /tiət/ (again) are completely different in the pronunciation of Khmer native speakers. Frequency measured, for example, of /iə/ in Khmer word /tiə/ (duck) was 354 Hz and /iə/ in Khmer word /tiət/ (again) was 374 Hz. Most importantly, there was, however, a huge differentiation of vowel duration between /tiə/ (duck) and /tiət/ (again) was 0.27 seconds and 0.12 seconds on mean duration. Should they be classified as different vowels?

Khmer vowels are traditionally separated into two series (a and b) and/or registers (first and second). In Phnom Penh long and short vowels, the first register vowels are lower and more open than the second register vowels. Moreover, the first register vowels are also diphthongized in Phnom Penh, respectively similar to the BB vowels reported by Ratree Wayland (1996). However, the short vowels, for /o/, /ɔ/, /ɑ/ and /a/, are more centralized than the long vowels. Even though in general the Phnom Penh vowel system is a canonical form of the standard Khmer vowel system, some differences exist both in phonology and phonetics.

In some cases, there are differences in such words as: ទាប ទៀត. Standard Khmer has two vowel distinctions /tiə/ and /tiət/: but in Phnom Penh dialect, there is only the diphthong /tiə/ /tiət/ and the vowel contrast was clearly identified in standard Khmer vowel system. In addition, in the Standard Khmer vowel system there are /eː/ and /ɛe/, however, in Phnom Penh dialect there is no difference between these two vowels. There is only one /eː/ in such these words ಃ /keː/ and ស /keː/.

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