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# An acoustic investigation of Arabic vowels pronounced by Malay speakers

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**Abstract** In Malaysia, Arabic language is spoken, and commonly used among the Malays. Malays use Arabic in their daily life, such as during performing worship. Hence, in this paper, some of the Arabic vowels attributes are investigated, analyzed and initial findings are presented based on tokens articulated by Malay speakers as we can consider the spoken Arabic by Malays as one of the Arabic dialects. It is known that in Arabic language there are 28 consonants and 6 main vowels. Firstly, the duration, variability, and overlapping attributes are highlighted based on syllables of Consonant–Vowel with each syllable representing every Arabic consonant with the corresponding vowels. Next, the dispersion of each vowel is examined to be compared with each other along with the variability among vowels that may cause overlapping between vowels in the vowel-space. Results showed that the vowel overlapping occurred between short vowels and their long counterpart vowels. Furthermore, an investigation of the Arabic vowel duration is addressed as well, and duration analysis for all the vowels is discussed, followed by the analysis for each vowel separately. In addition, a comparison between long and short vowels is presented as well as comparison between high and low vowel is carried out.


## 1. Variability and overlapping of Arabic vowels

While listening to vowels, it seems steady and unchanging due to the fast modification, which may happen in milliseconds in acoustic variables such as the fundamental frequency and formant frequencies. The modifications in acoustic variables may influence the uniqueness and intelligibility of the speaker's voice (Gordon, 2012). Variability in the production of vowels may include stress, context, speaking rate and formant frequencies. Three factors could influence the formant frequencies (Nicolaidis, 2003; Seung-Jae and Lindblom, 1994) namely:

(1) Duration of the vowel.
(2) Contextual environment.
(3) Articulatory effort.

There are two phonetic variables to describe the vowels specifically the quality and the quantity of the vowels. The

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vowel quality describes the vowel's articulation place, the tongue position inside the vocal tract, stricture size, the lips shape and the status of the vowel, whether nasalized or not, while the vowel quantity describes the vowel duration (Saadah, 2011). In addition, the vowel duration could be affected by the speech rate, for instance the vowel duration becomes shorter if the speech rate increases. Moreover, the speakers tend to produce scattered vowels if they spoke slowly and the vowels will be centralized in the vowel space if the subjects spoke faster (Souza and De Mora, 2014).

As stated earlier, there are six vowels in Modern Standard Arabic (MSA), and it can be divided into two categories. Firstly, are the short vowels, which include /a/, /i/ and /u/, and next are the long vowels which is comprised of /a:/, /i:/ and /u:/. Several researches have been carried out about Arabic vowels. A study by Saadah (2011) has investigated the production of Arabic vowels by English second language (L2) learners and heritage speakers of Arabic. Another study by Thesieres (2001) has addressed the vowels in Lebanese Arabic and the United Arab Emirates. Results of Lebanese Arabic vowels were compared with the results of Iraqi Arabic vowels based on a study conducted by Al-Ani (1970). Meanwhile, the experiments on Emirates Arabic vowels were compared to the Lebanese and Iraqi vowel experiments.

An investigation on the acoustic attributes of the Palestinian Arabic vowels was done by Saadah (2011). This research was based on tokens that have been articulated by six native Palestinian Arabic speakers with a total number of vowel tokens as 1368. His experimental results showed that F1 for short /i/ and short /u/ has a higher frequency than its counterpart vowel, and this refers to the high long vowels, which were produced with higher tongue position. However, the short low vowel /a/ has a lower F1 frequency compared to its long counterpart vowel. Meanwhile, for F2 frequencies, the speakers were more likely to articulate the short /i/ with a lower value than the long /i/ in contrast with the short /u/. The Palestinian vowels have lower F1 and F2 values compared to Iraqi vowels (Al-Ani, 1970) and Tunisian vowels (Belkaid, 1984). Another research on vowels in the Palestinian Arabic was conducted by Adam (2014) which aimed to study the variation in the vowel durations in two cases: normal speakers and speakers with Broca's aphasia. The study claimed that the vowel durations were longer for the speakers with Broca's aphasia compared to normal speakers. Researchers have also focused to study the vowels in other Arabic dialects. For example, Saudi, Sudanese and Egyptian Arabic vowels have been addressed by Alghamdi (1998) and its aim is to decide whether vowels in MSA are realized in the same way if spoken by individuals related to different dialects. The researcher found that the short vowels were likely to be centralized more than the long vowels. Another research on vowels in eight Arabic dialects is conducted by Haidar (1994). The dialects include Lebanese, Syrian, Qatari, Tunisian, Emirati, Jordanian, Saudi, and Sudanese. The researcher used monosyllabic words in her experiments. This study has shown a significant difference in the formant values among all eight dialects. Another study of the vowels in the Libyan Arabic is addressed by Ahmed (2008). The aim of this study is to provide acoustic and auditory descriptions about vowels in Libyan Arabic in order to compare it with vowel's attributes of other Arabic dialects. The use of monosyllabic words was recorded among 20 native Libyan Arabic native speakers. His results showed that the long and short vowels were significantly varied in both quantity and quality. In case of the short vowels, it was likely to be more centralized compared to other results reported by other studies. Formant based analysis of spoken Arabic vowels is also studied by Alotaibi and Husain (2009). The first two formants were considered in this study, in addition to the differences and similarities between vowels. All the carrier words were formed using Consonant–Vowel–Consonant style (CVC).

In addition, an analysis study of the formant frequencies of the Arabic vowels is achieved by Newman and Verhoeven (2002). This research was based on Quranic recitation tokens, which consists of 30 min of Qur'an recitation. The recorded token contains 400 vocalic observations, which cover all the Arabic vowels. Moreover, along with the Quranic recitation tokens, the researchers acoustically analyzed the same vowels depending on recorded tokens taken from colloquial Egyptian Arabic.

## 2. Duration of Arabic vowels

Every speech sound has its physical and perceptual properties. The perceptual values of any speech sound can be linked to the physical value measured. Duration can be defined as the physical property that represents the measured duration of a speech sound from the articulatory and acoustic points perspective (Hassan, 1981). From another point of view, the duration of a speech sound can also be in the representation of time dimension of an acoustical signal (Lehiste, 1970). On the other hand, length is defined as the perceptual attribute that leads to the perception of a speech sound. Several researches have done in depth investigation on the durational and articulatory parameters in vowel articulation. Some significant information based on the findings include the vowel duration, such as the ability of the listener to perceive vowels and the production mechanism of the vowel or even demonstrate the articulatory movements degree that are required for producing a particular vowel (House, 1961). Moreover, the acoustic studies have claimed that the vowel duration was beneficial for vowel identification and the intelligibility of speech (Ferguson and Kewley-port, 2007; Mok, 2011). The acoustic investigations have reported that the low vowels are longer than the high vowels, while vowels produced within closed syllables are shorter than vowels produced within opened syllables. In addition, vowels followed by voiced consonant phonemes were found to be longer compared with vowels followed by voiceless consonant phonemes. Alternatively, vowels before stop consonant phonemes are shorter than vowels followed by fricative consonant phonemes (Ladefoged, 2006) and because vowels in Arabic are a concern, a study on Arabic vowels was carried out by Alghamdi (1998). The vowels were pronounced by speakers representing three Arabic dialects: Saudi, Sudanese and Egyptian. The experimental results have shown that the main difference between the three dialects was in the first formant frequencies, but in terms of duration, the vowels did not show any significant difference from one another. In addition, it was found that the behavior of the short vowels was less than half of the long vowels. Another study on vowels in Arabic dialects has been addressed by Khattab and Al-tamimi (2007) for Lebanese Arabic. This study reported that there is no significant difference between the durational results