Voice Onset Time of Jordanian Arabic Stops

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Abstract—**This paper reports on findings of an acoustic measure of voice onset time (VOT) in Jordanian Arabic stops in syllable initial position. Results point out that VOT values corrolate to voice contrast. Also, a difference between VOT values is found due to the length contrast of the following vowel. In addition, our results seem to depart from the literature with regard to the effect of place of articulation on VOT values. The findings of this piece of research are discussed with respect to the importance of acoustic codes to the proper treatment of some low-level phonetic parameters.**

I. Introduction

It has already been attested that Voice Onset Time (VOT) is a major acoustic measure for voicing contrast in a number of languages [1]. This measure is defined as the durational interval that occurs between the release of stop closure and the onset of periodicity which reflects vocal fold vibration [2,3]. This measure is also found to be a useful perceptual cue of developmental voicing contrast [4,5]. Due, therefore, to the importance of this voicing measure, the real lack of Arabic studies on this important non-segmental structure for both speech production and perception, the present study is conducted. Previous research on voicing contrast in syllable-final position has shown that timing difference which is, an important acoustic measure in English and other European languages, is not a universal property. Mitleb [6]. found that voicing has non-significant effect on preceding vowel duration in Arabic. He also pointed out that the difference between English and Arabic in this non-segmental property has affected Arabs' production of English timing contrast of voicing in syllable final position [6]. Yet, in Hebrew VOT is found to be a significant acoustic cue of stop voicing contrast in syllable initial position [7]. Raphael and Tobin[7] reported that VOT Values for /p, t, k/ range from 22 to 45 ms whereas the range for/ b, d, g/ is from –75 to –90 ms.

Finding of the present research will add to the few Arabic acoustic studies about the different suprasegmental components such as timing, amplitude, fundamental frequency and other physical properties of speech. We also hope to set an experimental acoustic background through which comparisons between Arabic and other languages will have a positive influence on foreign language teaching and learning.

II. Method Subjects

The subjects were four male native speakers of Jordanian Arabic. All subjects were undergraduate students at the sophomore level enrolled in a class of English pronunciation course. They studied English from grade 5-12. None of the subjects was reported to have any hearing or speech disorders in their native Arabic tongue.

A. Stimulus Material:

This experimental research involved reading Arabic words, (See Table1) each of which is typed on a 3.5 card.

TABLE I.
ARABIC WORDS

tam	sam	kam
ram	dam	taam
sam	nam	gaam
larn	farn	daam
gam	kaam	

The initial consonants were matched for Jordanian Arabic ones. We thus, included g-k and excluded p-b contrast. The focus of this research is on alveolar and velar stops. Other sounds are included in the list for the purpose of distract the attention of the subjects from the intended sounds.

The subjects were instructed to read the list via a microphone into a computerized speech lab (CSL) in a sound treated room at the Speech and Hearing Center of Yarmouk University.

B. Procedure

Wide band spectrograms were produced for each test word. The duration of VOT was automatically measured from the release of a stop closure, the focus of this study, to the onset of vocal folds vibration of the vowel. The CSL programs enable the author to accurately measure the duration of VOT yet to verify the results, the author tried hand-scaled measurement of the intended portion of the stops to the nearest 5 ms.

III. RESULTS

A. Apical Stops /t-d/ Contrast

The VOT duration values of apical stops /t-d/ are given in Table 2 which are also represented in Figure 1&2.

The ratio of /d/ VOT to that of /t/ in a short vowel environment is about 27% ($p<001$ by t-test). In a long vowel environment, we, also, notice a significant difference between the voiced and voiceless apical pair. The ratio of voiced to voiceless VOT values is about 37% ($p<001$ by t-test). However the 10% difference between the two voiced environments of contrast is not a significant one. Yet, the difference between the VOT Values of /t/ in the two-vowel environments is highly significant by t-test ($p<001$).

B. Velar Stops /k-g/ Contrast:

VOT values of the velar stops (Table2 and Figure 1&2) are significantly different on the basis of voice contrast. Our results show that the VOT value of /k/ sound is 39 ms as opposed to 15 ms for /g/ in the short vowel environment. The ratio of voiced to voiceless context is 33.5% ($p<001$ by t-test). This VOT durational significant contrast holds good between /k/ and /g/ in the long vowel environment. The difference here amounts to 40ms. The ratio of voiceless to voiced frame here is 33% which is highly significant by t-test ($p<.001$). It is also of importance to point out that VOT values of the voiceless velar sound are significantly sensitive to vowel length. We, thus, found a difference of about 21ms. between the two VOT values of /k/. this is possibly due to vowel length contrast. This difference is also significant by t-test ($p<.001$).

TABLE II.
EFFECT OF PLACE OF ARTICULATION

	Short vowel environment	Long vowel environment	Words
t	37	64	tam vs taam
d	10	23	dam vs daam
k	39	60	kam vs kaam
g	15	20	gam vs gaam

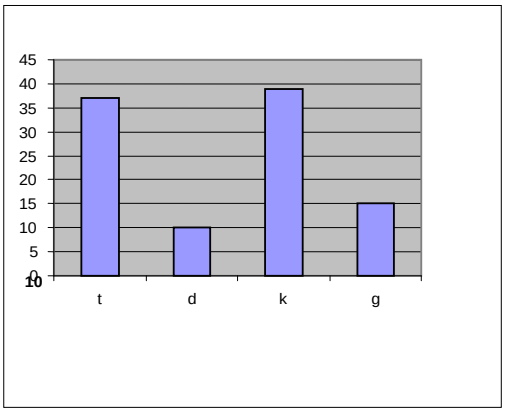

Figure 1. VOT Values for alveolar and velar stops followed by a short vowel

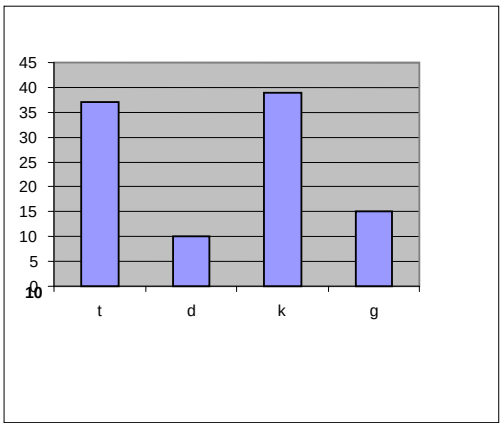

Figure 2. VOT Values for alveolar and velar stops followed by a long vowel

Examining the effect of place of articulation on the VOT values in both vowel length environments, we found no significant differences. The VOT of /t/ before a short vowel is 37ms whereas it is 39 ms for /k/ in the same vowel environment. Also the difference between the values of VOT for the alveolar /t/ and velar /k/ amounts to about 4ms. in the long vowel environment. As for voiced alveolar stop /d/ and voiced velar stop /g/ the differences of VOT values are insignificant. They amount to 5ms and 3ms for short and long vowel environments, respectively.

IV. DISCUSSION

Our finding that VOT values distinguish voiceless from voiced Arabic stops agrees with that of Lisker and Abramson [1] and Klatt, [8] for English and some other languages. Yet, our finding that Arabic vowel length contrast is a significant factor on the distinction between VOT values of voiced and voiceless stops syllable-initially in Arabic is, most possibly, a surprising one.

Although, we stand corrected, this is a case that has not been reported in the literature pertinent to this acoustic feature of voice contrast.

Another point of departure from a well-known research reports on the question of the relationship between place of articulation and VOT values is our finding that the voiceless alveolar stop /t/ is not any different from the voiceless velar stop /k/. For example, Lisker and Abramson [1] reported that VOT value increases as the place of articulation moves back in the oral cavity. Thus, they reported 67ms and 84ms VOT values for /t/ and /k/ in stressed syllables, respectively. Yet, we reported no difference due to place of articulation. Our /t/ VOT value is 37ms in the short vowel environment and 64ms in the long vowel environment whereas the VOT values for /k/ are 39 ms and 60ms in the short vowel and long one, respectively. This point of departure seems to fall within language- specific tendency. We may recall here that English voicing in syllable final position tends to be decided on the basis of voicing effect on preceding vowel duration [9] whereas Arabic does not show this timing property of voice contrast [6,10]. Furthermore, we have come across no data which support our finding that VOT value in a short vowel environment is significantly shorter than that before a long vowel. The fact that length is phonemic in Arabic [11] might explain our VOT distinction between the vowel length environments. This distinction is not found for English vowels which are found to be distinguished on the basis of quality [9].

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