

# AN ACOUSTIC INVESTIGATION OF THE GLOTTAL STOP IN ARABIC

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## ABSTRACT

The Arabic glottal stop was examined (among other sounds) in a previous study [15] where it showed some instances of variability. The present study aims at providing additional examination of the Arabic glottal stop in two contexts: isolated words and in a carrier phrase, and in three positions: initially, medially and finally. In addition, the glottal stop is examined in stressed and unstressed syllables. Measurements of voice onset time (VOT) were taken, where possible. The results of the examination revealed the following: first, the glottal stop had measurable VOT only in initial position, whether in the word context (VOT mean value was 26 ms.) or in the carrier phrase (VOT mean value was 32 ms.). Second, there was great variability in the other positions, where there were intermittent vocal folds vibrations preceding, during and/or following the closure of the stop. Third, stress had no effect on the glottal stop articulation.

**Keywords:** Arabic, glottal stop, variability, VOT.

## 1. INTRODUCTION

The glottal stop is usually defined as a complete closure at the glottis by the vocal folds [4, 9, 16, 21, 23]. And since the vocal folds act as the active articulators of the glottal stop, the voicing status has been controversial. Although the impossibility of being voiced is agreed upon [6, 23, among others], some studies have grouped the glottal stop within the voiceless sounds [4, 6, 21]. Yet, other studies reject using the term “voiceless” for the glottal stop. Bickford and Floyd [6] indicate that “the glottal stop is very different from the voiceless state of the glottis” (p.147). Cruttenden [10] seems to agree with this view showing that the “position of the vocal cords is not that associated with other voiceless sounds” (p.179); (for a detailed survey of studies on the glottal stop see [12, 13]). Lodge [18] shows, arguably, that “[voiceless]...means with an open glottis, whereas the glottal stop is produced with closed vocal cords” (p.18).

This production of the glottal stop has some peculiarities. The closure of the glottal stop may not be complete. Ladefoged & Maddieson [17] indicate that “in the great majority of languages we have heard, glottal stops apt to fall short of complete closure” (p.75); they refer to this state as having “irregular constricted voicing” (p.76). This “irregularity” is the main concern of the present study.

The dispute over the voicing status of the glottal stop is also attested among Arab scholars (see for example [2, 3, 7, 14] among others). Alghamdi [2] refers to the use of the term “unvoiced” to describe the unique status of the glottal stop (p.97). In addition, the instability of the glottal stop has been recognized. Al-Ani [1] states that the glottal stop “seems to be very unstable and does not set any definite pattern” (p.60). However, no specific details were given as to what shapes this instability takes. In a spectrographic study on Arabic stops aspiration, Kasim [15] has mentioned the “variability” of the glottal stop which either showed no closure phase and/or no aspiration, or abnormal vocal folds vibrations (pp. 8-12). As such, there is lack of data concerning the form(s) of the glottal stop variability. Thus, the present study aims at demonstrating the nature of this variability.

The glottal stop is differentiated in the present study from the phenomenon of glottalization which refers to “the concomitant articulation of a glottal stop along with some other articulation” [4] (p. 78) and [5], and may accompany different sounds [20]. This distinction is important since the glottal stop in Arabic functions as a distinct phoneme [19, 22, 24].

## 2. AIM OF THE STUDY

The present study draws on the findings of Kasim’s [15] study concerning the Arabic glottal stop variability in relation to voicing. An attempt is made here to examine the nature of this variability. The research question is: what are the different shapes of this variability?

### 3. METHOD

#### 3.1. Data

The Arabic glottal stop is investigated in two contexts, viz. isolated words and a carrier phrase; and in three positions, viz. initially, medially and finally. In addition, stressed is varied in medial position so that the glottal stop appears once in a stressed syllable and once in an unstressed syllable. Table 1 below contains all test data.

**Table 1:** The test data.

Position	Word	Gloss
initially	/ʔa:b/	August
medially-unstressed	/'dʒa:ʔa/	(he) came
medially-stressed	/dʒa:'ʔa:/	(they both) came
finally	/ma:ʔ/	water

Each word is printed on a flash card (9.5 cm x 6.5 cm) using Arabic scripts with a 168 pt font size.

#### 3.2. Subjects

Ten native speakers of Arabic served as subjects of the study; five males and five females. Their background variety of Arabic was Iraqi Arabic. However, they were instructed to use Standard Arabic in their performance. Their ages ranged between 20-40 years old. All of them were educated, and none of them reported any language disorders.

#### 3.3. Recording tools

A laptop PC was used for recording the data. A USB desktop microphone (type Logitech) was connected to the laptop. Praat [8] was used in recording and analysing the data. The sampling rate used for recording was 44100 Hz using a mono channel.

#### 3.4. Procedure

Each subject was asked to familiarize himself/herself with the Arabic test words on the flash cards. The subjects were instructed to use Standard Arabic pronunciation in their performance. There was a rehearsal period that preceded the recording. The purpose of this rehearsal period was three folds: first, to correct any performance mistakes; second, to practice a recording position where the subjects were instructed to put the microphone away from the mouth about 10 cm; and third, to practice putting each word in the carrier phrase.

There were two types of recording: word and phrase contexts. In the first type of recording, each subject was instructed to pronounce the word that s/he saw on the flash card when the researcher displayed the card. The test words were recorded

individually. Each word was recorded once. Thus, the total number of recorded tokens in the word context was 40 (4 words x 10 subjects). In this context, the glottal stop occurred 10 times initially, 20 times medially, and 10 times finally.

In the second type of recording, the subjects were instructed to pronounce the test words presented on the flash cards in the carrier phrase /qul kalimat..... marra'tajn/ "say the word..... twice". The flash cards were shuffled and presented for another round of recording. There were three rounds of recordings for each subject. Thus, the total number of tokens obtained in the phrase context was 120 (4 words x 3 rounds x 10 subjects). The glottal stop occurred in the phrase context 30 times initially, 60 times medially, and 30 times finally (see Table 1). The subjects were recorded individually in a quiet room.

### 4. DATA ANALYSIS

A spectrogram was obtained for each recorded item. There were two things to examine in the spectrograms: first, the closure of the glottal stop, and second, the existence of a period of voicelessness following the closure release. Analysis of the data revealed two observations. The first one showed clear glottal stop closure followed by a period of voicelessness where VOT measurements were obtained. The second observation displayed great variability of the glottal stop in all positions and contexts.

#### 4.1. Position and context

##### 4.1.1. Initially

The glottal stop had a post release period of voicelessness in 9 (out of 10) instances in the word context, and 17 (out of 30) instances in the phrase context (see Table 2). Fig. 1 displays an example of the glottal stop with measurable VOT.

**Figure 1:** The glottal stop is shown initially in the word /ʔa:b/ where the closure release is followed by a period of voicelessness (shaded selection); VOT is 50 ms.

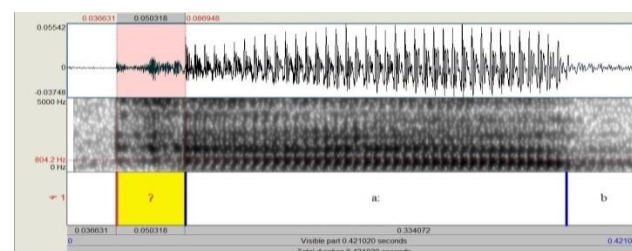


Fig. 1 shows clearly that the glottal stop has a period of voicelessness following the stop release. In the

word context, the VOT mean value was 26 ms. The phrase context, on the other hand, showed more variability (one similar to that in other positions); 13 out of 30 tokens had no measurements. The VOT mean value was 32 ms. (the values are rounded to the nearest digit).

**Table 2.** VOT values (in ms.) of the Arabic glottal stop in initial position in the word /ʔa:b/; S=subject, T=token

	phrase			
	word	T1	T2	T3
S1	68	48	37	28
S2	27	38	15	38
S3	10	---	---	---
S4	17	---	---	---
S5	10	---	41	---
S6	---	---	---	---
S7	15	25	31	---
S8	18	22	24	17
S9	54	40	50	49
S10	13	26	---	18

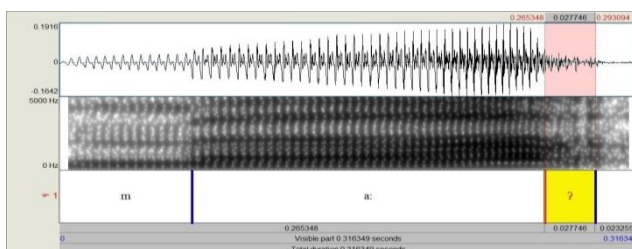
#### 4.1.2. Medially

In medial position, the glottal stop did not have any type of closure, neither in the word context nor the phrase contexts. Here, different types of variability were detected (see 4.2.).

#### 4.1.3. Finally

Similar to the medial position, the glottal stop had no closure in the word context finally. In the phrase context, on the other hand, there were only 4 tokens where clear VOT values were obtained (mean VOT value was 28 ms., see Fig. 2).

**Figure 2:** The glottal stop is shown in the word /ma:ʔ/ with a measurable VOT (shaded selection); VOT is 27 ms.



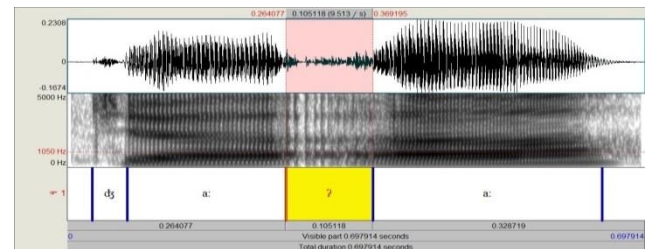
## 4.2. Different types of variability

In all positions and contexts, the glottal stop showed different types of variability. In addition to having measurable VOT initially (see 4.1.1. above), the glottal stop also showed variability in this position. The same thing was noticed medially and finally. In

fact, the majority of the tokens did not show stop closure or any measurable VOT, both in the word context (31 out of 40 tokens; 77.5%) and in the phrase context (99 out of 120 tokens; 82.5%). Moreover, varying stress in medial position did not affect the glottal stop production; i.e. the same variability was observed. The different forms of variability displayed by the glottal stop are summarized below. All instances discussed here are taken from the phrase context (which is similar to the word context).

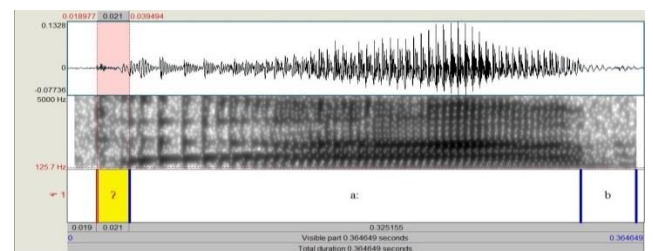
**4.2.1.** The first, and most widely noticed, observation in the majority of the tokens is the appearance of intermittent vocal folds vibrations during the glottal stop closure; see Fig. 3.

**Figure 3:** The shaded selection shows intermittent vocal folds vibrations during glottal stop closure in the word /dʒa:ʔa:/.



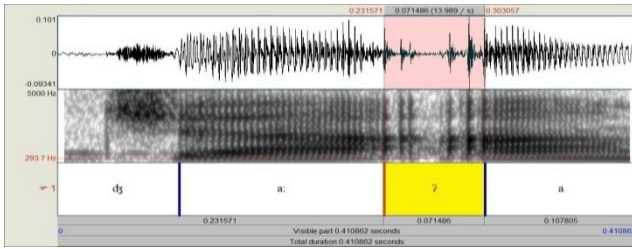
**4.2.2.** The glottal stop may be articulated with a stop closure followed by a short VOT which is in turn followed by intermittent vocal folds vibrations; see Fig. 4. This observation is noticed when the glottal stop occurs initially.

**Figure 4:** The shaded selection shows a short VOT (21 ms.) followed by intermittent vocal folds vibrations in the word /ʔa:b/.

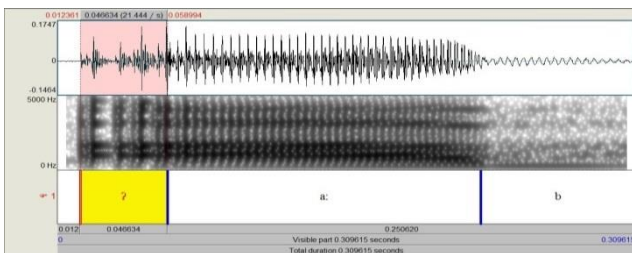


**4.2.3.** The same observation noted in 4.2.2 above is noticed when the glottal stop occurs medially; this time the intermittent vocal folds vibrations precede and follow the stop closure; see Fig. 5 below.

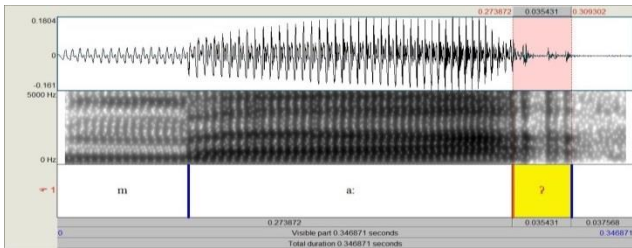
**Figure 5:** The shaded selection shows the glottal stop closure preceded and followed by intermittent vocal folds vibrations in the word /ʔa:ʔa:/.



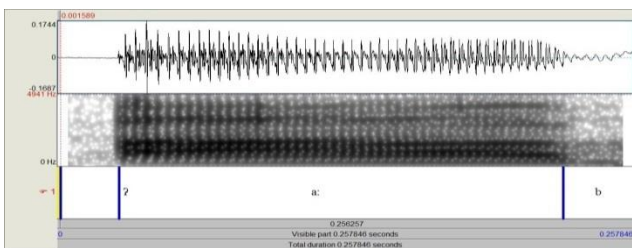
**Figure 6:** The shaded selection shows the glottal stop closure released into intermittent vocal folds vibrations in the word /ʔa:b/.



**Figure 7:** The shaded selection shows the glottal stop closure released into intermittent vocal folds vibrations in the word /ma:ʔ/.

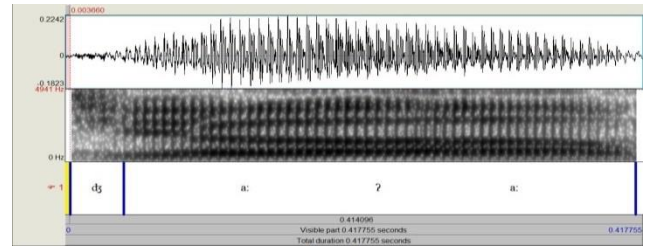


**Figure 8:** vocal folds vibrations start simultaneously with the glottal stop release in the word /ʔa:b/.



**4.2.6.** There may be no glottal stop closure at all. This is observed when the glottal stop occurs medially. The word is pronounced with a prolonged vowel without any closure; see Fig. 9 below.

**Figure 9:** The glottal stop has no closure in the word /dʒa:ʔa:/.



## 5. DISCUSSION

The findings of the present study support the claim that the glottal stop has incomplete closure (cf. [17]). It was only in the initial position where the glottal stop showed some clear closure and post release period of voicelessness. Neither position nor stress had any effect on the glottal stop articulation. Garellek [13] shows that the production of the glottal stop manifests variability, and he concludes that “this variability appears... to be mostly random” (p.132). For Ladefoged & Maddieson [17], a “true [glottal] stop occurs only in gemination in Arabic” (p.75). Al-Ani [1] shows that the variability of the glottal stop is noticed in all positions, but intervocally it appears as “a vowel like glide” (p.61). This is exactly noticed in medial position (see 4.1.2. and Fig. 9). Docherty & Foulks [11] express an interesting idea that is related to the “percepts of the glottal articulation” (p.176). The idea is explicitly stated by Bickford & Floyd [6] who indicate that the “glottal stop is perceived auditorily as being voiceless since there is no vibration of the vocal folds” (p.147). Thus, although the glottal stop shows variability at the production level, this variability is compensated at the auditory level.

## 6. CONCLUSION

The glottal stop in Arabic exhibited some variability in terms of articulation. In initial position, it showed measurable VOT that ranged between 26 ms. (in the word context) and 32 ms. (in the phrase context). But, the glottal stop also had different types of variability in all positions and contexts. The instances of this variability took the following shapes: either no closure was present, or intermittent vocal folds vibrations were observed preceding, during and/or following the closure. Although a small sample is used in this study, the findings are indicative and pose further questions to be investigated, especially in terms of quantifying the instances of variability observed in the articulation of the glottal stop. Additionally, a perceptual investigation is needed in order to complement the findings of this study.

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