Aspiration in Arabic : A Spectrographic Study

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Abstract

Aspiration was investigated in Arabic in relation to the five stop consonants /t/, /ṭ/, /k/, /q/, /ʔ/. These consonants were examined before /a:/ in two positions, viz. initially and medially, and in two contexts, viz. stressed syllables and unstressed ones. The analysis result showed that all the stop consonants had a period of voicelessness between the onset of the stop closure and the onset of the following vowel, though they differed in the duration of that period; /k/ had the longest duration (39 ms), and /ʔ/ had the shortest one (19 ms). Only /k/ and /t/ were marked as aspirated in all positions and contexts, though /q/ may be aspirated initially (whether in stressed or unstressed syllables). The controversy of the voicing status of /q/ was also investigated. It is suggested that this controversy could be explained if the subject is viewed from the production as well as perceptual viewpoints. In addition, /ʔ/ showed an unstable status in relation to voicing, especially in medial position. These findings were discussed in relation to the two positions and contexts where the five stops were examined.

1. Introduction

Aspiration is a phonetic phenomenon that plays an important role in the articulation of voiceless stop consonants. It is usually defined as "a period of voicelessness after stop release" (Raphael et al., 2011, p.134). More specifically, Ladefoged and Johnson (2010) define aspiration as "a period of voicelessness after the stop release and before the start of the voicing for the vowel" (p.57). This "period of voicelessness" is sometimes referred to as turbulent noise (Johnson, 2012, p.173; Holmes and Holmes, 2001, p.81) or "bursts of noise" (Ladefoged, 2001, p.51).

Some researchers have defined aspiration in relation to timing. Lodge (2009) states that aspiration is "a matter of timing relationship between no vibration of the vocal cords and vibration" (p.105). Similarly, Ladefoged (2001) indicates that aspiration is "…a small delay [of vocal cord vibration] before the following vowel in which air rushes out" (p.120).

The notion of timing in relation to aspiration has also been linked to voice onset time (VOT) which has been defined by Lisker and Abramson (1964) as the beginning of voicing relative to the stop release (p.416). As such, aspiration is regarded as "the automatic concomitant of a large delay in voice onset" (p.387). Ladefoged and Johnson (2010) also resort to VOT in dealing with aspiration stating that aspiration is "the amount of lag in the voice onset time" (p.151). This last account of aspiration is adopted in the present study.

The significance of aspiration lies in its being utilized in distinguishing voiced from voiceless stops (Holmes and Holmes, 2001, p.81; Raphael, 2005, p.190; Ashby, 2011, p.125, among others). Discussing the importance of VOT, and aspiration as a related feature, Fry (1979) says that VOT "has been found to constitute an important cue for the voiced-voiceless distinction" (p.136). Likewise, Raphael et

al. (2011) state that one of the cues that marks the voiceless stops /p, t, k/ is "extended periods of aspiration" (p.216). Furthermore, Ladefoged and Johnson (2010) show that Thai "contrasts three different voice onset times. …voiced, voiceless unaspirated, and aspirated stops" (p.154).

It is noticed that emphasis has been put on the voiceless stop consonants in many studies. This is not surprising if we know that the voiceless stops are the "most common" among the consonants used in different languages (Ladefoged, 2001, p.140). This justifies choosing them to be the subject of the present study.

1.2 The Nature of Aspiration

For aspiration to occur there are certain conditions that must be met. A very important feature is the amount of glottal opening. This amount of glottal opening will determine the distinction between voiceless unaspirated stops and voiceless aspirated ones (Ladefoged and Johnson, 2010, p.155), thus "the greater the opening of the vocal folds during a stop, the larger the amount of the following aspiration" (p.151). The second condition that must be observed is the place where aspiration noise occurs. Stevens (2000) states that "[i]f the principal source of turbulence noise is near the glottis, then the noise is called aspiration noise" (p.171). This is, actually, an important specification since there is more than one source of noise. Johnson (2012) distinguishes between burst noise and aspiration noise in that the former "is produced at the consonant place of articulation (like the fricative noise)" while the latter "is produced at the glottis" (p.174). Thus, what is of concern to us is the noise generated near or at the glottis which is an indication of aspiration.

1.3 Degrees of Aspiration

It has been mentioned earlier in this study that aspiration is defined in terms of a "period of voicelessness" or a "delay" in VOT. The question that may be raised in this connection is the amount of delay.

Different studies have proposed different views in connection with labelling stops in relation to aspiration. Johnson (2012) states that "many languages have a boundary between aspirated and unaspirated stops at about 30 ms VOT" (p.101). In this case, the stops are either aspirated or unaspirated. Another view of aspiration in a stop consonant marks three degrees: unaspirated (VOT of less than 20 ms), aspirated (VOT of about 50 ms), and strongly aspirated (VOT of about 150 ms) (Ladefoged and Johnson, 2010, p.151). Finally, Cho and Ladefoged (1999, p.223) propose four "phonetic categories" to describe aspiration in stop consonants: unaspirated (around 30 ms), slightly aspirated (around 50 ms), aspirated (around 90 ms), and highly aspirated (higher than 120 ms).

It is noticed that there is a kind of overlap in the last two types of labelling. Unaspirated stops have a VOT value of less than 20 ms according to Ladefoged and Johnson (2010), while they have a VOT value around 30 ms according to Cho and Ladefoged (1999). In the present study, Johnson's (2012) dichotomy will be adopted since it gives a clear-cut borderline. What is of interest to the present study is to see how aspiration in Arabic fits into these different degrees and locate Arabic in these categories.

2. Aims of the Study

All the above mentioned studies point to the importance of describing and analyzing aspiration. However, aspiration in Arabic has not received its due attention. There are certain studies that have described the different sounds of Arabic (see for example Al-Ani, 1970; Anees,

1990; Alghamdi, 2000; Ryding, 2005 among others). Some scholars have dealt with individual sounds only (see for example Odisho, 1977; AlDahri and Alotaibi, 2010a, 2010b; Alotaibi and AlDahri, 2011), but these studies have not examined the subject of aspiration in detail for the five stops /t/, /ṭ/, /k/, /q/, /ʔ/. Thus, the first aim of the present study is to examine and analyze aspiration in these Arabic stop consonants spectrographically.

Secondly, there is a debate on the voicing status of the Arabic uvula stop /q/ that is explained in detail by Amayrah (2004). The question is whether /q/ is voiceless (as attested by modern phonetic studies of Arabic, see for example Alghamdi, 2000, Al-Badrani, 2013) or voiced (as claimed by old Arab scholars; see for example Bishr, 2000, pp.385ff. for a detailed discussion). Hence, the second aim of the present study is to investigate this claim.

Thirdly, a claim is made about the Arabic glottal stop /ʔ/ being neither voiced nor voiceless (see for example Anees, 1990, p.77; Alghamdi, 2000, p.96-7), though this stop is listed within the Arabic voiceless group of stops by modern scholars. Therefore, the third aim is to test this claim.

3. Methodology

In order to investigate aspiration in Arabic stops a test was conducted. The following subsections present the details.

3.1 Data

Twenty meaningful Arabic words were selected in which each of the five stop consonants /t/, /ṭ/, /k/, /q/, /ʔ/ occurred in two positions, initially and medially, and in two contexts, stressed and unstressed syllables. In every word the stop was followed by the vowel /a:/. This was an attempt to normalize the context in which the stop occurred so that the focus is put on aspiration without any contextual effects other

than the ones under investigation. In addition, this normalization will result in context-free comparison of the five stops. Table (1) illustrates the different positions and contexts (where C_{stop} represents one of the stop consonants).

Table (1) The different positions and contexts of the test data.

	Initially	Medially
In a stressed syllable	ˈC_{stop} a: CVC	CVˈC_{stop} a:C
In an unstressed syllable	C_{stop} a:ˈCV:C	CVC_{stop} a:ˈCV:C

The words used in the test and their meanings are given in Table (2) below.

Table (2) The different words and their meanings of the test data.

	Position / Context	Initially	Meaning	Medially	Meaning
/ t /	stressed	/ˈta:siʕ/	ninth	/siˈta:r/	curtain
	unstressed	/ta:ˈri:x/	history	/kita:ˈba:t/	writings
/ ṭ /	stressed	/ˈṭa:hir/	pure	/maˈṭa:r/	airport
	unstressed	/ṭa:ˈwu:s/	peacock	/qiṭa:ˈra:t/	trains
/ k /	stressed	/ˈka:tib/	writer	/maˈka:n/	place
	unstressed	/ka:ˈbu:s/	nightmare	/ħika:ˈja:t/	stories
/ q /	stressed	/ˈqa:rib/	boat	/ʕiˈqa:b/	punishment
	unstressed	/qa:ˈbi:l/	Abel	/maqa:ˈsa:t/	measurements
/ ʔ /	stressed	/ˈʔa:dam/	Adam	/suˈʔa:l/	question
	unstressed	/ʔa:ˈla:m/	pains	/suʔa:ˈla:n/	two questions

Each word was printed on a flash card (4 cm X 11.5 cm) using Arabic script printed in “Times New Romans” with a font size of “100”.

3.2 Subjects

Six native speakers of Arabic (three males and three females) served as subjects of the test. The variety of Arabic they used was Iraqi (Mosuli) Arabic. However, they were asked to use Standard Arabic pronunciation in their performance. They were between 22 and 45 years old. All of them were educated and none of them reported any speech disorders.

3.3 Equipment

A laptop PC was used in order to record the subjects' performance using Praat. A USB desktop microphone (type Logitech) was connected to the laptop PC. The recording sampling rate was 44100 Hz using a mono channel.

3.4 Procedure

Each subject was instructed to familiarize himself/herself with the Arabic words on the flash cards. The researcher presented each flash card to each subject who was instructed to read the word in the card using Standard Arabic pronunciation, with the microphone about 10 cm away from the subject's mouth. There were three rounds of recordings for each subject in which the flash cards were randomized and presented for the subject to read. The subjects' performance was recorded individually in a quiet room. The result of the recordings was a total of 360 tokens (20 words X 6 subjects X 3 rounds).

4. Analysis

A spectrogram was obtained for each of the 360 recorded words. The Praat software, used in analyzing the data, provided spectrograms in addition to waveform, intensity and pulses all of which were utilized in measuring the aspiration period of the stop consonants. In a spectrogram, aspiration "is marked by the absence of energy in F1 and absence of the regular striations of voicing" (Ladefoged and Johnson,

2010, p.200). In addition, Lisker and Abramson (1964) supplement another mark of aspiration in a spectrogram stating that it “registers as noise…, mostly at the frequencies of the second the third formants of contiguous pattern segments” (p.386). Since aspiration is a period of voicelessness, it is differentiated from the following vowel (/a:/ in our data) by absence of the clear vertical striations present in the spectrogram which are the reflections of vocal cord vibrations of the vowel; i.e. the aspiration period lacks these striations. In addition, the waveform of the aspiration period has very low intensity, compared to that of the vowel, and is clearly distinct from the waveform of the following vowel. Absence of energy in F1 and occurrence of noise at F2 and F3 as indication of aspiration are shown in Figure 1 which illustrates two occurrences of aspiration in a spectrogram.

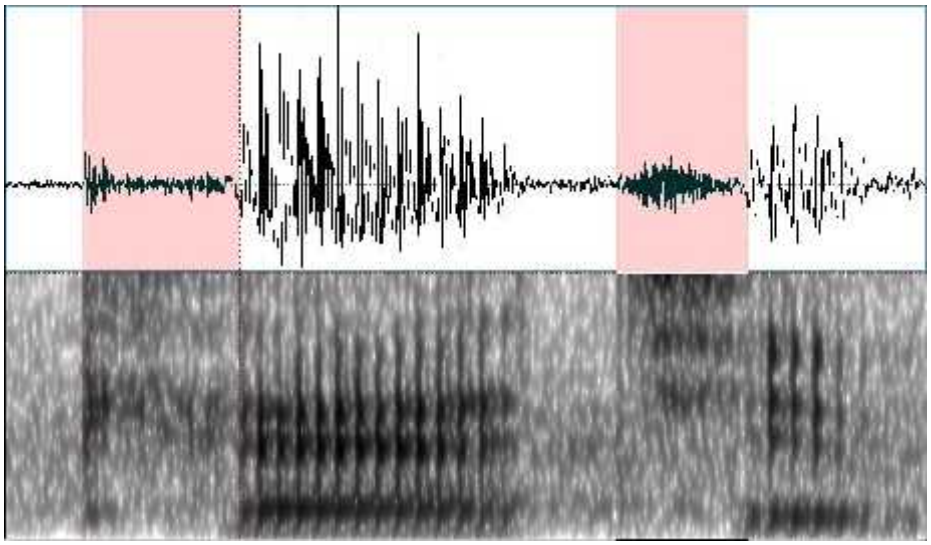

Figure 1. Aspiration of /k/ initially (marked by the first highlighted waveform) and /t/ medially (marked by the second highlighted waveform) in the word /ˈka:tib/ as marked by the waveform (upper view) and the spectrogram (lower view).

It would be convenient here to refer to some remarks related to the analysis of the glottal stop, which showed no stable state in relation to

aspiration (this instability has been referred to by Al-Ani, 1970) . In initial position it had different periods of voicelessness ranging from 4 ms to 64 ms (see Appendix 2).

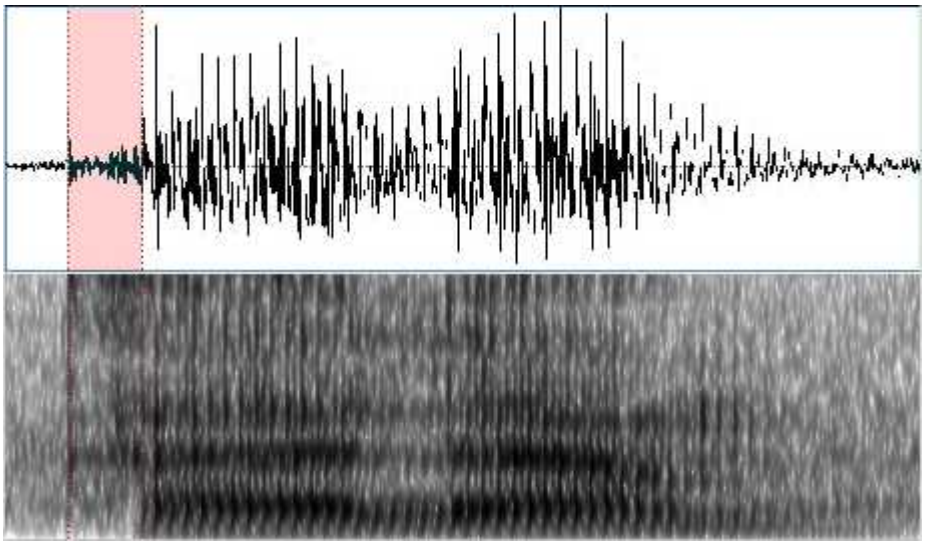

Figure 2 illustrates an example of the glottal stop aspiration initially.

Figure 2. Aspiration of /ʔ/ initially in the word /ʔaːˈlaːm/.

In most tokens of medial position, however, the glottal stop either showed no closure phase and no period of aspiration, or no aspiration in the presence of a closure phase. For the first case, there were 13 tokens (out of 36) of /ʔ/ medially in stressed and unstressed syllables with no closure. Figure 3 illustrates this case.

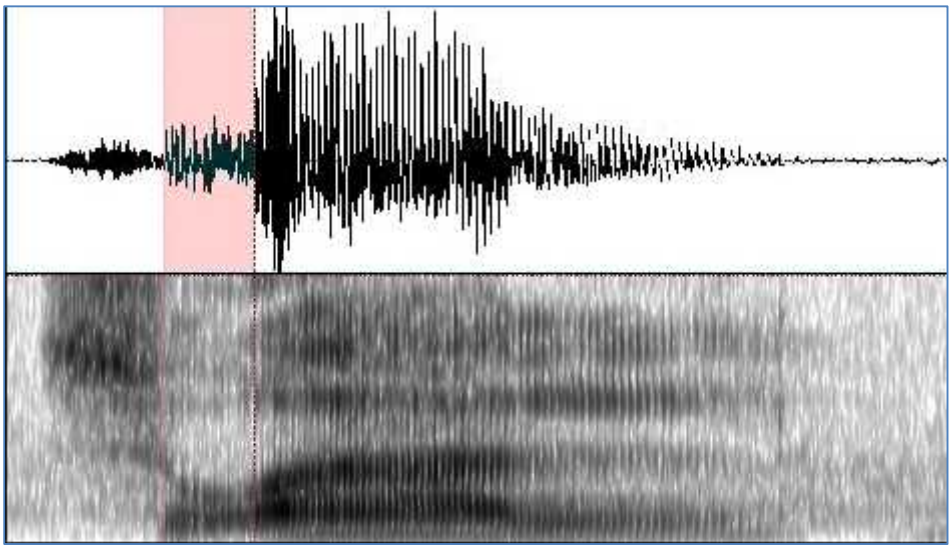

Figure 3. An example of no closure of /ʔ/ medially in the word /suˈʔa:l/.

This behaviour is also found initially, where there were 5 tokens (out of 36) in stressed syllables with no closure (see Figure 4).

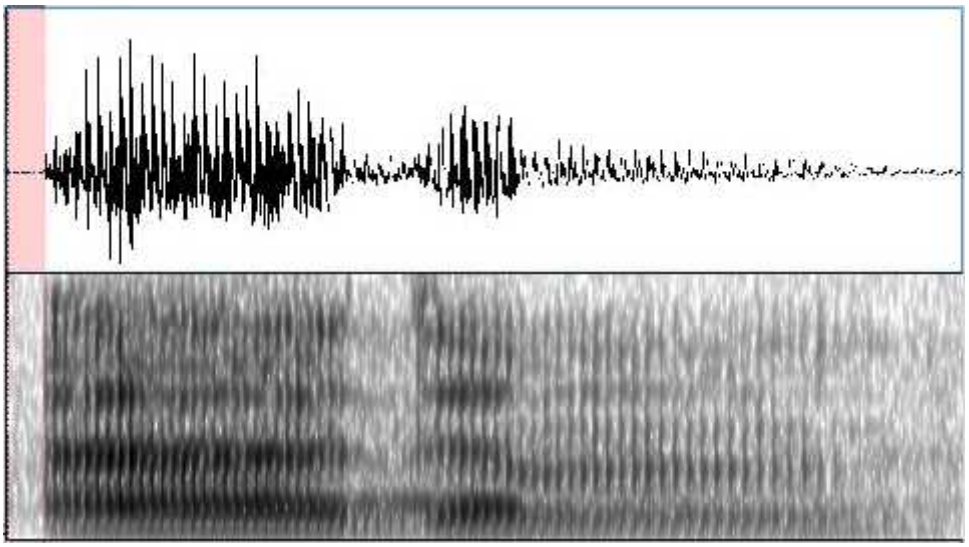

Figure 4. An example of no closure of /ʔ/ initially in the word /ˈʔa:dam/.

Concerning the second case, the glottal stop had a closure phase but with no aspiration period; see Figure 5 for an example.

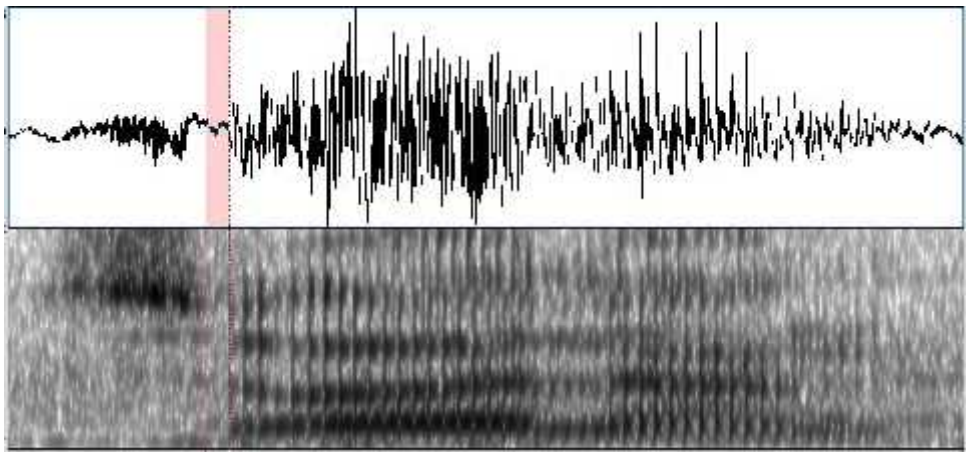

Figure 5. An example of /ʔ/ in which there is a closure phase but without aspiration in the word /suʔaːˈlaːn/.

The other remark about the Arabic glottal stop is its abnormal behaviour concerning vocal cord vibration. In many cases, where /ʔ/ had no closure medially, there were “slower” vocal cord vibrations during the articulation of the glottal stop into the following vowel. This phenomenon was observed across different subjects which, excludes the chance of being an idiosyncratic feature. This suggests a special type of voicing where the vocal cords do vibrate but in a different manner from that of the vowel. Figure 6 is an example of this case.

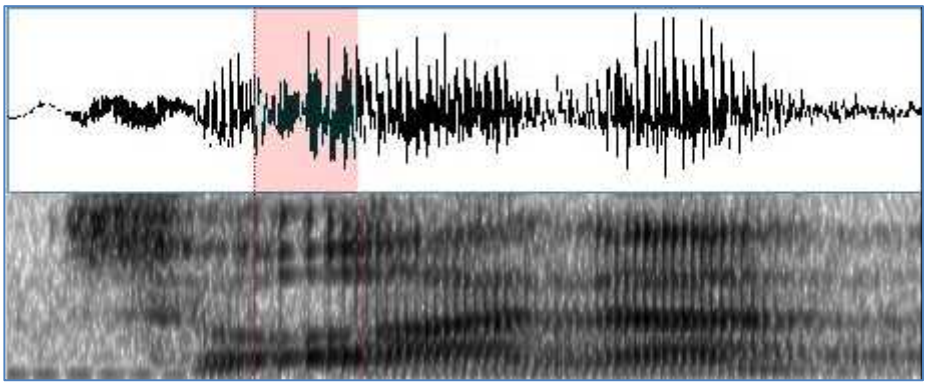

Figure 6. Another token of the word /suʔaːˈlaːn/ showing an abnormal behaviour of vocal-cord vibrations during the articulation of /ʔ/.

In this figure the vertical striations, indicating voicing of /ʔ/, are apart from each other (designating a slower rate of vibration) unlike those vertical striations of the following /a:/ vowel (which are more intense showing a faster rate of vibration). It is noted by Al-Ani (1970) that the glottal stop medially has a "vowel like glide" (p.61). However, he does not refer to the abnormal behaviour of the vocal cords.

Appendix 1 includes spectrograms of the five Arabic stops /t/, /ṭ/, /k/, /q/, /ʔ/ initially and medially showing aspiration periods in these consonants. It is noticed that a period of voicelessness occurs after the release of each stop.

5. Results

The results of the research test are shown in Table (3) in which the aspiration periods of each stop consonant are given (time measurements in ms).

Table (3) Measurements of aspiration periods of each stop consonant in ms.

	Position / Context	Initially	Average	Medially	Average
/ t /	stressed	/ˈta:siʕ/	27.44	/siˈta:r/	28.11
	unstressed	/ta:ˈri:x/	33.61	/kita:ˈba:t/	29.66
/ ṭ /	stressed	/ˈṭa:hir/	22.72	/maˈṭa:r/	19.11
	unstressed	/ṭa:ˈwu:s/	21.44	/qiṭa:ˈra:t/	23.27
/ k /	stressed	/ˈka:tib/	41	/maˈka:n/	39.16
	unstressed	/ka:ˈbu:s/	41.66	/ħika:ˈja:t/	33.05
/ q /	stressed	/ˈqa:rib/	33.22	/ʕiˈqa:b/	25.05
	unstressed	/qa:ˈbi:l/	32.55	/maqa:ˈsa:t/	21.61
/ ʔ /	stressed	/ˈʔa:dam/	19.07	/suˈʔa:l/	19
	unstressed	/ʔa:ˈla:m/	24.72	/suʔa:ˈla:n/	14.33

The measurements of aspiration of the stop consonants for each position and context are summarized in Table (4) below.

Table (4) Summary of aspiration measurements.

	Initially/stressed	Initially/unstressed	Medially/stressed	Medially/unstressed
/ t /	27.44	33.61	28.11	29.66
/ ṭ /	22.72	21.44	19.11	23.27
/ k /	41	41.66	39.16	33.05
/ q /	33.22	32.55	25.05	21.61
/ ʔ /	19.07	24.27	19	14.33

These measurements represent average durations, measured in ms, of aspiration periods of the five stop consonants. Comparisons of these aspiration periods in terms of position and context effects are presented in the following subsections.

5.1 Position Effect

One of the aims of the present study was to investigate the effect of position on aspiration (see section 2). Thus, the five stop consonants were examined initially and medially. Figure 7 presents a comparison of aspiration of the five stop consonants initially and medially in stressed syllables.

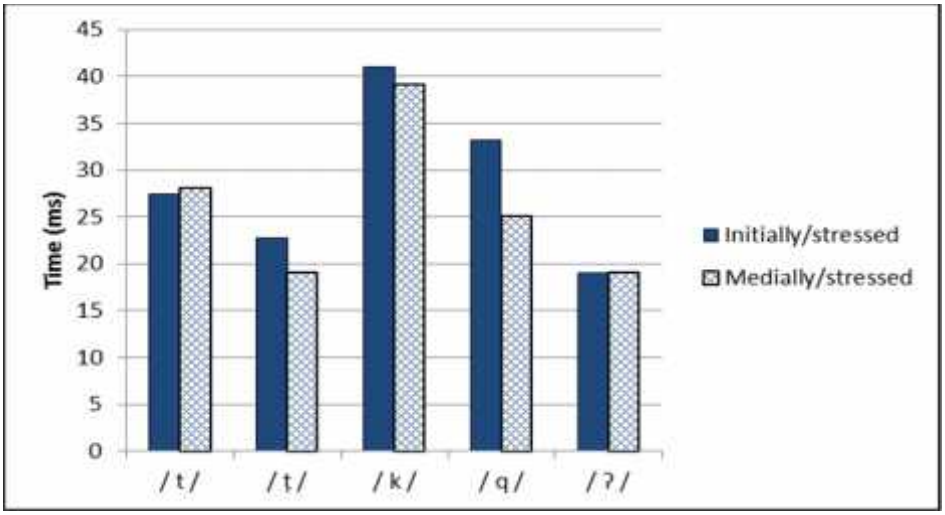

Figure 7. Position effect on aspiration in stressed syllables.

It is noticed that aspiration has longer periods initially than medially (with the exception of /t/ which behaves in an opposite direction, though the difference is not very big).

In Figure 8 a comparison of aspiration is made between initial and medial position in unstressed syllables.

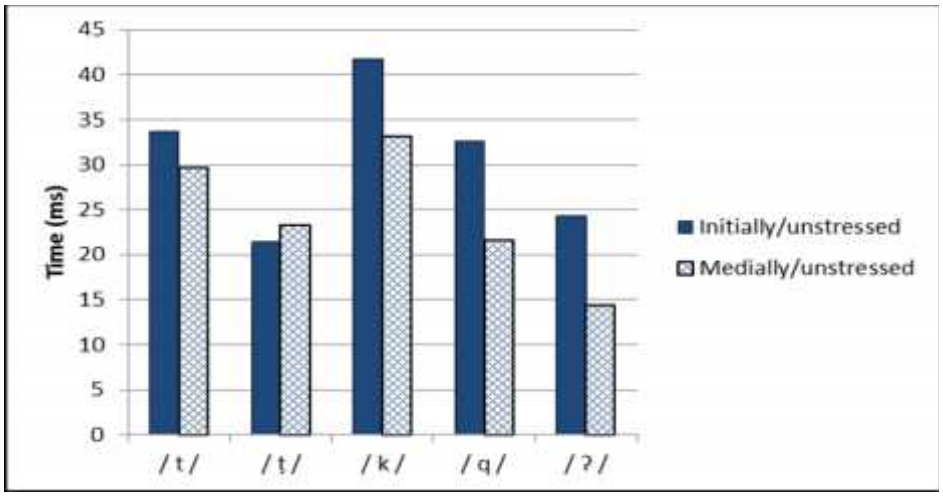

Figure 8. Position effect on aspiration in unstressed syllables.

It can be seen that the same tendency noticed in Figure 7 is observed here; i.e. initially aspiration has longer periods than medially (but this time the exception is with /ṭ/).

In conclusion, aspiration tends to have longer periods in initial position than in medial position whether in stressed syllables or unstressed ones.

5.2 Stress Effect

In order to investigate stress effect on aspiration, the five stop consonants were examined in stressed as well as unstressed syllables. Figure 9 displays a comparison of stress effect on aspiration in initial position.

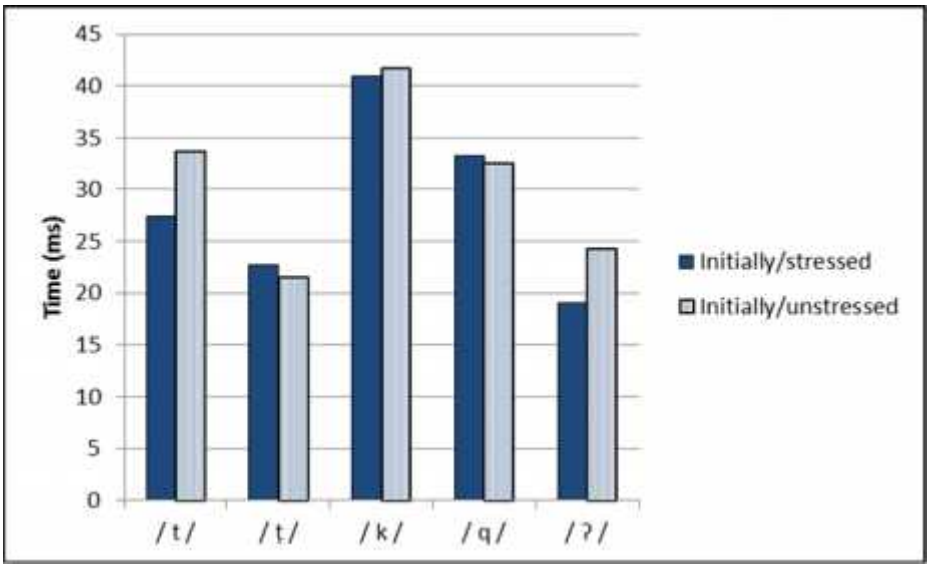

Figure 9. Stress effect on aspiration initially.

It can be seen that with /t/, /k/ and /ʔ/ in initial position aspiration has longer periods in unstressed syllables than in stressed ones. /ṭ/ and /q/, on the other hand, exhibited an opposite tendency.

Finally, Figure 10 presents a comparison of stress effect on aspiration in medial position.

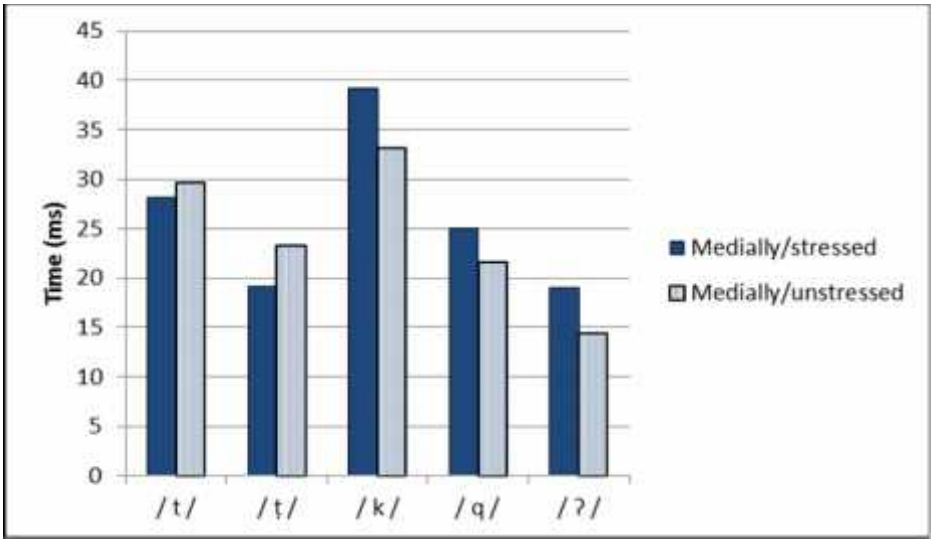

Figure 10. Stress effect on aspiration medially.

In medial position the three stop consonants /k/, /q/ and /ʔ/ had longer aspiration periods in stressed syllables than in unstressed ones. Only /t/ and /ṭ/ exhibited an opposite tendency.

To conclude, aspiration initially in unstressed syllables seemed to have longer periods than in stressed ones. Medially, on the other hand, aspiration had longer periods in stressed syllables than in unstressed ones.

6. Discussion

It has been mentioned in section 2 that the main aim was to describe and analyse aspiration in Arabic spectrographically and compare the aspiration periods with those obtained from other studies (see 1.3). Figure 11 represents the average values of aspiration periods for each stop consonant, initially and medially as well as in stressed and unstressed syllables, depicted from Table 4 (see section 5). These values have been rearranged in descending order; they have also been rounded to the nearest integer for ease of reference.

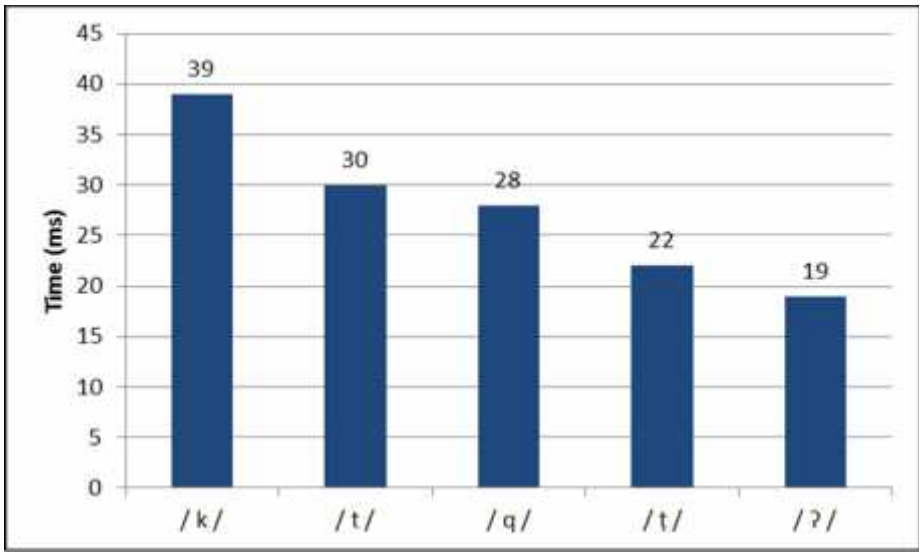

Figure 11. Average values of aspiration periods of the five stops for the two positions and two contexts.

It can be seen from this figure that /k/ has the longest aspiration period (39 ms), while /ʔ/ has the shortest one (19 ms). If we apply Johnson's (2012) dichotomy (see 1.3) of a borderline of 30 ms between aspirated and unaspirated stops, then we only have /k/ and /t/ that are aspirated, thus [k^h] and [t^h] (having VOT values of 39 ms and 30 ms, respectively); the other stops being unaspirated. However, it should be noted that these values could vary depending on context. The VOT values for /q/ initially in stressed and unstressed syllables were 33 ms and 32 ms, respectively (see Table 4). This indicates that /q/ is aspirated in these contexts. In a previous study on VOT in Arabic, Rahim and Kasim (2009) found that the VOT values of stop consonants were higher before a close vowel than a non-close one (in the present study the vowel that occurred after all the stops was a non-close vowel, i.e. /a:/). This means that if the vowel following the stops in this study had been a close one, then aspiration periods would have been different; i.e. higher. In any case, the values of [k^h] and [t^h] obtained in

this study are not considered very high compared to those values found in other languages. In English, for example, /k/ has a VOT value of 50-60 ms and less slightly for /t/ (Ladefoged, 2001, p.120). This is, in fact, not surprising if we know that aspiration plays an important role in distinguishing voiced stops from voiceless ones (Raphael, 2005, p.190). In Arabic, on the other hand, there are two things that are of relevance to aspiration. First, not all the voiceless stops have voiced counterparts; only /t/ and /ṭ/ have voiced counterparts; i.e. /d/ and /ḍ/, respectively. The stops /k/, /q/ and /ʔ/ have no voiced counterpart. Secondly, Rahim and Kasim (2009) have found that the voiced stops had negative VOT values that ranged between -98 ms and -56 ms. This means that Arabic does not need aspiration as a tool to differentiate between the voiced stops from the voiceless ones.

The other two variables examined in this study were position and context. As far as position is concerned, it was noted (see 5.1) that aspiration initially showed longer periods than medially. This finding is in line with other studies (see for example Gobl and Chasaide, 1999, p.122).

The context effect, on the other hand, showed some variability (see 5.2). In unstressed syllables, aspiration had longer periods than in stressed ones for the three stops /t/, /k/ and /ʔ/ in initial position (see Figure 9). Medially, on the other hand, only /t/ and /ṭ/ showed longer aspiration periods in unstressed syllables than in stressed ones (see Figure 10). The other stops had longer aspiration periods in stressed syllables both initially and medially. The tendency for aspiration to have longer periods in stressed syllables goes in line with current research on the relation between stress and aspiration (see for example Ogden, 2009, p.103). The opposite tendency observed in the present study, however, goes counter to that; i.e. aspiration having longer

periods in unstressed syllables. This finding could be attributed to the fact that the words containing the stops in unstressed syllables were bisyllabic and polysyllabic (see Tables 1 and 2). Hasan (1981), in discussing stress in Iraqi Spoken Arabic, states that "[i]n bisyllabic and polysyllabic words, the last long syllable… in a word takes the primary stress. If it is preceded by another long syllable this preceding long syllable takes a *secondary* stress [emphasis added]" (pp. 29-30). In the present study, both types of unstressed words containing the stop consonants had secondary stress. Thus, the syllables containing the stops investigated were not totally unstressed; i.e. the secondary stress could have affected aspiration periods. The attempt to normalize the context in which the stops occurred (all stops were followed by the same vowel; i.e. /a:/) may have affected negatively the results of the study. Thus, a more comprehensive investigation should be attempted where factors like secondary stress are taken into consideration.

Another aim of the present study was to investigate the voicing status of both /q/ and /ʔ/. For /q/, the VOT value shows clearly that it is voiceless (even though it would not be enough to mark the stop as aspirated in all contexts). The average positive value of VOT, i.e. 28 ms, indicates a period of voicelessness after the release of the stop closure. For Anees (1990) /q/ has developed from a voiced consonant (what he calls the "original /q/") to a voiceless consonant; he adds that in most modern Arabic dialects /q/ is voiceless, the only exception being Sudanese Arabic where /q/ is voiced (p.72); Alghamdi (2000, p.98) shares this view. It is suggested in the present study that the controversy of the voicing status of the Arabic uvular /q/ (whether it is voiced or voiceless, see section 2) could be explained by viewing the issue from the *production* and *perceptual* viewpoints. We have seen that the average VOT value for /q/ was 28 ms. This value indicates that

/q/ is voiceless from a production point of view. Since the old Arab scholars did not have our modern equipment and tools for the analysis of sounds, they had resorted to an auditory judgment deciding that /q/ is voiced. The reason behind their judgment, it is believed, is the low VOT value of /q/ which is not sufficient enough to make the listener perceive the stop as voiceless. Furthermore, unlike a continuant sound which provides enough time to sense its voicing status, a stop does not provide this time due to its articulatory manner.

As for the glottal stop, Cruttenden (2008), in dealing with English, states that the glottal stop is voiceless; though he refers to an "alternative viewpoint [that] regards [ʔ] as neither voiceless nor voiced" explaining that this is because "the position of the vocal cords is not that associated with other voiceless sounds" (p.179). In the present study, there was a period of voicelessness of the glottal stop in 39 out of 72 tokens (see Appendix 2); i.e. in about 54% of the tokens /ʔ/ was voiceless. The glottal stop even showed some aspiration in some individual tokens initially in the word /ʔaːˈlaːm/; i.e. its VOT value was higher than 30 ms. However, the other instances of the glottal stop, where there was no closure or no period of voicelessness, call for further research and analysis that may clearly illuminate the voicing status of the glottal stop in Arabic.

7. Conclusion and Suggestions for Further Research

The present study aimed at analysing aspiration in Arabic spectrographically. The five stops /t/, /ṭ/, /k/, /q/, /ʔ/ were investigated in two positions: initially and medially, and in two contexts: stressed and unstressed syllables. It was found that only /k/ and /t/ were marked as aspirated stops, thus [k^h] and [t^h] (VOT values were 39 ms and 30 ms, respectively; though /q/ may be marked as aspirated initially). In addition, position effect showed that aspiration periods were longer

initially. As for context effect, there was some variability; aspiration periods were longer in stressed syllables in medial position only.

The investigation of aspiration in this study revealed some aspects that need further research. On the one hand, the glottal stop showed some variability (see sections 4 and 6) with respect to voicing. On the other hand, context effect in relation to stress (see 5.2) needs more exploration, especially with regard to secondary stress; a variable that was not taken into consideration in the present study.

8. Acknowledgments

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References

Al-Ani, Salman H. (1970). **Arabic Phonology: An Acoustical and Physiological Investigation**. The Hague: Mouton.

Al-Badrani, Maryam F. A. (2013). **A Phonetic and Phonological Study of the Phenomenon of Qalqala in Reciting the Glorious Qur'an**. Unipublished MA Thesis. University of Mosul.

AlDahri, Sulaiman S. & Alotaibi, Yousef A. (2010a). A crosslanguage survey of VOT values for stops (/d, /t/). In **IEEE International Conference on Intelligent Computing and Intelligent Systems, vol. 3**, 334-338. Retrieved October 13th, 2013 from Iraq Virtual Science Library (IVSL).

AlDahri, Sulaiman S. & Alotaibi, Yousef A. (2010b). Phonetic investigation of MSA Arabic stops /t, d/. In the **3rd International Congress on Image and Signal Processing, vol. 7**, 3524-3527. Retrieved October 13th, 2013 from Iraq Virtual Science Library (IVSL).

Alghamdi, M. (2000). **Arabic Phonetics** (in Arabic). Riyadh: King Fahad National Library.

Alotaibi, Yousef A. & AlDahri, Sulaiman S. (2011). Investigating VOTs of Arabic stops /b, k/ with comparison to other languages. In the **4th International Congress on Image and Signal Processing, vol. 5**, 2413-2417. Retrieved October 13th, 2013 from Iraq Virtual Science Library (IVSL).

Amayrah, H. (2004). The sound /q/ between tradition books and modern phonetic analysis (in Arabic). **The Jordan Academy of Arabic Journal, 67**, 175-201. Retrieved October 13th, 2013 from http://www.majma.org.jo/majma/index.php/2009-02-10-09-36-00/299-67-5.html

Anees, I. (1990). **The Linguistic Sounds** (in Arabic). Cairo: Anglo Library.

Ashby, P. (2011). **Understanding Phonetics**. London: Hodder Education.

Cho, T. & Ladefoged, P. (1999). Variation and universals in VOT: evidence from 18 languages. **Journal of Phonetics, 27**, 207-227.

Cruttenden, A. (2008). **Gimson's Pronunciation of English**. (6th ed.) London: Hodder Education.

Fry, Dennis B. (1979). **The Physics of Speech**. Cambridge: CUP.

Gobl, C. & Ni Chasaide, A. (1999). "Voice source variation in the vowel as a function of consonantal context" In William J. Hardcastle & Nigel Hewlett (Eds.). **Coarticulation: Theory, Data and Techniques**. Cambridge : CUP.

Hassan, Z. M. (1981). **An Experimental Study of Vowel Duration in Iraqi Spoken Arabic**. Unpublished PhD. Thesis. University of Leeds, UK.

Holmes, J. & Holmes, W. (2001). **Speech Synthesis and Recognition**. (2nd ed.) London: Taylor & Francis.

Johnson, K. (2012). **Acoustic and Auditory Phonetics**. (3rd ed.). Malaysia: Wiley-Blackwell.

Ladefoged, P. (2001). **Vowels and Consonants: An Introduction to the Sounds of Languages**. Oxford: Blackwell Publishers.

Ladefoged, P. & Johnson, K. (2010). **A Course in Phonetics** (6th ed.). Boston: Thomson Wadsworth.

Lisker, L. & Abramson, Arthur S. (1964). A cross-language study of voicing in initial stops: Acoustical measurements. **Word, 20**, 384-422.

Lodge, K. (2009). **A Critical Introduction to Phonetics**. London: Continuum.

Odisho, Edward Y. (1977). Arabic /q/: A voiceless unaspirated uvular plosive. **Lingua, 42**, 343-347.

Ogden, R. (2009). **An Introduction to English Phonetics**. Edinburgh: Edinburgh University Press.

Rahim, Abbas. J. & Kasim, Ziyad. R. (2009). A spectrographic study of voice onset time in Arabic. **Journal of Education and Science, 16**, 28-41.

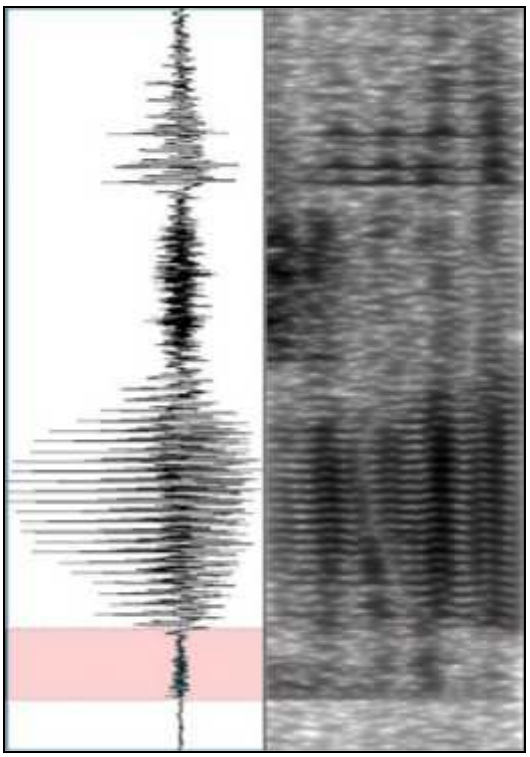
Raphael, Lawrence J. (2005). Acoustic cues to the perception of segmental phonemes. In David B. Pisoni & Robert E. Remez (Eds.), **The Handbook of Speech Perception** (pp. 182-206) Cornwall: Blackwell Publishing.

Raphael, Lawrence J., Borden, Gloria J. & Harris, Katherine S. (2011). **Speech Science Primer**. (6th ed.). Philadelphia: Lippincott Williams & Wilkins.

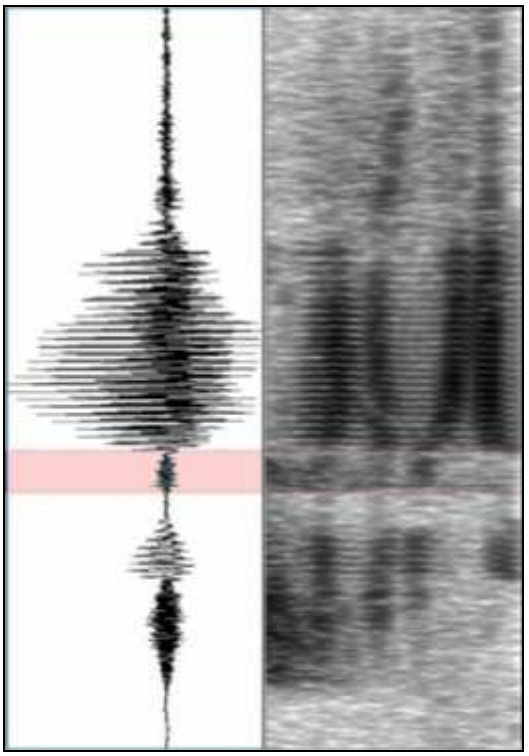
Ryding, Karen C. (2005). **Modern Standard Arabic**. Cambridge: CUP.

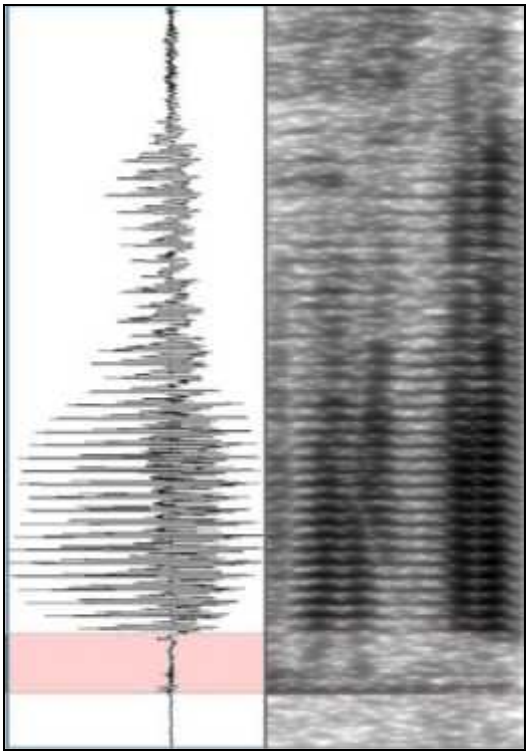
Stevens, Kenneth N. (2000). **Acoustic Phonetics**. MIT: MIT Press.

Appendix 1. Spectrograms of the five Arabic stops /t/, /ṭ/, /k/, /q/, /ʔ/, showing aspiration periods in these consonants (a) initially and (b) medially.

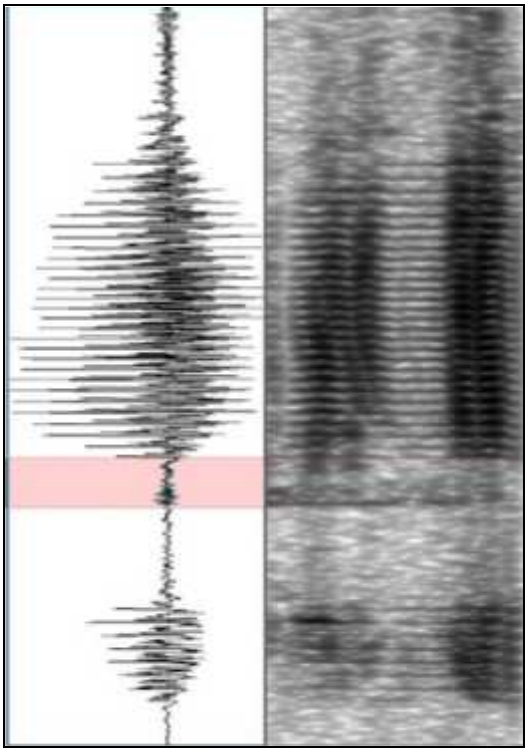


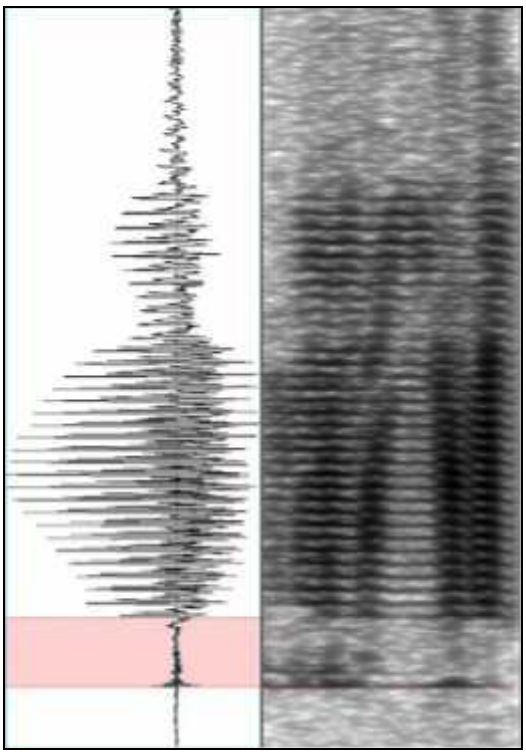
a. /



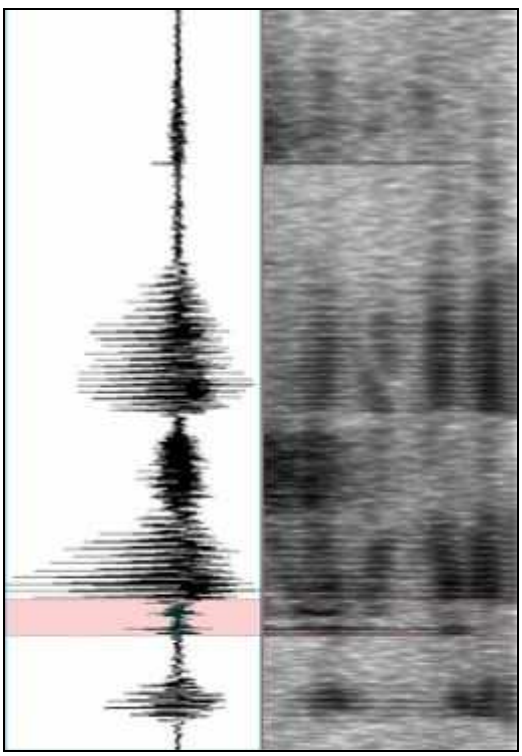


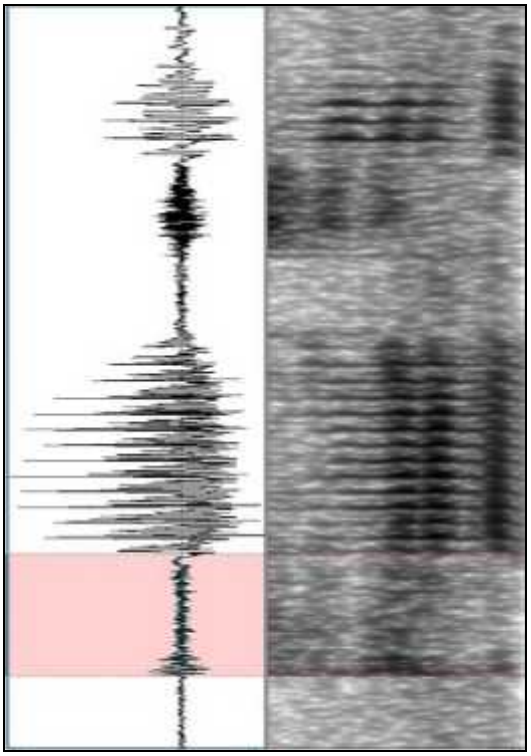
a. /



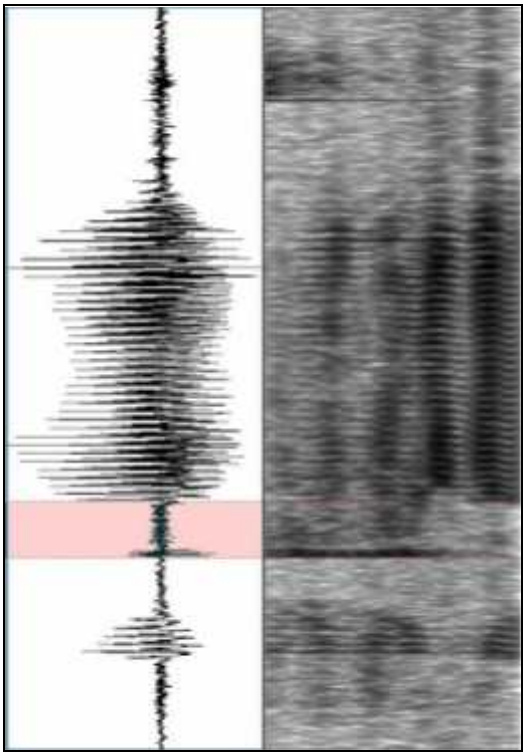


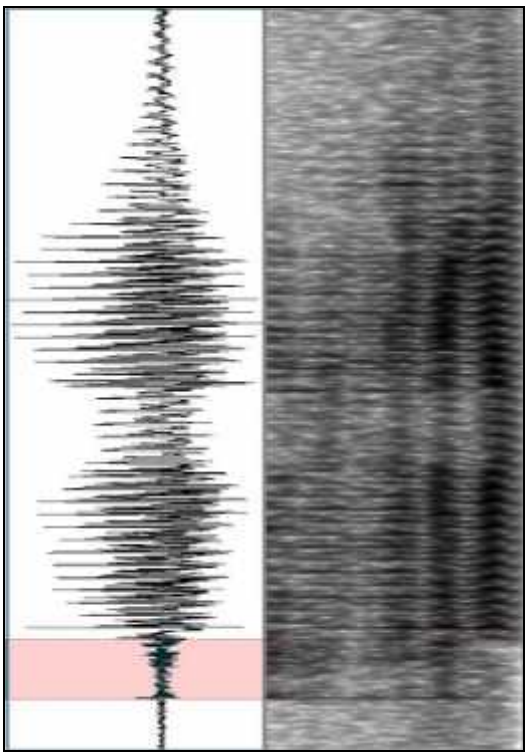
a. /



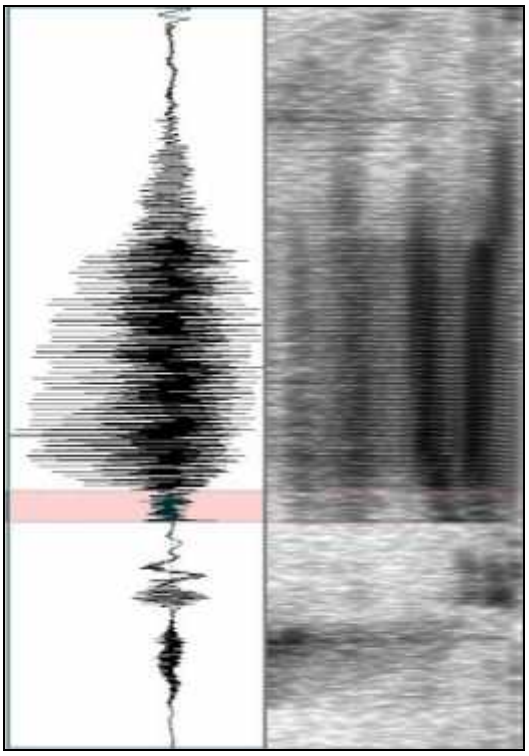


a. /





a. /



Appendix 2. The test subjects' performance. Values refer to time in ms; S=subject, T=token, n/a= no aspiration, n/c= no closure

		S1			S2			S3			S4			S5			S6			Average
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	
1	/ˈṭa:hir/	18	30	19	28	34	33	30	30	24	15	16	22	21	24	14	12	14	25	22.72
2	/ˈʔa:dam/	48	6	n/c	31	19	n/c	15	23	n/c	18	18	7	n/c	7	n/c	11	20	25	19.07
3	/ˈka:tib/	41	42	37	68	75	61	38	53	52	39	24	32	19	22	28	24	38	45	41
4	/suʔa:ˈla:n/	n/c	n/c	n/c	17	n/a	n/a	n/c	n/c	n/c	14	12	n/c	n/a	n/a	n/a	n/a	n/a	n/c	14.33
5	/ʕiˈqa:b/	11	24	9	21	36	28	34	41	46	17	12	17	40	39	14	13	20	29	25.05
6	/maqa:ˈsa:t/	9	17	18	22	35	23	39	38	36	15	12	15	23	13	10	22	16	26	21.61
7	/qiṭa:ˈra:t/	23	23	14	26	32	34	28	26	33	13	40	34	13	19	17	10	15	19	23.27
8	/maˈṭa:r/	13	13	19	20	25	21	25	28	28	13	17	17	14	17	18	16	12	28	19.11
9	/kita:ˈba:t/	53	40	37	33	50	35	33	36	34	20	32	29	25	15	18	16	15	13	29.66
10	/ħika:ˈja:t/	54	37	35	36	50	45	33	52	47	25	29	31	26	19	12	16	25	23	33.05
11	/maˈka:n/	43	40	44	39	39	42	45	50	56	43	25	44	38	33	21	28	41	34	39.16
12	/suˈʔa:l/	n/c	n/c	n/c	8	n/a	n/a	n/a	n/a	n/c	15	32	21	19	n/c	n/a	n/a	n/a	n/a	19
13	/siˈta:r/	37	34	48	43	41	32	33	36	39	24	27	13	17	18	14	11	23	16	28.11
14	/ta:ˈri:x/	47	30	34	39	52	47	40	51	30	47	21	37	18	22	20	14	16	40	33.61
15	/ˈqa:rib/	30	16	14	41	38	28	38	49	54	20	28	25	58	33	42	14	26	44	33.22
16	/ˈta:siʕ/	23	29	31	35	36	45	31	26	39	16	29	18	19	24	19	15	17	42	27.44
17	/ʔa:ˈla:m/	28	46	19	47	24	54	15	24	13	26	7	10	6	16	21	4	13	64	24.27
18	/ṭa:ˈwu:s/	19	10	20	26	25	29	23	40	25	15	17	21	22	19	15	14	16	30	21.44
19	/qa:ˈbi:l/	14	14	32	35	32	40	42	23	40	18	22	17	51	61	61	13	26	45	32.55
20	/ka:ˈbu:s/	51	58	47	54	45	60	35	43	39	26	27	39	44	35	33	32	34	48	41.66

النَفَسِية في اللغة العربية - دراسة صوتية طيفية -

زياد راكان قاسم

جامعة الموصل - كلية التربية للعلوم الإنسانية

الملخص

بُحِثت الظاهرة النَفَسِية (aspiration) في اصوات اللغة العربية الصامتة الوقفية (voiceless stop consonants) /t, ṭ, k, q, ʔ/. فُحِصت هذه الاصوات قبل الصائت /a:/ في موقعين هما بداية ووسط الكلمات فضلا عن موضعين هما ضمن مقاطع ذات نبر (stressed) وبدون نبر (unstressed). اظهرت نتيجة التحليل وجود فترة من الهمس (voicelessness) لتلك الاصوات الوقفية جميعها بين بداية حركة اعضاء النطق للسماح للهواء بالخروج وبداية الجهر للصائت الذي يليها، على الرغم من اختلاف هذه الاصوات فيما بينها في زمن هذه الفترة، إذ كان لصوت الـ /k/ اطول فترة (٣٩ ملليثانية) في حين كان لصوت الـ /ʔ/ اقصر فترة (١٩ ملليثانية). ظهرت النَفَسِية في صوتين فقط هما /k/ و /t/ في كلا الموقعين والموضعين، في حين ظهرت في صوت الـ /q/ عندما كان في بداية الكلمات فقط. وبُحِث الجدل المتعلق بصوت الـ /q/ حول كونه مجهورا ام مهموسا وكيف انه يمكن تفسير هذا الجدل بالرجوع الى طريقة نطق الصوت اضافة لكيفية سماعه. كما كان لصوت الـ /ʔ/ حالة غير ثابتة فيما يخص النَفَسِية، خاصة في وسط الكلمات. ثم نوقشت هذه الملاحظات فيما يتعلق بالموقعين والموضعين اللذين تم دراسة الاصوات الصامتة الوقفية الخمسة فيهما.