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Adab Al-Rafidayn Journal

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Editor-in-chief

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*An Acoustic Study of the Production of Iraqi
Arabic Stop Consonants*

*saif mohammed Al-Tai **

*Ziyad Rakan Kasim **

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Abstract

In this study, an acoustic description of the Iraqi Arabic (IA) stop consonants, /p, b, t, d, k, g, ʈ, q and ʔ/ in initial, medial and final positions in isolation and in carrier phrase was carried out. The acoustic parameters that were investigated were closure duration (CD), burst duration (BD) and voice onset time (VOT). The study aimed to contribute to the phonetic description of IA speech sounds by acoustically describing its stops and to find out whether there were differences between IA stops and the English stops. The data was collected from 20 educated subjects, 10 males and 10 females. In terms of CD, it was found that the IA voiceless stops had longer CD than the IA voiced stops. It was also found that the labial stops had longer CD than the alveolars and the velars. The results also showed that /q/ had longer CD than the others with some exceptions and /ʈ/ had longer CD than its plain counterpart, /t/. In terms of BD, it was found that the IA voiceless stops had shorter BD than the English stops and thus they were less aspirated than the English voiceless stops. Only /t/ and /k/ were found to be aspirated. In terms of the voiced stops, unlike the English voiced stops, it was found that the IA voiced stops were fully voiced which means that they have voicing during the closure represented by negative VOT values. The glottal stop showed a good example of a normal stop consonant only in initial and final positions in isolation. In other contexts, it showed a great deal of variability in its spectrogram where its acoustic make ups were not observed.

Keywords: Closure duration, Burst duration, Voice onset time, Iraqi Arabic..

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1. Introduction

Both articulatory and acoustic descriptions of speech sounds are important in analyzing speech since every articulatory movement has a particular acoustic outcome. In fact, they complement each other and alternate with each other in describing speech (Lodge, 2009: 183). Thus, there has been a great deal of interest to depend on acoustic analysis recently because it does not need special equipment like x-ray (Al Shareef, 2015). Acoustic cues are helpful to decide on the type of the sound being pronounced whether a stop, a fricative, an approximant, etc. Crystal (2003:7) adds that the importance of acoustic analysis lies in that it provides objective data for the researcher when s/he analyses speech.

Stop consonants are the most frequent consonants in languages throughout the world (Henton, Ladefoged & Maddieson, 1992:98). They are characterized by having a complete closure of the air stream. They are described as having three phases, the closure phase, the release phase which is like a little explosion, and the post-release phase which may or may not include aspiration (Ladefoged & Johnson, 2014). Stops are characterized by being non-resonant and they have a lot of acoustic cues relative to other categories of speech sounds. These acoustic features are: 1) The white band which represents the stop closure 2) The spike which represents the stop release 3) A period of voicelessness which represents aspiration in the case of aspirated stops. 4) High rate of formant transition of the adjacent vowels due to the rapid change of the shape of the vocal tract (Raphael, Borden & Harris, 2007: 205).

Western researchers did pay attention to the Arabic language until the 19th century (Al Ani, 1970:17). Arabic is much less researched than other languages despite being used by millions of Arabs in the Middle East and North Africa (Al Otaibi and Husain, 2010; Saadah, 2011 and Al Shareef, 2015). Many cross-linguistic studies have been conducted on the acoustic phonetic characteristics of many languages without tackling the Arabic language. For example the significant cross-linguistic study made by Lisker and Abramson (1964) measured the Voice Onset Time (VOT) values of

11 languages, but Arabic was not one of them. Another cross-linguistic study made by Cho and Ladefoged (1999) investigated the variations and universals of VOT values. The study examined 18 languages, but again Arabic was not included. Furthermore, even if Arabic was included in a study, it was dealt with superficially. For example, in another cross-linguistic study about phonation types in different languages, Gordon and Ladefoged (2001) only mentioned the word 'Arabic' once in the whole study and without giving any example from the Arabic language.

One of the earliest studies on Arabic acoustic phonetics was made by Al Ani (1970). Part of his study was about the description of the Iraqi Arabic (IA) stop consonants. According to Al Ani (1970), stops are physiologically characterized by two features: 1) the complete closure in the vocal tract 2) the sudden release. It was found that voiceless stops have longer bursts than voiced stops due to aspiration. It was also found that, in final position, both voiceless and voiced stops appeared to have a lot of variations in being released or not. However, Al Ani's (1970) study did not handle larger data, nor did it provide any descriptive statistics. In terms of cross linguistic studies, Flege and Port (1981) conducted more than one experiment comparing the Arabic stops with the English stops. In one experiment, they compared the Arabic stops with English stops in word initial and final positions in Saudi Arabic dialect. In terms of VOT, they found that the VOT values of Saudi Arabic voiceless stops were shorter than the English voiceless stops. However, it was found that Saudi Arabic voiceless stops had longer VOT values than Lebanese Arabic voiceless stops. These findings suggested that VOT patterns were language specific and there were even variations between the dialects within the same language. Because Saudi Arabic initial voiced stops, /b,d,g/, showed voicing during the whole closure, Flege and Port (1981) did not measure VOT but differentiated between them in terms of closure duration.

2. Acoustic Descriptive Parameters of Stops

Since every articulatory movement yields a particular acoustic outcome and since the production of stops involves a larger number of procedures relative to other categories of speech sounds like fricatives, thus, stops are described by having redundancy of acoustic cues relative to other speech sounds (Lodge, 2009: 183; Raphael, Borden & Harris, 2007:205). The acoustic parameters that are going to be measured in this study are closure duration (CD), burst duration (BD) and voice onset time (VOT). CD is the period between the articulatory closure of the stop consonant and the onset of the burst release (Cho & Ladefoged, 1999). The acoustic studies approve that voiceless stops are longer than their voiced counterparts (Ladefoged & Johnson, 2014; Fry, 1979). Lodge (2009: 208) also states that the different patterns of the closure phase of the stops are also cues for place of articulation. The reason behind the voiceless stops being longer in duration than their voiced counterparts is that there is no vibration of the focal folds during the closure (Ladefoged & Johnson, 2014: 70). In voiced stops, the built-up pressure behind the stricture is affected by the pressure of the air behind the vocal folds (Shaheen, 1979:101)

BD refers to the period of the voicelessness after the stop release represented by a spike in the acoustic analysis (Ladefoged & Johnson, 2014). Researchers measure BD of stops to find out whether they are aspirated or not. If the duration of the burst is equal or more than 30 ms, the stop is said to be aspirated (Ashby & Maidment, 2005:92). BD is seen in the acoustic analysis as a period between the stop release and the second formant of the following sonorant (Lisker & Abramson, 1964: 386).

VOT has been studied widely in the last few decades to serve the distinction among stop consonants (Al Shareef, 2015:1; Khattab, 2002:1 & Castonguay, 2016:10). Fry (1979: 136) states that VOT is considered the most important acoustic cue used in the voiceless-voiced distinction among stops. VOT refers to the period between the release of the closure to the beginning of the vibration of the vocal folds (Ladefoged & Johnson, 2014: 159). The term VOT is first advocated by Lisker and Abramson (1964) in their classical

study on the measurement of the VOT of the stop consonants of 11 languages. They define VOT as “the time interval between the burst that marks release of the stop closure and the onset of quasi-periodicity that reflects laryngeal vibration” p.422.

3. Utilization of Acoustic Description

What is the benefit of acoustic description? What is it used for? Teachers, researchers and education specialists can determine the efficiency of some particular methods on teaching some particular aspects of the target language by the aid of acoustic measurement. For example, Huang (2018) utilized acoustic measurement in determining the efficiency of “speech shadowing” in teaching pronunciation of English as a second language in Taiwanese elementary schools. The results of his study showed that, after a four-week training period, the pronunciation of /p/, /b/ and /d/ were better developed in the group in which speech shadowing was used than the other group. This was observed through the investigation of VOT of the participants’ /p,b,t,d,k,g/ production in reading and speaking conditions. English teachers can also use acoustic charts of the learners’ native language as a “reference point” to teach them the speech sounds of the target language (Ladefoged & Johnson, 2014: 234). Moreover, the orientation in teaching phonetics in the universities nowadays goes towards taking the benefit of teaching speech sounds in terms of the instrumental acoustic phonetics. This will support and enrich the traditional approaches, represented by the articulatory and auditory approaches. Students are taught speech sounds acoustically throughout changing some parameters such as duration (length), amplitude (loudness) or frequency (pitch) and see what happens in the analyses of the sound in question (Saustarsic, 2003).

Acoustic description can also be useful in other fields of study. In sociolinguistics, acoustic description is useful in the classification of the dialects of a particular language according to the acoustic features of their speech sounds (Themistocleous, 2017). The present study can be utilized in classifying and differentiating the dialect which will be dealt with in this study and compare it with

other Iraqi dialects. For dialect identification, a computer can be given the acoustic values of the dialect to be stored. The computer can identify this dialect by making a comparison between the values stored in the computer and the dialect introduced to it. Acoustic description has also a significant value for computer engineers. It is useful in speech recognition and what is called “voice print” which is a set of acoustic characteristics that uniquely identifies an individual. A computer can make a comparison between a speaker’s input data and the acoustic information stored in the computer in order to recognize the speaker (Ogden, 2009:31). It is also useful for the Iraqi computer engineers in programing local applications which utilize speech.

4. Problem of the Study

In the recent few decades, a large number of studies has been conducted on stop consonants in different languages and their dialects in terms of acoustic phonetics. Such investigation, however, is absent in a number of Arabic dialects including the IA.

5. Aims of the Study

The aims of the present study are 1) to make an acoustic description of the IA stop consonants to contribute to the phonetic description of the Iraqi Arabic speech sounds and to obtain a better understanding of its speech production, and 2) to find out whether there are differences between the IA stops and the English stops in terms of acoustic parameters. The objective of the first aim is to describe these stops in all three positions (initial, medial and final) and in two different contexts (in isolation and in carrier phrase). This objective includes answering the question: what is the acoustic description of IA stop consonants in terms of these different environments. The objective of the second aim is to make a contrastive analysis between the acoustic features of IA stops and those of English and to find whether there are differences between them.

6. Method

6.1 Language variety

Iraq **is** said to have three major Arabic dialects with a large number of sub dialects. These three major dialects are confined to

the geography of Iraq, the Northern dialect (represented, mainly, by the Mosuli dialect), the Central dialect (represented, mainly, by the Baghdadi dialect) and the Southern dialect (represented, mainly, by the dialect used in Basra) (Rahim, 1980). Due to time limits, one dialect will be dealt with in this study which is the Mosuli Iraqi Arabic dialect. This dialect is used in the city of Mosul in the North of Iraq. There are some features that distinguish it from other Iraqi dialects. One feature is the replacement of /a:/ by /e:/ in some words as in /wa:qif/ >> /we:qif/ “standing”. This feature is called ‘al-imaalah’. Another feature is the replacement of /r/ by /y/ in some words like /ʔahmar/ >> /ʔahmay/ ‘red’. A third feature is that this dialect is related to the ‘qiltu’ dialects in contrast to the ‘gilit’ dialects like those of Baghdad and Basrah; in other words, Mosuli Arabic speakers do not change /q/ into /g/ in words containing the letter ‘qaf’ (Altai, 2010:5 , Blank, 1964).

6.2 Data

The data set, shown in Table 1 below, consists of words containing the nine IA stop consonants, /p, b, t, d, ʔ, k, g, q, ʔ/. The words are used in isolation and in a carrier phrase, which is /qilli sit marra:t/ (say to me six times). Three words are used for each sound and for each position, initial onset, intervocalic (medial) and final coda positions. So, twenty seven words are involved in the study, (9 sounds x 3 positions = 27). The words are preferably monosyllabic so that stress placement and the number of syllables will have a minimal effect on segment duration. All the words representing IA stops in initial and final positions are monosyllabic while it is impossible to find monosyllabic words in medial position since Standard and dialectal Arabic words do not start with vowels but they are always preceded by the glottal stop, in addition to the fact that there are usually epenthetic vowels between consonant clusters (Al Ani, 1970:22). In other words, the structure of the words where the stops are used initially and finally is CVC (where the first C is one of the stops initially and the final C is one of the stops finally). Medially, the structure is CVCVC where the medial C is one of the stops. The words are printed on flash cards in 80 font size, in Arabic script with diacritics in order to direct the

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subjects to a dialectal production not to the standard. The selected words do not contain pharyngeal consonants to avoid the effects of pharyngealization. Nonsense words are not involved in the study.

Table 1. The words containing IA stops in initial, medial and final positions

No.	Stop	Token (initial)	Gloss	Token (medial)	Gloss	Token (final)	Gloss
1-	/p/	/pi:m/	Torch light	/'qapay/	Cover	/su:p/	Soup
2-	/b/	/bi:z/	A knitting knife	/'laban/	yogurt	/'hab/	Grain
3-	/t/	/ti:n/	Fig	/'ma'ti:n/	solid	/ze:t/	Oil
4-	/d/	/di:n/	Religion	/'i'de:n/	Hands	/'i:d/	Hand
5-	/ʈ/	/'ti:n/	Mud	/'maʈay/	Rain	/'xat/	Line
6-	/k/	/'ki:s/	Sack	/'ʃakar/	Sugar	/'ʃak/	Doubt
7-	/g/	/'ga:z/	Oil	/'lagan/	Gallon	/'dʒag/	Jack
8-	/q/	/'qi:s/	Measure	/'θa'qi:l/	Heavy	/'haq/	Right
9-	/'ʔ/	/'ʔax/	Brother	/'saʔal/	Asked	/'ha:ʔ/	abic letter

6.3 Subjects

Twenty IA monolingual educated adult speakers, ten males and ten females aged 18-40 years old, participated in the present study. The subjects were selected through personal contact. They were asked about their educational background, age, whether they were monolingual or not, and whether they had suffered from any speech or hearing disorders.

6.4 Procedure and Equipment

The procedure used in the present study in collecting the data followed the elicitation method, or as Lisker & Abramson (1964:389) say “elicitation procedure”. The flash

cards were presented to the subjects before starting the recordings to familiarize the subjects with the words and correct any mistakes in pronunciation. A head-mounted microphone (Sades SA-903) connected to Dell laptop computer was used in all the recordings. The distance of the microphone from the mouth was about 10 centimeters. All the recordings were made and analyzed using the computer software Praat (Boersma & Weenink, 2012) with a sampling rate 22100Hz using a mono channel. The recordings took place in different places according to the place at which the participants were available. The places of the recordings were selected carefully far from any source of noise. Three recordings were made for each token then the most two normal recordings were selected to be analyzed. The anomalous recordings, in which there was a lot of noise or the acoustic makeups of the stop consonants were not clear, were discarded since it was the normal cases that were sought not the anomalous ones. The recording sessions were divided into two halves. The first half included recording the words in isolation while the second half was for the words in the carrier phrase. The subjects were requested to pronounce the carrier phrases in a normal speaking conversation, and not to make pauses between the words. The first half took about twenty minutes while the second half took about thirty minutes.

6.5 Data Analysis

One thousand and eighty tokens were analyzed (9 stops x 6 tokens (three in isolation and three in carrier phrase) x 20 subjects). A spectrogram was obtained for each token. The acoustic analysis involved segmentation, annotation and measurement of CD, BD and VOT. The segmentation process involved identifying the beginning and end of the segment as well as the phases of the stops. It was done manually depending on spectrogram, waveform and hearing judgment. The segmented sounds were annotated by creating text grids and merge them with the analysis. All the measurements of

durations were made in milliseconds (ms). The acoustic values of the stop consonants, then, are presented on spectrograms, waveforms, tables and charts.

It is worth mentioning that, in the carrier phrase, the sound preceding the embedded word is a vowel and the sound following it is a fricative. Vowels and fricatives provide clear boundaries to the beginning and end of the stops in word initial and final stops. This was taken carefully to avoid stop consonants cluster.

7. Results

7.1 Closure Duration

The beginning of the closure can be determined from the point where the formant structures of the sonorant or the energy power of the non-sonorant consonants preceding the stop under investigation ceases. The offset of the closure can be determined from the point of the stop release represented by the release spike in the analysis. Figure 1 below demonstrates the closure of a voiceless stop.

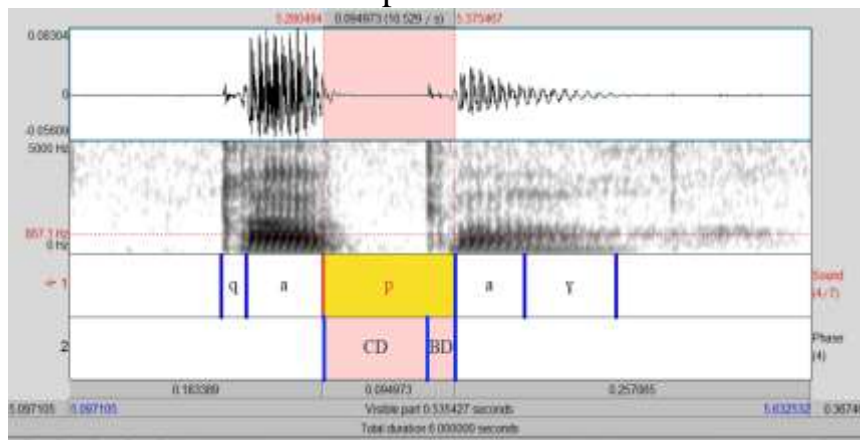


Figure 1. An example showing the closure of /p/ in /'qapay/

7.1.1 In Isolation (in each position)

Table 2 below presents the values of CD of IA stops for medial and final positions. CD in initial position could not be measured since the onset of the closure could not be specified

(Homma, 1980). Since the IA voiced stops are found to be fully voiced, it is worth mentioning that the IA voiced stops' CD values also represent their VOT.

Table 2. CD of IA stops in isolation context in medial and final positions.

	p	b	t	d	K	G	ṭ	q	ʔ
medially	76.4	51.9	68.6	57.5	66.5	54	73.5	82.2	32.2
finally	155.1	149	155.6	130	156.8	136.8	155.6	166.7	116.5

It is clear from Figure 2 below that CD of IA stops in final position is higher relative to CD in medial position. The highest value recorded in the measurement of CD in isolation is 166.7ms for the final /q/. The voiceless unaspirated stops, /p, ṭ, q/, have longer CD from the voiceless aspirated stops, /t and k/.

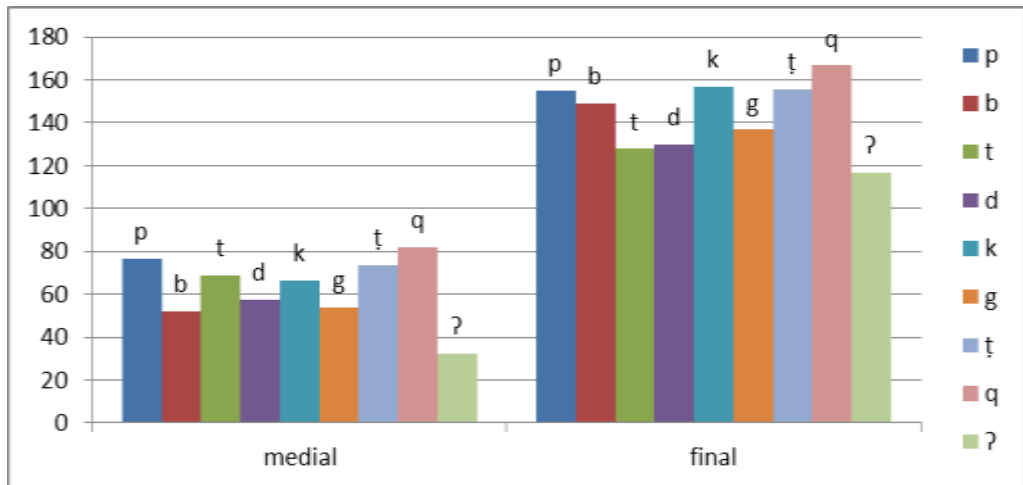


Figure 2. CD differences among IA stops and CD variations in medial and final positions.

7.1.2 In Carrier Phrase (in each position)

Table 3 and Figure 3 below show the CD values of IA stops in phrase context in initial, medial and final positions. The highest value of CD detected in the three positions in phrase context is 83.9ms for /p/ which is in initial position in phrase context. CD of the glottal stop could not be measured in all the

positions in phrase context because it did not appear as a stop consonant at all.

Table 3. CD of IA stops in carrier phrase in initial, medial and final positions.

	p	b	t	d	k	g	t̤	q	ʔ
initially	83.9	70	69.2	59.2	71.2	57	68.7	80.3	
medially	70.1	51.3	62	52.6	60.7	47.5	65.3	72.9	
finally	67.8	62	59.5	52.8	65.2	65.2	66.6	78.7	

Note. CD values of the voiced stops also represent their VOT values. A blank cell means that the CD of that stop cannot be measured in this position in this context.

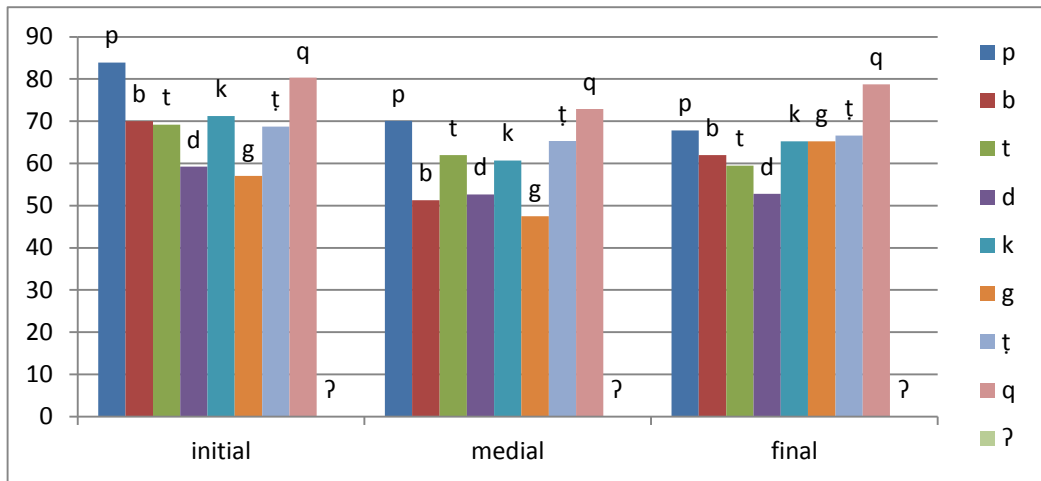


Figure 7. CD differences of IA stops and CD variations across initial, medial and final positions carrier phrase.

CD is found to be longer for the voiceless stops than for the voiced ones in most of the positions except /t/ and /d/ in final position in isolation and /k/ and /g/ in final position in phrase context. There is no significant nor systematic difference in CD between the alveolars and velars. In all the cases except in initial position in phrase context, the alveolar pharyngealized stop /t̤/ has relatively longer CD than the plain alveolar stop /t/. On the other hand, it is found that, similar to Standard Arabic, IA voiced stops are fully voiced. This means that voicing continues throughout all the phases of the voiced stops. Figure 4 below is an example of a voiced stop, medial /b/ in /laban/.

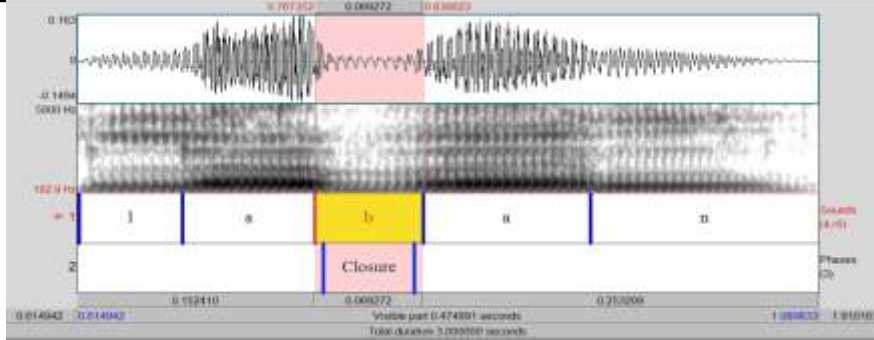


Figure 4. An example of a IA voiced stop, /b/ in /laban/.

7.2 Burst Duration and Aspiration

Lisker and Abramson (1964: 386) state that aspiration is seen in the spectrogram as “noise” or “random stippling” near the frequencies of the second and third formants of the following sonorant. If the duration of the burst is equal or more than 30ms, the stop is said to be aspirated (Ashby & Maidment, 2005:92).

7.2.1 In Isolation (in each position)

Table 4 and Figure 5 below present the mean values of BD of IA stop consonants in the initial and medial positions. BD cannot be measured in final position in isolation because its offset cannot be observed in most of the cases since stop consonants are usually unreleased in utterance final position (Homma, 1980). And even if they are released, it is impossible to measure BD because there is no following sound so the offset of the burst of noise cannot be detected precisely. Similar to what Zue (1976) notes, note that the BD values of the voiceless stops are the same of those of their VOT.

Table 4. BD of IA stops in isolation in initial and medial positions.

	p	b	t	d	k	g	ʈ	q	ʡ
initially	17.9	0.2	41.3	2.5	53.1	5.2	18.2	22.9	11.1
medially	15.7	2	50.8	6.2	33.1	4.6	12.8	19.7	2.8

Note. BD values of IA voiceless stops represent their VOT values too.

An Acoustic Study of the Production of Iraqi Arabic Stop Consonants
 saif mohammed Al-Tai & Zivad Rakan Kasim

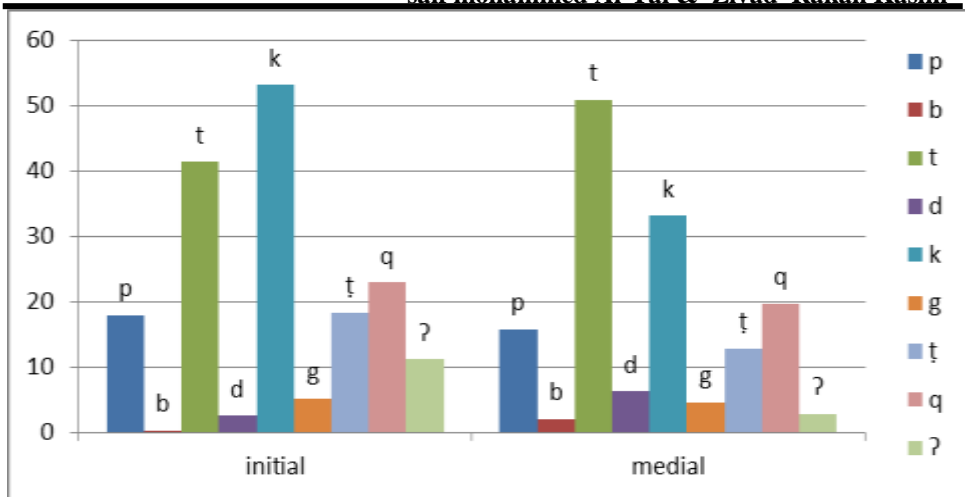


Figure 6. BD differences between voiceless and voiced stops and variations across different positions in isolation context.

It can be noticed that only /t/ and /k/ are aspirated since both have BD (or VOT) values higher than 30ms (See Table 4). The highest value found for BD in isolation is for /k/ in initial position, 53ms. The small values of the voiced stops represent the period in which the articulators part from each other and they do not represent a burst. So these small values can be neglected as far as aspiration is concerned. The reason why they are measured is to examine whether they are aspirated or not. Figure 7 below shows an example of the voiceless aspirated alveolar stop, /t/ in isolation.

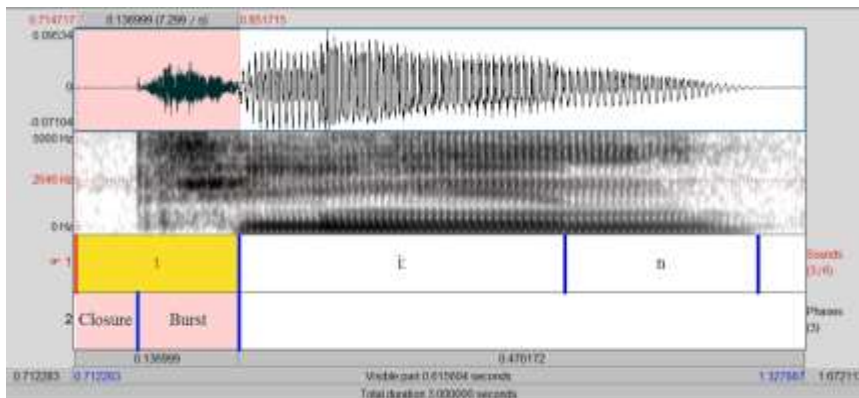


Figure 7. An example of an acoustic analysis of IA voiceless stops, /t/ in /ti:n/.

7.2.2 In Carrier Phrase (in each position)

Table 5 and Figure ۷ below present the mean values of BD in carrier phrase context for the three positions, initial, medial and final. When there is no value for a sound, it means that BD of that sound in this context cannot be observed and thus cannot be measured.

Table 5. Mean values of BD of IA stops in carrier phrase in initial, medial and final positions

Table 5. Mean values of BD of IA stops in carrier phrase in initial, medial and final positions

	p	b	t	d	k	g	ʈ	q	ʔ
Initially	20.1	4	43.7	6.9	50.6	9.2	20.5	16.3	
Medially	14.6	1.7	44.1	6.7	27.6	7.6	14.6	17.4	
Finally	8	3.3	6.2	4.8	17	13.8	7.1	16.2	

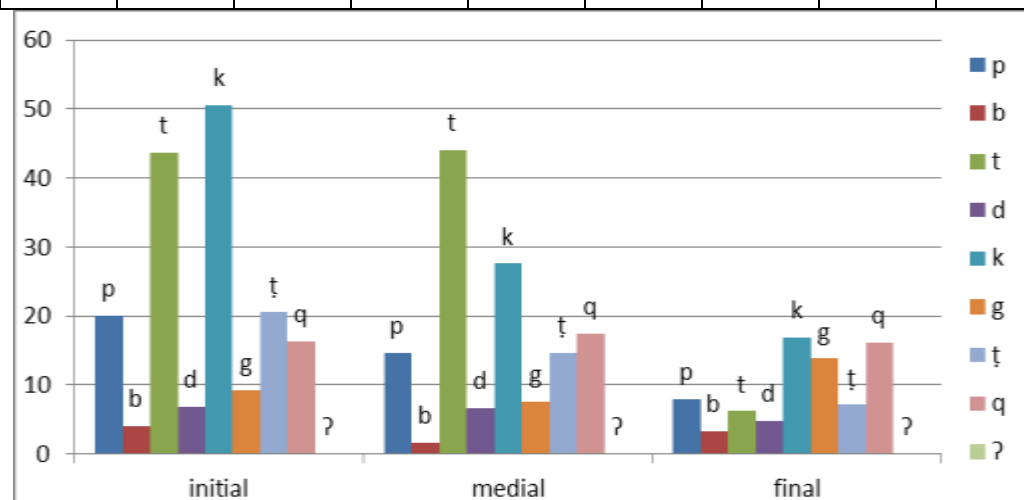


Figure ۷. BD differences between IA voiceless and voiced stops and BD variations across different positions.

The highest BD value is that of the voiceless velar stop /k/ in initial position, 50.6ms. In word-final position, the BD of each pair of the comparable stops, /p, b, t, d, k, g/, is close from each other. This is because the voiced stops are devoiced, as is seen above (See 7.1), so they are more like voiceless stops than voiced stops and the voiceless stops, on the other hand, have

shorter BD relative to BD in initial and medial position. Still the voiceless stops are unaspirated in final position even when they are put in a carrier phrase. The BD of the glottal stop cannot be measured in the phrase context. It is found that there is no significant difference between the values of BD of a position whether in isolation or in phrase context (see Tables 4 and 5 above).

7.3 Voice Onset Time

VOT refers to the period between the release of the closure to the beginning of the vibration of the vocal folds (Ladefoged & Johnson, 2014: 159). The following subsections present descriptive statistics of VOT of IA stops in isolation and in carrier phrase. It is to be noted that VOT values of the voiceless stops are the same of their burst duration and VOT values of the voiced stops are the same of their closure duration since IA voiced stops are fully voiced. That is why the section of VOT results is located after those of BD and CD. VOT cannot be observed in utterance final position because of two reasons. First, larynx activity hardly continues up to the moment of the burst of noise. Second, stops are not released at all for many speakers in final position (Fry, 1979: 136).

7.3.1 In Isolation (in each position)

Table 6 below presents the VOT values of IA stop consonants in initial and medial positions in isolation. VOT could not be measured in final position.

Table 6. *VOT of IA stops in initial and medial positions in isolation.*

	p	b	t	d	k	g	ʈ	q	ʔ
initially	17.9	-74.1	41.3	-82.1	53.1	-70.6	18.2	22.9	11.1
medially	15.7	-53.7	50.8	-57.5	33.1	-53.6	12.8	19.7	2.8

7.3.2 In Carrier Phrase (in each position)

Table 7 below presents VOT values for IA stop consonants in initial and medial positions in phrase context.

VOT could not also be measured in sentence final position in the present study since the following word started with a voiceless fricative, /s/. The reason behind selecting a fricative sound and not a sonorant sound is to avoid the intervocalic environment because the GS is expected to have a problematic state in such context. As mentioned in (5.5), VOT values of the voiceless stops are the same of the values of their BD. So the IA aspirated stops, /t/ and /k/, have longer VOT than the other unaspirated IA stops. VOT of the voiced stops has negative values since IA voiced stops are fully voiced; in other words, they have voicing during the closure. Moreover, as expected, /t/ has longer VOT than its pharyngeal counterpart which is unaspirated in all contexts.

Table 7. Mean VOT values of IA stops in carrier phrase in initial and medial positions.

	p	b	t	d	k	g	ʔ	q	ʕ
initially	20.1	-69.9	43.7	-59.2	50.6	-57	20.5	16.3	--
medially	14.6	-51.3	44.1	-52.6	27.6	-47.5	14.6	17.4	--

Note. VOT could not be measured in final position

7.4 The Glottal Stop

In the present study, the only contexts in which the GS showed a clear state of a stop consonant are the initial and final positions in isolation only. In other contexts, it showed a great deal of variability where the acoustic make up of a stop consonant could not be specified. Thus, it is treated separately from other IA stops. Shaheen (1979: 108) states that, in the acoustic analysis in phrase context, the GS is neither voiceless nor voiced since it does not conform to neither a voiceless pattern nor to a voiced one.

7.4.1 Initially and Finally in Isolation

The GS showed a good example of a stop consonant in the initial and final positions in isolation. It showed a measurable VOT for most of the speakers (67 out of 80 tokens). Figures 8 and 9 below show a normal GS showing a period of

voicelessness after the release in the context of initial and final positions in isolation.

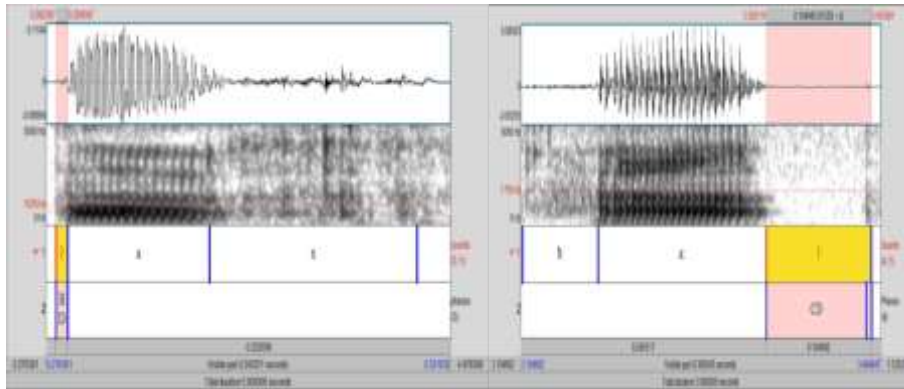


Figure 9. An example showing a normal GS, Figure 9. An example showing a normal GS, /ʔax/, in initial position in isolation. /ha:ʔ/, in final position in isolation.

7.4.2 Anomalous Cases of the Glottal Stop

The other contexts, in all the positions in carrier phrase in addition to the medial position in isolation, show abnormal cases that do not represent the case of a normal stop consonant. In other words, there is no closure, release and post release phases in the acoustic analysis. The types of the variability observed include: either no closure was observed but only a creaky voice or different shapes of intermittent vocal folds vibration were observed preceding, during and/or following the glottal closure. The following figures (10-13) show some instances of these variations.

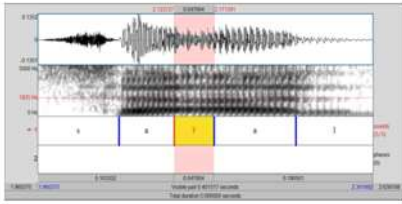


Figure 10. The GS is seen in the analysis as a sporadic continuation of the voicing of the preceding vowel in /'saʔa/ in intervocalic position isolation. This case is the most frequent case found in the present study.

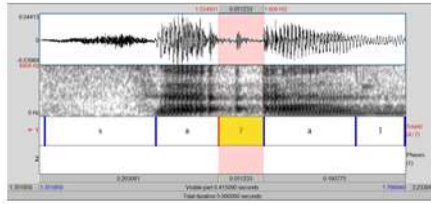


Figure 11. A GS showing a relatively large CD in which there is a small sporadic vibration of the vocal folds.

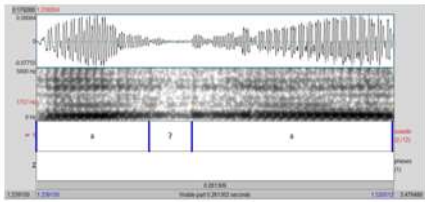


Figure 12. A GS showing an observable closure in which voicing occur, i.e., the GS is seen as a fully voiced stop. This is ascribed to the impact of the intervocalic environment.

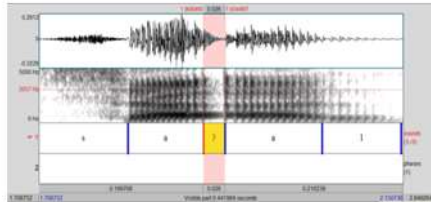


Figure 13. The intermittent voicing even precedes and follows the closure of the GS.

Discussion

Closure Duration, Burst Duration and Voice Onset Time

Lisker (1957) reports that variation in CD can serve to the voiceless/voiced distinction within English stop consonants. In Egyptian Arabic, Shaheen (1979:102) reports that CD of voiceless stops is longer than their voiced counterparts. The CD results in the present study are in agreement with the standard view which states that voiceless stops have longer CD than their voiced counterparts (Ladefoged & Jonson, 2014:64; Wolf, 1978: 305). For example, /p/ has CD of 83.9 ms, 70.1 ms and 67.8 ms for initial medial and final positions respectively, while /b/ has CD of 70 ms, 51.3 ms and 61.9 ms for initial, medial and final positions respectively. In final position, however, this pattern does not always occur. /k/ is longer than /g/, in isolation, with CD of 156.8 ms and 136.8 ms, respectively, but /k/ and /g/ have the same CD in phrase context, 65,2 ms for both, and /t/ has shorter CD than /d/ in final position in isolation (see Tables 2 and 3 and Figures 2 and 3). The reason behind the voiced stops having long CD in final position relative to other positions is that they are unvoiced partly

or wholly. So the pressure of the vibrating vocal folds on the occlusion is absent. Thus, the closure remains longer .

The idea which says that the farther back a stop is produced, the shorter the CD it has (Anderson & Maddieson, 1994:136; Fischer-Jorgenson, 1964; Zue, 1976 and Keating, 1984) is not completely proved in the examination of IA dialect. What is constant is that /p/ has longer CD than the /t/ and /k/. However, /t/ has CD shorter than /k/ in initial and final positions in both contexts. The only position in which we can see the labial< alveolar< velar pattern, excluding the IA uvular and pharyngealized voiceless stops, is in medial position in isolation and in phrase contexts. However, /q/ has longer CD than /t/ and /k/ in all the contexts and longer than /p/ in all contexts except in initial position in phrase context in which /p/ has the highest value of CD overall .

Do voiceless unaspirated stops have longer CD than the aspirated ones? Dutta (2007: 34) states that, in Hindi, unaspirated voiceless and voiced stops have longer CD than the aspirated voiceless and voiced stops. The findings of the present study show that IA voiceless unaspirated stops have longer CD than IA voiceless aspirated stops. Thus, the findings of the present study concerning CD support the view which says that CD and aspiration are inversely related (Cho & Ladefoged, 1999: 213). Thus, it is found that /p/ and /q/, which are unaspirated, have longer CD than the voiceless aspirated stops, viz. /t/ and /k/ .

It has been agreed upon that the distinction among the homorganic stops in initial position is made throughout aspiration and that the duration of the preceding vowel serves in such distinction in final position (Lisker, 1957: 42f). How about the intervocalic position? Lisker (1957: 43) concluded that CD can work in this position. For a list of thirty four isolated words containing /p/ and /b/, the mean CD of /p/ is 120 ms and the mean CD of /b/ is 75 ms. The present study shows this pattern in the intervocalic position as well as other positions. /p/ has CD of 70.1 ms and /b/ has 51.3 ms. CD of /t/ is 62 ms and CD of /d/ is 51.3 ms. CD of /k/ is 60.7 ms while it is 47.5 ms for /g/. These values

are for the words in phrase context. See Table 2 for more information about CD in medial position in isolation .

Beside the importance of the CD to examine whether the voiceless stops are longer than their counterparts or not, the presence of glottal pulsing during the closure interval, Voice Lead Time (VLT) which refers to a negative VOT (Ladefoged & Johnson, 2014), appears to be a strong cue for voicedness (Ohman, 1962, cited in Wolf, 1978:305). In fact, the present study suggests that VLT is considered a more important cue than the CD itself as far as IA voiceless/voiced distinction is concerned. This is because the differences in CDs between IA voiceless and their voiced counterparts are not more than 20 ms and IA voiced stops are fully voiced so they can be clearly distinguished from IA voiceless stops.

A large number of studies **confirms** that the farther back the place of articulation of a stop is, the longer the duration of the burst will be (Lisker & Abramson, 1964; Dutta, 2007; Shaheen, 1979). It is not always the case, however, that VOT values follow the pattern of velar< dental-alveolar< labial. This is what is found in the present study in addition to other studies like that of Cho, Jun & Ladefoged (2002). In their study, they found that Korean velar stops have VOT longer than labial and dental-alveolar stops, but there was no significant difference between the VOT of both the Korean alveolars and the labials. In the present study, however, the pattern mentioned above is present in initial position only concerning /p/, /t/ and /k/. Thus, the finding concerning VOT in initial position of the present study is in accordance with what was found in other investigations of VOT like (Lisker & Abramson, 1964; Khattab, 2002). /q/ and /t/ are not in agreement with the pattern mentioned above since /t/ has almost the same VOT of /p/ and /q/ has shorter VOT than /k/. In medial position, however, such pattern is not found. VOT of /t/ is longer than VOT of /k/ in both isolation and phrase contexts. In final position, all the voiceless stops are unaspirated and they have a small amount of burst.

The IA voiceless stops VOT mean value that are comparable with the English ones, viz., /p, t, and k/, in initial position is 38.13ms. English mean VOT values of /p, t and k/ in

initial position in Klatt (1975) is 61ms. Thus, IA voiceless stops are less aspirated than English voiceless stops. This agrees with what is found about other Arabic dialects that Arabic stops are less aspirated than English stops (Al Ani, 1970; Al Shareef, 2015). IA voiced stops mean VOT value in initial position is -75.6ms while it is -54.93ms in medial position. This is a big difference from what is found on English stops which have positive VOT at least in initial position (Klatt, 1975). Mean English VOT value for initial voiced stops is 18ms (Klatt, 1975). This means that they are not truly voiced in initial position whereas IA voiced stops are fully voiced. Thus, it can be stated that, unlike English speakers, IA speakers utilize voicing more than aspiration in the voiceless-voiced distinction.

The IA voiced velar stop /g/ differs from other IA voiced stops in that the spike representing the burst is relatively more prominent than the others and that there is a period of noise after its burst. This case is found in other dialects of Arabic like the Egyptian one (Shaheen, 1979: 109). However, there are differences between the findings of the present study and the findings of Shaheen (1979:117) about Egyptian Arabic. He, surprisingly, reports that aspiration is longer in final position than in initial position and that /g/ is aspirated in final position while the present study shows that even IA voiceless aspirated stops are unaspirated in final position and that IA voiced stops are unaspirated in all positions.

As expected, differences are found between IA /t/ and /t̤/. /t/ has longer VOT than its pharyngealized counterpart which is even unaspirated in all contexts, 41ms for /t/ and 18ms for /t̤/. Since aspiration is thought to reflect the degree of glottal opening at the release of the stop (Kim 1970), the VOT values of the alveolar pharyngealized stop suggest a smaller degree of opening of the glottis during its production in comparison to the other stops. This small degree of opening is expected with all the pharyngealized consonants (Kriba, 2010: 215f). Thus, either VOT or BD can serve to differentiate between the plain consonants and their pharyngeal counterparts (Kriba, 2010:216). This decrease in the value of VOT of /t̤/ is compensated by a longer CD than the

CD of the plain /t/. This inverse relation between VOT and CD and the significant VOT variation between the pharyngealized and the plain consonants are reported in different Arabic dialects, e.g., Tunisian Arabic (Ghazali, 1977), Jordanian Arabic (Khattab, Al-Tamimi & Heselwood, 2006), Iraqi Arabic (Giannini & Pettorino, 1982; Heselwood, 1996; Kasim, 2018; Odisho, 1973), Moroccan Arabic (Zeroual, 1999), Qatari Arabic (Bukshaisha, 1985) and Yemeni Arabic (Al-Nuzaili, 1993), which all show that /t/ is aspirated while /t̤/ is unaspirated .

Zue (1976:100) argues that the value of VOT is not affected by the quality of the adjacent vowel. He states “we are unable to find any dependency of VOT on vowel context”. He continues elaborating on the differences of some acoustic results by stating that these differences are attributed to the different techniques used in different studies. Old studies like Lisker (1957), Lisker & Abramson (1964) and Klatt (1975) utilize only spectrograms while in recent studies VOT is measured better through the waveform, from the release to the first sign of the periodic wave. This first sign of the periodic wave is difficult to be measured in the spectrogram, so old studies include a portion of the following vowel or sonorant to the burst of the stop. Zue (1976:85) also supports the idea of the inverse relationship between the CD and BD. He (1976:85) also measures the total duration of stops, which is closure plus burst durations, and finds that they are mostly identical, 150msec for /p/ and /t/ and 148msec for /k/. However, although it is found that IA voiceless unaspirated stops have longer CD than IA voiceless aspirated ones, this increase is relatively small, if compared with the aspiration of /t/ and /k/. /p/, for example, has CD of 76.4msec whereas /t/ and /k/ have CD of 68.6msec and 66.5msec, respectively. Thus, this small amount of increase of CD for the unaspirated stops does not compensate the duration of aspiration of the aspirated stops. Therefore, still IA voiceless aspirated stops are longer than IA voiceless unaspirated ones. However, only in final position in isolation, all the IA voiceless stops have significantly close values of CD from each other.

ʌ, ʔ The Glottal Stop

The GS has a controversial case that its state is not agreed upon. It has a great deal of variability, especially in IA (See Kasim, 2019), in its acoustic makeups (Tatham & Morton, 2011). Bickford and Floyd (2006:147) indicate that “the glottal stop is very different from the voiceless state of the glottis”. Cruttenden (2008:179) seems to agree with this view showing that the “position of the vocal cords is not that associated with other voiceless sounds”. Lodge (2009:18) shows that “voiceless” means with an open glottis, whereas the GS is produced with closed vocal folds. It is a fact that speech sounds affect each other during the process of speech production. However, each sound retains its makeup features, for example, closure and burst for stop consonants. The GS, however, has a great deal of variability that in many occasions, (152 out of 240 tokens), it is not seen as a stop in which there is neither closure nor burst but it is seen as an irregular vibration of the vocal folds similar to a creaky voice or what is also called laryngealization. Faris (2010: 102f) states that it is often difficult to distinguish between a glottal stop and a creaky voice since they are phonetically similar and may occur next to each other in speech.

This case is not exclusive to IA dialect but to the Standard Arabic and to other languages like English, French and German. Hocket (1955: 125f cited in Priestly 1976: 271) lists over seventy languages in which this kind of variation exists. The case of the glottal stop found in the present study is also found in Kohler’s (1994) investigation of the glottal stop and glottalization in the German language. He explains the state in which the glottal stop and glottalization are represented by irregular pulsing in that the glottal stop does not have a complete closure in such cases, and that this irregular pulsing represents the closure of the glottal stop. Hillenbrand & Houde (1996: 1182) state that the glottal stop which occurs in the context of VCV is not shown as a stop in the acoustic analysis at all. It is seen as a continuation of the voicing during its gesture. That is why it can be considered as a voiced stop in this position .

In English, the glottal stop has also the same phenomenon, for it is not necessarily a stop. Priestly (1976: 268) says “phonetically, we deal with two different sounds, one of them is being occlusive and the other is being constrictive”. In Danish, this case is referred to by Ringgaard (1960) as the variation between glottal stop and glottal constriction or laryngealization. The same sort of variation is reported in Swedish (Lindqvist, 1972) and in Hausa and Margi (Ladefoged, 1964:17.)

Garellek (2013:2) states that the GS is highly variable in the acoustic analysis spanning from a complete stop to a laryngealized voicing and listeners normally rely on such kind of voicing in perceiving it as a GS. Thus he, justifiably, says that it appears that the glottal stop is not a ‘stop-like’ sound as far as acoustic realization and perception are concerned. He also reports that different degrees of laryngealization exist in different languages and/or across speakers (Garellek, 2013:31). That is why it may be possible to measure it in one language while it may not in another and also it may give different results even in intralingual studies. In Garellek’s (2013) study, 90 per cent of the tokens show a complete GS in the initial and final positions in isolation. He reports that the variability increases when the GS is put in intervocalic position and when words-initial and word-final GS are put in phrases. This is exactly what is found in the present study in which the GS shows a good example of a stop consonant in initial and final positions in isolation context only whereas it shows a state of creaky voicing in the intervocalic position and when the word-initial and word-final GSs are put in the carrier phrase.

The reasons behind the GS being significantly variable are controversial. They can be either phonetic or phonological. Priestly (1976: 271) reports that it seems like it is normal that the speakers of the languages in which this phenomenon occurs replace laryngealization instead of a complete glottal stop and the reasons behind that are speech tempo and, to a less extent, the rhythm of speech. Kohler (1994:50) states that the reasons behind this incomplete occlusion are the shift from a supraglottal gesture to a glottal gesture which needs a greater amount of time in comparison to a shift from an oral to another oral gesture especially when the preceding and the following sounds are voiced

and the vibration of the vocal folds is required. He justifies that this incomplete glottal stop is sufficient for the listener to perceive it. He also gives a phonological explanation for this phenomenon. If the complete closure of the glottal stop is produced with a greater force than the creaky voice, this resulted creak is regarded as a weakening, lenition, of the glottal stop (Kohler, 1994: 50 .(

The present study confirms with Kohler (1994) that the reasons behind such case of the GS are phonetic and phonological. Since the intervocalic context is a weakening environment (Lass, 1984: 181), so the GS is prone to lenition in such context. And because voicing is the lenition factor and because the vocal folds are the articulators involved in the gesture of the GS, the variations in its gesture are significant. Finally, it can be debated that the GS is considered a heavy sound on speakers. That is why we can find speakers substitute the glottal stop by another sound, most likely a vowel. For example, /ðiʔb/ < /ði:b/ “wolf”, /biʔr/ < /bi:r/ “well” and /kaʔs/ < /ka:s/ “cup”. What happens here is either that the GS is turned into a vowel identical to the preceding vowel or it is just that the vowel is lengthened and the GS is deleted .

.³Conclusion

In this study, a descriptive acoustic analysis of the IA stop consonants was carried out. The acoustic parameters measured were CD, BD and VOT. The IA stops showed a wide range of variability of the values of VOT since the IA voiced stops had negative VOT values while IA voiceless stops showed positive VOT values. Thus IA voiced stops were characterized by being fully voiced. The only IA voiceless stops that were found to be aspirated were /t/ and /k/. The other IA voiceless stops were unaspirated, having BD less than 30ms. The findings of the present study showed that the acoustic features of the IA stops were different from those of the English stops. These differences are: IA voiced stops are fully voiced whereas English voiced stops are not and IA voiceless stops are less aspirated than the English stops .

The idea which says that the farther back a stop consonant is produced, the longer the BD and the shorter the CD was not completely observed in this study. What was observed was that /p/

always had longer CD than the /t/ and /k/ while there was no constant pattern between /t/ and /k/. However, the uvular IA /q/ had longer CD than /t/ and /k/ in all the contexts and longer than /p/ in all contexts except in initial position in phrase context in which /p/ has the highest value of CD overall. Concerning BD, the above mentioned idea was only in agreement with IA /p/, /t/ and /k/ in initial position only whereas IA /t/ and /q/ showed inconsistent values. Furthermore, the findings of this study were in agreement with the fact which says that voiceless stops are longer than their voiced counterparts. Moreover, it was found that IA speakers depended on VOT, including VLT, more than the CD since the VOT variations across IA voiceless and voiced stops were bigger.

The IA glottal stop showed some acoustic variability. It showed a good example of a normal stop consonant in initial and final positions in isolation only. In other contexts, it exhibited a great deal of variability in which the acoustic makeup that forms a stop consonant was not observed. The types of this variability observed include: either no closure was observed but only a creaky voice or different shapes of intermittent vocal folds vibration were observed preceding, during and/or following the glottal closure .

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دراسة صوتية لنطق الأصوات الانفجارية العراقية العربية

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المستخلص

يتناول البحث وصفاً صوتياً للأصوات الانفجارية لهجة العراقية العربية التي تضم الأصوات /p, b, t, d, k, g, ʈ, q and ʔ/ في موضع بدء الكلمة ومنتصفها ونهايتها، وفي سياق الكلمة المعزولة، وسياق توضع فيه الكلمة في جملة موحدة، والعوامل الصوتية التي فُحصت هي مدة الانغلاق (Closure Duration) ومدة الانفجار (Burst Duration) وزمن بدء الجهر (Voice Onset Time)، إذ يهدف البحث تعزيز الوصف الصوتي للأصوات العراقية العربية عن طريق وصف أصواتها الانفجارية، فضلاً عن معرفة الفروقات بين الأصوات الانفجارية العراقية العربية وبين الأصوات الانفجارية الإنكليزية، وجمعت البيانات من عشرين شخص، عشرة ذكور وعشرة إناث، وأوضحت النتائج بخصوص مدة الانغلاق (Closure Duration) أنَّ الأصوات الانفجارية المهموسة (voiceless) تمتلك مدة انغلاق أطول من الأصوات الانفجارية المجهورة (voiced)، وأوضحت النتائج أيضاً أنَّ الأصوات الشفهية (labials) تمتلك مدة انغلاق أطول من الأصوات الحلقية الوسطية (alveolars)، والحلقية الخلفية (velars)، وأوضحت النتائج أيضاً أنَّ الصوت /q/ يمتلك مدة انغلاق أطول من كل الأصوات السابقة، على الرغم من وجود بعض الاستثناءات، والصوت /t/ يمتلك مدة انغلاق أطول من /t/، كما أوضحت النتائج مدة الانفجار (Burst Duration) أنَّ الأصوات المهموسة الانفجارية العراقية العربية تمتلك مدة انفجار أقصر من مدة انفجار الأصوات المهموسة الانفجارية الإنكليزية، وبذلك فإنَّ اللفظ بملء النفس (aspiration) للأصوات المهموسة (voiceless) يكون أقل في لهجة العراقيَّة العربية عن الإنكليزية، وأنَّ الأصوات التي عُدت تلفظاً بملء النفس هما الصوتان /t/ و /k/ فقط.

الكلمات المفتاحية: فترة الانغلاق، فترة الانفجار، زمن بداية الجهر، اللهجة العراقية

العربية.

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