

## The Phenomenon of Qalqala in Qur'ān Recitation \*

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### Abstract

This study investigates the phenomenon of qalqala, a feature unique to Qur'ān recitation. It aims at analyzing the sound accompanying the qalqala sounds [q, t, b, ḍ, d] acoustically to see whether or not this sound has a vowel-like articulation. Therefore, an acoustic analysis has been conducted to the sound accompanying the qalqala sound together with the preceding and following vowels to give their acoustic features such as the amplitude (i.e. the intensity), the formant frequencies (F1 and F2) and the recurrence of waves at regular intervals. The main conclusions of the present research are: (a) the sound accompanying the qalqala sound is a vowel-like articulation (b) this vowel, in most cases, tends to be /ə/ and (c) the phenomenon of qalqala is of two levels, minimum and maximum.

**Keywords:** qalqala, recitation, Qur'an, acoustic analysis, phonemic status.

المستخلص

يدرس البحث ظاهرة القلقلة التي هي سمة خاصة بتلاوة القرآن الكريم، ويهدف إلى تحليل الصوت المصاحب لأصوات القلقلة: القاف والطاء والباء والجيم والذال من أجل التحقق مما إذا كان شبيهاً بأصوات العلة. لذا أجري التحليل الصوتي لهذا الصوت وكذلك الصوت الذي يسبقه والصوت الذي يليه من وتكرار الموجة بفترات منتظمة. إن الاستنتاجات الرئيسية التي تم التوصل إليها في هذا البحث هي: (أ) formant frequencies و amplitude حيث ال و (ج) إن ظاهرة القلقلة بمستويين: قلقلة صغرى [ə] إن الصوت المصاحب لأصوات القلقلة شبيه بأصوات العلة و (ب) في معظم الحالات كان هذا الصوت و قلقلة عظمى.

### 1. Introduction

The phenomenon of qalqala in Qur'ān recitation violates the natural human tendency for economy of muscular effort, since it is much more difficult to produce a sound like [b] with qalqala than producing a simple non-muqalqal [b]. It is realized as a sound that accompanies the release phase of the five Arabic stop sounds of qalqala [q, t, b, ḍ, d]. Making qalqala with these sounds prevents the sound of qalqala from becoming like the following sound in some feature(s), as in the sound [b] in [jabtavi:] becoming \*[japtavi:], or avoids assimilating [d] to the following [s] in the phrase [laqadṣar'rafna:] to make it sound as \*[laqaṣṣar'rafna:]. Both of these cases which result from not making qalqala violate the rules of recitation.

Many studies have described the sounds of qalqala from the articulatory point of view and described the sound that accompanies the qalqala sound as a sound that results from the separation of the contact between the articulators. Old Arab grammarians like "Sībawayhi describes qalqala sounds as the musharraba, i.e. accompanied by something not of its nature, viz. a slight movement or ṣuwayt" (Bishr, 2000: 384). Contemporary Arab grammarians view qalqala as "the strength of turbulence in the place of articulation of the sound when uttered in its non-vocalized form resulting in strong strain" (Al-Ghawthāniyy, 2011: 107 and Zalat, 2005: 62). On the other hand, non-Arab scientists define qalqala as an insertion of a schwa after qalqala sounds (e.g. Denny, 1989: 19 and Nelson, 2001: 22f). Arab scholars differ in their viewpoints about qalqala types (i.e. levels). Some believe that it is of two types according to the position of the sound in the word ignoring the geminate/non-geminate distinction of the non-vocalized form in word-final position (e.g. Arbāwiyy, 2004: 40 and Swayyid, 2011: 189). Others divide it into three types; the third being the geminated pausal form of qalqala sound in final position which is considered as the strongest (e.g. Al-Ḥarbiyy, 2006: 13 and Sulaymān, 1988: 57). This study describes the phenomenon of qalqala acoustically by means of adobe audition 2.0. An acoustic analysis has been conducted to measure the acoustic features of qalqala sounds such as the amplitude (i.e. intensity), the formant frequencies (F1 and F2) and the recurrence of waves at regular intervals.

### 2. Statement of the problem

The present research tries to investigate the phenomenon of qalqala instrumentally in order to arrive at the instrumentally-evidenced phonetic facts about this unique phonetic phenomenon which, to the best of our knowledge, has not been studied instrumentally before.

### 3. Aim of the study

This study aims to present an acoustic description of the sound accompanying the qalqala sound by measuring its intensity and formant structure and comparing it with that of the vowels that precede and follow it in order to determine the phonetic and phonemic identity of the sound accompanying the qalqala sound.

### 4. Procedures

The procedures to be followed in this research are as follows:

- Examining the sound accompanying the qalqala sound acoustically to show its waveform and formant structure; this will be done for each of the four Qur'ān reciters<sup>(1)</sup>.
- Working out the phonemic status of the sound accompanying the qalqala sound.

### 5. Hypotheses

- The sound accompanying the qalqala sound in the post-release phase is realized as a vowel-like articulation.
- The vowel occurring as a result of the phenomenon of qalqala is mostly [ə].
- The phenomenon of qalqala in reciting the Glorious Qur'ān is of two levels, minimum and maximum.

### 6. Acoustic Investigation of the Qalqala Sounds

In the acoustic investigation of the qalqala sounds, three things have been accounted for: amplitude, formant frequency and waveform repetition. These have been worked out for each of the four reciters.

#### 6.1 Amplitude Analysis

Ladefoged (1993: 163) states that "the intensity is proportional to the average size, or amplitude, of the variations in air pressure...measured in decibels (abbreviated as dB) relative to the amplitude of some other sounds". Al-Ghāmiyy(2000: 105) defines *amplitude* as the amount of sound intensity which is measured by decibel. The amplitude of the sound that accompanies the qalqala sound is calculated by taking the summation of ten peaks of this sound and dividing the number by ten to give the mean value of the intensity of this sound and prove that this sound is a vowel-like articulation.

#### 6.1.1 Sa'ad Al-Ghāmiyy

In Al-Ghāmiyy's performance, analysis of the post-release phase of the qalqala sounds [q, t, b, dʒ, d] in word-medial position shows that the sounds accompanying [q] in [ʔuqʔsimu]<sup>(2)</sup>, [t] in [ʔatʔʕamahum], [b] in [ʕabʔri], [dʒ] in [ʕadʒʕal] and [d] in [ʕadʔrak]<sup>(3)</sup> have amplitudes of +12dB, +12dB, +10dB, +8dB and +14dB, respectively (see Figure 1).

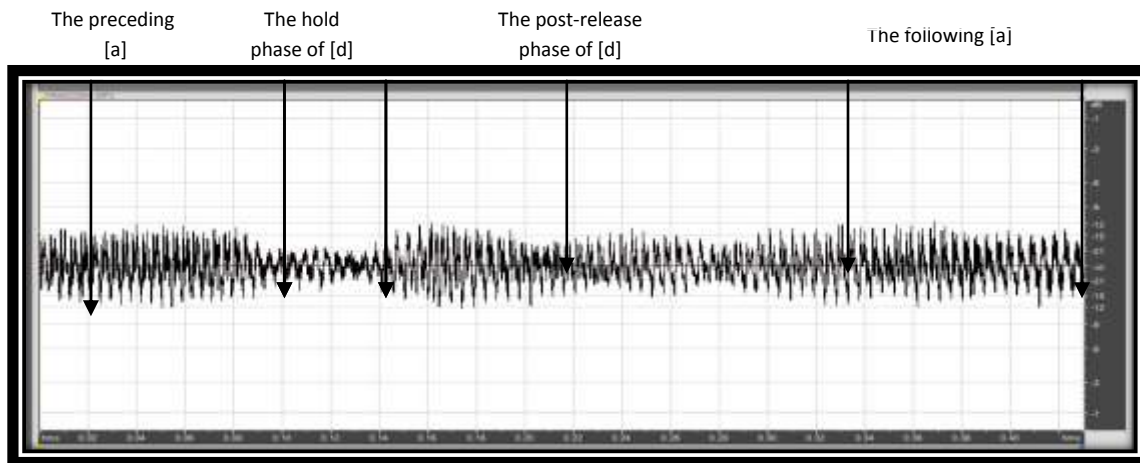


Figure 1: Waveform of the preceding [a], the sound accompanying [d] and the following [a] in [ʕadʔrak] for Al-Ghāmiyy.

<sup>(1)</sup> The four reciters are: Sa'ad Al-Ghāmiyy of Saudi Arabia, Muḥammad Ṣiddīq Al-Manshāwiyy of Egypt, Abdul-Hādil-Kanākiriyy of Syria and Ni'mat Al-Hassān of Iraq.

<sup>(2)</sup> The mark (?) indicates the sound accompanying the qalqala sound before knowing its identity.

<sup>(3)</sup> These words will be the basis of analysis for word-medial qalqala when accounting for the other reciters, so they will not be repeated.

In word-final position, the sounds accompanying [q] in [ʔis'tabʔraqʔ], [t] in [ʔlu:tʔ], [b] in [ʔwaqabʔ], [dʒ] in [ʔħaradʒʔ], [d] in [ʔkabadʔ] and the geminated [q] in [ʔħaqqʔ]<sup>(4)</sup> have amplitudes of +12dB, +12dB, +14dB, +8dB, +14dB and +13dB, respectively(see Figure 2).

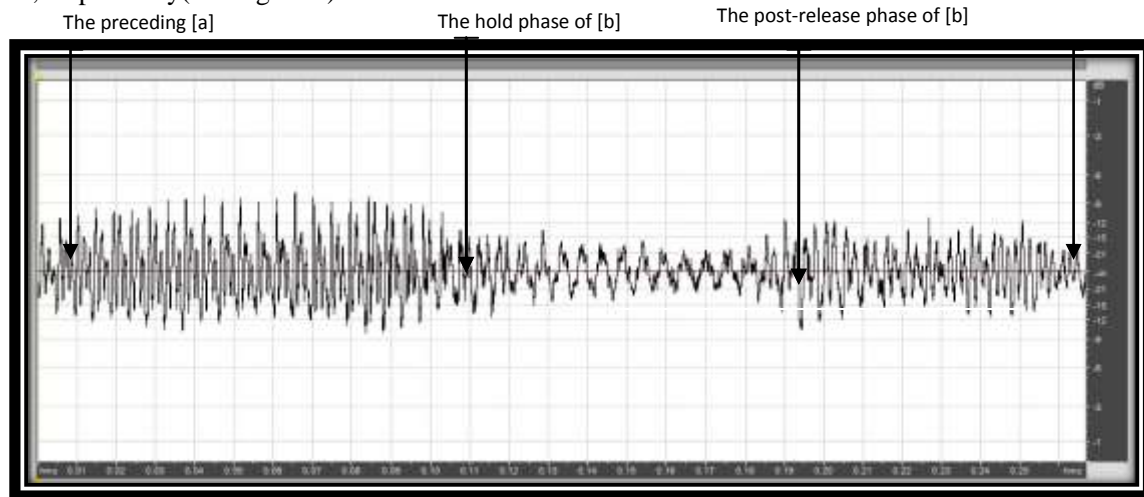


Figure 2: Waveform of the preceding [a] and the sound accompanying [b] in [ʔwaqabʔ] for Al-Ghāmidīyy.

### 6.1.2 MuhammadŠiddīq Al-Manshāwiyy

In Al-Manshāwiyy's performance, analysis of the post-release phase of the qalqala sounds [q, t, b, dʒ, d] in word-medial position shows that the sounds accompanying [q], [t], [b], [dʒ] and [d] have amplitudes of +17dB, +12dB, +15dB, +10dB and +13dB, respectively (see Figure 3).

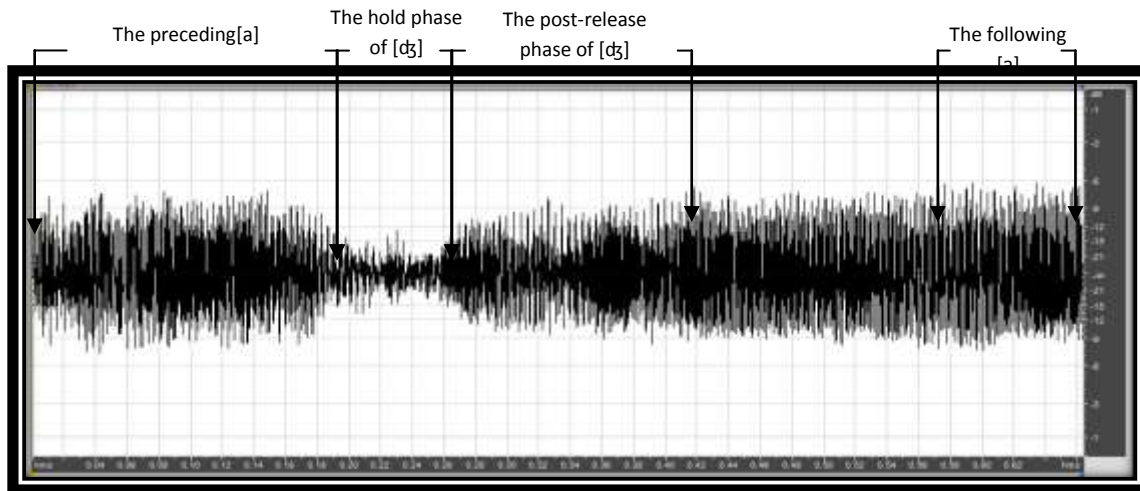


Figure 3: Waveform of the preceding [a], the sound accompanying [dʒ] and the following [a] in [ʔjadʒʔʕal] for Al-Manshāwiyy.

In word-final position, the sounds accompanying [q], [t], [b], [dʒ], [d] and the geminated [q] have amplitudes of +21dB, +16dB, +14dB, +19dB, +18dB and +13dB, respectively (see Figure 4).

<sup>(4)</sup>These words will be the basis of analysis for word-final qalqala when dealing with the other reciters, so they will not be repeated.

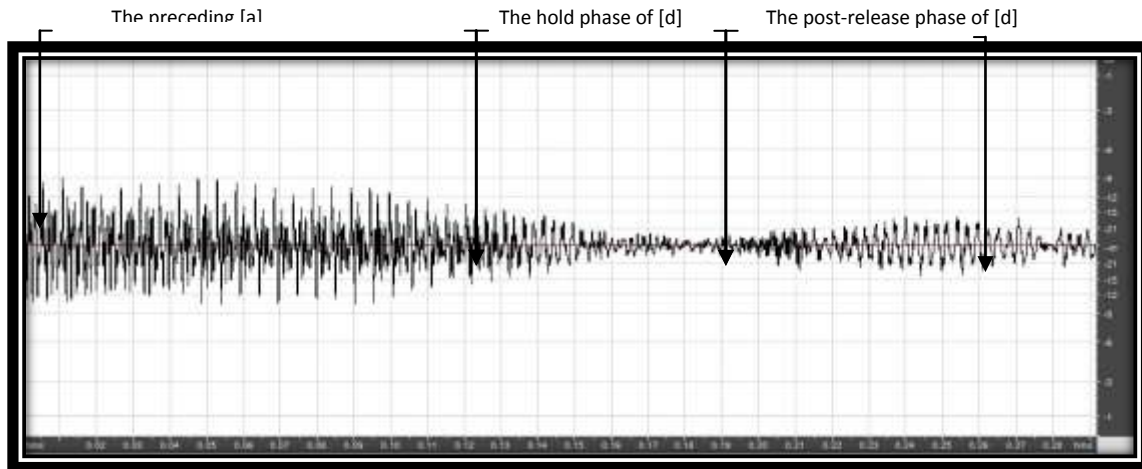


Figure 4: Waveform of the preceding [a] and the sound accompanying [d] in ['kabad?]' for Al-Manshāwiyy

### 6.1.3 Abdul-Hādil-Kanākiriyy

In Al-Kanākiriyy's performance, analysis of the post-release phase of the qalqala sounds [q, t, b, dʒ, d] in word-medial position shows that the sounds accompanying [q], [t], [b], [dʒ] and [d] have amplitudes of +2dB, +1dB, +6dB, +3dB and +1dB, respectively (see Figure 5).

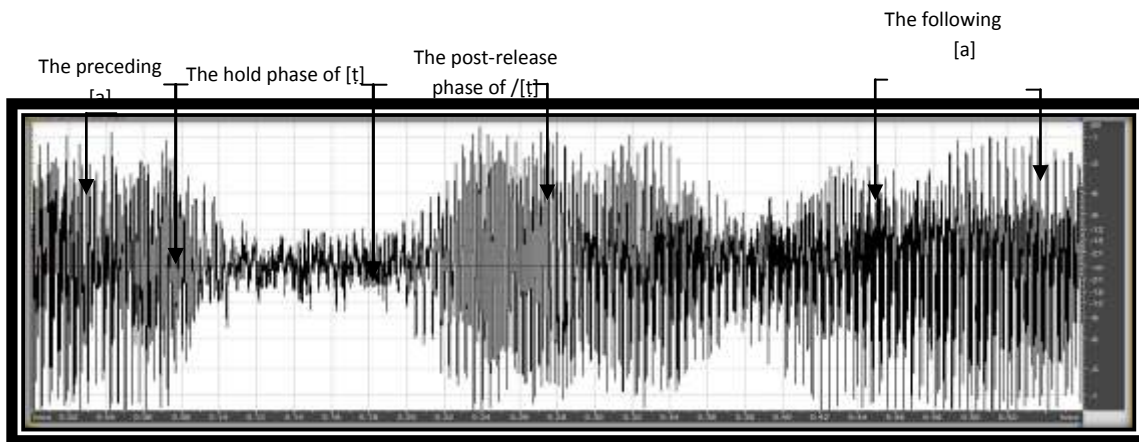


Figure 5: Waveform of the preceding [a], the sound accompanying [t] and the following [a] in [ʔatʔʕamahum] for Al-Kanākiriyy.

In word-final position, the sounds accompanying [q], [t], [b], [dʒ], [d] and the geminated [q] have amplitudes of +4dB, +12dB, +5dB, +3dB, +7dB and +8dB, respectively (see Figure 6).

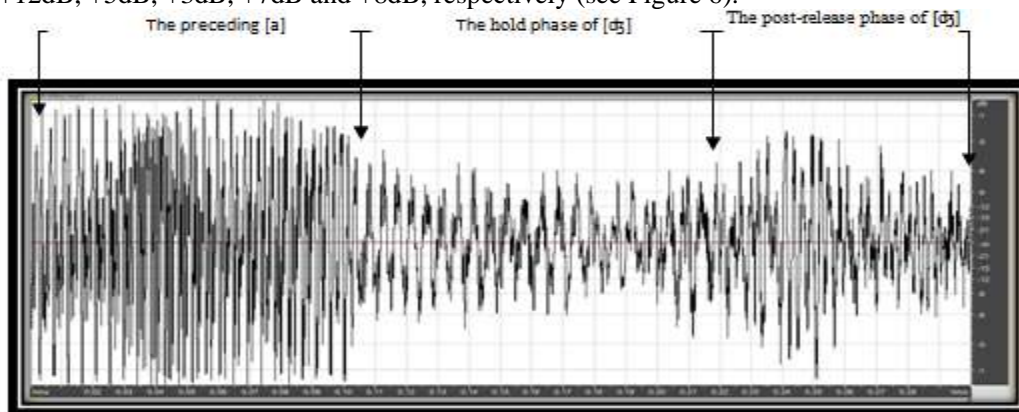


Figure 6: Waveform of the preceding [a] and the sound accompanying [dʒ] in ['haradʒ?]' for Al-Kanākiriyy.

### 6.1.4 Ni'mat Al-Hassān

In Al-Hassān's performance, analysis of the post-release phase of the qalqala sounds [q, t, b, dʒ, d] in word-medial position shows that the sounds accompanying [q], [t], [b], [dʒ] and [d] have amplitudes of +4dB, +4dB, +8dB, +6dB and +4dB, respectively (see Figure 7).

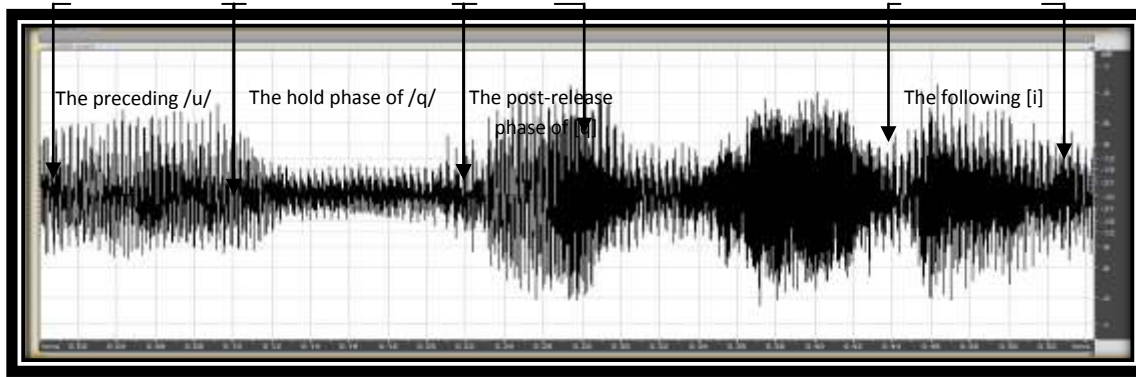


Figure 7: Waveform of the preceding [u], the sound accompanying [q] and the following [i] in ['ʔuqʔsimu] for Al-Hassān.

In word-final position, the sounds accompanying [q], [t], [b], [dʒ], [d] and the geminated [q] have amplitudes of +5dB, +4dB, +9dB, +7dB, +12dB and +2dB, respectively (see Figure 8).

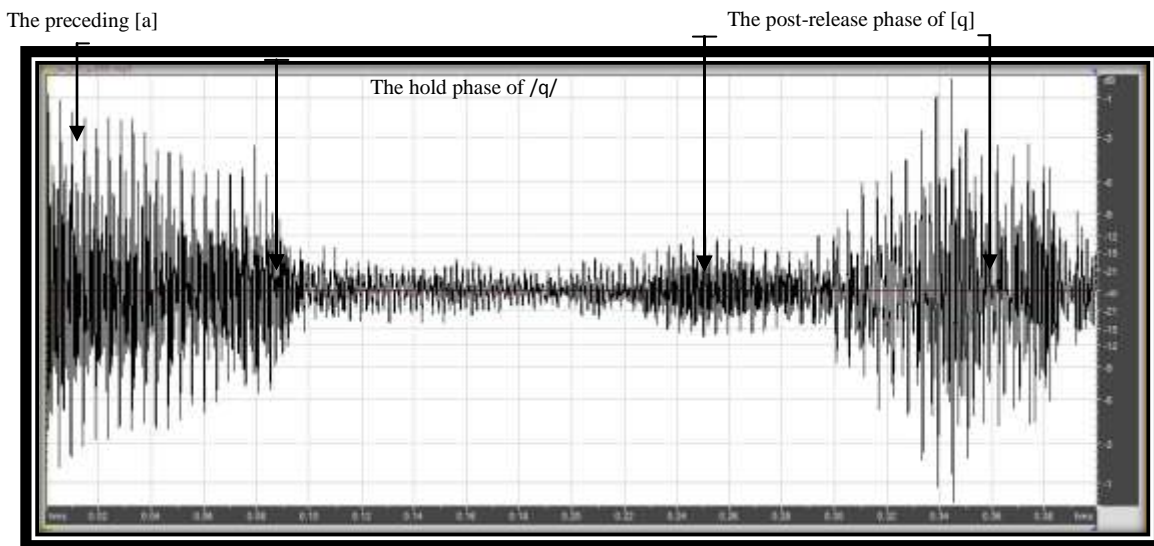


Figure 8: Waveform of the preceding [a] and the sound accompanying [q] in [ʔis'tabʔraqʔ] for Al-Hassān.

## 6.2 Formant Frequency Analysis

Ladefoged (1993: 162) writes:

"**Frequency** is...the number of complete repetitions (cycles) of variations in air pressure occurring in a second. The unit of frequency measurement is the Hertz, usually abbreviated as Hz. If the vocal cords make 220 complete opening and closing movements in a second, we say that the frequency of the sound is 220Hz".

Al-Ghāmiyy (2000: 105) defines *frequency* as the number of vibrations in one second, measured by Hertz. Thus, the formant frequencies F1 and F2 of the sound accompanying the qalqala sound has been measured to arrive at the quality of this sound and then to compare it with the preceding and following vowels in word-medial position and with the preceding vowel in word-final position.

In word-medial position, analysis of the four reciters' performance of the qalqala sounds shows that F1 and F2 of the preceding [u], the sound accompanying [q] and the following [i] in ['ʔuqʔsimu] are as follows:

**Al-Ghāmiyy:** 260Hz and 500Hz, 280Hz and 510Hz, and 260Hz and 555Hz, respectively; hence ['ʔuqusimu].



**Al-Manshāwiyy:** 220Hz and 432Hz, 189Hz and 394Hz, and 200Hz and 400Hz, respectively; hence [ʔuqəsimu] since F1 and F2 of [ə] in [ʔdʒepədi]<sup>(5)</sup> are around 187Hz and 390Hz.

**Al-Kanākiriyy:** 260Hz and 516Hz, 240Hz and 470Hz, and 270Hz and 516Hz, respectively; hence [ʔuqəsimu].

**Al-Hassān:** 253Hz and 555Hz, 225Hz and 555Hz, and 280Hz and 570Hz, respectively; hence [ʔuqəsimu].

In [ʔatʔʕamahum], F1 and F2 of the preceding [a], the sound accompanying [t] and the following [a] are as follows:

**Al-Ghāmidiyy:** 270Hz and 510Hz, 270Hz and 520Hz, and 270Hz and 520Hz, respectively; hence [ʔatʔʕamahum].

**Al-Manshāwiyy:** 225Hz and 430Hz, 195Hz and 370Hz, and 215Hz and 400Hz, respectively; hence [ʔatʔʕamahum] since F1 and F2 of [ə] in [ʔdʒepədi] are around 187Hz and 390Hz.

**Al-Kanākiriyy:** 272Hz and 545Hz, 256Hz and 495Hz, and 256Hz and 495Hz, respectively; hence [ʔatʔʕamahum].

**Al-Hassān:** 220Hz and 410Hz, 195Hz and 400Hz, and 220Hz and 417Hz, respectively; hence [ʔatʔʕamahum] since F1 and F2 of [ə] in [ʔdʒepədi] are around 187Hz and 390Hz.

In [ʔʕabʔri], F1 and F2 of the preceding [a], the sound accompanying [b], and the following [i] are as follows:

**Al-Ghāmidiyy:** 260Hz and 540Hz, 260Hz and 530Hz, and 230Hz and 450Hz, respectively; hence [ʔʕabari].

**Al-Manshāwiyy:** 220Hz and 440Hz, 190Hz and 380Hz, and 200Hz and 400Hz, respectively; hence [ʔʕabəri] since F1 and F2 of [ə] in word-medial position in [ʔventʔərə] are around 165Hz and 360Hz.

**Al-Kanākiriyy:** 208Hz and 416Hz, 185Hz and 380Hz, and 220Hz and 425Hz, respectively; hence [ʔʕabəri] since F1 and F2 of [ə] in [ʔdʒepədi] are around 187Hz and 390Hz.

**Al-Hassān:** 232Hz and 487Hz, 232Hz and 450Hz and 215Hz and 415Hz, respectively; hence [ʔʕabəri].

In [ʔjadʔʕal], F1 and F2 of the preceding [a], the sound accompanying [dʒ], and the following [a] are as follows:

**Al-Ghāmidiyy:** 250Hz and 500Hz, 250Hz and 500Hz, and 240Hz and 475Hz, respectively; hence [ʔjadʔʕal].

**Al-Manshāwiyy:** 235Hz and 472Hz, 235Hz and 472Hz, and 235Hz and 472Hz, respectively; hence [ʔjadʔʕal].

**Al-Kanākiriyy:** 235Hz and 470Hz, 190Hz and 390Hz, and 235Hz and 470Hz, respectively; hence [ʔjadʔʕal] since F1 and F2 of [ə] in [ʔdʒepədi] are around 187Hz and 390Hz.

**Al-Hassān:** 274Hz and 540Hz, 274Hz and 540Hz, and 274Hz and 540Hz, respectively; hence [ʔjadʔʕal].

In [ʔʕadʔrak], F1 and F2 of the preceding [a], the sound accompanying [d], and the following [a] are as follows:

**Al-Ghāmidiyy:** 260Hz and 500Hz, 232Hz and 450Hz, and 232Hz and 450Hz, respectively; hence [ʔʕadarak] (see Figure 9).

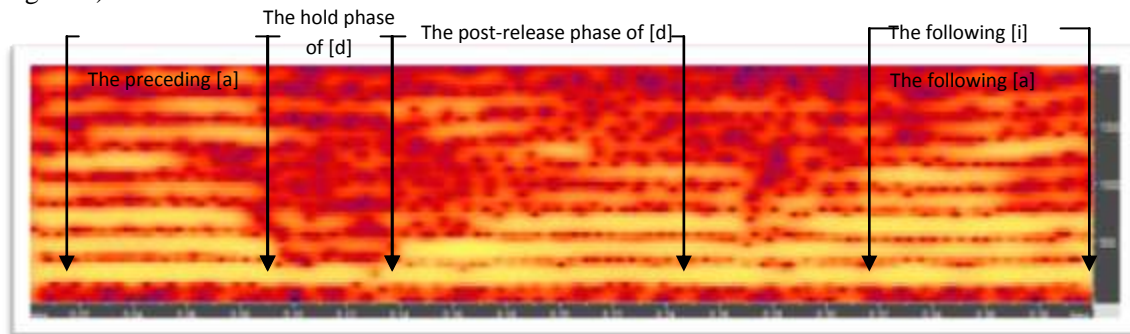


Figure 9: F1 and F2 of the preceding [a], the sound accompanying [d] and the following [a] in [ʔʕadarak] for Al-Ghāmidiyy.

The preceding The hold phase

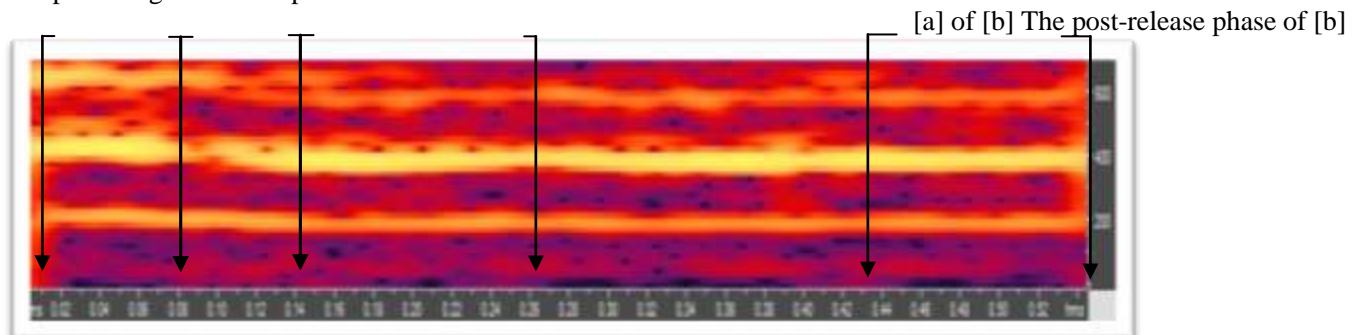


Figure 10: F1 and F2 of the preceding [a], the sound accompanying [b] and the following [i] in [ʔʕabəri] for Al-Manshāwiyy.

(5) The Recorded materials for the schwa have been taken from Exercise 1 of Tape Unit 9 in Roach (1983: 176f).

**Al-Kanākiriyy:** 280Hz and 530Hz, 235Hz and 487Hz, and 235Hz and 487Hz, respectively; hence ['šadarak] (see Figure 11).

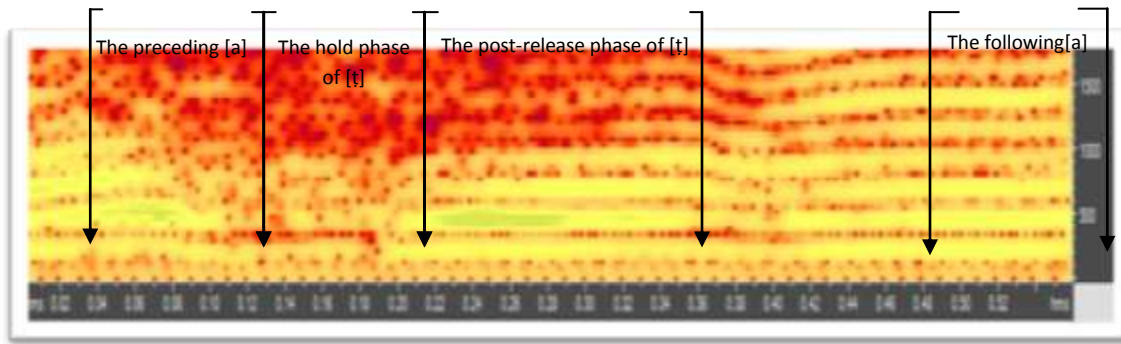


Figure 11: F1 and F2 of the preceding [a], the sound accompanying [t] and the following [a] in [ʔaʔaʕamahum] for Al-Kanākiriyy.

**Al-Hassān:** 295Hz and 590Hz, 285Hz and 590Hz, and 264Hz and 494Hz, respectively; hence ['šadarak] (see Figure 12).

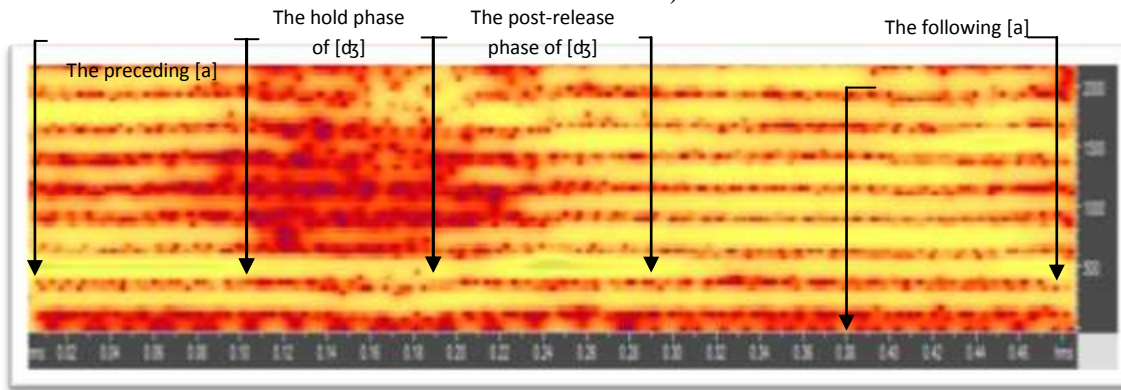


Figure 12: F1 and F2 of the preceding [a], the sound accompanying [dʒ] and the following [a] in [ʕadʒaʕal] for Al-Hassān.

In word-final position, F1 and F2 of the preceding [a] in [ʔisʔabʔraqʔ] and of the sound accompanying [q] are as follows:

**Al-Ghāmidīyy:** 230Hz and 430Hz, and 190Hz and 370Hz, respectively; hence [ʔisʔabəraqə] since F1 and F2 of [ə] in [ʕentʃə] in word-final position are around 170Hz and 365Hz.

**Al-Manshāwiyy:** 230Hz and 450Hz, and 195Hz and 395Hz, respectively; hence [ʔisʔabəraqə] since F1 and F2 of [ə] in [ʕentʃə] are around 174Hz and 364Hz.

**Al-Kanākiriyy:** 250Hz and 520Hz, and 168Hz and 370Hz, respectively; hence [ʔisʔabəraqə] since F1 and F2 of [ə] in [ʕentʃə] are around 174Hz and 364Hz.

**Al-Hassān:** 240Hz and 420Hz, and 190Hz and 360Hz, respectively; hence [ʔisʔabəraqə] since F1 and F2 of [ə] in [ʕervjə] are around 190Hz and 360Hz.

In [lu:ʔʔ], F1 and F2 of the preceding [u:] and the sound accompanying [t] are as follows:

**Al-Ghāmidīyy:** 240Hz and 480Hz, and 160Hz and 380Hz, respectively; hence [lu:ʔə] since F1 and F2 of [ə] in [ʕnɔŋə] are around 167Hz and 355Hz.

**Al-Manshāwiyy:** 230Hz and 470Hz, and 176Hz and 387Hz, respectively; hence [lu:ʔə] since F1 and F2 of [ə] in [ʕentʃə] are around 174Hz and 364Hz.

**Al-Kanākiriyy:** 230Hz and 473Hz, and 160Hz and 380Hz, respectively; hence [lu:ʔə] since F1 and F2 of [ə] in [ʕentʃə] are around 174Hz and 364Hz.

**Al-Hassān:** 216Hz and 444Hz, and 184Hz and 368Hz, respectively; hence [lu:ʔə] since F1 and F2 of [ə] in [ʕentʃə] are around 174Hz and 364Hz.

In [ʕaʔabʔ], F1 and F2 of the preceding [a] and the sound accompanying [b] are as follows:

**Al-Ghāmidīyy:** 250Hz and 470Hz, and 208Hz and 407Hz, respectively; hence [ʕaʔabə] since F1 and F2 of [ə] in [ʕervjə] are around 190Hz and 395Hz.

**Al-Manshāwiyy:** 202Hz and 404Hz, and 177Hz and 370Hz, respectively; hence ['waqabə] since [ə] in ['neitʃə] whose F1 and F2 are around 174Hz and 364Hz, respectively.

**Al-Kanākiriyy:** 240Hz and 450Hz and 185Hz and 380Hz, respectively; hence ['waqabə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz.

**Al-Hassān:** 282Hz and 550Hz and 282Hz and 525Hz, respectively; hence ['waqaba].

In ['haradʒ?], F1 and F2 of the preceding [a] and the sound accompanying [dʒ] are as follows:

**Al-Ghāmidiyy:** 230Hz and 440Hz, and 180Hz and 320Hz, respectively; hence ['haradʒə] since F1 and F2 of [ə] in ['kʌlə] are around 130Hz and 300Hz.

**Al-Manshāwiyy:** 210Hz and 410Hz, and 185Hz and 370Hz, respectively; hence ['haradʒə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz.

**Al-Kanākiriyy:** 245Hz and 470Hz, and 195Hz and 375Hz, respectively; hence ['haradʒə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz.

**Al-Hassān:** 210Hz and 410Hz, and 188Hz and 376Hz, respectively; hence ['haradʒə] since F1 and F2 of [ə] in ['pɒstʃə] are around 167Hz and 375Hz.

In ['kabad?], F1 and F2 of the preceding [a] and the sound accompanying [d] are as follows:

**Al-Ghāmidiyy:** 206Hz and 430Hz, and 206Hz and 430Hz, respectively; hence ['kabada].

**Al-Manshāwiyy:** 220Hz and 400Hz, and 184Hz and 360Hz, respectively; hence ['kabadə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz.

**Al-Kanākiriyy:** 240Hz and 490Hz and 182Hz and 370Hz, respectively; hence ['kabadə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz.

**Al-Hassān:** 238Hz and 477Hz and 228Hz and 447Hz, respectively; hence ['kabada].

In the case of the geminated [q] at the end of ['haqq?], F1 and F2 of the preceding [a] and the sound accompanying [q] are as follows:

**Al-Ghāmidiyy:** 260Hz and 478Hz, and 200Hz and 400Hz, respectively; hence ['haqqə] since F1 and F2 of [ə] in ['servjə] are around 190Hz and 395Hz (see Figure 13).

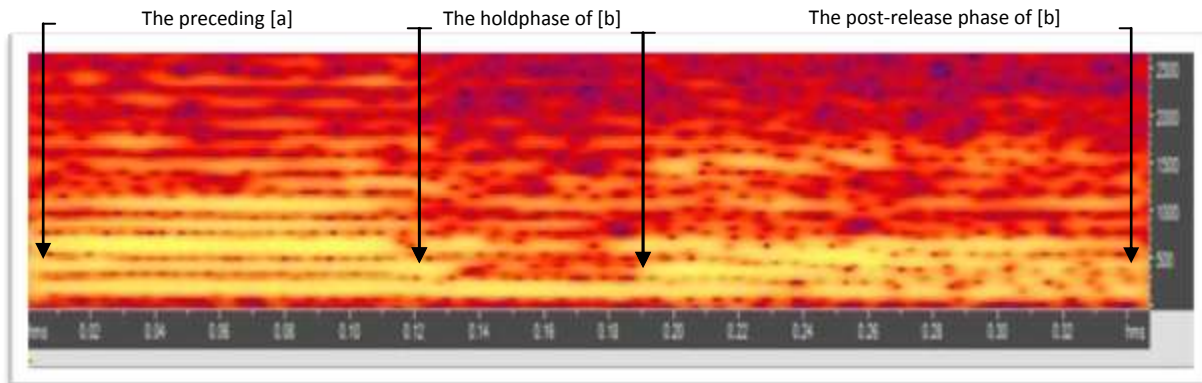


Figure 13: F1 and F2 of the preceding [a] and the sound accompanying [b] in ['waqabə] for Al-Ghāmidiyy.

**Al-Manshāwiyy:** 212Hz and 430Hz, and 168Hz and 340Hz, respectively; hence ['haqqə] since F1 and F2 of [ə] in ['neitʃə] are around 174Hz and 364Hz (see Figure 14).

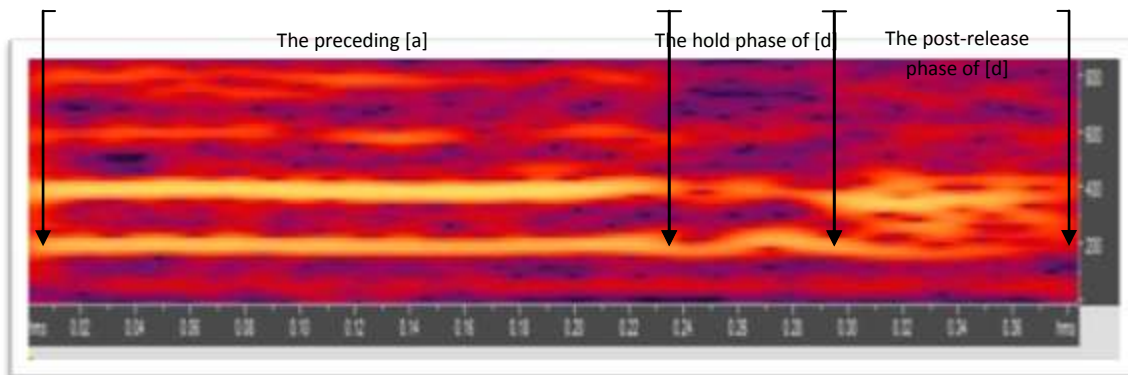


Figure 14: F1 and F2 of the preceding [a] and the sound accompanying [d] in ['kabadə] for Al-Manshāwiyy.



**Al-Kanākiriyy:**270Hz and 500Hz and 185Hz and 385Hz, respectively;hence[ʰaqqə] since F1 and F2 of [ə] in [ʰnertʃə] are around 174Hz and 364Hz(see Figure 15).

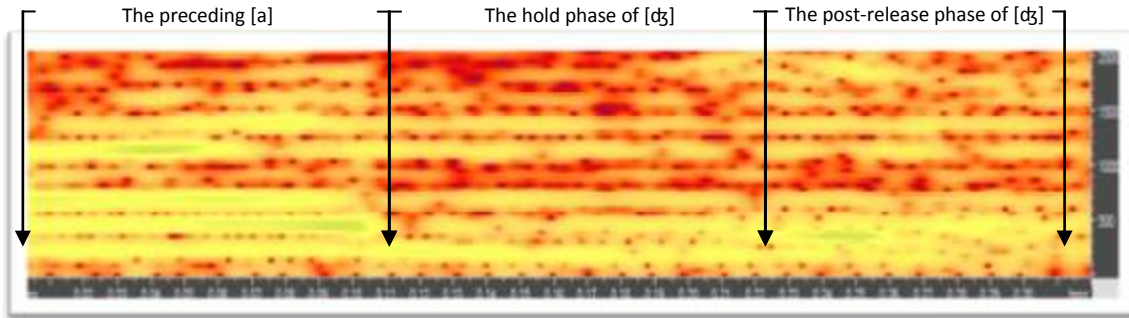


Figure 15: F1

and F2 of the preceding [a] and the sound accompanying [dʒ] in [ʰaradʒə] for Al-Kanākiriyy.

**Al-Hassān:**270Hz and 520Hz, and 260Hz and 509Hz, respectively; hence [ʰaqqə] (see Figure 16).

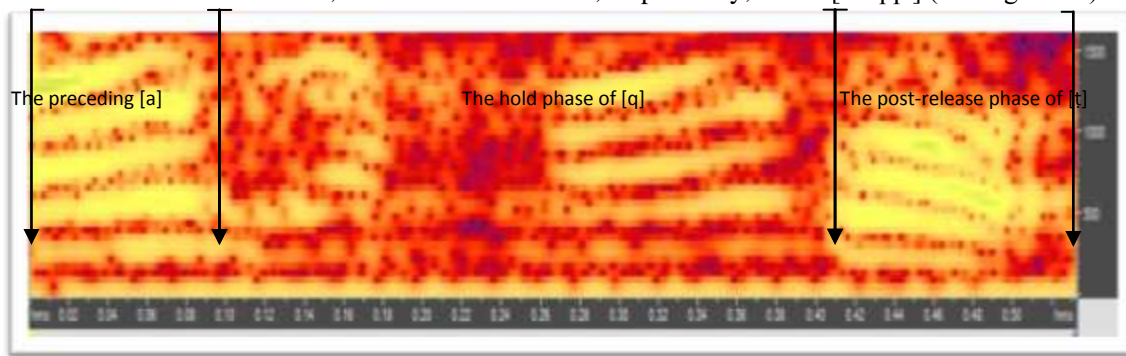


Figure 16: F1 and F2 of the preceding [a] and the sound accompanying the geminated [q] in [ʰaqqə] for Al-Hassān.

### 6.3 Waveform Repetition

Ladefoged (1996: 49) states that "vowels which continue for a comparatively long time; contain a number of consecutive waves which are almost identical to one another." These waves have different shapes according to vowel quality; so, a difference in the shape of the wave means a difference in the quality of the vowel and "they are heard as different vowels because each has a characteristic wave shape....in each of them the complex pattern repeats itself every one-hundredth of a second" (Ladefoged, 1996: 28).Analysis of the post-release phase of the qalqala sound together with the other vowel in the utterances shows that the sound accompanying the qalqala sound has a waveform which repeats itself every 0.02-0.06sec. This applies to the post-release phase of all the qalqala sounds. For example, in word-medial position, the waveform of the preceding vowel [a] and the sound accompanying [b] in [ʰʂabari] repeats itself every 0.03sec.This means that the sound accompanying [b] is a vowel similar to the preceding vowel [a] in waveform repetition (see Figures17 and 18).

Waveform of the preceding [a]

Repetition of the waveform of the preceding [a]

Repetition of the waveform of the preceding [a]

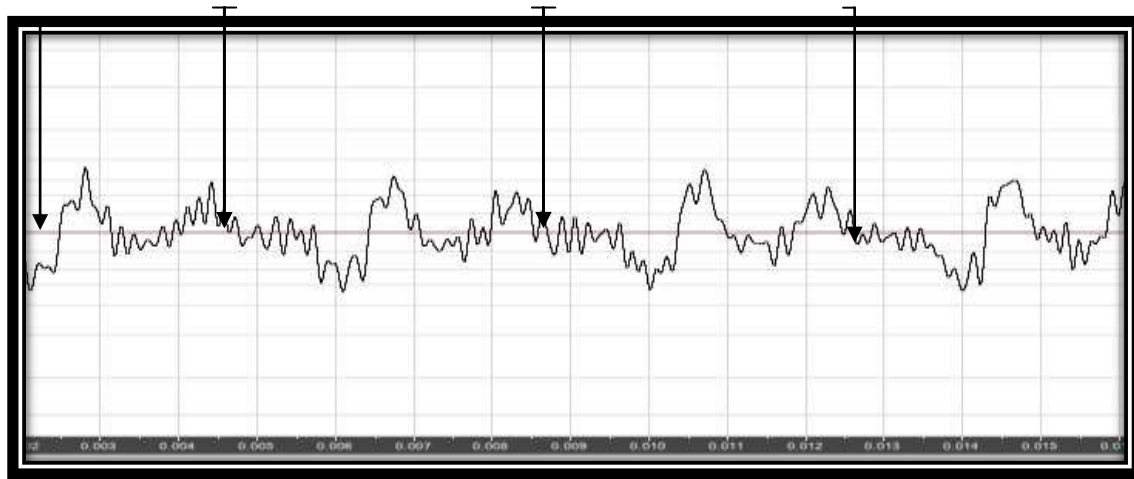


Figure 17: Repetition of the waveform of the preceding vowel [a] in ['šabari] every 0.03sec. for Al-Ghāmidīyy.

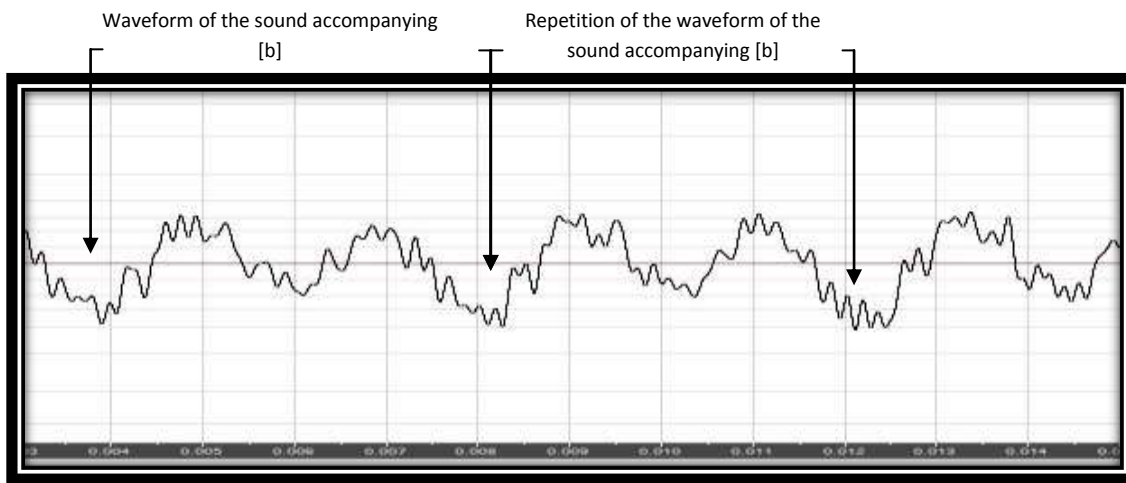
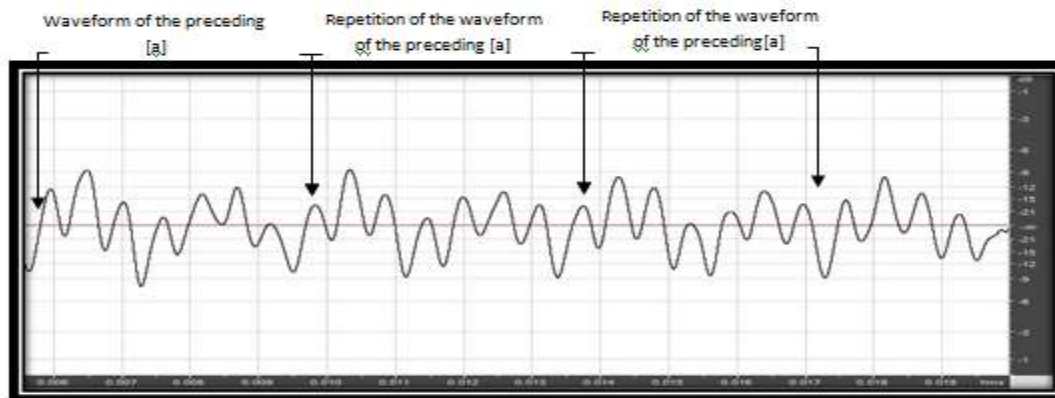


Figure 18: Repetition of the waveform of the sound accompanying [b] in ['šabari] every 0.03sec for Al-Ghāmidīyy.

In the articulation of the qalqala sound [dʒ] in ['jadʒaʕal], the waveform of the preceding [a] and that of the sound accompanying [dʒ] repeats itself every 0.02sec (see Figures 19 and 20).

Figure 19: Repetition of the waveform of the preceding [a] in ['jadʒaʕal] every 0.02sec. for Al-Manshāwiyy.



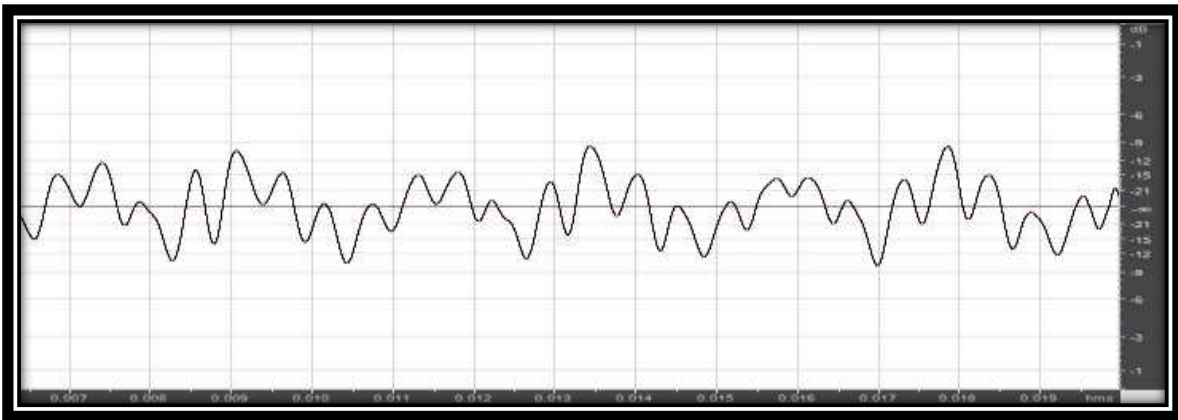


Figure 20: Repetition of the waveform of the sound accompanying [dʒ] in ['jadʒaʕal] every 0.02sec. for Al-Manshāwiyy.

In the articulation of the qalqala sound [d] in ['ʕadarak], the waveform of the preceding [a] and that of the sound accompanying [d] repeat itself every 0.04sec (see Figures 21 and 22).

Waveform of the preceding [a]    Repetition of the waveform of the preceding [a]

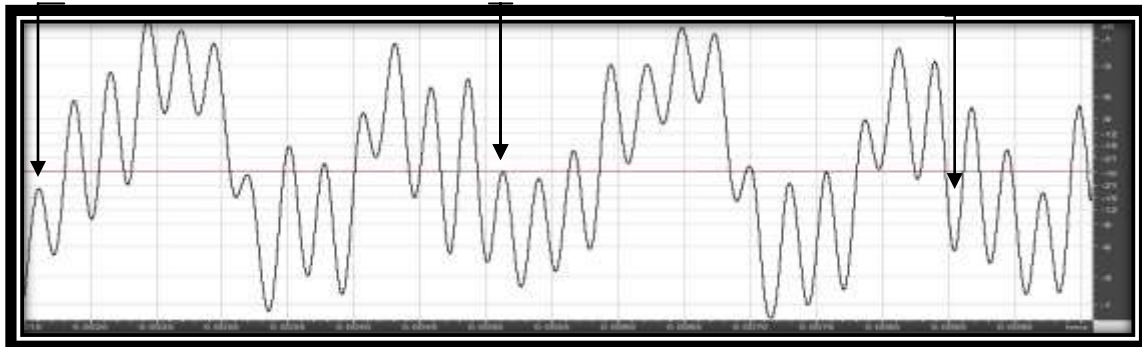


Figure:21: Repetition of the waveform of the preceding [a] in [ʕadarak] every 0.04sec for Al-Kanākiyyi

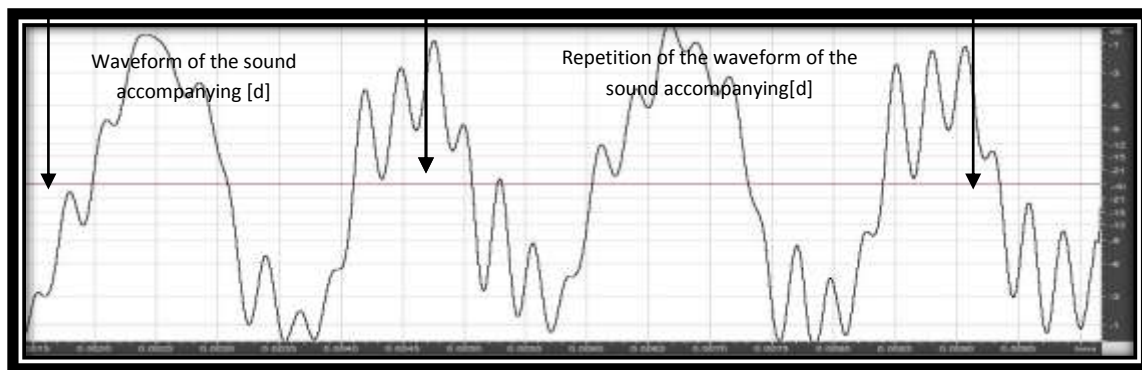


Figure: 22: Repetition of the waveform of the sound accompanying [d] in [ʕadarak] every 0.04sec for Al-Kanākiyyi.

In the articulation of the qalqala sound [d] in ['ʔahadə], the waveform of the preceding [a] and that of the sound accompanying [d] repeats itself every 0.03sec (see Figures 23 and 24).

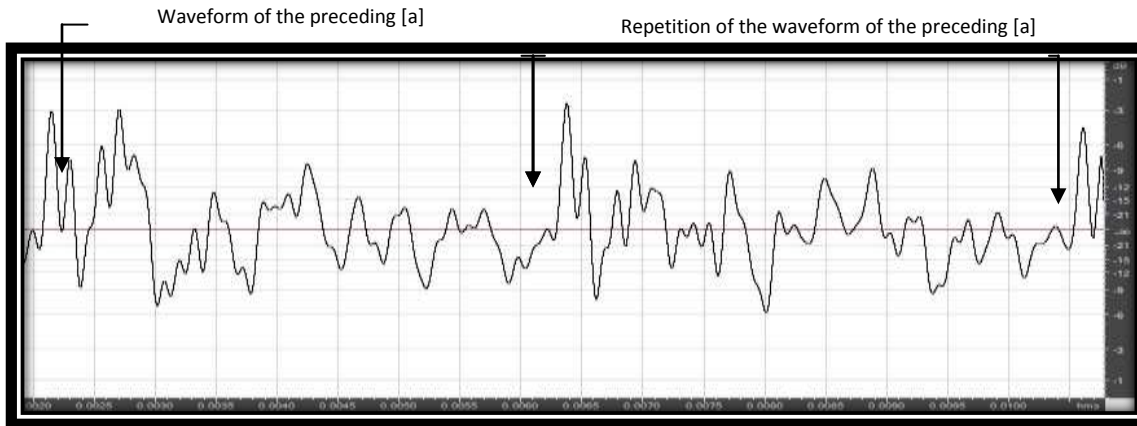


Figure 23: Repetition of the waveform of the preceding [a] in [ʔahadə] every 0.03sec.for Al-Hassān.

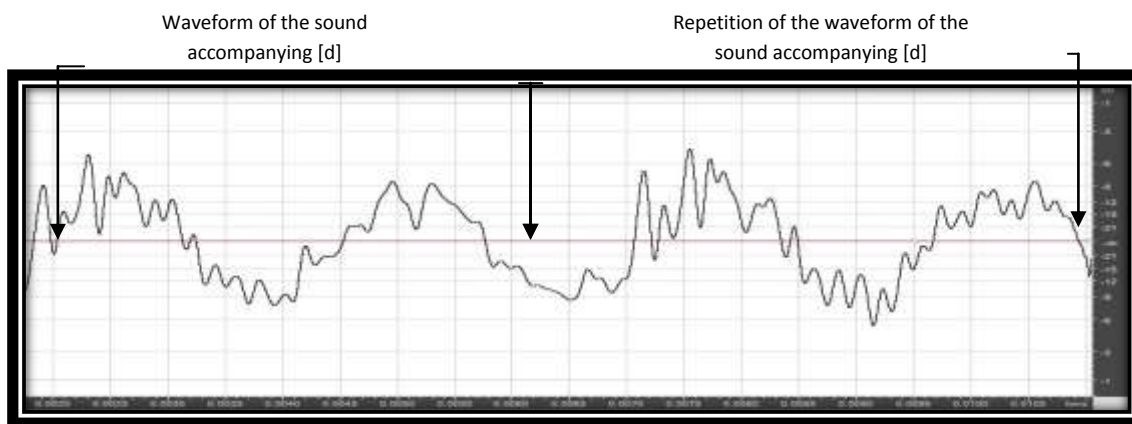


Figure 24: Repetition of the waveform of the sound accompanying [d] in [ʔahadə] every 0.03sec.for Al-Hassān

### 7. The Phonological Status of the Sound Accompanying the Qalqala Sounds

Since the sound accompanying the qalqala sound is a vowel like fatha, dhamma and/or schwa, then it is considered as a phoneme which occurs whenever the qalqala sounds occur. [a] and [u] have long been established as distinctive segments in Arabic, i.e. separate phonemes /a/ and /u/. As regards schwa [ə] which occurs only as a sound realizing the phenomenon of qalqala in reciting Qur'ānic verses, there is a well-established phonological principle: "once a phoneme, always a phoneme", thus the sound accompanying the qalqala sound is a phoneme which can be tested by the "minimal-pair test" as follows:

[ʃabər] "patience" / [ʃabar] "he showed patience"  
 [qadər] "dignity" / [qadar] "destiny"  
 [badər] "full moon" / [badar] "he came unexpectedly"  
 [naqəd] "rescission" / [naqad] "he refuted"  
 [liʔadʒəlihi] "for his sake" / [liʔa'dʒalihi] "for his moment of death"  
 [qaʔəʃ] "assertion" / [qaʔaʃ] "he asserted"  
 [fadʒər] "dawn" / [fadʒar] "he acted immorally"

From the above minimal-pair test, we may conclude that [ə] functions in Qur'ānic recitation as a distinctive segment, i.e. a separate phoneme /ə/, just like the other vowels accompanying the qalqala sounds, i.e. /a/ and /u/.

### 8. Results and Discussion

The results of the acoustic analysis of the qalqala sounds in terms of amplitude, formant frequency and waveform repetition are as follows:



### 8.1 Amplitude Analysis

When measuring the amplitude of the sound accompanying the qalqala sound (the post-release phase of the qalqala sound), the spectrographic analysis shows that this sound is a vowel since it has intensity like any other vowel in the examined utterances for all the four reciters. However, the value for intensity is different from one reciter to another.

### 8.2 Formant Frequency Analysis

The results of F1 and F2 of the sound accompanying the qalqala sound in word-medial position show that this sound is mostly close to [a] in Al-Ghāmiyy's performance. In word-final position, on the other hand, the spectrographic analysis shows that the sound accompanying the qalqala sound is close to [ə].

The spectrographic analysis of Al-Manshāwiyy's performance shows that the sound accompanying the qalqala sound is close to [ə] in word-medial and word-final positions. The results of Al-Kanākiriyy's performance show that the sound accompanying the qalqala sound is close to [a] in word-medial position, whereas it is close to [ə] in word-final position.

Finally, the results of the spectrographic analysis of Al-Hassān's performance show that the sound accompanying the qalqala sound is close to /a/ in word-medial position, whereas in word-final position it is sometimes close to /a/ and sometimes close to /ə/.

### 8.3 Waveform Repetition

The results of waveform repetition of the four reciters show that the sound accompanying the qalqala sound is a vowel that has a waveform which repeats itself every 0.02-0.06 sec similar to the other vowels in the utterance.

## 9. Conclusions

It may be concluded that the sound accompanying the qalqala sound is a vowel-like articulation since it has intensity; this vowel is, in view of its F1 and F2, mostly close to [ə]. The waveform of the sound accompanying the qalqala sound repeats itself at regular time intervals. It is also concluded that the phenomenon of qalqala is of two levels: minimum and maximum, since there is no real difference between the geminated qalqala sound and its non-geminated counterpart. Because the phenomenon of qalqala is a feature that goes against the natural human tendency for economy of muscular effort, there is no stability among the four reciters' performance of qalqala sounds.

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