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ABSTRACT

Using acoustical evidence from spectrograms and physiological evidence from X-ray sound films, it appears that the most common allophone for the Arabic voiced pharyngeal fricative, at least in Iraqi, is a voiceless stop, and not a voiced fricative, as many believe. The author considers the phoneme in different environments and describes its behavior. Comments from other linguists are included along with photographs of the spectrogram findings. (VM)

SALMAN H. AL-ANI

AN ACOUSTICAL AND PHYSIOLOGICAL INVESTIGATION OF THE ARABIC /ع/

In all previous works on Arabic—classical, modern and the various dialects—the /ع/ has been described as a voiced pharyngeal fricative and has been classified as the counterpart of /ħ/.

However, after a careful acoustical examination of the /ع/, it was surprisingly noticeable that the most common allophone of the /ع/ is actually a *voiceless stop* and *not* a voiced fricative. It would then seem more appropriate to place the /ع/ as a counterpart of the /ʔ/ leaving the /ħ/ to team up with /h/[1]. In reaching this conclusion spectrograms were made, specified and measured by male informants from different sections of Iraq and the following discussion applies only to Iraqi Arabic both on the literary and spoken levels. However, spectrograms were also analyzed for a few informants (mostly male college students) from every other Arab country with the exception of North Africa [2]. (Informants were not available from this area.)

In addition to the acoustical investigation, the Iraqi /ع/ was also examined physiologically by way of X-ray sound films [3]. However, the results were not as revealing as expected even though the films are extremely clear and cover the whole vocal tract, lips to glottis. It is very hard to see the movements of the pharyngeal muscles and it is equally difficult to examine the interior of the larynx. This is because the films are two-dimensional.

On the spectrograms the /ع/, in initial position, appears as a burst—occasionally with a few vertical spikes-duration 40—50 msec followed

[1] For additional information on these phonemes see: al-Ani, Salman H., *Arabic Phonology: An Acoustical and Physiological Investigation*, Mouton & Co., The Hague, The Netherlands, in "Janua Linguarum", series practica, 61, 1970.

[2] The majority of the spectrograms were made at the Communications Sciences Laboratory, Ann Arbor, Michigan, with the able help and advice of both the late Dr. Charles E. Peterson and Dr. June E. Shoup who is now at the Speech Communications Research Laboratory, Santa Barbara, California.

[3] The X-ray sound films were made at the Department of Otolaryngology and Maxillofacial Surgery, University of Iowa, Iowa City, Iowa, under the directorship of Drs. Kenneth Moll and James Lubker. An accompanying script is on file at the University of Iowa with the films.

11—c. 14

by random noise. The /ʔ/ also appears as a burst in this position but the burst is weaker and shorter in duration than that of the /ʕ/ — approximately 10—20 msec. On the other hand, the /ħ/ is obviously a voiceless fricative and appears as noise with no burst. Duration of noise approximately 100—150 msec. Also the frequencies of the /ʕ/and /ʔ/ (especially the /ʕ/) are lower than those of the /ħ/. (See Fig. 1.)

The characteristics of the medial /ʕ/ are determined by their environment and whether the /ʕ/ is geminated or single.

When geminated, the /ʕ/ is always a voiceless stop appearing as a silence gap—approximate relative duration from 300—330 msec. (The duration varies from one person to another—even with the same person depending on the manner of speech.) This gap is preceded by some sort of a glide along F1—F2 of the vowel before the gap. The approximate duration of this glide is 30—40 msec. The gap is followed by a burst—similar to the burst appearing with the initial /ʕ/.

The medial geminated /ħ/ is a voiceless fricative appearing as noise with higher frequencies than those of the medial geminated /ʕ/. There is no doubt that there is a difference between the medial geminated /ʕ/ and the medial geminated /ħ/—the contrast being not so much that one is voiced and the other voiceless but that one is a stop and the other is a fricative. (see Fig. 2.)

However, on the spectrograms, the medial geminated /ʕ/ appears to be similar to the medial geminated /ʔ/ except for the neighboring vowel formants. This is true especially with /a/ and /aa/ where the F2 of both of these vowels is lower when next to the /ʕ/ than when next to the /ʔ/. (Compare figures 2 and 3.)

Intervocalically the /ʕ/ and /ʔ/ are in free variation most often appearing as glide continuations of the preceding and following vowel formants. Less often they appear as stops—mostly with slow careful speech. Frequently the space they occupy appears as a random striation of voiced noise with no clear tracings of formants—especially in their center positions. In these positions, no frequencies of the /ʕ/ are visible above 2000 cps because it is a low pitched sound. However, the /ʔ/ usually has higher frequencies. (See Fig. 4.)

The intervocalic /ħ/ is a voiced fricative with higher frequencies than those of both the /ʕ/ and /ʔ/.

The medial single /ʕ/ forms clusters with most consonants. Since the Arabic sound system does not permit a cluster of more than two consonants, a syllable cut divides the cluster and the first member of the cluster is the coda, or 'offset', of the preceding syllable. The second member is the onset of the following syllable. Therefore, when the /ʕ/ occurs as a first member of a cluster the conditioning hardly goes beyond the syllable boundary. This is often the case when the second member of the cluster is a stop. When the second member is other than a stop, the /ʕ/ is in free

variation—either a stop or a glide—depending on the style of speech (fast or careful).

When the /ℰ/ occurs as a second member of a medial cluster it is conditioned by the environment. When the preceding consonant is a stop the acoustic characteristics are similar to those of the initial /ℰ/. When the preceding consonant is other than a stop, the /ℰ/ is in free variation—either a stop or a glide.

In final position, the /ℰ/ is in free variation being either released or unreleased. When released it is usually aspirated appearing as a silence gap—relative duration 170—200 msec—preceded by a glide along F1—F2 of the preceding vowel. This gap ends in a breath release which usually appears as a noise and sometimes as a weak spike. The frequencies of this noise release are low—around 1000 cps.

When unreleased, there is no way to measure the duration because nothing appears on the spectrograms.

The characteristics of the /ʔ/ in final position are quite similar to those of the /ℰ/ except that the /ʔ/ has higher frequencies. (See Fig. 5.)

In contrast to the /ℰ/ and /ʔ/, the /ħ/ in final position has much higher frequencies that appear as random noise.

In general, the high back vowels (/u/ and /uu/) and the high front vowels (/i/ and /ii/) have relatively less allophonic variations than the low central vowels (/a/ and /aa/). (Phonemic length is indicated by writing the vowel symbol twice.) When /ℰ/ is next to /i/ and /ii/, the vowels have slightly centralized and lower allophones than when they neighbor the /ʔ/ or /ħ/. On the spectrograms these vowels are indicated by a slight lowering of the onset of F2. There is no lowering of F2 when they are next to /ʔ/ and /ħ/. When /ℰ/ neighbors /a/ and /aa/, the vowels are slightly lower and farther back than when they are next to /ʔ/ and /ħ/. These vowels are recognized acoustically by possessing a lower F2 than either the /ʔ/ and /ħ/. The /u/ and /uu/ do not seem to be affected when next to the /ℰ/ and have similar allophones as those of /ʔ/ and /ħ/[4].

In conclusion, the most common allophone of the /ℰ/ for all of the Iraqi informants is a voiceless stop. With informants from other Arab countries it seems to vary. For the most part, the most common allophone seems to be a fricative except for Kuwait and Saudi Arabia where it seems similar to the Iraqi /ℰ/. Of course this is a preliminary investigation as only a few informants were used from these countries. See figure 6 which illustrates a geminated medial /ℰ/ of a Jordanian informant. Here the /ℰ/ appears as a fricative. However, the noise appearing on the spectrograms is not as much as with the geminated medial /ħ/.

[4] For further details concerning the allophones of these phonemes see al-Ani, *ibid.*, Chapters II and V.

DISCUSSIONS

T. F. MITCHELL :

I warmly welcome Dr. al-Ani's paper for the experimental acoustic confirmation it provided of the belief I have formed impressionistically as to the nature of /ʔ/ in Kuwaiti Arabic, which had seemed to me in most environments to involve concomitant features of glottal closure and pharyngal constriction and to differ notably therefore from corresponding articulatory complexes in Egyptian and North African varieties of Arabic. However, the label "voiceless stop" was perhaps insufficiently precise, although, of course, the facts of Iraqi and Kuwaiti pronunciation might differ markedly. It is also relevant to ask what Dr. al-Ani had implied by his statement that, given the recognition of /ʔ/ as a "voiceless stop", /ħ/ (*sc.* a voiceless pharyngal fricative) was "left to match up with /h/ (*sc.* a so-called glottal fricative)". In what terms was "matching" to be made, and why, perhaps on the basis of possibly similar behaviour in regard to syllable patterning, should /ħ/ not only be "matched" with /h/ but also *inter alia* with /x/ (*sc.* a voiceless uvular fricative)?

We were remarkably ignorant of what goes on and can go on in the pharyngo-laryingeal region. It was, for instance, possible to produce a fricative *sui generis* from the approximation of the trachea and the under surface of the epiglottal fold (a possibility apparently exploited by the Berber dialect of Zuara in Tripolitania). Again, the "root" of the tongue may be popped in and out of the trachea, the epiglottis may be trilled, the whole of speech may be imbued with pharyngal quality, pharyngal plosion may be produced (and indeed occurs in allophones of /q/ (*sc.* a voiceless uvular plosive) in the Arabic of Fez in Morocco), etc. It was greatly to Dr. al-Ani's credit that he had made so interesting a start towards filling such gaps in our knowledge and it was much to be hoped that he and others would provide further experimental evidence either in support or refutation of currently accepted notions as to facts of pronunciation, notions which as a rule are impressionistically based. There is probably in general a need for those of us who are ill-equipped in the field of acoustic phonetics to be prepared to re-think and re-form our phonetic frameworks of observation and reference and for this purpose Arabic provides a particularly appropriate field of study.

The old Arab Grammarians were no mean phoneticians and orthoepists. Was it not al-Khalil who devised the written shape of Hamza from the upper part of *ʿayn*, and was it not interesting to reflect on the justification given him by Dr. al-Ani's experiments today?

Y. GOLDENBERG :

It is for the first time, as far as I know, that *ʿayn* as pronounced in Iraq, is shown to be a voiceless stop — at least in most of its allophones —

and not a voiced fricative, as it generally is elsewhere in the Arab World. The spectrograms presented by Prof. al-Ani leave no doubt on this peculiar pronunciation. It may be worth mentioning that J. Cantineau had observed, in his studies on the Arabic dialects of *Ḥōrān* (Syria), the existence of two types of *ʿayn*, depending on environing sounds : *muraqqaqa* and *mufaḫḫama*, i.e., followed or not by *ʾimāla*. It seemed to him that for *ʿayn muraqqaqa* the contraction of the pharyngal muscles occurred "somewhat lower". Further acoustical investigation on informants from that area may show if this particular pronunciation of the *ʿayn* is not related somehow to that described by Prof. al-Ani, knowing that the Iraqi dialects are highly influenced by the Beduin dialects of Northern Arabia. Moreover, the so-called *tarqīq* of the *ʿayn* may account, perhaps, for the loss of its voiced character.

A. S. ABRAMSON :

The phonetic details in your report make me wonder whether the historical contrast between /ʕ/ and /ʔ/ is in fact maintained. Have you tested this perceptually? Perhaps, in at least some of the traditional distributions, the distinction has collapsed in Iraqi Arabic.

Your spectrograms suggest that the Iraqi /ʕ/ is a stop, but your X-ray films do not unambiguously show a closure of the tongue back or root against the wall of the pharynx. I should like to speculate that this phoneme is manifested as a glottal stop along with /ʔ/. From your data on F2 lowering in at least some vocalic environments of /ʕ/, one might infer that where it is kept distinct from etymologically expected /ʔ/, /ʕ/ is best viewed as sharing the feature of pharyngeal constriction with the emphatic consonants of the language. Your X-rays may even now show pharyngeal constriction for /ʕ/. Transillumination of the larynx might show glottal closure. The fact that F2 in /ʕ/ does not fall as much as in the emphatics need not matter; it is the relative value that counts.

Intervention de L. LISKER

SALMAN H. AL-ANI :

(*Mitchell*) I tend to agree with Prof. Mitchell that the label 'voiceless stop' may not be a suitable choice. When my investigation of the /ʕ/ is completed—particularly on the physiological level—this term may be replaced. I have used it thus far with an open mind mainly to point out the difference between the Iraqi /ʕ/ and the /ʕ/of Egypt and North Africa which is a 'voiced fricative.'

As for the contrast of the /ħ/ and /h/, the term 'matching up' refers to the contrast between pharyngealized and non-pharyngealized consonants as /t̪/ vs. /t/, /ʕ/ vs. /ʔ/, etc.

(*Abramson*) The /ʕ/ vs. /ʔ/ were tested perceptually and the phonemic contrast is maintained in Iraq both on the literary and dialectal levels. Also, one thing that is clear to me—even though my investigation of the /ʕ/ is in a preliminary stage—is that there is a closure. This fact is most apparent on spectrograms, some of which are listed with this paper.

One thing that I have not been able to establish as factual, on a physiological level, is where the above mentioned closure takes place. I therefore speculate with Prof. Abramson that the closure is being maintained as a glottal stop along with the hamza. I would even venture further and not eliminate the possibility that the closure could be made by the false vocal cords.

Wherever the closure does take place it is accompanied by a pharyngeal construction. The X-ray films show a narrowing of the pharynx against the back of the tongue manifested by the pharyngealization of the /ʕ/ supported by the conditioning of the neighboring vowels. (This aspect is covered quite thoroughly in my book; *Arabic Phonology: An Acoustical and Physiological Investigation*, Mouton and Co., Janua Linguarum, series practica, 61, 1970.)

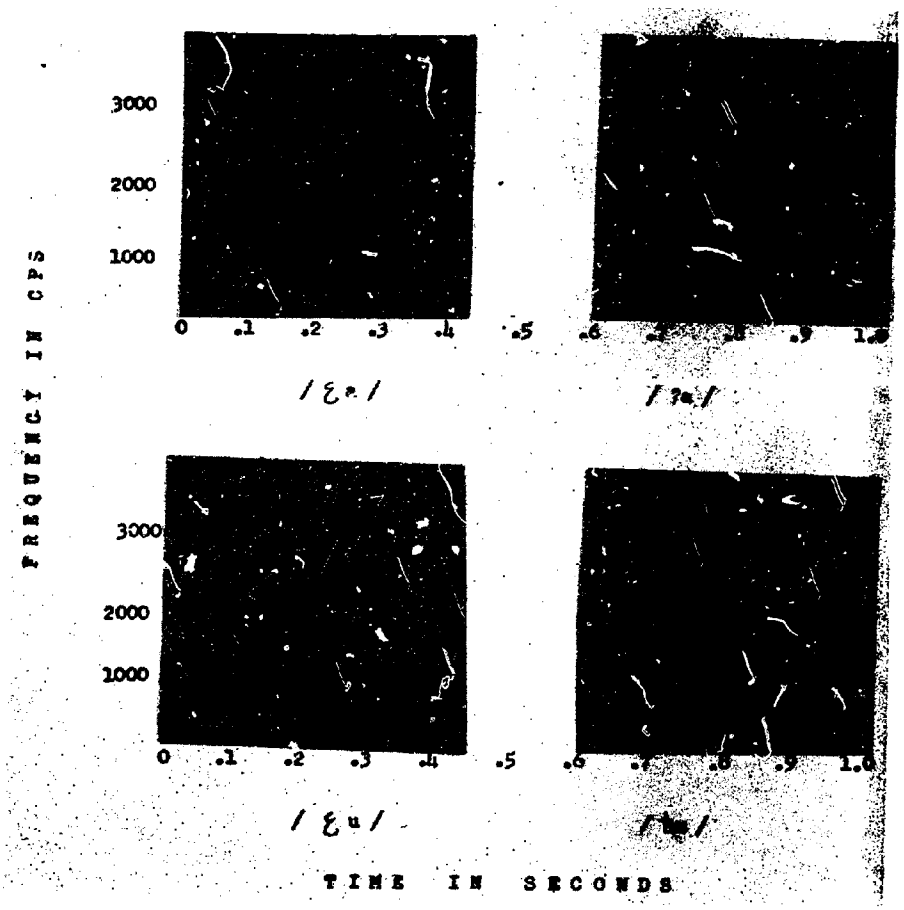

Fig. 1. — Broadband spectrograms illustrating the [ℰ], /ʔ/ and /ɦ/ in initial position. (Pronounced by the author.)

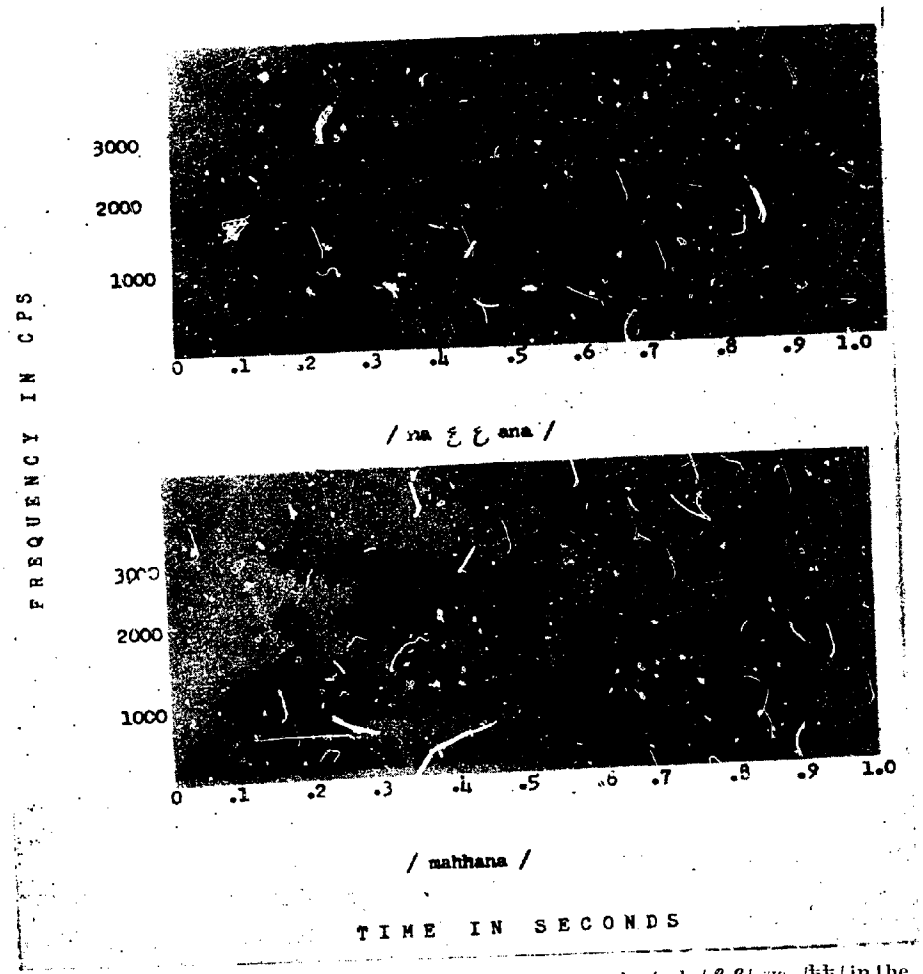

Fig. 2. — Broadband spectrograms illustrating the geminated /ʕʕ/ vs. /hh/ in the minimal pair /maʕʕana/ — /mahhana/. (Pronounced by the author).

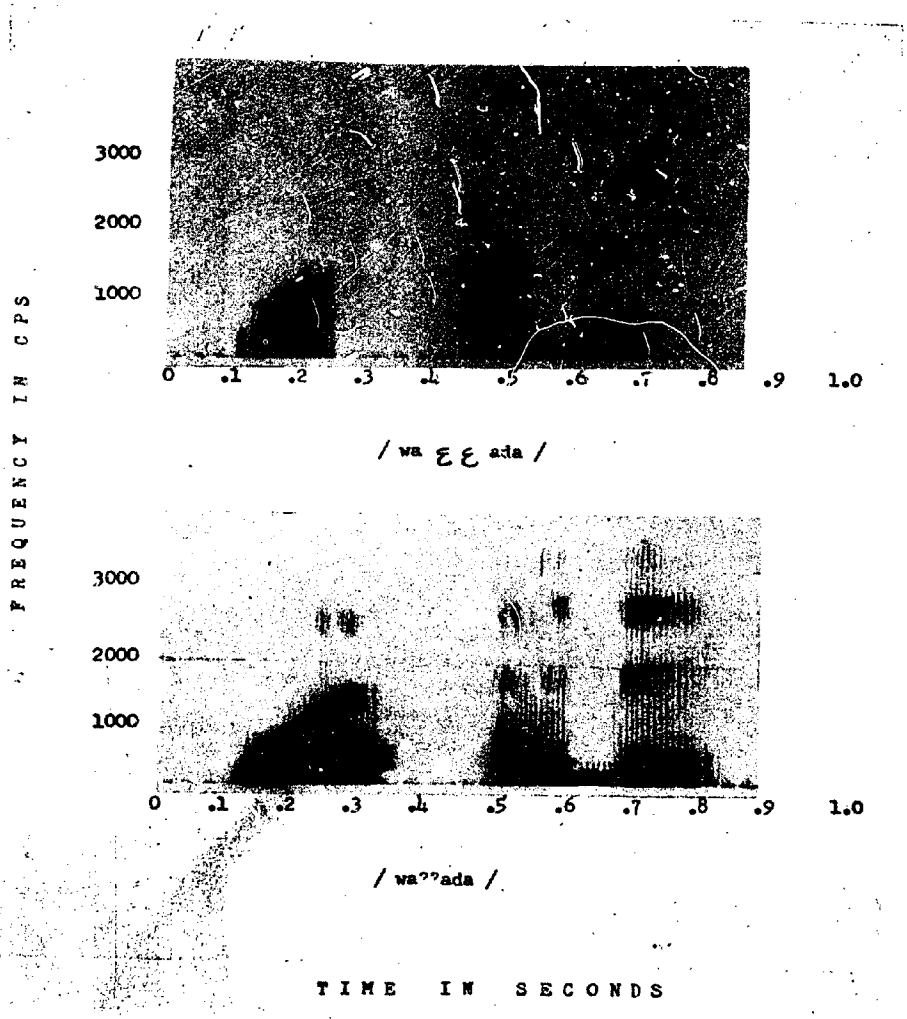

Fig. 3. — Broadband spectrograms illustrating the geminated /ɛɛ/ vs. /??/ in the minimal pair /waɛɛada/ — /wa??ada/. (Pronounced by an Iraqi informant — not the author.)

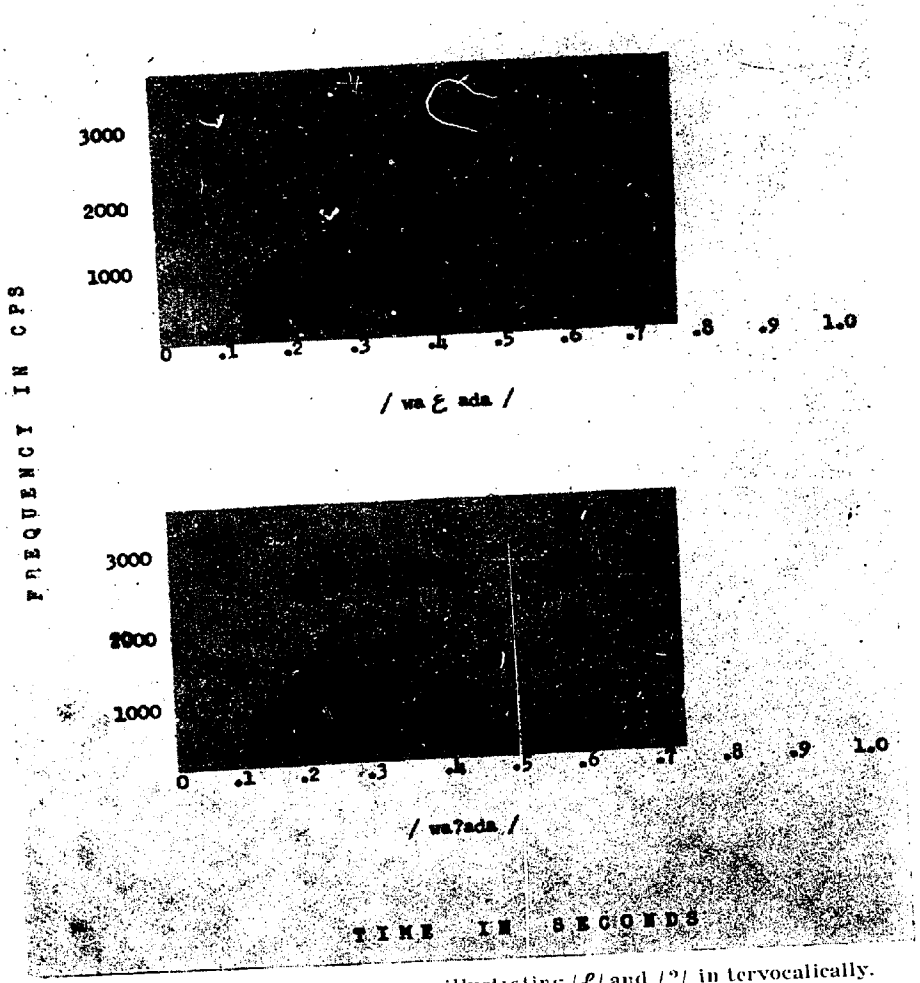

Fig. 4. — Broadband spectrograms illustrating /ɛ/ and /ʔ/ in tervocalically. (Pronounced by an Iraqi informant — not the author.)

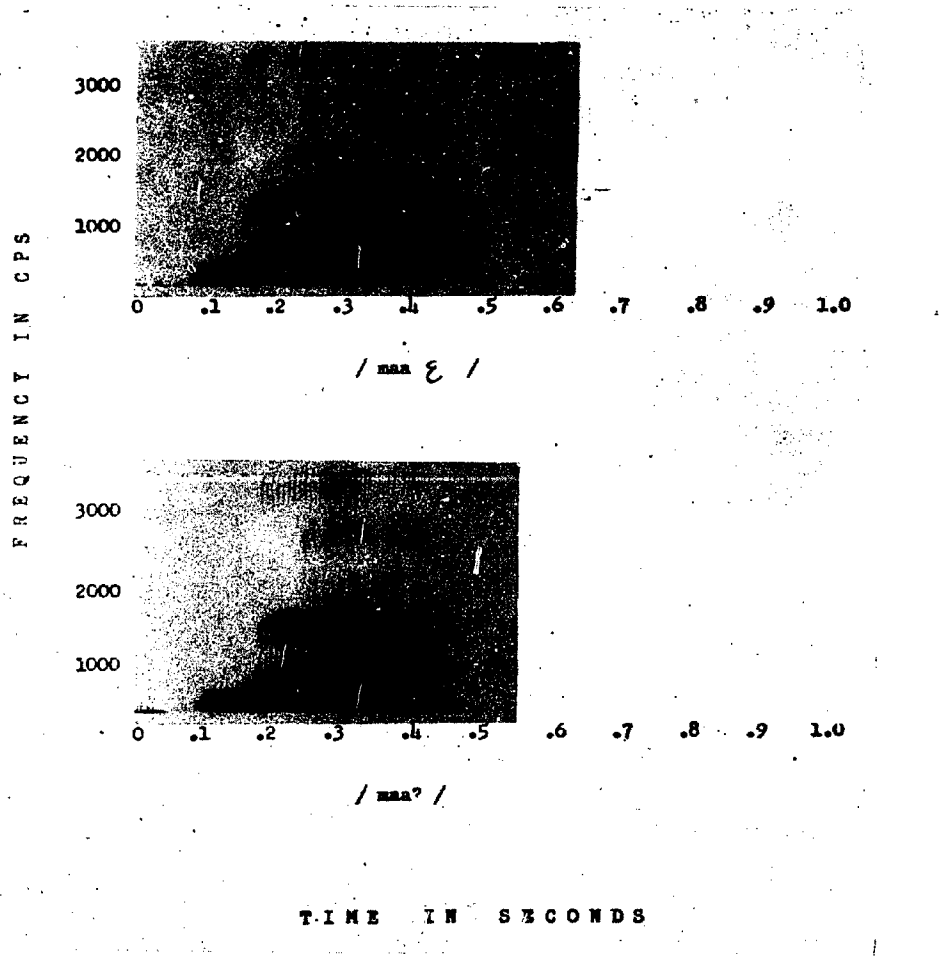

Fig. 5. — Broadband spectrograms illustrating the /ε/ and /ʔ/ in final position. (Pronounced by an Iraqi informant — not the author.)

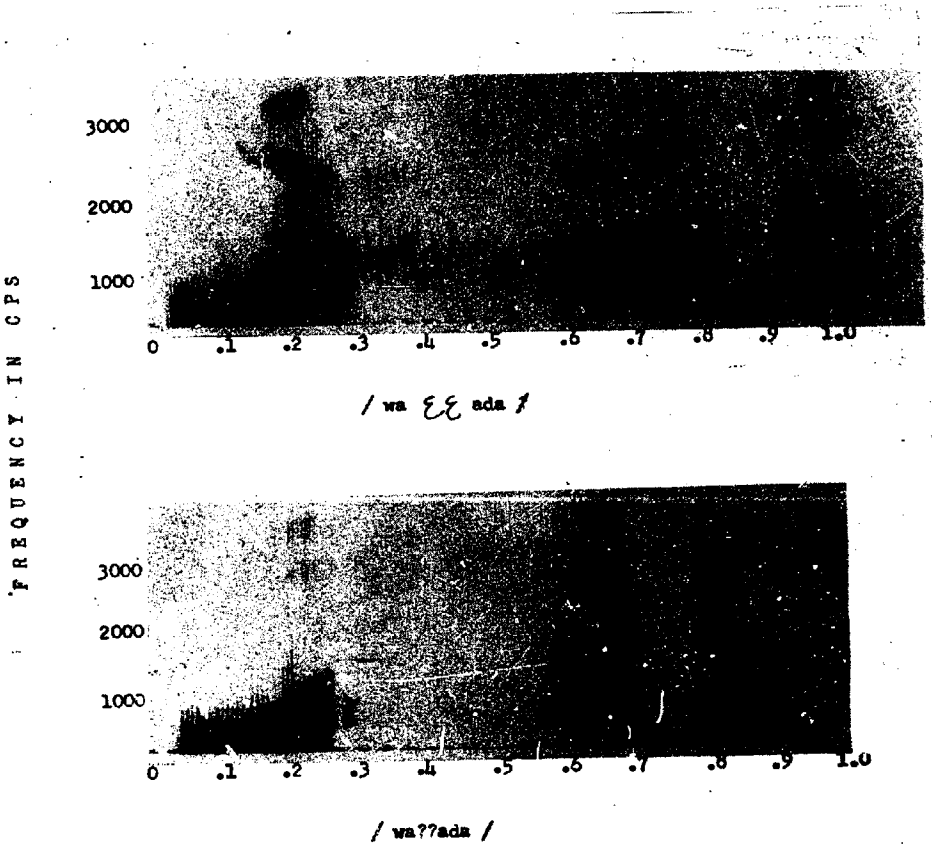

Fig. 6. — Broadband spectrograms illustrating the /ʕʕ/ and /??/ in medial position, geminated, as pronounced by an informant from Jordan. Notice that the /ʕʕ/ is a voiceless fricative whereas the Iraqi /ʕʕ/ is a voiceless stop.