An Electropalatographic study of the Singleton-Geminate contrast in Arabic

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ABSTRACT

This study investigates the articulatory correlates of the singleton and geminate consonants in Tripolitanian Libyan Arabic (TLA) using Electropalatographic (EPG) data. The aim of this study is to ascertain whether underlying differences are reflected in articulatory dissimilarity. The location, size and shape of linguopalatal contact were examined together with the flatness of the tongue degree. The articulatory results show systematic articulatory differences between the singleton and geminate consonants. The data provide evidence of the use of different regions of articulators for gemination. The data provide evidence for apical contact for singletons as opposed to laminal contact for geminates and a flatter shape of the tongue in geminate articulation. The results are suggestive of a strengthening effect on the articulatory level. The results of the current study confirm the robustness of the effect of the phonological context on the articulatory gestural plans of the singleton and geminate consonants.

Keywords: Electropalatography (EPG), gemination, articulatory data, Libyan Arabic, sonorant sounds.

1. INTRODUCTION

Traditionally, durational cues to gemination have formed the main emphasis in investigating the singleton-geminate contrast and, generally, these studies in various languages have shown that duration is the most robust correlate of gemination (see e.g. [1], [2] and [3], among others). A number of non-durational correlates of geminates have also been investigated by researchers for many languages (see e.g. [4], and [5], among others). Some of these cues can be investigated acoustically, while others can also be investigated through articulatory analysis. For instance, [5] and [6] showed that, in Italian, geminate laterals are more palatalized compared with their singleton counterparts both acoustically and articulatorily. She also found articulatory evidence, using Electropalatography, for the existence of apical contact for singletons as opposed to laminal contact for geminates and a flatter shape of the tongue in geminate articulation [6].

Moreover, some articulatory studies showed that, in languages that allow word-initial voiceless geminate stops, even though the geminate contrast is neutralized perceptually and acoustically (in cases where no significant secondary cues to gemination exist), articulatorily, the distinction still holds in languages such as Tashlhiyt Berber [7] and Swiss German [8, 9]. It is shown in these articulatory studies that word-initial geminates were systematically longer in their articulation than their singleton counterparts. Another finding of these studies was that stops were longer in phrase-initial position than in phrase-medial position, which was interpreted as prosodic lengthening and strengthening in cases whereby it involved more linguopalatal contact. [6] also reported that gemination in Italian involved longer consonant duration as well as greater linguopalatal contact and the use of different regions of articulators. Based on these findings, [6] analysed gemination in Italian as a fortitional (i.e., strengthening) process.

Although these geminate articulatory correlates have been investigated for some languages, they have not been investigated for Arabic. All consonant phonemes in TLA have geminate counterparts which can occur both word-medially and word-finally with the exception of the glottal stop /ʔ/ ‘hamza’ which can only be geminated word-medially. Geminate consonants in TLA are contrastive, very frequent, and play an important role in the grammar of the language. However, very little is known about the phonetic realisation of gemination in this dialect (see [3]), with the articulatory cues to the singleton-geminate contrast have not been investigated yet. The acoustic results of [10] show that the singletons and geminates sonorants in TLA have similar formant structure and intensity values, which indicates that gemination in TLA does not show strengthening effects. However, it will be interesting to investigate whether these results are mirrored at the articulatory level. That is, to find out whether the sonorant geminates in TLA show longer and/or greater linguopalatal contact despite the fact that they do not show strengthening by the acoustic parameters.

This study contributes to the literature on gemination and the literature on Arabic language (and TLA) by examining the articulatory correlates of the singleton-geminate contrast in TLA using Electropalatography (EPG). The drive for

investigating the articulatory gestures of the singleton-geminate contrast is to ascertain whether underlying differences are reflected in phonetic dissimilarity.

2. METHODOLOGY

2.1. Language variety and subject

TLA is a variety of Arabic spoken in the northwest region of Libya (a country in the Maghreb region of North Africa) known as Tripolitania (Trablus) province. Due to the difficulty in finding subjects willing to take part in this kind of research and, also, due to the limited financial resources, only one male native TLA speaker participated in this experiment. He was naive as to the purpose of the study. At the time of the experiment, he was 34 years old, and had no obvious speaking or hearing defects. He was born and lived in Tripoli. He had lived and been educated there until he got his first degree. He speaks a typical TLA dialect. He was monolingual during childhood and his parents do not speak languages other than TLA. He was a postgraduate student who speaks English as a second language, and he lived in West Yorkshire during the time of the recording. He had been in the UK for about four years.

2.2. EPG data collection and recording

The system used was WinEPG (Articulate Instruments Ltd.). The model of the custom-made electro-palate was that of the Articulate-style. In this system there are eight rows of electrodes in the electro-palate, six electrodes on the first row (the one behind the front teeth) and eight on each of the other seven rows, forming a total of 62 electrodes. These sensors are spread between the point behind the upper front teeth and the back of the hard palate. The audio signal was sampled at 22.05 KHz and the EPG sampling rate was 100 frames per second.

The speaker was asked to read a list composed of trisyllabic minimal or near minimal word pairs containing the sonorant sounds /l, n, r/ in medial intervocalic position at normal speech rate. The test tokens were randomized and filler words were inserted after each 2-3 utterances. Equal number of singleton and geminate contrasts of these sounds were included. The carrier sentence was “ma tguli:ʃ _____ ta:ni” ‘Don't say (fm)_____ again’. Table 1 shows examples of the test tokens.

Singleton	Gloss	Geminate	Gloss
/lili:na/	‘for Lina’	/fil:ina/	‘cork’
/lina:ʒi/	‘for Naji’	/bin:a:ʒi/	‘Surname’
/liri:ma/	‘for Rima’	/bir:i:ma/	‘valve’

Table 1: Examples of test tokens.

2.3. Data analysis and measurements

The analysis of articulatory data was done with the Articulate assistant software (version 1.18). The EPG data was annotated using the analysis task window of the software, in which the waveform display, spectrogram display and EPG palate display are presented simultaneously. The constriction area for the alveolar region was defined as the first three rows from the front of the palate (R1-3). The research presented in this paper is part of a bigger project examining gemination in TLA. Many articulatory parameters were measured for the singleton and geminate sonorants, however only two subsets of the results are presented here.

3. RESULTS

3.1. The location, size, and shape of contact

The location, size, and shape of contact are presented graphically using representative palatograms for each sound combination separately. The contact patterns can provide information about the location of contact on the passive articulator and can be suggestive of the involvement of the active articulator. The depth of the constriction was taken into account as well in order to extrapolate tongue configurations (see [6]).

Figure 1 presents the palatograms for the alveolar lateral /l/. It is clear that the geminate laterals show more linguopalatal contact than singletons at rows 2 and 3. They also show somewhat deeper contact (i.e., go further back in the mouth – in this case, extends to row 4) than singletons, something that could be

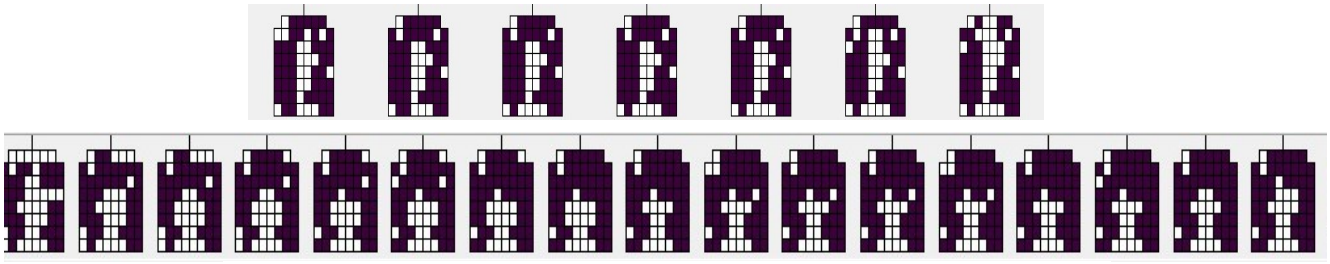

Figure 1: EPG palatograms of the singleton (top) and geminates (bottom) /l/.

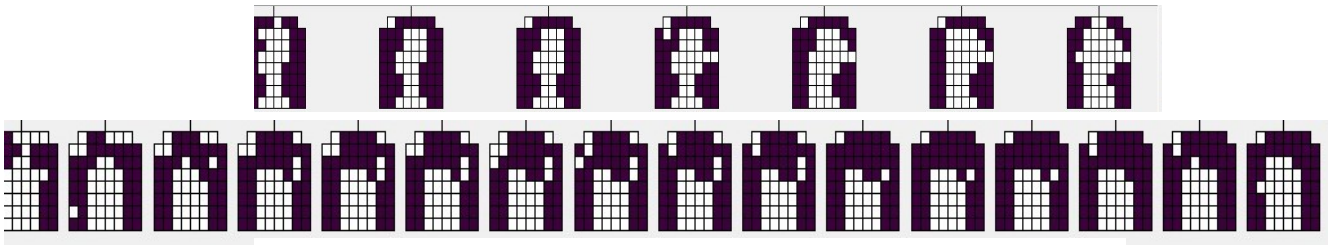

Figure 2: EPG palatograms of the singleton (top) and geminates (bottom) /n/.

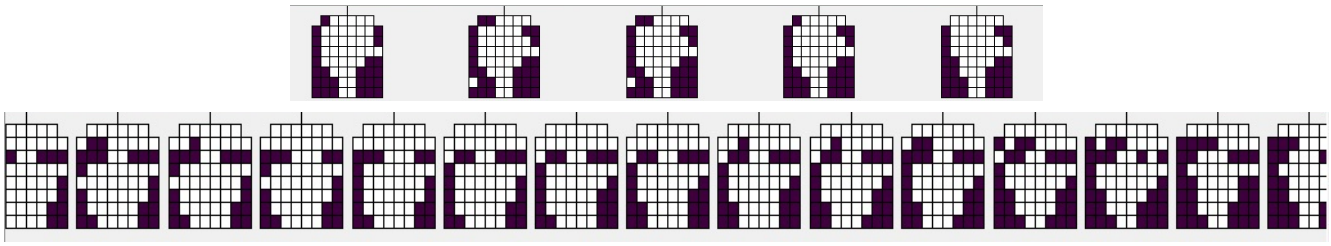

Figure 3: EPG palatograms of the singleton (top) and geminates (bottom) /r/.

interpreted as a more laminal contribution to the articulation of geminates and an apical production of singleton.

The differences between the singleton and geminate palatograms in the case of the alveolar nasal /n/ are presented in Figure 2. Geminates show more linguopalatal contact than singletons. Regarding the location of the contact, for singletons, the main contact lay along the first row indicating an apical articulation; in the case of geminates, the occlusion occurred in the first three rows with more linguopalatal contact at rows 2-3, something that could be taken to indicate an apico-laminal articulation. The firm contact at the two lateral columns for both singleton and geminate nasals could correspond to a 'cupped' (concave) tongue configuration. This shape of contact is compatible with the apical and apico-laminal interpretation of the contact patterns.

Figure 3 presents the palatograms for the alveolar rhotic /r/. Geminates show more linguopalatal contact than singletons. The main contact lies in the first row for the singletons and in third row for the geminate. This indicates that the /r/ is produced with an apical tongue configuration in all cases. However, the tongue is fronted in the case of singletons and retracted in the case of geminates. That is, as an apical anterior alveolar for singletons vs. apical posterior alveolar for geminates.

3.2. Flatness index

Flatness of the tongue, which is the mean contact divided by the maximum possible contact of the relevant region (see [11]), was measured for the singleton and the geminate consonants. If the contact profile is relatively flat, then the contact remains near maximum for more of the duration of the consonant and, therefore, this index will be closer to 1. The assumption is that gestures that maintain a constriction will be flatter than those that form a closure that is quickly released. The index of flatness was measured to investigate whether geminates are produced with flatter tongue configurations than singletons.

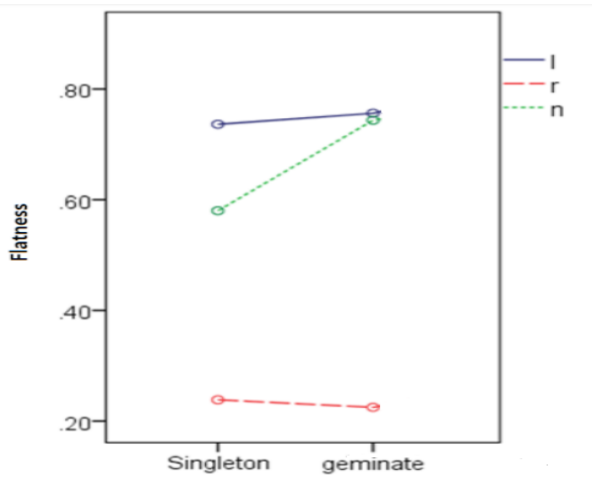

Figure 4: The flatness degree for the singleton and geminate sounds.

Figure 4 shows the flatness of the tongue degree for the singleton and geminate sounds. It is clear from Figure 4 that there is difference in the degree of flatness between the three sounds tested in this study with the alveolar rhotic /r/ showing the least degree of flatness compared to /n/ and /l/. The alveolar lateral /l/ show the highest degree of flatness only as a singleton. The alveolar lateral /l/ and the alveolar nasal /n/ show similar degree of flatness as geminates and both show flatter tongue configurations as geminates than singletons. On the contrary, the alveolar rhotic /r/ does not show flatter tongue

configurations as a geminate. The results of the flatness of the tongue degree supports the visual observations of the frames presented above.

4. DISCUSSION

The visual inspection of the palatograms was used in this study to provide information about the location of contact on the passive articulator which can be suggestive of the involvement of the active articulator.

The location, size and shape of contact presented in the current study are found to be robust articulatory cues for the distinction between singleton and geminate consonants in TLA. This study provides evidence that the articulation of geminate consonants involves deeper contact than singletons, something that could be interpreted as a more laminal (in the case of /l/) or apico-laminal (in the case of /n/) contribution to the articulation of geminates and an apical production of singletons. This observation of the existence of apical contact for singletons as opposed to laminal contact for geminates is generally comparable to what has been found for Italian [6].

Although the alveolar rhotic showed apical tongue configurations both as a singleton and a geminate, it was produced as an apical anterior alveolar for singletons but apical posterior alveolar for geminates. This difference in the articulatory configurations contributes to the singleton-geminate distinction of this sound.

The palatograms presented in Figures 1, 2, and 3 show longer articulatory duration for geminates compared to singletons. The articulatory gestures of geminate consonants show more contact frames than those of the singletons reflecting an increased articulatory duration. Geminates also show more linguopalatal contact than singletons. The number of the activated electrodes over the course of the production of the target sounds is higher in the case of geminates. This observation is generally comparable with what has been found for Italian nasals, laterals and stops by Payne [6] with the geminates involving more linguopalatal contact than singletons.

As regarding the flatness of the tongue index, the results of the current study provide clear evidence that the tongue is flatter during the production of geminates. The degree of flatness among the sound categories investigated here is different, however. The /l/ shows the highest degree of tongue flatness followed by /n/ and then /r/. The results of the flatness of the tongue among the three sound categories matches the extrapolated observations of the location, size and shape of contact.

As mentioned in in the introduction section above, the results of longer articulatory duration together with the greater amount of linguopalatal contact for geminates have been interpreted as lengthening and strengthening for some languages. The general assumption is that if geminates involve a stronger articulation, then the amount of contact with which it is produced is expected to show positive correlation. In the current study, and as mentioned above, geminates are found to involve more linguopalatal contact than singletons. However, whether to consider this as a strengthening effect for TLA geminates may not be straightforward since the behaviour of sonorant consonants may be difficult to understand with respect to consonant strengthening. That is, they are inherently quite vowel-like and thus might weaken or strengthen by becoming less like a vowel. As suggested by [12], weak sonorants will resemble vowels more closely in terms of formant structure and intensity whereas strong sonorants will have less formant structure and less intensity. In the current study, geminates are found to have more linguopalatal contact than singletons. However, the results of [10] for TLA sonorants show that the singleton and geminate consonants have similar formant structure and intensity values. Based on the acoustic evidence alone, there seem to be no indication of strengthening effects for gemination in TLA. However, and by considering the current results, it could be that the strengthening effects for TLA sonorants are evident only on the articulatory level.

In conclusion, the articulatory results of the current study show systematic articulatory differences between the singleton and geminate consonants in TLA. These results show that underlying differences are reflected in articulatory dissimilarity. The data provide clear evidence of the use of different regions of articulators for gemination. The data provide evidence for apical contact for singletons as opposed to laminal contact for geminates. The data also show a flatter shape of the tongue in geminate articulation. Furthermore, there is evidence of longer articulatory duration and greater linguopalatal contact for geminates. These results are suggestive of a strengthening effect on the articulatory level. The location, size and shape of linguopalatal contact together with the flatness of the tongue degree provide clear evidence that singletons are dynamically distinct from geminates in TLA. These results confirm the robustness of the effect of the phonological context on the articulatory gestural and temporal plans of the singleton and geminate consonants.

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