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JORDANIAN ARABIC FINAL GEMINATES: AN EXPERIMENTAL CLINICAL PHONETIC STUDY

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ABSTRACT

An experimental study was carried out to investigate word-final geminates in Jordanian Arabic. Monosyllabic singleton and geminate minimal pairs (CVC and CVCC) were considered to answer the three main questions of the study: Does gemination occur word-finally in Jordanian Arabic? Is there a temporal compensatory relationship between the vowels preceding geminate/singleton consonants? Are these differences contrastive? Eighteen participants produced 324 tokens with /m, n, l and m:, n:, l:/ occurring word-finally.

Spectrographic and videofluoroscopic analyses show that final geminates are permissible in Jordanian Arabic. The temporal compensation maintained with the preceding vowel and the tension in articulating the geminates enhance perceptuality boundaries and maintain phonemicity.

KEYWORDS: Gemination; phonetics; Jordanian Arabic; videofluoroscopy.

1. Introduction

In Arabic, a geminate consonant is represented orthographically with a single letter and the diacritic (ّ ; *shadda*; شدّة) placed above it; e.g. /θan:a/ (ثنّى) with the *shadda* on top of the nasal consonant (نّ). *Shadda* literally means 'to tighten' or 'bring together'. It was Al-Khalil (714–786 AD) who devised the sign to preserve phonemic contrast between the geminate and its singleton counterpart (/θana/ ثنى 'bent'; /θan:a/ ثنّى 'did it twice'). Before Al-Khalil, Quranic manuscripts used a semicircle (˘ or ˆ) to represent gemination (El-Saaran 1951: 157). Using *shadda* was preferred by old Arab grammarians to doubling the letter "since the latter would have been offensive to Arabic writers in so far

as it involves a basic alteration in the received spelling and orthography" (El-Saaran 1951: 158).

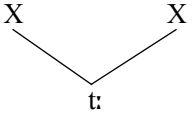
A great volume of literature has dealt with the phonetic implementation and phonological representation of geminates across different languages. Phonetically, geminates are treated as long sounds (Ladefoged and Maddieson 1996; Ball and Rahilly 1999) that counterpart singletons in Italian (Esposito and di Benedetto 1999), Pattani Malay (Cohen et al. 1999), Cypriot Greek (Arvaniti and Tserdanelis 2000; Tserdanelis and Arvaniti 2001), Arabic (Al-Tamimi 2004), etc. "Greater muscular tension in the articulating organs" is needed to produce geminates (Trubetzkoy 1969: 161) and "to hold the articulators and maintain a longer occlusion time for the geminate contoid" (Catford 1977: 298). There has been myodynamic, aerodynamic and acoustic evidence (Hassan 1981; Al-Tamimi 2004) that there is a temporal compensation relationship between geminates and vowels preceding them (e.g. Cypriot Greek: Tserdanelis and Arvaniti 2001; Italian: Esposito and di Benedetto 1999; Arabic: Al-Tamimi 2004; Rembarrnga: McKay 1980; English, German, Spanish and French: Delattre's 1971; etc.).

Phonologically, a Geminate has been viewed at the level of syllable structure as two identical consonants produced in two articulatory phases or as one long consonant. The two-phase theory states that geminates involve rearticulation with the first phase constituting "a syllable final occurrence of the consonant, while the second, rearticulated phase starts the next syllable and thus constitutes a syllable-initial occurrence of the consonant" (Morton and Tatham 1973: 131). The closure gesture of the first phase that constitutes the coda of the first syllable is anticipated by the preceding vowel, while the opening gesture that constitutes the onset of the second syllable is anticipated by the vowel that follows (Delattre 1971). Thus a geminate consonant might be represented within the frame of the two-phase theory as in (1).

(1)

As long consonants, Clark and Yallop (1990: 52) state that "lengthened consonants are always treated as the uninterrupted succession of two identical short consonants [...], in which case they may be called GEMINATES". In this case, geminates are represented as single melody units or one root linked to two skeletal slots without the existence of two phases (Levin 1985) as represented in (2).

(2)



Whether geminates are sounds produced with two phases or with two skeletal slots, linguists agree that in both cases they are long consonants serving as counterparts to the singletons (Ball and Rahilly 1999; Ladefoged and Maddieson 1996). However, the term "long" might be elusive. It is based on the general view that "most languages with a distinction of consonant length have only two distinctive lengths" (Ladefoged and Maddieson 1996: 93). This distinction is most apparent intervocalically. Intervocalic gemination is more common than peripheral gemination (Thurgood 1993; Muller 2001; etc.). This typology is usually correlated with evidence showing that word-initial and word-final geminates are perceptually less salient because the difference in duration between geminates and singletons is less perceptible when the following sound is a consonant rather than a vowel. The duration ratio usually shows that geminates are 1.5–3 times as long as singletons. This ratio becomes lower when gemination occurs peripherally (Pająk 2009).

Within this framework, the three main questions that the current study wants to answer are:

(1) Does gemination occur word-finally in Jordanian Arabic? If yes,

(2) Is there a temporal compensatory relationship between the vowels preceding geminate/singleton consonants? If yes,

(3) Are these differences contrastive?

2. Gemination: word position and duration phonemicity

Cross-linguistically, geminates tend to occur in certain phonetic environements; intervocalically and after short stressed vowels (Thurgood 1993). Thurgood (1993: 1) states that "syntagmatically, the most favored environment for long consonants to occur in is intervocalically, following a short, stressed vowel and preceding another short vowel". Therefore, most of the proposed phonological representations of gemination come "almost exclusively from intervocalic geminates, it is perhaps unsurprising that they should face some difficulties in representing non-intervocalic geminates" (Muller 2001: 12).

In Standard Arabic, gemination can occur in word medial and final positions. Mitchell (1990: 63) believes that "gemination or doubling of consonants is an important device of Arabic morphology, and any consonant may be doubled intervocalically and finally". Intervocalic and word final geminates can be preceded by any of the Arabic short or long vowels (Hassan 2003), e.g. /sam:/ 'poison' or /sa:m:/ 'poisonous'. The old Arab grammarian, Ibn Al-Jazari (1350–1432) states in his *Al-Tamihiid* that geminates in pause forms word finally are difficult to articulate and need be pronounced distinctly so

that they can be heard. In the Arabic vernaculars, word final geminates occur when a "word takes a pausal form where the geminate (CCV) pattern is reduced to (CC)" (Ghalib 1984: 30). The final vowel that reflects the nominative case is deleted, e.g. /samːu/ → /samː/ 'poison'. Intervocalic geminates contrast distinctively with their corresponding singletons, e.g. /θana/ (ثنى) 'bent' vs. /θanːa/ (ثنّى) 'did it twice' (Al-Tamimi 2004). However, distinctiveness of word final geminate/singleton contrast in Arabic is controversial. Mitchell (1990) lists the two Arabic words /ʕaːm/ 'year' and /ʕaːmː/ 'public' to exemplify distinctiveness. El Saaran (1951) lists /ħaːd/ 'deviated' and /ħaːdː/ 'sharp' as other examples that prove distinctiveness in word final geminate/singleton contrasts.

On the other hand, Cowell (1964: 23) states that in Syrian Arabic, word final geminates "may occur after an accented vowel"; however, they "do not actually contrast with single ones". Ghalib (1984: 31) adopts the same view, stating that "geminates occurring word-finally are non-distinctive in Arabic because contrasts between single and geminate consonants in this position are non-significant".

With regard to temporal differences between geminate/singleton consonants, the volume of literature on Arabic shows that intervocalic geminates witness temporal compensation with the preceding vowel (Blanc 1952; Mitchell 1990; Al-Tamimi 2004; etc.). In final position, no experimental study to our knowledge has been conducted on Arabic vernaculars to find out if geminates and singletons contrast phonemically for length.

3. The Arabic language

Phonetically speaking, Arabic has 28 consonant phonemes (Table 1) and six vowels contrasting for length (a – aː, i – iː, u – uː). All Arabic consonants can be geminated resulting into two types: fake and proper geminates. A fake geminate results from merging a sequence of two identical consonants arising under morphological concatenation. In Arabic, this results from certain phonological processes, mainly when the definite article /ʔal/ 'the' precedes alveolar or dental consonants, e.g. /ʔal daːr/ → /ʔadːaːr/ 'the house'. The proper geminates are part of the internal structure of the morpheme, e.g. /θana/ 'bent' → /θanːa/ 'did it twice'; /ʕaːm/ 'year' and /ʕaːmː/ 'public'.

Arabic syllables can be of different types: CV, CVC, CVV, CVVC, CVCC, CVVCC. All words in Standard and colloquial Arabic start with consonants. There are three levels of stress in Arabic: primary, secondary and weak (Al-Ani 1970). Stress in Arabic is non-phonemic. It is predictable in the sense it is primarily assigned to the last long syllable in the word or to the long syllable nearest to the end.

The Arabic language is diglossic. It stratifies into two markedly different linguistic levels: standard and colloquial. The standard level is used in formal and religious situations, while the colloquial level is the everyday lect of Arabs.

Table 1. Standard Arabic consonants.

	Labial	Labio-dental	Inter-dental	Alvo-dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Laryngeal
Plosive	b			t d				k	q		
(Emphatic)				tˤ dˤ							
Fricative		f	θ ð		s z	ʃ		x ɣ		ħ ʕ	h
(Emphatic)			ðˤ		sˤ						
Affricate						dʒ					
Nasal	m				n						
Lateral						l					
Trill						r					
Glide								j	w		

4. Methodology

4.1. Data collection

The broad aim of this study is to find out if there is contrastive word final gemination in Jordanian Arabic. To achieve this goal, eighteen native adults of Jordanian Arabic living in Irbid, a city in the North of Jordan, participated in the study (Table 2) without knowing its goal. The initial number of participants was twenty-four; six of them were not included in the analysis because their pronunciation did not sound natural. The remaining eighteen subjects were asked to repeat six singletons counterparting with their geminates word-finally (Table 3) in the carrier sentence /ɪħkɪ ..., ɪħkɪ .../ 'say ..., say ...' three times. A judgment group of five educated native speakers of Jordanian Arabic was asked to judge the word list for familiarity and phonemicity. All confirmed the word list familiarity to the Jordanian linguistic community and the different meanings they denoted. The total number of tokens collected for analysis was 324 words. Singleton/geminate words differed from each other in writing with the *shadda* added above the geminate consonant, e.g. سَد /sad/ 'water dam' versus سَدّ /sadː/ 'closed'. It was completely impossible to find out singleton/geminate minimal pairs represented by pictures to use them instead of the word list or to collect naturally spoken data containing singleton/geminate minimal pairs with constant supra-segmental features. To avoid or at least minimize the role of the diacritic *shadda* added above the letter in over emphasizing the pronunciation of the geminate consonants by speakers, two things were done:

(1) A judgment group of three educated native speakers of Jordanian Arabic participated in the study. They were not from the first judgment group that was asked to evaluate the word list for familiarity. These three educated speakers

Table 2. Participants.

Speaker	Age	Gender
1	21	Male
2	20	Male
3	20	Male
4	25	Male
5	30	Male
6	21	Female
7	25	Male
8	32	Female
9	22	Male
10	21	Male
11	26	Male
12	42	Male
13	38	Female
14	35	Male
15	22	Female
16	26	Male
17	22	Male
18	26	Male

Table 2. Study words.

Singleton transcription	Arabic graphemics	Gloss	Geminate transcription	Arabic graphemics	Gloss
/sad/	سَد	water dam	/sadː/	سَدّ	closed
/man/	مَن	who	/manː/	مَنّ	did someone a favour
/lam/	لم	never	/lamː/	لمّ	collected

were unaware of the study goals. They were asked to judge the naturalness of the participants' pronunciation of the singleton/geminate minimal pairs by marking their pronunciation as ± natural. No chance was given for any doubt.

Therefore, the three interraters worked separately to achieve a 100% agreement. They disagreed on a few tokens of six participants out of the twenty-four participants that the study initially included. These six participants were excluded completely from the study though not all their tokens sounded unnatural.

(2) A different judgment group of three was asked to listen to the recorded material and write down the meanings of the words. To eliminate the chance of listening

to the list of words twice as they were produced by the participants, the judgment group listened to the first productions only of the minimal pairs for all speakers. All words were given their correct meaning with 100% agreement among the judgment group.

So, all possible procedures were taken to choose a familiar word list and record natural material that would yield to representative data and authentic results.

4.2. Data analysis

For acoustic analysis, data were recorded directly to Praat (4.1.23) software. The analysis intended to measure out the durations of the target consonant, i.e. singleton and geminate, and the duration of the preceding vowel. Target singleton/geminate consonants in the current study are either the nasal stops (/m, n/) or the oral stop (/d/). The duration of vowel was measured from the onset to the offset of clear formant structures (Bouarourou et al. 2008) paralleled with its regular glottal pulses. If a nasal consonant followed, its duration would be measured from the clear reduction in intensity and sudden shift in formant structure of the preceding vowel. However, if a stop followed, the hold phase was measured from the end of glottal pulses to the burst.

Two participants of the study volunteered to do the videofluoroscopy. They signed consent sheets and were aware of the nature of the procedure. The videofluoroscopy was performed with the participants reading the word list in an upright position in a lateral projection using a Philips videofluoroscopy machine coupled with two monitors. X-ray videofluoroscopy provides excellent anatomical detail of the oropharyngeal process in real time at a rate of 30 frames/second. Two professionals attended the videofluoroscopy sessions: a radiologist to administer the procedure and the first author to watch the image, note its number on the screen.

5. Results

To achieve the aims of the current study, the data were analyzed experimentally: acoustic and videofluoroscopic analyses. Acoustic analysis included two factors: vowel length and target consonant length. Videofluoroscopic data were examined for the maximum degree of contact.

5.1. Acoustic results

The target consonants of the study are /d – d:, m – m:, n – n:/. The hold phase and preceding vowel durations were measured for /d – d:/ (Figure 1) and the nasal murmur and preceding vowel durations were measured for /m – m:, n – n:/ (Figure 2).

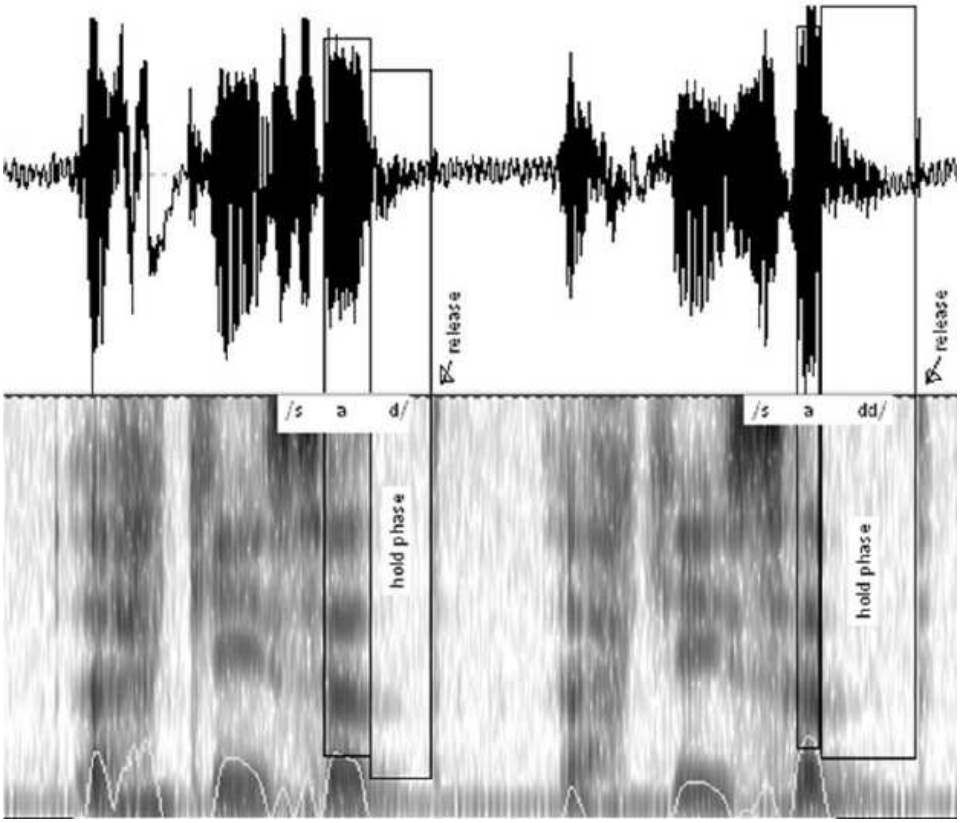


Figure 1. Vowel and hold phase duration for /sad/ and /sad:/ produced by a male speaker with a clear difference in durations between the singleton and the geminate.

Acoustic results reveal that there are differences in vowel/consonant durations between singletons and geminates in word final positions (Figure 3). The average ratio of vowel duration in the vicinity of singletons and geminates is 1:1.4 in favour of the vowel preceding the singleton, while the average ratio of singleton versus geminate duration is 1:1.5 in favour of the geminate consonant.

5.2. Videofluoroscopic results

Videofluoroscopic data reveal that Jordanian Arabic final geminates are produced with a combination of articulatory gestures that make them more tense when compared to singletons. The geminate consonants are produced with wider laryngo- and oropharynx, more elevated hyoid bone, narrower vertical distance between the uppermost point of

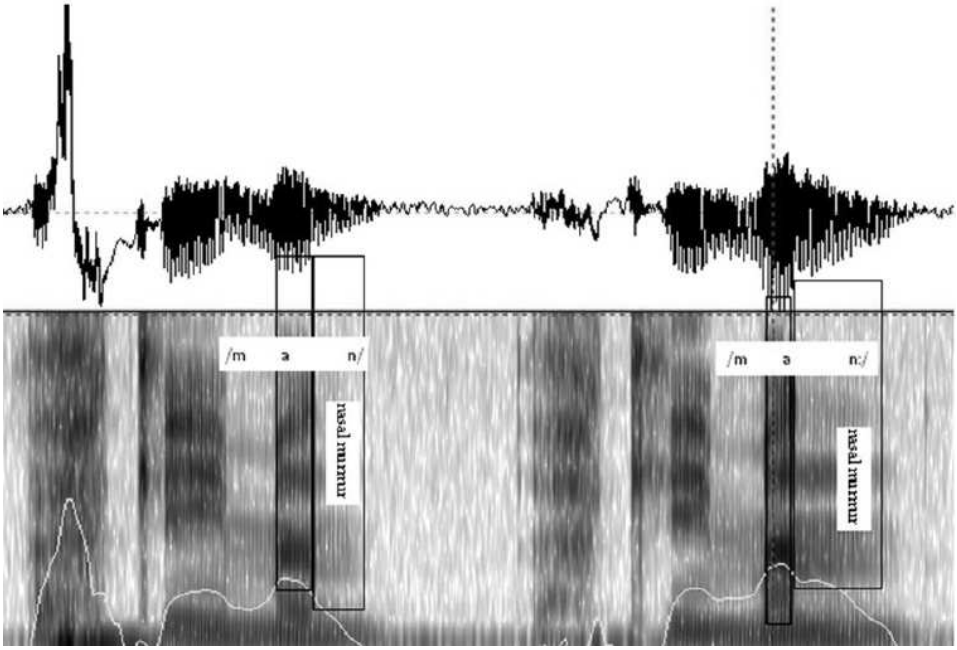


Figure 2. Vowel and nasal murmur for /man/ and /man:/ produced by a male speaker.

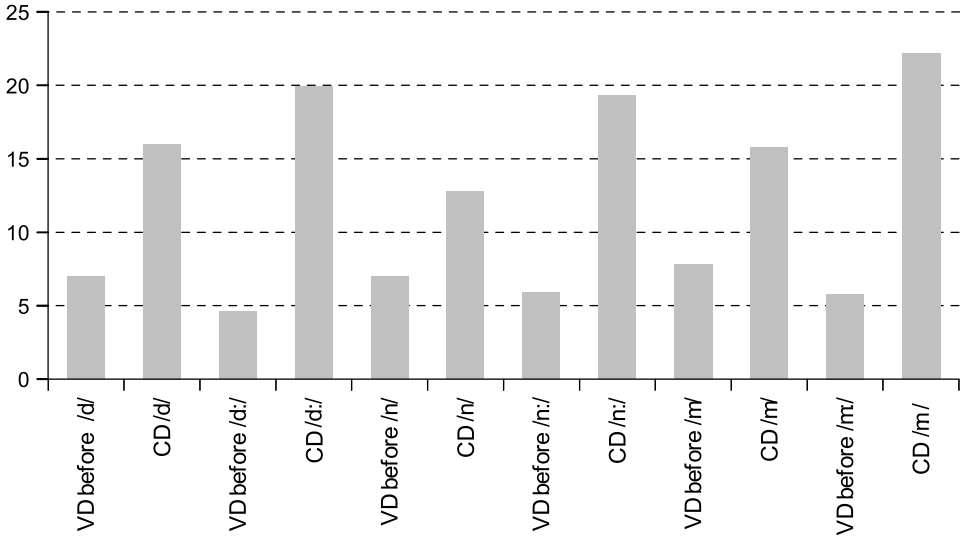


Figure 3. Means of vowel duration (VD), and singleton and geminate durations (CD) in word-final position.

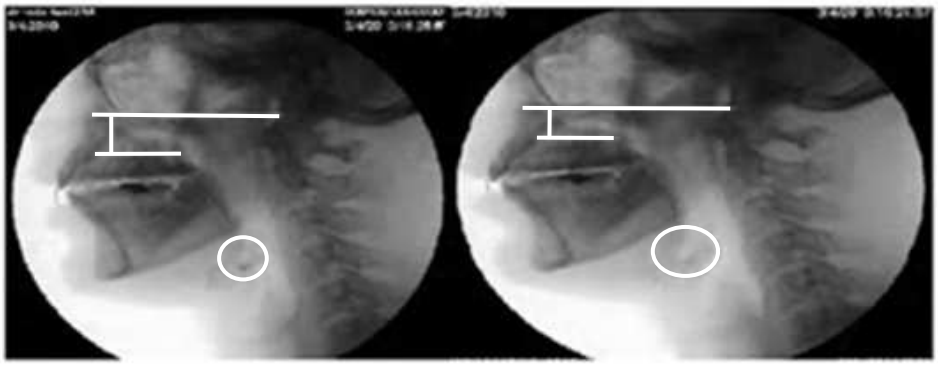


Figure 4. /sad/ and /sadː/.

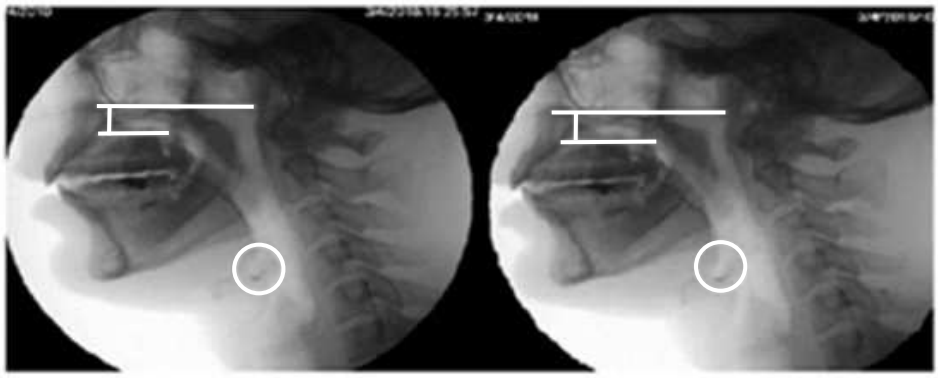


Figure 5. /man/ and /manː/.

the tongue body and the roof of the mouth, more raised soft palate, and tighter and larger contact extents in comparison to the singleton consonants.

6. Discussion

The main three questions of the current study attempt to understand the nature of gemination word finally in Jordanian Arabic. As for the first question, it is apparent that Jordanian Arabic gemination can occur word finally in pausal forms in the patterns -VCC or -VVCC. The debate that usually arises here is whether this gemination is contrastive or not. Most of the studies that comment on this point are impressionistic. Even Ghalib's (1984) experimental study of geminates in Iraqi Colloquial Arabic is restricted to gemination in word medial position because he believes that "geminate consonants

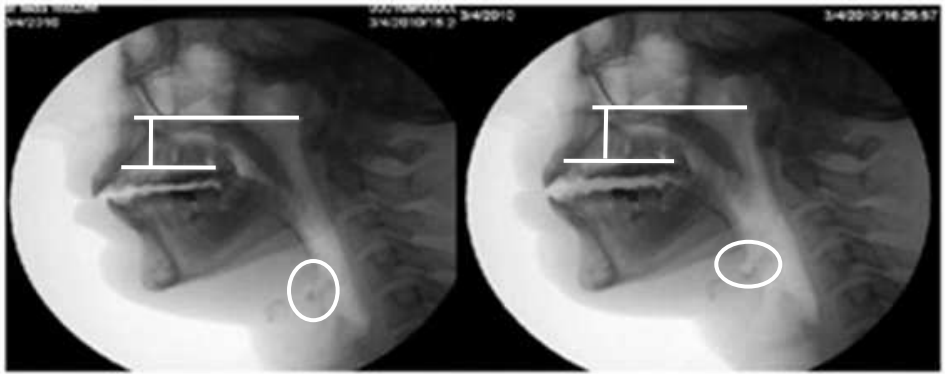


Figure 6. /lam/ and /lam:/.

occurring word-finally are non-distinctive in Arabic because contrasts between single and geminate consonants in this position are non-significant". He does not present experimental results to support his view.

In Modern Standard Arabic, final geminates are permissible, "though there occurs sometimes, under vernacular influence, a reduction of length in final position" (Mitchell 1990: 63). Mitchell's insistence on resisting shortening the final geminate and pronouncing it "at least twice as long as its single counterpart" for foreign learners of Arabic (Mitchell 1990: 63–64) does not denote the loss of difference in duration, especially when he notes that in spite of this shortening "the muscular tension [...] is always present in contrast with final non-geminates" (Mitchell 1990: 65). The ratio of difference found between word final singletons and geminates in the current study is almost similar to that found between consonants (m – m:, n – n:, l – l:/) occurring word medially (1:1.5) in Jordanian Arabic in a previous study by Al-Tamimi (2004). If the ratio of difference is still the same and it is possible for listeners to recognize word medial singletons/geminates, it would then be possible for these listeners to discriminate between singletons and geminates word finally. Though it is usually reported that peripheral geminates are avoided because they are perceptually less salient than the intervocalic ones, their production longer than the singletons emphasizes their distinctiveness.

This distinctiveness is associated with temporal compensation between the stressed vowels preceding the single and geminate consonants. Vowels preceding singletons are longer by almost two milliseconds than those preceding the geminates, on average. On the other hand, these geminates are longer by five milliseconds in comparison to the singletons, on average. This difference in duration is due to the muscular tension accompanying their production. Belasco's (1953: 1016) explanation for shortening the preceding vowel revolves around the fact that "more of the total energy needed to produce the syllable is concentrated in the consonant. The opposite is true of course when the consonant has a weak force of articulation". In our videofluoroscopic data this tension is manifested in the entire oro-pharyngeal musculature.

Mitchell clearly states that "all types of gemination reveal not only an increase of duration over non-gemination but also greater muscular tension and pulmonary pressure, a more extensive spread of tongue-palate contact" (Mitchell 1993: 92). This tension or strength is the main feature in the articulation of geminates. "The intensity of the pronunciation leads to a natural lengthening of the duration of the sound, and that is why strong [consonants] differ from weak ones by greater length. [However,] the adjoining of two single weak sounds does not produce a strong one […]. Thus, the gemination of a sound does not by itself create its tension" (Kodzasov 1977: 228; as translated by Ladefoged and Maddieson 1996: 97–98). In other words, it is tension that creates extensive articulatory configuration that results in geminated/long consonants and not vice versa.

Projecting these facts on our data, we find that there is a difference of widening in the laryngopharynx and oropharynx in favour of the geminates. Widening the laryngopharynx is caused by the elevation and anterior protrusion of the hyoid bone. The suprahyoid muscles elevate the hyoid bone upwardly and anteriorly causing the larynx to raise and the laryngopharynx to widen. The larynx for the singletons is opposite the lower edge of the 5th vertebra or between the 5th and 6th vertebrae. It rises to the middle of this cervical vertebra for geminate consonants. The widening of the oropharynx is an indication of the higher tongue protrusion into the oral cavity. The velum also rises dragging the uvula from the upper edge of the 2nd cervical vertebra in the singletons to the lower edge of the 1st cervical vertebra for the oral geminate /dː/ causing tight contact with the posterior wall of the nasopharynx. For nasal consonants (m – mː, n – nː), the soft palate is raised from the level opposite the middle surface of the 2nd vertebra for the singletons to the upper edge of the same vertebra for the geminates, leaving a wider isthmus faucium space. The higher protrusion of the tongue into the oral cavity causes extended contact and spread for the tongue in the zone of articulation of the sound. The tongue moves from the alveo-dental region for /n/ and /d/ to the postalveolar region for /nː/ and /dː/. As for the bilabial /mː/, the outer (exolabial) and inner (endolabial) parts of the lips make firm contact to distinguish it from /m/ which is produced endolabially only. These findings are not restricted to Jordanian Arabic. Bouarourou et. al. (2008) find that regardless of the position of the geminate stops within the word, geminates are systematically longer in constriction duration than the singletons. They also find in their X-ray data that geminates maintain contact-extents longer than the singletons. What is different in our findings from Bouarourou et. al. (2008) findings is that gemination affects the duration of the adjacent vowel, even word-finally. Other studies have also shown that duration is an important feature in discriminating geminates (Aoyama 2001; Mattei and di Benedetto 2000; Arvaniti and Tserdanelis 2000; etc.).

With this tense articulation and temporal compensation in the production of the geminate, the perceptibility saliency is enhanced. Investigators usually report the importance of consonant duration or vowel duration in the categorical perception of the geminates (O'Dell 1999; Kraehenmann 2001; Rochet and Rochet 1995; etc.). In a com-

prehensive study aiming at finding out the acoustic parameters playing important roles in enhancing perception of gemination, Esposito and di Benedetto (1999) emphasize the role of two acoustic parameters in discriminating between geminates and singletons perceptually. These are consonant closure length and preceding vowel length, with the first parameter playing the major role.

In our study, this difference in duration between singletons and geminates with the temporal compensation relationship they have with the preceding vowel and the tension in articulation seem to be enough acoustic cues for listeners to differentiate between them word finally. The judgment group listened to the participants productions yielded 100% agreement in phonemicity between minimal pairs ending with singletons and geminates. In the absence of previous experimental studies, as far as we know, that claim the opposite, Jordanian Arabic final gemination is contrastive.

7. Conclusion

The current study answers three main questions concerning the possibility of having contrastive singleton/gemination that exhibit temporal compensation with the preceding vowel word-finally in Jordanian Arabic. Findings prove that final geminates that are permissible in Standard Arabic word-finally are also permissible in Jordanian Arabic. The temporal compensation maintained with the preceding vowel and the tension in articulating the geminates enhance perceptuality boundaries and maintain phonemicity.

Future research should examine gemination across different Arab vernaculars based on free speech data.

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