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The acoustics of word-final fake gemination in Egyptian Arabic

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Abstract

Holes (2004) observes that neutralization of word-final geminates (long consonants) in some dialects of Arabic ([ˈsakat] "he was quiet" vs. [saˈkat-t] "I was/you (fem.) were quiet") may lead to phonemic stress if degemination occurs (e.g. [saˈkat]) (62). I explore this understudied issue as it concerns Egyptian Arabic; analysis of acoustic data demonstrates that degemination does not occur, speakers maintaining acoustic distinctions between word-final singletons and word-final fake geminates, which result from proximity of identical consonants. Three speakers participated in the present study, reading fifteen verbs in two different forms from a list. Two speakers from Alexandria read 3MSG imperfect and 2SG imperfect forms, and a third speaker from Qalubiya read the 3MSG imperfect and 2FSG imperfect for comparison between word-final and intervocalic geminates. The recordings were measured in the phonetics program Praat (Boermsa & Weenink 2015) for preceding vowel length, stop closure duration, and length of stop burst. Word-final fake geminates were found to be 1.3 times as long as singleton consonants, with no appreciable difference in vowel length preceding singletons and geminates. The intervocalic "geminates," however, were found to have a 1:1 ratio to their singleton counterparts. These findings are contrary to research on word-final true geminates in Urban Jordanian Arabic (Al-Tamimi, Abu-Abbas, & Tarawnah 2010), which found that word-final true geminates were 1.5 times longer than singleton consonants, with shorter preceding vowels. This may suggest that true and fake geminates in Arabic varieties are distinguished by their differing acoustics. I conclude with a typology of strategies that varieties of Arabic and other languages may use to preserve fake geminate contrasts.

Keywords: Acoustic phonetics; fake (concatenated) gemination; word-final consonants; Egyptian Arabic

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1 Introduction

[1] notes that, in some dialects of Arabic, the /-t/ prefix of the first person singular and second person singular perfect verbs may neutralize word-finally, leading to a situation where stress is no longer "automatic and nonphonemic" (62). Because the first person singular and second person singular perfect verbs end in heavy syllables before neutralization, stress shifts backward, leading to a contrast with the third person masculine singular perfect verb for those verbs which end with /t, d, tˤ, dˤ/: One finds, for example, (1) [ˈsakat] for the third person masculine singular, with penultimate stress, and (2) [saˈkatt], with ultimate stress, for the first and second persons [1] (62). With the neutralization of the final geminate in (2), which results from the proximity of the final stem consonant of the verb and the suffix /-t/, there is no longer any predictable stress. [1] notes that this phenomenon has not yet been investigated acoustically to determine whether neutralization has, in fact, occurred. This study is a partial answer to this gap in the literature on gemination.

I have chosen to focus my acoustic investigation on Egyptian Arabic, which is a colloquial variety of Arabic that does not epenthesize a vowel between the final stem consonant and the following suffix, as some other varieties of Arabic (such as Levantine Arabic) do. This ensures that any possible final geminates are fully expressed by speakers. My main research questions are the following: 1) Does phonemic stress exist in Egyptian Arabic because of degemination of word-final fake geminates? 2) If word-final fake gemination does occur, what are the acoustic correlates of this phenomenon?

2 Background

Gemination is defined as "a sequence of identical adjacent segments of a sound in a single morpheme, e.g. Italian *notte* /nɔtte/ ('night')," an important characteristic being their "'inseparability'" (i.e. their resistance to epenthesis), which distinguishes "'true'" geminates from "'apparent'" or "'fake'" geminates resulting from "morphological concatenation," although fake geminates also can result from assimilation and word boundaries [2]. The phenomenon is typologically rare, although it exists in a number of languages, including Italian, Japanese, Hungarian, Polish, Tashelhiyt Berber, Inuit, Ingrian, Central Numic, Mussau, Tigre, and Arabic (from a look at the available literature on gemination). [3] found a total of 73 languages across the world with word-medial singleton/geminate consonant contrasts; geminate consonant inventories included stops, fricatives, nasals, laterals, rhotics, and glides. Almost any class of consonants appears to geminate in one language or another.

Previous research on gemination has focused mainly on word-medial gemination, rather than word-initial and word-final gemination, simply because word-medial gemination is more common [3]. Geminates are usually found between two vowels, although some languages do allow word-

initial geminates, followed by a vowel, and word-final geminates, preceded by a vowel [4]. The rarest type of gemination occurs with geminates surrounded by consonants [4]. Phonological analysis has focused on how geminates are represented phonologically and how they can be distinguished from their singleton counterparts. This discussion has mainly revolved around autosegmental tiers and the linking of geminates to various representations in these tiers, which represent different kinds of syllable structure, i.e. whether geminates are represented by length or by weight [4]. While this discussion is interesting, the main focus of this paper is the acoustic characteristics of word-final fake gemination, not on true geminates. I will focus mainly on acoustic research pertaining to geminates and remain agnostic about the formal representation of geminates.

3 Previous work

Early literature on the acoustics of gemination includes [5], an investigation of word-medial and word-initial true gemination in two varieties of Arabic (both in production and perception), and [6], which investigated fake word-boundary geminates in English, French, German, and Spanish. Both concluded that stop closure duration was a robust cue for gemination. Additionally, [6] demonstrated that stop closure duration was longer for geminates than singletons and that preceding vowels were not appreciably different before singleton and geminate consonants. [7] provide additional evidence for the importance of stop closure duration in identifying geminate consonants, and, crucially, they demonstrate that there is no acoustic difference between geminates that occur tautomorphemically or by concatenation or total assimilation. So-called fake geminates, then, are acoustically identical to true geminates. [7] investigated acoustic differences between Turkish true geminate voiceless stops /t/ and /tt/ and /k/ and /kk/ in order to determine the acoustic correlates of gemination, measuring 1) the duration of the preceding vowel (which [8] claims may be shorter before geminates than before singleton consonants); 2) the stop closure duration; and 3) the voice onset time (VOT) from the consonant burst to the beginning of a following vowel. Results showed that vowel length was essentially identical before singleton and geminate consonants, but stop closure duration proved to be a readily identifiable cue for gemination: Geminate consonants were, on average, 2.9 times longer than singleton consonants [7]. These results were repeated with perception; [7] cross-spliced geminate stop closures onto singleton consonants, and Turkish listeners identified these 96% of the time as geminates (333). VOT was significant, overall, but cross-splicing stimuli with the opposite VOTs did not change identification of singletons versus geminate consonants. The average VOT difference was around 11 msec, so, while VOT did contribute to the identification of a stop as a singleton or geminate consonant, stop closure duration was the better acoustic cue [7] (331-333).

In order to investigate whether different acoustics were associated with geminates with different origins (whether they were tautomorphemic, heteromorphemic, or the result of assimilation), [7] recorded Bengali speakers pronouncing each of the three kinds of geminates, which exist plentifully in Bengali, and non-geminates. Like with the Turkish data, they found a significant difference between singleton /t, k/ and geminate /tt, kk/ stop closure durations, finding that Bengali geminates were roughly twice as long as singleton consonants [7]. Differences in

preceding vowel length were significant overall for singleton versus geminate consonants, but not for all speakers, as was the case with VOT in Turkish; VOT was not significant in Bengali [7]. Importantly, there were no acoustic differences between geminates of different types, demonstrating that, despite their phonological origins, different types of geminates are acoustically identical [7].

All of the previous studies have referred primarily to word-medial gemination, whether true gemination or fake gemination, with the exception of [5], who included the word-initial geminate /sˤsˤ/. The first experimental study investigating word-final gemination in Arabic is [9], which investigated word-final gemination in Urban Jordanian Arabic using spectrographic and videofluoroscopic evidence. They note that previous non-experimental research on word-final gemination in Arabic has been conflicting, with some linguists arguing for word-final distinctiveness arguing that gemination is non-distinctive word-finally [9].

[9] recorded eighteen Jordanian Arabic speakers from the city of Irbid saying the words /sad/ "water dam," /sadd/ "closed," /man/ "who," /mann/ "did someone a favor," /lam/ "never," and /lamm/ "collected" three times in a carrier sentence, /ɪħkɪ…ɪħkɪ/ "say…, say…" (115-116). Two separate judgement groups determined the familiarity of the words in the word list and the naturalness of the elicitations [9]. [9] measured preceding vowel duration and stop closure duration for the oral stops /d/ and /dd/ and preceding vowel duration and nasal murmur for the nasal stops /n/, /nn/, /m/, and /mm/. They found that vowels preceding singleton consonants were 1.4 times longer than vowels preceding geminates and that geminate consonants were 1.5 times longer than singleton consonants [9]. Videofluoroscopic evidence showed differences in muscular tension, with geminates being "produced with wider laryngo- and oropharynx, more elevated hyoid bone, narrower vertical distance between the uppermost point of tongue body and the roof of the mouth, more raised soft palate, and tighter and larger contact extents in comparison to the singleton consonants" [9] (118-120). [9] theorize that a "temporal compensation" relationship exists between the shortened preceding vowel and the following longer stop closure duration of geminate consonants (121). The greater cue to gemination is the longer stop closure duration, but the shorter preceding vowel also contributes to the perception of a geminate by emphasizing the greater length of the stop closure duration.

Finally, [10] investigated acoustic distinctions between true and fake geminates in English, noting that conflicting results have been found for fake geminates. They point out that [7] did not find preceding vowel length differences between true and fake geminate consonants or between different types of fake geminate consonants in Bengali, whereas [11] did find preceding vowel length distinctions between true and fake geminates in Tashelhiyt Berber, with shorter preceding vowels before true geminates [10]. An important difference between the two studies is that [7] investigated word-internal fake geminates caused by suffixation, while [11] investigated fake geminates formed from proximity across word boundaries (the same kind of gemination that [6] investigated for English, German, Spanish, and French) [10]. [10] theorize that the consonant to preceding vowel (C:V1) ratio would distinguish between true and fake geminates in [11]'s findings. They also argue that word-boundary strengthening effects could cause a difference in the C:V1 ratio between fake geminates occurring across word boundaries, where "boundary-adjacent syllable lengthening" would occur, and word-internal fake geminates [10] (83).

In their experiment, [10] recorded eight participants saying 24 English words in the carrier phrase "I said _____ again"; words were divided into word-internal singletons ("ammonia," "annex"); word-internal fake geminates (words beginning with "im-," a less decomposable Latinate affix, and words beginning with "un-," a more decomposable Germanic affix); and word-boundary fake geminates ("dim morning," "one nail"). Recordings were elicited in a normal speaking style and a more careful speaking style [10]. Prior to performing the experiment, 10 Korean listeners, who natively have a nasal length distinction, determined the length of the nasals in each category; they found that singleton consonants were shorter than word-internal fake geminates, which were, in turn, shorter than word-boundary fake geminates [10]. They measured preceding vowel duration and nasal consonant duration (both relative and absolute) along with "non-durational boundary cues," including the change in F0 across the the VC(C)V sequence and "the presence or absence of pauses" [10] (85). Results supported their hypothesis that word-internal fake geminates would show differences from word-boundary fake geminates. Word-internal fake geminates beginning with "in-" were as long as true geminates both relatively and absolutely, while word-boundary fake geminates were only longer than singleton consonants absolutely, bolstering the idea that lengthening of the preceding vowel occurs because of the word boundary [10]. "Un-" word-internal fake geminates patterned with "in-" word-internal fake geminates in normal speech, as they were both relatively and absolutely longer than singleton consonants, but occasionally patterned with word-boundary fake geminates in careful speech [10]. For [10], this suggested that concatenated fake geminates (with "un-") are represented in two possible ways, with or without intervening morpheme boundaries.

As the previous review of the acoustics literature on geminates suggests, both the type of gemination and the place of a geminate within the word may have different acoustic effects. Egyptian Arabic fake geminates with /-t/ are word-internal and concatenated, so they may pattern either with other word-internal fake geminates (such as assimilated geminates, like /ʔaʃʃams/ "the sun") and true geminates or with word-boundary geminates. There may or may not be vowel length distinctions before word-internal fake geminates, although the literature generally suggests that there will not be.

4 Methods

I recorded three speakers of Egyptian Arabic directly into the Praat [12] phonetics program using a Logitech USB headset noise-cancelling microphone. Each was recorded in quiet rooms in the School of Middle Eastern and North African Studies at the University of Arizona. All speakers were consented using the standard consent form from the Douglass Phonetics Laboratory at the University of Arizona and received candy bars as compensation for their participation. Two speakers were male (aged 28 and 43) and one speaker (aged 23) was a female. The twenty-eight-year-old male speaker was from Qalubiya, in the Cairo área, and the forty-three-year-old male and the female were both from Alexandria.

Participants were recorded saying fifteen Arabic verbs in two different forms. Participants read from a sheet of paper with the verbs written in Arabic (by a high functioning second language speaker of Egyptian Arabic) in each of the two forms, reading the third person masculine

singular perfect form first, followed by either the first person singular perfect or second person feminine singular perfect. Two speakers (M 43 and F 23) produced the first person singular and third person masculine singular perfect forms, while a third speaker (M 28) produced the first person singular and second person feminine singular perfect. This latter elicitation provides interesting evidence to contrast with the other elicitations, particularly because the second person feminine singular perfect prefix /-ti/ ends in a vowel.

I chose each of the fifteen verbs because they ended in a coronal consonant, either /t/, /d/, /tˤ/, or /dˤ/, which can form a geminate with the /-t/ suffix of the first person singular perfect form. The consonants /d/ and /dˤ/ devoice next to the /-t/ suffix, while /tˤ/ and /dˤ/, both "emphatic" consonants, pass on their "emphasis." The resulting word-final geminates created are /-tt/ and /-tˤtˤ/, respectively. Because I initially intended to work with Levantine Arabic speakers, instead of Egyptian Arabic speakers, I collected the verbs from the glossaries of [13] and [14]. I checked these with my Egyptian participants, rejecting a sixteenth verb I had that does not exist in Egyptian Arabic and changing the final verb /itwalad/ from /inwalad/ (which also exists in Egyptian Arabic, but is less common, as it has a slightly different meaning).

After recording all my participants, I analyzed each of the recordings in Praat. After opening each recording in Praat and generating a narrowband spectrogram, I made a series of measurements from the spectrogram of the recording and its spectrum. I measured 1) the duration of the vowel preceding the final consonant; 2) the duration of the stop closure of the final consonant; and 3) the duration of the stop burst of the final consonant. The duration of the preceding vowel was measured from the onset of clear vowel formants to the offset of vowel formants, and the stop closure duration was measured from the offset of vowel formants to the start of the stop burst of the final consonant. The final stop burst was measured from the onset of burst noise to the first obvious trail off of burst noise.

5 Results

Of the three acoustic measurements I made, only stop closure duration was important in distinguishing fake geminates from singleton consonants. Preceding vowel length did not appear to play a role in the Egyptian Arabic fake geminates. Vowels were, on the whole, equal in length or just slightly longer (less than 20 msec), than vowels preceding singleton consonants. This correlates with [7]'s data on Bengali, which found no differences in vowel length before geminate consonants when compared to their singleton counterparts. The length of the actual burst was not important, except for a few marginal cases where the length of the stop closure duration was not as long as for geminates as it was for singletons.

When averaged, by dividing the length of the geminate stop closure duration by that of the singleton, the stop closure durations of geminate consonants were 1.3 times longer than singleton counterparts. This acoustic characteristic was the major acoustic identifier of geminate versus singleton consonants, but only of the geminates in the first person singular perfect form of the verb. The second person feminine singular perfect verbs, which the M 28 participant believed contained geminates, and which are written that way as well (/radatti/), had a 1:1 correspondence between singleton and supposedly geminated consonants. Two tokens had

individual ratios of 1:1.2 and 1:1.3, but the overall ratio remained 1:1. This ratio demonstrates that the second person feminine singular perfect form of the Egyptian Arabic verb does not contain any fake geminates; it contains singleton consonants like the third person masculine singular perfect. It is possible that the following vowel neutralizes the fake geminate contrast; it is also important to note that the second person feminine singular perfect form of the verb is unique and is not similar to any other conjugation (unlike the first person singular and third person masculine singular perfect forms, which differ only in stress).

Verb	Speaker F 23	Speaker M 43	Speaker M 28
raditt/radad	1.2	1.4	1.0
mutt/maːt	1.7	1.3	1.2
inˤbˤasˤatˤtˤ/inˤbˤasˤatˤ	1.2	1.5	1.1
sikitt/sikit	1.5	1.4	1.3
fadˤfitˤtˤ/fadˤfadˤ	1.3	1.3	1.1
falatt/falat	1.8	1.2	1.0
ʕajjitt/ʕajjid	1.2	1.4	0.9
saːʕitt/saːʕid	1.2	1.4	1.0
ʕaratˤtˤ/ʕaradˤ	1.0*	1.6	1.0
ʕaːritˤtˤ/ʕaːridˤ	0.9*	1.3	1.0
gaditt/gaddid	1.1	1.5	0.9
ittaħatt/ittaħad	1.0*	1.3	0.9
ʔaxatt/ʔaxad	1.2	1.3	1.1
ħamatt/ħamad	1.2	1.1	0.9
itwalatt/itwalad	1.2	1.3	0.8
Overall Ratio:	**1:1.2**	**1:1.4**	**1:1**

Table 1: Singleton to Geminate Stop Closure Duration Ratios

Interestingly, the M 43 and F 23 speakers from Alexandria, who did have geminate consonants in their speech, differed in the overall length of the stop closure duration. The male speaker had an overall singleton to geminate length ratio of 1:1.4, which is very close to results on geminates that have been previously reported. The female speaker, though she had longer geminate consonants overall, also had longer singleton consonants, and only had a ratio of singleton to geminate consonant length of 1:1.2. This may be a gender difference, but there is too little data to tell conclusively.

It was also interesting to note that the voiced stops ending some of the verbs were not truly voiced. There was obvious pre-voicing, but the voicing bar trailed off before the burst, so that the resulting consonant sounded more like a voiceless stop.

6 Conclusions

While the fake geminates measured in this paper were slightly shorter than the true geminates that [9] investigated, and there was no shortening of the preceding vowel as they found, the fake geminates were significantly longer than their singleton counterparts and were comparable

to true geminates in other varieties of Arabic. This confirms [7]'s data and agrees with [10]'s conclusions as well. The fact that the fake geminates were 1.3 times longer than their singleton counterparts and not quite as long as the 1:1.5 ratio that [9] found likely has more to do with the idiosyncrasies of these two speakers than it does with any principled distinction. The speaker M 43 came very close to the ratio that [9] found for Urban Jordanian Arabic, while F 23 simply had a smaller length ratio between her singleton and geminate consonants, although, in absolute terms, her geminates were much longer than M 43's (sometimes being 4 sec in length). It may also be that Egyptian Arabic simply has shorter geminates than Urban Jordanian Arabic, but that would be a topic for a new study.

What this data suggests to me is that there are three distinct possibilities in how word-final gemination can be treated in the grammars of different varieties of Arabic: 1) Preservation of contrast by accentuation of acoustic characteristics of geminates; 2) Loss of contrast by degemination; and 3) Preservation of contrast by epenthesis. Both Egyptian Arabic and Urban Jordanian Arabic have been shown to employ the first strategy, accentuating relevant acoustic characteristics of geminates to preserve a contrast word-finally between geminate and singleton consonants. For true geminates, there is a specific temporal compensation relationship (as [9] refer to it): Preceding vowels are shortened and stop closure duration is lengthened compared to singleton consonants. This directly confirms aspects of [15]'s auditory enhancement hypothesis, which asserts that speakers "exert independent control over most of the component structures involved in speech production" (123). Speech communities are able "to select components which mutually enhancing auditory effects," ensuring that important auditory contrasts are perceived correctly [15] (123).

While I do not believe that speakers exert conscious control over their speech, it cannot be a coincidence that so many aspects of speech mutually enhance each other's perception; if we view the totality of a language as a kind of evolutionary system, it makes sense that the contrasts preserved should be mutually enhancing, and that those contrasts which cannot be enhanced (and, thus, are not well-perceived) simply disappear from the language, through historical evolution. For true geminates, the shortening of the preceding vowel enhances the longer stop closure duration associated with geminates. It makes the closure seem even longer, just as the longer vowel before voiced stops in English enhances the perception of a final stop as voiced (as in /bɪt/ versus /bɪːd/). Importantly, the shorter vowel preceding true geminates also distinguishes true geminates from word-internal fake geminates, as [10] point out. Final word-internal fake geminates in Egyptian Arabic likely do not have shorter preceding vowels owing to the fact that they are always stressed. Word-boundary fake geminates are theorized by [10] to have even longer preceding vowels (although [6]) did not find longer preceding vowels) than even word-internal fake geminates, so this may provide an additional acoustic means of differentiation between geminates themselves.

A second possibility also exists for final degemination, the possible loss of contrast between word-final singleton and geminate consonants. [16] notes that many studies treat final degemination as a given (echoing the debate about final geminates that [9] refer to). It is assumed in both Gulf Arabic and in Levantine Arabic. The acoustic data suggests that a distinction between singleton and final geminate consonants can be perceived and remains, but it is also possible that degemination may sometimes occur even in those varieties that preserve

this distinction. There may also be varieties of Arabic that always degeminate and do not preserve the geminate contrast word-finally. In the case of word-final fake geminates, there is no real reason why speakers could not degeminate, because the stress shift would still be preserved. In fact, [17] reports that Chadian Arabic has lost the /-t/ prefix of the first person singular perfect form of the verb, with the first person singular perfect and third person singular perfect being distinguished only on the basis of (phonemic) stress: 3msg /ˈkatab/ versus 1csg /kaˈtab/.

A third possibility exists with epenthesis, which preserves the consonantal components of the geminate without having a surface geminate. This is the strategy with word-final fake geminates in Palestinian Arabic and Iraqi Arabic, which splits up the geminate with the epenthetic vowel /i/ [18], [19]. The epenthetic vowel in word-final fake geminates in Iraqi Arabic actually leads to "non-automatic stress" patterns, with stress assignment ignoring the epenthetic vowel and assigning stress on what would have been the heavy syllable [19] (42). This strategy preserves the prefix /-t/ largely as a means to avoid word-final consonant clusters, but it crucially preserves information, rather than allowing information loss (as in degemination).

Much research still remains to be done, however. Does final degemination occur in those varieties of Arabic in which it has been posited? Are there differences between true and fake geminates in Egyptian Arabic and other varieties of Arabic? Are there differences between types of fake geminates in Egyptian Arabic and other varieties of Arabic? Does speech style affect gemination in Egyptian Arabic and other varieties of Arabic? (In other words, do singleton/geminate distinctions exist in casual, connected speech, as opposed to reading styles?) Why do the Egyptian Arabic fake geminates investigated here pattern with less decomposable concatenated "fake" geminates in other languages? Each of these questions begs for another acoustic study. [18]'s assertion that a distinction exists between words like /ˈʕarab-na/ "our Arabs" and /ʕaˈrabb-na/ "on our God" demand further inquiry, because acoustic data is lacking and linguists' and speakers' perceptions differ. A study on the scale of [10], looking at the same distinctions in a language like Arabic, which has phonemic length distinctions, is critical for fully understanding the complex phenomenon of gemination. It is also important that these studies be conducted in as many different varieties of Arabic as possible, because it is very possible that different varieties will do different things. The question of gemination in different speech styles is also relevant, because there do appear to be differences based on the type of style being used, which [10] demonstrated. Further questions also exist in whether listeners perceive differences between different types of fake gemination, whether the posited characteristics about them are actually attended to by listeners and help in their accurate perception.

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