Spectral properties of vowels surrounding singleton and geminate sonorants in Lebanese Arabic

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Introduction

Existing studies on gemination in Arabic show that durational cues play a major role in the contrast, with little or no overlap in the duration ranges for singleton and geminate consonants (e.g. Ghalib 1984; Ham 2001; Hassan 2003; Khattab, 2007; Khattab and Al-Tamimi, 2008; 2014).

There have been hardly any investigations of non-durational cues in the implementation of the singleton-geminate contrast in Arabic. Yet the Arabic word for gemination is /taʃdiid/, which means *strengthening* or *intensification*.

Our recent work on fricatives in Lebanese Arabic (Al-Tamimi and Khattab, 2015) showed systematic non-durational manifestations in the realisation of geminate fricatives and their surrounding vowels. These included intensity, *f*0, spectral peak and shape, dynamic amplitude and voicing patterns of medial fricative; vowel quality and voice quality correlates of surrounding vowels. Their collective patterns suggested tenseness as a secondary feature.

Singleton fricatives are generally long, leading to small g-s ratios (1:1.85).

Hypothesis: non-temporal cues in fricatives support a durational contrast that is less salient/perceptible than for other manners.

CC to C duration ratios vary widely according to manner → is there a trade-off between quality and duration in the realisation of Arabic geminates?

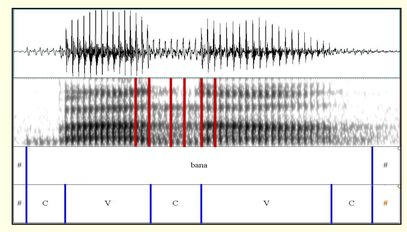
To test this hypothesis, we looked at sonorants (laterals and nasals) which have much higher g-s ratios (1 : 2.64 and 1: 2.60 respectively).

Methods

- 20 Lebanese adults from Beirut (10 males, 10 females).
- Read randomised word lists with the following structures:

ˈCV1CV2	ˈCVV1CV	ˈCV1CCV2	ˈCVV1CCV2
ˈmalak	ˈmaalak	ˈmallak	ˈmaalla
(he) owned	*your money*	*(he) made someone own*	*(she) is bored*

- Medial C: /m/, /n/ and /l/ (~ 480 tokens)
- Measurements:
  - Duration of V(V)1, C(C), V2
  - F1-*f*0; F2-F1; F3-F2 at V(V)1 offset and V2 onset
  - *f*0 + intensity of V(V)1 offset, C(C) midpoint, V2 onset

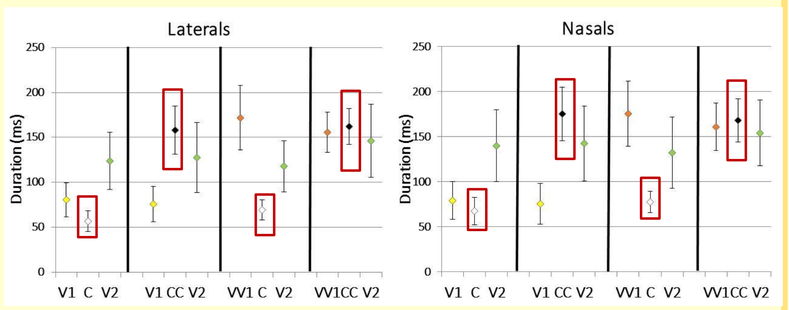


- Statistical design:
  - Three-way Linear Mixed effect Models (LMM) for laterals (Consonant Length*Vowel length*Sex) and four-way for nasals (Consonant Length*Vowel length*Sex*Place of Articulation)
  - Dependent variables: acoustic measures
  - Random slopes: Consonant Length*Vowel Length
  - Crossed random intercepts: speaker and item

Results

High level interactions for sex, place and manner of articulation were not significant, so the remaining comparisons explore consonant and vowel length. While durational differences between singleton and geminate consonants are stark and non-overlapping, **the non-temporal manifestations in the consonants and surrounding vowels are largely insignificant**, showing that the contrast for s-g sonorants is firmly rooted in durational differences in the consonant.

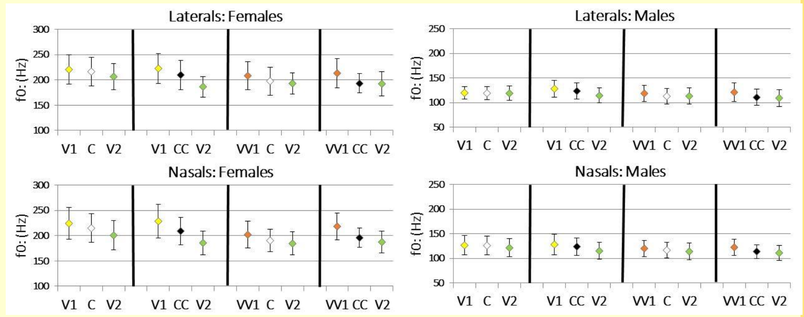
Duration



C duration	V1CCV2	VV1CV2	VV1CCV2
V1CV2	***	***	***
V1CCV2		***	***
VV1CV2			***

V1 duration	V1CCV2	VV1CV2	VV1CCV2
V1CV2	ns	***	***
V1CCV2		***	***
VV1CV2			ns

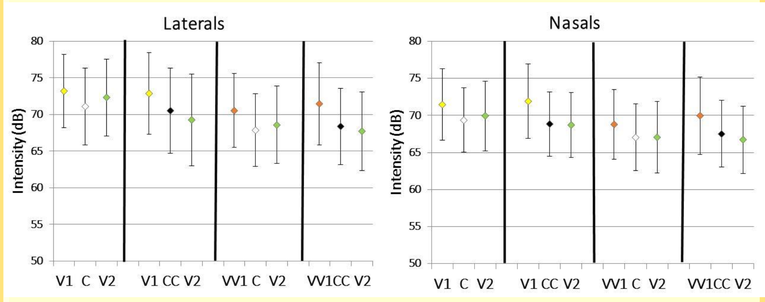
*f*0



Laterals:
- Lower *f*0 in in long VV1 context for fem. (p<0.05)
- Lower *f*0 for C(C) in long VV1 context (p<0.005)
- Lower *f*0 in V2 in geminate context (p<0.01)

Nasals:
- Lower *f*0 in in long VV1 context (p<0.005)
- Lower *f*0 for C(C) in long VV1 context (p<0.0001)
- Lower *f*0 in V2 in geminate context (p<0.01)

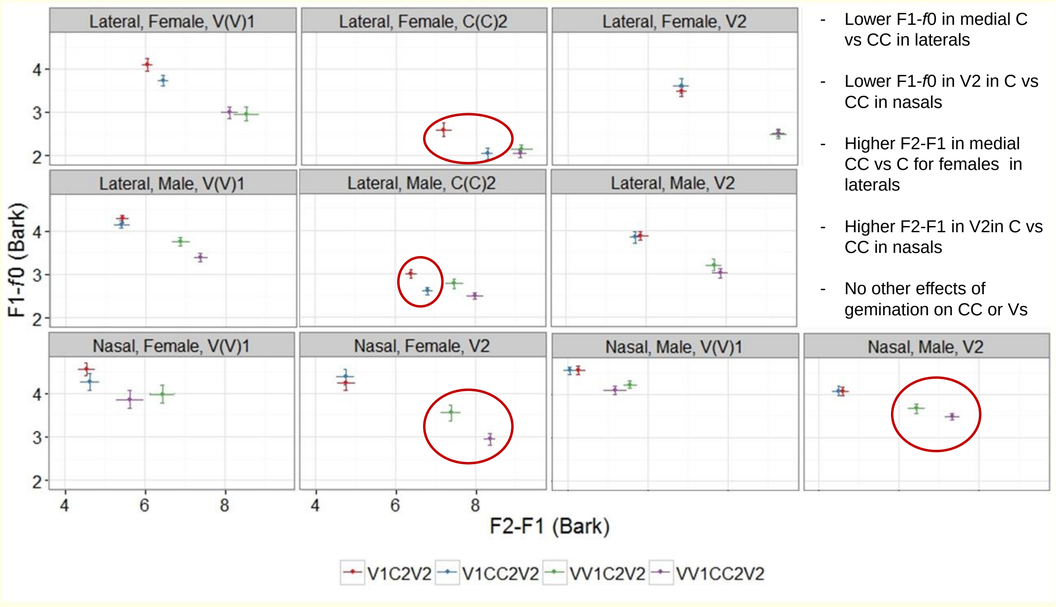
Intensity



Laterals:
- Lower dB in in long VV1 context for fem. (p<0.05)
- Lower dB for C(C) in long VV1 context (p<0.001)
- Lower dB in V2 in geminate context (p<0.01) and long VV1 (p < 0.001)

Nasals:
- Lower dB in in long VV1 context (p<0.0001)
- Lower dB for C(C) in long VV1 context (p<0.0001)
- Lower dB in V2 in geminate context (p<0.01) and long VV1 (p < 0.001)

Results (cont.)



- Lower F1-*f*0 in medial C vs CC in laterals
- Lower F1-*f*0 in V2 in C vs CC in nasals
- Higher F2-F1 in medial CC vs C for females in laterals
- Higher F2-F1 in V2in C vs CC in nasals
- No other effects of gemination on CC or Vs

Discussion

- Duration was a robust cue for the singleton-geminate contrast in sonorants in Lebanese Arabic.
- *** No V(V)1 shortening was found in CC contexts → similar results to Engstrand and Krull, 1994 for Estonian.
- Non-temporal cues appear to be minimal in the realisation of sonorant geminates and their surrounding vowels in Lebanese Arabic.
- Very little evidence of strengthening or fortition in nasal and lateral geminates, and the implementation of gemination is very local rather than long domain (cf. Arvaniti and Tserdanelis, 2000; Local and Simpson, 1999; Payne 2006) → fortition is not an automatic consequence of duration in LA
- Spectral effects are noted in the consonant, mainly showing lower F1 and higher F2, suggesting closing and fronting effects of gemination.
- Hypothesis confirmed: despite geminate sonorants being dispreferred due to their vowel-like patterns which blur their boundaries with those of surrounding vowels, their high g-s ratio plays a role in their salience and robustness of the contrast without recourse to secondary cues.

References

1. Al-Tamimi, J. & Khattab, G. 2015. Acoustic cue weighting in the singleton vs geminate contrast in Lebanese Arabic: The case of fricative consonants. *The Journal of the Acoustical Society of America*, *138*(1), 344-360.

2 Arvaniti, A. & Tserdanelis, G. 2000. On the phonetics of geminates: evidence of Cypriot Greek. *Proceedings of 6th International Conference on Spoken Language Processing* 2. 559-562 **3.Ghalib, G.B. M. 1984.** *An Experimental Study of Consonant Gemination in Iraqi Colloquial Arabic*. Unpublished Ph.D. Thesis, University of Leeds. **4. Engstrand, O. & Krull, D. 1994.** Durational correlates of quantity in Swedish, Finnish and Estonian: Cross-language evidence for a theory of adaptive dispersion. *Phonetica*, *51*(1-3), 80-91. **5. Ham, William. 2001.** *Phonetic and phonological aspects of geminate timing*. New York: Routledge. **6. Hassan, Z. M. 2003.** Temporal compensation between vowel and consonant in Swedish and Arabic in sequences of CV:C and CVC: and the word overall duration. *PHONUM*, 9: 45-48. **7. Khattab, G. & Al-Tamimi, J. 2008.** Durational Cues for Gemination in Lebanese Arabic. *Language and Linguistics* 22. 39-55. **8. Khattab, G. & Al-Tamimi, J. 2014** Geminate timing in Geminate timing in Lebanese Arabic: the relationship between phonetic timing and phonological structure. *Laboratory Phonology*, *5*(2), 231-269. **9. Local, J. and Simpson, A.. 1999**. Phonetic implementation of geminates in Malayalam nouns. In J. J. Ohala, Y. Hasegawa, M. Ohala, D. Granville & A.C. Bailey *Proceedings of the 14th International Congress of Phonetic Sciences, v.1*, 595-598. San Francisco, CA **10. Payne E. 2006.** Non-durational indices of gemination in Italian. *Journal of the International Phonetic Association* 36(1). 83-95

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