Final laryngeal neutralization in Najdi Arabic

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The present study investigates the acoustic characteristics of the laryngeal neutralization process in Najdi Arabic stops in utterance-final position. The study is couched within the tenets of laryngeal realism and aims to unravel language-specific differences in final laryngeal neutralization that are due to the phonological representation of the voicing contrast. Previous work has shown differences in the laryngeal behaviour of stops in final position depending on whether the voicing contrast in the language in question is best represented by [spread glottis] or [voice] [1, 2, 3]. In languages with a [spread glottis], the contrast tends to be manifested in the preceding vowel and release, while in languages with a [voice] it tends to be manifested in the closure and the burst. Previous work on Najdi Arabic (NA) stops revealed an unusual voicing manifestation, with both [spread glottis] and [voice] as active features in the voicing contrast. Specifically, NA contrasts prevoiced and aspirated stops in initial position [4, 5, 6] and contrasts fully voiced (phonologically Voiced) and fully devoiced stops (phonologically Voiceless) in word-medial intervocalic position.

A host of durational and spectral acoustic correlates were measured in final stops in C**V:C** words and their preceding vowel. This included preceding vowel duration, F0 offset, F1 offset, and *H*1*-*H*2* offset in the preceding vowel, and closure duration, %voicing in the closure, burst duration, and burst intensity in the stop. The target words were embedded in sentences and were produced by the 32 native Najdi speakers (15 males, 17 females) at two rates (normal and fast). A set of Linear mixed effects models were built to test each of the acoustic correlates as a function of voicing (voiced, voiceless), rate (normal, fast), gender (male, female), place of articulation (bilabial, alveolar, velar), and vowel type (a, i, u).

The results revealed systematic variation in the implementation of voicing in final Voiced and Voiceless stops in NA. The first striking result was the complete lack of distinction in vowel duration preceding Voiced and Voiceless stops (Table 1). Durational correlates in the stop itself did, however, show major difference as a function of voicing. One surprising finding was the longer closure for Voiced rather than Voiceless stops in both normal and fast speech rates. Voiced stops exhibited significantly less devoicing in their closure than Voiceless stops, while only Voiceless stops exhibited aspiration (Table 2). Other acoustic correlates that showed significant differences between Voiced and Voiceless stops were burst duration, burst intensity, and *H*1*-*H*2* offset, once again demonstrating robust differences in the implementation of voicing in the stop itself rather than the preceding vowel.

These results show that NA occupies an intermediate position between Voicing and Aspirating languages in terms of its voicing manifestations in final position. On the one hand, it behaves like Voicing languages (e.g. French) in terms of employing release burst properties for voicing distinction rather than preceding vowel duration [7]. On the other hand, it behaves like Aspirating languages in the way Voiceless stops showed heavy aspiration and an increase in *H*1*-*H*2* offset which is associated with glottal opening, indicating breathiness. Additionally, the results for closure duration were similar to those found in German [8] in that Voiced stop showed longer closure utterance-finally. These findings complement earlier results for word-initial and word-medial position in NA and suggest that utterance-final stops in NA are specified with both [spread glottis] and [voice]. Voiced stops in utterance-final position are phonologically specified but passively devoiced due to aerodynamic reasons. Following on from Jessen's (2001) work [9], we postulate associations between the acoustic correlates for voicing and the distinctive features that represent these correlates. That is, the high value of *H*1*-*H*2* offset is associated with [spread glottis] while the low value of it is associated with [voice].

Table 1. Duration measures (in ms) for preceding vowel (PVD), stop closure, burst and aspiration, along with % voicing in the closure

	Voiceless normal		**Voiced normal**			**Voiceless fast**		**Voiced fast**		
	Mean	SD	Mean	SD	D	Mean	SD	Mean	SD	D
PVD	152	36.4	152	37.3	0	126	25.9	125	26.5	1
Closure duration	86.8	13.1	96.1	13.2	9.3	61.8	11.8	70.9	11.2	9.1
% Voicing	0.95	2.94	16.5	15.9	15	2.18	3.63	19	17.4	16.8
Burst duration	4.73	1.09	3.43	0.91	1.3	4.37	1.48	3	1.37	1.37
Aspiration	80.7	17.6	25.8	7.12	54	56.3	14.2	2.9	5.37	53.4

Table 2. The acoustic results for the spectral correlates.

	Voiceless normal		**Voiced normal**			**Voiceless fast**		**Voiced fast**		
	Mean	SD	Mean	SD	D	Mean	SD	Mean	SD	D
F0 offset	187	60.3	186	55.3	1	181	53.5	178	50.2	3
F1 offset	414	77.5	420	82.1	6	415	75	424	81.1	9
*H*1*-*H*2* **offset**	6.42	2.89	3.55	3	2.8	5.85	3.04	2.86	3.56	2.29
Burst Intensity	42.8	4.13	44.1	4.78	1.3	44.1	3.69	45.5	4.56	1.4

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