Acoustic Evidence for Gestural Alignment: Vowel Devoicing in Malagasy

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Introduction: Vowel devoicing has been variably described as a phonological process (e.g., [1]) or as a phonetic consequence of overlapping gestures (e.g., [2] for Korean; [3] for Turkish). Research on devoicing puts itself at the center of a debate on the nature of such sound processes, as each of these accounts makes a different assumption about the role of phonetics and phonology in the grammar. In this paper, I will show acoustic data (Center of Gravity) from Merina Malagasy (Austronesian, Madagascar) that serves as evidence for the gestural account. These data are then modelled in a variant of Articulatory Phonology [4,5] that uses Alignment constraints to regulate the relative timing of gestures. This result shows that an account of vowel devoicing in Malagasy must make reference to both the articulators involved and the phonological constraints that modulate them, indicating that the phonology must have access to phonetic information.

Data: High vowels are frequently devoiced in unstressed utterance-medial syllables in the Merina dialect of Malagasy, but the precise realization and distribution of these vowels has not been investigated. Here, I present data collected from two speakers of Merina who produced a total of 319 tokens targeting unstressed /a/, /i/, and /u/ in various segmental environments. The acoustic analysis reveals that vowels in the devoicing environment may be realized as co-articulated or deleted.

Of interest to us are co-articulated vowels: these vowels are realized concurrently with the preceding consonant, typically a fricative. Acoustically, the result is extended high energy frication whose Center of Gravity reflects the underlying vowel. Compare Figure 1, which shows the spectrogram for /si/, with Figure 2, /su/: for /su/, CoG lowers, indicative of a rounding gesture associated with /u/; this is not present for /si/. In both cases, no voiced vowel is realized.
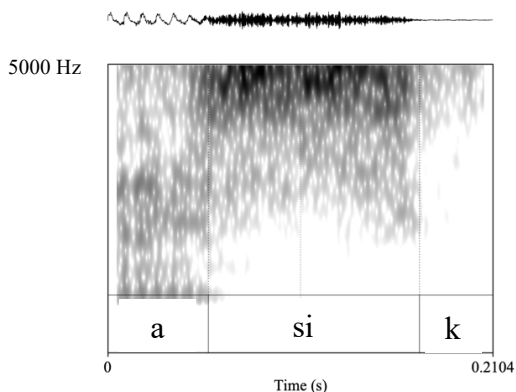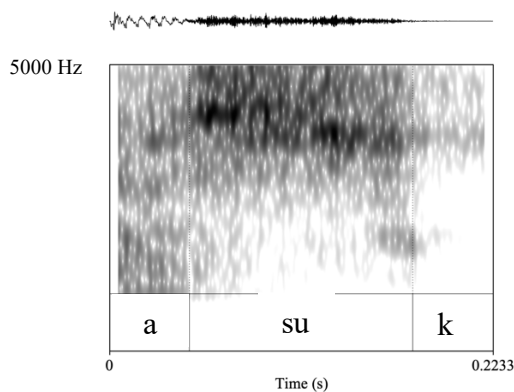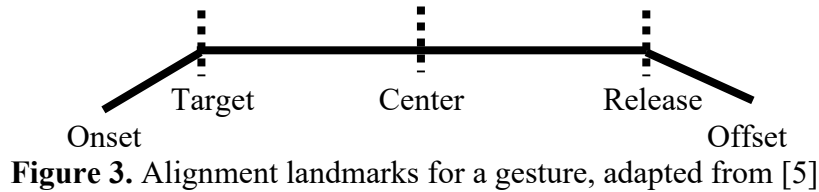

Fig.1 Co-articulated /si/

Fig.2 Co-articulated /su/

Analysis: These acoustic data can be explained by a theory of gestural overlap: in sum, before a consonant gesture ends, the vowel gesture begins, causing the observed effects on CoG of the consonant. In these cases, the vowel's glottal gesture is completely overlapped by the preceding voiceless consonant's, and thus no audible voiced vowel is observed.

I analyse the Malagasy data using Gafos's [5] variant of Articulatory Phonology [4] in which gestural overlap is regulated by language-specific constraints on the alignment of these gestures. Each gesture associated with a sound consists of five landmarks to which another sound's gestures can align, shown in Figure 3. Following Delforge's [6] work on devoicing in Andean Spanish, I use such alignment constraints to account for the Malagasy data.

Figure 3. Alignment landmarks for a gesture, adapted from [5]

For Malagasy, the co-articulated devoiced data can be described using two constraints: The first, ALIGN (C_1, CENTER, V, ONSET) assigns a violation to any CV sequence where the onset of the vowel gesture does not coincide with the center of the consonant. In the grammar, this constraint, which favours ease of articulation, competes with a constraint ALIGN (C_1, RELEASE, V, ONSET), which favours perceptibility by aligning the vowel so that it overlaps less with the consonant. In Malagasy, a high ranking for ALIGN (C_1, CENTER, V, ONSET) would result in gestural overlap of CV sequences, including the glottal gesture, which would produce the sort of co-articulation shown in Figures 1 and 2. This is shown in Tableau 1, where underlying /sin/ results in devoicing of /i/, phonetically realised as palatalization of /s/.

/sin/	Align (C_1, CENTER, V, ONSET)	Align (C_1, RELEASE, V, ONSET)
a. ☞ [sʲn] glottal oral		*
b. [sin] glottal oral	*!	

Tableau 1. Underlying /sin/ results in devoicing of /i/. In this tableau, candidates consist of two gestural levels for expository purposes, glottal and oral, as well as the corresponding pronunciation in IPA. On each level, consonant gestures are represented with the black angled lines, while the vowel is represented with the red curved line.

The low vowel /a/ as well as stressed vowels do not undergo devoicing. This can be explained by duration: low vowels are inherently longer than high vowels [7], and in Malagasy stressed vowels are longer than unstressed [8]. Even if the onset of the vowel occurs at the center of the preceding consonant, the vowel gesture is long enough that the overlap by the consonant is not complete, leaving a voiced portion of the vowel. In the remainder of the analysis, these Alignment constraints are used similarly to account for vowel deletion that occurs after some sonorants, showing that vowel devoicing and deletion can be uniformly described as one articulatory outcome (overlap), but acoustically, this is realized differently in different segmental environments.

Discussion: Here, I've demonstrated that many so-called devoiced vowels in Malagasy are realized as co-articulated with the preceding consonant; this realization lends support to an account of gestural overlap as an explanation for devoicing, and I show that specific Alignment constraints in an Articulatory Phonology framework neatly account for the acoustic data. This result is theoretically consequential as it indicates that the phonological grammar has access to information about the articulators. In sum, processes like devoicing in Malagasy cannot be described as purely phonetic or phonological, but must take into account both.

References:
[1] Vogel, R. (2022). *Phonology of vowel devoicing: A typological perspective*.
[2] Jun, S. A., Beckman, M., Niimi, S., & Tiede, M. (1997). Electromyographic evidence for a gestural-overlap analysis of vowel devoicing in Korean. *Speech sciences*, *1*, 153-200.
[3] Jannedy, S. (1995). Gestural phasing as an explanation for vowel devoicing in Turkish.
[4] Browman, C. P., & Goldstein, L. M. (1986). Towards an articulatory phonology. *Phonology*, *3*, 219-252.
[5] Gafos, A. I. (2002). A grammar of gestural coordination. *Natural language & linguistic theory*, 269-337.
[6] Delforge, A. M. (2008). Gestural alignment constraints and unstressed vowel devoicing in Andean Spanish. In *Proceedings of the 26th west coast conference on formal linguistics* (pp. 147-155). Somerville, MA: Cascadilla Proceedings Project.
[7] Lehiste, I. (1970). Suprasegmentals.
[8] Howe, P. (2019). Central Malagasy. *Journal of the International Phonetic Association*, *51*(1), 103-136.