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When good oral stops go bad: Voicing, nasality, and oral obstruency

It has been suggested that nasalization is universally antagonistic to the production of oral obstruents because velopharyngeal opening depletes supralaryngeal pressure and therefore weakens the back pressure needed to produce these sounds (Ohala and Ohala 1993). Schourup (1972) and Cohn (1990) found evidence for a hierarchy of consonants that blocked spreading nasalization / nasal harmony: obstruents are most likely to block nasal harmony, followed by liquids, then glides, then vowels. Walker (2001) observed similar patterns in a large corpus of typologically diverse languages. Among the rarest phonological systems are those that allow nasalization to spread through oral stops and fricatives. Moreover, nasals appear to have a special property among voiced sounds, i.e. they frequently promote the voicing of obstruents which follow them, whereas vowels, glides, and liquids (all voiced) promote voicing less consistently (Hayes 1995).

Phonetic investigation of nasal spreading has been conducted from acoustic and aerodynamic angles (Cohn 1990; Walker 2000; Demolin 2009). In the present study I present results from a novel combination of synchronized aerodynamic (nasal flow) and EPG instrumentation. These results suggest that the entire occlusion during /nd/ sequences is generally nasalized, challenging traditional assumptions about the nasal specification of voiced oral obstruents.

In the present study, speakers of American English and Spanish uttered VndV, VntV, and VnV sequences while wearing custom-designed 62-sensor electropalates and a nasal mask fitted with a pneumotach connected to a low-flow pressure transducer. Nasal, oral, and EPG signals were internally synchronized using an Articulate Instruments EPG scanner. Matlab scripts were used to automatically detect complete horizontal occlusion across the palate. The beginning and ending of nasal flow was marked by hand using a threshold set at 15% the maximum nasal flow during /n/ (see Figure 1). The duration of post-occlusive nasality was observed to be negative for /nt/ sequences, small but positive for /nd/ sequences, and relatively great (and positive) for /n/. These differences were found to be significant using a mixed linear model with speaker as random effect, $F(2,33)=49^{***}$, $p<0.001$, with /nt/-/nd/**, /nt/-/n/**, /nd/-/n/* all manifesting significant differences. /nd/ and /n/ seem to differ not in terms of whether nasalization is extinguished during the occlusion (as would be expected for an oral stop; cf. /nt/) but in terms of how long nasalization persists after the occlusion breaks.

It is well known that an open velopharyngeal port facilitates voicing by helping to maintain a trans-glottal pressure differential (van den Berg 1958; Ohala and Ohala 1993). The present findings suggest that the voicing which usually persists after the production of nasal consonants is driven not by the voicing of the nasal but by the velic gesture that accompanies it. The voicing in /nd/ sequences, even in the latest stages of the occlusion, is strongly nasalized. These findings add phonetic detail to our understanding of postnasal voicing and help explain why it is so much more common than postnasal devoicing (Hyman 2001; Zsiga et al. 2006; Coetzee et al. 2007). The evidence also lends support to assertions that voiced oral obstruents are effective blockers for nasal spreading whereas voiceless oral obstruents are even more resistant to the phenomenon.

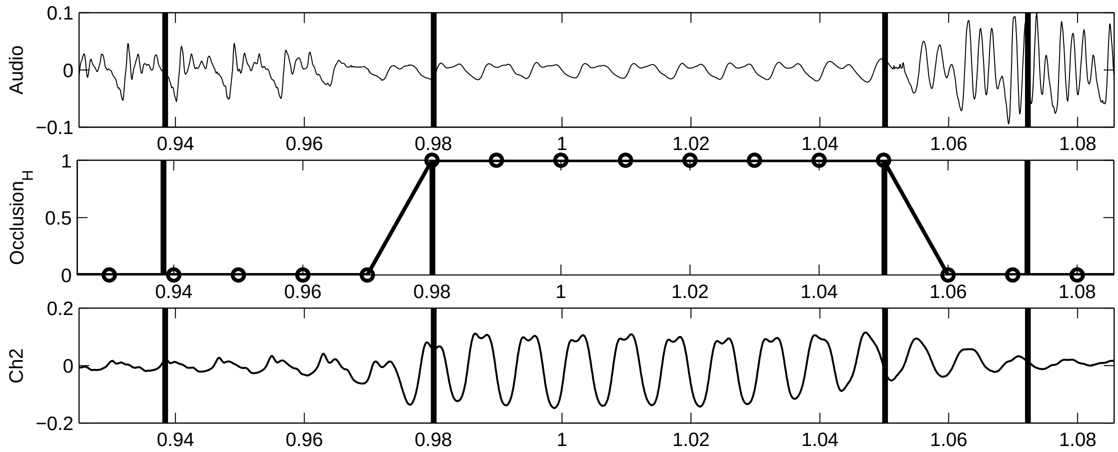

Figure 1. Boundaries set for (1) the onset of nasalization; (2) the onset of occlusion; (3) the offset of occlusion; and (4) the offset of nasalization in the sequence /anda/. Top frame illustrates audio; middle frame illustrates occlusion derived from EPG (1=occluded; 0=not occluded); bottom frame illustrates (unfiltered) nasal flow.

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