Temporal vs. area-sum measurements of vowel nasality

Nasometric and aerodynamic instruments easily express the relationship between oral and nasal activity at any given point but require extra calculations to quantify an entire vowel's nasality. The current standard is a temporal ratio centered around a threshold, expressing a nasal phase's relative length but ignoring intensity values. In this presentation, I argue that this sort of formula conflates essential information on certain vowels and propose in response an area-sum measure of oral and nasal phase energies, the Differential Energy Ratio (DER). Using personally collected data, I compare this measurement with a commonplace temporal measurement based in Nasalance (e.g., Rochet & Rochet 1991), hereafter NAS. While the two converge on almost all vowel types, they diverge significantly on high nasalized vowels. Based on these vowels' nasal energy slopes and the phonetic relationship between vowel height and nasality, I argue that the DER is a more appropriate measure of vowel nasality.

The NAS and DER were calculated for 2,640 tokens of a nasometric corpus of all vowel phonemes of French, in both oral and pre-nasal (VN) contexts. Each vowel's DER was calculated with respect to a differential energy curve (oral minus nasal energy), by taking the ratio of the nasal phase's area (where nasal $>$ oral energy) to total area under this curve. NAS was then calculated and subtracted from DER for each vowel, and this difference was averaged by height and context, as plotted in Fig. 1. Both measurements correlate within 5% of each other for all categories except high pre-nasal vowels, on average 13% less nasal by NAS. Figure 2, which graphs the oral and nasal energy curves of two unique productions of pre-nasal /y/ (same speaker), exemplify the cause of this disparity.

Fig. 1: Average measurement difference by vowel type

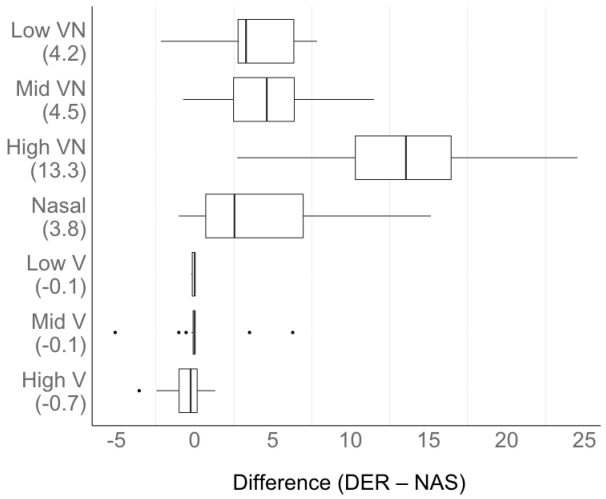
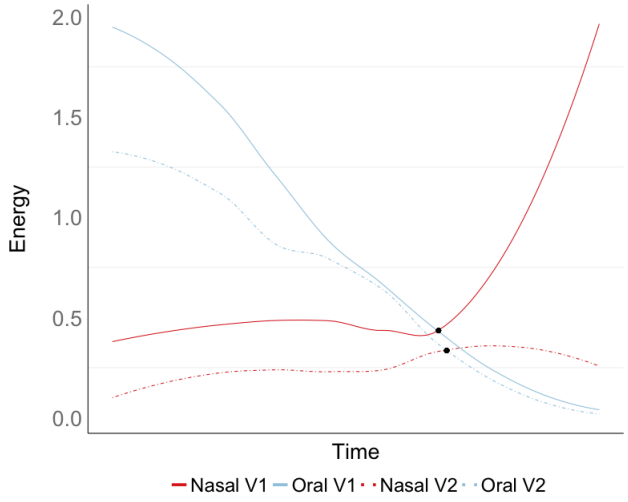


Fig. 2: Oral and nasal energy, pre-nasal /y/



Since nasal energy overtakes oral at the same point, both vowels have an equal NAS (24.1%). However, since the DER models actual energy levels—not a ratio—the rapid rise of V1's nasal energy earns it a higher DER (39.3%) than that of V2 (12.2%). On average, for pre-nasal contexts in the entire corpus, nasal energy on high vowels rises nearly twice as quickly as on others.

High vowels stand out in the phonetic literature as well, requiring very little coupling to be nasalized very quickly, in articulatory (e.g., Bell-Berti & Krakow 1991), aerodynamic (Clark & Mackiewicz-Krassowska 1977) and perceptual (e.g., Maeda 1982) terms. Also, in keeping with this study's findings, Audibert & Amelot (2011) conclude that difference-based accelerometer measurements more accurately describe changes in nasality over time, versus ratio-based measurements. To its advantage, though, the DER can be performed on data from easier-to-calibrate equipment (excluding voiceless segments). Ultimately, whether a difference (e.g., between V1 and V2 in Fig. 2) is perceivable or encodable in grammar is yet to be determined. However, from a purely phonetic standpoint, temporal measures cannot make this distinction, and may therefore underreport nasalization in the experimental literature.