Lingual response to vowel nasalization

It has been observed that in a variety of languages, under the influence of nasalization, high vowels tend to lower and low vowels tend to raise (Beddor 1983). This phonologized variation in F1 is congruent with both acoustic and perceptual accounts of nasalization (Beddor et al. 1986; Beddor 1993). Krakow et al. (1988: 1146) observe that the F1 variation inherent in nasalization "bear[s] a resemblance" to acoustic changes associated with tongue height and jaw position. It is well known that nasal coupling significantly alters the low-frequency domain of the sound spectrum through the introduction of additional pole-zero pairs. The lowest pole associated with the nasal transfer function, sometimes referred to as the nasal formant, has been shown to perceptually "merge" with the lowest pole of the oro-pharyngeal transfer function (Maeda 1993). In cases where F1 is high (for low vowels like /a/) the effect is to lower the percept of F1; in cases where F1 is low (for high vowels like /i/) the effect is to raise the percept of F1.

Articulatory centralization of the height of nasal vowels is not a categorical inevitability, however. Despite the common pattern of the articulatory centralization of vowels under the influence of nasalization, it has also been observed that in some languages nasalized vowels shift away from articulatory centralization (i.e. high vowels raise and low vowels lower). The reason for this variation may not lie solely in phonemic vowel nasal patterns, however, but in the universal phonetic underpinnings of these patterns. We directly measure tongue height position during the vowel in nonce CVN and CVC syllables produced by speakers of American English. English provides a ripe empirical testing ground for co-articulatory patterns of nasalization because it does not have phonemic nasal vowels, but does manifest extensive gestural co-articulation in VN sequences (Krakow 1993, Bell-Berti and Krakow 1991, Cohn 1990, Bell-Berti 1980). Our results reveal that the high vowel /i/ is produced with a higher tongue position when under the influence of anticipatory nasalization. Nevertheless, an acoustic analysis shows that the F1 center of gravity of the nasalized vowels is not significantly different than that of oral vowels. Given the acoustic resemblance between the effects of nasalization and tongue height on vowel production, this result suggests that tongue raising is used as a way of compensating for the acoustic effect of nasalization. In other words, the raising of F1 due to anticipatory nasalization is offset by the raising of the tongue, which lowers F1, effectively negating the change in F1 due to nasalization.

We propose, therefore, that diachronic variation in the articulatory space of nasal vowels across languages can be seen as different responses to the same stimulus. That is, the phonologization of vowel nasalization may be linked to a universal tendency for an articulatory response to the acoustic effects of velopharyngeal coupling.

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