

## Following nasals motivate vowel shifts in Western American English

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We investigate the phonetic motivation for changes in vowels before /ŋ/. In Western American English, short-a and short-i are raised and fronted before /ŋ/. The vowel in *hang* has merged with long-a (the vowel in *Hague*). The vowel in *ring* is also raised and fronted, merging with long-e for some speakers. These changes parallel the coarticulatory effect associated with a following velar consonant (the “velar pinch”). By hypothesis, the change is a phonologization of coarticulation. Wisconsin English features a related change: short-a merges with long-a before both velar stops and nasals (Zeller 1997). Short-a becomes long-a before velar nasals in both dialects, but before velar stops only in Wisconsin. This suggests that /ŋ/ has a more potent “velarizing” effect than /g/. We hypothesized that this is because velarization is doubly-encouraged in the articulation of /ŋ/: it occurs as a result of the tongue dorsum raising to the velum (as with /g/), but *also* as a result of the velum lowering toward the tongue body. This extra effect could explain the Western American short-a pattern.

To test this hypothesis, we examined the effect of velum height on F1 and F2 in 12 speakers of Western American English. They produced vowels in monosyllables. Stimuli were of the form {b,d,g}\_\_ {b,d,g,m,n,ŋ}. Acoustic and nasal flow recordings were made. Nasal flow is a proxy for velum height. Words containing short-a, short-i, and short-e were analyzed. (Short-e is of interest because the *pin/pen* merger in Southern speech, which is conditioned by nasals.)

Separate regression analyses were performed for each speaker and each vowel. Formant frequencies were the dependent variables, with the following independent variables: nasal flow, place of articulation of the following consonant, and time (the square and cube of time were also included to account for non-linearity in the formant trajectories). Data from vowels with following velars were not included, to isolate the role of the lowered velum on the formants.

The results of the statistical analysis generally support the hypothesis. Variability between speakers is present, but population trends can be identified. Increased nasal flow – a lowered velum – is associated with raising and fronting of short-a, consistent with the observed sound change. Data from short-i indicated that increased nasal flow is associated with raising and backing of the vowel. The effect of nasal flow on short-e patterned with short-i. Backing, or lowering of F2, is rather unexpected in short-i and short-e, but it is important to note that the results represent a tendency associated with increased nasal flow. F2 is actually *raising* during the production of the vowels, as a consequence of the formant transition for the following velar. Some of the formant perturbations are attributable to aerodynamic consequence of coupling the nasal resonator (cf. Stevens 1999:311), while others can only be attributed to the lowered velum.

In summary, a phonetic motivation can be associated with front vowel shifts and mergers that are conditioned by following nasals. The mechanism suggested is novel: change in the vocal tract brought about by the lowered velum.