Regional variation in formant dynamics
and the phonologization of pre-velar raising in American English

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The phonologization of phonetic effects is central to our understanding of phonological phenomena. To understand how a mechanical phonetic effect is exaggerated and incorporated into the phonological system, it is instructive to compare phonetic and phonological versions of the same pattern when they can be observed coexisting in related language varieties. Solé (2007) showed that nasalization is a mechanical feature of Spanish vowels but a controlled feature of English vowels. While Ladefoged (1984) treats coarticulation as a language-specific controlled behavior, Gick et al. (2013) suggest that at least some coarticulatory patterns are consistent with simple temporal overlap of canonical muscle activations. In this paper, we examine the formant dynamics of English /æ/ in two American English varieties that differ in the raising effect of a following /ɡ/, to access whether raising of /æɡ/ is a consequence of coarticulation or phonologization of a coarticulatory pattern.

The raising and fronting of /æ/ before various following consonants is a major axis of regional dialect variation and change in North American English with some forms (e.g. raising before nasals, henceforth BAN) firmly phonologized in some dialects (Labov, Ash, and Boberg 2006). However, the phonological status of the raising of /æɡ/ but not /æk/ (henceforth BAG and BACK), found in the Upper Midwest (Purnell 2008; Zeller 1997) is still undetermined. Purnell (2008), using x-ray microbeam and acoustic data, showed that in Wisconsin the articulation of BAG has a more steady movement towards the target throughout the duration of articulation, while BACK is steady for a portion with a rapid movement towards the target later in duration. He attributes this effect at least partially to differences in duration due to voicing, i.e. BACK has less time to hit the target. However, the differential effect of duration on trajectories has not been systematically investigated. Since coarticulation from the following consonant is one likely candidate for eventual phonologization (Garrett and Johnson 2013) and shorter durations are expected to cause more contextual coarticulation (Lindblom 1963; Moon and Lindblom 1994), we would expect that the effects of duration on formant trajectory would differ between a dialect where pre-velar raising in BAG has been phonologized (e.g., in Wisconsin) and one that has not (e.g., in North Carolina).

Data for this study come from 84 speakers from Northwest Wisconsin (43 Female and 41 Male), and 40 speakers from Western and Central North Carolina (27 Female and 13 Male), who were interviewed following a standard sociolinguistic protocol (e.g. Tagliamonte 2006). At the end of the interview each respondent read a list of words, a list of sentences, and a short story. Recordings were conducted using a headset mic either in the homes of the respondents, at the first author’s place of residence, or in library study rooms. F1 and F2 were measured for all /æ/ vowels (n = 16,588) recorded for each task (excluding interviews). These formants were measured at 50 equidistant time-points throughout the whole vowel (including CV and VC transitions) and Lobanov normalized.

In order to model the trajectory of /æ/ as a function of the following environments we used Generalized Additive Mixed Effects Models (GAMM) from the mgcv package in R (Wood 2015). Models were built for F1 and F2 in a nested design, with a baseline model that included random effects for speaker and task, fixed effects for preceding and following place of articulation, and a thin-plate smoothing spline for time-point. The most complex model that was considered contained a thin-plate smoothing spline term for each unique combination of state (Wisconsin or North Carolina), following consonant (e.g. BAG, BACK, BAN, BAD, BAT), and sex interacted with log(duration) and year of birth, as well as a random-slope-
by-speaker for duration. All spline terms were significantly non-linear, with subsequent inferences made from plotting the predicted interaction surfaces.

The figure below contains the predicted F$_2$ surface for the duration-by-smooth interaction for BAG and BACK for males across states. These figures can be read as the dynamic change of the curve shape at different durations, with the color scale and topographical lines indicating the predicted curve height. The figure shows that the trajectories of BAG in WI are higher and fronter and start sooner than those in NC, with the effect of longer duration moving the transition further into the vowel. This is starkly different from both BAG in NC and the BACK trajectories in NC and WI which are only slightly different by state but very different from BAG. This progressive movement of the transition into the vowel for BAG in WI, is an indication that the transition is no longer a coarticulatory effect from the following /g/, but rather is a phonologized property of the class of words containing /æɡ/. This claim is strengthened by the fact that the time point of the transition varies by duration in WI, but is stable in NC, indicating a dialect-specific pattern of phonologization.


