CROSS-DIALECTAL DIFFERENCES IN NASAL COARTICULATION IN AMERICAN ENGLISH

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ABSTRACT

We use acoustic measurements from spontaneous corpora data to compare the social conditioning of nasal coarticulation across two American English dialects: Mid-Atlantic (Philadelphia Neighborhood Corpus) and Midlands (Buckeye Corpus). Each dialect is represented by 40 speakers stratified by age and sex. An acoustic measure of nasal coarticulation is calculated using the within-speaker by-vowel difference between A1-P0 in pre-nasal contexts (*ban*) and A1-P0 in non-nasal contexts (*bad*), with measurements taken automatically at 6 equidistant points throughout the vowel.

The overall amount of nasal coarticulation is found to be larger in Philadelphia than in Columbus. However, in Philadelphia, the young speakers produce less nasal coarticulation than the older speakers, with older men producing the greatest nasal coarticulation. In Columbus, the young women set themselves apart from the other groups by using very little nasal coarticulation. We suggest that both dialects are reducing their degree of nasal coarticulation, which we argue is a socially-motivated change.

Keywords: nasal coarticulation, sound change, dialect differences, phonetic variation, corpus study

1. INTRODUCTION

While most investigations of the changes in progress that differentiate dialects of American English has focused on vowel quality [5, 6], sociophonetic research in other languages and varieties has made clear that other subphonemic properties of speech can also change over time and vary by dialect. Examples include F0 [4], /s/-articulation [11], /t/-glottalization [3], and consonant strength [8]. In this paper we compare the patterning of degree of nasal coarticulation, a non-contrastive phonetic property in English, across two American English dialects. We show first of all that these dialects differ in the overall amount of nasal coarticulation, and secondly that averaging across social categories masks differences in how nasal coarticulation patterns with respect to age and gender. The apparent-time interpretation of the patterns we identify suggests a change in progress in both dialects, namely a reduction in the degree of nasal coarticulation. We argue that such a change is unexpected under mechanistic approaches to coarticulatory sound change and is more suitably attributed to social evaluation, making this case parallel to the many socially-motived vowel changes in progress observed in American dialects.

2. DATA AND METHODS

2.1. The corpus samples

The data for this study are drawn from two corpora of conversational speech, which were constructed using similar sociolinguistic methods. Because the size and demographic composition of the corpora are different, we created matched samples to improve comparability.

2.1.1. The Buckeye Corpus

The Buckeye Corpus of Conversational Speech (BC) [9] contains conversational interviews with 40 middle-class white English speakers native to Columbus, Ohio. Speakers were stratified into four categories by age and sex: male or female and under 30 (“young”) or over 40 (“old”).

The corpus creators used a sociolinguistic interview protocol which took place on a university campus and emphasized the solicitation of speaker opinions about everyday topics. The interview recordings were orthographically transcribed, time-aligned at the phone level using Entropics Aligner, then hand-corrected.

2.1.2. The Philadelphia Neighborhood Corpus

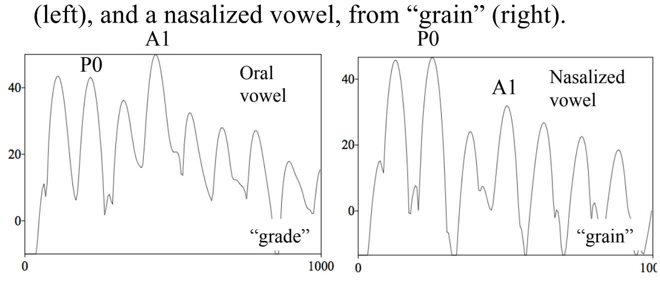
The Philadelphia Neighborhood Corpus of LING560 Studies (PNC) [7], like BC, contains recorded, transcribed, and time-aligned conversational interviews. Speakers in the corpus are of a wider range of backgrounds than in BC, and on-going transcription efforts mean that the number of speakers is still growing. We selected 40 white speakers native to Philadelphia to fill the same four demographic categories as in BC (male/female by young/old). The PNC speakers are upper-working to lower-middle class and are engaged in sociolinguistic interviews that place a higher premium on narratives of personal experience; extensive listening by the first author, however, indicates substantial overlap in the actual speech styles elicited by the two corpora's interview protocols.

Like BC, the PNC files were orthographically transcribed, then forced-aligned using the FAVE suite [10]. Because the PNC alignment has not been hand-checked, we hand-corrected the relevant phone boundaries when necessary, with attention given to placing the vowel-nasal boundary at the point of abrupt increase in amplitude of the higher formant frequencies in the spectrogram.

2.2. Measurement of acoustic nasality

We used a Praat script first to extract all monosyllabic VN and C(C)VN words from each interview, then to automatically measure acoustic nasality over each vowel. Lowering the velum during speech production acoustically couples the nasal passages with the oral cavity, amplifying nasal resonances in addition to dampening oral ones during vowel production. The nasal formants fall in relatively predictable and stable frequency ranges, with the lowest nasal formant around 250 Hz [2]. As nasality increases, the relative amplitude (in dB) of these nasal formant peaks increases, while the amplitude of the oral formant peaks, especially F1, decreases. Thus the difference in amplitude between one of the nasal formants and F1 gives us a relative measure of nasalization: A1-P0 dB (A1 = amplitude of the F1 harmonic peak; P0 = amplitude of the lowest nasal peak). Figure 1 displays these spectral characteristics, which compares vowel spectra from the words "grade" and "grain". Since as nasality increases, A1 decreases and P0 increases, smaller A1-P0 dB values indicate greater vowel nasality. The low F1 of high vowels can overlap with and thus obscure P0 [2]; therefore, only words with non-high vowels were targeted in the current study to verify acoustic nasality measurement in the stimuli.

Figure 1: Spectra for an oral vowel, from "grade" (left), and a nasalized vowel, from "grain" (right).



This measurement was taken at 6 equidistant points in each vowel token to provide a picture of the coarticulatory trajectory over the course of a vowel.

Note that nasality is reflected inversely in the A1-P0 dB measure, with high A1-P0 values indicating less nasalization. To exclude probable measurement errors without hand-checking each measurement, we removed measurements that were greater than 2.5 standard deviations from the grand mean, as well as vowels with a duration below 50 msec.

2.3. Comparing nasal coarticulation across speakers

The acoustic measurement of nasality is relatively new territory, and cross-speaker comparisons bring unresolved methodological issues to the fore. While the A1-P0 dB measure is known to correspond to patterns of nasal airflow [12] and contrastive nasal consonant perception [13], it is not well understood whether the measure can also be impacted by other factors in speech production. To account for that possibility, we subtract out each speaker's mean A1-P0 in oral ((C)VC) contexts on a by-vowel basis, so that the measure we use reflects only the additional modulation to the A1-P0 measure introduced by nasal coarticulation and not speaker-specific voice quality parameters. We then multiply by -1 to orient the measure intuitively (so that higher values represent greater nasality) and refer to this value as n(A1P0).

2.4. Target words

The current study focuses on monosyllabic, content words containing exactly one nasal segment extracted from the interviews. Only words with vowels preceding a nasal consonant (i.e., CVN such as *home*) were extracted for acoustic measurement. (Monosyllabic content words containing only oral segments were also extracted and measured for the n(A1P0) calculation). The data set consisted of 18,662 data points, represented by 186 word types with a VN sequence.

2.5. Statistical modelling

We fit linear mixed-effects regressions using the `lme4` package in R. The dependent variable is n(A1P0) as described in 2.3. In addition to the social predictors of dialect (Philadelphia, Columbus), age (young, old) and sex (male, female), we include as predictors: normalized log word frequency using the SUBTLEX norms [1], normalized log vowel duration, normalized F1, and vowel identity. We also include the measurement point in the vowel (1-

6) and its interaction with dialect, age and sex to allow for the identification of sociolinguistic differences in coarticulatory patterns. The random effects structure specified is a random intercept by word and a random slope for normalized F1 by speaker.

We fit three models: one for each dialect and one for the combined data from both dialects, with an additional interaction term by dialect added to the three-way interaction term specified in the single-dialect models.

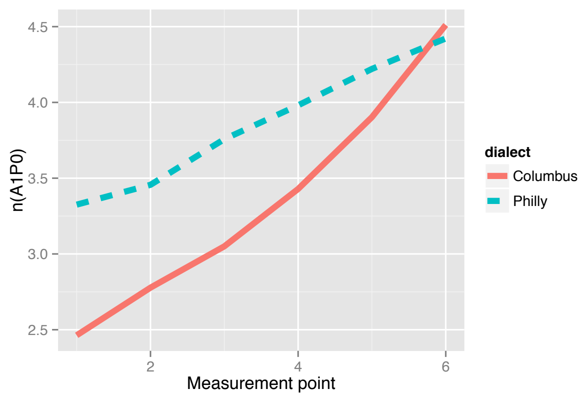
3. RESULTS

3.1. Effects of linguistic predictors

The effects of the linguistic predictors, from the overall model, are in line with our expectations given previous research [14]. F1 has an effect such that lower F1 from higher vowels decreases degree of nasality (estimated coefficient for F1=-0.4, se=.13, *t*=-3.01). Additionally, vowel duration also significantly influenced degree of nasal coarticulation: longer vowels had greater degree of nasal coarticulation (estimated coefficient for VOWEL DURATION=0.9, se=.04, *t*=2.1). There was not a significant effect for word frequency across the samples (estimated coefficient for WORD FREQUENCY=.18, se=.15, *t*=1.2).

3.2. Overall comparison of Philadelphia and Columbus

Figure 2: Nasal coarticulation (as n(A1-P0)) by dialect (model fit values) in vowels preceding nasal segments (CVN words).

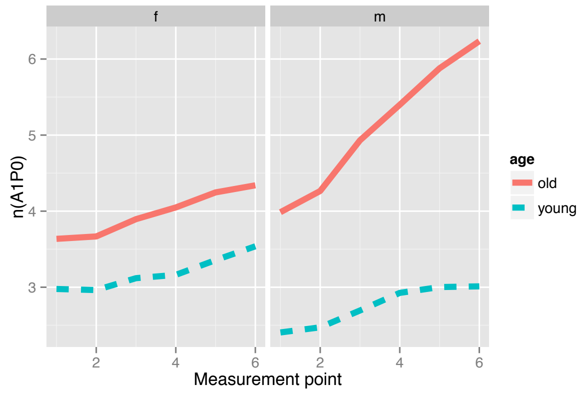


With respect to the predictors involving the social factors, observe first that overall, Philadelphia speakers show greater nasality and a shallower coarticulatory slope than Columbus (estimated coefficient for PHILADELPHIA by POINT=-0.32, se=0.09, *t*=-3.7).

3.3. Age and gender differences across dialects

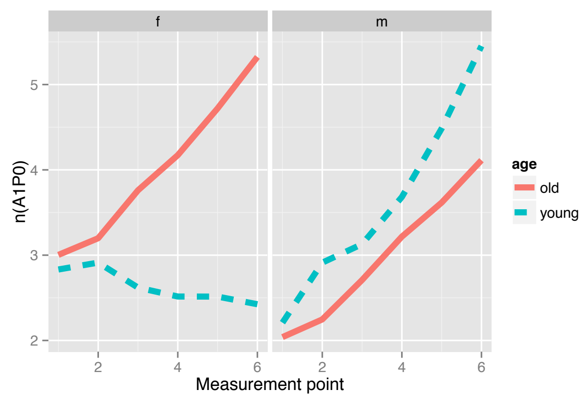
Within Philadelphia, we find that among the older generation the women have less nasal coarticulation than the men, with a shallow trajectory (estimated coefficient for MALE by POINT interaction=0.33, se=0.07, *t*=4.5). But by the younger generation the men have caught up and may even exceed the young women in their reduction of nasal coarticulation (estimated coefficient for YOUNG by MALE by POINT interaction=-0.29, se=0.12, *t*=-2.5).

Figure 3: Nasal coarticulation (as n(A1-P0)) by age and sex in Philadelphia (model fit values) in vowels preceding nasal segments (CVN words).



In Columbus, we find most notably that the young women behave differently than the other demographic categories, with a very low degree of nasal coarticulation and shallow coarticulatory slope (estimated coefficient for YOUNG by POINT interaction=-5.5, se=0.1, *t*=-5.5; estimated coefficient for YOUNG by MALE by POINT interaction=0.7, se=0.13, *t*=5.3).

Figure 4: Nasal coarticulation (as n(A1-P0)) by age and sex in Columbus (model fit values) in vowels preceding nasal segments (CVN words).



4. DISCUSSION

An apparent-time interpretation of these results is plausible given previous work showing a change in progress in nasality in Philadelphia [14]. We suggest that both dialects are undergoing a female-led change toward a lesser degree of nasal coarticulation. In Columbus, the change is incipient, being innovated by the current young women as shown in Figure 4. In Philadelphia, the same sort of change is further advanced, with the origin of the change located in the older generation of women and then passed on to both genders in the younger generation. In other words, the solid (red) lines in Figures 3 represent the same stage of the change as the dashed (blue) lines in Figure 4. If our interpretation of the results is correct, it predicts that the next generation of speakers in Columbus should pattern like the young speakers in Philadelphia in having moved away from a strong degree of nasal coarticulation.

5. CONCLUSION

The identification of cross-dialectal differences, as well as changes in progress in degree of nasal coarticulation, lends support to the growing body of evidence that a wide range of subphonemic details shows meaningful variation. Nasal coarticulation thus presents a new opportunity for testing theories of sound change while the changes are in progress. It is of particular interest because the apparent direction of the change is towards lesser, rather than greater, coarticulation over time, diverging from the expectations of some models of leniting sound change. Identifying such potentially unexpected patterns in changes in progress may allow for the refinement of theories of historical sound change, as well as the improvement of our understanding of the relationship between social and physiological forces in shaping speech.

6. REFERENCES

[1] Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior research methods*, *41*(4), 977-990.

[2] Chen, M. Y. (1997). Acoustic correlates of English and French nasalized vowels. *The Journal of the Acoustical Society of America*, *102*(4), 2360-2370.

[3] Docherty, G. J., & Foulkes, P. (2005). Glottal variants of /t/ in the Tyneside variety of English. *A figure of speech A festschrift for John Laver*, 173-197.

[4] Fox, R. A., Jacewicz, E., & Hart, J. (2013). Pitch pattern variations in three regional varieties of American English. In *Interspeech* (pp. 123-127).

[5] Jacewicz, E., Fox, R. A., & Salmons, J. (2011). Vowel change across three age groups of speakers in three regional varieties of American English. *Journal of phonetics*, *39*(4), 683-693.

[6] Labov, W., Ash, S., & Boberg, C. (2006). Atlas of North American English: Phonology and Phonetics. *Berlin: Mouton de Gruyter*.

[7] Labov, W. & Rosenfelder, I. (2011). The Philadelphia Neighborhood Corpus.

[8] Lavoie, L. M. (Ed.). (2001). *Consonant strength: Phonological patterns and phonetic manifestations*. Psychology Press.

[9] Pitt, M. A., Dilley, L., Johnson, K., Kiesling, S., Raymond, W., Hume, E., & Fosler-Lussier, E. (2007). Buckeye corpus of conversational speech (2nd release). *Columbus, OH: Department of Psychology, Ohio State University*.

[10] Rosenfelder, I., Fruehwald, J., Evanini, K., Yuan, J. (2011). FAVE Program Suite [Forced alignment and vowel extraction].

[11] Stuart-Smith, J. (2007). Empirical evidence for gendered speech production: /s/ in Glaswegian. *Laboratory phonology*, *9*, 65-86.

[12] Zellou, G. (2012). *Similarity and enhancement: Nasality from Moroccan Arabic pharyngeals and nasals* (Doctoral dissertation, University Of Colorado At Boulder).

[13] Zellou, G., & Dahan, D. (2014). Gradient perception of within-category nasality in English vowels. *The Journal of the Acoustical Society of America*, *135*(4), 2223-2223.

[14] Zellou, G., & Tamminga, M. (2014). Nasal coarticulation changes over time in Philadelphia English. *Journal of Phonetics*, *47*, 18-35.