SIMULTANEOUS VOWEL CHANGES IN BRITISH COLUMBIAN ENGLISH

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ABSTRACT

System-wide vowel investigations acknowledge the interrelationship of sounds, and recognize that changes often involve multiple sounds within the systems. When vowels change together this may be driven by structural relationships and/or social meaning; the cause is not always apparent. We introduce the term simultaneous changes to describe vowels changing together without implying a causal relationship. We explore whether simultaneous changes in the British Columbia English vowel system are present across apparent time using a novel method involving Generalized Additive Mixed Models and Principal Component Analysis [1]. While we find evidence of simultaneous changes, where adjacent vowels with structural relationships pattern together, we also see non-adjacent vowels co-patterning. Framing sound co-patterning as simultaneous changes allows us to sidestep the insurmountable challenges of diagnosing the impetus of these changes.

Keywords: chain shifts, vowel systems, English

1. INTRODUCTION

Vowels do not behave independently. Rather, individual vowels are part of a larger structured system. Within a system, small individual changes may have knock-on effects that lead to changes in the wider system over time. Vowel patterns may shift over time, moving into new phonetic space or impinging on other vowel categories, which may result in mergers of categories or additional changes within the vowel space. Sets of vowel changes that have been causally linked (e.g., through structural relationships) have been dubbed push or pull chain shifts, depending on whether the first change in the shift was one that "pushed" another category into new phonetic space or "pulled" another category into a vacated position [2, 3]. Other structurally-linked vowel changes are suggested to happen in parallel, driven by shared features, such as the fronting of GOAT and GOOSE vowels in North American Englishes [4]. There is also evidence that non-adjacent, seeming unrelated changes occur. For example, the fronting of GOOSE and the lowering of DRESS have been observed in, for example, California English [5, 6]. Generally, providing strong evidence for the changes' impetus is difficult (e.g., [7, 6]. We introduce the term simultaneous changes to convey the coordination of such changes without implying a mechanistic connection between the vowels. Their coordinated behavior may be rooted in either shared social meaning or phonetic/phonological structure. While these patterns are all observable from a bird's eye view of the system, the quantification of change on the system level has been a challenge, often amounting to simple correlations between variables.

A method for studying vowels together as a system in a more unified quantitative framework is introduced in [1]; see the methodological details in 2.2. In an exploratory analysis, we apply these methods to 11 monophthongs in British Columbia English (henceforth BCE), the western-most variety of Canadian English. The BCE vowel space is ideal for investigating changes involving the coordination of sets of vowels, as it has been described to be undergoing two sets of changes in the vowel space that involve multiple vowels: the Canadian Vowel shift (hereafter CVS [8, 9, 10]) and a set of changes in the front lax vowels preceding /g/ and /ŋ/ [11, 12]. The changes simultaneous with the CVS are lowering and/or retraction of KIT, DRESS, and TRAP, and fronting or centralization of STRUT, with the impetuous for the CVS suggested to be the merger of THOUGHT and LOT. KIT, DRESS, and TRAP have also been suggested to be undergoing raising, fronting, and/or diphthongization before voiced velars. In other words, the same "vowels" (but different allophones) are participating in different changes. The fact that there have been such strong suggestions of coordinated behaviour of vowels in the BCE vowel system makes this an ideal place to explore system-wide co-variation of vowel categories. We examine to what extent these changes are simultaneous changes – that is, are they patterning seemingly in concert? To be clear, the goals of this set of analytic methods is for identifying patterns of co-variation in vowel formant structure, as opposed to providing descriptions of specific vowel characteristics.

2. METHODS

2.1. Data

Data were collected via a browser plugin that saved recordings as .wav files as part of the Determining Regional Accents With Literature (DRAWL) project (https://blogs.ubc.ca/drawl/). This project asks participants from British Columbia, Canada to read a short story composed to include tokens of interest for local regional variation. Audio files were high quality at 44.1kHz sampling rate and 16 bit rate, but subject to variation in individuals microphones, sound cards, and recording environment. Here we analyze the data from 170 participants. Participants self-categorized their "voice type" as female or male (126 females, 44 males) and provided age (in years: M = 41.38, SD = 15.97, range = 14-78).

Recordings were orthographically transcribed, force-aligned with the Montreal Forced Aligner [13], and hand-checked for major errors. Files were downsampled to 16kHz and formants were estimated using emuR [14]. Formants were estimated separately for female and male voices by changing the gender parameter, which changes the nominal F1 value from 500 Hz (for male) to 560 Hz (to female) and affects the formant frequency range table [15].

F1 and F2 midpoint values for stressed FLEECE, KIT, FACE, DRESS, TRAP, GOOSE, GOAT, NURSE, STRUT, THOUGHT, and LOT were normalized for apparent talker size using the [16] algorithm. Local speech rate was estimated for each vowel using the average segment duration in the word in which the vowel occurred.

2.2. Analysis

Our analysis follows closely the methods described in [1], and we direct readers to that paper for a more verbose description of the methods. The basic steps of this analysis are as follows: 1) separate GAMMs for each formant by vowel category are run with random smooths for speakers and words; local speech rate is a control. Models include smooth terms using additive smooths for speech rate, reader age, and reader age by voice type. There were smooth and parametric terms for voice type. 2) Speaker intercepts are extracted from the models; 3) a PCA is run on the speaker intercepts taken from each of the vowel formant GAMM models.

The vowels included in the analysis are: FLEECE, KIT, FACE, DRESS, TRAP, GOOSE, GOAT, NURSE, STRUT, THOUGHT, and LOT. KIT, DRESS and TRAP before voiced velars are coded separately with BIG, EGG, and BAG, respectively as their lexical sets. After outlier removal processes, 44,217 tokens were analyzed.

3. RESULTS

Figure 1 visualizes the trajectories of the vowel categories over apparent time. The arrows start from the estimated values of the oldest speakers and end at the estimated values of the youngest speakers. From this we can observe that KIT, BIG, DRESS, and EGG are mostly lowering, while BAG is raising and fronting. We also see fronting of GOOSE, and backing of GOAT, LOT, and THOUGHT. In the middle of the vowel space we see NURSE also appears to be lowering. We see the maintenance of an allophonic contrast between BIG and KIT and EGG and DRESS, despite the observation that these vowels are lowering over time. While the CVS is often characterized by a backing of TRAP, that is not observed, which may suggest it was already backed by our oldest speakers. Contrary to descriptions, we also see LOT and THOUGHT midpoints are distinct, and STRUT and LOT are close together in the F1 by F2 space for older speakers.

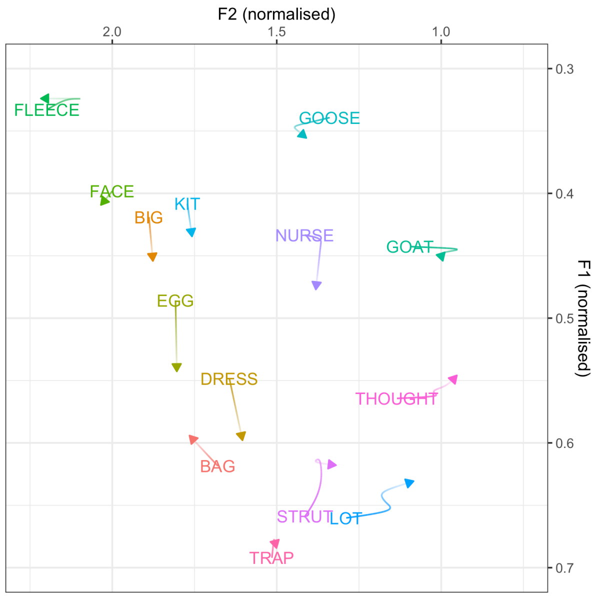

Figure 1: Trajectories of the vowels under investigation based on the GAMM smooths of reader age (older speakers = labels; younger speakers = arrows).

The group-level observations gleaned from this static figure obscures the extent to which any individual participates in these changes. Unlike [1], we are primarily interested in the co-variation of vowels and system-wide effects rather than individuals that are more or less advanced in the sound changes. Our focus is less on who are the leaders and laggers in these changes and more on characterizing which vowel specific formants pattern together within individuals.

The PCA on the by-speaker intercepts returned with two PCs accounting for more than 10% of the variance (PC1 = 44% of the variance, PC2 = 13.1% of the variance). Given space limitations, we only describe the patterns within PC1. In contrast to [1] where a few vowels loom large in their PC1, we see in Figure 2 that many vowels contribute to the first PC. In this figure, the vowels and formants are plotted in their order of contribution to the PC. Their sign (+/-) of the loadings is arbitrary, but vowel formant combinations that pattern with the same sign pattern in the same direction. For example, DRESS F1 and KIT F1 (+ sign) and EGG F2 (- sign) all contribute strongly to PC1 and so are co-varying, but DRESS and KIT F1 are patterning in the same direction – we can interpret from Figure 3 that they are increasing, while EGG F2 is patterning in the opposite direction, i.e., decreasing. The vowel formants and their PCA values are grayed-out once 50% of the variance within PC1 has been accounted for. This cut-off at contributing to 50% of the variance within PC1 seems more arbitrary in our dataset than [1], as the first two grayed-out vowel/formants – F1 of STRUT and F1 of FACE – are nearly equivalent in their PC value to the last bolded one – F2 of EGG. F2 of KIT, FACE, DRESS, EGG, and BAG all pattern together (with an arbitrary - sign) and F1 of KIT, DRESS, NURSE, GOAT, and LOT all pattern together (with an arbitrary + sign).

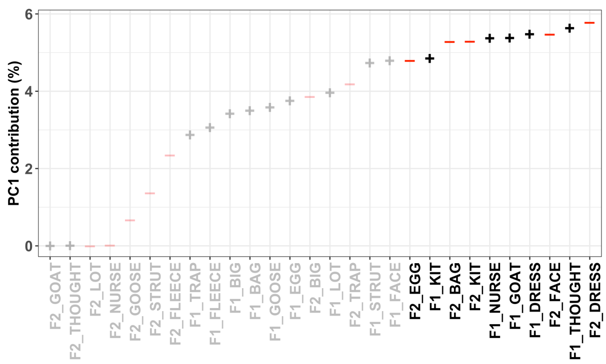

Figure 2: The contributions of each vowel/formant to PC1. The sign +/-, redundantly colour-coded, indicates the (arbitrary) direction of the loadings. The bold-faced formants contribute to the first 50% of the variance for PC1.

Figure 3 presents the relationship between the speaker intercepts from the GAMM models and the speaker PC values by reader age for all of the vowels and formants. Positive speaker PC signs from the PCA are in green and negative signs are in black. The vowel-formant combinations that contributed to more than 50% of the variance in PC1 are boxed in yellow. The percent of variance accounted for by each vowel formant is reported; the yellow box's brightness indicates the contribution of that vowel formant to the PC. The red line in each of the panels is the sound change smooth from the GAMM, and one observes that it clearly separates the green and black speaker PCA points in most panels. The individuals with data points above the line are more innovate, while those below are more conservative.

Due to the large number of vowel formants contributing to this first PC, an eloquent synopsis of the data is challenging. There is clearly structured variation in that the regression line bifurcates green (+) and black (-) data points. Starting with BAG, we see a pattern where the F2 value becomes higher over time, indicating a fronting pattern; this is accompanied by a lowering of F1, indicating a raising in the vowel space. For TRAP, we see a lower, backer vowel in comparison to BAG, with little change over time, but substantial variation. This may suggest that TRAP had already reached its retracted position as part of the CVS for even the oldest speakers in this sample. Individuals who have more fronted and raised TRAP are more likely to have a BAG that is fronted and raised. Such a pattern holds across the front vowels in voiced velar environments: individuals who have more fronted and raised TRAP, DRESS, and KIT have more fronted and raised BAG, EGG, and BIG. These same speakers also have fronter and higher FACE vowels, and to some extent FLEECE too. These same speakers have higher THOUGHT, NURSE, and GOAT vowels as well. While this analysis is not set up to directly quantify change over time, we can observe some patterns from the regression lines. For example, there is an indication that FACE is fronting and GOOSE has fronted over time, with a clear elbow in the GAMM prediction. LOT and THOUGHT are backing, which is related to PC2 and not discussed in detail here. NURSE and GOOSE are lowering. EGG and BIG are lowering, while DRESS lowers and retracts. BAG is fronting and raising.

4. DISCUSSION AND CONCLUSION

An individual speaker's vowels are part of a vowel system, which is, in turn, structured by the patterns of a speech community and the phonetic and

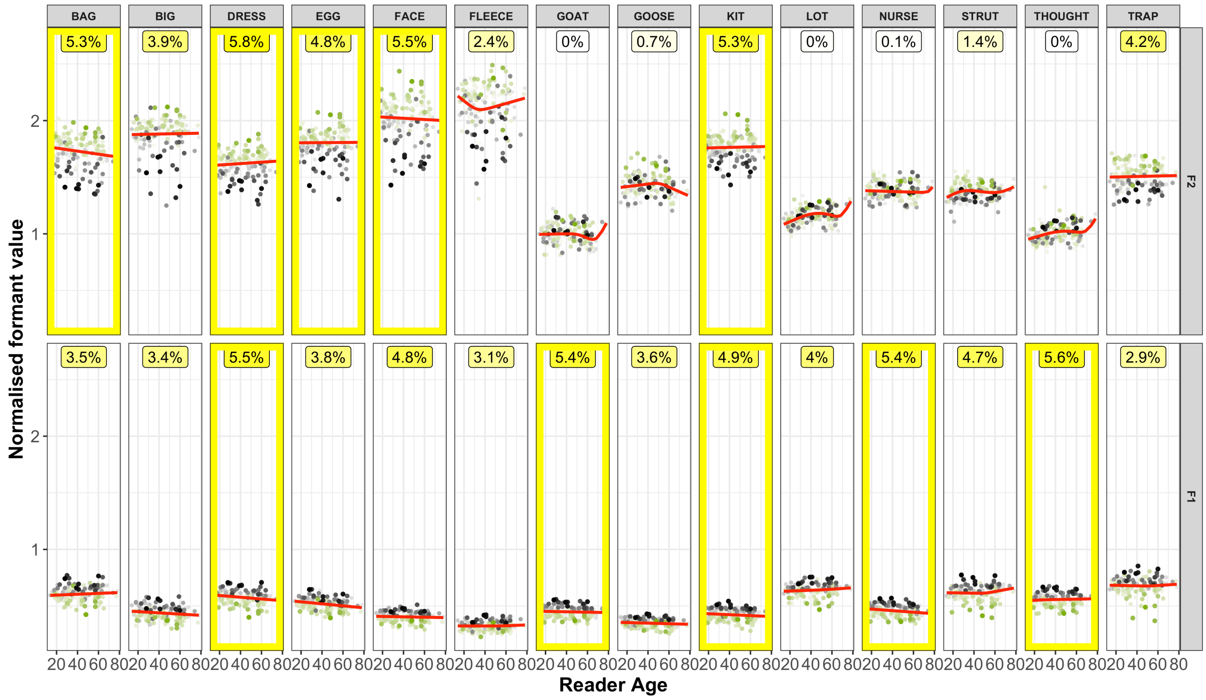

Figure 3: The trajectories of vowel formants by reader age (younger = left; older = right). Speaker intercepts are presented as points. The point color denotes the direction of the speaker's PC score with green as positive and black as negative. The contribution of each vowel formant is provided with the yellowness of the box indication strength of contribution.

phonological structure of the vowels themselves. The application of this GAMM + PCA analysis method allows us to see how vowel variation across a large number of vowels is structured within individuals in a speech community and to some extent across apparent time. We find that 10 vowel-specific formants simultaneously pattern together in individuals' productions, contributing over 50% of the variation in PC1, which itself accounted for 44% of the variance in the data. We see evidence of expected vowel patterns for the BCE vowel system, such as BIG, EGG, and BAG being separate from KIT, DRESS, and TRAP in F1/F2 space and GOOSE fronting. However, we also find unexpected patterns, such as THOUGHT and LOT's midpoints not occupying the same F1/F2 space, and NURSE lowering.

As the use of this vowel system analysis is still novel, we draw attention to the fact that our PC1 accounted for 44% of the variance in our data, while PC1 in [1] accounted for just 17.2% of the variance in their New Zealand English data. This suggests that the vowels we examine in BCE are behaving more uniformly across speakers. There are several reasons to suspect this is the case. Our data are operating on a more contracted time depth, with ages ranging from 14 to 80, compared to the 118 year time depth in [1]. Their work uses spontaneous speech from multiple regions in NZ, compared to our read speech from BC only, which not only elicits a more constrained style, but is just a single style, as opposed to the myriad styles that may be present in the ONZE corpus. It is also possible that the vowels of BCE are less variable than those of NZE.

Scholars often entertain causal explanations related to phonetic or phonological structural relationships when adjacent vowels shift in the F1/F2 space. While we lack evidence for any causal mechanism, we see co-patterning of both adjacent and non-adjacent vowels. The term simultaneous changes allows us to qualify the observation that particular phonetic variation across vowels co-occurs without proposing the causation. One potential explanation for any coordinated variation is its indexing of social meaning. The methods deployed here do not allow for the assignment or interpretation of social meaning, but having identified the coordinated loci of phonetic variation, we can now begin hypothesis-driven work that examines structural relationships between co-patterning vowels and how the array of observed phonetic variation cues listeners to interpret particular social meaning(s).

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