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IS PHONETIC TARGET UNIFORMITY PHONOLOGICALLY, OR SOCIOLINGUISTICALLY GROUNDED?

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ABSTRACT

In this paper, I investigate to what degree phonetic uniformity in diachronic vowels shifts can be accounted for in terms of a shared phonetic implementation rule of phonological features [6, 10], versus a shared social evaluation of the phonetic realizations [19]. I take a particular focus on the parallel fronting and subsequent retraction of the GOOSE, GOAT and MOUTH vowels, as well as the raising of the preconsonantal FACE and pre-voiceless PRICE vowels in Philadelphia, drawing data from the Philadelphia Neighborhood Corpus [15]. Using generalized additive models [21] I fit models for these vowels accounting for gender, date of birth, educational attainment, and vowel duration using tensor product smooths. Looking at the correlation of the by-speaker random intercepts, back vowel fronting appears to be highly correlated, thus likely phonologically grounded, while FACE and PRICE raising is not, thus likely socially grounded.

Keywords: sound change, phonology, phonetics, parallel shifts

1. INTRODUCTION

It has been argued that the structured variation of phonetic parameters across segments may be understood in terms of the phonetic implementation of phonological features, what Chodroff & Wilson [6] call Target and Contrast Uniformity. Target Uniformity describes the case when segments with a shared phonological feature have a shared phonetic parameter, while Contrast Uniformity describes the case when segments with a common phonological contrast are similarly contrasted along a phonetic parameter. Strong correlations have been found to support Target Uniformity in synchronic stop VOT [5, 6, and sources cited therin]. Fruehwald [9, 10] argues that Target Uniformity can also be observed in diachronic changes in the case of parallel phonetic shifts. Examples include the parallel retraction of /ɪ/, /ɛ/ and /æ/ in many varieties of North American English [3], parallel fronting of /uː/, /oʊ/ and /aʊ/ in White Philadelphia English [16], and the parallel diphthongization of /eː/ and /oː/ in York, UK [12]. The parallelism of these shifts means that they are not amenable to the typical "Push" or "Pull" analysis of Chain Shifts [13] and related explanations, such as dispersion theory [4].

However, alternative explanations for diachronic uniformity exist. For example, Watt [19] points out that in the parallel diphthongization of /eː/ and /oː/ in Tyneside English, these vowels share not only a phonological relationship, but also a sociolinguistic one. The phonetic forms [ei] and [oʊ] share a common prestigious social evaluation due these being phonetic realizations more commonly found in Southern Standard British English, thus aligning the social capital of these phonetics with the long standing political and economic differentials between the North and South in England. An additional possibility is that apparent parallelism of two vowel shifts is grounded in neither phonological representation nor social evaluation, but is rather grounded in nothing other than an accident of history that two vowels shifted at a similar point in time. Under this analysis, parallel shifts are "incoherent" in the same way that it has been argued that chain shifts are [18].

Results from the study of the geographical diffusion of sound changes, and the coherence of lects suggest that these competing explanations may be disambiguated. As a complex series of interrelated sound changes spread geographically, they do not necessarily maintain coherence across speakers [14]. Similarly, unrelated but similarly socially stratified sociolinguistic variables also do not always exhibit coherence between speakers [11, 1]. If a strong correlation along a phonetic parameter persists between two vowels after accounting for their diachronic trajectories (i.e. their potential accidental history) and for their social stratification, the case for uniformity being due to shared phonological representation is stronger. I attempt such an analysis here.

2. THE CURRENT STUDY

For this study, I examine the correlation between 5 vowels that have been described as undergoing

diachronic change in White Philadelphian's speech [16], 3 allophones that are not undergoing a change, and one control vowel which did not undergo any notable changes. I draw upon data from the Philadelphia Neighborhood Corpus [15], which is collection of sociolinguistic interviews carried out in Philadelphia between 1973 and 2013. I specifically focus on the subcorpus of White speakers whose educational attainment has been recorded. The corpus has been transcribed, force aligned, and vowel formant data automatically extracted using the FAVE-suite [17]. Table 1 outlines the 9 vowels analyzed, their Labovian labels (which will be used from here on out), as well as the phonetic dimension used in the analysis. Contextual vowel allophones with specialized labels are [Tuw] (post-coronal /uː/), [eyF] (word final, pre-vocalic /ei/), and [ay0] (pre-voiceless /ai/). Due to small N for some vowel classes, not all speakers have all vowels represented. For any pairwise correlation coefficient, the N for that case should be understood to be the smaller NSpeaker value of the pair.

Table 1: Vowels classes in the current study.

IPA	Label	Measure	N	NSpeakers
uː	uw	$F2_n$	2,321	248
	Tuw	$F2_n$	1,095	233
oʊ	ow	$F2_n$	8,292	260
aʊ	aw	$F2_n - F1_n$	13,197	261
ei	ey	$F2_n - F1_n$	20,875	261
	eyF	$F2_n - F1_n$	2,690	252
	ay0	$-F1_n$	16,225	261
ai	ay	$-F1_n$	12,870	260
ɪ	i	$F2_n - F1_n$	30,451	261

The vowels /uw, ow, aw/ were described by Labov et al [16] as undergoing a fronting shift, then subsequent reversal. The [Tuw] allophone is exceptionally fronted by White Philadelphians, but doesn't undergo any particular shift in the 20th century. The allophones [ey, ay0] both underwent a raising change, while the allophones [eyF, ay] remained in their original positions. /i/ did not undergo any notable changes, thus serves as a control vowel. While the two sets of vowels undergoing phonetic shifts could potentially described as sharing phonological features, Labov et al [16] also describe them as sharing a social evaluation. Specifically, /uw, ow, aw/ reversed their fronting trend as part of a dialectal reorientation of Philadelphia from a Southern norm to a Northern one, while the raising of [ey, ay0] continued in a linear change across the 20th century for

Figure 1: Change trajectories for the nine vowels

gender —— men - - women
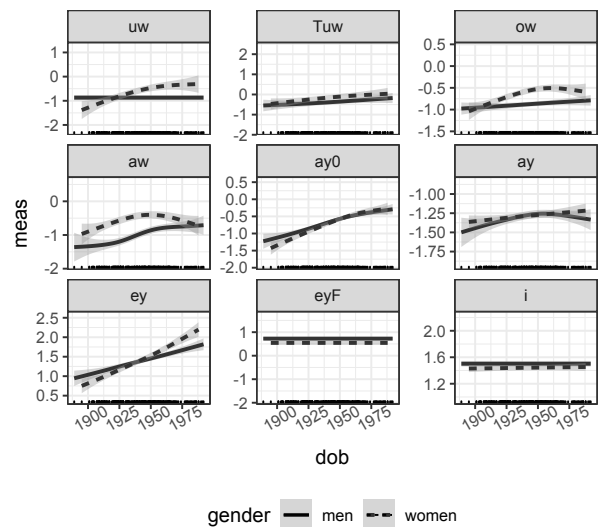
the same reason.

The phonetic measures $F1_n$ and $F2_n$ represent z-score normalized F1 and F2, and are used to capture vowel shifts in height and backness, respectively. $F2_n - F1_n$ captures vowel shifts along the front diagonal of the vowel space [16].

3. INITIAL CORRELATION OF SPEAKER MEANS

In the first instance, speaker means for each vowel class along the relevant measure for that vowel class were estimated, then all unique pairwise Pearson's product moment correlation coefficients were estimated. For all vowel pairs, a 95% bootstrap confidence interval was estimated using 5,000 bootstrap replicates, and p-values from all tests were adjusted according to the Bonferroni method. Of all 36 correlations, 15 had a significant adjusted p-value. However, most of these significant correlations had relatively small correlation coefficients, with the median absolute value of $r = 0.28$. The largest correlation coefficient involving /i/, which underwent no diachronic change, was $r = 0.26$. Only three vowel pairs had bootstrap confidence intervals excluding this value, shown in Table 2 along the next largest two correlations, which are of theoretical interest.

The next largest correlation after those presented in Table 2 was between [ay0] and /ow/, with $r = 0.28$, for which there is no particular phonological nor social account. Although this correlation is significant, it may not be meaningfully interpretable at the time being. Since the correlation between /uw/ and /aw/ is of a similar magnitude, I would argue

Table 2: Correlation of vowel means

Pair	r	(ci)	p-adj
ey,ay0	0.57	$(0.5 - 0.64)$	3×10^{-22}
ow,aw	0.52	$(0.42 - 0.60)$	1×10^{-17}
uw,ow	0.43	$(0.33 - 0.53)$	3×10^{-11}
Tuw, uw	0.35	$(0.22 - 0.48)$	3×10^{-6}
uw, aw	0.29	$(0.17 - 0.4)$	1×10^{-4}

Figure 2: Representative Model Fit

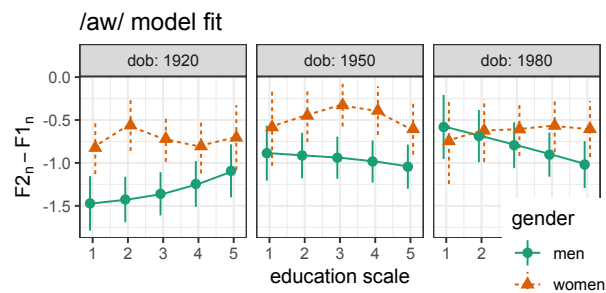that it should also be treated similarly.

4. MODELING

In order to disambiguate between phonological and social uniformity, we need to factor out effects of generational cohort, gender, and other factors of social stratification as much as possible. If the remaining individual-level variation in these vowels remains correlated, then the case for their phonological grounding is stronger. I attempt to do this by fitting a mixed effects model, and using the random intercepts by speaker as the measure of remaining individual level variation.

In the PNC, speakers' date of birth and gender are recorded. The only recorded class marker available is educational attainment, which I re-coded into a 5 level variable:

1. less than high school
2. high school degree
3. some college, or 2 year degree
4. four year college degree
5. graduate degree

For the 9 vowels, I fit a generalized additive model [21] for the outcome measure variable, including gender as a categorical fixed effect, as well as a three dimensional tensor product smooth [20] by gender for date of birth (centered at 1900), educational attainment, and log scaled and median centered vowel duration. Random intercepts were included for word, preceding and following segment, and (crucially) speaker. The same model specification was used for all vowels. For some vowels, a simpler model specification would have almost certainly sufficed, but for some vowels at least the three dimensional interaction between date of birth, education, and gender was necessary, as demonstrated in the model fit for /aw/ in Figure 2. Therefore, the more complex specification was used for all vowels for the sake of comparability.

After fitting a gam for all 9 vowels, the random intercept terms for all speakers were extracted from the models. These random intercept terms will be used as the best approximation for the idiosyncratic vowel targets of individual speakers after factoring out the effects of their broader demographics. These random intercepts will also exhibit "shrinkage," meaning that more extreme outliers and speakers with low token counts will tend to have their random intercepts closer to 0 than otherwise.

5. RANDOM EFFECTS CORRELATION

As was done previously, all pairwise Pearson's product moment correlation coefficients were estimated for the random intercepts. The largest correlation involving /i/ among the random intercepts was 0.24. Again, only three vowel pairs had confidence intervals excluding this coefficient, but it was not the *same* three as before. /uw, ow/ and /ow, aw/ were still highly correlated, but now /uw/ and its post-coronal allophone [Tuw] passed the threshold as being a large correlation.

Table 3: Correlation of random intercepts. Correlation coefficient for mean values also included.

Pair	ranef r	(ranef ci)	mean r
uw, ow	0.53	$(0.44 - 0.62)$	0.43
uw, Tuw	0.47	$(0.34 - 0.57)$	0.35
ow, aw	0.41	$(0.28 - 0.52)$	0.52

Only one vowel pairing had non-overlapping bootstrap confidence intervals for the correlation of mean values and the correlation of random effects: /ey/ and [ay0]. Speakers' random intercepts for these vowels were much less correlated than their means.

Additionally, only one random intercepts correlation lie outside of the mean correlation confidence intervals in the direction of a greater magnitude: /ey/ and [eyF].

Table 4: Comparison of Pearson's r and bootstrap confidence intervals between speaker means and random intercepts for /ey/ and [ay0]

	r	(ci)
mean	0.57	$(0.5 - 0.64)$
ranef	0.12	$(0.01 - 0.23)$

Table 5: Comparison of Pearson's r and bootstrap confidence intervals between speaker means and random intercepts for /ey/ and [eyF]

	r	(ci)
mean	0.15	$(0.04 - 0.28)$
ranef	0.32	$(0.2 - 0.43)$

6. CONCLUSION

These results can be summed up succinctly as follows:

1. The long back vowels that are adjacent to each other in height (/uw, ow/ and /ow, aw/) are highly correlated, no matter whether these correlations are estimated on speaker means or speaker random intercepts.
2. The high correlation between /ey/ and [ay0] in speaker means disappears in the correlation of random intercepts.
3. Factoring out broad demographic effects notably boosted the correlation between two allophone pairs (/uw/ and [Tuw], and /ey/ and [eyF]).

The case for the phonological grounding of the diachronic parallelism of the back vowels seems to be supported by these results. After factoring out the diachronic component, educational attainment, and gender, speakers with fronter /uw/ tend to also have fronter /ow/, and speakers with fronter /ow/ tend to have fronter /aw/. This would seem to be a strong case for Target Uniformity: there is some phonological feature that is mapped to the phonetic dimension of vowel backness, and the phonetic implementation rule for that feature underwent a change in Philadelphia. However, more work needs to be done to flesh out exactly *how* this phonetic implementation for vowel backness is mediated by vowel height. The high correlations only exist between adjacent vowels, while the correlation between /uw, aw/ is not notable.

It is worth noting that the evidence *for* phonological grounding of the parallelism of these vowels is not evidence *against* a common social evaluation of them. While it has been argued that social evaluation does not target more abstract phonological properties [8], it would seem that the evaluation of these vowels as "Southern" has targeted their shared phonological status, especially since the other vowels with Southern-like phonetics (e.g. [eyF]) were not correlated with them.

The strength of this evidence is bolstered by the fact that /ey/ and [ay0], while having highly correlated speaker means, have a fairly weak correlation in speaker random intercepts. The case for a shared phonological feature between /ey/ and [ay0] is less easy to make. [ay0] is a phonologically restricted to pre-voiceless consonants, and it has been argued that the phonological feature picking out this allophone for phonetic change is [−long] [2]. /ey/ on the other hand, is distinguished from its allophone [eyF] by being pre-consonantal. Whichever phonological feature picks out /ey/ to undergo its change, it is not likely to be the same that picks out [ay0] unless we propose a diacritic feature expressly for this purpose. The high correlation between /ey/ and [ay0] in speaker means, then, is either due to their shared social evaluation as broadly Northern vowel qualities, or simply do an accident of history.

Another notable result is the boost in correlation that both /uw/ and [Tuw] and /ey/ and [eyF] received in the random intercepts analysis. It could be argued that this is indicative of an effect of Contrast Uniformity becoming visible after diachronic trends have been factored out. While the difference between allophones is not "contrast" as typically conceived of in phonology [7], they must have different phonological representations at the point they are interpreted by phonetic implementation rules.

7. DISCUSSION

The analysis in this paper has focused on large correlation coefficients, however, the correlation coefficients covered a broad range of values, and most passed the threshold of statistical significance. This is an especially acute problem for vowel variation in English, since there are so many vowel categories and allophones, but it would suggest that a more systematic and principled approach to interpreting correlations along phonetic parameters in terms of shared phonological structure is necessary.

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