One Hundred Years of Sound Change in Philadelphia: Linear Incrementation, Reversal, and Reanalysis

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ONE HUNDRED YEARS OF SOUND CHANGE IN PHILADELPHIA: LINEAR INCREMENTATION, REVERSAL, AND REANALYSIS

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The study of sound change in progress in Philadelphia has been facilitated by the application of forced alignment and automatic vowel measurement to a large corpus of neighborhood studies, including 379 speakers with dates of birth from 1888 to 1991. Two of the sound changes active in the 1970s show a linear pattern of incrementation in succeeding decades. The fronting of back upgliding vowels /aw/ and /ow/ shows a reversal in the direction of change, beginning with those born after 1940. The study also finds a general withdrawal from two salient features of local phonology, tense /æh/ and /oh/, led by those with higher education. Younger speakers with higher education have also reorganized the traditional Philadelphia tense/lax split of short-*a* to form a nasal system with tensing before all and only nasal consonants. The development of the Philadelphia vowel system can be understood in the geographic context of neighboring dialects. Features in common with North and North Midland dialects have accelerated in use while features in common with South Midland and Southern dialects have been reversed in favor of Northern patterns. The microevolution of a linguistic system can be seen here as subject to phonological generalizations but driven by social evaluation as features rise in level of salience for members of the speech community.*

Keywords: sound change, dialect geography, sociolinguistics, variation

1. INTRODUCTION. At the intersection of sociolinguistics and historical linguistics lies the study of change in progress. The quantitative measure of linguistic variables across age levels yields a view of linguistic change in APPARENT TIME, which may be confirmed by a variety of REAL-TIME data—by qualitative observations at an earlier time, by reinterviews of the same subjects at a later time (panel studies), or by repeated samplings of the community as a whole (trend studies).[1] An increasing number of such restudies have confirmed the general view that most speakers stabilize their linguistic system in late adolescence, with a decreasing tendency to adopt new forms, so that apparent-time studies will underestimate the rate of change in most cases only slightly (Sankoff & Blondeau 2007). As a result, the apparent-time pattern corresponding to change in progress shows sharp incrementation among children, reaching a peak at about seventeen years of age, and a linear declining function of age among adults (Labov 2001, Tagliamonte & D'Arcy 2009).

Once sound change in progress has been identified, the further study of language in its social context can throw light on questions that have been raised on the nature of linguistic change (Weinreich et al. 1968): What are the CONSTRAINTS that distinguish possible from impossible changes? What is the path of TRANSITION from one stage to another? How is change EMBEDDED in the linguistic and social system? How does the social EVALUATION of a change affect the mechanism of change? And what determines the ACTUATION of change at a particular place and time? It has become evident that definitive answers to these questions call for a considerable expansion of the data sets used to address them.

* The research reported here has received support from a series of NSF grants, which is gratefully acknowledged: #7500245, 'The quantitative study of linguistic change and variation'; #7610980, 'Research on linguistic change in progress'; #921643, 'Automatic alignment and analysis of linguistic change'.

[1] Apparent-time studies are exemplified by Labov 1963, 1966, 2001, Cedergren 1973, Trudgill 1974, Sankoff & Thibault 1980; panel studies by De Decker 2006, Gregersen et al. 2009, Harrington 2006, MacKenzie & Sankoff 2009. Poplack & Dion 2009 and the work to be presented here are long-term trend studies.

This article reports the results of such an expansion to describe a hundred years of change in the vowel system of Philadelphia, through yearly studies of local neighborhoods across the city from 1973 to 2010. A database of 899,000 vowel measurements has been created with new techniques of forced alignment and automatic measurement that have increased speed and accuracy by several orders of magnitude. With these data, we are able to describe the vowel systems of 379 speakers with dates of birth ranging from 1888 to 1991. With these empirical foundations we chart the path of change in progress in finer detail than in previous studies, and make a substantial contribution to the transition and embedding problems in the theory of language change.

2. Phonological framework. The phonological framework that is used in this account of Philadelphia vowels is the hierarchical structure of four vowel subsets adopted by the *Atlas of North American English* to compare all North American dialects (Labov, Ash, & Boberg 2006; henceforth *ANAE*). It utilizes the binary notation that registers the diphthongal character of North American long vowels and the phonotactic generalization that no words terminate with a short stressed vowel in American English. In Table 1, the Wells (1982) word-class terminology is added for those more familiar with that notation. The /æh/ class is unique to the Mid-Atlantic States, representing the morphologically and lexically conditioned split of tense and lax short-*a*.[2] Note that /o/ is unrounded in Philadelphia.

	SHORT		LONG					
			UPGLIDING				INGLIDING	
			FRONT UPGLIDING		BACK UPGLIDING			
	V		Vy		Vw		Vh	
NUCLEUS	front	back	front	back	front	back	unrounded	rounded
high	i	u	iy			uw		
	KIT	FOOT	FLEECE			GOOSE		
mid	e	ʌ	ey	oy		ow	æh	oh
	DRESS	STRUT	FACE	CHOICE		GOAT		THOUGHT
low	æ	o		ay	aw		ah	
	TRAP	LOT		PRICE	MOUTH		PALM	

Table 1. Binary phonemic representation of Philadelphia English vowels (with J. C. Wells word classes added).

3. Earlier studies of the Philadelphia vowel system. In 1972, the project on Linguistic Change and Variation in Philadelphia (henceforth LCV) began a study of the social context of linguistic change in the city with the aim of determining where in the social system the leaders of change were to be found. Ten socially stratified neighborhoods were selected for long-term interviewing over three or four years. The vowel systems of 116 speakers were analyzed acoustically, five to ten tokens of each vowel class having been selected.[3] The generality of the results for the city was confirmed by a random sample of sixty telephone users. Procedures and results are described in detail in Labov 1980, 2001.

[2] The following representations are used throughout the article: a vowel followed by /y/ indicates a front upgliding diphthong, /w/ indicates a back upgliding diphthong, and /h/ indicates an ingliding diphthong; F appended to a vowel symbol indicates the free allophone, C indicates the checked allophone, 0 indicates vowels before voiceless consonants, and N indicates vowels before nasals; Tuw = /uw/ after coronals, and Kuw = /uw/ after noncoronals.

[3] Most vowel analyses were from the first interview, though several of the central figures in the social networks were recorded many times, and variation in the social context was a central feature of one study (Hindle 1980).

Figure 1 (from Labov 2001, fig. 4.8) displays the LCV findings for the Philadelphia vowel system as a whole, with circles for the means and arrow vectors showing values for speakers twenty-five years younger and older than the mean. For example, the mean value for F1 of checked /eyC/ in *made*, *pain*, *eight*, and so on is 579 Hz, and the age coefficient for F1 is 1.04. The expected value for speakers twenty-five years younger than the mean is then 579 – 25 * 1.04 or 563.

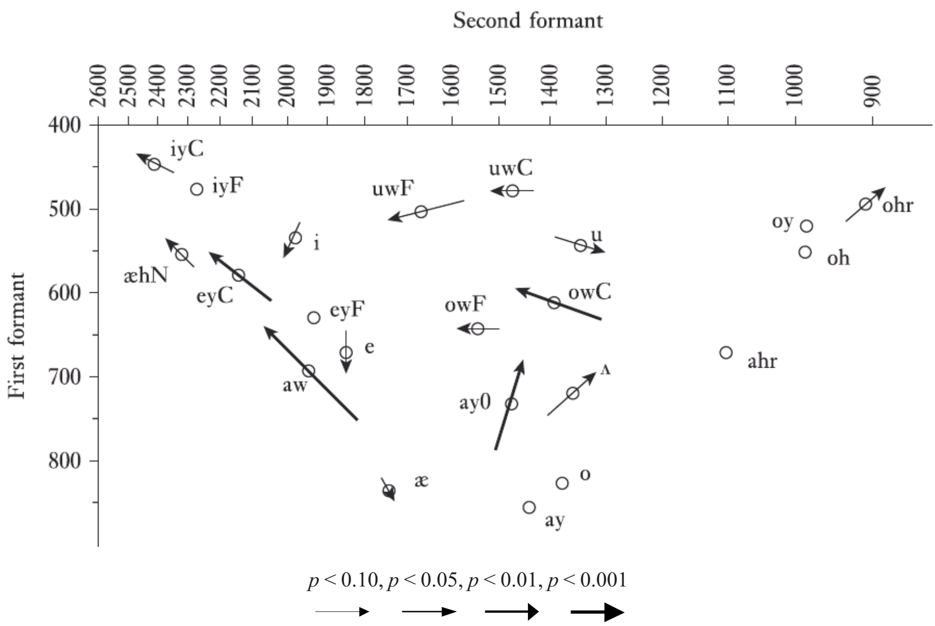


FIGURE 1. Movement of Philadelphia vowels in apparent time of the 1970s. Circles show mean values for 116 speakers in the Philadelphia Neighborhood Study. Heads of arrows show expected values for speakers twenty-five years younger than the mean, tails of arrows for those twenty-five years older than the mean.

One change—the shift of /ahr/ in *car*, *card*, and so on to mid back position—was completed and showed no variation by age or social class. The raising and fronting of the tensed allophones of short-*a* (represented in Fig. 1 by the /æhN/ allophone) was found to be a nearly completed change, with small age coefficients. The fronting of /uw/ and /ow/ were classified as 'mid-range' changes with the qualification that they were not currently attached to any vigorous movement in apparent time or anchored in any social process (Labov 2001:Ch. 5).

Three of the fifteen changes were characterized as 'new and vigorous': they did not appear in earlier qualitative reports on Philadelphia phonetics and showed a high correlation with age and other social dimensions. These changes were:

- /eyC/: raising of checked /ey/ in *made*, *pain*, etc. along the front diagonal
- /ay0/: raising of /ay/ before voiceless consonants ('Canadian raising')
- /aw/: raising of /aw/ in *south*, *down*, etc. along the front diagonal, with an accompanying shift of the glide target from [ʊ] to [ɔ].

The 1970s raising of /ey/ only in checked position is unusual in North American English. It did not appear in the qualitative phonetic observations of mid-twentieth-century observers. For /ey/, de Camp (1933) shows only [ɛi] in all environments. Kurath and McDavid (1961) use a comparable notation [ɛɨ] for most vowels. Only one token of a mid high nucleus [e] appears. Some indication of a backing to nonperipheral position, however, appears in the notation for final /ey/ in the tables for the cultivated speaker: [ε˔>ɨ]. This suggestion of the Southern Shift (Labov 2010:Ch. 1) at work in Philadelphia is reinforced by Tucker (1944), who states that 'In "long *a*," as in *day*, the first element ranges from [æ] to [a]', and compares Philadelphia to Cockney in this respect.

The second new and vigorous sound change in Philadelphia is Canadian raising of /ay/ before voiceless consonants (/ay0/). This widely reported allophonic difference separates the phoneme in a manner quite different from that found in Philadelphia /ey/. *ANAE*, map 14.10, defines such Canadian raising by a 60 Hz difference between the F1 values of the nuclei of /ay0/ and /ayV/. It is solidly maintained in Canada and strongly represented in the North, the North Central region, Eastern New England, and Western Pennsylvania, but not in the Upper South where it had been reported in Kurath and McDavid (1961). Here again, qualitative reports from earlier phoneticians show no evidence of this development in progress in mid-twentieth-century Philadelphia. For /ay/, Kurath and McDavid (1961) do not differentiate /ay0/ from /ayV/, and use a back nucleus [ɑɪ] for both; nor does de Camp (1933), who uses both [ai] and [ɑi]. Tucker (1944) states specifically that both /ay/ and /aw/ have identical nuclei before voiced and voiceless finals, though they are quite different in his own speech and 'in most American dialects'.

The third vowel undergoing new and vigorous change is /aw/, which does not show the parallel Canadian raising in Philadelphia. In the LCV study, for older speakers the nucleus was low front [æ] with a back upglide as in *out* [æʊt]. Middle-range speakers raised the nucleus to [ε] and lowered the glide to [o] as in [εot], and advanced speakers raised [ε] to [e] and lowered the glide to [ɔ] as in [eːɔt].

4. The philadelphia neighborhood corpus. At the same time as the LCV project, a parallel series of neighborhood studies began in Philadelphia, conducted by University of Pennsylvania students enrolled in Linguistics 560 (LING560) 'The Study of the Speech Community'.[4] In this course, groups of three to six students select neighborhoods, observe the use of language in the local setting, make initial contacts, carry out interviews, trace social networks, identify linguistic variables, complete quantitative analyses, and write final reports on the use of language in the neighborhood. The course was taught yearly from 1972 to 1994, and every two years from 1994 to 2010.[5] The accumulated archive to date includes 1,107 recorded interviews from sixty-one different neighborhoods. A subset of these interviews has been selected for inclusion in the Philadelphia Neighborhood Corpus (PNC), and transcribed and analyzed acoustically (see below). In addition to the LING560 interviews, the corpus has been supplemented with additional material from other studies conducted within Philadelphia during the time span covered. Recordings selected for inclusion in the PNC were transcribed in ELAN (EUDICO Linguistic Annotator) by undergraduate research assistants in accordance with the project transcription guidelines, and were subsequently analyzed acoustically using the FAVE program suite (see §5).

A 'neighborhood' is initially defined as a 'block', comprising all of the houses on both sides of a fully inhabited street, and including corner stores, bars, churches, and parks used by residents. The target sometimes expands to more distant residences if close personal ties warrant it. The ideal goal of the neighborhood study is to become acquainted with and record as many residents as possible within the limited time of the

[4] The course has been taught mainly by Labov, together with Gillian Sankoff during the 1980s and 1990s; by Tony Kroch and Gillian Sankoff (1979–80); and once in collaboration with Erving Goffman (1980–81).

[5] It continues through the present (academic year 2012–13 at time of writing).

course, with a strong emphasis on following social networks and extended family ties. In several cases, one or two members of the LING560 research groups have continued their contacts and research over several years, sometimes leading to dissertations (Matossian 1997) or publications as papers (Schiffrin 1981, Henderson 1996, Banuazizi & Lipson 1998, Charity & Sanchez 2000).

The general method used in contacting subjects and interviewing is described in Labov 1984. The goals of interviewing are tripartite: (i) to obtain samples of spontaneous speech that approach the vernacular,[6] (ii) to obtain comparable demographic data on history of residence, schooling, occupation, and language use, and (iii) to control the use of linguistic variables in formal elicitation and field experiments.

Figure 2 shows the geographic distribution of the neighborhoods studied by LING560 classes from 1973 to 2010. The main concentration was on the mainstream white neighborhoods in South Philadelphia, Kensington, Port Richmond, Manayunk, Roxborough, and Overbrook, but neighborhoods with African American, Hispanic, and Asian populations are also represented. This report will deal with the linguistic development of the white Philadelphia neighborhoods, but future studies will deal with the interaction of communal groups with that system (Labov 2010:Ch. 16).

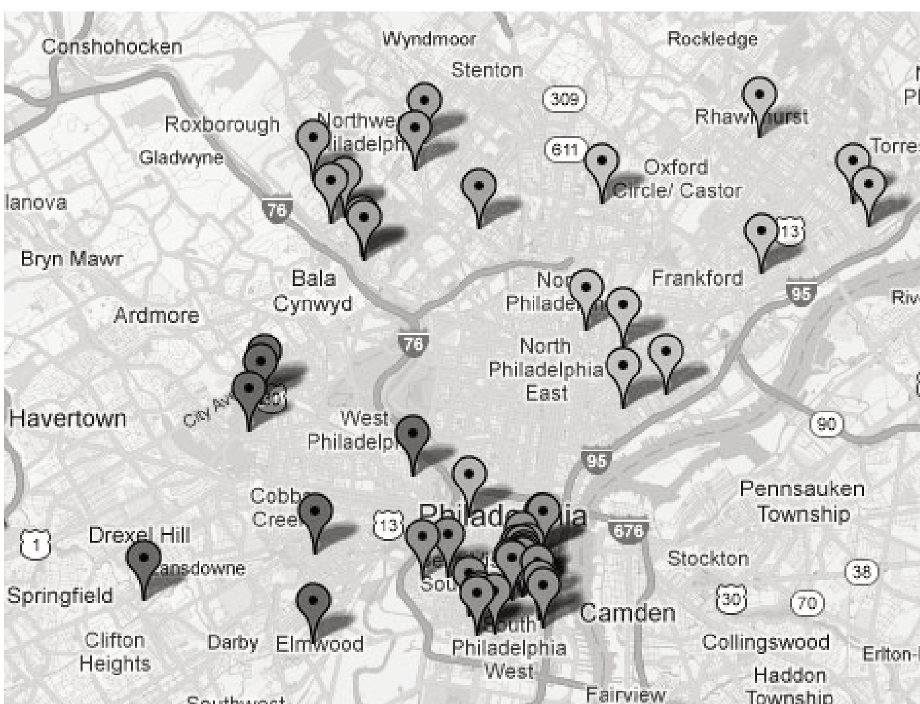


FIGURE 2. Location of sixty-one neighborhoods studied by LING560 students in the Philadelphia Neighborhood Corpus, 1973–2010.

5. FORCED ALIGNMENT AND AUTOMATIC VOWEL FORMANT MEASUREMENTS. The vowel measurements carried out by the LVC project were the product of manual selection

[6] That is, to take steps toward a solution to the 'observer's paradox' (Labov 1972): to observe how speakers behave when they are not being observed. Among the four methods of reducing the effect of observation, the most productive are techniques for eliciting narratives of personal experience.

of tokens of phonemic categories (five to ten tokens each) followed by hardware-implemented LPC analysis. The processing of an individual vowel system required approximately forty hours per selection, typically yielding 300–350 measurements. Software advances since that time have facilitated the routines for vowel measurement (e.g. PRAAT, ESPS (Entropic Signal Processing System)). However, selecting the words containing a given vowel and choosing the point in time for formant measurement remained time consuming until the development of programs for forced alignment (e.g. Yuan & Liberman 2008) and automatic formant measurements (Evanini 2009).

The present study uses these techniques to increase the number of vowel measurements obtained from a single interview by an order of magnitude (from 300–350 to 3,000–9,000) by using the FAVE (Forced Alignment and Vowel Extraction) program suite. Transcripts from the PNC are exported from ELAN in a tab-delimited .txt format and submitted to FAVE-align, an adaptation of the Penn Phonetics Lab Forced Aligner (Yuan & Liberman 2008) specifically designed for sociolinguistic interviews or other types of recordings with multiple speakers. FAVE-align makes use of the fact that speakers are transcribed in short annotation units, or breath groups (corresponding to roughly one sentence each) in ELAN. FAVE-align aligns each annotation unit, conserving the structure of the original transcription, which allows for an accurate representation of speaker overlap (speakers talking at the same time), background noises, and so on. The Penn Phonetics Lab Forced Aligner uses the HTK Toolkit for phonetic alignment (which itself has been in development since 1989), which transforms orthographic transcriptions into phonemic notation using the CMU Pronouncing Dictionary,[7] with missing words supplied by the user. This yields a phonemic representation of each utterance, which is in turn time-aligned with the speech signal. The result is a Praat TextGrid with two tiers for each speaker: an orthographic tier and a phonemic tier, based on the ARPABET notation of the CMU dictionary.

This resulting TextGrid is then submitted to a Python program (FAVE-extract) for automatic vowel measurement. This is a modification of Evanini 2009, designed to improve the accuracy of the formant measurement and to ensure that measured formant frequencies correspond to the auditory impression of the tokens in question. First, the maximum formant to be passed to Praat's formant tracking algorithm is set based on the speaker's sex (5500 Hz for females, 5000 Hz for males). Then, formant tracks are estimated based on a range of different poles in the LPC analysis (6, 8, 10, and 12), producing a set of four candidate formant tracks. From each set of candidate formant tracks, a single measurement point is chosen to represent the central tendency of the nucleus as a whole. Certain techniques developed by the *ANAE* were adapted and refined for automation of this step. Some vowels have special heuristics for determining their measurement point:[8]

- /eyC/, /eyF/, /ayV/, and /ay0/: The measurement point is selected at maximum F1 of the estimated formant track.
- /owC/, /owF/, and /aw/: The measurement point is selected at the midpoint between the segment onset and maximum F1 of the estimated formant track.
- /Tuw/: The measurement point is selected at the vowel onset.

[7] Available at http://www.speech.cs.cmu.edu/cgi-bin/cmudict.

[8] Several other heuristics were included in FAVE-extract as options. While the data presented in this article reflect the measurement-point selection method described here, several others can be selected in the online interface.

- All other vowels: The measurement point is selected at one-third between onset and offset, as was found effective by Evanini (2009).

These heuristics were found to reduce measurement errors due to choosing a measurement point too far into the nucleus-glide transition. The F1, F2, and log-bandwidth of F1 and F2 are taken at these measurement points to form a set of candidate measurements. For the sake of clarity, it should be understood in this section that one 'measurement' consists of the set {F1, F2, log-bandwidth F1, log-bandwidth F2}, and with the four different pole settings, we have extracted four such sets.

This set of candidate measurements is then compared to the distribution of F1, F2, and log-bandwidth of F1 and F2 of the same vowel in the hand measurements from the *Atlas of North American English*. Specifically, the Mahalanobis distance (essentially a multidimensional *z*-score) is calculated between each measurement and the *ANAE* distribution. The candidate measurement with the smallest Mahalanobis distance is taken as the final measurement. We can refer to this method of comparing a candidate set of measurements to a previously established distribution of measurements as Bayesian formant tracking. In the terminology of Bayesian inference, the *ANAE* distribution is the PRIOR, the set of candidate measurements is the LIKELIHOOD, and the measurement that is ultimately chosen is the POSTERIOR. Importantly, this comparison method does NOT simply shrink the measurements of a given speaker toward the *ANAE* distribution, since it selects only one measurement from the set of candidates, without weighting or scaling that measurement. There may actually be no candidate measurement that is particularly close to the *ANAE* distribution. In this sense, it is fully possible to arrive at measurements that had low prior probabilities, or were unexpected.

FAVE-extract then reevaluates the selected measurements based on the speaker's own distribution. After comparing the measurement candidate set to the *ANAE* distribution, a single measurement is arrived at for each token. FAVE-extract estimates the multidimensional distribution of each vowel sound for the speaker based on these measurements. It then iterates back over every vowel token, comparing each candidate measurement for that token to the speaker-specific distribution for the vowel in the same way it previously compared them to the *ANAE* distribution, selecting the measurement with the smallest Mahalanobis distance. This two-step process (comparison to the *ANAE* distribution, followed by comparison to the speaker-specific distribution) eliminates the vast majority of gross errors in formant estimation.[9]

For comparison across age and gender, all formant measurements are normalized using the Lobanov (1971) normalization procedure, which transforms a speaker's vowel space into *z*-scores.[10] These *z*-scores are then rescaled to hertz (Hz) values with an overall mean of 650 Hz and a standard deviation of 150 Hz for F1, and an overall mean of 1700 Hz and a standard deviation of 420 Hz for F2.

Figure 3 shows the distribution by year of interview and age of the 379 speakers in the Philadelphia Neighborhood Corpus currently transcribed and analyzed by the FAVE program suite. Density of coverage is greatest from 1973 to 1994, when LING560 was taught annually.

[9] For further information on the FAVE program suite, see the FAVE website http://fave.ling.upenn.edu. This website provides an interface that allows users to upload their own sound files and transcriptions (for FAVE-align, the aligner) or TextGrids (for FAVE-extract, the formant measurement program) to the server, which processes their data and returns the results as email attachments.

[10] See Adank 2003. The data for the LCV project of the 1970s were normalized with the logmean procedure (Nearey 1977, Hindle 1978), but our studies of the PNC data find the Lobanov method superior in eliminating differences due to vocal-tract length without eliminating differences in social distribution.

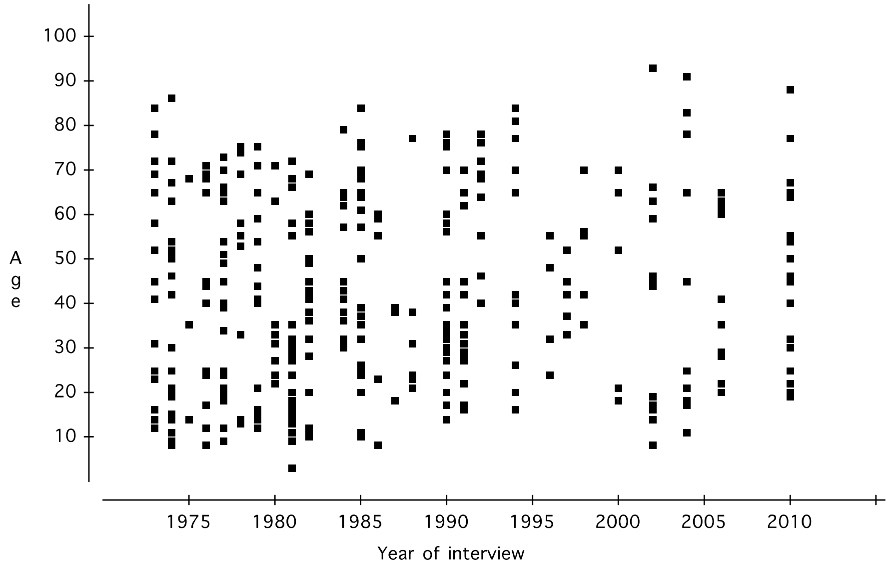


FIGURE 3. Distribution of the 379 speakers in the Philadelphia Neighborhood Corpus currently transcribed and analyzed by the FAVE program suite.

5.1. ACCURACY OF AUTOMATIC VOWEL MEASUREMENT. Past efforts to automatically measure formant values of vowels have been accompanied by a loss of precision, largely the result of erroneous selection of reinforced harmonics to represent formant values. The FAVE program suite allows us to increase the number of measurements considerably. A fifty-minute interview yields approximately 9,000 measurements of vowels of duration greater than 50 ms, as opposed to 300 by the typical routine of hand selection and measurement. Figure 4 plots the number of vowels measured for twenty vowel categories for one *ANAE* subject using hand measurements, and one PNC subject analyzed using the FAVE program suite.

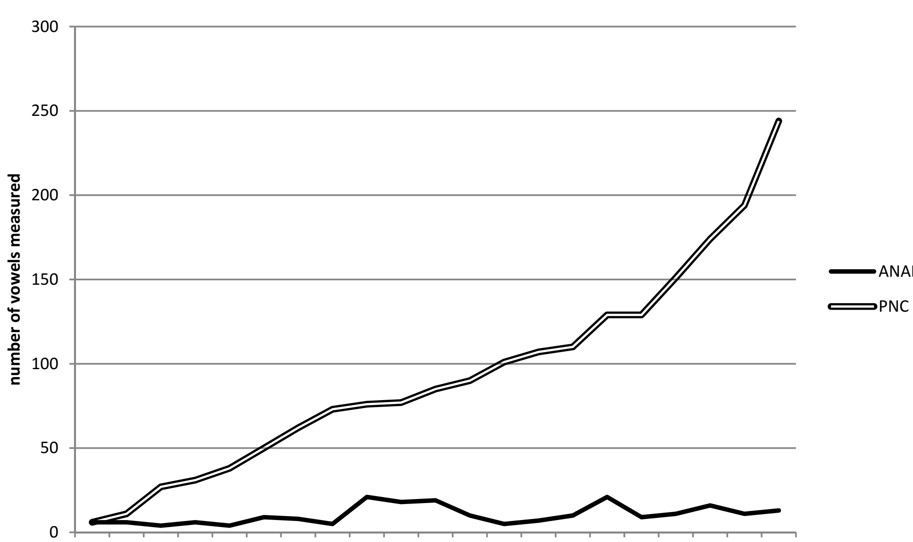


FIGURE 4. Number of tokens measured per vowel category for *ANAE* subject John O'D. (total $N = 321$) and PNC subject Patrick M. (total $N = 6,044$).

This volume of measurement raises an immediate question: is the increase in the number of tokens measured accompanied by a gain or loss of precision? This is answered by Figure 5, which calculates the precision of the mean values by the standard error of the means for each vowel category for these two speakers. The standard error of the mean of a vowel cluster (vs. the standard deviation) is of crucial importance to our arguments in this article because we use within-speaker vowel means for nearly all of our analysis and inference. Comparing Figs. 4 and 5, it is evident that once the number of tokens in a category rises above fifty (for the vowel /Kuw/), the standard error of the mean falls well below 10 Hz and stays there.

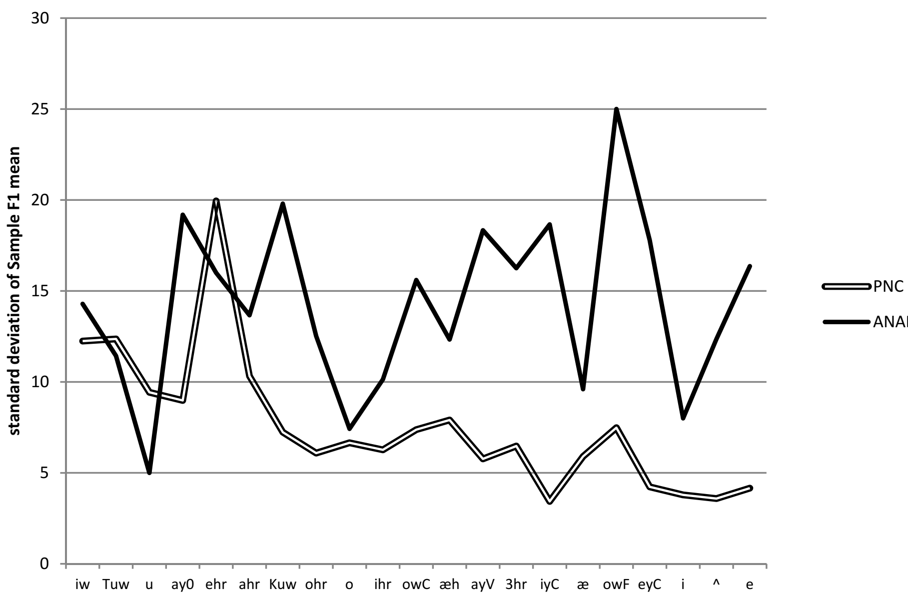


FIGURE 5. Standard error of the mean for F1 in analysis of two Philadelphia subjects: *ANAE* subject John O'D. (total $N = 321$) and PNC subject Patrick M. (total $N = 6{,}044$).

6. LINEAR INCREMENTATION OF SOUND CHANGE. We now apply these methods for the automatic measurement of vowel systems to 379 speakers with dates of birth ranging from 1888 to 1991, using 899,000 measurements to trace the progress of sound change in Philadelphia for over a century.

Language change has been shown to exhibit an S-shaped incrementation, over time: change begins slowly, accelerates to a maximum, then declines in a manner closely modeled by the logistic function. This pattern obtains both for changes involving competition between two variants (Kroch 1989) and for change along continuous gradients like the vowel shifts discussed here.

In addition to the S-shaped generational change, language change logically must also involve change in individual speakers' language between early childhood and late adolescence. At birth, children will not be the most advanced speakers along the axis of change. In fact, it has been shown that young children adopt the linguistic system of their primary caretakers in fine quantitative detail (Roberts 1997, Foulkes et al. 2005, Smith et al. 2009), even though that linguistic system may be an entire generation behind along the axis of language change. Figure 6 is a model of the incrementation of language change. The horizontal axis registers the age of speakers in four-year intervals and the vertical axis the degree of advancement of an arbitrary change. The symbols track the results of successive measurements of the community pattern every four years. Speakers from five to seventeen augment their use of the change by a logistic incrementation. From age seventeen onward, each individual's language changes along the axis of change at a reduced rate of 1/age^2. This model produces a near linear incrementation of language change across generations for speakers aged seventeen and over, which has been observed in nearly every study of language change, as well as an 'adolescent peak' in apparent time, which has also been observed by empirical study of language change (Labov 2001:Ch. 19, Tagliamonte & D'Arcy 2009).

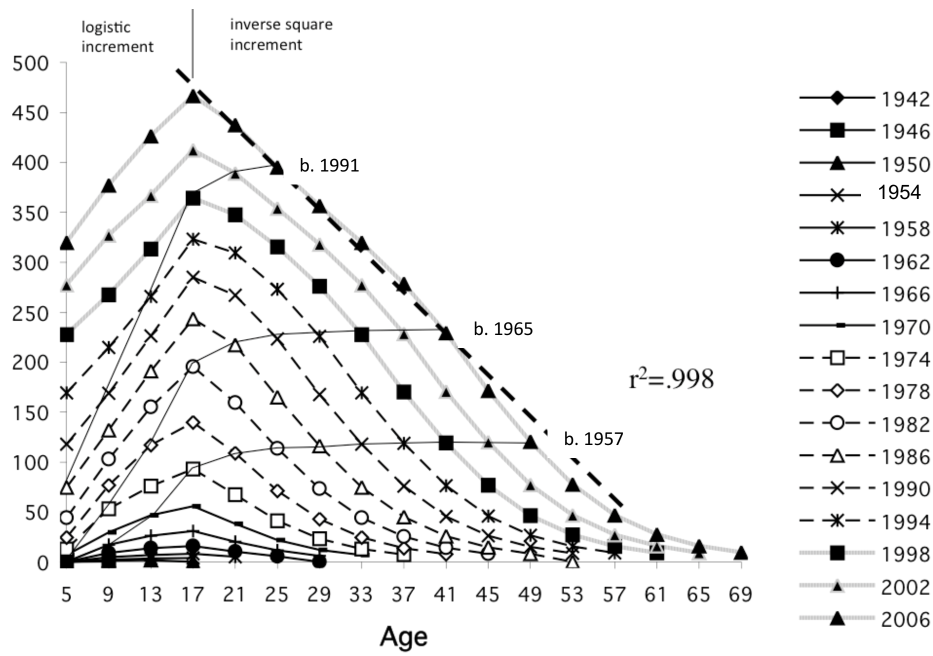


FIGURE 6. Model of an arbitrary sound change in four-year periods with logistic incrementation to age seventeen and inverse square incrementation thereafter.

In short, when plotting patterns of language change across speakers' age, the observed trends in speakers between childhood and late adolescence reflect patterns of language change within individuals, and trends seen after late adolescence into adulthood reflect language change across generations.

The adolescent peak also appears in the Philadelphia Neighborhood Corpus data, as illustrated with two vigorous sound changes: the raising of /eyC/ along the front diagonal, and the raising of /ay0/ on the F1 axis. In Figure 7, these changes are plotted across speakers' age for all speakers in the PNC. Both changes exhibit an adolescent peak in the seventeen-to-nineteen age range. Since the focus of this article is on intergenerational language change, as opposed to intraspeaker language change, we exclude the data from speakers aged seventeen and under from here on, confining our analysis to the 264 white adult speakers of the PNC.

6.1. ACOUSTIC MEASURES. We track changes across time in F1 and F2 of vowels, as these are well-known measures of vowel height and backness. Several of the vowel movements we are investigating, however, do not exclusively move along the height or

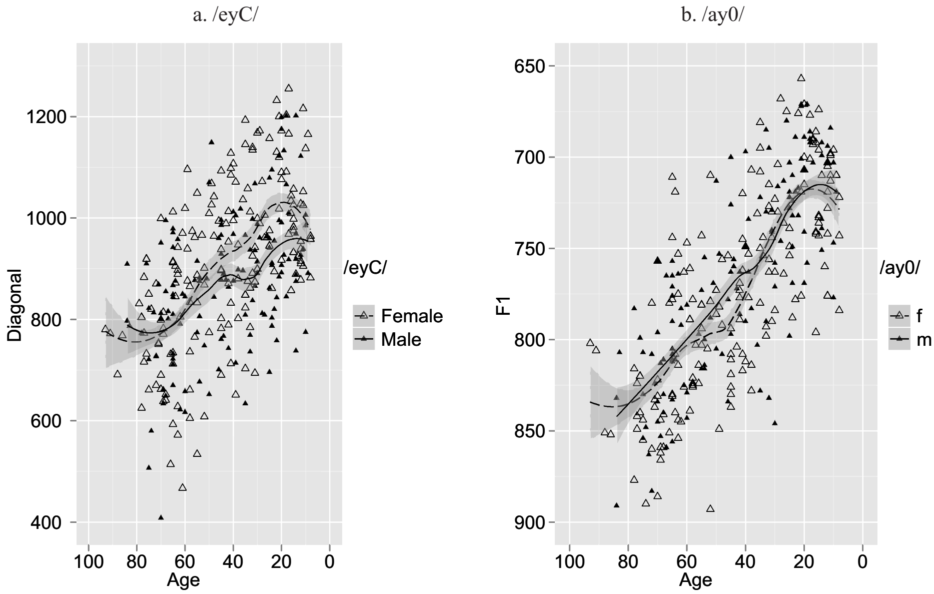


FIGURE 7. Raising of /eyC/ along the front diagonal and of /ay0/ on the F1 axis by age and sex for 310 white speakers from the Philadelphia Neighborhood Corpus, showing a peak at 17–19 years of age; f: female, m: male.

backness dimension, but a combination of the two, notably, /eyC/, /aw/, and /æh/. These vowels vary in a diagonal trajectory along the front periphery of the vowel space. We have found that a measurement of this diagonal movement along the front periphery is best derived by the parameter F2 – (2 * F1). Figure 8 shows how this measure fits the front periphery of the distribution of mean values of all vowels from all speakers. The points are shaded according to their diagonal measure, and the diagonal direction is indicated by the solid line.

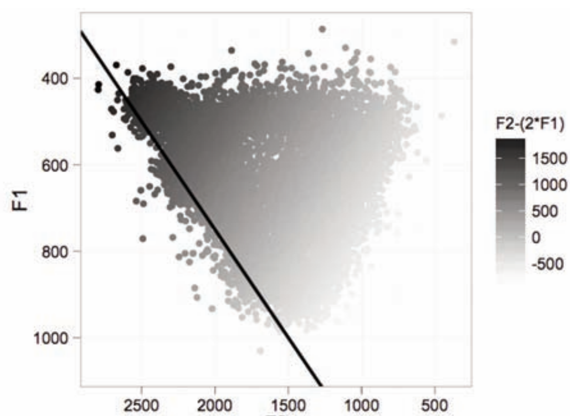


FIGURE 8. Measurement of location along the front diagonal of the vowel space as derived by F2 – (2 * F1).

6.2. TEMPORAL MEASURES OF CHANGE IN PROGRESS. Three possible temporal measures can be considered for the analysis of the PNC data. Age alone might show age grading rather than change in progress, since speakers of a given age were recorded across a thirty-eight-year time range. We might also consider year of interview and date of birth (DOB) of the speaker.

One way of showing the relevance of these three temporal measures is to examine the r^2 statistic associated with a linear regression analysis of the position of /eyC/ along the front diagonal. If the variation of /eyC/ is a case of age-grading, with no change in the community, then r^2 for the amount of variation explained by year of interview will be zero, while r^2 for age will be equal to or greater than r^2 for DOB. If we consider a community change in which speakers of all ages participate simultaneously,[11] then r^2 for age will be zero and r^2 for year of interview will equal r^2 for DOB. If the rate of intraspeaker change shown by adults falls off sharply in the manner found in most real-time studies (Sankoff 2005, 2006, 2013, Sankoff & Blondeau 2007), then DOB will explain the most variation, followed by age and then year of interview. Although none of these three extreme possibilities is borne out by the data, Table 2 shows that DOB is well ahead of the other two temporal measures in accounting for /eyC/ and /ay0/. In this and all further studies of sound change in the PNC data we use DOB as the temporal measure, extending from 1888 to 1991.

	/eyC/	/ay0/
Year of interview	.083	.054
Age	.25	.425
Date of birth	.353	.502

Table 2. Adjusted r^2 values for linear regression showing effect of three temporal measures in explaining variance of /eyC/ along the front diagonal, and of /ay0/ on the F1 axis.

6.3. Linear incrementation of /eyC/. Figure 1 showed that in the early stages of sound change in the 1970s, Philadelphia /ey/ was much closer to /iy/ than to /ay/. Figure 9 displays the distribution of /iyC/, eyC/, and /ay/ in the speech of an older conservative speaker from the PNC. The distance between the means of /iyC/ and /eyC/ along the front diagonal is just 62% of the distance between /eyC/ and /ay/. The well-established tendency toward maximal dispersion of vowels in phonological space (Martinet 1955, Liljencrantz & Lindblom 1972, Lindblom 1988) would lead to the lowering of /eyC/, but instead Fig. 9 shows the reverse: a continued raising of /eyC/ along the front diagonal, overlapping with high front /iyC/, while vowels in free final position (eyV) remain in lower mid position.[12]

Figure 10a is a locally weighted regression (LOESS) analysis of the raising of the mean position of /eyC/ along the front diagonal F2 – (2 * F1) by date of birth for the 264 white adults. Each symbol represents the mean for one speaker. Gray areas indicate the limits of the 95% confidence intervals. The pattern shows a continuous linear incrementation from DOB 1888 to 1991. Figure 10b shows a very different pattern—almost level—for the free allophone /eyV/.[13] There is a small but significant raising of /eyV/ with a DOB coefficient of 11.5 per decade as against 33.9 per decade for /eyC/, so that the difference between the two increases steadily over the century.

[11] A rare event, approximated by the introduction of new lexicon in nationwide discourse, as in the case of *sputnik*.

[12] Fruehwald (2011) showed that this sound change is defined at the word level rather than the stem level: *days* and *played* behave like *daze* and *made*. Such a clear division between these two allophones is not found in other dialects.

[13] A similar pattern appears for F1 alone, but without clear differentiation by gender.

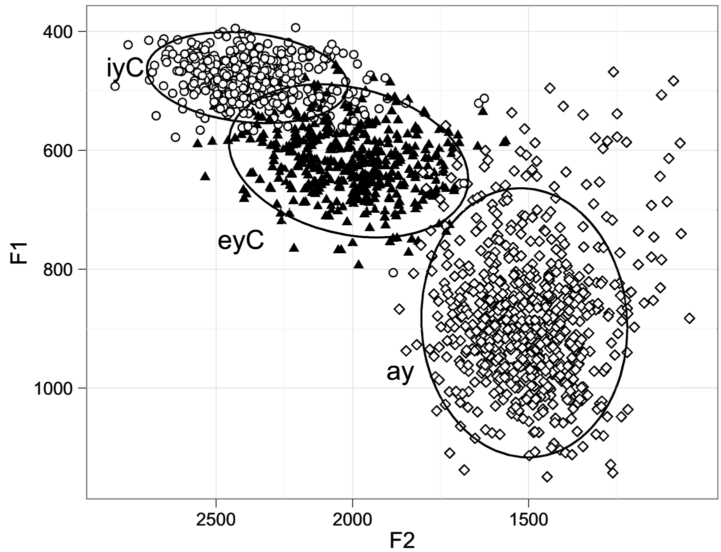


FIGURE 9. Distribution of /iyC/, /eyC/, and /ay/, and 95% data ellipses for Mary C., 62 (1973), South Philadelphia.

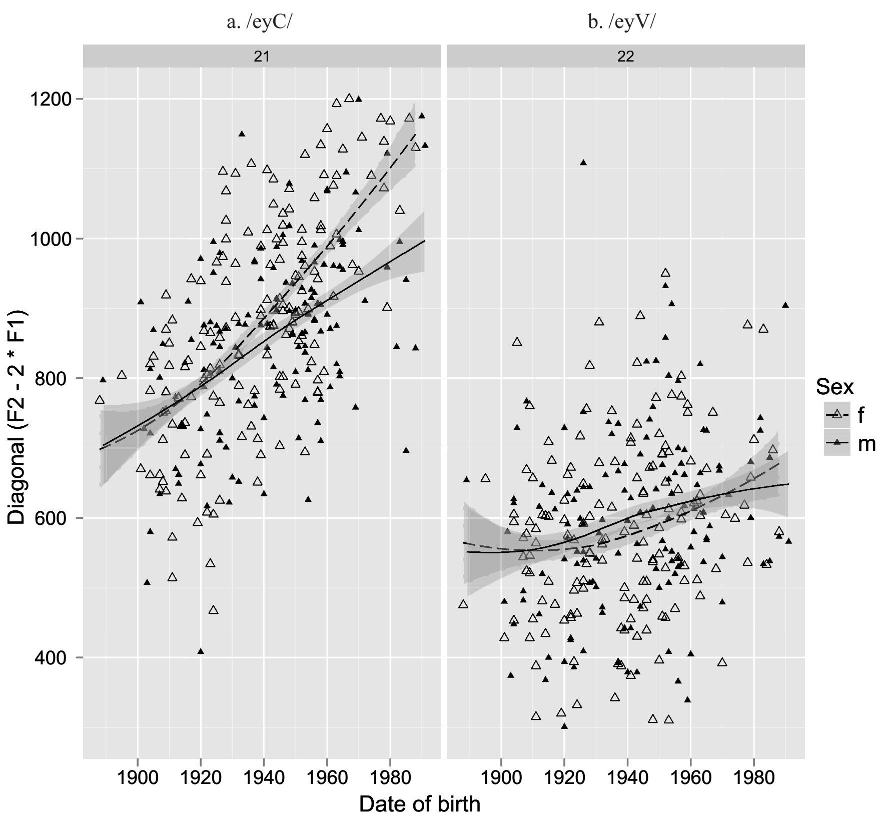


FIGURE 10. Locally weighted regression analysis of /ey/ allophones along the front diagonal by date of birth and sex in the Philadelphia Neighborhood Corpus ($N = 264$); f: female, m: male.

Figure 10a shows more than a linear regression table. The distribution of empty and solid triangles and the LOESS smoothing with 95% confidence intervals display the consistency of the relatively small, but gradually increasing gender differentiation.[14] This indicates that the pattern of the 1970s has continued in the same direction for over thirty years since.

Conn (2005) found a similar continuity in the raising of /eyC/ in his restudy of Philadelphia carried out thirty years after LCV. Again, gender was a secondary influence, with younger women leading men in the youngest age range (Conn 2005, fig. 5.21).

There is then ample evidence that the raising of /eyC/ has continued in the same direction for over a century. As in the majority of other sound changes, women are in the lead (Labov 2001:Chs. 8, 9).

6.4. The raising of /ay/ before voiceless consonants. Figure 11 is a locally weighted regression diagram comparing /ay0/ with all other /ay/, labeled /ayV/. Again, the new and vigorous change has continued in an almost linear fashion for over a hundred years of DOB. For speakers born before 1920, it appears that Canadian raising did not exist. For those born before 1900, the difference between /ayV/ and /ay0/ is a nonsignificant 28 Hz, and with each successive decade the smoothed central tendency of /ay0/ shifts upward. For the youngest speakers, the difference between the F1 of /ayV/ and /ay0/ is 220 Hz, well beyond the 60 Hz difference that defines Canadian raising in *ANAE* map 14.10.

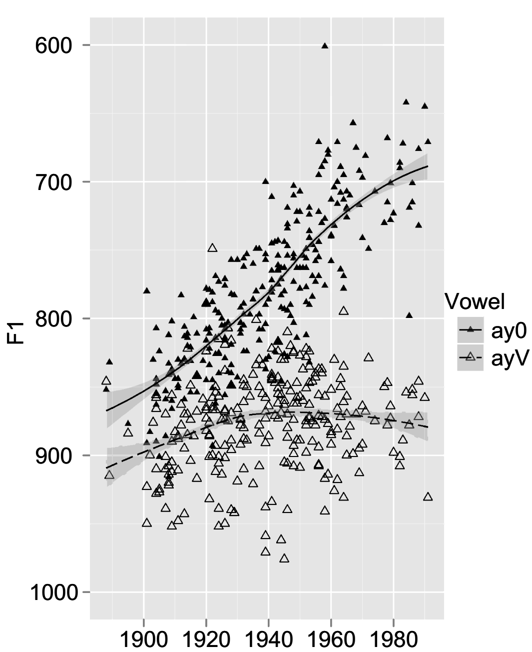


Figure 11. Locally weighted regression analysis of /ay/ allophones on F1 by date of birth in the Philadelphia Neighborhood Corpus ($N = 264$).

[14] Darker gray areas indicate the limits of the 95% confidence interval, so that any lighter gray space separating lines is a significant difference.

7. The reversal of sound change.

7.1. The raising of /aw/ along the front diagonal. The linear incrementation of /eyC/ and /ay0/ is not continued with the third new and vigorous sound change of Fig. 1. This is /aw/, an unconditioned change of the vowel of *south*, *now*, *mountain*, and so on from conservative [æʊ] to innovative [ɛːo] and [eːɔ]. Figure 12 shows a dramatic reversal of the upward path of /aw/ in *south*, *now*, *mountain*, and so on. Sometime in the 1950s, the mean value of /aw/ along the front diagonal came to be reversed, and moved steadily in the other direction. The decline is not as strong as the rise, but Table 3 shows that it is significant.

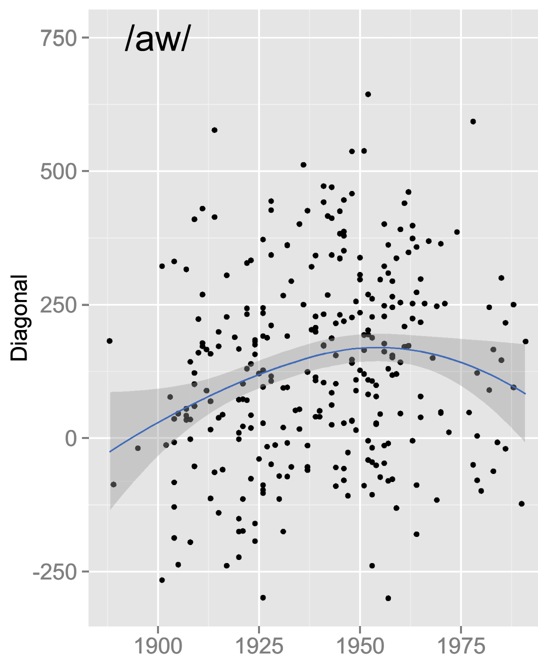


Figure 12. Locally weighted regression analysis of /aw/ along the front diagonal by date of birth in the Philadelphia Neighborhood Corpus ($N = 264$).

	born before 1958		born after 1958	
variable	coeff.	p-value	coeff.	p-value
DOB by decade	33.4	≤ 0.0001	–49.6	0.036
Female	193	≤ 0.0001	109	0.023

Table 3. Regression coefficients for /aw/ along the front diagonal by date of birth before and after 1958.

Table 3 was constructed by locating the binary division of the date-of-birth dimension that showed the most significant reversal of the coefficient value. However, that point—the year 1958—shifts its value when we examine Figure 13a, a locally weighted regression that adds sex to DOB. Here it appears that women were from the outset well in advance of men but reversed this orientation much earlier than men did. This change in orientation toward /aw/ was initiated among women born in 1940. The nucleus of /aw/ was then steadily lowered by women until those born in 1980 had reached the same moderate values as men. As in many other female-led changes, men raised their values of /aw/ a generation behind women, as male children acquired the advanced forms of their mothers a generation later (Labov 1990). The same generation lag appears in the downturn of the male values for those born in 1980 and beyond.

Figure 13b shows that speakers with higher education (beyond high school) were always conservative in their treatment of /aw/. The increasing gap between those with higher education and others shows the moderate social sensitivity to the /aw/ variable that was demonstrated experimentally by the LCV project (Labov 2001:Ch. 6).

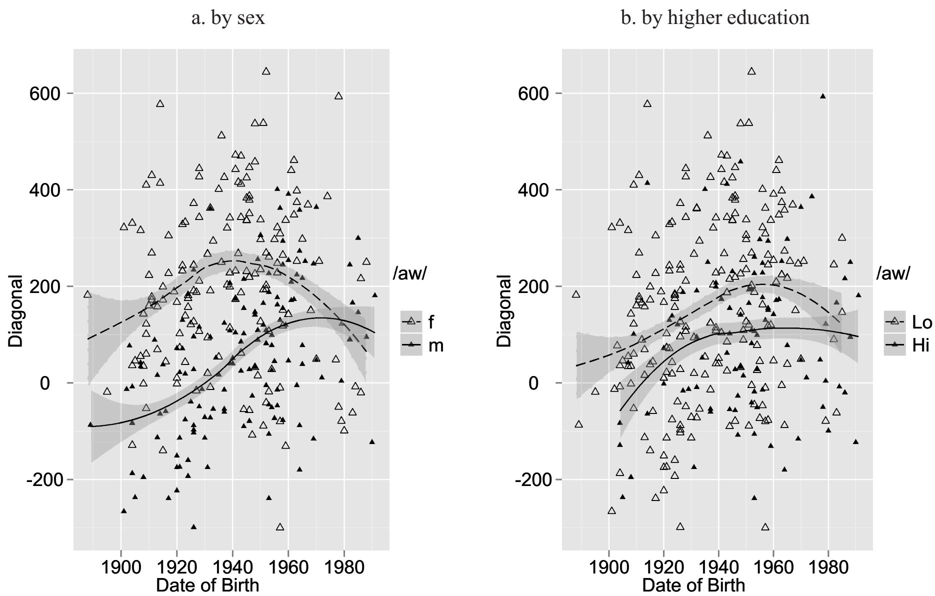


FIGURE 13. Locally weighted regression analysis of the raising of /aw/ along the front diagonal by date of birth in the Philadelphia Neighborhood Corpus ($N = 264$); f: female, m: male.

7.2. THE FRONTING OF /ow/ ALLOPHONES. Among the ‘middle-range’ changes described by the LCV project was the fronting of the nucleus of /ow/ in both checked (/owC/) and free (/owF/) allophones (Fig. 1). It can be observed that the fronting and backing of /ow/ is parallel to the front-back component of /aw/.[15] Figures 14a and 14b superimpose the mean F2 values of /aw/, /owC/, and /owF/ by DOB.

Figures 14a and 14b agree in the location of the change in the speech community and show the method for defining a point in time when community values were effectively reversed. They differ in the values of the LOESS span parameter, which sets the width of the window used for the locally weighted regression procedure. The span of 1.0, seen in Fig. 14a, is the relatively broad setting used in most of the figures in this report.[16] Both 14a and 14b show a remarkable parallel in the steady increase of fronting, with /aw/ in the frontest position, /owF/ next, and /owC/ in the rear, up to DOB 1940, and then a steady and parallel decline. Fig. 14b shows a narrower span setting of 0.7, with a resultant sharpening of the peak, defined even more precisely at DOB 1940.

[15] The front-back component of the movement of /aw/, as reflected in second formant values, was found to be more closely correlated with social factors than the first formant values in the LCV study (Labov 2001:Ch 5).

[16] With the exception of Fig. 7, which focuses more narrowly on the peak values for younger speakers.

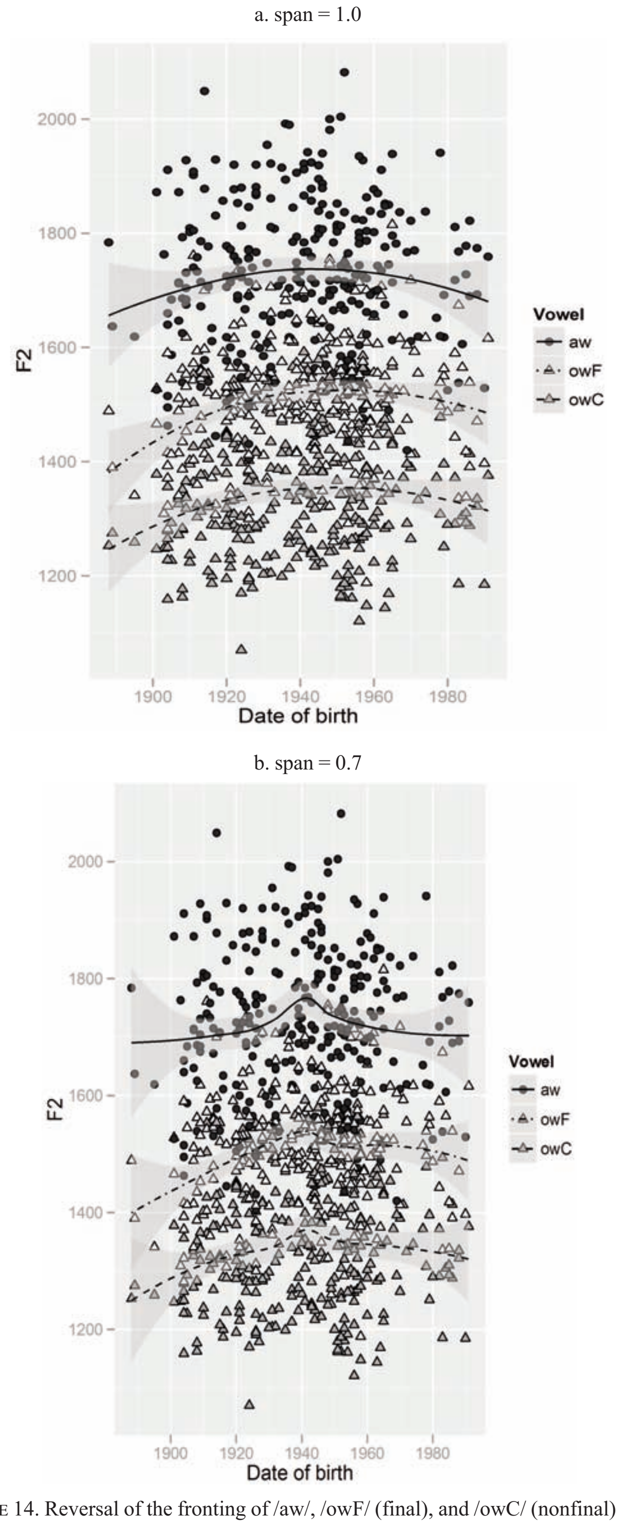


FIGURE 14. Reversal of the fronting of /aw/, /owF/ (final), and /owC/ (nonfinal) in the Philadelphia Neighborhood Corpus (N = 264).

Given the difference between the point of inflection for women and men for /aw/ in Fig. 13, it is worth asking whether the date for this radical reversal of /owC/ and /owF/ is also different for men and women. An examination of the patterns by sex shows that women are entirely responsible for the reversal of the fronting of all three variables in Fig. 14, and that the reversal takes place for the speakers born after 1940. Figure 15 displays the development of the fronting of /ow/ by sex for both the checked and free allophone. Though the F2 values for /owF/ are some 150 Hz higher than for /owC/, the two complex patterns are remarkably similar, reinforcing our confidence in this portrait of the dynamics of the community. For those born at the turn of the twentieth century, there is no difference between the sexes in the fronting of /ow/. The value for women then rises steeply until the turning point for those born in the 1940s, when it declines almost to the level of the outset. Men show no or very little increment for the first half of the century, so that the gap between men and women steadily rises until the 1940s, when it declines and disappears entirely for the most recent decade.

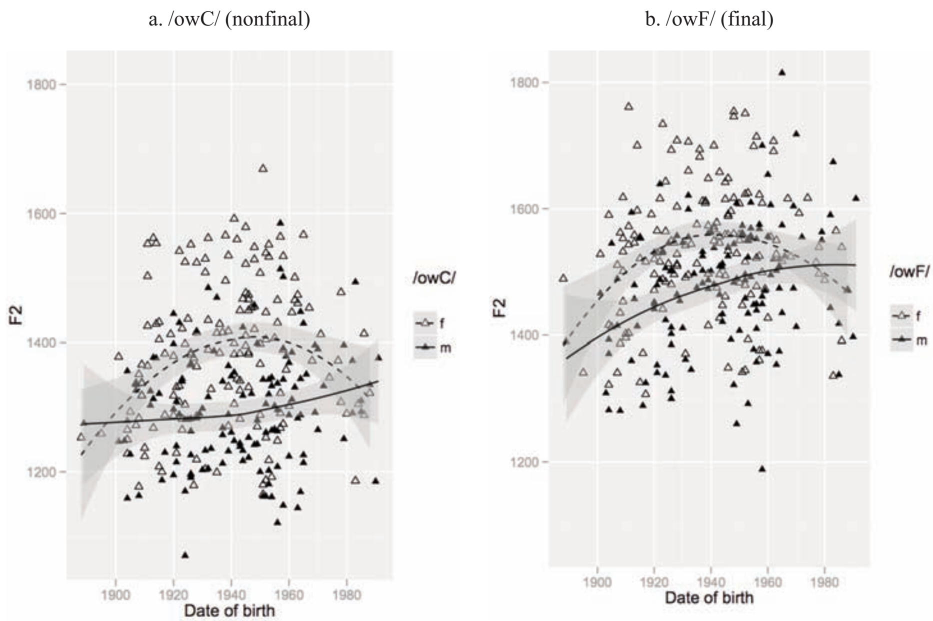


FIGURE 15. Locally weighted regression analysis of /ow/ allophones by date of birth and sex in the Philadelphia Neighborhood Corpus ($N = 264$); f: female, m: male.

Table 4 shows the coefficients for the date of birth by decade and p-values for women only for the variables of Fig. 15. The two allophones /owC/ and /owF/ are exactly symmetrical around the date of 1940, with equal positive and negative coefficients in the period before 1940 and after 1940.

	BORN BEFORE 1940		BORN AFTER 1940	
VARIABLE	COEFF.	p-VALUE	COEFF.	p-VALUE
/owF/	30.2	0.0036	–30.2	≤ 0.0001
/owC/	32.5	0.0008	–32.7	≤ 0.0001

TABLE 4. Regression coefficients for the fronting of /ow/ by females born before and after 1940.

8. A UNIFIED ACCOUNT: THE GEOGRAPHIC CONTEXT. In tracing sound changes in progress in Philadelphia, the results given so far show two radically different patterns.

- Type 1: the raising of /eyC/ and /ay0/ in a linear and uniform pattern across the entire period with no significant differences in gender or educational categories.
- Type 2: the initial raising of /aw/ along the front diagonal led by women in the first half of the twentieth century, and a reversal beginning with women born in the 1940s, with men following behind a generation later. A parallel trajectory is found for the fronting of both allophones of /ow/.

One can see phonological generalizations operating here, in the raising of /eyC/, /ay0/, and /aw/ and the general fronting of /ow/ and /aw/.[17] But the explanatory force of such generalizations is limited. None of these movements can be accounted for by structural adjustments to maximize the functional economy of the system (Martinet 1955). It has been shown that such tendencies operate within subsystems V, Vy, Vw (Labov 1994:273–79). In the Vy system, the raising of /eyC/ is in the opposite direction from what a tendency to maximal dispersion would predict, bringing it closer and closer to /iyC/, and the raising of /ay0/ cannot be seen as a response to any such pressures. In the Vw system, the fronting of /ow/ brings it closer and closer to raised and fronted /aw/ so that in *Now I know*, *now* [nɛː˂o] may be distinguished from *know* [nɛː˂o] by only a small difference in the second formant of the nucleus. To understand the driving forces behind these two types of sound change we have to look elsewhere for a common property that would account for such differences in direction.

One way of looking at sound change in Philadelphia is to examine the end result in terms of the dialect geography of North America. Figure 16 displays the 'Southeastern super-region' from *ANAE* map 11.11. The gray symbols indicate speakers with two defining characteristics: fronting of the nucleus of /ow/ beyond 1200 Hz and the maintenance of the *cot/caught* distinction. This region includes the South, and extends beyond it to embrace the southern part of the Midland area and Philadelphia and other Mid-Atlantic cities. Outside of the Southeast are the North, North Midland, Western Pennsylvania, New York City, Eastern New England, and the West.

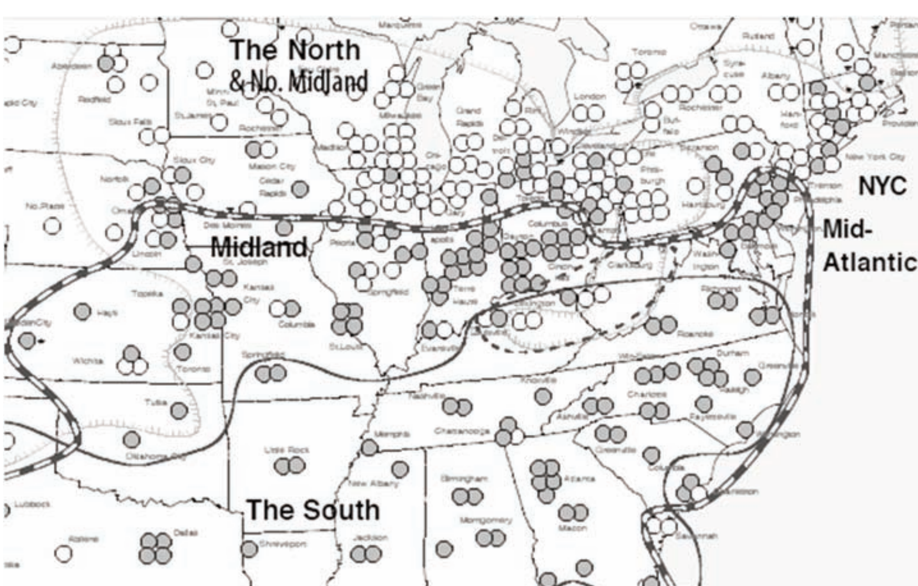


FIGURE 16. The Southeastern super-region. Barred isogloss and gray symbols: F2 of /owF/ > 1200 Hz and /o/ ≠ /oh/ (from *ANAE* map 11.11).

[17] And to some extent /uw/, in the section to follow.

The Philadelphia subjects selected by the telephone survey for the *Atlas* are all shown as gray symbols here: one man and two women, all interviewed in 1996 and born in the 1960s. Their measures for the vowel variables tracked in Figs. 10–15 are generally not far from the mean values shown for those born in the 1960s with the exception of /ay0/, where they are considerably less advanced.

Earlier qualitative descriptions of the Philadelphia dialect (de Camp 1933, Tucker 1944, Kurath & McDavid 1961) reflected an association with this Southeastern super-region as constructed by the *ANAE*. They portray Philadelphia as the northernmost of Southern cities by five indicators:

(i) While the South proper is defined as a dialect region by glide deletion of /ay/ before obstruents, a broader area of glide deletion before resonants /m, n, r, l/ extends to the southern half of the Midland region (Fig. 16). Two of the three Philadelphian subjects register this phenomenon (*ANAE* map 18.3).

(ii) Early Philadelphia English showed lowering of the nucleus of /ey/, the second stage of the Southern shift (as indicated by the statement of Tucker (1944) that the first element of the vowel of *day* 'ranges from [æ] to [a]'). *ANAE* map 10.17 shows the three *ANAE* subjects with an F1 in the range of 573 to 628 Hz, as opposed to values of 441 to 533 Hz characteristic of the North.

(iii) The most prominent difference between the North (and North Midland) and the South (and South Midland) is in the fronting of the nucleus of /ow/ in checked *boat*, *rode* and free *go*, *know*. Philadelphia has traditionally been a full participant in the fronting of this vowel to a degree characteristic of the South and South Midland, as indicated in Fig. 16. The Philadelphia *ANAE* speakers all have values above 1475 Hz, as opposed to the North and North Midland where mean values are typically less than 1200 Hz.

(iv) A parallel division between the North and Southeast is the degree of fronting of the nucleus of /aw/. Philadelphia is traditionally on the Southern side on this matter, with /aw/ fronter than /ay/, as in *right now* [rɑɪt næʊ] vs. Northern [raɪt nɑʊ]. All three *ANAE* subjects are above 1800 Hz for the F2 of /aw/.

(v) The phenomenon known as 'Canadian raising' is actually common to the North and Canada for /ay/.[18] The raising of the nucleus of /ay/ before voiceless consonants presented here as /ay0/ is a general North and North Midland phenomenon. One of the three *ANAE* subjects in Philadelphia satisfies the criterion of a 60 Hz difference between /ay0/ and /ayV/.

8.1. THE NORTHERN TREND IN PHILADELPHIA. Although the two types of sound change appear to differ radically in their trajectories across the twentieth century, they are similar in their outcome. At the beginning of the changes, Philadelphia was aligned with the neighboring Southeastern dialects of North America. At the current endpoint, Philadelphia is aligned with North and North Midland dialects. In the first half of the twentieth century, Philadelphia sound changes were moving in opposite directions in this respect. In the second half, the type 2 sound changes were realigned and continued in parallel with those of type 1, transforming the Philadelphia dialect from a typologically Southern pattern to a typologically Northern pattern.

Of the five Southeastern features of the earlier Philadelphia dialect listed above, all but the first are shifted to a more Northern orientation:

[18] It is also reported for the Upper South by Kurath and McDavid (1961), but the *ANAE* results of the 1990s show only two points in that area.

(i) Glide deletion before resonants: maintained.
(ii) Lowering of /ey/: reversed for /eyC/ to Northern levels. When first discovered, this was seen as ‘a retrograde movement’ (Labov 1994:81).
(iii) Fronting of /ow/: Southeastern pattern increased, then reversed to Northern levels.
(iv) Fronting of /aw/: Southern pattern increased, then reversed to Northern levels.
(v) Canadian raising: introduced and increased to Northern levels.

The net result of the two types of sound changes in Philadelphia is therefore similar, but the mechanism is different. We may clarify this situation further by examining a third /Vw/ variable.

8.2. The case of /uw/: differentiation by coronality of onset. The fronting of Philadelphia low and mid back upgliding vowels was found to show a type 2 reversal in real time. Turning to /uw/, the third of these Vw vowels, we find a different situation. Here the relevant allophonic division is by place of the onset instead of characteristics of the coda. Throughout North America, /uw/ is massively more fronted after coronal consonants (Tuw)—*too*, *two*, *do*, *noon*—than after noncoronals (Kuw)—*move*, *roof*, *boot*, *coop*. The difference dwarfs all other coarticulatory effects, extending to 400–600 Hz in most cases.[19] Figure 17a displays the locally weighted regression curves for /Tuw/ and /Kuw/ in the Philadelphia Neighborhood Corpus. While /Tuw/ is of type 1, rising steadily across the century, /Kuw/ is of type 2, matching /aw/ and both /ow/ allophones. Furthermore, Figure 17b shows the gender pattern of /Kuw/ to be the same as that characteristic of /aw/ and /ow/, with women rising to a peak of fronting and then receding, and a weaker version a generation later for men.

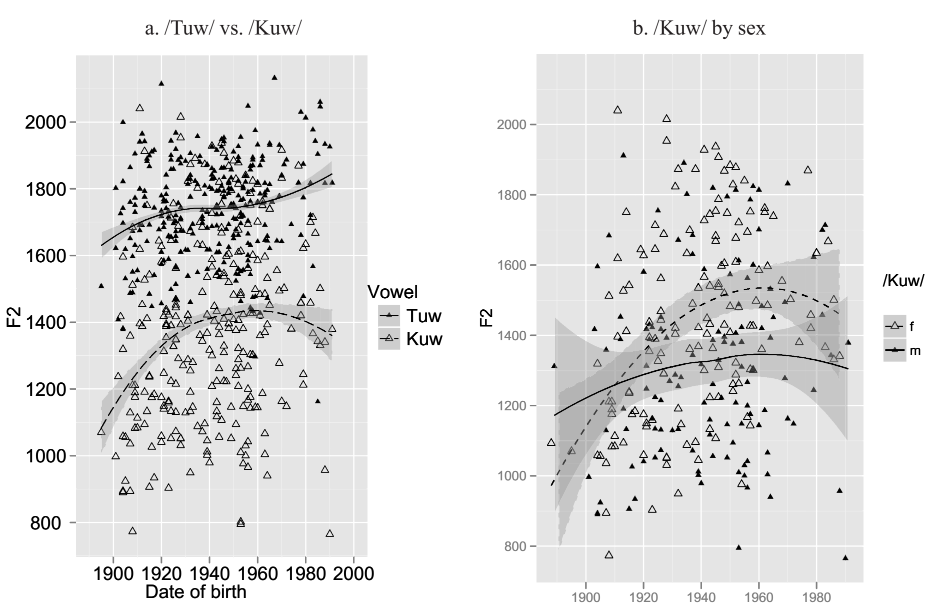


Figure 17. Locally weighted regression analysis of /uw/ allophones by date of birth and sex in the Philadelphia Neighborhood Corpus ($N = 264$).

[19] This exaggeration of the coronal onset effect has been attributed in Labov 2010:Ch. 5 to a complex series of phonological events, beginning with the total loss of the [j] glide after coronals in North American English. This led to the opposition of /iw/ vs. /uw/ in pairs like *dew* [dɪu] vs. *do* [dʊu] (*ANAE* map 8.3). This

This differentiation of /Tuw/ and /Kuw/ is consistent with the Northern trend that unifies the patterns of Philadelphia sound change in the second half of the century. The fronting of /Tuw/ beyond the mid-line of the vowel system is almost universal in North America (*ANAE* map 12.1).[20] It prevails in Canada, the Inland North, the West, and the Midland, as well as the South. By contrast, Figure 18 shows that /Kuw/ differentiates the South and South Midland from the North Midland and the North, with /Kuw/ being fronted in the southern regions but remaining back of center in the northern. The linear incrementation of /Tuw/ and reversal of /Kuw/ thus fit in with the Philadelphia pattern of turning away from its Southeastern heritage and turning toward the North.

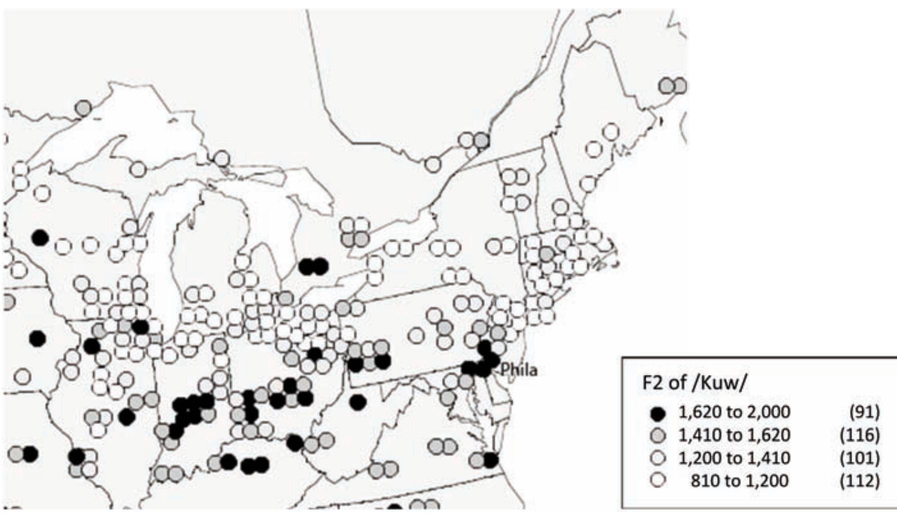


FIGURE 18. The fronting of /Kuw/ (based on *ANAE* map 10.26). Figures in parentheses represent the number of subjects in each range.

The generalization across the two types of sound change then seems clear. Dialect features that Philadelphia shares with the North and the Inland North show a linear incrementation across the century. Dialect features that differentiate Philadelphia from the North and North Midland and identify Philadelphia with the Southeastern region show an increase up to the middle of the twentieth century (for speakers born before 1940), and a symmetrical decline in favor of the Northern pattern thereafter.

9. SALIENCE. The geographic reorientation of the Philadelphia dialect might be an effect of population movement and dialect contact, following Bloomfield's principle of density (1933:476). If it could be shown that there was a sudden increase of migration to Philadelphia from North Midland areas in the 1950s, that would provide support for such a view.[21] In the absence of such data, we must infer that the type 2 reversals are the results of changes in social evaluation. We accordingly turn now to evidence for the so-

vocalic opposition was collapsed in the front position, leading to the great differentiation of the vowel from the noncoronal allophones.

[20] Only small areas of Eastern New England and Minnesota/Wisconsin are exempt from this fronting.

[21] Some inference on recent population movement can be drawn from filings for income tax exemptions (http://www.forbes.com/2010/06/04/migration-moving-wealthy-interactive-counties-map.html; accessed November 4, 2012). My summaries for 2008 show that 1,401 persons moved into Philadelphia County from Northern and New England counties (outside of the Inland North) but only 1,010 from counties in Southern states. A much greater influx would be required to account for the reversal of the 1950s.

cial evaluation of the Philadelphia changes in the twentieth century, to see how it may account for the difference between type 1 and type 2 changes and, more generally, the driving force behind these changes.

The LCV project of the 1970s explored Philadelphians' subjective evaluation of the changes in progress (Labov 2001:Ch. 6). Two types of field experiments were used. In the self-report test, subjects were asked to identify which of four pronunciations of a word was closest to their own use. The four pronunciations covered the range of forms recorded, from the most conservative to the most advanced. Results showed a significant tendency ($p < 0.0001$) to underreport the new and vigorous changes /aw/ and /ay0/ and the mid-range changes /owF/ and /Kuw/. The mean reports for /ay0/ were the lowest on the four-point scale, and for the thirty-eight subjects for whom acoustic and experimental data were obtained, the mean degree of underreporting was half that for /aw/. Responses to the self-report test for /ay0/ showed consistent lack of recognition of the more advanced forms, which were often attributed to foreigners or other dialects.

In the subjective reaction test, subjects heard speech extracts containing a variable spoken by four females with different degrees of advancement of the change and were asked to rate them on a scale of JOB SUITABILITY ('What is the highest job this person could hold, speaking as she does?').[22] The social evaluation of the variable is indicated by the difference between the rating assigned to a given extract and a 'zero' passage containing none of the variables. Results for ninety-nine subjects showed a downward shift of job ratings for the use of advanced forms of /aw/, /ow/, and /ay0/. The pattern of response was quite general across the community: multiple regression showed no significant effects for age, gender, or social class.

It appears that the Philadelphia community in the 1970s had developed a moderate degree of social awareness of the type 2 variables /aw/, /ow/, and /Kuw/, but a lower degree for /ay0/. As far as /eyC/ is concerned, there are no data on social awareness to report. It was discovered only in the course of quantitative analysis by the LCV project, and to this date no evidence of social recognition has emerged. It is never mentioned by popular observers of the Philadelphia dialect in the media, nor has it ever been recognized by any Philadelphian speaker in the course of sociolinguistic interviews from 1972 to the present.

Type 1 and type 2 changes then differ in the degree of social evaluation by members of the community in addition to their relation to the geographic context. /aw/, /ow/, and /Kuw/ are Southern oriented with moderate social evaluation; /eyC/ is Northern oriented with no social evaluation; /ay0/ is Northern oriented with a low degree of social evaluation. In the terminology of Labov 1966, /eyC/ is an indicator and the others are sociolinguistic markers. The next section considers two stereotypes: variables that are considerably more salient than those discussed so far.

10. TYPE 3: WITHDRAWAL FROM STEREOTYPES. Two features of Philadelphia phonology are frequently mentioned when discussion turns to language. One is the tensed short-*a* vowel in *mad*, *bad*, *pass*, *laugh*, and so on represented in Table 1 as /æh/. The complex distribution of this vowel has been the subject of much linguistic inquiry and analysis (Ferguson 1975, Kiparsky 1982, Labov 1989, Bermudez-Otero 2007), but the distribution is not a feature of public discussion. Public mention focuses on the quality of the

[22] In order to test for covert values that might oppose the overt valuation of the job suitability scale, a scale of friendliness was also used: 'If you got to know this speaker well, how likely is it that she would become a good friend of yours?'. No significant differences were found between responses to this question and the job suitability question.

tense vowel itself (the 'harsh, nasal *a* in *Camden* and *bad*') rather than on which words are tense and which are lax. In self-report tests, /æh/ showed by far the highest degree of underreporting. In response to the advanced forms, subjects ruefully acknowledge their own use: 'Unfortunately, it's South Philly slang, not the best pronunciation.' In subjective reaction tests, /æh/ produced the strongest negative responses on the scale of job suitability (Labov 2001:210).

The parallel back vowel is /oh/ in long open-*o* words *talk*, *lost*, *off*, and so on. Here the social stereotype is firmly fixed on one word, *water*, pronounced with a high back nucleus.[23] For the majority of the PNC speakers, both /æh/ and /oh/ are upper mid long and ingliding vowels, with F1 well beyond the 700 Hz line that distinguishes upper from lower mid vowels in this normalized system. This variable was not used in the experimental approaches to evaluation.

Figures 19a and 19b display locally weighted regression analyses of the history of the two most salient vowels across the century by date of birth and sex. For both vowels we see a general phonetic withdrawal from the traditional upper mid level. In both cases, women's vowels are considerably higher than men's, but show a steeper decline so that for the youngest speakers there is no significant gender effect. For /æh/, women's decline starts from a higher level, while those born at the turn of the century are still raising /oh/. The general decline of /oh/ starts earlier than for the /Vw/ vowels, with those born in the 1920s rather than 1940s.

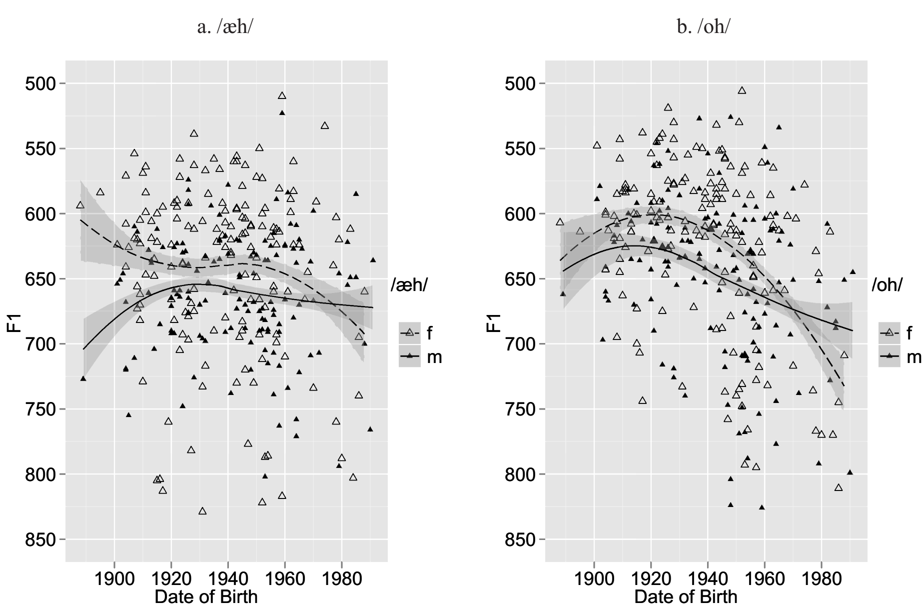


FIGURE 19. Locally weighted regression analysis showing the lowering of /æh/ and /oh/ on the F1 axis by date of birth and sex in the Philadelphia Neighborhood Corpus (N = 264); f: female, m: male.

Figure 20 shifts the social dimension from gender to education, distinguishing those with higher education (beyond the twelfth grade) from others (high school or less). In

[23] The focus on this word is enhanced by the lexical contrast of unrounded /a/ in this one word in neighboring areas of Pennsylvania. In fact, the vowel of *water* is identical with that in *daughter* in the uncorrected Philadelphia system.

the case of /æh/, the decline is largely on the part of speakers with higher education. The two educational levels are also differentiated sharply for /oh/, but both decline in parallel, with higher-education speakers leading the change. The increasing levels of education across the century[24] are reflected by the fact that 61% of the PNC adults born after 1980 had higher education but only 30% of those born before 1980. The general lowering of these vowels is largely the reaction of the higher-education group to these two salient aspects of local Philadelphia phonology. For both social groups, the withdrawal of /oh/ begins with those born in the 1920s rather than the 1940s. Table 5 is a regression table for F1 of both variables, showing the similar negative coefficients for females (higher vowels) and positive coefficients for Higher Ed (lower vowels).

	/æh/		/oh/	
VARIABLE	COEFF.	*p*-VALUE	COEFF.	*p*-VALUE
Date of birth	0.54	0.0001	1.136	< 0.0001
Female	–17	0.0099	–12	–0.069
Higher Ed	21	0.0051	19	0.012

TABLE 5. Regression coefficients for F1 of two maximally salient vowels.

In the most recent LING560 reports, Prichard and Tamminga (2011) documented the role of higher education on this withdrawal from salient features, and pointed to the increasing effect of local, regional, and nationally oriented institutions.

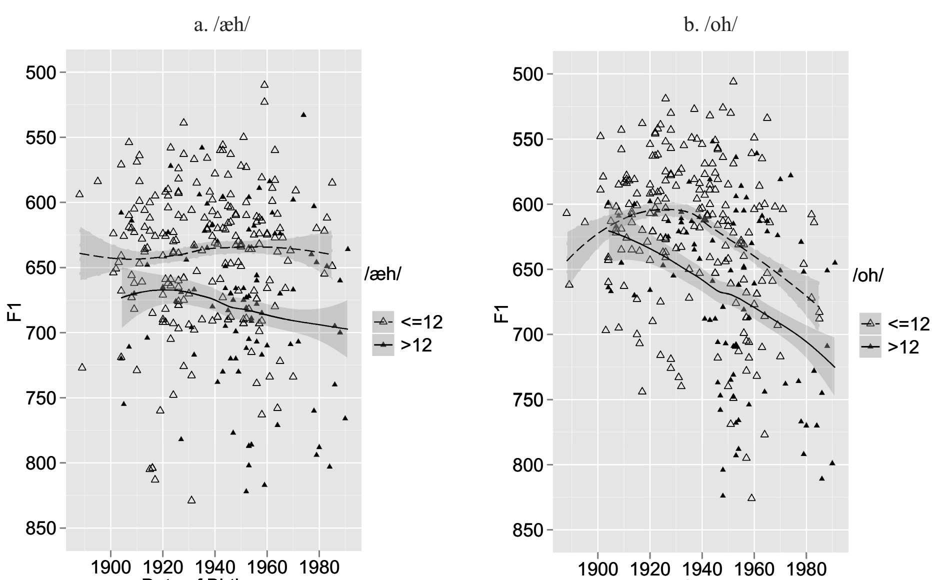


FIGURE 20. Locally weighted regression analysis showing the general lowering of /æh/ and /oh/ on the F1 axis by date of birth and higher education (> twelve years) in the Philadelphia Neighborhood Corpus ($N = 264$).

10.1. THE REORGANIZATION OF THE SHORT-*a* SYSTEM. We now turn to a new and surprising phenomenon that has to do with the phonological organization of the Philadelphia system rather than its phonetic realization: the distribution of tense and lax

[24] Percentage of those with B.A. degrees (of those who graduated high school four years earlier) rose from 20% in 1929 to 50% in 1999 (US Census, http://www.census.gov/statab/hist/HS-21.pdf).

members of the opposition /æh/ ~ /æ/. In the traditional Philadelphia phonology, short-*a* is tense in syllables closed by front nasals and voiceless fricatives and in three words before /d/ (*mad*, *bad*, *glad*), excepting the irregular verbs *ran*, *swam*, *began* and function words *and*, *am*, *an*, learned words (*alas*, *wrath*), and polysyllabic words with zero onset (*aspirin*, *asterisk*) (Ferguson 1975, Labov 1989, Roberts & Labov 1995, Roberts 1997).[25]

In Philadelphia, the withdrawal from the upper mid target is not general for all /æh/ words. Instead, we find many younger speakers with higher education converting their short-*a* pattern into the nasal system, in which vowels before nasal consonants are raised to upper mid position, while all others remain in low front position. For Philadelphians, this means raising three sets of vowels from the /æ/ class that are traditionally lax: /æ/ before velar nasal /ŋ/, for example, *bank*, *angry*, *hang*; /æ/ before nasals in open syllables, for example, *hammer*, *Miami*, *flannel*; and /æ/ in the irregular verbs *ran*, *swam*, *began*. At the same time, a host of special conditions on raising are eliminated under the general rule of laxing all vowels before oral codas (tensing *mad*, *bad*, *glad* before /d/; tensing before inflectional but not derivational boundaries; the laxing of learned words).

This most recent development of the nasal system among young Philadelphians in college is surprising in its high degree of regularity. College students frequently show an irregular result of the superposition of nonlocal norms on their local phonology.[26] But the short-*a* distributions of Philadelphia college students in our data show a remarkable regularity. This regularity will appear most clearly in the short-*a* system of Andrew P., a nineteen-year-old freshman at the University of Pennsylvania (total number of vowels measured = 7,364, yielding 179 tokens of /æ/ and 108 of /æh/) displayed in Figure 21. This is typical of the nasal short-*a* systems that have appeared most recently in Philadelphia college students from local neighborhoods. In Fig. 21a, the triangles representing tense vowels in the traditional system are divided into two groups. The fifty-four tokens before nasals, shown with a heavy black outline, are concentrated in the tensed area of upper mid phonological space, with a single exception of the word *man* (at 780 Hz, 1586 Hz). The other fifty-four triangles—vowels that are traditionally tense before the consonants /f, s, θ/—are in low front position. Their distribution matches that of the traditionally lax vowels shown by the squares of Fig. 21b (*cap*, *cat*, *pack*, *cab*, *sad*, *bag*, etc.). In Fig. 21a, one token of *ass* (at 740 Hz, 1986 Hz) edges over into the tense area.

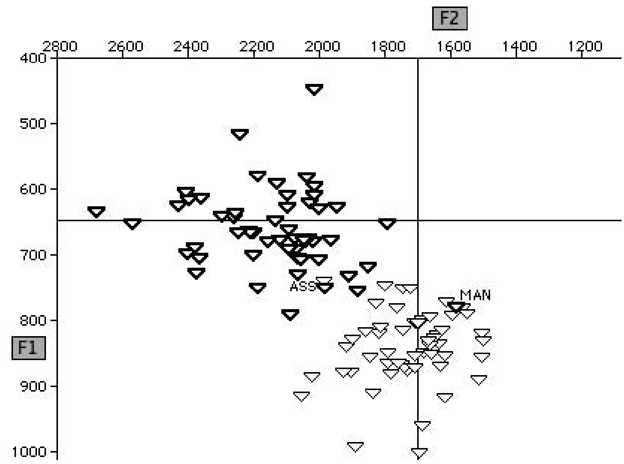
Fig. 21b also shows the tensing of a subset of traditionally lax vowels. They are shown as squares with a heavy black outline, located in the tense area: before nasals in open syllables (*Miami*, *hammer*, *Danny*), before velar nasals (*angry*, *ankle*), and the three irregular verbs that are normally lax (*ran*, *swam*, *began*). There is one exceptional case of lax *angry* (at 916 Hz, 2048 Hz).[27]

[25] The mean phonetic values for tense short-*a* for each speaker displayed in Figs. 18a and 19a incorporate the conventions of *ANAE*. This means that all short-*a* words before nasals are excluded from the calculation, since in almost all dialects of English, the distribution in this environment is quite different from others.

[26] This aspect of style shifting by New Yorkers is documented in Labov 1966 and in *ANAE* fig. 17.4. Until recently, the speech of educated Philadelphians resisted such irregularity, as shown in particular by the uniformity of the basic tense/lax split across social classes, including twenty upper-class speakers (Kroch 1996, Labov 2001:190).

[27] The token of *swam* appears in the lower edge of the tense class, due to the lowering and backing influence of the preceding /w/. Function words *am*, *an*, *and*, which are lax in the traditional system, are also subject to tensing but are not shown in Fig. 21.

a. Distribution of short-*a* words that are tense in the traditional Philadelphia system.
Bold triangles = vowels before nasal consonants (N = 108).



b. Distribution of short-*a* words that are lax in the traditional Philadelphia system.
Bold squares = vowels before nasal consonants (N = 179).

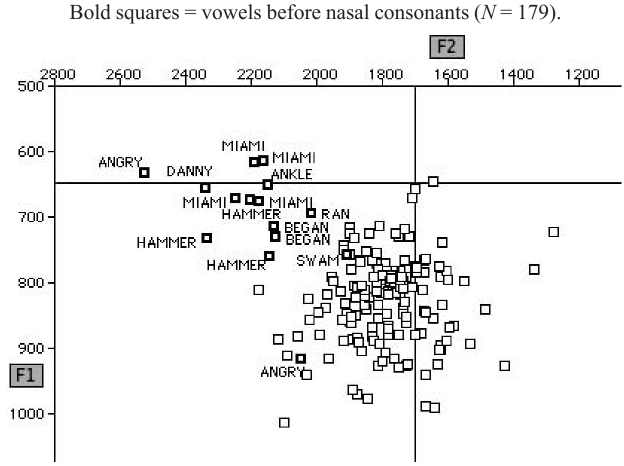


FIGURE 21. Nasal short-*a* system of Andrew P., 19 (2012), University of Pennsylvania freshman.

The withdrawal from the traditional tensing target by younger college-educated students shown in Fig. 20a is quite general, but the close to flawless implementation of the nasal system in Fig. 21 is a new development. Andrew P. is a first-year student at Penn, a graduate of 'Maxwell High School', the premier public school in Philadelphia with a high proportion of students going on to nationally oriented universities. His recording is drawn from a new body of exploratory interviews that aim to discover how general is the shift to the nasal system, and how early in life does such a systematic reformulation take place. His friends and classmates show similar patterns.

The regularity of the reorganization of the short-*a* system is shown in Table 6 for nine college students from a recent pilot study, who graduated from two different Philadelphia high schools: Maxwell and 'Archbishop Cahill', a highly rated parochial school. We can observe:

- Tensing of the traditional tense class before nasals is preserved.
- Laxing of the traditional tense class before oral consonants is almost perfectly accomplished.

- Tensing of the traditional lax class before nasals appears regularly among Maxwell graduates but variably among Cahill students.
- The traditionally lax class before orals remains intact.

			TRADITIONALLY TENSE		TRADITIONALLY LAX	
NAME	HIGH SCHOOL	COLLEGE	/æhN/	/æhC/	/æN/	/æC/
Charles	Maxwell	Tulane	26/26	0/49	16/16	0/82
Dennis	Maxwell	Yale	42/42	3/84	7/11	0/117
Andrew	Maxwell	Penn	53/54	1/52	11/12	1/162
Melanie	Maxwell	Penn	36/42	0/41	9/12	0/84
Cory	Cahill	Penn	34/43	1/71	1/10	2/112
James	Cahill	Temple	30/31	2/32	0/5	0/75
Donald	Cahill	Penn	8/14	2/19	–/–	0/33
Ken	Cahill	Penn	37/43	2/71	7/10	0/115
Jake	Cahill	Penn	39/40	4/32	4/5	0/75

TABLE 6. Tensing of short-*a* before nasal and oral consonants for college students from two Philadelphia high schools.

The nasal system of Table 6 is not without precedent in the LING560 studies. We have reports of it in neighborhoods not fully integrated into the Philadelphia speech community. One case appeared in the study of a community with many recent immigrants from Russia in the Bustleton region of north Philadelphia (Friesner & Dinkin 2006). Only one of eight speakers studied showed the Philadelphia short-*a* split, and four, including native speakers, displayed the nasal system. The nasal system has also appeared in the speech of children from southern New Jersey families with Philadelphia parents (Ash 2002). There is then reason to suggest that the nasal short-*a* system is beginning to operate as the 'default' or 'unmarked' system in the Philadelphia area.

The parallel withdrawal of the back vowel /oh/ does not lead to a similar structural organization. The distance between /oh/ and /o/ in *caught* and *cot* is greatly diminished as /oh/ moves down toward a lower mid back position, below 700 Hz, but there is no sign as yet of a merger between these two categories. Figure 22 displays the distribution of /o/ and /oh/ for Andrew P., where the two phonemes are quite distinct. At the extreme upper left is a token of *water* (at 488 Hz, 539 Hz), Andrew's version of the stereotype of the Philadelphia dialect used by others [wʊɾɚ], and two other less extreme examples of how people think that Philadelphians pronounce this word (at 603 Hz, 959 Hz and 628 Hz, 754 Hz). At the lower right are two tokens of Andrew's version of how the others (his girlfriend) insist that one SHOULD say the word (at 951 Hz, 953 Hz and 988 Hz, 989 Hz). His own versions of how he thinks he says *water* are seen at 815 Hz, 897 Hz and 741 Hz, 1025 Hz. They fall in the center of his /oh/ distribution and show, along with several other tokens from spontaneous speech, that he has a fairly good idea of how he actually realizes /oh/ in this word.

It is important to note that the withdrawal from the tense targets of /æh/ and /oh/ does not represent a general abandonment of local Philadelphia phonology. The linear incrementation described in §6 is shared by speakers with higher education, who are significantly ahead of the rest of the population in the raising of /eyC/ and /ay0/. The PNC speakers with higher education do not share the reversal of /aw/ of §7, and show a continuing advance rather than reversal of the fronting of /ow/. Figure 23a documents this behavior of higher-education speakers for /eyC/ and Figure 23b does the same for /ay0/. The withdrawal from Philadelphia phonology is entirely confined to the two salient features /æh/ and /oh/. The younger speakers with higher education can now be seen as Philadelphian in the more general sense in that they are leading both in the incrementa-

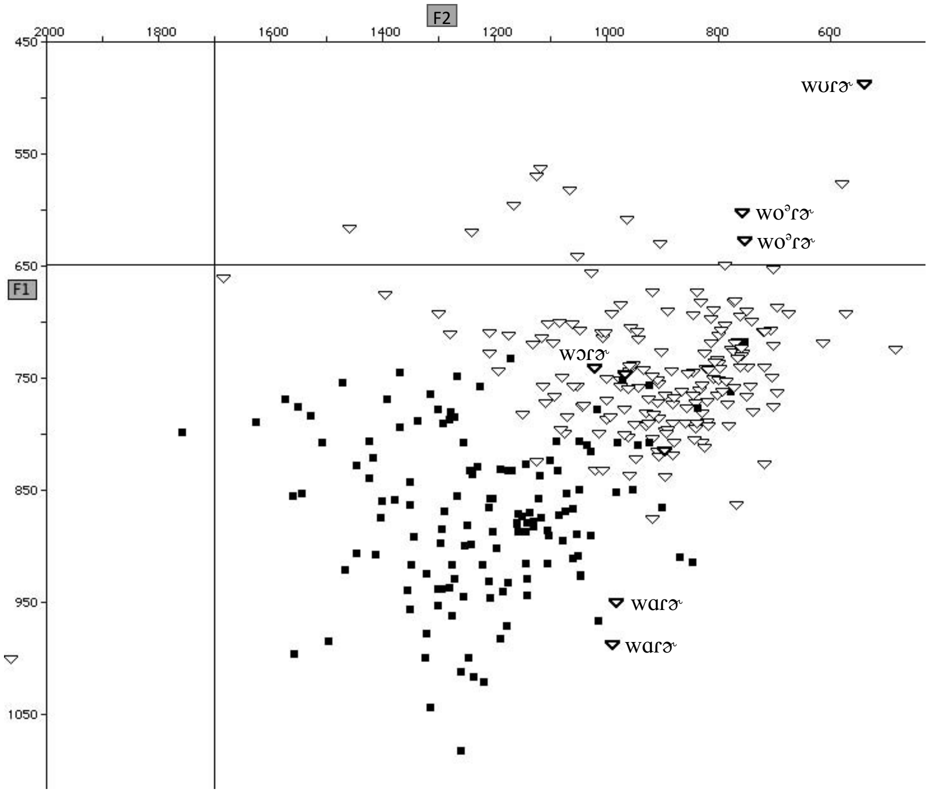


FIGURE 22. /o/ and /oh/ of Andrew P., 19 (2012), University of Pennsylvania freshman.

tion of new features and in withdrawal from salient features.[28] Following the logic of §7, it will be helpful to examine the geographic context of this withdrawal.

10.2. THE GEOGRAPHIC AND SOCIAL CONTEXT OF THE WITHDRAWAL. Section 10.1 documented the Philadelphia withdrawal from the two salient features of its traditional dialect, /æh/ and /oh/, led by younger speakers with higher education. The geographic context of this phenomenon is shown in Figure 24 (based on *ANAE* map 13.5). The gray circles show dialects with split short-*a* systems, ranging from Baltimore to New York City. While the Philadelphia system is similar to that of Wilmington, Reading, and Baltimore, New York shows a discretely different superset of conditions for short-*a* tensing (Trager 1942, Labov 1966, Becker & Wong 2009).

The geographic pattern for raised and backed /oh/ is a narrow belt of cities along the northeastern corridor that coincides closely with the area of split short-*a* systems, extending one notch further to include Providence, Rhode Island (*ANAE* maps 10.31–32). In this urban corridor, the NYC form of /oh/ is the highest, followed by Philadelphia and Providence, just above the F1 = 700 Hz criterion for upper mid vowels. This raised /oh/ is a long, ingliding vowel with typically pursed rather than rounded lips. It is associated with the public stereotype of New York City dialect with the spelling ‘Noo Yawk Tawk’,[29] and it is the feature commonly used to identify that dialect by speakers from

[28] Although data are sparser among the youngest speakers, the 95% confidence intervals are well separated in Fig. 23.

[29] As shown by the Broadway musical of that name and some 75,000 tokens on Google search as of June 2012.

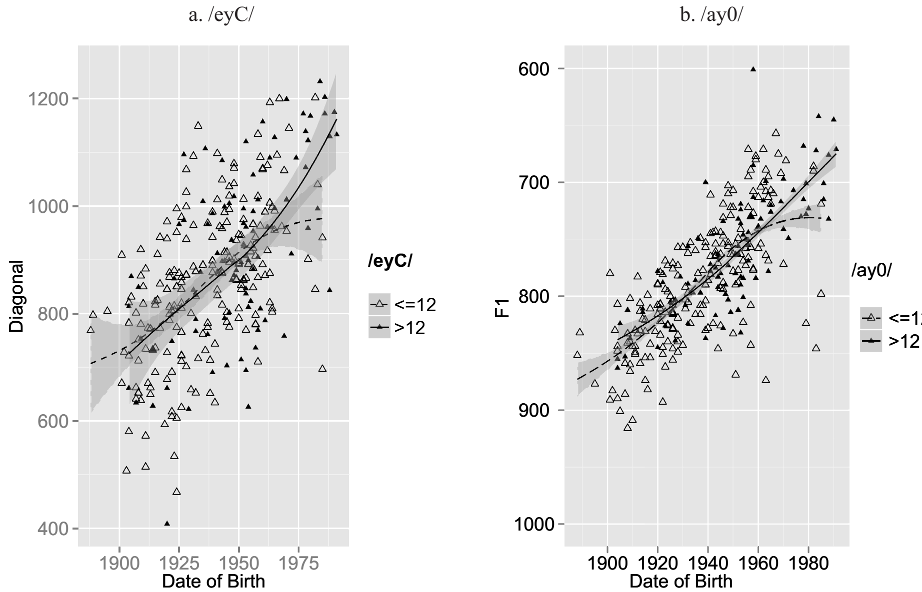


FIGURE 23. Locally weighted regression analysis showing the general raising of /eyC/ and /ay0/ along the front diagonal (for /eyC/) and on the F1 axis (for /ay0/) by date of birth and higher education (> twelve years) in the Philadelphia Neighborhood Corpus (N = 264).

other areas. Recent restudies of the Lower East Side of New York have found withdrawal from the high forms of /æh/ and /oh/ in striking parallel to those reported here (Becker & Wong 2009, Becker 2013). Given the salience of the New York City dialect on the national scene (Preston 1996), it is not unreasonable to attribute the withdrawal from raised /oh/ in Philadelphia to the stigmatization through association with the low prestige New York City vernacular. Yet it is more likely that the two withdrawals are part of a general reaction against this aspect of local phonology.

Figure 24 also displays the distribution of the nasal short-*a* system as solid black symbols, dominant in northern New Jersey, New England, Pittsburgh, and the North Midland cities of Canton, Columbus, and Indianapolis.[30] It can be seen that the withdrawal of Philadelphians from both salient targets of raised /æh/ and /oh/ is consistent with the shift toward a North Midland pattern illustrated in §8. To the extent that the lowering of /æh/ takes the form of a nasal system reorganization, this is consistent with the incrementation of /eyC/ and /ay0/ and the retreat from the fronting of back upgliding vowels. The end result of the lowering of /oh/ is a narrower opposition between /oh/ and /o/ for some speakers that is characteristic of those North Midland areas that are in a transitional state in relation to the low back merger (*ANAE* Ch. 19).

11. THE ACTUATION PROBLEM. The unexpected discoveries of §7 of this article focus our attention on the mid years of the last century. The reversal of /aw/, /owC/, /owF/, and /Kuw/ is regularly found starting with speakers born in the 1940s, who achieved whatever incrementation was involved in their sound patterns in the late 1940s and 1950s. The same time period showed the beginning of the withdrawal from raised /æh/, preceded by the beginning of the retreat of /oh/.

[30] The distinction between a discrete nasal system and a continuous system is sometimes a gray area of decision, so that many of the open circles in the North Midland are not radically different from those categorized with black symbols.

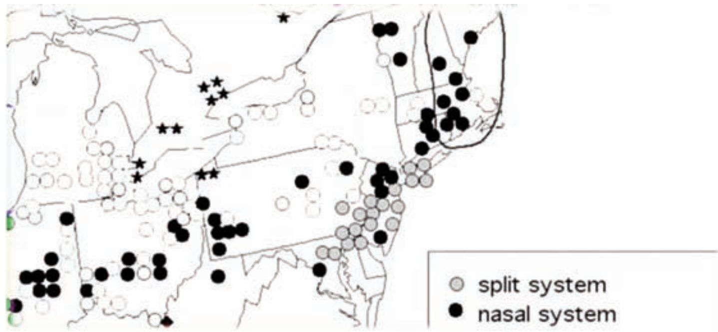


FIGURE 24. Geographic distribution of the split short-*a* and nasal systems. Gray open circles = continuous short-*a* system with raising in the order /m,n/ > /d/ > /g/. Stars = Canadian short-*a* system with raising in the order /m,n/ > /g/ > /d/.

Section 8 associated this reversal with a retreat from Southeastern features in favor of Northern features. We are then faced with the actuation problem: what happened in the period 1945–1960 that reoriented Philadelphians toward a Northern realization of their vowel system? The extensive population movements during World War II may be cited, but the fact that women are the leaders in most of these changes would lead one to look elsewhere. The ‘baby boomers’ born between 1946 and 1964 have been identified as a population cohort with its own characteristics of mobility, privilege, and expectation (Jones 2008), but there are no obvious correlations with Philadelphia’s geography, economy, or population changes.

Philadelphia grew from 1.5 million in 1900 to 2 million in 1940, remained stable for forty years, then in 1980 began a decline that returned to 1.5 million in 2000.[31] The decline is largely due to the outward movement of the white population, with some inmigration of African Americans from the South and a smaller current of Spanish speakers from Caribbean areas. Preliminary exploration of the African American and Hispanic speakers in the Philadelphia Neighborhood Corpus show radically different trajectories for the vowels that are the focus of this study of the white population. It has been demonstrated experimentally that the fronting of /aw/ in Philadelphia is associated with white identity (Graff et al. 1986). Further reports will attempt to relate these two streams of linguistic variation and change in Philadelphia.

12. THE MICROEVOLUTION OF LANGUAGE. This report on a hundred years of sound change in Philadelphia has brought to the study of linguistic change in progress a volume of data and a precision of measurement that goes considerably beyond previous studies.

It was noted at the outset that the study of linguistic change in progress is a strategy for discovering the causes, mechanism, and effects of the longer-range changes that are responsible for the diversity of languages over time. As in the study of the microevolution of species, the close examination of ongoing variation shows alternations of direction as the social and physical environment changes.[32] The last hundred years of evolution of the Philadelphia dialect displays some structural patterns that account for the directions of change: the generalization across parallel structures (nucleus-glide dif-

[31] US Census, http://www.census.gov/population/cencounts/pa190090.txt

[32] See Grant & Grant 2008, tracing the rise and retreat of large-beaked finches in correlation with changes in rainfall in the Galapagos.

ferentiation of back upgliding vowels, peripheral raising of long and ingliding vowels, the simplification of the short-*a* system). It has also shown coarticulatory effects that disrupt the unity of the phoneme (coronal onsets for /uw/; consonantal codas for /ey/; voiceless codas for /ay0/). Given our understanding of these mechanisms, it might seem natural—and predictable—that they would continue indefinitely in the same direction, and sometimes they do. But the unexpected reversals of direction we have encountered demonstrate an interaction with the larger social environment that we understand less well. This study points to the unifying effect of convergence with or divergence from neighboring dialects. In the LVC study of the early 1970s, Philadelphia was seen as still moving 'within the orbit of the Southern Shift' as far as the back upgliding vowels were concerned (Labov 2001:Ch. 4), but retreating from the Southern pattern of the front upgliding vowels. At that time, the raising of /eyC/ was seen as a 'retrograde movement'. The type 2 patterns found in the current study show this retreat generalized to the back upgliding vowels just at the time that the LVC study was nearing completion. Even more recently, type 3 changes mark a retreat from the salient features shared with New York City.

The reversal of Philadelphia sound changes echoes broader social processes in North America. The two mostly widely recognized, and stigmatized, regional dialects are Southern and New York City English (Labov 1966, Preston 1996). Both are in retreat. There is strong evidence that the major sound shifts of the South are receding, especially in large urban areas (*ANAE* Ch. 18, Baranowski 2007, Dodsworth & Kohn 2012). We have cited parallel evidence for withdrawal of both /æh/ and /oh/ from their high position in the New York City system of long and ingliding vowels (Becker & Wong 2009, Becker 2013).

An accounting for the positive direction of Philadelphia sound changes is not so readily available. As noted in §9, we do not have a record of population changes in mid-twentieth-century Philadelphia that would account for a sudden increase of Northern influence. In its absence, we might argue that the Philadelphia shift in that direction is simply a move toward an unmarked system. However, the continuing incrementation of /eyC/ and /ay0/ does not support such an argument, and the most strongly supported generalization is that Philadelphia has moved away from its Southern heritage in favor of a Northern system, avoiding those forms that are most saliently associated with local phonology.[33]

To the extent that the uniformitarian principle applies, it follows that the long-term evolution of language is the result of such micro-fluctuations in the social context, controlled by the structural imperatives that govern the production of speech in everyday life. These social changes can be traced in the behavior of individuals, although the individual is not a significant unit in the linguistic system (Labov 2012). It remains to ask, at what level of social organization do we find operating the forces that drive linguistic change? The term 'social meaning' is often used to indicate a factor governing the agentive behavior of individuals, maximizing their situation in small group interaction. But the great size of the populations engaged in parallel behavior calls for higher-level explanations. It is the need to discover the mechanisms by which such language changes are generalized beyond the group, village, neighborhood, or metropolis that leads us to look for large-scale geographic patterns of change.

[33] We refer here to the broader North as defined in *ANAE* Chs. 11, 14, not the Inland North, since the Northern Cities Shift that dominates that region is not exportable to systems with lax short-*a* firmly located in low front position.

This is the problem that Fridland confronted when she found close parallels in the development of the variable /ay/ among white and black residents of Memphis, although there was minimal communication across the races. She questioned explanation through the notion of 'communities of practice where social entities co-construct symbolic identity in so far as they participate in shared practices'. Fridland would expand this framework, noting that:

> these shared practices do not necessarily require individuals' social cohesion but merely require shared historical experience and a strongly circumscribing environment that places speakers in a similar social position relative to the external social world. (2003:296)

She argues that Southern identity fits this description, 'given the long settlement history of Blacks and Whites and the uniformly negative linguistic and cultural stereotyping experienced by both groups outside the South' (ibid.).

The hundred years of sound change in Philadelphia that we have traced appears to reflect the operation of cultural factors at this more general level of social organization. Although individuals can be identified as leaders of linguistic change (Labov 2001:Ch. 12), their leadership reflects a sensitivity to the social factors that drive the system as a whole.

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