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# Phonological emergence and social reorganization: Developing a nasal /æ/ system in Lansing, Michigan

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**Abstract**

Phonological rule innovation is thought to come about via reanalysis of some phonetic variation (e.g., Bermúdez-Otero, 2007; Hyman, 1975; Ohala, 1981; Pierrehumbert, 2001). Yet, empirical evidence suggests instead that the role of phonetic variation during phonological rule innovation is minor (Fruehwald, 2013, 2016). This paper adds to this ongoing debate an empirical analysis of an emergent allophonic contrast—an "/æ/ nasal system"—in White Michigan English. Analyses of speaker-level acoustic data from a sociolinguistic corpus ($n = 36$) and a subphonemic judgment task ($n = 107$) suggest that Lansing exhibits gradual phonological rule emergence. Social conditioning appears to act as the catalyst of phonological rule formation and its spread. The mechanism of actuation was thus "the chance alignment of social and phonetic variability" (Baker, Archangeli, & Mielke, 2011), suggesting that social conditioning on phonetic variability must play a major role in phonological emergence.

One of the many challenges for any phonological theory is accounting for rule innovation, that is, how do members of a speech community posit a phonological rule that had never before existed in their speech community. The prevailing sentiment surrounding phonological emergence is that it develops gradually—some exaggerated difference between two phonetic variants is eventually reanalyzed (by speakers and/or hearers) as a phonological rule (Baker, Archangeli, & Mielke, 2011; Bermúdez-Otero, 2007; Blevins, 2004; Hyman, 1975; Moreton & Thomas, 2007; Ohala, 1981). Others have argued, however, that there need not be a phonetic precursor to phonological emergence—change to the grammar is sudden and does not require anything in the phonetics to prompt the change (Fruehwald, 2013; Janda & Joseph, 2003).

Though the mechanisms of community spread have been widely explored, the mechanisms that govern phonological emergence or "phonologization" remain understudied. This is likely because as Hockett (1958:456) surmised, phonological emergence is rare and occurs suddenly—*too soon for anyone to detect this kind of event by direct observation*. What we do know about phonological emergence has been deduced from the results of perception studies, simulations, synchronic analyses, and observations about historical data. As Fruehwald (2017) pointed out, underrepresented in the literature are portraits of phonological emergence using language production data while the change is in progress. The few analyses examining the development of a phonological allophonic split (Berkson, Davis, & Strickler, 2017; Fruehwald, 2017), the phenomenon explored in this paper, disagree as to whether emergence is gradual or abrupt.

The present investigation focuses on one case of phonological allophonic emergence—/æ/ nasal allophony in Lansing, Michigan. Whereas /æ/ in Lansing was previously raised to [ɛæ] in all phonological environments, younger generations exhibit a nasal allophonic system whereby /æ/ is raised only before nasal consonants (Nesbitt, 2021; Nesbitt, Wagner, & Mason, 2019; Wagner, Mason, Nesbitt, Pevan, & Savage, 2016). To investigate the mechanisms by which this phonological rule emerged in Lansing, I utilize a combination of analyses, examining speaker-level distributions and community-level acoustic target analyses from a natural language corpus ($n = 36$), and the results of a judgment task ($n = 107$). The results support a theory of gradual phonological emergence. I show that no speaker/respondent before or at the beginning of the community change distinguished prenasal from preoral /æ/. Over time, community members developed a phonetic distinction between the two allophones, which was then followed by social conditioning on these allophones, and then the appearance of some speakers who exhibit a phonological rule. These results highlight the importance of accounting for external/social conditioning during theory development. Our social conditioning findings provide support for the hypothesis put forward by Baker et al., who stated that "sound change depends on phonetically-motivated inter-speaker variation that precedes socially motivated inter-speaker variation, [which] permits a solution to the actuation problem" (Baker et al., 2011:351).

In what follows, I describe the two main phonological emergence theories with evidence from recent studies examining the same emergence phenomenon in different locales. I then examine the empirical motivation for the current analysis, highlighting the synchronic patterns of /æ/ in North American English and the preliminary diachronic account of system change in Lansing. I then turn to the methods and results where I examine phonological emergence and community spread in Lansing. While I find support for the gradual analysis, I ponder in the discussion whether external/social conditions on the ground might help to distinguish between communities in which emergence is gradual versus abrupt.

## Phonological emergence: abrupt versus gradual

Theories of gradual phonological emergence posit that change proceeds through the grammar incrementally, first occurring in the phonetics and then in the phonology. One theory of gradual change is that of The Life-Cycle of Phonological Processes (the Life-Cycle; Bermúdez-Otero, 2007, 2015). According to the Life-Cycle, phonological processes first begin as language-independent or mechanical phonetic effects (stage 1) that, through a process called phonologization (stage 2), become cognitively controlled

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language-specific phonetic implementation effects. They then become stabilized as a phrase-level categorical/phonological rule (stage 3), and by domain narrowing over time the rule applies only at the word level (stage 4), and then the stem-level (stage 5). In its last stage (stage 6), the process advances to the lexicon through morphologization and/or lexicalization. Much of the theory of the Life-Cycle is based upon observations of synchronic variation within a language (Bermúdez-Otero, 2007), for instance, in North American English /æ/ systems (Dinkin, 2011; Labov, Ash, & Boberg, 2006), which we will focus on in this paper, where each Life-Cycle stage can be observed in a different regional variety. For Bermúdez-Otero, the Life-Cycle could account for synchronic variability as well as diachronic change, because though various dialects of a language can undergo the same change—toward allophony, for example—they do so at different rates. Other theories of gradual phonological emergence include the "accumulation-of-errors" hypothesis (Ohala, 1981, 1989, 1993), continued reanalysis at later stages (Hyman, 1975, 2013), Evolutionary Phonology (Blevins, 2004), and Exemplar Theory (Garrett & Johnson, 2011; Pierrehumbert, 2001). Though the details of each theory are different, they all consider phonetic variability to be a significant catalyst to phonological emergence.

In contrast, the Big Bang Theory of Phonological Processes (Janda & Joseph, 2003) suggests that phonetic factors guide sound change only briefly and that phonological conditioning takes over quickly. To motivate this argument, Janda and Joseph (2003) re-examined the synchronic variation of two processes, one of which is Swiss German o-lowering. In German, o-lowering originally occurred only before /r/, a rule that persists in the central city of Schaffhausen, Switzerland. Lowering has generalized in different ways in surrounding villages. For example, in some locales, lowering occurs before all obstruents except /b/ while in other locales lowering occurs only before nasals and coronal obstruents. Crucially for Janda and Joseph (2003), these environments did not phonetically favor a lowered /o/, suggesting that if phonetic variation did play a role in this change, it must have been brief and overruled by the phonology instantly. There is, however, no data to support this hypothesis.

Indeed, as Fruehwald (2013) pointed out, much of our understanding of phonological emergence suffers from a paucity of empirical evidence. Our current knowledge rests on observations of synchronic variation, like the story of o-lowering in German locales (see also Bermúdez-Otero, 2007; Dinkin, 2011; Turton, 2017), completed changes (Britain, 1997a, 1997b; Trudgill, 1986), experimental simulations (Garrett & Johnson, 2011; Pierrehumbert, 2001), perception studies (Ohala, 1981), or prior theories. Below I describe the findings from two studies examining the same emergence phenomenon—Canadian Raising—in two disparate North American communities, analyzing data observed during the change. Fruehwald (2013, 2016) observed abrupt emergence while Berkson, Davis, and Strickler (2017) demonstrated a gradual emergence process.

### *Abrupt versus gradual phonological emergence*

Fruehwald (2013, 2016) offers an analysis of Canadian Raising of /aɪ/ (CR) in the speech of 326 Philadelphia-born speakers born 1889 to 1998. In Philadelphia, and most other North American English varieties, the nucleus of /aɪ/ raises before voiceless codas (e.g., *knife* and *write)* but remains low before voiced codas (e.g., *knives* and *ride)*. When /aɪ/ raises before a flapped /t/ (e.g., *writer*), raising is phonological because, though flapped /t/ is voiced on the surface, it is underlyingly voiceless (Halle, 1962; Idsardi, 2006). Fruehwald compared three measurements of /aɪ/ (nucleus, offset, and duration) in preflap /t/ position to that before faithful /t/ (*write*), faithful /d/ (*ride*), and flapped /d/ (*riding*). Fruehwald found that the /aɪ/ allophones began to diverge from each other along F1 in the 1920s; the prevoiceless allophone moving up the vowel space while the prevoiced allophone remained stable. Most interestingly, he showed that phonetic raising (Life-Cycle stage 2; the raising of /aɪ/ only before faithful /t/) did not predate phonological raising (Life-Cycle stage 3). All speakers at the beginning of the change raised /aɪ/ before flapped /t/ (*writing*) and before faithful /t/ (*write*), so that these two phonological categories were phonetically similar. One of these categories (before faithful /t/) underwent a phonetically gradual change in height while the other remained low. CR in Philadelphia was thus an abrupt change. Nevertheless, the rise of CR in communities across North America (Davis & Berkson, 2021) has provided an opportunity to compare emergence patterns in recent years. At least two analyses counter the abrupt analysis put forth by Fruehwald.

Berkson and colleagues (2017) offered an individual-systems level analysis of CR in the speech of speakers from Fort Wayne, Indiana. They observed four patterns among their twenty-seven speakers (aged nineteen to seventy-eight): no raising, phonetic raising, and two types of phonological raising. Crucially, the phonological raising patterns were observed among five of their oldest speakers, which suggests that the change might be abrupt. In a follow-up analysis, the authors noted a different acoustic pattern between these older phonological raisers and the younger phonological raisers, suggesting that the older speakers have acquired phonological CR via lifespan change (Davis, Berkson, & Strickler, 2021). This would suggest that, in Fort Wayne, phonological CR was a gradual process, though they conceded that "phonetic factors guide sound change only for a brief period before phonologization takes place" (Berkson et al., 2017:e190). Another analysis of allophonic emergence examined /aw/-raising in New Orleans English (Bissell & Carmichael, 2022). Their findings align with Berkson et al. (2017), suggesting that phonologization is gradual. In their data, the oldest speakers did not exhibit phonetic raising, and middle-aged speakers exhibited phonetic raising and were, on average, much older than phonological raisers. Like the speakers in Berkson et al. (2017), the phonetic raisers demonstrated key acoustic differences from phonological raisers.

The current paper provides another analysis of allophonic emergence to reconcile these different findings. I find evidence of gradual emergence and suggest in the conclusion that this may be due to external/social factors, that is, different contact profiles in Fort Wayne, Lansing, and New Orleans as compared to Philadelphia during the emergence event.

### *Social conditioning and phonological emergence*

Another impetus for the current analysis is the need for an account of the social/external factors active during the change. This is important because: (1) as stated by Labov (2001:322), echoing Weinreich, Labov, and Herzog (1968), "the forces active

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in qualitatively new changes include social factors, and any effort to account for the initiation of change by purely internal arguments will fail to a significant degree"; and (2) crucially, though variability can be active in any given community, social conditioning on that variability must be in place to drive community change. Baker and colleagues (2011) hypothesized that this is in fact why phonological allophonic emergence is so rare; the change likely requires the chance alignment of extreme social and phonetic variation. Because of the dearth of empirical data showcasing phonological allophonic emergence, we have yet to explore these factors. This paper provides a step in that direction by examining the chance alignment of gender and socioeconomic status conditioning on /æ/ systems in Michigan.

## Phonological allophonic emergence in Lansing, Michigan

There are robust descriptions of cross-regional /æ/ patterns in North American English. Crucially, these patterns map onto the Life-Cycle stages described above (Bermúdez-Otero, 2007; Dinkin, 2009, 2011) providing synchronic evidence for the theory. However, the best evidence would come from an examination of these patterns over time. A diachronic progression from earlier stages to later stages would support a theory of gradual phonological change, while the presence of later stages at the beginning of phonetic change would support a theory of abrupt phonological change.

### *North American /æ/ patterns*

Analyses of individual systems like that in Berkson et al. (2017) (see also Baker et al., 2011, Sneller, 2018; Turton, 2014) give important insight into the mechanisms of change at the level of the individual. The current analysis will take this approach to investigate the emergence of a nasal /æ/ system in Michigan. The first Life-Cycle stage is traditionally observed in the Inland North dialect area, situated around the North American Great Lakes. In this *unconditioned raised /æ/ system*, /æ/, as part of the Northern Cities Vowel Shift (NCS), is unconditioned by phonological environment, so that /æ/ before nasal codas are "interspersed with /æ/ before voiced stops and after palatals" in the token cloud (Labov et al., 2006:177). The Life-Cycle stage two is characteristic of the *continuous /æ/ system* most often observed in Canada and the North American Midland states (Labov et al., 2006). In this system, the /æ/ cloud forms an "unbroken phonetic continuum from least to most raised, influenced by numerous features of the vowel's phonetic environments" (Dinkin, 2011:78). Life-Cycle stage three—a categorical/phonological rule stage whereby allophones have "widely separated targets…and their tokens occupy discrete, largely nonoverlapping regions in phonetic space" (Bermúdez-Otero, 2015:16)—is instantiated in the nasal /æ/ system observed in Eastern New England and the North American West (Boberg, 2001; Labov et al., 2006, *inter alia*). The last stages of the Life-Cycle are exhibited in the split-/æ/ systems of Mid-Atlantic cities (e.g., Baltimore, Philadelphia, New York City), whereby /æ/ raising is subject to complex phonological (and sometimes morphological and/or lexical) conditions that vary from city to city. In Philadelphia, for example, /æ/ is divided into two separate phonemes: a tense vowel class made up of tokens before

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voiceless fricatives, voiced stops, and tautosyllabic nasals, and a lax vowel class elsewhere (including function words). However, there are lexical exceptions, for instance, the /æ/ in *sad* is lax while *glad, mad, bad* are all tense (Labov, 1994:429–437). This synchronic view of /æ/ systems provides us with a methodological opportunity to assess individual systems if an Inland Northern community appears to move toward a late-stage system, as has been observed in recent analyses (Driscoll & Lape, 2015; Nesbitt, 2021; Thiel & Dinkin, 2017; Wagner et al., 2016).

### *Preliminary analyses of phonological emergence in Lansing*

In Lansing, the change toward predominantly nasal systems appears to have been initiated in the mid-twentieth century (Nesbitt, 2018; Nesbitt et al., 2019; Wagner et al., 2016). Wagner and collaborators (2016) documented the change in F1/F2 target of prenasal and preoral (nonprenasal) allophones in a sociolinguistic corpus ($n = 51$, birthyears: 1907 to 1999). They showed that no speakers at the beginning of the change exhibited a nasal system, but speakers born in the 1990s almost exclusively exhibited nasal systems, suggesting that phonological allophonic emergence in Lansing was gradual. There were, however, very few speakers ($n = 5$) who were born before the differentiation in acoustic space began, and the sample was unbalanced by socioeconomic class and birth year. Thus, it could have been the case that the Wagner et al. analysis was simply showing a snapshot of language use in different subcommunities; one where the working-class had phonetic allophony and the middle-class had a phonological split, neither of which is exhibiting apparent time change.

A follow-up acoustic analysis of preoral /æ/ in Lansing adds considerable credibility to the argument above that social/external factors must be accounted for in any theory of allophonic emergence. Nesbitt (2021) conducted an acoustic analysis of preoral /æ/ in a socially balanced corpus of natural language data from thirty-six Lansing natives. The analysis found considerable variation with respect to F1, F2, and formant trajectory in the oldest speakers that was followed by social conditioning in the Baby Boomer generation such that women exhibited significantly higher, more forward, and more diphthongal variants of /æ/ than men. In the subsequent Gen X generation, blue-collar men continued this pattern while women retreated away. Crucial for the current analysis is the fact that these /æ/ variants were socially constrained during the proposed timing of allophonic emergence. This scenario is thus ripe for initiating major structural linguistic change, as hypothesized by phonological change theorists.

## Goals

This paper explores data from two types of studies: the first comes from speech production data from the Lansing Speech Corpus and the second from an experimental paradigm utilizing a subphonemic judgment task. The goals are threefold:

1. To describe the nature of phonological allophonic emergence in Lansing, Michigan: Do speakers have a phonological distinction when the vowel in the two

environments begin to assume different phonetic targets (abrupt), or do speakers develop the phonological rule at some point after the two allophones begin separating (gradual)?
2. To describe the social conditions relevant to the change so as to identify the initiators of the change.
3. To develop a more robust version of a commonly used task—the minimal pair test—by increasing stimuli counts, thus ensuring that all phonological environments are well represented.

The paper therefore has theoretical and methodological implications for the study of phonological change. This is one of few studies to examine phonological allophonic emergence in a community using speech production data before and during a change in progress, and the first to examine the social/external conditions upon which phonological allophonic rules emerge.

## Studies

### *Production study: Lansing Speech Corpus*

The production data comes from the Lansing Speech Corpus, which is a combination of oral history recordings and sociolinguistic interviews conducted in the 2000s with Lansing, Michigan natives (see Nesbitt, 2019). Table 1 provides a summary of the distribution of the social parameters in the Lansing Speech Corpus.

All participants self-identified as White. Participants were binned into one of three generational cohorts delineated from the Pew Research Center classifications (Pew Research Center, n.d.). Occupation and education level are utilized as a proxy for socioeconomic status, whereby speakers in manual labor or service/care occupations were classified as *blue-collar* while those in managerial positions and in occupations that require at least two years of post-high school technical training were classified as *white-collar*. Speakers were characterized as either male or female according to their self-identification.

*Production methods.* The casual conversation portion of each interview in the Lansing Speech Corpus was transcribed in ELAN (version 6.5; ELAN, 2023), and then passed through the Forced Alignment and Vowel Extraction (*FAVE*) suite (Rosenfelder, Fruehwald, Evanini, Seyfarth, Gorman, Prichard, & Yuan, 2014) for forced alignment and vowel measurement. The FAVE suite runs through each speaker's data twice, identifying and eliminating any outliers due to alignment errors. The current analysis relies on Lobanov normalized (Lobanov, 1971) /æ/ F1 and F2 measurements taken at the

**Table 1.** Distribution of the Lansing Speech Corpus by generation, social class, and gender[1]

| Generational Cohort | Birth Year | Blue Collar | | White Collar | | Total |
|---|---|---|---|---|---|---|
| Silent | 1925–1945 | 3f | 3m | 3f | 3m | 12 |
| Baby Boomer | 1946–1964 | 3f | 3m | 3f | 3m | 12 |
| Generation X | 1965–1984 | 3f | 3m | 3f | 3m | 12 |
| Total | | 9 | 9 | 9 | 9 | 36 |

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mid-point. Eliminated from this analysis were /æ/ tokens that were outliers for individual speakers, /æ/ tokens that are commonly reduced in casual speech (those in an unstressed syllable or a function word), and those preceding /r/ due to its merger with /eɪ/ and /ɛ/ in that environment in the Inland North and other regions (Labov et al., 2006). In all, 4,158 /æ/ tokens were analyzed (1,590 were pre-/m/, /n/, or /ŋ/). I set aside pre-/l/ and pre-affricate tokens during the trajectory analysis due to low token count ($n = 174$ and $n = 166$, respectively, ~3 tokens per speaker).

*Production analysis: Individual/speaker systems.* For each speaker, context overlap in phonetic space is taken here as an indication of phonological distinction. Speaker-level systems were measured using the Pillai-Bartlett statistic (Hall-Lew, 2010; Hay, Warren, & Drager, 2006), which utilizes MANOVA to evaluate the distance between two distributions and their variance. Pillai-Bartlett scores range from 0 to 1, where 0 indicates no difference between distributions and 1 indicates complete separation of the distributions. Three /æ/ systems in the Lansing Speech Corpus are displayed in Figure 1. Below I describe how Pillai-Bartlett scores map onto these systems. On the left, Jack Down's /æ/ system displays the traditional Inland Northern raised /æ/ system that exhibits no phonetic tendency for raising prenasal above preoral tokens. Michelle Baulch, center, exhibits a continuous system where there is a large degree of overlap between prenasal and preoral token clusters but some tendency for prenasal tokens to be higher and forward in the cloud. Ben Langdon, on the right, exhibits a nasal system where prenasal and preoral token clouds barely overlap. These systems map on to the Pillai-Bartlett scores that increase from 0.07 on the left to 0.73 on the right. Thus, a speaker with a raised /æ/ system is likely to have a Pillai-Bartlett score closer to 0 while those with a continuous /æ/ system would have a score closer .5, and those with a nasal system should have Pillai-Bartlett scores closer to 1.

Because each speaker exhibited only one Pillai-Bartlett score, an analysis of variance (ANOVA) was utilized to determine the impact of social class, gender, and generational cohort on this measure. The fixed effects were operationalized as follows: Social Class (blue-collar, white-collar), Gender (female, male), and Generation (Silent, Boomer,

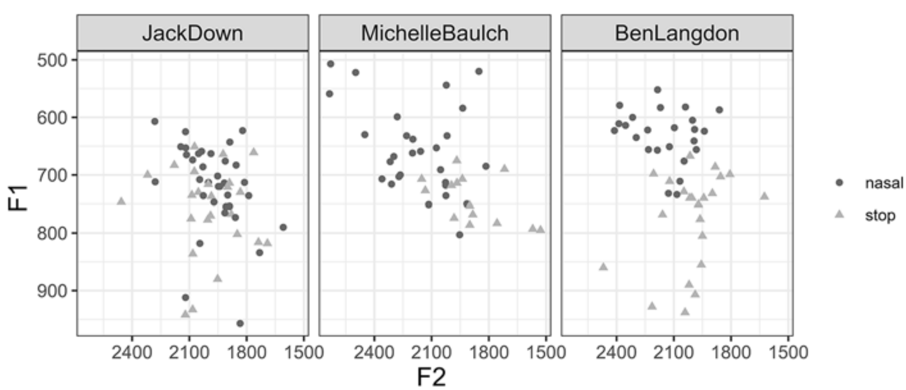


**Figure 1.** Three Lansing /æ/ systems: Jack Down (born 1924), advanced raised continuous system; Michelle Baulch (1971), continuous system; Ben Langdon (1994), nasal system.

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Gen X). Interactions between the fixed effects were included in a full model and those fixed effects or interactions that were not significant were removed. Model outputs are provided for reference in each section below. Welch's two-sample t-tests were performed whenever there was a significant three-way interaction and whenever an effect with more than two levels was significant. These statistical analyses test the hypothesis that generational cohort, gender, and social class condition nasal systems in twentieth century Lansing.

*Production results: Community-level phonetic target change.* I begin with an analysis of phonetic target change in the Lansing Speech Corpus to determine when the prenasal and preoral allophones assume different phonetic targets in F1/F2 space. Figure 2 displays the trajectory of /æ/ before fricative, nasal stop, and oral stop codas in the vowel space over time. Here we see a clear distinction between the trajectories of the prenasal and preoral (fricatives and stops) allophones. Starting at a diagonal measurement of about 500 Hz in the 1920s, the prefricative (dark gray line) and preoral stop

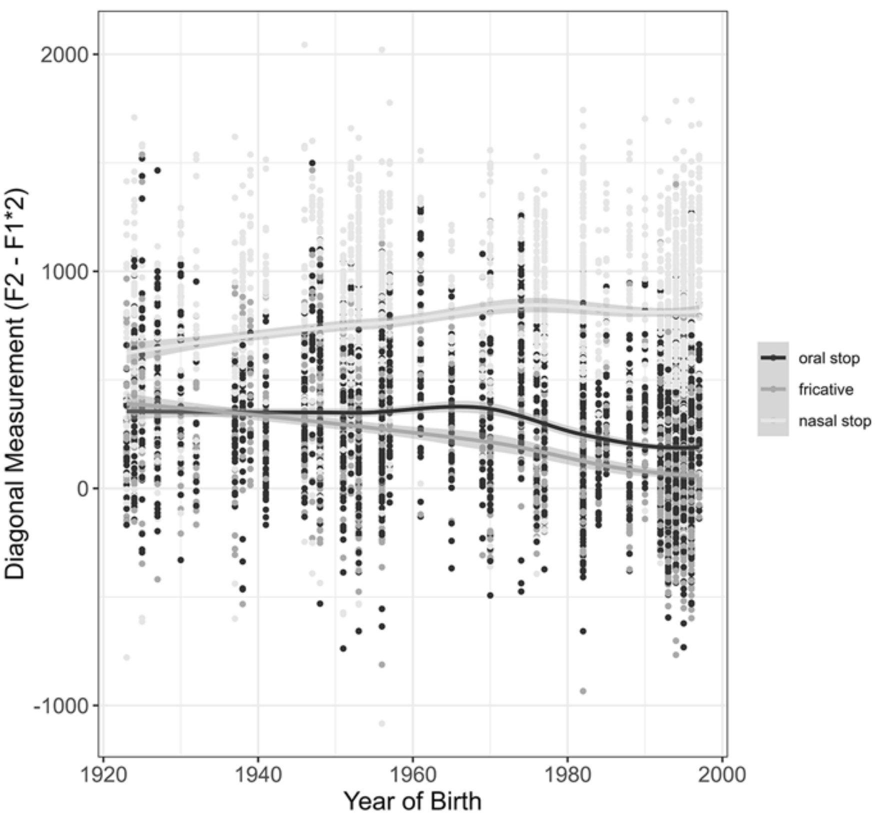


**Figure 2.** Per token diagonal measurement of /æ/ in three following phonological contexts by speaker year of birth in twentieth century Lansing.

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(black line) allophones continue to fluctuate into the 1960s at which point the diagonal measurements begin to decline into the 2000s, moving down and backwards in the vowel space over time. This contrasts with the prenasal (light gray line) allophone that remains relatively stable from the 1920s onward.

As for an estimation of when in apparent time the prenasal and preoral allophones of /æ/ began to diverge, we focus on the trend lines in the 1920 to 1940 birth year range in Figure 2. In the period between 1920 and 1930, the prenasal (light gray line) and preoral stop (black line) allophones are moving in lockstep both upward, while the prefricative allophone (dark gray line) already shows a divergent trajectory downward. In the 1930s, the pre-stop allophone diverges from its upward trajectory while the prenasal allophone remains relatively stable. From the 1940s onward, the preoral stop and prefricative allophones move in lockstep away from the prenasal allophone. Therefore, upon visual inspection of the F1/F2 trajectory of /æ/ in different environments, the phonetic target change appears to have begun in the 1930s with the mid-Silent generation (birth year 1925-1945). Therefore, the speaker-level analysis that follows will focus on Silent generation speakers. We ask the question whether any of these speakers exhibit phonological allophony. If phonological change was abrupt in Lansing, at least some Silent generation speakers should exhibit a phonological system. If, however, the change was gradual in Lansing, no Silent generation speaker/respondent will exhibit a phonological system. Only those in subsequent generations will.

*Production results: Speaker-level distributions.* Figure 3 displays the Pillai-Bartlett scores, measuring preoral and prenasal /æ/ overlap for each speaker in the Lansing Speech Corpus across birthyear. For speakers born prior to 1940, Pillai-Bartlett values range from 0.038 to 0.351. These speakers exhibit /æ/ distributions that range from

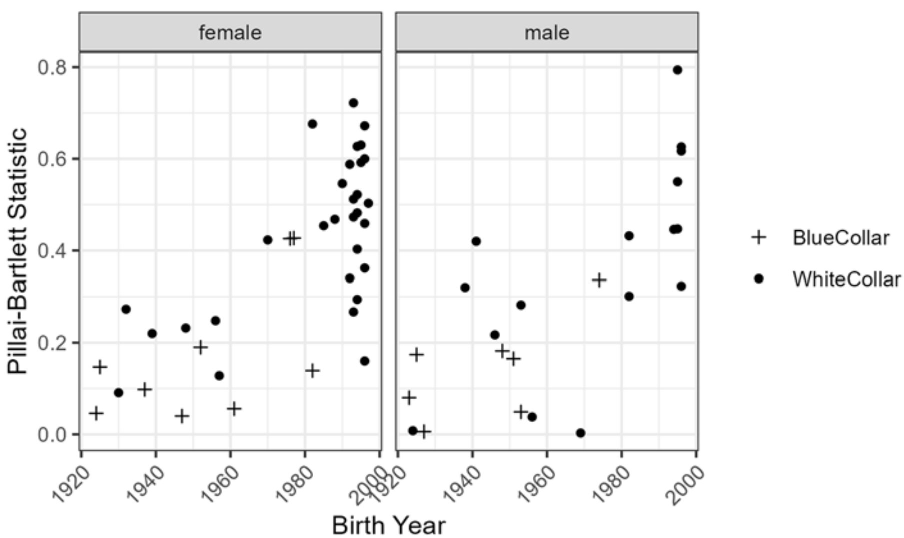


**Figure 3.** Per speaker Pillai-Bartlett score of prenasal and preoral /æ/ distribution by generational cohort, gender, and social class in twentieth century Lansing.

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**Table 2.** ANOVA on Pillai-Bartlett values in twentieth century Lansing ($n = 36$)

| | Sum of Squares | *df* | Mean Square | *F* | *p*-value |
|---|---|---|---|---|---|
| Generation | 20.08 | 2 | 10.04 | 8.19 | 0.008*** |
| Class | 4.60 | 1 | 4.60 | 3.75 | 0.046* |
| Gender | 1.54 | 1 | 1.54 | 1.25 | 0.238 |
| Generation:Class | 3.385 | 2 | 1.693 | 1.606 | 0.219 |
| Generation:Gender | 6.170 | 2 | 3.085 | 2.927 | 0.071 |

*** $p < 0.001$, ** $p < 0.01$, *$p < 0.05$, $p < 0.1$

unconditioned Inland North systems to phonetically conditioned continuous systems. Crucially four out of six of the 1920s-born speakers exhibit the former system with values close to zero, while 1930s speakers exhibit the latter system. None of the speakers in this Silent generation exhibit Pillai-Bartlett scores of 0.5 or above, indicating that they do not distinguish prenasal and preoral /æ/ phonologically.

Also indicated in Figure 3 and the ANOVA model (Table 2), the proportion of speakers with Pillai-Bartlett scores close to 1 continuously increases over time. Pillai-Bartlett scores above 0.5 do not appear until the 1970s (Generation X). This indicates that speakers with a phonological distinction appear at least three generations after the prenasal and preoral allophones assume different F1/F2 trajectories, which is indicative of a gradual phonological change.

Also evident in Figure 3 and Table 2 is social distinction at different times in the Lansing community regarding /æ/ systems. First, a class effect in the Silent generation whereby white-collar speakers exhibit significantly higher Pillai-Bartlett values than blue-collar speakers. This class effect is lost in subsequent generations, giving way to a gender effect in Gen X. In Gen X (1965-1984), women exhibit notably higher Pillai-Bartlett values than men whose scores remain lower than 0.5 throughout the twentieth century. In contrast to blue-collar men whose Pillai-Bartlett values increase over time, white-collar men's values remain below 0.5 and appear to remain stable until the 2000s. This is the same trend noted in Nesbitt's (2021) analysis of preoral /æ/ where white-collar men exhibited stable low and retracted realizations, never adopting Inland Northern NCS raising.

In sum, the analysis of Lansing Speech Corpus production data reveals a change in the relationship between prenasal and preoral /æ/ allophones in twentieth century Lansing such that /æ/ in these two environments have become phonologically distinguished over time. Many speakers born in the 1920s had Pillai-Bartlett scores close to 0, indicative of Inland Northern advanced raised /æ/ systems. Speakers born in the 1950/60s exhibit higher Pillai-Bartlett scores indicating that the dominant system during that time was the continuous /æ/ system. Speakers born in the 1990s have Pillai-Bartlett scores even closer to 1, indicating increased prenasal conditioning. The general trend, then, is that the Inland Northern raised system is gradually giving way to a nasal system. It is important to note that this change is incomplete. The highest score in the sample is 0.722, indicating that none of the speakers in this sample has a true gap in phonetic space between prenasal and preoral token clouds. Indeed, some younger community members, namely men, are not yet participating in this change.

### *Subphonemic judgment task*

In combination with the individual-level analysis, I utilize a modified version of the minimal pair task (Baranowski, 2013; DiPaolo, 1988; Herold, 1997; Johnson & Nycz, 2015; Labov et al., 2006; Mellesmoen, 2016), which garnered a larger participant pool than the Lansing Speech Corpus, allowing for an investigation of the social parameters governing /æ/ systems in the community. The task was disseminated via Qualtrics (Qualtrics, 2005) as an online survey, though twenty-four participants opted to complete a paper version. In this experiment, participants were visually presented with American English lexical CVC pairs and asked to judge whether the vowels in the pairs sounded the same or different to them. The following instructions were positioned at the top of their screen/paper throughout the experiment, so that they could read it every time a new pair of words was presented. Participants then either clicked on *the same* or *different* to indicate their judgment.

> For each pair of words, read aloud each word and indicate whether the vowels in those two words sound the same or different to you. Try not to think too hard about your response. Provide the first response that comes to mind. There are no right or wrong answers.

*Sub-phonemic judgment task: Participants.* This survey was disseminated to the Lansing Speech Project participants and offered as extra credit to Michigan State University undergraduate students who also distributed it through their social networks. In total, 252 respondents participated in the experiment, though data from only 107 were analyzed. Respondents were excluded from the study if they identified as some combination of the following, which identified them as being outside of the target population for traditional /æ/-raising: they were non-White, a non-native English speaker, were born and/or raised outside of the Inland North, lived outside of the Inland North for longer than three years, or were younger than eighteen years old. Sixty-five participants were excluded from the analysis due to various performance-related issues (e.g., they did not answer at least 90% of the experimental questions, provided the same response [either *same* or *different*] to 75% or more of the pairs in the survey, or judged more than one of the Condition 6 pairs to be the same). The demographic distribution of the remaining 107 participants is provided below in Table 3.

**Table 3.** Distribution of judgment task participants by generational cohort, socioeconomic status, and gender

| Generational cohort | Birth year | Blue-collar | | White-collar | | Total |
|---|---|---|---|---|---|---|
| Silent | 1925–1945 | 6f | 3m | 5f | 2m | 16 |
| Baby Boomer | 1946–1964 | 14f | 3m | 10f | 8m | 35 |
| Generation X | 1965–1984 | 11f | 3m | 11f | 3m | 28 |
| Millennial | 1985–1996 | 10f | 3m | 9f | 6m | 28 |
| Total | | 53 | | 54 | | 107 |

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*Subphonemic judgment task: Experimental stimuli.* Thirty lexical CVC pairs were utilized for this task and fall into one of six conditions,[2] as displayed in Table 4. Condition 1 pairs, the *target* condition, were American English words that had the same onset and nucleus /æ/ but differed in whether their coda consonant was nasal or oral. One of the target pairs in this study was FAN-FAT, whose only difference is their coda consonant nasal /n/ or oral /t/. Condition 2 pairs, the *control* condition, resembled Condition 1 pairs, except that they both ended in an oral consonant. For example, PASS and PACK differ in that one ends in the stop /k/ and the other a fricative /s/.

Condition 2 pairs were included as a control to test whether phonetically different pairs might prompt an individual to respond *different*. If phonetic differences are enough to prompt that reaction, then the judgment task would be unsuitable for drawing conclusions about phonologization. If phonological difference drives *different* responses in this task, respondents should judge Condition 2 pairs as *the same*—whether they produce them with different acoustics or not. Consider, for example, Condition 2 pairs PACK and PASS. Although /æ/ before /k/ and before /s/ are gradiently different in the vowel space, this difference is not expected to be meaningful to respondents, and thus the expectation is that they will judge /æ/ in these pairs to be the same. If a respondent judges Condition 2 pairs to be different, then this is an indication that the participant is relying on phonetic implementation differences in the acoustics to make their judgment. In this case, a claim that Condition 1 judgments are an indication of phonological representations would be unsubstantiated. If a respondent judges Condition 1 pairs to be different but Condition 2 pairs to be the same, it is more likely that their judgments about Condition 1 pairs are representative of a perceived phonological difference rather than phonetic difference alone. If both Condition 1 and 2 pairs were judged as the same, then this might suggest that they are relying on some cue other than phonology, perhaps orthography.

Conditions 3-5 were included as experimental distractors. Condition 3 and 4 pairs were like Condition 1 and 2 pairs, respectively, but had either /ɛ/ or /ɪ/ as the short vowel nucleus. Condition 5 pairs compared /ɑ/ and /ɔ/. Condition 6 pairs were included as a measure of participant attention. Some of these pairs had vowels and final consonants that did not match orthographically or phonemically (e.g., BIT, BOMB), while the vowels and consonants of other pairs matched orthographically but differed in phonemic representation (e.g., MAKE, MACK). These were included to ensure that participants were not making judgments based on orthography alone or simply not

**Table 4.** Subphonemic judgment task conditions with example CVC lexical pairs

| Condition | Vowel phoneme | Final consonant nasality | Example pair |
|---|---|---|---|
| 1 | /æ/ | nasal-oral | FAN-FAT |
| 2 | /æ/ | oral-oral | PASS-PACK |
| 3 | /ɛ/ | nasal-oral | PEN-PET |
| 4 | /ɛ/ | oral-oral | PET-PECK |
| 5 | /ɑ/ and /ɔ/ | various | BOT-BOUGHT |
| 6 | various | various | BIT-BOMB |

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taking the task seriously. Data from participants who judged more than one Condition 6 pair to be the same were eliminated from the final analysis.

*Subphonemic judgment task: Analysis.* A binomial mixed-effects logistic regression model in *R* (version 4.1.0; R Core Team, 2013) was utilized to examine the linguistic and social factors surrounding this phonological change. Response (*same, different*) was entered as the dependent variable, while Condition (1, 2), Generational Cohort (Silent, Boomer, Gen X, Millennial), Social Class (Blue-collar, White-collar), and their interactions entered as predictor/independent variables, and Participant and Pair as random intercepts. To determine whether the phonological change was abrupt or gradual, we compare Condition 1 responses to Condition 2 responses in the Silent generation—the generation where prenasal and preoral /æ/ diverge from one another in F1/F2 space, as determined by the production analysis. Phonologization is interpreted as abrupt if, in this generation, there are significantly more *different* responses to Condition 1 pairs than to Condition 2 pairs. As with the production data, an analysis of generational change and social class was utilized to determine when the change began to significantly spread throughout the community and who the linguistic innovators are.

*Subphonemic judgment task: Results.* Table 5 displays count and percentages of *different* responses by generation and social class for Conditions 1 (PAT-PAN) and 2 (PAT-PASS). As with the production analysis, our subphonemic judgment task analysis will first focus on Silent generation responses to determine whether the phonological change in Lansing was abrupt or gradual.

Community spread is explored through the analysis of the Condition/Generation interactions and main effect of social class in subsequent generations. Though Gender is not significant on its own or in interactions, we explore interesting trends in the data with suggestions for future analyses. Figures 4a and 4b display the distribution of *different* responses to Condition 1 (FAT and FAN) and 2 (PAT and PASS) pairs over time. Figure 4a shows the distribution of average responses per birth generation, while Figure 4b displays average responses per speaker.

**Table 5.** Counts and percentages of different responses by generation and social class

| | | Condition 1 (PAT-PAN) | | Condition 2 (PAT-PASS) | |
|---|---|---|---|---|---|
| Generation | Class | *n* Different | % Different | *n* Different | % Different |
| Silent | Blue-collar | 0 | 0 | 1 | 1.4 |
| | White-collar | 0 | 0 | 1 | 1.9 |
| Baby Boomer | Blue-collar | 1 | 0.6 | 1 | 0.8 |
| | White-collar | 10 | 5.6 | 5 | 3.6 |
| GenX | Blue-collar | 15 | 10.7 | 1 | 0.9 |
| | White-collar | 43 | 30.7 | 8 | 7.3 |
| Millennial | Blue-collar | 33 | 25.4 | 1 | 1 |
| | White-collar | 90 | 60 | 5 | 4.2 |

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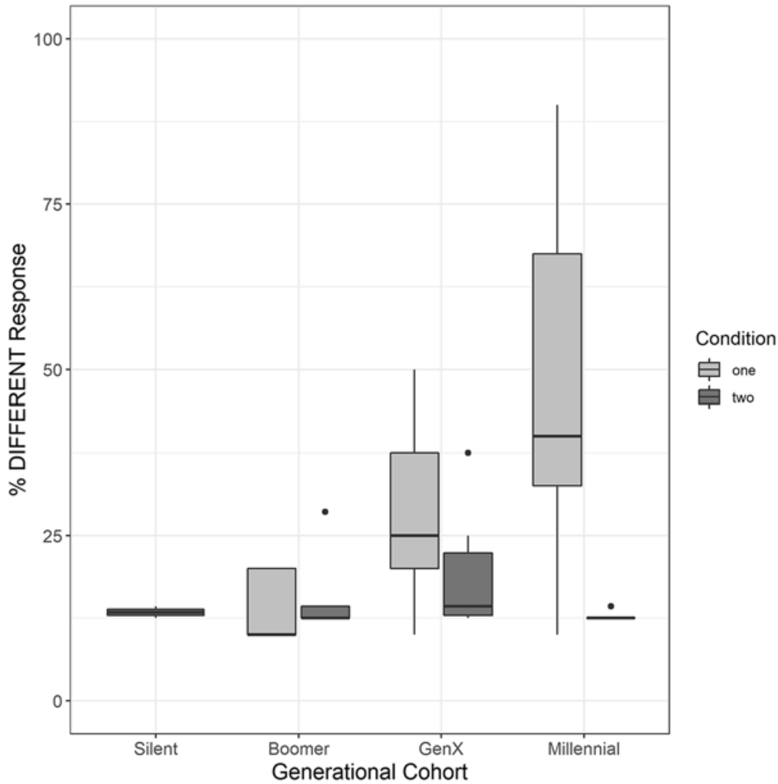


**Figure 4a.** Distribution of *different* responses to Condition 1 (PAT-PAN) and Condition 2 (PAT-PASS) pairs over time.

Focusing on Silent generation responses, *different* responses in both Condition 1 (PAT-PAN) and 2 (PAT-PASS) were zero and 2%, respectively. The low incidence of *different* responses in this generation prohibited a statistical analysis comparing *same* and *different* responses[3] (see Table 6). However, as we see in Table 5, Silent generation participants judge Condition 1 pairs to be the same.

As for change over time, *different* responses to Condition 1 (PAT-PAN) increase over time, while those for Condition 2 pairs (PAT-PASS) remain below 5% in every generational cohort. Condition 1 *different* responses increase from zero in the Silent generation to 3% in the Baby Boomer generation, 20.7% in Generation X, and then 44% in the Millennial generation. Therefore, we find a gradual increase of respondents differentiating between prenasal and preoral tokens, though the difference between Condition 1 and 2 responses is only significant in the Millennial generation (Table 5). Millennial respondents are significantly more likely than their predecessors to judge prenasal and preoral /æ/ to be different from one another than various combinations of preoral pairs.

*Results: Social class, gender, and community spread.* There was no significant interaction of social class with generation and condition, indicating that the proportion of

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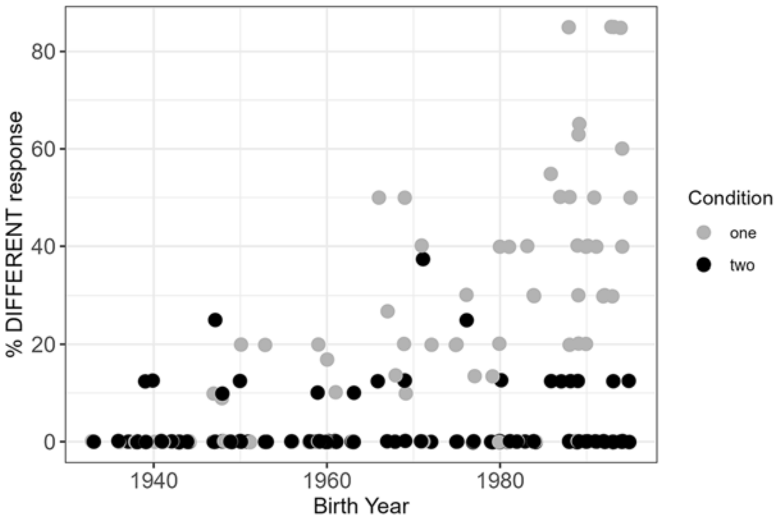


**Figure 4b.** Speaker-level distribution of *different* responses to Condition 1 (PAT-PAN) and Condition 2 (PAT-PASS) pairs over time.

**Table 6.** Mixed-effects binomial regression model for responses to CæC lexical pairs

| | Estimate | Std. Error | *z*-value | *p*-value |
|---|---|---|---|---|
| Intercept | −2.78 | 0.38 | −7.40 | 0.000*** |
| Condition | | | | |
| Cond1 (reference) | | | | |
| Generation | | | | |
| Boomer (reference) | | | | |
| Generation X | 1.08 | 0.36 | 2.96 | 0.003** |
| Millennial | 2.08 | 0.36 | 5.81 | 0.000*** |
| Class | | | | |
| Blue-Collar (reference) | | | | |
| White-Collar | 1.04 | 0.20 | 5.25 | 0.000*** |
| Cond2:Millennial | −2.36 | 0.72 | −3.26 | 0.001** |

*** $p < 0.001$, ** $p < 0.01$, *$p < 0.05$, $p < 0.1$

*different* responses increased over time regardless of social class (Figure 5). There are, however, some interesting trends in the data that I discuss below and that could be taken up in future analyses.

Here I only report on responses to Condition 1 pairs (light gray), since, as we have observed, responses to Condition 2 pairs remain stable over time. While the trend of increasing *different* responses over time holds in both social class groups, the white-collar group appears to be leading the change. In the Silent generation, respondents in both social class groups indicated that Condition 1 pairs were the same. The groups behave the same in the Baby Boomer generation, with *different* responses remaining

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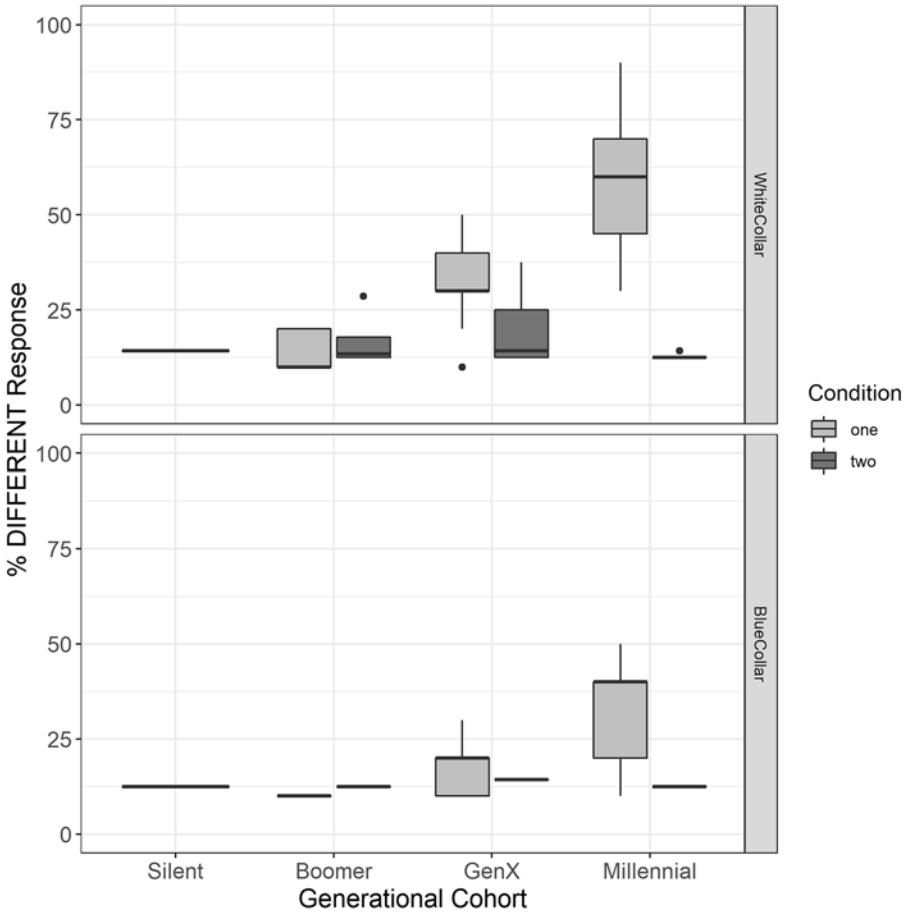


**Figure 5.** Distribution of responses to Condition 1 pairs (PAT-PAN) compared to Condition 2 pairs (PAT-PASS) over generational time and by Social Class (white-collar respondents at the top).

below 7%. In Generation X, however, *different* responses for blue-collar respondents remain relatively low at 10.7% while white-collar respondents' *different* judgments reach 30.7%. In the Millennial generation, these responses again increase to 25.4% in the blue-collar group and to 60.4% for the white-collar group. Thus, though both social class groups show the general pattern of increasing *different* responses over time, they do so at different rates with white-collar responses reaching significance before blue-collar responses.

It is worth specifying here that the specific leaders of this change are likely white-collar women. Gender conditioned /æ/ acoustics were reported in Nesbitt (2019, 2021), where women advanced and then retreated from raising and fronting while men remained stable on these measures. Thus, we might expect gender to be important to the phonological make-up of this variable. A visual inspection of responses in this task points to this same trend. Figure 6 displays the distribution of responses to Condition 1

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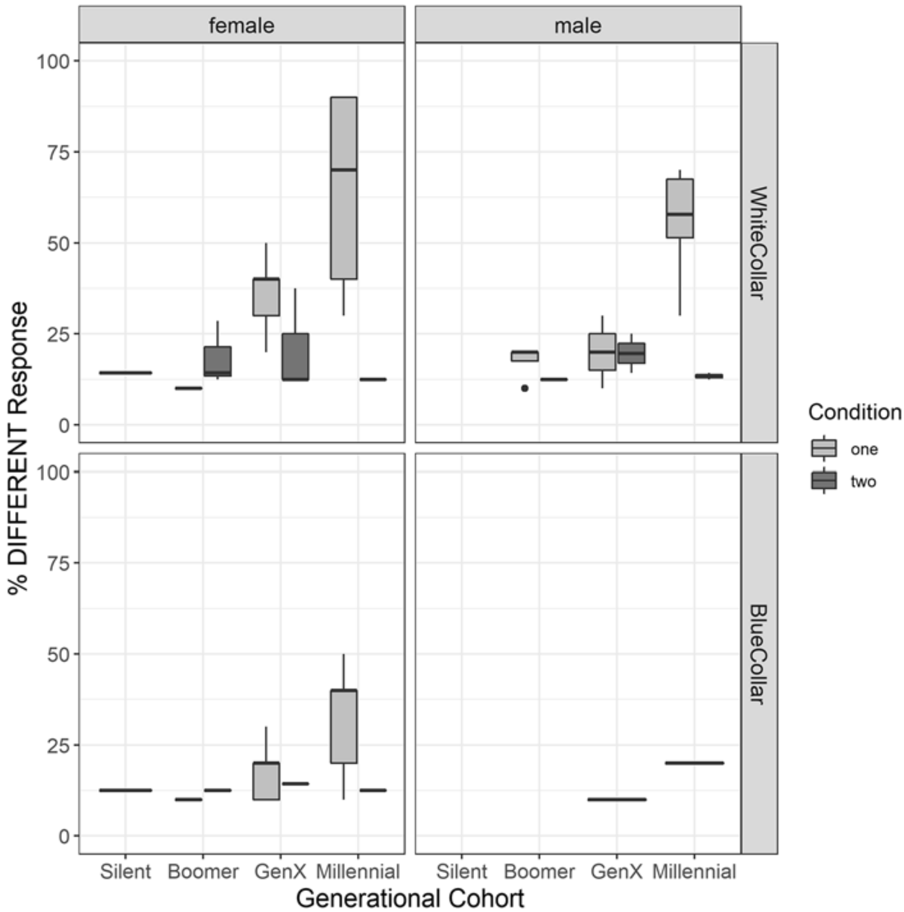


**Figure 6.** Distribution of responses to prenasal and preoral /æ/ over generational time, by social class (white-collar respondents at the top) and gender (women on the left).

pairs only, by generational cohort (x-axis), social class (side facet; white-collar on top), and gender (top facet; female respondents on left).

Crucially, white-collar women appear to be driving this change. This is at first apparent in Generation X where men of both class groups and blue-collar women pattern the same: prenasal and preoral /æ/ incur *different* responses about 20% of the time for these groups, while *different* responses for Generation X white-collar women are higher (∼40%). In the subsequent Millennial generation, *different* responses increase for white-collar men and women and for blue-collar women, although *different* response proportions are more pronounced for the white-collar respondents than blue-collar respondents. The apparent conditioning of gender and class on nasal allophony is based on a small sample size, and gender was not controlled for in this task because the sample is overwhelmingly female (see Table 3). Therefore, these observations should be interpreted with caution, but they suggest that given a more robust sample, white-collar

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women would be the first in Lansing to posit a phonological rule and that other community members are on the trailing end of this change. And, in line with the acoustic trends in Nesbitt (2019, 2021), blue-collar men are not yet participating. This provides an avenue for future studies examining the diffusion of phonological allophonic emergence and language change in the Inland North.

## Discussion and conclusions

Here I summarize the production and judgment task results. First, the data show that there are three allophony systems observed in the present-day Lansing speech community with respect to prenasal and preoral conditioning environments. Silent generation speakers who exhibit phonetically implemented but not controlled allophony have overlapping prenasal and preoral token clouds in the vowel space, and they do not judge /æ/ in these environments to be different. Those (mostly Baby Boomer generation) who exhibit controlled phonetic allophony do not report that the vowels in these two environments sound different from one another, but they do exhibit some conditioning of the prenasal environment in production. Younger speakers with a phonological system have discretely separated prenasal and preoral token clouds and are more likely to report that /æ/ is different in these environments. Based on the production and judgment speaker-level analyses, we see that these systems map onto the initial three stages of the Life-Cycle of Phonological Processes (Bermúdez-Otero, 2007). A follow-up study in which production and judgment data are taken from the same participant would validate these findings.

The analyses of speaker-level production distributions and subphonemic judgments in the Silent generation suggest that /æ/ nasal allophony in twentieth century Lansing developed gradually. Though there was apparent time change toward higher Pillai-Bartlett scores and more *different* responses, no community members at the beginning of acoustic differentiation—Silent generation speakers/respondents—exhibited a nasal system. In fact, a phonological system was not posited in either task until three generations later in the Millennial generation. The apparent time progression in Lansing reflects a progression predicted by the Life-Cycle of Phonological Processes (Bermúdez-Otero, 2007; Bermúdez-Otero & Trousdale, 2012)—a diachronic progression from Life-Cycle stage 1 and 2 systems to a preponderance of Life-Cycle stage 3 systems—but runs counter to theories of abrupt phonological change (Fruehwald, 2013, 2016; Janda & Joseph, 2003).

The results also support Baker et al. who noted that "sound change depends on phonetically-motivated inter-speaker variation that precedes socially motivated inter-speaker variation, [which] permits a solution to the actuation problem" (2011:351). In Lansing, community members begin to distinguish between the prenasal and preoral allophones in Generation X, which is one generation after social conditioning on phonetic variability was in place (Nesbitt, 2019, 2021). Therefore, in Lansing, the "chance alignment" of interspeaker variation and social influence is what appears to have motivated allophonic emergence. More specifically, upon social conditioning of the pool of /æ/ variants in the Baby Boomer generation (raised and more forward realizations exhibited by women and lowered and retracted realizations exhibited by men), it appears that the /æ/ variants were reallocated to two phonological environments: raised and more forward pronunciations were allocated to the prenasal environment while the lowered and more retracted pronunciations were allocated to the preoral environment. This account of reallocation echoes the *Contact, Focusing, and Reallocation* hypothesis advanced by Trudgill and Britain (Britain, 1997a, 1997b; Britain & Trudgill, 1999; Trudgill, 1986) to account for the emergence of Canadian Raising in Canada and the British Fens, respectively. Under this hypothesis, a mixture of /aɪ/ variants is introduced into the community via the influx of speakers that exhibit traditionally different /aɪ/ pronunciations, and upon contact, the realizations are redistributed based on natural phonetic tendencies. In Canada, this process resulted in an allophonic distribution whereby [əi] is produced before voiceless codas and [aɪ] is produced elsewhere.

This scenario resembles the change in Lansing /æ/, though Lansing is not an area of major contact, like the British Fens during reclamation and Canada during settlement. Although there was considerable in-migration in the first half of the twentieth century from non-Michigan locales to Michigan cities such as Detroit, population change in Lansing was predominantly driven by in-migration from (mostly rural) Michigan towns (Fine, 2008), thus it was not the case that large numbers of speakers from dialect/language backgrounds with different /æ/ systems migrated there (see Nesbitt [2019] for a summary of demographic changes in the area). During this time of in-migration, Michigan towns had either traditional NCS /æ/ systems or, in the case of rural towns, a low nasal /æ/ configuration (Ito, 1999, 2001; Nesbitt, 2019; Wagner et al., 2016). Therefore, though this does not seem to be contact-induced change in Lansing, the movement toward the "pan-American" nasal system does appear to be socially motivated. Bissell and Carmichael (2022), who found gradual phonologization, also found allophonic change amid endogamous change in New Orleans.

The exogenous/endogenous dichotomy perhaps explains the departure of this paper's findings from that of Fruehwald (2013, 2016). Increased in- and im-migration may account for the abrupt change in Philadelphia as the city has witnessed considerable in-migration of nonlocals over the last two centuries (e.g., speakers of Spanish, Vietnamese, and Yiddish linguistic backgrounds; see Katz, Creighton, Amsterdam, & Chowkwanyun, 2010). It may be that nonlocal /aɪ/ pronunciation in Philadelphia was not captured in Fruehwald's analysis because his sample was exclusively made up of "Philadelphia-born" speakers (Fruehwald, 2016:380). If speakers of /aɪ/ productions that varied considerably from that in the local community immigrated to the city at the period of phonetic target change (1930-1940s), then it is possible that Canadian Raising was an exogenous change in Philadelphia, though this remains to be determined. These findings suggest that endogenous and exogenous allophonic changes appear to operate via the same mechanism: social conditioning layered on top of phonetic variability. The difference, however, is that in exogenous changes, social conditioning is sudden while this can be a longer progress for endogenous changes.

If endogamy is indeed relevant for allophonic phonologization, it is unsurprising that phonological change was gradual in Lansing and New Orleans but abrupt in Philadelphia. Endogamy as a conditioning factor in delineating abrupt from gradual phonological allophonic change can be tested in the future and has been attested in the literature on phonemic mergers in progress (see Guy 1990; Herold, 1997). For phonemic mergers, the incidence of either type of change is dependent on when variable realizations and social conditioning are introduced into the community, abrupt in contact scenarios but gradual otherwise. It is my contention then, that upon empirical scrutiny, the speed with which phonological allophonic systems emerge will be subject to the same conditioning as phonemic mergers. If the emergence of allophonic systems and phonemic mergers are governed by the same mechanisms, we can conclude that the likelihood of abrupt phonological emergence (of any kind) depends on the co-occurrence of linguistic and social variability, thus allowing us to account for historical changes and predict future changes.

The apparent time analysis of social factors in this paper suggests that white-collar women are likely the drivers of this allophonic restructuring scenario. Though the judgment task resulted in a significant finding of social class conditioning, the corpus analysis found minimal effects of social class earlier on and gender in later years. The rather small social effect in the corpus as opposed to judgment task is likely due to the former's small sample size (i.e., three speakers for any given gender/generation/class grouping). Nevertheless, in both analyses, change toward phonologization actuated in the white-collar community and then spread to the blue-collar community in Lansing. Because women made up much of the judgment task sample, it may very well be the case that social class conditioning is only relevant for women, and white-collar women are the innovators of this change. The gender difference is unsurprising given that "men appear to be less invested in the social value of linguistic variation" (Labov, 2001:321), but what is the significance of social class in this reallocation scenario? Why do blue-collar women lag behind even white-collar men? One potential explanation for why white-collar women would lead in this reallocation scenario is that the amount of social variation with respect to preoral /æ/ productions might have been highest in the white-collar community in the middle of the twentieth century. Women of both class groups continued /æ/-raising in the Boomer generation, and then working-class men in Gen X followed. Thus, the largest and most prolonged amount of social variation in /æ/ productions would have been in the white-collar community. Either the amount of variability in /æ/ production or the social salience of that variability was most evident in their networks first. I leave these important questions for future research. These questions certainly only touch the surface of identifying the innovators of phonological allophonic rules, but, unsurprisingly, this study shows that allophonic phonological changes are subject to the same sociolinguistic tendencies observed for changes at other levels of the grammar.

This paper has provided empirical evidence for phonological allophonic emergence. The evidence suggests that phonological change in this community was gradual, progressing as predicted by the Life-Cycle of Phonological Processes. I argue that phonological allophony behaves just like other forms of phonological change, namely phonemic mergers, requiring social conditioning to enhance phonetic variability. Indeed, the incidence of abrupt or gradual change is conditioned by how suddenly this enhancement occurs. This paper thus highlights, like many sociophonology analyses past, the need to account for social variation in examining phonological processes (Weinreich et al., 1968).

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**Competing interests.** The author declares none.

## Notes

**1.** Data from twenty-one Millennial speakers (born 1985 to 2004) from Wagner et al. (2016) are included as a temporal reference in visualizations but excluded from statistical analyses due to an imbalance of social class and gender; eighteen are middle-class women.
**2.** The complete list of lexical items is included in the appendix.
**3.** It is important to note that though no statistical tests were performed on Condition 3 and 4 pairs, *different* responses in these conditions (as with Condition 2) remained lower than 5%, which suggests that these combinations of environments (prenasal versus preoral /ɛ/ and /ɪ/, and preoral versus preoral /ɛ/, /ɪ/, and /æ/) are only phonetically distinct and thus continue to act at earlier stages of the Life-Cycle.

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## Appendix

**Table A1.** Pairs of lexical items for the Sub-Phonemic Judgment Task

| Condition | Vowel phoneme | Final cons nasality | Lexical items | |
|---|---|---|---|---|
| 1 | æ | nasal-oral | FAN | FAT |
| 1 | æ | nasal-oral | TRAM | TRACK |
| 1 | æ | nasal-oral | RAN | RAG |
| 1 | æ | nasal-oral | PAM | PASS |
| 1 | æ | nasal-oral | BAN | BAT |
| 2 | æ | oral-oral | PASS | PACK |
| 2 | æ | oral-oral | RASH | RAT |
| 2 | æ | oral-oral | PACK | PAT |
| 2 | æ | oral-oral | RAT | RAG |
| 2 | æ | oral-oral | SAP | SACK |
| 3 | ɛ | nasal-oral | RENT | REST |
| 3 | ɛ | nasal-oral | PEN | PET |
| 3 | ɛ | nasal-oral | TEN | TECH |
| 3 | ɪ | nasal-oral | KIM | KIT |
| 3 | ɪ | nasal-oral | BIN | BIT |
| 4 | ɛ | oral-oral | REST | LET |
| 4 | ɛ | oral-oral | PECK | PET |
| 4 | ɛ | oral-oral | FETCH | FED |
| 4 | ɪ | oral-oral | KISS | KIT |
| 4 | ɪ | oral-oral | BIT | BIG |
| 5 | ɑ/ɔ | oral-oral | BOSS | BOUGHT |
| 5 | ɑ/ɔ | oral-oral | TOT | TAUGHT |
| 5 | ɔ/ɑ | oral-oral | STALK | STOCK |
| 5 | ɔ/ɑ | oral-oral | CAUGHT | COT |
| 5 | ɔ/ɑ | nasal-nasal | DAWN | DON |
| 6 | ɛ/ɑ | oral-oral | REST | COT |
| 6 | ɪ/ɛ | nasal-nasal | PIN | PEN |
| 6 | ɑ/ɪ | nasal-oral | BOMB | BIT |
| 6 | æ/ɔ | oral-oral | SAT | SAW |
| 6 | eɪ/æ | oral-oral | MAKE | MACK |

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