

Social and Structural Constraints on a Phonetically-Motivated Change in Progress: (str) Retraction in Raleigh, NC

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1 Introduction

1.1 Social Constraints

The phenomenon of (str) retraction is a process in some varieties of English in which /s/ retracts towards [ʃ] in /str/ clusters. This change appears to be quite widespread, having been reported at various stages of completion in regions across the US (Durian, 2007; Gylfadottir, 2015; Labov, 1984; Rutter, 2014), the UK (Altendorf, 2003), New Zealand (Lawrence, 2000), and in some communities in Newfoundland (Clarke, 2004).

Evidence of the status of the (str) retraction as an ongoing change in progress is robust. A significant lead of younger speakers in retraction has been found in rapid anonymous surveys (Durian, 2007; Bass, 2009; Hinrichs et al., 2015), analyses of recorded corpora (Glain, 2014), and apparent time studies of communities carried out through sociolinguistic interviews (Durian, 2007; Hinrichs et al., 2015; Gylfadottir, 2015). Rutter (2014) finds that this change in progress is likely spreading through a process of lexical diffusion. Analyzing the spontaneous and elicited speech of mothers and their children (ages 4;1–8;1), Rutter observes that children as young as 5 seem to have already acquired the lexically-specific retraction patterns of their mothers.

While data from Rapid Anonymous Surveys presented by some researchers suggest a male lead in retraction (Durian, 2007; Bass, 2009; Hinrichs et al., 2015), analyses of sociolinguistic interviews have not replicated a sex effect (Durian, 2007; Gylfadottir, 2015). In fact, Gylfadottir (2015) suggests that in Philadelphia there may have been a female lead in the earlier stages of the change, although she argues the change may have progressed past the point of sex differentiation in her data. Such an analysis aligns with similar findings of women as leaders in language change (Labov, 2001). Glain (2014) finds a significant male lead in *Instances of Contemporary Palatalization* (of which (str) retraction is a subset) in data from the IDEA corpus of scripted and unscripted speech from the UK and the US. It is unclear, however, whether this sex difference is true of (str) retraction by itself or if it only emerges when all the palatalization processes presented in Glain (2014) are analyzed as a whole.

One possible explanation for variable effects of sex may come from differences in stylistic context and speech setting. It has been shown that, for speakers in some communities, (str) retraction is sensitive to context and subject to stylistic manipulation (Rutter, 2014; Hinrichs et al., 2015). Altendorf notes that this variable may have already gained explicit indexical value in the UK, with “those who use [retracted] forms affiliat[ing] themselves with the ‘young’ and ‘cool’ and distanc[ing] themselves from the ‘formal’ and the ‘stuffy’,” (2003, p. 154). Stylistic setting and formality are by definition different in sociolinguistic interviews when compared to Rapid Anonymous Surveys or corpora of both scripted and unscripted speech. It is unclear, however, the degree to which differences in stylistic setting and context may explain the variance of reported sex effects across data sets. Additionally, Rapid Anonymous Surveys may not be the most appropriate lens through which to analyze (str) retraction. Given that potentially retracted variants must be put into the context of their speaker’s overall /s/–/ʃ/ space, targeted elicitations of isolated tokens of (str) are not as informative as comprehensive samples of an individual speaker’s entire /s/–/ʃ/ space. Without these reference points, it is impossible to rule out the possibility that a speaker with a retracted (str) has an equally retracted /s/ in other contexts and is not, in fact, participating in this sound change.

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1.2 Linguistic Constraints

In the earliest literature discussing (str) retraction, the specific phonetic motivation for the gradient retraction was an issue of some debate. While Shapiro (1995) presents evidence in favor of the long-distance coarticulatory effect of /ɪ/, Lawrence (2000) argues against /ɪ/ being the sole conditioning factor. Instead, Lawrence puts forth the affrication of /t/ in contact with /ɪ/ as the direct cause of /s/ retraction. This picture is further complicated by evidence presented in Baker et al. (2011) which demonstrated gradient phonetic retraction of /s/ in /stɪ/ clusters to be correlated to specific /ɪ/ articulation strategy, but only in non-retracting speakers. In speakers determined to be retractors, distributions of retracted /s/ were not significantly affected by variability in /ɪ/ articulation; their retraction in /stɪ/ clusters had already reached categorical levels and was no longer sensitive to coarticulatory forces. It may prove difficult to tease apart the effects of contact with affricated /t/ and variably-articulated /ɪ/ on the retraction of /s/ and isolate a single underlying cause or set of causes.

The role of preceding phonological environment in (str) retraction has been relatively understudied. Durian (2007) notes the most extensive (str) retraction occurs when the fricative follows a high vowel, an unsurprising context for palatalization. Both Durian (2007) and Gylfadottir (2015) demonstrate that vowels following the (str) cluster appear to be too distant to influence the articulation of /s/.

In those studies which have investigated position of the cluster within the word (word-initial or word-medial), a robust effect of medial environment conditioning more retraction of (str) has been found (Durian, 2007; Gylfadottir, 2015). Additionally, in the data presented by Gylfadottir (2015) there is a significant interaction between birth year and position, with younger speakers showing even more retraction in medial environments. From his data, Durian (2007) argues that the observed lead in medial position is actually indicative of this position being the locus of actuation, with (str) retraction first beginning in medial position and then later expanding to other environments.

The prominence of medial position over word-initial position is intriguing given perceptual work on the role of position and contrast in maintaining perceptual distinctions between /s/ and /ʃ/. Scudieri (2012) examined the perceptual distinctiveness of these two phonemes in different syllable positions in nonsense words using a perceptual similarity rating task. In her experiments, /stɪ/ and /ʃtɪ/ pairs were rated more distinct when occurring inter-vocally, and more similar when occurring word-initially. Scudieri attributes this to the possible influence of perceived morphological boundaries, with listeners treating word-initial pairs as a single onset, but inserting a morpheme boundary between the clusters word-medially, thereby allowing the constituent parts to be analyzed as belonging to separate syllables. In his production data, Durian (2007) also attributes the prominence of retraction word-medially to the interaction of morphology and syllable boundaries. Examining data from Korean, Cho (2001) finds greater articulatory variation and co-articulation across morpheme and word boundaries than within a single morpheme, a phenomenon which might plausibly explain the greater coarticulation of (str) in medial position. An additional explanation for the medial lead is presented by Rutter (2011), who hypothesizes that maintenance of the /s/–/ʃ/ distinction is important for successful lexical retrieval, a process which relies more heavily on word-initial segments than word-medial ones (Beckman, 1998).

In a later experiment, Scudieri (2012) carried out a speeded AX discrimination task between [stɪ] and [ʃtɪ] pairs in comparable contexts and positions. For this group of listeners, no effect of word position was observed in the aggregate. However, an incredible degree of individual variability was observed in the accuracy of distinctions between the [stɪ] and [ʃtɪ] pairs. While some listeners distinguished between the two variables with near perfect accuracy, other listeners found it impossible, with some listeners having “a mean accuracy of 0% across all pairs,” (Scudieri, 2012, p. 27). Additionally, some listeners were more accurate in distinguishing between [stɪ] and [ʃtɪ] pairs word-initially and worse inter-vocally; the opposite was not observed. As Scudieri notes, these results represent “the first indication that a perceptual merger between [stɪ] and [ʃtɪ]” and supports the claims that “this sound change is quite actively occurring across speakers” (2012, p. 27).

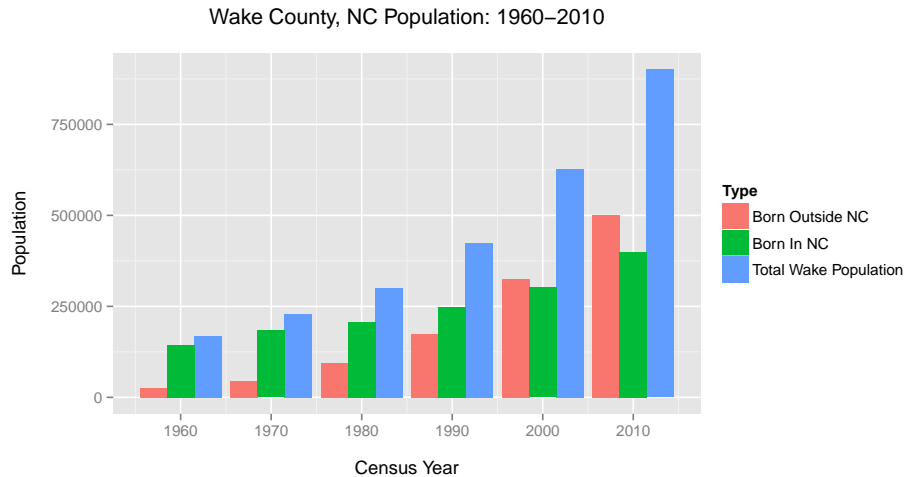


Figure 1: Wake County Population Statistics retrieved from US Census (1960–2010).

1.3 Research Aims

Given this previous body of research on (str) retraction, the current project has two main research questions. First, to what extent is (str) present over time? If so, when does it begin to emerge in apparent time? Does the timeline of this variable align with other linguistic changes in the community, namely the reversal of the Southern Vowel Shift? Secondly, what linguistic factors condition the realization of retracted variants? Can we observe support for claims of the medial position as the locus for this sound change and source of most retraction as claimed by (Durian, 2007)?

2 Methodology

2.1 Corpus

The data analyzed for this paper are drawn from a corpus of sociolinguistic interviews carried out with lifelong residents of Raleigh, NC (Dodsworth and Kohn, 2012). Data collection began in 2008 and is ongoing. Interviews were typically carried out in the participant’s home or workplace or in the interviewer’s office. Recordings were digitized at a rate of 44100Hz.

Raleigh, NC is a particularly interesting field site for investigations of language change and variation due to its unique demographic profile. During the late 1950s and early 1960s, Raleigh experienced a dramatic population boom as skilled tech laborers from the North immigrated to the city to work for the burgeoning tech industry in the Research Triangle Park (RTP) area. This influx of new speakers from different dialect areas has continued over the past half century. As presented in Figure 1, the percentage of the population of Wake County (of which Raleigh is the center) born outside of North Carolina has increased dramatically over the past fifty years. In 1960, only 14.8 percent of Wake County residents were born outside of North Carolina. By 2010, a tremendous 55.6 percent of Wake County’s population was born outside of the state.¹

The effects of this rapid immigration and changing demographics on language norms in the community have been dramatic. Raleigh continues to shift further from ‘standard’ Southern features, such as the Southern Vowel Shift (SVS), as dialect leveling occurs (Dodsworth, 2013, 2014; Dodsworth and Kohn, 2012; Forrest, 2013, 2015). This rapid urbanization and retreat from certain

¹While the “Born Outside NC” category includes both immigrants from other US states as well as foreign immigrants, the former group represent the majority of this category: 95 percent in 1960 and 76 percent in 2010.

Generation	Birthyear Range	Women	Men	Total
1	1923–1954	28	27	55
2	1955–1978	32	24	56
3	1979–1996	15	14	29
		75	65	140

Table 1: Demographic breakdown of Raleigh speakers under analysis.

Southern features is not unique to Raleigh, nor even to North Carolina, as similar processes have been observed in other urban centers in the South (Fridland, 2012; Koops, 2010; Thomas, 1997; Tillery and Bailey, 2008). Raleigh’s changing demographics and expanding population make it an interesting field site for investigating language changes in progress. By observing the leveling and koineization processes that occur in such dramatic immigration and contact situations, we can better understand the processes and patterns governing language change.

The specific speakers analyzed at present represent a subset of 140 speakers from the Raleigh corpus, roughly balanced for sex and birthyear. Their demographic information is presented in Table 1. Generation information is loosely based on the coding scheme outlined in Dodsworth and Kohn (2012) and reflects the divisions between people who grew up before the influx of skilled laborers (Generation 1), people who grew up during this boom (Generation 2) and who would have had extensive contact with the children of the immigrant tech workers, as well as the people growing up after the first wave of immigration (Generation 3).² Following Gylfadottir (2015), the data set only includes speakers with more than four tokens of (str). Given that the current sample restricts the analysis to White speakers, I would like to emphasize that all references to the “community” that follow must be qualified as referring to the White community.

2.2 Data Processing

Interviews were force-aligned using P2FA³ (Yuan and Liberman, 2008) and all /s/ and /ʃ/ tokens from each speaker with a duration greater than 40 ms were extracted. Given the nature of applying automatic segmentation to a dataset this large, there are undoubtedly some errors in segmentation. Although force-aligning technologies are of tremendous assistance to the researcher, segmentation errors do occur and, worse, these errors are not distributed evenly across segments (Goldman, 2011). The current study and claims made within it must be evaluated keeping the possibility of segmentation errors in mind.

Using Praat and the One Script infrastructure (Mielke et al., 2016), a band-pass filter from 500–11000Hz was applied to each token in order to exclude residual voicing as well as environmental noise in the higher frequencies. A power spectrum was then calculated from a 30ms Hamming window centered on the midpoint of this band-pass filtered token. Using this power spectrum, the first spectral moment, Center of Gravity (COG), was calculated (Forrest et al., 1988). COG treats the spectrum as a random probability distribution and computes information about the central tendency of that distribution. COG has been shown to be a reliable measure of the distinction of place of articulation between /s/ and /ʃ/ (Jongman et al., 2000; Baker et al., 2011). While most previous investigations of (str) retraction have used COG as their dependent acoustic measure, (Rutter, 2011) chooses to instead utilize peak frequency. Spectral peaks have also been utilized to great effect by Reidy (2015) and Koenig et al. (2013) using multi-taper spectral analyses. While such a measure is perhaps preferable over COG since it has a much clearer source-filter mapping, pilot investigations

²Generation information is presented only for context; birthyear is treated as a continuous variable in all analyses.

³11050Hz models.

were not able to establish accurate and robust methods to automatically calculate the relevant peak information.

Each token was classified for a variety of linguistic factors including the preceding phone, the following phone, whether it occurred in a stressed or unstressed syllable, its duration, the frequency of the word in which the segment occurred, as well as the segment's position within a word (initial or medial). Medial position is further broken down by whether the segment occurs as an onset or coda. Importantly, medial (str) (and initial (str), for that matter) always occurs as a syllable onset. Word frequency is defined as the log of the Laplace-smoothed word frequency count from SUBTLEX-us (Brysbaert and New, 2009). In order to account for words in the data set not appearing in SUBTLEX (word types $n = 1193$; word tokens, $n = 10770$), the frequency of every word in the corpus was calculated. For each word missing a SUBTLEX frequency value, its stand-in value was calculated as the mean SUBTLEX frequency of all the words with identical frequencies in the corpus. In a handful of cases, there were words without an identical corpus frequency with which to calculate stand-in SUBTLEX frequencies. In these cases, the stand-in SUBTLEX frequencies were calculated in the same way using the word's nearest corpora frequency neighbor. A total of 99,150 tokens remain for analysis: 81437 /s/, 15135 /f/, and 2578 (str). Unless otherwise stated, /s/ henceforth refers to the subset of /s/ tokens that do not occur in /sti/ clusters.

3 Results

3.1 Statistical Modeling

Mixed-effect linear regression models were fit to the data using the *lme4* package in R with COG as the dependent variable. Model comparisons were carried out with AIC decrease as the indicator of improved model fit. Models were constructed in a nested fashion, incrementally adding variables of interest. Constructing models in this way allows us to test specific hypotheses about the roles of individual independent variables and interactions in reducing the amount of residual variation and improving model fit. The dependent variable in all models is the retraction ratio presented in Baker et al. (2011) and defined as:

$$\text{Retraction Ratio} = \frac{(\text{speaker mean /f/ COG} - \text{Observed COG})}{(\text{speaker mean /f/ COG} - \text{speaker mean /s/ COG})} \quad (1)$$

Additionally, all models have an identical random effects structure: with random intercepts for SPEAKER and WORD and by-speaker random slopes for LOG(DURATION).

3.2 Analysis 1

Analysis 1 investigates the progression of (str) retraction relative to the /s/–/f/ dimension. Linear regression modeling was carried out as described in 3.1 and the best fit model included a four-way interaction between SEX, BIRTHYEAR, TYPE (/s/, /f/, or /sti/), and POSITION (initial or medial), as well as fixed effects for LEFT and RIGHT contexts.

Due to the immense difficulty associated with directly interpreting coefficients produced by four-way interactions (especially those containing two continuous variables), analysis of model results will be carried out through visualization. Figure 2 presents the model coefficients and standard errors from the best fit model in order to investigate the shape of the /s/–/f/ space in the community over time, with a focus on the position of (str) relative to /s/ and /f/. The dashed horizontal line corresponds to a retraction ratio of 0.755 which Baker et al. (2011) establish as the mean retraction ratio of all phonological retractors in their data.

The necessity of the complex interaction between sex, position, and birthyear is clear from Figure 2. (str) is retracting rapidly in the women's speech in medial position (e.g., 'restructure'). The women's retraction of (str) is not nearly as advanced in initial position (e.g., 'strategy'). For the men, the relationship between /s/ and (str) appears to remain fairly stable over time, with (str) being produced with some degree of baseline retraction.

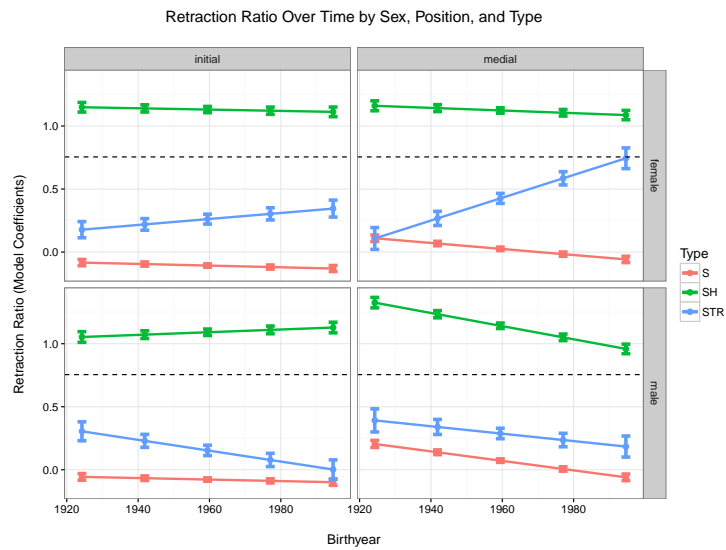


Figure 2: Retraction Ratio by Birthyear, Sex, Position, and Type (Speaker Means).

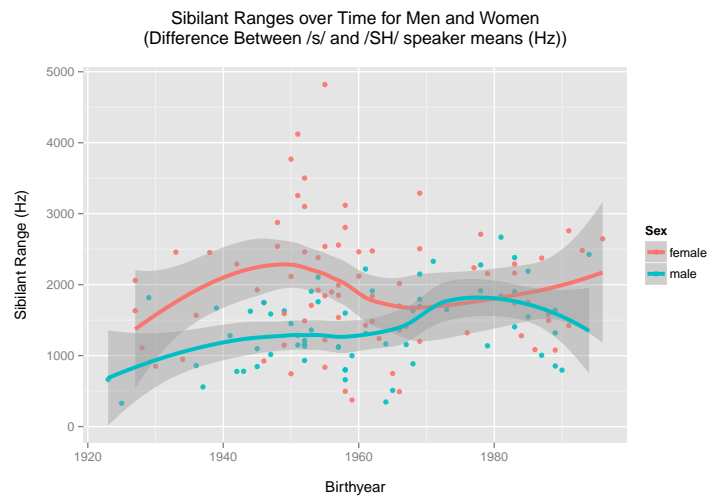


Figure 3: Difference between Mean /s/ and Mean /j/ (Hz) for Each Speaker.

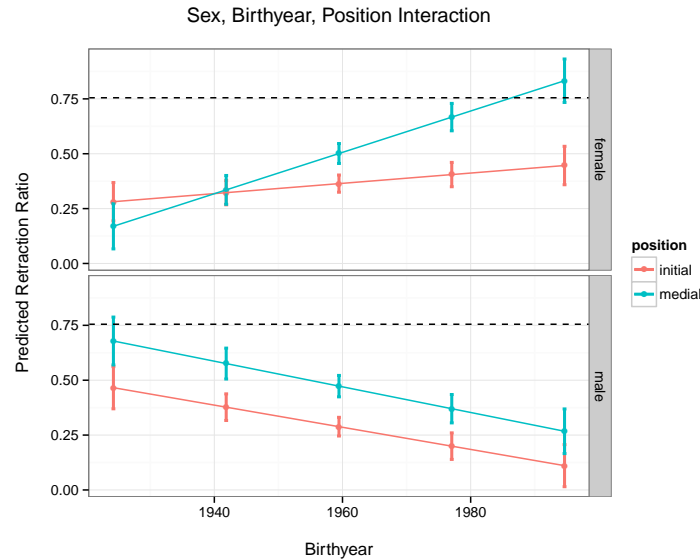


Figure 4: Visualization of Interaction Term: Birthyear * Sex * Position.

While the retraction ratio normalizes the relationship between mean /s/ COG and mean /ʃ/ COG across speakers, it is important to consider the variability in raw COG values produced by different speakers. Figure 3 presents a measure of an individual’s /s/–/ʃ/ space calculated as the difference between that speaker’s mean /s/ COG (not including (str) tokens) minus their mean /ʃ/ COG. Those women with ranges greater than 3000Hz, while outliers from the community trend, are not subject to bad measurements or alignment. These women have extremely high COG means for /s/ ranging from 7500–9000Hz and typical mean values of /ʃ/, causing their /s/–/ʃ/ ranges to be much larger than other members of the community. It is unclear whether these differences are due to articulatory or stylistic forces.

Important for the current analysis is the fact that an overall increase in the width of the men’s /s/–/ʃ/ spaces over time can be observed, with distinctions between /s/ and /ʃ/ increasing in apparent time. Crucially, situated within this overall expansion, (str) does not retract significantly in the male speech.

3.3 Analysis 2

Having established the relationship of (str) retraction to the /s/–/ʃ/ space in Analysis 1, Analysis 2 focuses in on the (str) subset of data in order to pinpoint the specific factors conditioning this change. These data are a near perfect subset of the (str) tokens considered in the previous section, with the exception that tokens were excluded if their preceding phone did not occur at least 20 times in the data set. This arbitrary threshold was established in order to improve model estimation and ensure that effects were not calculated for factor levels with extremely low token counts. The tokens currently under analysis represent 97 percent of the original (str) set (2499/2578).

The best fit model includes a three way interaction between SEX * BIRTHYEAR * POSITION, fixed effects of PREVIOUS PHONE and LOG(DURATION), and random intercepts for word and speaker and by-speaker random slopes for DURATION.

The interaction term from the model is presented visually in Figure 4. Like Figure 2, the current figure directly represents the main effect of single interaction term net the other independent variables. Again, the dashed line corresponds to the mean retraction ratio of 0.755 the phonologically retracting group in Baker et al. (2011). We can observe that (str) is becoming less retracted over time for male speakers in both medial and initial positions. Although these two positions have the

freedom in the model to vary their slopes, they do not. It can be noted that at all points in apparent time, medial position is significantly more retracted for the male speakers and this appears to be a quite stable effect. Medial and initial positions behave differently in the speech of the women, however. Beginning in 1960, medial position begins to become significantly more retracted than initial position. This trajectory continues in apparent time until the youngest females in the community are producing (str) in medial position equally or more retracted than the most retracted group of Baker et al. (2011).

4 Discussion

The data presented here strongly support the progression of the (str) retraction in the speech of Raleigh natives. Retracted (str) can be seen to emerge gradually in the speech of the women, with medial position driving this retraction. Although unattested in previous sociophonetic analyses, the clear female lead in this ongoing sound change in Raleigh is unsurprising given the tendency for women to more frequently produce innovative variants (Labov, 2001).

What is unclear, however, is the specific impetus for the beginning of (str) retraction. While it is likely that (str) retraction has emerged in parallel in separate communities across the English-speaking world (no large-scale immigration between New Zealand and Newfoundland, for example), it is telling that (str) retraction begins in earnest in Raleigh in the 1960s. This time period is meaningful in that Raleigh experienced enormous demographic changes as immigrants from the Northern US came to the area, bringing with them new linguistic systems and norms. This contact has been shown to have directly affected retreat from the SVS (Dodsworth, 2014) with the influx of non-Southerners dramatically changing the network structure of the city. However, even before the community changes experienced in the mid-20th century, (str) was slightly, yet significantly, more retracted than /s/. If this baseline phonetic coarticulatory effect was already extant within the community, why did (str) retraction emerge when it did, and not at an earlier time?

An analysis presented by Baker et al. (2011) offers relevant insight, holding that noticeable levels of inter-speaker variation are crucial to the initiation of sound change, with “phonetic effects that vary between speakers [being] more likely candidates for new sound changes” (p. 369). Under this analysis, the baseline phonetic retraction which existed before the 1960s was constant at the level of the community, with no noticeable sex differences. Because this effect was constant throughout the community and phonetically motivated, it could be robustly compensated for perceptually. With the influx of new speakers with, presumably, differing levels of (str) retraction [e.g., retraction in Philadelphia is much more advanced (Gylfadottir, 2015)], inter-speaker variability in the community increased. It is possible, then, that this increased variability in (str) production reached a critical point and led to a reanalysis of the previously perceptually compensated retracted variants as novel pronunciations, thereby setting into motion the first stages of this sound change.

This theory is intriguing given the fact that the data at present show medial position as the environment in which the retraction is occurring. Greater rates of retraction in medial position have led some authors like Durian (2007) to hypothesize that this position was the locus for the change, later spreading to initial position. The current data (c.f. especially Figure 4) support this analysis. Retraction rates in initial position have remained relatively stable over time, with significant retraction in medial position for women beginning in the 1960s. If (str) retraction is driven by the diffusion of a retracted variant developed elsewhere, do these incoming speakers only have retraction in medial position? If the retraction in medial position demonstrated by the young Raleigh women is to be attributed to diffusion, it would seem logical that these positional constraints would reflect the incoming variety. The alternative view, in which increased variability at the community level led to a reanalysis of the baseline (str) retraction as an inherent characteristic of that segment and not simply due to coarticulation, would also predict such a medial lead. Without more evidence on the specific linguistic systems of the incoming immigrants to Raleigh in the 1960s, it may prove difficult to establish whether (str) retraction in Raleigh is a diffusion of the retracted variant or a case of novel innovation due to increased community-level variation.

Separate from the phenomenon of (str) retraction, the current data demonstrate a change in

progress in the men's speech in which the /s/-/ʃ/ space is expanding overall as shown in Figure 3. This effect is not limited to idiosyncratic individuals, but is progressing at the level of the community. Qualitatively, this difference in /s/-/ʃ/ space between the older and younger males does not appear to be caused by articulatory difficulties or physiological changes caused by aging, as a similar tendency is absent from the speech of the women. It should be noted, however, that these data do not rule out the possibility of sex differences in age-related physiological effects on the articulation of these sibilants. This expansion of the /s/-/ʃ/ range in the male speech is, to this author's knowledge, unprecedented in the literature and not an attested feature of older varieties of Southern American English. However, given that many of the investigations coming out of the large-scale Southern speech corpora have focused on vocalic changes, rather than sibilants, it is possible that this change has existed relatively unstudied in certain populations in the South. Comparisons of data from the current corpora with older male speakers from other regions in the South may shed some light on this unexpected development.

5 Conclusion

The current project has demonstrated that (str) retraction is indeed present in the speech of Raleigh, NC. Although baseline phonetic retraction existed prior to the change, with the influx of non-Southerners in the 1960s, (str) retraction began to progress through the community with a strong female lead. Hypotheses on the contextual source of this change have been supported, as apparent time data demonstrate that medial position is the driving force behind this sound change. While (str) retraction is not as prominent in the men's speech, a separate phenomenon has been noted in which the men's /s/-/ʃ/ space expanded over time, with the oldest men having reduced acoustic distinction between /s/-/ʃ/. This finding is unexpected and previously unreported in the literature. What is unclear at present is whether (str) retraction represents an example of innovative sound change, diffusion of an external innovation, or some intermediate position in which increased inter-speaker variability sowed the seeds for phonetically motivated sound-change. Further investigations may shed light on the changing structure of the sibilant system in the South.

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