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Network Embeddedness and the Retreat from Southern Vowels in Raleigh

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Abstract
This paper introduces the social network procedure of cohesive blocking (Moody & White 2003) as a strategy for fine-grained quantitative network analysis in sociolinguistics. In Raleigh, North Carolina, the Southern Vowel Shift is reversing, due in part to large-scale migration from outside the South since the mid-20th century. Acoustic analysis of the five front vowels from a 140-speaker subset of the conversational Raleigh corpus reveals steady change across apparent time. The community's network structure is considered via a bipartite, or two-mode, network of schools and individuals. Cohesive blocking generates a network hierarchy in which individuals are "nested" at different levels. Nestedness is then tested as a predictor of linguistic variation in linear mixed effects models, which reveal significant nestedness effects for three of the five vowels, net of age, sex, and occupation. Speakers with higher nestedness lead the retreat from the Southern Vowel Shift.

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Robin Dodsworth*

1 Introduction

The capacity of social network factors to influence linguistic variation and change is neither widely doubted nor well understood. Foundational neighborhood-based research in Belfast (Milroy 1980) and in Harlem (Labov 1972) called attention to network density and centrality as well as to an individual's position in the network and the complexity of his/her relationships with others. Milroy and Milroy (1992) further proposed a model of the relationship between socioeconomic class and social network in shaping linguistic variation. Subsequent sociolinguistic research has often included data about speakers' inter-ethnic contact (Cheshire et al. 2011, Fridland 2003, Sharma 2011, Hoffman and Walker 2010), their exposure and attention to people outside the immediate community (Hazen 2002, Labov 2001), and their participation in potently iconic activities or groups (Eckert 2000, Mallinson 2006). Many of these studies construct network indices to quantify self-reported interactional habits. However, the systematic representation of a community's network structure, and of an individual's location in the network, remains an area of great potential for sociolinguistics. In most cases, our sample sizes are (for good reasons) too small for any attempt at a precise quantitative representation of, for example, a speaker's centrality in the community network, or of the relationships among densely connected clusters within the community. This article proposes that *two-mode* network analysis can yield useful advances in sociolinguistic network analysis, given a moderately large speaker sample.

The rapidly growing Southern U.S. city of Raleigh, North Carolina is gradually retreating from the Southern regional vowel system, due in large part to the migration of affluent Northerners to Raleigh during the past half-century (Dodsworth and Kohn 2012, Dodsworth 2013). While some social factors emerge (in particular, a white-collar lead in the shift away from Southern vowels) they exist in the context of a largely uniform set of linguistic norms during any generation. Britain (1997:42) grapples with the social mechanisms by which a focused new dialect emerges quickly from a heterogeneous contact setting such as Raleigh, concluding that "dialect koineization appears… to be linked to a complex interplay of recurrent and embedded social behavior, network strength, norm enforcement, the language acquisition process, and the development of linguistic salience." All of these forces are likely at work in Raleigh's new dialect formation process.

2 The Dialect Contact Setting of Raleigh, North Carolina

The Southern Vowel Shift (Labov 1991, Labov, Ash, and Boberg 2005, Fridland 2001) unites a wide range of regional dialects in the southeastern United States. It may have begun during the late 19th century (cf. the discussion in Thomas 1997:310-311, Bailey 1997). While Southern vowel systems differ from other regional systems in multiple ways, the Southern Vowel Shift (hereafter SVS) refers specifically to the monophthongization of /aɪ/ (postulated by Labov et al. as the triggering event for the SVS), the backing and lowering of the nuclei of the front tense vowels /i/ and /e/, and the raising and fronting of the nuclei of the front lax vowels /ɪ/, /ɛ/, and /æ/. The result is often described as a "reversal" of the front tense and lax pairs. Because the shift was mainly confined to the first half of each vowel's trajectory, these vowels also variably became diphthongal. Labov et al. (2005) find a wider geographic distribution for the mid front reversal than for the high front reversal, and Raleigh, North Carolina lies in a region characterized by the mid front but not a full high front reversal (though as shown below, the high front vowels did shift somewhat in Raleigh). The current study focuses on the five front vowels, leaving aside the extremely iconic variable of /aɪ/ monophthongization.

The *retreat* from the SVS, which began in Raleigh during the mid-20th century, refers to the shift by all five front vowels away from their Southern positions and toward a regionally unmarked American system: the front tense vowels are becoming higher and fronter, and the front lax vowels are becoming lower, backer, and more monophthongal. Many Southern urban areas are experiencing rapid retreat from the SVS as the result of post-WWII migration from outside the South. In Raleigh, migration and the resulting urban growth were catalyzed by the development of Research Triangle Park (RTP), a technology industry hub that has attracted thousands of professionals from the Northern U.S. since the early 1960s (Rohe 2011). Contact between Southern and non-Southern dialects in Raleigh has led to the gradual but quick elimination of Southern variants, such that the vowel systems of young speakers in Raleigh have few distinctive regional features (Dodsworth & Kohn 2012). The current investigation of Raleigh vowel systems takes as a point of departure the assumption that, in a contact setting, interaction between the children of migrants and the children of natives, especially in school, drives the formation of a new, stable dialect (Kerswill and Williams 2000), where "migrant" translates in Raleigh to one of the typically well-educated professionals who moved from outside the South. In addition to contact, it can be safely assumed that the avoidance of stigma associated with Southern identities contributes to the gradual retreat from the SVS, and that this identity work is only partly the product of contact. As Torgersen and Kerswill (2004:25) observe, "…an understanding of the balance of 'contact' versus 'identity' or 'attitudes' in explaining the diffusion of change is in its infancy."

The Raleigh corpus consists of conversational interviews, each roughly an hour long, with about 270 people who grew up in and currently live in Raleigh. Data collection began in 2008 and is ongoing. Most interviews took place in speakers' homes with just the speaker and, in some cases, a spouse or friend present. While the interviews are largely unstructured, most speakers were asked where they attended school from earliest to latest, where in Raleigh they grew up, whether they knew any children of migrants from outside the South while growing up, where their parents grew up, what occupations their parents had, whether their parents attended college, and what their own past and current occupations are. Most speakers discussed the rapid social and economic changes that Raleigh has undergone, in particular the loss of Southern cultural norms. The majority of the interviews were conducted either by the author or by Mary Kohn or Danica Cullinan.

The current analysis uses acoustic data from 140 of the interviews to investigate change over time in the front vowel system (Table 1). Speakers in this subset were born between 1923 and 1993 (mean=1961), and they are all White. Formant values were measured in Praat. For 51 speakers, vowel tokens were identified by hand in the conversational interviews. Approximately 20 closed-syllable tokens per speaker of each of the five front vowels were measured, as well as 20 tokens of /ɑ/ (the 'cot' vowel, which remains distinct from the 'caught' class for many Raleigh speakers) to supplement normalization. The remaining 89 interviews in the present sample were transcribed and aligned to the sound file using the P2FA forced aligner (Yuan and Liberman 2008). Vowel tokens were identified and measured automatically in Praat, then hand-corrected where necessary. These methods have increased token counts. Vowel tokens are excluded from the quantitative analysis if they meet any of the following criteria: duration under .06 seconds, unusually high pitch, breathy, adjacent to a vowel, liquid, or glide, or occurring before a nasal consonant. Lobanov normalization (Lobanov 1971) and all other analysis is implemented in R. Additional back vowels (other than /ɑ/) were excluded from the normalization procedure due to the highly variable occurrence of back vowel fronting in Southern dialects. Token counts appear in Table 2.

	Number of speakers
Sex	
female	75
male	65
Occupation	
blue collar	13
unskilled white collar	18
white collar	109
Total	140

Table 1: Summary of speakers.

Phoneme	Number of tokens
/i/	6728
/ɪ/	7218
/e/	8873
/ɛ/	7799
/æ/	9557

Table 2: Token counts per phoneme.

The dependent variable in all subsequent quantitative analysis is the normalized F2 minus the normalized F1 (Z2-Z1) at 25% of the vowel's duration. This measure captures height and frontness together and reflects their relationship along the front diagonal of the American English vowel space (Labov et al. 2013). Figure 1 shows the trajectories of change across apparent time using speaker means. All five vowels began to shift away from their Southern positions around 1950: the tense vowels shift higher and frontward along the diagonal, and the lax vowels shift in the opposite direction. Figure 1 additionally shows that the high vowels were never reversed in the aggregate, whereas the nuclei of the mid vowels were not distinct in the aggregate before 1950.

Previous work (Dodsworth 2013) finds that white collar speakers lead the retreat from the SVS. The present analysis additionally considers network embeddedness as a predictor of vowel position, under the hypothesis that speakers who are well connected to others in Raleigh are more likely to adopt linguistic changes in progress. Speakers who grew up in peripheral neighborhoods, especially in areas south of the city that have seen less suburban development, may not only have fewer connections to other areas of the city but also less exposure to the incoming non-Southern dialects. However, young speakers growing up in far North Raleigh, many of them children of migrants from the North, may also occupy peripheral network positions and have little contact with groups of speakers with the indigenous Southern vowel system. As the current sample includes relatively few such speakers, it remains reasonable to hypothesize a (noisy, age-dependent) positive correlation between network embeddedness and retreat from the SVS.

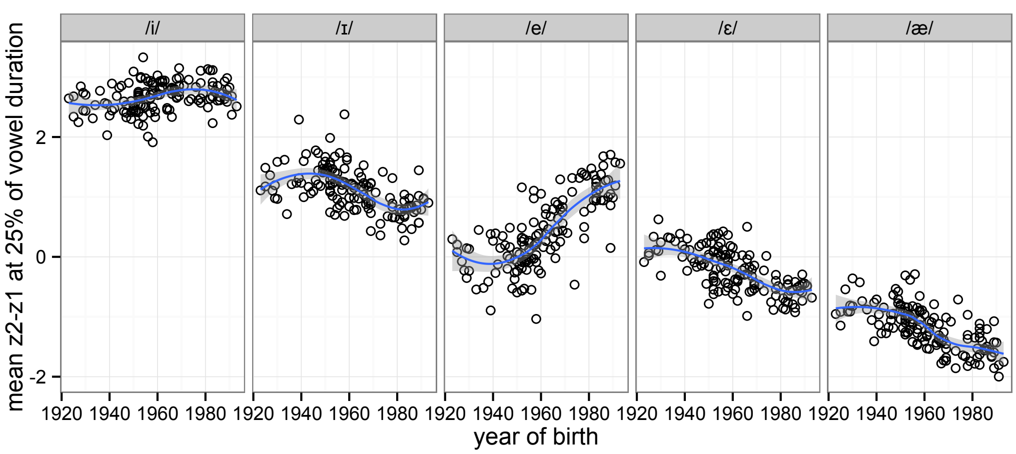

Figure 1. Change across apparent time in Raleigh's front vowel system. Each circle represents one speaker's mean. All vowels are shifting away from their Southern positions.

3 Two-mode Networks and Cohesive Blocking

In a community-based sociolinguistic study, it is desirable but usually impractical to collect enough data on patterns of interaction among people for quantitative analysis. Self-reporting of friendship networks is a useful but incomplete and subjective proxy; similarly, a categorical variable encoding neighborhood of residence can reveal much about segregation and clustering within the community, but it falls short of indicating which people come into contact with one another regularly, either within or between neighborhoods. Further, it is difficult to collect network data from adults about long-past interactions that occurred when they were acquiring their dialects.

Two-mode, or bipartite, network data offers a partial solution. Two-mode network models differ from traditional models in having two distinct classes of nodes representing different things in the world. Ties occur only between nodes of different types. For example, in Newman (2001), one class of nodes represents authors of scientific papers, and the other class of nodes represents the papers. A tie between nodes indicates authorship. If two author nodes are linked to the same paper node, then they are co-authors. The "one-mode projection" of this two-mode network has only the author nodes, and links between nodes indicate co-authorship. Thus a two-mode network can document interaction between people via their shared participation in an event, membership in an organization, etc. (Davis, Gardner and Gardner 1941, Latapy, Magnien and Del Vecchio 2008, Opsahl 2013). For sociolinguistics, the utility of two-mode network data lies in the ability to model regular interaction between people as a function of their shared presence in a place where they routinely go and talk to others, such as workplaces, club meetings, or social hangouts. Shared presence does not, of course, guarantee that two people talk to one another, but it does suggest repeated exposure to many of the same people and sociolinguistic norms.

A two-mode network was constructed from the Raleigh corpus by representing individual speakers with one set of nodes and schools (elementary, middle, and high schools) with the other set of nodes (Figure 2). A link between a speaker and a school indicates attendance at the school for at least a year. The network is intended to model the differential exposure to others that Raleigh speakers had while growing up, under the assumption that many aspects of a speaker's dialect stabilize prior to adulthood (Johnson and Newport 1989, Flege 1999). The dense core in Figure 2 shows that many speakers attended the older, geographically central schools. The periphery represents not only southern, somewhat working class neighborhoods, but also the newer neighborhoods in North Raleigh built during the 1960s and onward to accommodate the growing population. Figure 3 shows the one-mode projection of Figure 2, such that all nodes represent individual speakers and links indicate co-attendance at a school, possibly at different points in time.

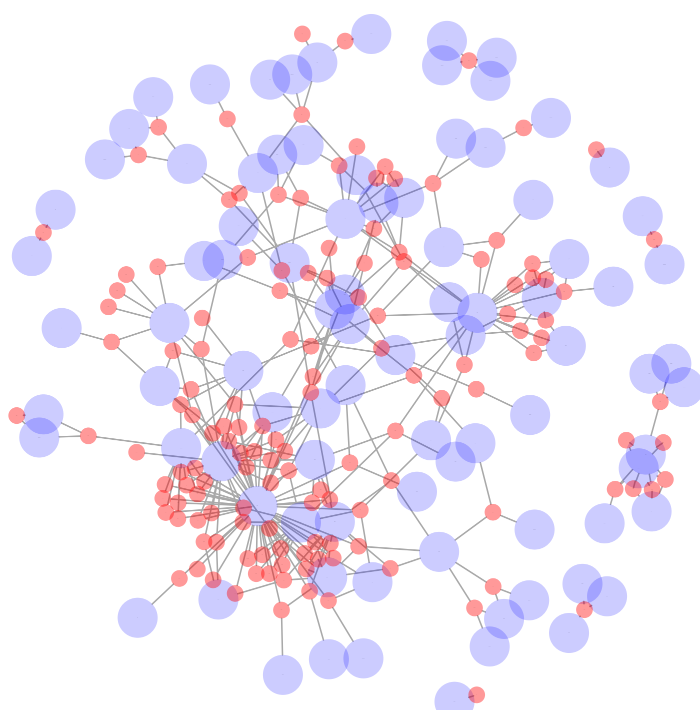

Figure 2. Two-mode Raleigh network. Large nodes represent schools, and small nodes represent individual speakers. A link between nodes indicates a speaker's (former) school attendance.

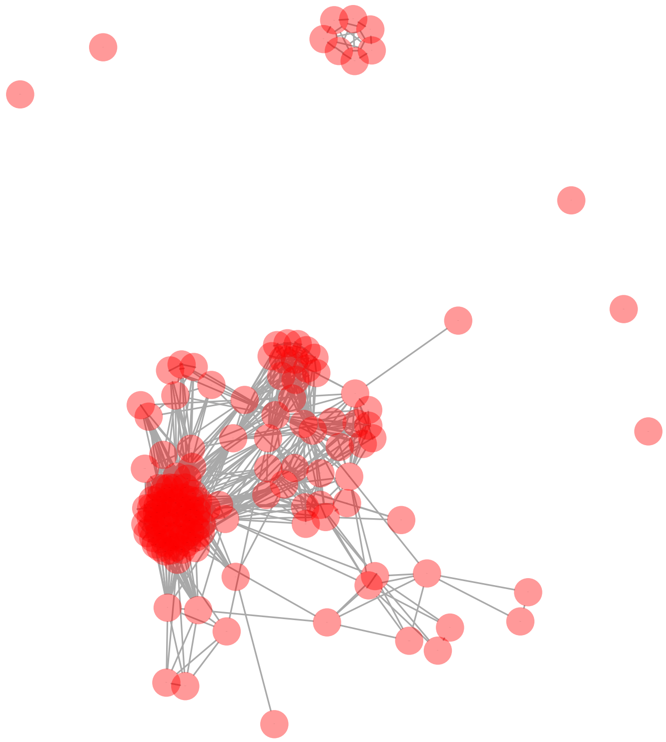

Figure 3. One-mode projected network derived from the two-mode network in Figure 2. Nodes represent individual speakers. A link between nodes indicates co-attendance at a school, not necessarily at the same time.

The projected one-mode network data were analyzed quantitatively using the *cohesive blocking* procedure (Moody and White 2003). Cohesive blocking identifies connected subgroups of nodes within or beside other subgroups. Consider, for example, a group of 100 connected nodes that can be disconnected via the removal of *k* nodes, where "disconnected" means that there no longer exists a path from each node to every other node. When the group of 100 nodes has been disconnected, there may nevertheless remain connected subgroups. If *k* is the level of connectivity of the original group of 100 nodes, then cohesive blocking recursively identifies all connected subgroups with *k*+1 connectivity, and so on. In this process, "each iteration of the procedure takes us deeper into the network, as weakly connected nodes are removed first, leaving stronger and stronger connected sets, uncovering the nested structure of cohesion in the network" (Moody and White 2003:109). For the Raleigh network, the value of cohesive blocking is that it finds the most well-connected subgroup to which each node (speaker) belongs. Speakers who attended the same schools as many other speakers belong to dense, well-connected subgroups that survive multiple iterations of cohesive blocking, while speakers who attended geographically peripheral or small private schools are removed at earlier stages. A node's *nestedness* is the level at which it falls out of the cohesive blocking procedure due to low connectivity. Moody and White use nestedness as an independent variable in regression models predicting 1) U.S. adolescents' feelings of belonging in their school communities, and 2) similarity in political contribution behavior across firms that have financial ties (via shared stockholders, for example). Nestedness in the Raleigh network will be used to predict degree of participation in, or retreat from, the SVS.

Figure 4 shows the hierarchy resulting from cohesive blocking of the one-mode Raleigh data in Figure 3. Higher blocks (i.e., those with lower numbers) have lower connectivity, such that the most well-connected subgroups lie at the bottom. The lowest block in the hierarchy to which a speaker belongs is his/her nestedness score. Thus a high nestedness score indicates membership in a well-connected subgroup. Six speakers do not appear in any block, and thus have no nestedness score, because they do not share a school with any other speaker in the sample. Table 3 gives broad definitions for the lowest terminal blocks in Figure 4.

Block in Figure 4	How speakers in the block are connected	Number of speakers
14	an older North Raleigh middle school	10
15	eastern city high school	18
16	an older North Raleigh high school	13
19	a newer North Raleigh high school	11
21	a central elementary school	13
25	central city high school plus a central middle school	31
26	central city high school	60 (includes everyone in block 25)

Table 3: Selected terminal blocks and their definitions.

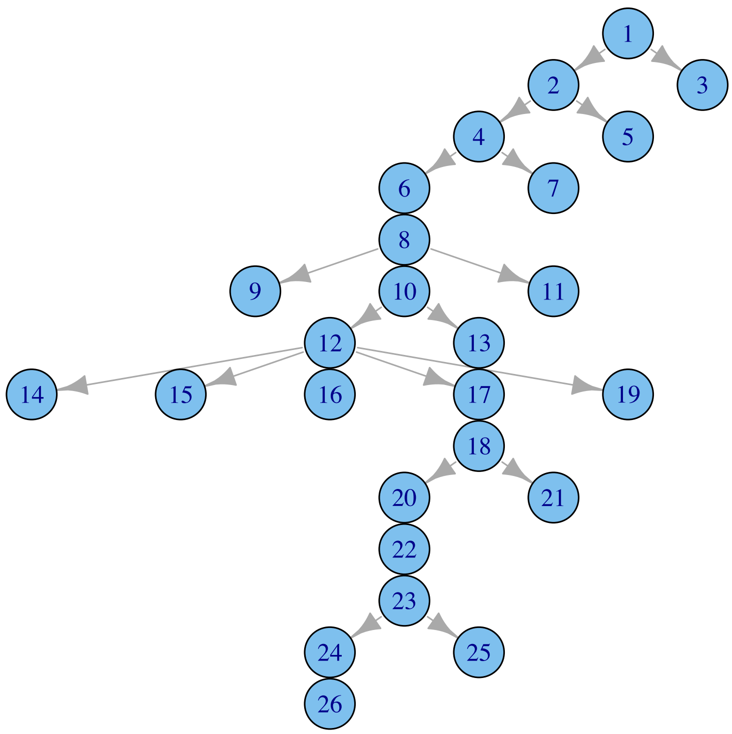

Figure 4. Cohesive block hierarchy for the projected one-mode network in Figure 3.

Because suburban schools were built over time to accommodate the growing population, especially in North Raleigh, older speakers are more likely to have attended the geographically central schools, which coincide with higher nestedness. Figure 5 plots nestedness as a function of year of birth and of occupation. Most speakers born before 1950 have high nestedness scores, while younger speakers from all three occupational groups show a wide nestedness range, reflecting data collection in both affluent North Raleigh and in less affluent suburban neighborhoods to the south. In view of both the homogeneous nestedness scores among the oldest speakers and, more importantly, the fact that the retreat from the SVS began around 1950 (Figure 1), the following analysis includes only the speakers born in 1950 or later.

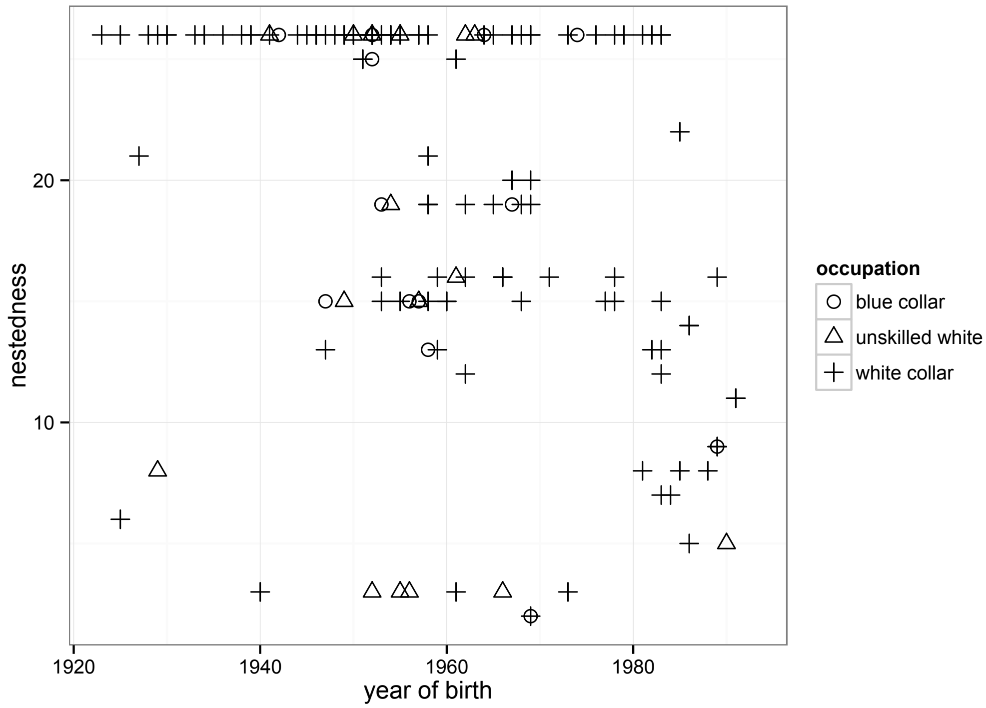

Figure 5. Nestedness as a function of year of birth and occupation in the Raleigh data.

Nestedness was evaluated as a predictor, net of Year of birth, Sex, and Occupation, in linear mixed effects models for each of the five front vowels (Tables 4-8). The other fixed effects are place of articulation of the preceding consonant and vowel duration. Each model also includes random intercepts for speakers, random intercepts for words, and within-speaker random slopes for duration. The reference level for Occupation is blue collar. Model comparison (last row of each table) was carried out via ANOVA.

Nestedness significantly improves the model, net of the other fixed effects, for three of the five vowels. In all three cases, the models predict that greater nestedness coincides with a more advanced retreat from the SVS, i.e., less Southern vowel realization: /i/ is higher and fronter, and the lax vowels /ɪ/ and /ɛ/ are lower and backer for more nested speakers. The interaction between Nestedness and Year of birth is not significant in any model. The statistical results are elucidated in Figure 6, which shows per-speaker mean Z2-Z1 as a function of year of birth and nestedness for each of the three vowels with significant nestedness effects. Two impressionistic observations will be noted. First, among speakers who grew up around the time that large-scale contact began (i.e., were born in the 1950s), those with high nestedness scores may be either “leaders” or “laggers” in the retreat from the SVS. However, there are five speakers born before 1970 who attended high school in Garner, a southern area relatively untouched by the in-migration of Northerners, especially during the early stages of migration. These speakers all have the nestedness score of 3 and thus show up as the smallest characters in the left half of Figure 6. As a group, they are more Southern than the non-Garner speakers with respect to all three vowels. The second impressionistic observation is that after 1970, the speakers with the highest nestedness scores mostly fall on the “leading” side of the regression lines (corresponding to greater retreat from the SVS), while speakers with lower nestedness scores fall either on the regression line or on its “lagging” side, with the exception of a low-nestedness speaker born in 1973 who leads in the case of /ɪ/. None of these speakers attended high school in Garner. However, the speaker born in 1989 who most visibly lags with respect to /ɪ/ and /ɛ/ in Figure 6 attended a southern city high school that draws some students, including himself, from areas further to the south of Raleigh. Thus there is some evidence that growing up in a peripheral neighborhood to the south of Raleigh exerts a conservative force on a speaker’s vowel system.

	Model 1	Model 2	Model 3	Model 4
Year of birth	.08 (.03)	.07 (.03)	.05 (.03)	.09 (.04)
Sex (male)		.14 (.07)	.19 (.07)	.19 (.07)
Occupation			Unskilled white .23 (.14) White .33 (.11)	Unskilled white .26 (.14) White .30 (.11)
Nestedness				.08 (.04)
AIC	13605	13602*	13597*	13595*

Table 4: Estimates (and standard errors) for /i/. The dependent variable is Z2-Z1. Asterisks show the results of model comparison between each model and the previous model.

	Model 1	Model 2	Model 3	Model 4
Year of birth	-.17 (.03)	-.18 (.03)	-.17 (.03)	-.21 (.04)
Sex (male)		.02 (.07)	-.01 (.07)	-.001 (.07)
Occupation			Unskilled white -.17 (.14) White -.27 (.11)	Unskilled white -.21 (.14) White -.24 (.11)
Nestedness				-.09 (.04)
AIC	13203	13205	13203	13199*

Table 5: Estimates (and standard errors) for /ɪ/. The dependent variable is Z2-Z1. Asterisks show the results of model comparison between each model and the previous model.

	Model 1	Model 2	Model 3	Model 4
Year of birth	.43 (.04)	.43 (.04)	.41 (.04)	.42 (.05)
Sex (male)		-.19 (.08)	-.14 (.09)	-.15 (.09)
Occupation			Unskilled white .16 (.18) White .35 (.14)	Unskilled white .18 (.18) White .34 (.14)
Nestedness				.04 (.05)
AIC	14906	14903*	14899*	14901

Table 6: Estimates (and standard errors) for /e/. The dependent variable is Z2-Z1. Asterisks show the results of model comparison between each model and the previous model.

	Model 1	Model 2	Model 3	Model 4
Year of birth	-.20 (.03)	-.18 (.03)	-.17 (.03)	-.21 (.03)
Sex (male)		-.12 (.06)	-.1 (.06)	-.09 (.13)
Occupation			Unskilled white .13 (.13) White -.01 (.10)	Unskilled white .09 (.13) White .01 (.10)
Nestedness				-.08 (.03)
AIC	13307	13306	13307	13304*

Table 7: Estimates (and standard errors) for /ɛ/. The dependent variable is Z2-Z1. Asterisks show the results of model comparison between each model and the previous model.

	Model 1	Model 2	Model 3	Model 4
Year of birth	-.23 (.03)	-.23 (.03)	-.22 (.03)	-.22 (.03)
Sex (male)		.06 (.06)	.05 (.06)	.05 (.06)
Occupation			Unskilled white -.01 (.13) White -.16 (.10)	Unskilled white -.01 (.13) White -.16 (.10)
Nestedness				.01 (.03)
AIC	17182	17183	17182	17184

Table 8: Estimates (and standard errors) for /æ/. The dependent variable is Z2-Z1. Asterisks show the results of model comparison between each model and the previous model.

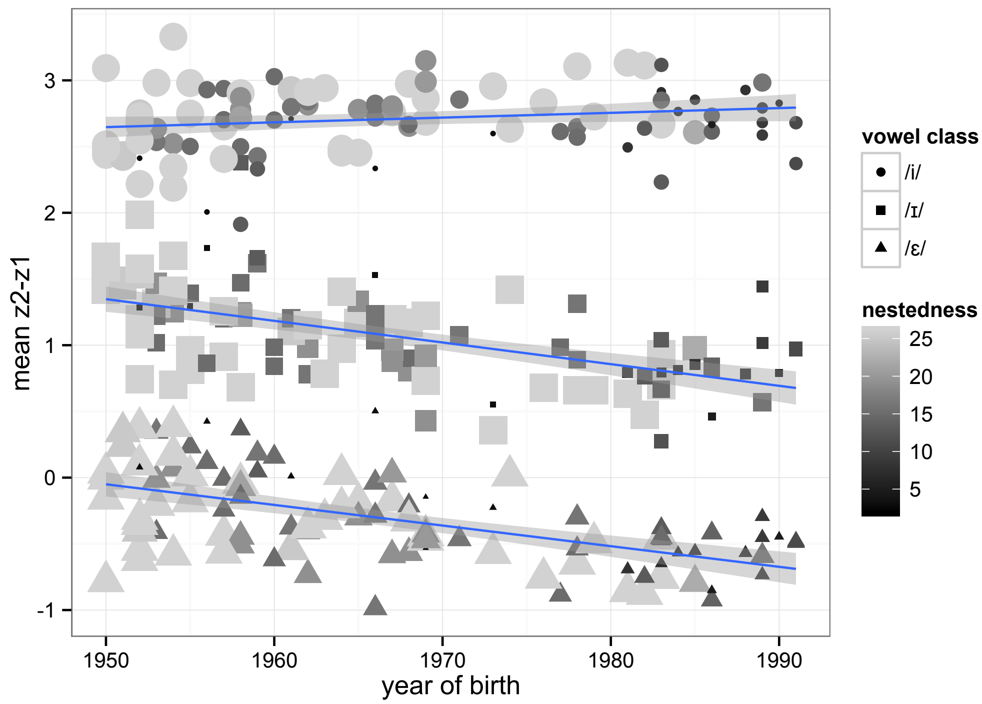

Figure 6. Nestedness and year of birth in relation to vowel position for the three vowels showing significant nestedness effects (cf. Tables 4-8). Nestedness is represented via both size and color (larger and lighter = more nested).

While the results partially support the hypothesis that more nested speakers would show more advanced retreat from the SVS, the present analysis leaves open important questions such as why only three of the five vowels show network effects. There are also significant limitations imposed by sample bias and data scarcity. In particular, speakers born in 1985 or later have a mean nestedness score of only 10.85, as compared to 20.08 for speakers born earlier. This difference reflects not only Raleigh's outward growth over time, but also a paucity of geographically central young speakers in the present sample as well as a greater number of speakers in the sample born during the 1950s. The present sample also lacks young speakers who attended school in Garner. More generally, adding more speakers from the Raleigh corpus will allow for robust statistical testing of interactions between nestedness and the other social factors, in addition to more detailed network analysis. Data quantity remains an obstacle to useful network analysis in sociolinguistics, but automated methods and increasingly large-scale corpora promise new opportunities for relational approaches akin to the one demonstrated here.

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