VOWEL DISPERSION AS A DETERMINANT OF WHICH SEX LEADS A VOWEL CHANGE

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ABSTRACT

Women typically produce more dispersed vowels than men (for example, [1], [2], [10], [12]). This sex difference makes predictions about the role of each sex in vowel changes. Specifically, we predict that women lead changes that maintain the distance between vowels, such as chain shifts, while men lead changes that reduce the distance between vowels, such as vowel mergers. That women lead chain shifts is well-established [6]. That men lead mergers has not been established. An investigation of vowel mergers among the *Atlas of North American English* [7] speakers suggests that men tend to lead mergers, and that speakers with a less dispersed vowel space show more instances of mergers, regardless of sex. I conclude by positing vowel dispersion as an internal explanation of which sex leads a vowel change.

Keywords: vowels, language change, mergers, sex differences, sociophonetics.

1. MEN, WOMEN, AND VOWELS

Women typically produce more dispersed vowels than men. For example, Labov [4: 304] observes:

> On Martha's Vineyard, men are more 'closed-mouthed' than women, and use more contracted areas of phonological space; … women in New York City and Philadelphia use wider ranges of phonological space than men.

This sex-based difference in the pronunciation of vowels has been empirically demonstrated for English, Swedish, French, Dutch [2], and Korean [12]. Both Henton [2] and Yang [12] plotted normalized vowel data for men and women on F1 by F2 plots. In all cases, the females' vowel spaces were larger than males' vowel spaces.

Women are also known to lead vowel chain shifts [6: 284]. Recent work on a vowel chain shift in Midwest United States [3] has linked women leading the shift to their clearer articulation: "women [lead] the vowel change by producing longer and clearer vowel variants" (p.311). Longer vowels are less schwa-like [11], that is, they are farther dispersed from the centre of the vowel space, suggesting a link between vowel dispersion and chain shifts.

If vowel dispersion is connected to women leading chain shifts, then vowel dispersion may also be connected to vowel changes for men. Specifically, the more contracted vowel space of men predicts that men may lead sound changes that further reduce the distance between vowels, such as vowel mergers. The objective of this paper is to test this hypothesized connection between vowel dispersion and vowel mergers. The vowel formant and vowel merger data are drawn from the *Atlas of North American English* ([7], hereafter ANAE), which I introduce in detail in the next section.

I test for a connection between vowel dispersion and mergers in three steps. First, I demonstrate that the male speakers from the ANAE are leading the mergers. Second, I show that the female speakers have more dispersed vowel spaces with two metrics of dispersion, one for front vowels and one for back vowels. Third, I show that there is a correlation between vowel mergers and the vowel dispersion metrics.

2. THE DATA SOURCE

The ANAE is a detailed examination of the Canadian and American English vowel systems. The ANAE team analyzed merger data from interviews with 762 speakers. Vowel formant data were also extracted for 438 of the speakers. The interviews were conducted over the telephone and recorded with a Nagra IV, a Nagra E, or a Tandberg Model 9021 reel-to-reel tape recorder, or a SONY TCD-D8 DAT recorder. The interview included the elicitation of minimal pairs such as *hot*/*caught* by prompting the speaker for the words with questions such as, "What is the opposite of cold?" The prompts were then followed by the request for a judgement on how well the two words rhymed, in terms of "same," "close" or "different." A follow-up interview consisted of the speaker

Merger	Sex	Same		Close		Different		Significance	
		%	N	%	N	%	N	χ^2	p
HILL–HEEL	female	10.5	45	7.3	31	82.2	351	0.23	.891
	male	11.7	29	6.8	17	81.5	203		
FULL–FOOL	female	12.0	54	7.5	34	80.5	363	9.63	.008
	male	12.4	33	14.6	39	73.0	195		
BELL–BAIL	female	10.8	41	7.6	29	81.6	310	1.37	.504
	male	10.9	23	10.4	22	78.7	166		
PIN–PEN	female	28.7	129	10.9	49	60.4	272	6.66	.036
	male	36.2	96	13.2	35	50.6	134		
MERRY–MARY	female	61.5	152	4.1	10	34.4	85	12.04	.002
	male	69.1	103	10.1	15	20.8	31		
MERRY–MARRY	female	81.0	201	8.1	20	10.9	27	0.34	.844
	male	83.3	125	7.3	11	9.3	14		
HOARSE–HORSE	female	1.5	6	2	8	96.5	386	2.67	.263
	male	3.5	8	1.7	4	94.8	218		

Note: d.f. = 2 for all tests

Table 1: Distribution of sex by merger category for seven mergers in North American English

reading a full-page word list that was provided in the mail.

The ANAE provides merger and formant data on a separate CD. The merger data are in the form of impressionistic judgments by the speaker of their own minimal pairs.[1] The formant data were extracted with the Computerized Speech Lab program by Kay Elemetrics. The interviews were digitized at a sampling rate of 11,000 Hz. Only highly stressed vowels were selected for formant analysis. This resulted in between five and ten tokens of each vowel in each environment for each speaker, or approximately 300 tokens per speaker. Altogether, approximately 134,000 vowel tokens were measured. The ANAE also provides some social information on each speaker, of which I make use of speaker sex and dialect region.

3. SEX DIFFERENCES IN MERGERS

The ANAE investigates a total of thirteen mergers:

- six mergers of /ɑ/ and /ɔ/ (COT–CAUGHT) in various environments
- two mergers of tense and lax vowels before /l/ (HILL–HEEL, FULL–FOOL)
- the merger of /ɪ/ and /ɛ/ before /n/ (PIN–PEN)
- two mergers before intervocalic /ɹ/ (MERRY–MARY, MERRY–MARRY)
- the merger of /ɔɹ/ and /oɹ/ (HORSE-HOARSE)
- the merger of /w/ and /ʍ/ (WEAR-WHERE)

Merger data are provided for all 762 speakers, but not all minimal pairs were elicited for all regions, or for all speakers in a region. The COT–CAUGHT mergers are excluded in this study, as they participate in a chain shift ([7: 19], [7: 147]), and therefore may be led by the female speakers. The WEAR–WHERE merger is also excluded, as it is not a vowel merger. For the remaining mergers, a Pearson's Chi square test of significance was carried out to determine if the men and the women are behaving significantly differently from each other. The results are listed in Table 1. The merger category percentages are the percent of speakers of that sex in that category for that merger, so that each row in the table totals to 100 percent. The percentages allow us to compare directly men and women.

Altogether, three of the mergers show significant sex differences: FULL–FOOL, PIN–PEN, MERRY–MARY. Men produce more merged and close minimal pairs than women for all three mergers. Men lead in the merged category of the other mergers as well, although the differences are not significant; none of the seven mergers examined are even suggestive of women leading mergers.

4. THE VOWEL DISPERSION METRICS

Vowel dispersion refers to how dispersed the vowels are in phonological space. Previous research on vowel dispersion uses a single metric based on each vowel's distance from the average of all vowel formants ([1], [10]). However, this approach is not sensitive to regional variation in vowel dispersion within the vowel space. There are a number of vowel changes currently taking place in North American English. Some of the changes involve the front vowels while others involve the back vowels. By keeping the measure of vowel distinctiveness to within either the front or the back region of the vowel space, we gain more sensitivity to the interaction between vowel dispersion and vowel mergers. Therefore, I use two metrics of vowel dispersion: the distance between /i/ and /æ/ as a measure of Front Vowel Dispersion (FVD); and the distance between /u/ and /ɑ/ as a measure of Back Vowel Dispersion (BVD).

Following the ANAE (p.39–40), the formant measurements were normalized using the log-mean normalization procedure posited by Nearey [9]. Normalization allows for a comparison of vowel dispersion across the sexes by compensating for the longer vocal tracts of the male speakers.

I calculate the distance between vowels by treating the first and second formant measurements as points in Euclidian space [11]. For example, the distance between /u/ and /ɑ/ is:

(1) $$d = \sqrt{\left(F1_a - F1_u\right)^2 + \left(F2_u - F2_a\right)^2}$$

Table 2 lists the average FVD and BVD by sex for the 431 speakers from the ANAE with sufficient formant data for normalization. The average vowel dispersion metrics for the women are larger than for the men for both FVD and BVD. These differences are significant (FVD: $t(429) = 2.45$, $p = .020$; BVD: $t(429) = 4.85$, $p < .000$). In general, women produce more dispersed vowels than men for both the front and the back vowels even after normalization. These results are consistent with other studies ([1], [2], [10], [12]) of sex differences in vowel dispersion.

	N	FVD		BVD	
		mean	st. dev.	mean	st. dev.
female	268	603 Hz	190.5	670.7 Hz	149.6
male	163	560 Hz	171.3	598.7 Hz	149.2

Table 2: Average FVD and BVD by sex

5. LINKING MERGERS TO DISPERSION

I test for a link between the vowel dispersion metrics and merger categories “same,” “close,” and “different” by looking for correlations between the merger category and the vowel dispersion metrics. There are, however, two considerations. The first consideration is the relationship between the merger categories “merged,” “close” and “distinct.” The second consideration is which data to include.

The relationship between the merger categories is ordinal but not linear. The statistical test for relationships between an ordinal variable and scalar independent variables is Ordinal Regression Analysis. This analysis is carried out by first transforming the continuous independent variables into discrete categories, and then using the Pearson’s Chi square test statistic to test for a significant relationship. The model does not predict the cumulative probabilities directly, but rather a function of those values. The mathematical transformation that then produces the probabilities is called the “link function,” and is chosen to match the distribution of the dependent data across the ordinal categories [8]. The link functions chosen are listed along with the results (Table 3).

The second consideration concerns which data to include for each merger. Not all data were included because some of the regions represented in the ANAE show no or limited variation between speakers. In these regions, the merger is either in its preliminary stages, or it is in its final stages. Because these regions show little variation between the speakers, including these regions runs the risk of concealing the relationship between vowel dispersion and merger category. Each region was examined individually, and any region that contained more than 80 percent of its speakers in a singled merger category was removed from the data. This process of region selection was repeated for each of merger.

For each merger, two Ordinal Regression Analyses were run, one with FVD as the predictor of merger category, and one with BVD as the predictor of merger category. The results are listed in Table 3. Altogether, ten of the fourteen correlations are significant or marginally significant. Every merger except HOARSE–HORSE shows at least one significant correlation with a vowel dispersion metric. These results strongly corroborate the hypothesis that vowel mergers are linked to vowel dispersion.

Of the mergers listed in Table 3, five involve the front vowels, while the other two involve the back vowels. With the exception of the MERRY–MARRY merger, the mergers involving front vowels correlate stronger with FVD than with BVD. The reverse pattern holds for the two mergers involving back vowels — the correlation

Merger	Link Function	N	FVD		BVD	
			χ^2	p	χ^2	p
FILL–FEEL	Comp.	141	21.2	.000	4.05	.044
FULL–FOOL	Comp.	171	0.01	.908	4.32	.038
BELL–BAIL	Comp.	136	13.8	.000	3.08	.079
PIN–PEN	Cauchit	279	14.2	.000	9.88	.002
MERRY–MARY	Cauchit	145	13.5	.000	3.37	.066
MERRY–MARRY	Neg.	35	.677	.411	7.33	.007
HOARSE–HORSE	Comp.	18	0.10	.755	2.54	.111

Notes: d.f. = 1 for all tests, Comp. = Complementary log-log, Neg. = Negative log-log

Table 3: Ordinal Regression Analysis for the seven mergers

with BVD is stronger than the correlation with FVD. This pattern implies that vowel mergers are typically more sensitive to vowel dispersion in their local region of the vowel space, and justifies the use of separate front and back measures of vowel dispersion.

6. CONCLUSIONS

One of the established principles of sociolinguistics is "that women are generally the innovators in linguistic change" [5 :205]. Labov goes on to say that it is unclear how differences between sexes can account for this pattern. In this paper, I attempted to account for the sex pattern for vowel changes by arguing that sex differentiation in vowel changes is linked to sex differentiation in vowel space dispersion. This was done by showing that for the mergers taking place in North American English: 1) men tend to lead the mergers; 2) women tend to produce more dispersed vowels; and 3) for both sexes, speakers with less dispersed vowel spaces tend to lead the mergers. Although I cannot prove causality, these results, along with the results from [3] introduced above, suggest that the role of sexes in vowel changes is determined by sex-based differences in vowel dispersion.

The next step towards accounting for sex differences in phonetic-level sound change is to examine sound changes other than vowels to see if the pattern seen here still applies. That is, do women typically lead sound changes that involve the maintenance of phonetic-level distinctions (regardless of segment type), while men typically lead sound changes that involve the reduction of phonetic-level distinctions? If so, then a re-interpretation of the role of sex in phonetic-level sound change in terms of the maintenance of phonetic distinctions may go a long way towards illuminating how differences between sexes can account for why women tend to lead phonetic-level sound changes.

7. REFERENCES

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[1] The ANAE also provides analysts' perceptions of speakers' productions of minimal pairs as well. However, these production data do not show significant sex differences, and therefore are omitted from discussion.