LEXICAL CHARACTERISTIC MEDIATE THE INFLUENCE OF SEX AND SEX TYPICALITY ON VOWEL-SPACE SIZE

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ABSTRACT

Sex differences in vowel acoustics were found to be mediated by words' frequency of use and phonological neighborhood density. Larger sex differences in vowel-space expansion were found for words with high frequency of use and for words with small phonological neighborhoods, than for words than for words with low frequency of use and high neighborhood density. Results suggest that talkers' production of social-indexical variants is constrained by the influence these might have on word recognition.

Keywords: Vowel Acoustics, Sex Differences, Word Frequency, Neighborhood Density

1. INTRODUCTION

It is well established that talkers use permissible linguistic variation to convey social identity. This variation occurs in many different linguistic domains, including conversational pragmatics, word choice, and pronunciation. The nascent discipline of sociophonetics examines talkers' manipulation of fine phonetic detail to code social categories. Perhaps one of the best studied categories is gender. Gender-related variation occurs both at the level of categorical variation, such as women's greater use of 'standard' variants, such as the pronunciation [ɪn] for the English verbal morpheme –ing. Gender differences also occur in subphonemic detail in speech. For example, women produce more expanded vowel spaces than men [2]. A variety of investigations have shown that sex differences in vowel-space size are due to numerous factors. [3] proposed that the vowel-space expansion differences are the consequence of attempts that women make to counter the intelligibility decrement that would otherwise result from the harmonic-formant misalignment that would occur because of the high f0 in their speech [3]. [12] argued that one source of these differences is sex differences in the size of the oral cavity. Still others have argued that women's larger-sized vowel spaces are a reflection of their greater use of standard forms.

The purpose of this investigation was to examine sex differences in one dependent measure, vowel-space expansion, are equivalent for words of different frequencies and phonological neighborhood densities. The motivation for this study was as follows. Previous research has shown that words that are low in frequency and high in neighborhood density are more difficult to perceive than words that have the opposite characteristics [12]. Other research has shown that the acoustic vowel spaces of high-frequency words are less expanded than those for low-frequency words, and that high-density words' vowel spaces are more expanded than those of low-density words, perhaps reflecting a tacit attempt to counter the perceptual difficulties of these words [6], [13]. If women's more-expanded vowel spaces reflect active attempts to maintain intelligible speech, then they should be greater for words that are predicted to be difficult to perceive than for ones that are predicted to be easier to perceive. Such a finding would be predicted by the H&H model [5], which proposes that the acoustic characteristics of speech maximize perceptibility while minimizing effort. An ancillary purpose of this study is to examine whether any effect of frequency and neighborhood density that are found are mediated by the sex typicality of the talker being examined. Previous research has established a relationship between vowel-space size and listener-identified sex typicality for men [9],[11] and women [8]. This investigation examines whether sex typicality effects are also mediated by the frequency and neighborhood density of the stimuli being examined.

2. METHODS

1.1. Participants

Participants consisted of 44 talkers (11 each lesbian/bisexual women [1 bisexual, 10 lesbian], heterosexual women, gay men, and heterosexual men). All of the talkers were between 18 and 40 years of age. Men and women differed significantly in height. Height did not differ as a function of sexual orientation, nor did sex and sexual orientation interact. Participants reported no history of speech, language, or hearing disorders. All reported being native speakers of English. All reported having been born in the North Central dialect region [4], and having spent the majority of their post-teenage lives in this area. This minimized the extent to which differences in regional dialect might have affected results. Previous analyses of this cohort have examined speech characteristics as they relate to self-reported sexual orientation. For this analysis, talkers were divided into equal-sized groups of prototypical and non-prototypical sounding men and women based on listener percepts from two experiments, one in which they rated masculinity (for the men) or femininity (for the women), and one in which they rated the extent to which the talker sounds gay. These two measures were combined into a summary measure of sex typicality, and the groups were divided into equal-sized groups of prototypical and non-prototypical speakers based on their ranking relative to the median of this summary score.

1.2. Stimuli

Stimuli for Experiment 1 were 31 CVC words with monophthongal vowels. They included all of the stimuli from [7] except the diphthong [oɪ] in the word *voice*. Stimuli were chosen to contain a variety of vowels (/i/, /ɪ/, /eɪ/, /ɛ/, /æ/, /oʊ/, and /u/). All of the words had an average familiarity rating (per [10]) of 6.0 or greater, indicating that they would be familiar to most participants. Sixteen words were selected from the larger corpus of words for this analysis. The sixteen words comprised eight pairs of words containing the same vowel, one of which was high in density, and the other of which was low. The average number of phonological neighbors for the high-density words was 23.6 (SD=3.6), and the average number for the low-density words was 13 (SD=3.6). The average log frequency of was 4.3 for the low-density words (SD=1.1) and 3.5 for the high-density words (SD=1.3). Between-groups multivariate analysis of variance (MANOVA) showed that the difference in neighborhood density was statistically significant, $F[1,13] = 35.7$, $p < 0.001$, partial $\eta^2 = 0.72$. The difference in frequency was not statistically significant, $F[1,13] = 2.2$, $p = 0.15$.

Sixteen words were selected from the larger corpus of words for this analysis. The sixteen words comprised eight pairs of words containing the same vowel, one of which was high in frequency of usage, and the other of which was low. The average log frequency for the high-frequency words was 5.5 (SD=1.1), and the average of the low-frequency words was 2.5 (SD=1.5). The average number of phonological neighbors for the high-frequency words was 18.2 (SD=2.7). The low-frequency words had an average of 16.8 neighbors (SD=6.1). MANOVA showed that the differences in frequency were significant, $F[1,13] = 18.2$, $p = 0.001$, partial $\eta^2=0.57$. The difference in phonological neighborhood size was not statistically significant, $F[1,13] = 0.5$, $p = 0.54$.

The words in [8] were not selected to vary orthogonally in frequency and neighborhood density. Thus, the word sets used to examine the influence of word frequency and neighborhood density did overlap.

2.3. Analysis

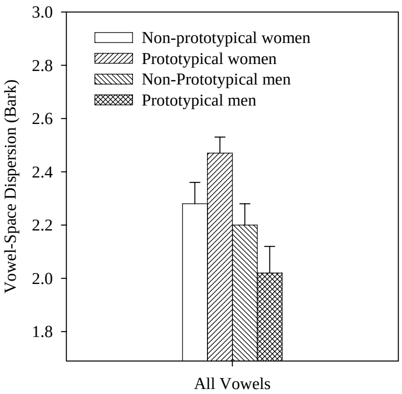
Acoustic measures were made using the Praat signal-processing program [1]. The onset and offset of each phoneme in each word was marked in Praat by a coder who was blind to the talker's sexual orientation. All acoustic analyses were done automatically in Praat using custom-written scripts; all of these made reference to these labels. The duration, F1 and F2 of each vowel were measured. Duration was measured automatically in Praat. Bark-scaled F1 and F2 were extracted from LPC formant analyses with eight coefficients; these were taken at vowel midpoint. For each talker, average F1 and F2 were calculated for individual vowels. These values were averaged to compute an overall average F1 and F2. In addition, average vowel-space expansion was computed for each subject. As in previous research [2], [7], [14], this was measured as the average Euclidian distance from the center of the subject's vowel space.

2. RESULTS

3. All Vowels

When vowel-space dispersion was examined for all 31 vowels, a significant main effect of sex was found, $F[1,40] = 10.84$, $p = 0.002$, partial $\eta^2 = 0.21$. The main effect of gender typicality was not significant, $F[1,40] < 1$, $p > 0.05$. There was a significant interaction between sex and gender typicality, $F[1,40] = 5.4$, $p = 0.025$, partial $\eta^2 = 0.12$. This interaction arose because the effect of sex typicality on vowel-space expansion was in opposite directions for women and for men, as shown in Figure 1.

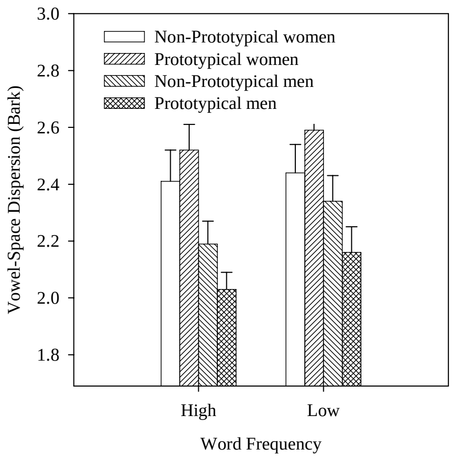
Figure 1: Average vowel-space dispersion for the entire set of 31 words. Error bars represent one standard error of measurement.



3.2 High- and Low-Frequency Words

When vowel-space dispersion was examined for the 16 high- and low-frequency words, a significant main effect of sex was found, $F[1,40] = 13.65$, $p = 0.001$, partial $\eta^2 = 0.25$. The main effect of gender typicality was not significant, $F[1,40] < 1$, $p > 0.05$. The main effect of word frequency was also significant, $F[1,40] = 12.73$, $p = 0.001$, partial $\eta^2 = 0.23$. The interaction between sex and gender typicality did not achieve statistical significance at the $\alpha < 0.05$, but did approach it, $F[1,40] = 3.2$, $p = 0.08$, partial $\eta^2 = 0.07$. This interaction arose because the effect of sex typicality on vowel-space expansion was in opposite directions for women and for men, as shown in Figure 2. Moreover, the interaction between frequency and sex, though again not significant at the a < 0.05, did approach significance, $F[1,40] = 3.6$, $p = 0.06$, partial $\eta^2 = 0.08$. As shown in Figure 2, this interaction arose because both groups of men produced more-reduced vowel spaces for high-frequency words than for low-frequency ones. In contrast, there was no influence of word frequency on vowel-space size for either group of women.

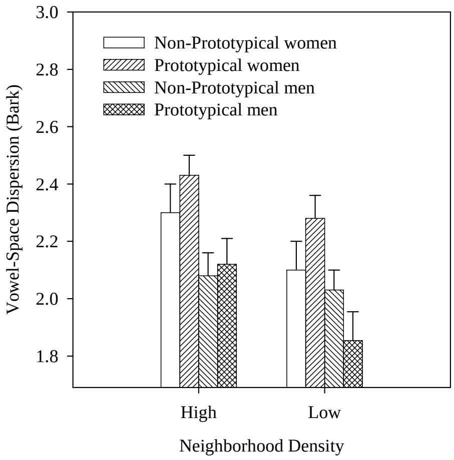
Figure 2: Average vowel-space dispersion for high- and low-density words. Error bars represent one standard error of measurement.



3.3 High- and Low-Density Words

When vowel-space dispersion was examined for the 16 high- and low-density words, a significant main effect of sex was found, $F[1,40] = 12.6$, $p = 0.002$, partial $\eta^2 = 0.23$. The main effect of gender typicality was not significant, $F[1,40] < 1$, $p > 0.05$. The main effect of density was also significant, $F[1,40] = 18.8$, $p < 0.001$, partial $\eta^2 = 0.32$. There was a significant interaction between sex and gender typicality, $F[1,40] = 4.5$, $p = 0.04$, partial $\eta^2 = 0.10$, and among sex, gender typicality, and neighborhood density, $F[1,40] = 7.1$, $p = 0.01$, partial $\eta^2 = 0.15$. This interaction can be seen by comparing bar heights in Figure 3. As this figure shows, the heterosexual-sounding men showed a considerably larger effect of neighborhood density on vowel-space dispersion than did the gay-sounding men, who produced roughly equivalent-sized vowel spaces for both stimulus types.

Figure 3: Average vowel-space dispersion for high- and low-frequency words. Error bars represent one standard error of measurement.



3. DISCUSSION

These results suggest that sex differences in one parameter, vowel-space expansion, are constrained by the impact that those differences might have on listeners' percepts. There were larger differences between men and women for words that are predicted to be easier to perceive than for words that are predicted to be difficult to perceive. There was some evidence that this effect was gradient: men who were rated previously as sounding prototypically male reduced their vowel spaces disproportionately in low-density words; non-prototypical men did not. The interaction between sex and lexical characteristics of the words suggests that sex differences in vowel-space expansion are not solely due to sex differences in oral cavity size. One explanation for these findings is simply teleologic: talkers have tacit knowledge of the acceptable range of vowel-space expansion and compression that can be used to convey social identity without impacting word recognition negatively. That is, men are tacitly aware that they can reduce their vowel spaces to convey masculinity more in high-frequency and low-density words than in words with the opposite characteristics without compromising words' intelligibility. Such an interpretation would be consistent with the H&H model. We concede, however, that further research is needed. Evidence presented by [6] suggests that indexical effects on perception are limited by the time-course of processing. Such a finding might imply that talkers *learn* indexical variants more robustly in high-frequency and low-density words because of the reduced processing load associated with perceiving them, a scenario advanced by [9] to explain [13]'s original findings.

4. REFERENCES

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