The influence of sexual orientation on vowel production (L)

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Vowel production in gay, lesbian, bisexual (GLB), and heterosexual speakers was examined. Differences in the acoustic characteristics of vowels were found as a function of sexual orientation. Lesbian and bisexual women produced less fronted /u/ and /ɑ/ than heterosexual women. Gay men produced a more expanded vowel space than heterosexual men. However, the vowels of GLB speakers were not generally shifted toward vowel patterns typical of the opposite sex. These results are inconsistent with the conjecture that innate biological factors have a broadly feminizing influence on the speech of gay men and a broadly masculinizing influence on the speech of lesbian/bisexual women. They are consistent with the idea that innate biological factors influence GLB speech patterns indirectly by causing selective adoption of certain speech patterns characteristic of the opposite sex. [DOI: 10.1121/1.1788729]

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I. INTRODUCTION

Sexual orientation, social identity, and language use are all matters of intense interest. These issues come together in the question of whether gay, lesbian, and bisexual (GLB) adults are able to use distinctive speech patterns that convey their social identity. In many cultures, a popular stereotype holds that there are systematic differences in speech production as a function of sexual orientation. Indeed, Carahaly (2000) and Linville (1998) both found that listeners can judge the sexual orientation of speakers at greater than chance levels based on speech samples alone.

A small number of instrumental studies have examined the acoustic characteristics that may cue these judgments. However, these studies are limited in their scope and have yielded mixed results. Linville (1998) reports differences in the duration and spectrum of /s/ for a small group of five gay and four heterosexual men. Gaudio (1994) found no differences in vocal pitch between gay men and heterosexual men. Avery and Liss (1996) report vowel differences relating to perceived effeminacy in men, but they did not obtain information about the actual sexual orientation of their subjects. Furthermore, the few existing instrumental studies of lesbian or bisexual women's speech report null results (Waksler, 2001).

This study goes substantially beyond prior work by examining acoustic characteristics of a small number of vowels produced by a considerably larger ($n=103$) cohort of GLB and heterosexual men and women than has been examined in previous research. Our analysis bears on the ongoing debate about the origins of same-sex attraction and its potential relationship to speech characteristics. Prior research on language acquisition and speech production suggests three alternative theories for how sexual orientation could influence speech patterns. One possibility is that an innate biological factor influences both sexual orientation and the anatomical structures that underlie speech production. A related and more sophisticated hypothesis is that sexual orientation relates to hormonal exposure *in utero*, and that the primary biological reflex in adults is sex-typical versus sex-atypical patterns of neural differentiation. This is the position of Bailey (2003a), who reviews a variety of research demonstrating same-sex attraction to be associated (at least at the group level) with hormonal environment *in utero*. These variants of biological determinism have in common the prediction that the speech patterns of gay men should be shifted toward female norms, compared to those of heterosexual men. The patterns of lesbian women should be shifted toward male norms, compared to those of heterosexual women. The shift could arise directly, if anatomical structures of GLB adults partially resemble those of opposite-sexed heterosexual adults. It could arise indirectly, if patterns of speech motor control resemble those of opposite-sexed heterosexual adults.

A second possibility is that an innate biological factor influences both sexual orientation and the trajectory of language acquisition. Distinctively GLB speech patterns would

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be due to the influence of this factor on higher-level aspects of language production, such as attention to adult models during acquisition. This explanation is consistent with theories of sexual orientation that posit a common biological basis for both sexual orientation and vocational and avocational choices. It differs from the first conjecture in that it posits that the common factor influences higher-level aspects of language acquisition and use, rather than anatomical structures.

Finally, GLB speech patterns may be completely learned as a special speech register for the GLB culture (Zwicky, 1997). The existence of such speech registers has been documented widely in other groups [e.g., Eckert, 2000]. This register learning would only begin when people came to identify with a GLB peer group. According to this third possibility, attention to peer models, rather than to opposite-sexed adult models, would be the crucial factor in question.

These theories differ in their predictions about how GLB vowels should pattern in comparison with those produced by heterosexual men and women. Under the first theory, speech patterns of GLB speakers should generally resemble those of opposite-sexed heterosexual speakers. Under the second and third theories, the vowels of GLB speakers could easily differ from those of heterosexual speakers in a way that cannot be characterized as a general displacement. We explore these alternatives by looking at the overall spacing of vowels in the F1/F2 space (a measure of how much GLB vowels are shifted in their ensemble toward those of opposite-sex adults) and vowel-space dispersion (a measure of articulatory effort and precision). We also examine the acoustic characteristics of individual vowels. It has been well established that the acoustic characteristic of vowels are related to both peripheral anatomical patterns (e.g., Lindblom and Sundburg, 1971) and to learned production patterns (e.g., Mendoza-Denton, 2003)

A baseline for understanding differences between GLB and heterosexual people is provided by general speech-production differences between adult males and females. These occur as a function of both anatomical differences and social factors. For males, the larynx becomes more massive at puberty, and its position is lowered. An increased mass causes the fundamental frequency (f0) range of men to be lower than for women. Larynx lowering causes the vocal tract to be longer and differently proportioned for men than for women, with derivable consequences for the vocal tract resonances (Stevens, 1998). On average, men have longer vocal tracts than women (Fitch and Giedd, 1999). As a consequence, their formants tend to be lower than those of women.

Socially conventional differences between male and female speech also exist. Some of these are exaggerations of the patterns that result from anatomical differences. For example, in some cultures women exaggerate the high f0 and breathy voice quality that typically result from their smaller, lighter laryngeal structures (Van Bezooijen, 1995). Young children adopt sex-specific speech traits even before sex-related anatomical differences begin to appear, and the sex of children as young as four years old can be accurately identified from speech (Perry *et al.*, 2001). Such differences are clearly learned through imitation of adult models. The amount of latitude in the system leaves ample room for learning of socially conventional patterns and for individual choices relating to personal identity.

II. METHOD

The data in this study were collected from a large group ($n=103$) of Chicago-area self-identified GLB and heterosexual women and men participating in a broad-based social psychology study of sexual orientation. There were 26 self-identified heterosexual men, 29 self-identified gay men, 16 self-identified heterosexual women, 16 self-identified lesbian women, and 16 self-identified bisexual women. The lesbian and female bisexual groups were combined because no significant differences between them were observed in initial data analyses; they are henceforth referred to as the LB (lesbian/bisexual) women. The speech samples for this study were gathered in the course of a survey of personal and social characteristics related to sexual orientation. As a component of the study, the speakers were recorded, reading a standard set of phonetically balanced sentences (IEEE, 1967). They were not given any instructions regarding speaking style. The talkers were recorded in an academic office using a Shure 10A microphone attached directly to the hard drive of a Celeron 667 mHz personal computer with a Soundblaster sound card. The recording quality was variable, limiting the measures that could be obtained for the present post-hoc analysis.

Four of these sentences (*It's easy to tell the depth of a well; Help the woman get back to her feet; Four hours of steady work faced us*; and *The soft cushion broke the man's fall*) were used as stimuli in a perception study (Bailey, 2003b). Bailey demonstrated that listeners had significant success in judging sexual orientation from this small speech sample. Here, 80 listeners listened to 4 of the sentences and rated each talker on a scale of 1 (''sounds totally straight'') to 7 (''sounds totally gay/lesbian''). Listeners were tested in a quiet university laboratory. Gay men were rated as significantly more-gay sounding than heterosexual men, and LB women as significantly more lesbian-sounding than the heterosexual women. The average value for gay men was 4.6 and for heterosexual men was 3.2; the average value for LB women being 4.3 and that for heterosexual women being 3.2. These differences were significant at the $\alpha<0.05$ level. These results strongly support the claim that speech traits can effectively cue the sexual orientation of many gay, lesbian, and bisexual adults, even in a very neutral communication situation. Objective acoustic differences must be present, at least on average, in the speech signal.

In this study, acoustic measurements of five vowels were made, to gauge the range of acoustic cues to which the listeners in Bailey (2003a) may have been attending. F1, F2, F3, and duration were measured for the vowels /ɑ/ in the word *box*, /i/ in *feet*, /eɪ/ in *makes*, /u/ in *blue* and /æ/ in *back*. The Praat signal-processing program (Boersma and Weenink, 2003) was used to make acoustic measurements. Formant measurements were taken from Linear Predictive Coding (LPC) formant tracks calculated by Praat using a 20-millisecond window and 10 coefficients. Measurements were made blindly, without reference to self-reported or perceived sexual orientation of the speakers. Formant tracking errors were hand corrected by a trained phonetician (TB). The measurement used in these analyses was taken from the midpoint of the vowel. All formant measurements were converted from the Hertz scale to the Bark scale (Zwicker and Ternhardt, 1980) prior to statistical analyses. Bark measures allow perceptual distances between vowels to be compared. Four summary measures were taken for each speaker. The first was the mean duration for the five vowels. The second and third were average F1 and F2 values across the five vowels studied (e.g., the centroid of the vowels). The fourth was a measure of overall dispersion in the F1/F2 space. This was measured using a method from Bradlow *et al.* 1996, as the average Euclidian distance from the center of the speaker's F1/F2 space. This measure reflects overall clarity and effort in speaking. F3 data were also analyzed, but results are not reported here because no significant differences were found as a function of sexual orientation.

III. RESULTS

The first analysis focused on vowel-space shift. Mean F1 and F2 values were submitted to a two-factor (sex by sexual orientation) between-subjects MANOVA. There was a significant main effect of sex on F1 ($F[1,99]=37$, $p<0.01$, partial $\eta^2=0.28$) and F2 ($F[1,99]=133$, $p<0.01$, partial $\eta^2=0.58$). There was no significant main effect of sexual orientation. Moreover, there was a small but significant sex by sexual orientation interaction for F2 ($F[1,99]=6.1$, $p<0.01$, partial $\eta^2=0.06$), and a marginal interaction for F1 ($F[1,99]=2.7$, $p=0.10$, partial $\eta^2=0.03$). In *post-hoc* tests of significant main effects, heterosexual women produced higher formant frequencies than heterosexual men, reflecting their shorter vocal tracts ($F[1,41]=21.7$, $p<0.01$ for F1; $F[1,41]=91.8$, $p<0.01$ for F2). LB women produced average F1 and F2 values that were significantly lower than heterosexual females' values ($F[1,46]=4.7$, $p<0.05$ for F1, $F[1,46]=5.7$, $p<0.05$ for F2). However, Fig. 1 shows that this effect is primarily due to the back vowels /ɑ/ and /u/. The F1 and F2 values for /ɑ/ and the F1 value for /u/ all differed significantly as a function of sexual orientation ($F[1,46]>5$, $p<0.01$ for all tests); the F2 value for /u/ differed marginally ($F[1,46]=3$, $p=0.08$). The F1 and F2 frequencies vowels /i/, /e/, and /æ/ were comparable for LB and heterosexual women.

In contrast, average vowel formant values for gay and heterosexual men were not statistically significantly different ($F[1,53]<1$, $p>0.05$ for F1; $F[1,53]=1.3$, $p>0.05$ for F2). Figure 2 shows that gay men produced vowel spaces that were different from those of heterosexual men, but that the direction of the difference varied according to vowel. *Post-hoc* tests showed that gay men produced the vowel /ɑ/ with a significantly lower F2 value and a significantly higher F1 value than heterosexual men ($F[1,52]>4$, $p<0.05$ for both tests). The vowel /i/ had a higher F2 value and a lower F1 value in gay men than in heterosexual men; again, these differences were statistically significant ($F[1,52]>5$, $p<0.01$ for both tests). Finally, /æ/ had a significantly higher F2 and a marginally higher F1 in gay men than in heterosexual men ($F[1,52]>5$, $p<0.01$ for F2, $F[1,52]=3.8$, $p=0.06$ for F1). The vowels /u/ and /eɪ/ did not differ between the two groups of men.

TABLE I. Mean F1 and F2 values, duration, and dispersion for individual vowels produced by the four groups.

Group	Vowel	F1 (bark)	F2 (bark)	Duration (ms)	Dispersion (bark)
Heterosexual women	i	3.74	14.69	140.7	2.94
	e	5.16	13.73	90.1	1.38
	æ	7.21	12.32	126.8	1.61
	a	8.05	10.89	142.6	2.92
	u	4.08	10.84	109.0	2.39
	all	5.65	12.49	121.8	2.25
Heterosexual men	i	3.63	13.45	116.7	2.46
	e	4.72	12.46	84.2	1.20
	æ	6.42	11.23	118.5	1.51
	a	6.79	9.65	139.3	2.58
	u	3.64	10.57	94.3	1.88
	all	5.04	11.47	110.4	1.93
LB women	i	3.55	14.67	134.5	3.09
	e	5.07	13.79	90.3	1.65
	æ	7.13	12.20	122.3	1.78
	a	7.58	10.33	134.8	2.94
	u	3.82	10.26	107.8	2.63
	all	5.43	12.25	117.5	2.42
Gay men	i	3.28	13.77	120.8	2.87
	e	4.78	12.70	85.3	1.25
	æ	6.63	11.27	114.6	1.65
	a	7.10	9.58	132.4	2.88
	u	3.59	10.67	89.8	1.96
	all	5.08	11.59	108.7	2.12

The second analysis focused on vowel-space dispersion. This measure was examined in a two-factor (sex by sexual orientation), between-subjects ANOVA. A significant main effect of sex was found, $F[1,99]=30.9$, $p<0.01$, partial $\eta^2=0.24$. The vowel spaces produced by women were more dispersed than those produced by men. This is consistent with previous research on sex differences in speech clarity and precision (e.g., Bradlow *et al.*, 1996). Moreover, there was a significant main effect of sexual orientation, $F[1,99]=10$, $p<0.01$, partial $\eta^2=0.09$. Both gay men and LB women produced significantly more-expanded vowel spaces than heterosexual speakers. The two factors did not interact, $F[1,99]<1$, $p>0.05$. Inspections of Figs. 1 and 2 suggest that the effect of sexual orientation on vowel-space dispersion was due to different factors for men and women. The greater vowel-space dispersion in women was due to the LB women producing back vowels with lower F2 values. The difference between gay men and heterosexual men was more global. Three of the five vowels showed shifts toward more extreme values. (See Table I.)

An expanded vowel space can result either from a slower speech rate, which permits articulatory targets to be achieved more completely (Moon and Lindblom, 1994), or from greater articulatory precision and effort (Lindblom, 1990). Therefore, vowel durations were analyzed in relation to vowel space dispersion. A two-factor (sex by sexual orientation) between subjects ANOVA showed that women produce significantly longer vowels than men ($F[1,99]=6.2$, $p<0.05$. partial $\eta^2=0.06$). However, there was no significant effect of sexual orientation or interaction of sex with sexual orientation. These results suggest that the relationship of sexual orientation to vowel-space dispersion reflects differences in articulatory precision and effort rather than speech rate.

IV. DISCUSSION

This analysis found reliable differences in vowel production between GLB and heterosexual men and women. The specific results are inconsistent with the hypothesis that gay men have shorter, more feminine vocal tracts than heterosexual men and that lesbian and bisexual women have longer, more masculine vocal tracts than heterosexual women. Although the vowels of GLB speakers did differ from those of heterosexual speakers, they were not uniformly shifted in the way that this hypothesis predicts. They are also inconsistent with the hypothesis that GLB speakers generically display speech motor control patterns of the opposite sex. Although the gay men did have an expanded vowel space, like women, LB women also displayed an expanded vowel space, contrary to the hypothesis. Furthermore, the expansion of the vowel space was not attributable to all vowels equally. For the LB women, the dominant contributor was more extreme back vowels. For gay men, three out of five vowels had more extreme values, with the effect on /æ/ being the dominant one.

One reasonable interpretation of this finding is that GLB speech patterns reflect learned manipulation of the phonetic space. They are consistent with the suggestion that GLB speakers learn to model the speech of opposite sexed speakers in specific respects. The values for the LB women were intermediate between male and female targets for /u/, and more back than men for /ɑ/. The use of backness in back vowels to convey social identity is not unprecedented. According to one sociolinguistic field study (Habick, 1991), the freedom with which English permits in the production of /u/ is exploited by adolescents to convey social identity. A back variant of /u/ was associated with membership in a group known for its ''tough'' stance. The notion that the LB women were using backness to convey social identity rather than overall masculinity is supported by our finding that they did not mimic the articulatory reduction that is typical of male speech.

Gay men produced vowel spaces with more dispersion than heterosexual men. Since greater precision is also widely reported for women's speech (Bradlow *et al.*, 1996), this could reflect selective learning of a female speech feature. It is noteworthy, however, that the vowels were far from uniformly affected. It is also noteworthy that gay men did not display any analog to the exaggerated diminutivity that has been reported for some female speech populations (Van Bezooijen, 1995). Specifically, we did not find the overall raising of formant values that would result from active articulatory maneuvers to shorten the vocal tract. Linville (1998) found no differences in the average spectrum; the adoption of a breathy, feminine, voice quality would affect this measure. Gaudio (1994) found that gay men do not have higher average f0 than heterosexual men. Thus, the gay men in these studies have at most adopted aspects of female speech that convey social engagement and emotional expressiveness, such as vowel-space dispersion, and not those that would convey diminutivity or subservience, such as a higher f0 or overall higher-scaled formants.

In summary, the distinct speech patterns of GLB speakers do not reflect the direct impact of biological factors on speech production. Instead, they appear to be learned. They could in principle be learned in adolescence as a special speech register that the speakers acquire when they begin to identify with a GLB peer group. However, our results are equally consistent with the idea that young people predisposed to becoming GLB adults (perhaps through a genetic disposition or difference in prenatal environment) selectively attend to certain aspects of opposite-sex adult models during early language acquisition. Future research should examine this question more directly.

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