Title

Sociophonetic Differences in Queer Speech of Spanish Speakers

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1. Abstract

Previous studies have shown the existence of phonetic features often associated with queer speech production and listeners' ability to detect a speaker's sexuality. Production of sibilants, mean vowel formants, as well as fundamental frequencies have so far been linked with "gay speech" (Katchell et al., 2018) while pitch, pitch range, vowel formants, and creakiness have been linked with "lesbian speech." (Barron-Lutzross, 2015). The present study aims to investigate if the acoustic patterns described above play a role in identifying the speech of queer Spanish speakers. To do so, recordings were collected from four groups of interest: self-identified queer men, queer women, heterosexual men, and heterosexual women. The recordings were then analyzed in PRAAT to extrapolate patterns linking the acoustic correlates of their speech to their self-reported gender and sexual self-identifications. A main focus was placed on the production of vowels (F1-F4), production and articulation of sibilants (through analysis of COG), as well as any changes in pitch (F0) or word duration that might be noticed. A second experiment was conducted in which these recordings were modified and presented to new participants in a matched-guise task. The aural stimuli presented were divided into two different groups: one accompanied by visual stimuli introducing a bias in participants' responses , while the others only contained the audio. A total of four voices were chosen and presented three times resulting in twelve critical stimuli, which were meant to determine whether implicit and explicit stereotypes influence queer speech perception.

Experiment one yielded significant differences in vowel production as well as pitch range and mean pitch. Non-Normalized vowels /a/, /o/, and /u/ showed the largest effect for queer men and queer women respectively yielding F1 and F2 values similar to those of the opposite gender. Straight women also produced higher F2 values for front and mid vowels and lower F2 values for back vowels when compared to queer women, the opposite of which was seen in men. Normalized vowels saw the same patterns with frontalizing and backing vowels. In addition, production of queer men was similar to women in all five vowels when normalized. Queer men and both women groups exhibit the largest pitch ranges while heterosexual men had a relatively small range. When looking at average pitch, like expected, heterosexual men had the lowest mean pitch overall followed by queer men. COG from sibilant production did not yield significant results.

Experiment two exhibited high accuracy at rating the sexuality of speakers when no visual cues were presented. The addition of visual cues, however, completely controlled the ratings from participants proving that while acoustic cues play a role in queer speech perception, they are not the most significant.

2. Introduction

It is well-studied that listeners can distinguish between normative male and female voices with almost perfect accuracy due to changes in speech caused by physiological differences (e.g. vocal fold length) based on "biological sex," which alters pitch and production more generally (Jacobs et al., 2000). A unique phenomenon takes place, however, when trying to distinguish between the voices of queer and non-queer speakers perceived to be of the same gender. It has been discovered that listeners can accurately distinguish between these voices with high enough accuracy to discard the possibility of it being caused by chance **(**Kachel, et al. 2018; Mack 2010, Smyth, et al. 2003**)**. This leads to the theory that acoustic differences exist that influence queer speech perception, even when physiological differences are not presumed to be the determining factor. Most stereotypes associated with queer speech often cite pitch as the main factor in its perception, making it a focus in acoustic research **(**Kachel, et al. 2018; Barron-Lutzross 2018; Zimman 2017; Smyth, Jacobs, Rogers 2003; Smyth & Rogers 2008**)**. Aside from pitch, production of sibilants (Kachel, et al. 2018; Zimman 2017; Smyth & Rogers 2008), vowel production (Smyth & Rogers 2008, Esposito 2020; Mack 2010; Crisoto, et al. 2015), VOT (Kachel, et al. 2018; Pahis 2017; Smyth & Rogers 2008), and length of word segments (Esposito, 2020) have also been correlated with this phenomenon. While the production and perception of queer speech has been studied at length, most extant data comes from English, limiting our knowledge of queer speech production and perception in other languages.

3. Literature Review

3.1 Theory 1: Reflection of Identity

The first of two approaches that have been seen in previous research, as first stated by Fabiana Piccolo (2008), considers queer speech as a reflection of identity. Under this theory, sexualities have a unique set of phonetic features characteristic of that specific group, making speakers passive enactors of their sexuality. Following this approach, researchers like Gaudio (1994), Weaksler (2001), Munson (2004), and more recently Barron-Lutzross (2015, 2018) and Pahis (2017), to name a few, have attempted to acoustically analyze speech recordings of self-reported gay or lesbian speakers to extrapolate patterns linking their sexuality to their speech. This approach allows researchers to take into consideration the pre-existing stereotypes associated with each sexuality and investigate those ideas further. A main example of this is the common stereotype that gay men speak in a manner similar to that of women, while lesbian women are considered to sound more similar to men, especially in terms of pitch. This popularized stereotype resulted in numerous papers studying pitch differences between queer and non-queer speakers, more specifically lesbian speech (Camp, 2009; Waksler, 2001; Cuddy, 2019; Van Borsel, et al., 2013) and gay speech (Katchel, et al., 2018; Gaudio, 1994; Rendall, et al., 2007).

Previous literature has also shown that listeners have the ability to accurately point out phonetic features and distinguish between the voices of queer and non-queer speakers, even when no visual cues were presented, with high enough accuracy to discard the possibility of it being caused by chance (Kachel, et al. 2018; Mack 2010, Smyth, et al. 2003). Research on this specific phenomenon has shown that it is easier to distinguish between the voices of homosexual and heterosexual male speakers compared to homosexual and heterosexual female speakers. Despite this challenge, however, research on both genders has shown great results and evidence to further support this theory.

While no concrete results have been concluded under this theory, extant data has proved the existence of acoustic cues related to each group and patterns have been observed numerous times (see sections 3.3 and 3.4 for a thorough explanation of these patterns). For example, production of sibilants, mean vowel formants, as well as fundamental frequencies have so far been linked with “gay speech” (Pahis, 2017) On the other hand, pitch, pitch range, vowel formants, and creakiness, which is described by linguist Susan J. Behrens (2014) as "a type of phonation (vocal fold vibration) whereby the vocal folds start to slow down and beat irregularly before closing, toward the end of an utterance. This behavior causes a rough voice quality, a lowered voice pitch, and sometimes a slower rate of speech. All contribute to make a speaker's voice sound creaky or raspy" and have been linked with “lesbian speech.” (Barron-Lutzross, 2018).

3.2 Theory 2: Performativity and Perceived Sexuality

The second approach that has been used while investigating queer speech states that speakers are social actors of their identity, and identity is not directly linked to a set group of phonetic features. In other words, queer speech is a reflection of society and its surroundings and is constantly being affected resulting in everchanging speech patterns. Supporters of this theory often use the idea of "performativity" introduced by Judith Butler (1990). Deborah Cameron explains this idea in her 1997 paper as, '"Feminine" and "masculine" are not what we are, nor traits we HAVE, but effects we produce by way of particular tilings we DO.'" This is further supported by Jennifer Coates (1986), in which she states that "in becoming linguistically competent, the child learns to be a fully fledged male or female member of the speech community; conversely, when children adopt linguistic behaviour considered appropriate to their sex, they perpetuate the social order which creates gender distinctions." Following these principles, this theory considers queer speech as being a form of free variation, in which different phonetic features do not pertain to specific groups but rather are used interchangeably between them.

While this theory is supported for multiple reasons, the main argument in favor of this approach is that it accounts for speakers who may not fit the stereotypes associated with queer speech. For example, there are gay men who do not "sound gay" or lesbian women who do not "sound lesbian," similarly one may find heterosexual men and women who may have acoustic features associated with queer speech. This challenges the first theory by going against the belief that a set group of phonetic features exist for each sexuality. The first theory also cites pitch as a clear example of how queer speakers have a unique set of phnetic features, however Rudolf P. Gaudio (1994) provides some evidence against this theory by stating that "Following the general practice in sociolinguistics of treating the categories "female" and "male" as both given and unitary, references to gender differences in intonation typically describe "feminine"-sounding speech in men and "masculine"-sounding speech in women as code-switching behavior between essentially "male" and "female" intonational styles." Once again arguing that queer speech is not characterized by specific acoustic cues, but is rather a style of speech that is altered by speakers in their own ways giving them the the freedom to choose what to sound like or how to interpret their own identities.

Proponents of this theory include Smyth et al. (2003), and more recently Mack (2010) and Kachel et al. (2018), to name a few. Some of the experimental procedures utilized to test this approach focus on listeners' perception of speech rather than the acoustics of audio from self-reported gay or lesbian speakers. This method solves the previously discussed issue where acoustic features may not be directly correlated to sexuality but rather used by groups interchangeably. As seen in Smyth et al. (2003), data was grouped by listeners' judgment of the voice stimuli presented and whether or not they sounded "gay" allowing participants to judge both straight and gay voices equally. Similar methodologies were also seen in Mack (2010) in which 23 participants rated the voices of 20 men on a scale of 1 to 5 ranging from "very gay" to "straight", and Katchel et al. (2018) in which 51 voices (25 gay and 26 straight) were categorizes as gay or straight by 74 listeners.

3.3 Characteristics of Gay Speech

3.3.1 Production of Sibilants

A large number of studies on gay speech have placed an enphasis on testing the differences in production of sibilants, in particular /s/, due to what is commonly known as the "gay lisp." . The "gay lisp" is a phenomenon considered to be the most influential at affecting listeners' judgment of sexuality (Munson, 2007), and is characterized by a frontally realization of /s/, a dentalized /s/, or an /s/ produced with an especially high frequency (Mack & Munson, 2012). Research done on this phenomenon often share similar methodologies, in which linguistics measure the center of gravity (COG) in the production of the sound to compare between gay and straight men.

Results from previous studies on this sound have yielded good results, yet often contradictory from one another. For example, high amplitude and negative skewness in the production of /s/ has been seen to be more likely to be judged as a straight voice while low amplitude and the less negative skeweness was more likely to be judged as gay (Borders, 2015). These results were contradictory to those seen in Munzon et al. (2006) and Munzon (2007), which discovered that higher higher amplitudes and negative skewness were perceived as gay.

Katchel et al. (2018) also carried out an experiment in which tokens of /s/ and /ʃ/ were analyzed from a group of 54 male German speakers. Two nouns/adjectives were chosen for each sibilant: /s/ from Nässe ("wet") and mies ("nasty"), /ʃ/ from Schaufenster ("shop window") and neidische ("envious"). What was interesting about the results was that even though there was an acoustic difference between gay and straight men (straight men produced lower centers of gravity in /s/ than gay men who produced higher centers of gravity in /s/), differences within groups were much stronger suggesting the existence of dispersion inaccuracies.

While most of the research on queen speech has been done through a lens on sexuality, there has been attempts to study the effects gender identity has on speech as well, like is the case with with Zimman (2017) in his study on transmasculine voices and how the production of sibilants was different in this case. The results found a correlation between time on testosterone and the COG of /s/ in trans speakers further showing the influence this specific sound has on the perception of gender and sexuality.

3.3.2 Vowel Formants

Vowel formants have also been broadly studied to try to find patterns associating sexuality with speech. While some studies have been done with English speakers (Babel & Johnson, 2006; Podesva, 2011; Johnson & Tracy, 2014), Most research involving vowels has been done on other languages like German (Katchel et al., 2018) and Spanish (Pahis, 2017; Ezquerra, 2015; Mack, 2010). While results have varied depending on the language being studied, most have come to the conclusion that vowel production plays a role in linking speech to sexuality.

For English speakers, it has been observed that F1 and F2 of front vowels are used by listeners to make judgements about sexual orientation (Babel & Johnson, 2006) as well as vowel length (long vowel productions) and vowel space size (productions with large vowel spaces), both of which are connected with the perception of "gayness," even when not directly observed in the vowel production of self-identified gay speakers (Johnson & Tracy, 2014). Similar results with vowel formants were seen among German Speakers, in which higher mean F2 values were connected to femenine-sounding speech as well as higher mean F1 values. On the other hand, Straight men were producing significantly mean F1 values. (Katchel et al., 2018).

When it comes to Spanish, results have not been as successful. Pahis (2017) collected data from three groups of interest: gay men, straiught men, and straight women. In her results, however, it was discovered that no significant differences were observed with respect to vowel highness or backness between gay and straight men. However, it was seen that both gay men and straight women have similar patterns in fronting with respect to the back vowels /o/ and /u/. Ezquerra (2015) saw similar results in which no significant correlation was sidcovered between gay and straight men in terms of F1 and F2 values. These features were also not signicant in terms of judgements of perceived sexual orientation. Mack (2010), however, achieved promising results by discovering that perceived sexual orientation was significanlty correlated with F2 values, especially with the vowel /e/. Higher F2 values were often perceived as gay, similar to the results seen in Katchel et al. (2018).

3.3.3 Pitch and Fundamental Frequency (F0)

Most stereotypes on gay speech often refer to pitch as the most influencial factor in its perception, the most common stereotype being that men speak at a higher pitch resembling that of women. This feature is interesting to study as pitch is the most prominent male-female difference among adults. When it comes to differentiating between sexuality and not gender, however, studies have yielded different results. Jacobs et al. (2000) discovered no significant relationship between mean pitch and the number of times they were judges as gay-sounding, however, pitch range and pitch variability were better cues for listeners. Smyth et al. (2003) yielded similar results in which there was no significant correlation between mean pitch and “sounds gay” ratings, also matching those from Gaudio (1994), whose results suggest that overall pitch range and pitch variability do not by themselves crucially affect whether or not a man will be perceived as "sounding gay. Aside from the studies previously mentioned, there have also been some that yielded better results. Munson (2007) discovered that while F0 only had little influence on perception of sexuality, it did have a large impact on perception of masculinity. Katchel et al. (2018) also discovered that speakers were perceived as sounding straighter, the lower their median F0. While these results are not strong enough to conclude that pitch may play a significant factor (or even be the most important as theorized), there is backing evidence showing that it may play a role in perception, along with other acoustic cues.

3.4 Characteristics of Lesbian Speech

3.4.1 Overall Production

Unlike previous research on men, most research on female speakers has had varying results, most of them yielding no concrete evidence that there are differences in the speech of lesbian and straight women, at least not acoustically speaking. Barron-Luztross (2015) had a total of 54 participants who self-identified as homosexual, bisexual, or heterosexual. In her first experiment she acoustically tested pitch, vowel production, sibilant production, creak, rate of speech, as well as word-final /t/ release. Despite the broad range of phonetic cues being tested, her experiments discovered that none of them were correlated with sexuality, yielding contradicting results from previous research like that of Van Borsel et al. (2013). Similarly, Weaksler (2001) had a total of 24 participants to test pitch range and its connection to sexuality. Her results, like those from Barron-Luztross, concluded that pitch range may not be a distinguishing factor for female sexual orientation. Despite the lack of concrete results, some patterns have been discovered, most of them related to pitch and creaky voice. These patterns greatly differ from those of male speakers which have shown that specific acoustic cues, like sibilant and vowel production, are associated with sexuality.

3.4.2 Pitch and Fundamental Frequency (F0)

Like with men, most stereotypes associated with female lesbian speech often consider pitch to be the main factor linking perception to sexuality, however, pitch has a higher correlation with lesbian speech than gay speech. People believe lesbian speech to sound more “masculine” and often contain more slang when compared to heterosexual speech. This study and the ones being reviewed, however, only focus on phonetics and perception rather than morphology, syntax, or semantics.

In their 2013 study, Van Borsel et al. studied the average pitch and pitch variation of a group of 34 lesbian women and 68 heterosexual women through acoustic analysis of read speech. The results showed a large correlation between sexuality and pitch, in which lesbian women had a lower mean fundamental frequency (194.9 Hz) when compared to heterosexual women (204.4 Hz). Similar results were also seen in their pitch variation which ranged from 111 to 232 Hz for lesbian women compared to 94 to 314 Hz for heterosexual women, also showing lesbian women have a lower pitch variation. Despite lesbian women having lower mean pitch as well as lower pitch variation, these results do not necessarily confirm the stereotype that lesbian women have a more masculine speech. Very similar results were concluded in Camp (2010), which discovered that heterosexual women exhibited a higehr average pitch compared to lesbain women, this being almost two semitones higher. In terms of pitch variation, a correlation was also discovered in which a wider range was associated with heterosexual speakers while a shorter range was associacted with lesbian speakers, there results had a difference in range of 1.2 semitones. These results were replicated once again in Cuddy (2019), which concluded that lesbian women had a mean F0 about 5.5 Hz lower than heterosexual women; unlike the other two, however, Cuddy’s results on pitch range showed no statistical significance.

While all results discussed so far have been connected with production, perception of sexuality in speech has also been thoroughly studied. Barron-Lutzross (2015) found a high correlation between acoustic factors and the perception of sexuality. Speakers with a higher median pitch were more likely to be rated as heterosexual. Like median pitch, the range of a speaker’s pitch was also found to have a correlation and women with wider pitch ranges tended to be rated as more likely to sound lesbian (contradicting some of the production results previously discussed). Camp (2009) also showed that lower mean F0 as well as shorter range in the pitch range were often correlated to the perception of lesbialinsm. Cuddy (2019) also discovered there is a correlation between F0 and perceived sexuality. In this study, lower F0 values were perceived as “less feminine” overall when compared to higher F0 values, with a cutoff happening with a semitone between 10 and 13.

3.4.3 Creakiness

Creakiness is a phonetic phenomenon described as "a type of phonation (vocal fold vibration) whereby the vocal folds start to slow down and beat irregularly before closing, toward the end of an utterance. This behavior causes a rough voice quality, a lowered voice pitch, and sometimes a slower rate of speech. All contribute to make a speaker's voice sound creaky or raspy" (Behrens, 2014). This has been found to be correlated to the perception of lesbian speakers in Barron-Lutzross (2015) and Barron-Lutzross (2018). In her 2015 paper, she discovered that a higher proportion of creaky voice often received higher lesbian ratings. The same result was recreated in 2018, where she once again noticed that a higher proportion of creaky voice was correlated with perception of lesbian speech. The reason why creak might me highly correlated to the perception of lesbian voices might be due to the effects it cases on the voice itself. As stated before, it tends to result in a rough voice quality and a lower pitch, both of which are connected to lesbian speech stereotypes. Another cue that is part of the creak is speech rate. It can be concluded from these results that slower speech rates might be associated with perception of lesbian speech, though this phenomenon was not studies specifically or in an isolated manner in these experiments.

4. Present study

The present study aims to determine wheter phonetic differences exist between queer and non-queer Spanish-speakers and how much these influence speech production and perception by focusing in four groups of interest: Spanish-speaking self-identified gay men, heterosexual men, lesbian women, and heterosexual women. To do this, two experiments will be carried out, one focusing on speech production and participants' acoustics and a second one focusing on speech perception and perceived sexuality. Both experiments will follow similar methodologies as previous experiments discussed above, however, the main focus will be to determine whether the same phenomena seen with English speakers can also be observed in Spanish speakers.

5. Experiment 1

5.1 Production and Acoustic Analysis

Following previously discussed studies, the first experiment in this paper will test hypothesis one. This hypothesis states that each sexuality has a unique set of acoustic cues characteristic of that specific group. To test this out, participants were asked to record themselves reading a short story out-loud. Every participant was presented with the same story (Appendix A) which consisted of innocuous and non-thematically-charged content. The audio files were then analyzed through PRAAT in an attempt to extrapolate any acoustic patterns that were observed. To determine whether or not these phonetic cues exist, the audios were compared between groups (straight men vs gay men and straight women vs gay women). An extra comparison was also done which compared gay men with straight women and lesbian women with straight men, in order to determine whether the stereotypes associating these groups together are real. Methodology and results are further discussed in detail in the following sections.

5.2 Methodology

5.2.1 Participants

Data was collected from a total of eleven participants in total, all from each group of interest previously mentioned. Participants were all undergraduate and graduate students at the University of California, Berkeley (UCB), University of California, Los Angeles (UCLA), and surrounding areas. They were recruited through flyers posted across campus as well as online posts on social media and word of mouth. Participants were asked to self report their identity and sexuality yielding the following population: Heterosexual (N=6), Gay (N=2), Lesbian (N=3), male (N=4), female (N=7). Participants' ages range from 18-53, however, since most were students, the age range is skewed left with 18-23 being the most common having only one age above this range. All participants live in the United States and are also speakers of Spanish with six of them being native speakers and two of them being fluent speakers of the language, all of which spoke Mexican Spanish. Due to the nature of data collection, only eight of the eleven participants yielded usable recordings and those eight were analyzed for this project. The eight participants were broken down as follows: Heterosexual men (N=2), Gay men (N=2), Lesbian women (N=2), (N=4), heterosexual female (N=2).

5.2.2 Procedure and Materials

Due to the ongoing pandemic restrictions, all experiments and data collection were collected remotely through UC Berkeley licensed Qualtrics. A survey was created in which participants were presented with a brief introduction of the project followed by consent forms and media release forms. If participants wished to continue with the project, they were presented with a trial recording of the sentence "*Al niño le encanta jugar en la computadora*" ("the kid loves to play on the computer"). This sentence served as a trial to understand and learn how to use the online recorder, which was added into the survey through Phonic.ai implementation using HTML. Once participants were comfortable with the recorder, the stimuli were presented. Stimuli consisted of a short story which consisted of innocuous and non-thematically-charged content (Appendix A). Following common sociophonetic research methodologies, the story was borrowed from a children's book. The story was broken into four parts to maintain the length of recordings short (all resulting in approximately one minute). Once participants finished the audio recordings, they were redirected to a short socio demographic survey (Appendix B) to learn more about language background, language usage, and other demographic information. Once finished, participants were presented with a thank you message and the survey was concluded. Once data was collected, audios were downloaded to a Macbook Pro 2021 model from Phonic.ai and transferred to a university-provided password-protected storage cloud.

5.3 Analysis

Due to the way the online recorder was set up, all audios had to be converted to mono audio prior to being aligned with the Montreal Forced Aligner. Once downloaded, audios were assigned a unique identifier (e.g. SM01) and were grouped by the sexuality of the speaker. These audios were then transcribed in PRAAT (Boersma, 2001) and the transcripts were aligned using the Montreal Forced Aligner. Once all audio transcriptions had been aligned, PRAAT scripts (created by the author) were used to extract measurements from each participant for further analysis.

The first set of measurements extracted was vowel formants. F1, F2, and F3 were extracted from every vowel production made by each participant and the average as well as the max and min values were calculated for the vowels /a e i o u/. Following Barron-Luztross (2015) analysis, I converted the measurements from Hz to Equivalent Rectangular Bandwidth to allow these measurements to be more similar to how vowels are processed through the auditory system. The function:

$$\mathbf{ERB = 21.4*log(4.37*(f/1000)+1)}$$

was used to calculate these measurements. With these measurements, vowel spaces were calculated and measurements were compared between speakers to determine whether sexuality creates a difference in production. Vowel formants were also normalized by NORM using the Lobanov method (Thomas, R., and Kendall, 2007). This was done to eliminate all differences caused by gender, anatomical, and physiological variation.

The second set of measurements extracted were the spectral moments of the fricative /s/, these being: Center of Gravity (COG), skewness, standard deviation, and kurtosis. These values were also extracted through the use of PRAAT scripts and average values were calculated for each participant and group of participants as a whole. While all four spectral moments were extracted, a main focus was placed on the COG, though the rest of the measurements were also compared and taken into consideration for the results.

Lastly, Pitch and pitch range were also extracted from each recording and the average and ranges were calculated for each participant and group of participants as a whole. These values were then compared between groups to extrapolate any significant differences between them.

5.4 Results

This first section will show the results collected from vowel production. F1 and F2 values were analyzed from 10 different vowel productions from each participant (20 tokens per group) and the mean of those values was calculated, results can be seen in the chart below in hertz (individual productions can be seen in Appendix E):

Vowel	F1	F2	Group
/a/	692.65	1421.80	SM
	643.02	1521.93	QM
	729.07	1772.45	SW
	703.24	1613.66	QW
/e/	484.20	1614.40	SM
	446.38	1713.65	QM
	498.51	2145.66	SW
	553.92	1996.53	QW
/i/	345.89	2114.27	SM
	357.69	2136.41	QM
	414.59	2685.01	SW
	393.18	2509.86	QW
/o/	542.07	1266.58	SM
	502.40	1175.10	QM
	527.56	1172.87	SW
	539.64	1264.10	QW
/u/	471.31	979.08	SM
	390.36	858.25	QM
	375.80	1049.94	SW
	394.91	1078.63	QW

SM=Straight Men
QM=Queer Men
SW=Straight Women
QW=Queer Women

Table 1: **Non-Normalized Vowel Formants (Hz)**

These values were also transformed into ERB yielding the following results:

Vowel	F1	F2	Group
/a/	12.95	18.36	SM
	12.43	18.91	QM
	13.31	20.15	SW
	13.05	19.39	QW
/e/	10.56	19.39	SM
	10.06	19.88	QM
	10.75	21.74	SW
	11.43	21.14	QW
/i/	8.56	21.62	SM
	8.75	21.71	QM
	9.61	23.65	SW
	9.29	23.07	QW
/o/	11.29	17.45	SM
	10.80	16.86	QM
	11.11	16.84	SW
	11.26	17.43	QW
/u/	10.39	15.46	SM
	9.25	14.48	QM
	9.03	15.99	SW
	9.32	16.20	QW

Table 2: **Non-Normalized Vowel Formants (ERB)**

Using this data, a vowel chart was created plotting the mean values for each group (SM, SW, QM, QW). The chart can be seen below where sexualities and genders are distinguished by color and symbol.

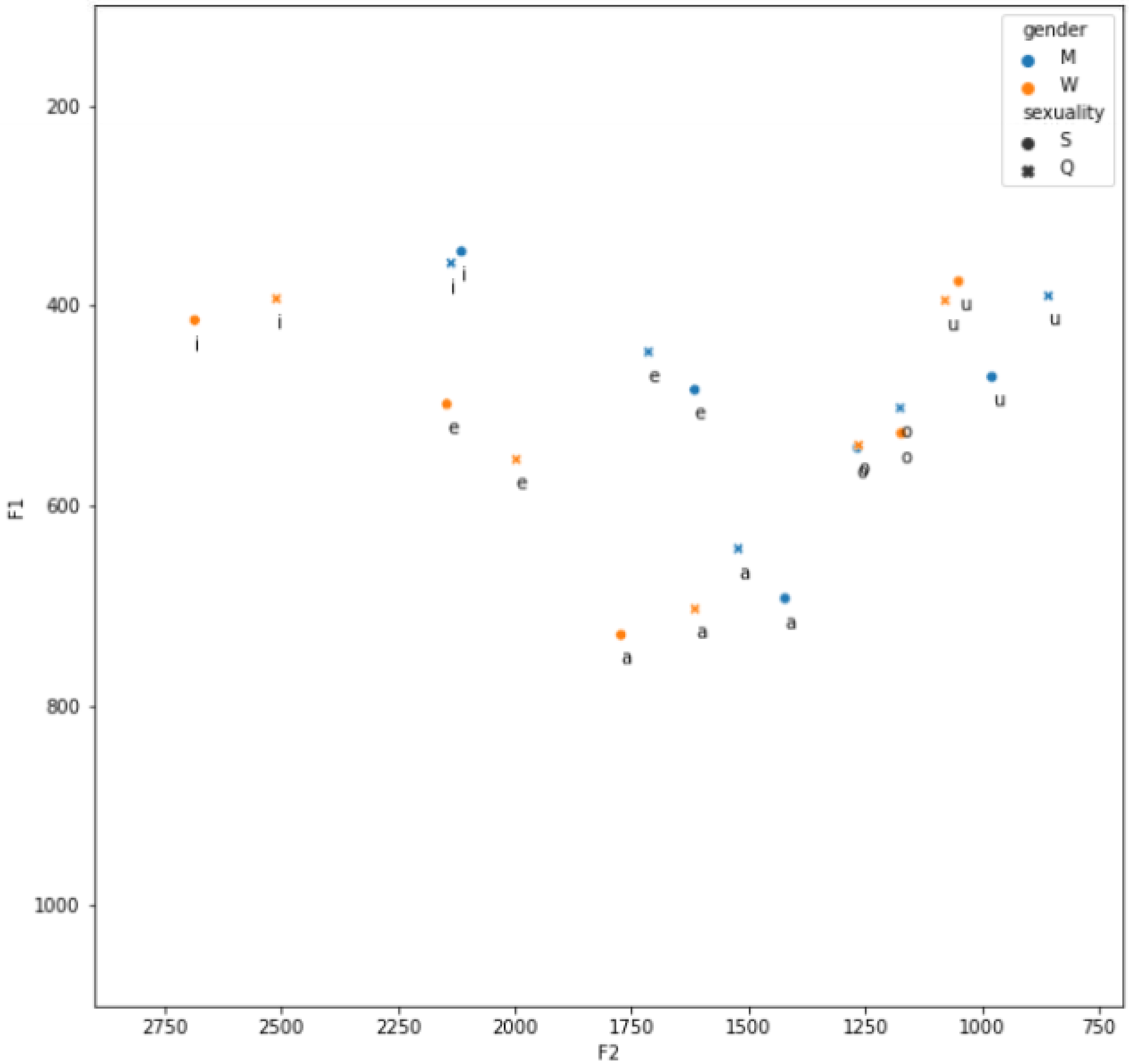

Figure 1: **Non-normalized Vowel Spaces for Gender and Sexuality**

The vowel plot shows some significant results. First, when looking at the vowel spaces we can see that women in general have a much wider vowel space compared to both male groups, which is expected. The biggest differences in terms of sexuality, however, were observed with men. While in most vowels, F1 and F2 were relatively similar between both male groups, queer men do share some similarities with both female groups. The vowels /a/ and /u/, for example, showed similar F2 values between queer men and both female groups, more clearly seen with /u/. The biggest results from non-normalized vowels come with /o/. As seen in the chart, this vowel had the most similarities between groups of opposite genders. Queer men and straight women produced almost identical /o/s different from those of queer women and straight men which also had very similar productions to one another. These results are particularly interesting as it supports some of the common stereotypes associated with these groups, these being queer women often have productions similar to those of men while the opposite happens for queer men. Another interesting pattern observed is that straight women tend to produce higher F2 values for front and mid vowels and lower F2 values for back vowels when compared to queer women. The opposite is seen however, when observing the data from both male groups. Queer men seem to follow the same pattern as straight women while straight men tend to follow the same pattern as queer women.

Following these results, all vowel productions were normalized by NORM using the Lobanov method (Thomas, R., and Kendall, 2007) to isolate sexuality and get rid of differences in vowel production caused by gender, anatomical, and physiological variation. The results can be seen in the following table (individual productions can be seen in Appendix F):

Vowel	F1	F2	Group
/a/	799.10	1640.82	SM
	772.37	1830.74	QM
	750.25	1824.95	SW
	739.53	1698.01	QW
/e/	558.92	1863.24	SM
	536.67	2060.21	QM
	513.35	2209.08	SW
	583.25	2104.29	QW
/i/	399.41	2441.05	SM
	430.11	2567.91	QM
	426.95	2764.64	SW
	414.87	2640.77	QW
/o/	625.31	1461.65	SM
	603.82	1414.81	QM
	542.81	1206.77	SW
	569.24	1327.36	QW
/u/	543.21	1130.96	SM
	469.58	1031.48	QM
	386.16	1079.14	SW
	420.90	1139.51	QW

Table 3: **Normalized Vowel Formants (Hz)**

These values were also transformed into ERB yielding the following results:

Vowel	F1	F2	Group
/a/	13.96	19.52	SM
	13.72	20.42	QM
	13.51	20.39	SW
	13.41	19.80	QW
/e/	11.49	20.57	SM
	11.22	21.40	QM
	10.94	21.99	SW
	11.77	21.58	QW
/i/	9.39	22.83	SM
	9.83	23.26	QM
	9.79	23.90	SW
	9.61	23.50	QW
/o/	12.24	18.59	SM
	12.00	18.32	QM
	11.30	17.07	SW
	11.61	17.82	QW
/u/	11.30	16.56	SM
	10.37	15.86	QM
	9.19	16.20	SW
	9.70	16.62	QW

Table 4: **Normalized Vowel Formants (ERB)**

Using this data, a vowel chart was created plotting the mean values for each group (SM, SW, QM, QW). The chart can be seen below where sexualities and genders are distinguished by color and symbol.

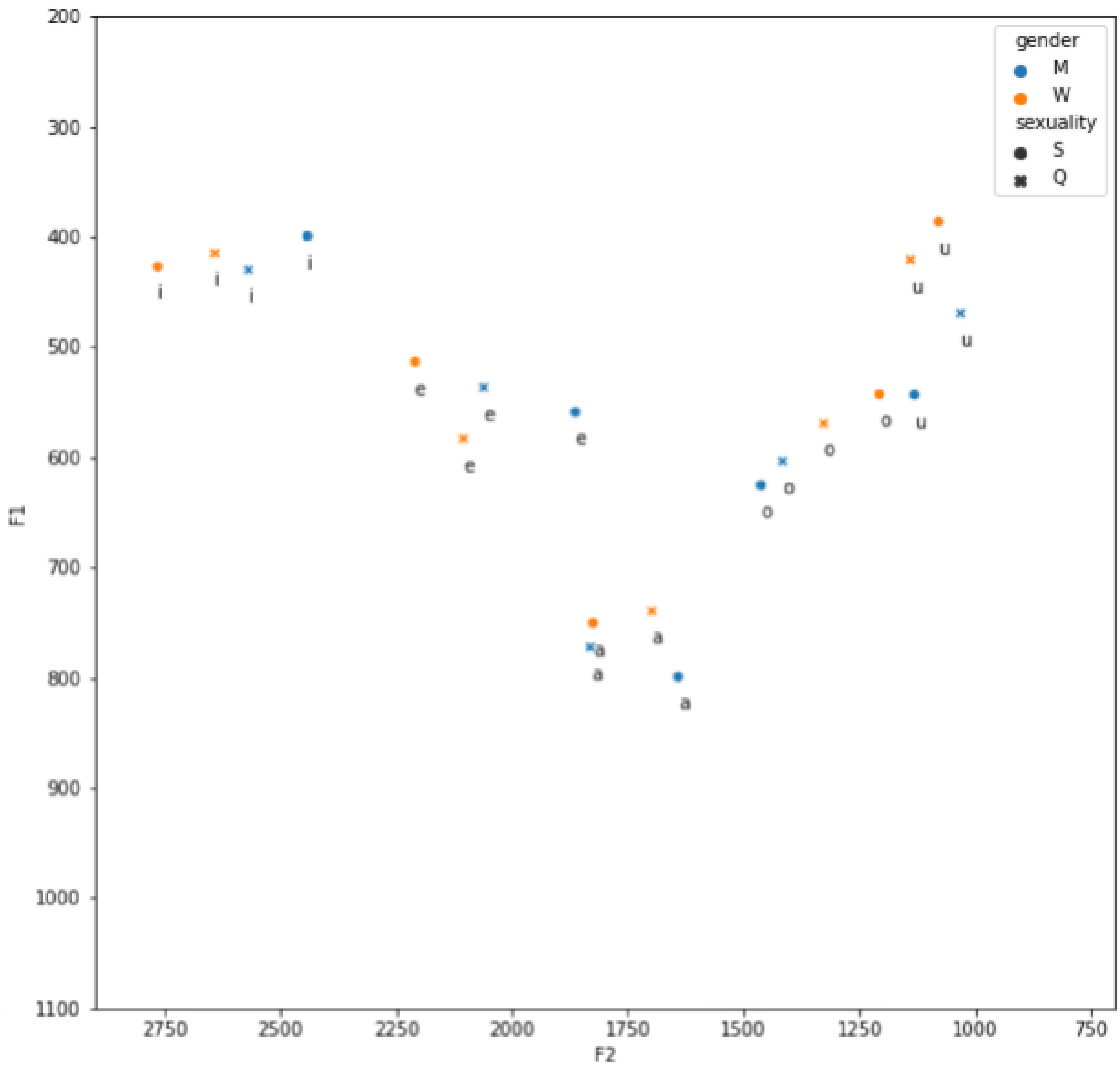

Figure 2: **Normalized Vowel Spaces for Gender and Sexuality**

Once again we see the same pattern where straight women tend to produce higher F2 values for front and mid vowels and lower F2 values for back vowels when compared to queer women and the opposite for men. What was interesting about this new vowel space containing normalized formants, is that new patterns emerge that were not seen in the previous figure. In all vowels, queer men have more similar productions to queer women and significalty different from straight men (with teh exception of /o/). Seeing this pattern is interesting because it once again supports the stereotype that queer men "speak like women". Unlike men, however, no significant differences were observed between female groups or when comparing each female group to male groups. Both female groups had relatively similar productions for all five vowels.

The second acoustic cue analyzed was pitch. The chart below contains the minimum and maximum values as well as the mean values for each participants' pitch. Following Barron-Lutzross (2015), these values were calculated by extracting the pitch from stressed vowels in all recordings. The middle point of each vowel was used to collect pitch measurements:

Participant	Min. Pitch (Hz)	Max. Pitch (Hz)	Mean Pitch (Hz)
SM01	102.6	199.1	129.7
SM02	111.58	158.6	124.66
SW01	147.91	493.31	200.12
SW02	124.76	361.46	192.93
QM01	75.7	487	165.97
QM02	91.77	398.93	149.89
QW01	86.4	283.8	172.4
QW02	90.84	300.2	216.46

Table 5: **Pitch Measurements of Each Participant**

These values were then divided by group and plotted into a box plot yielding the following:

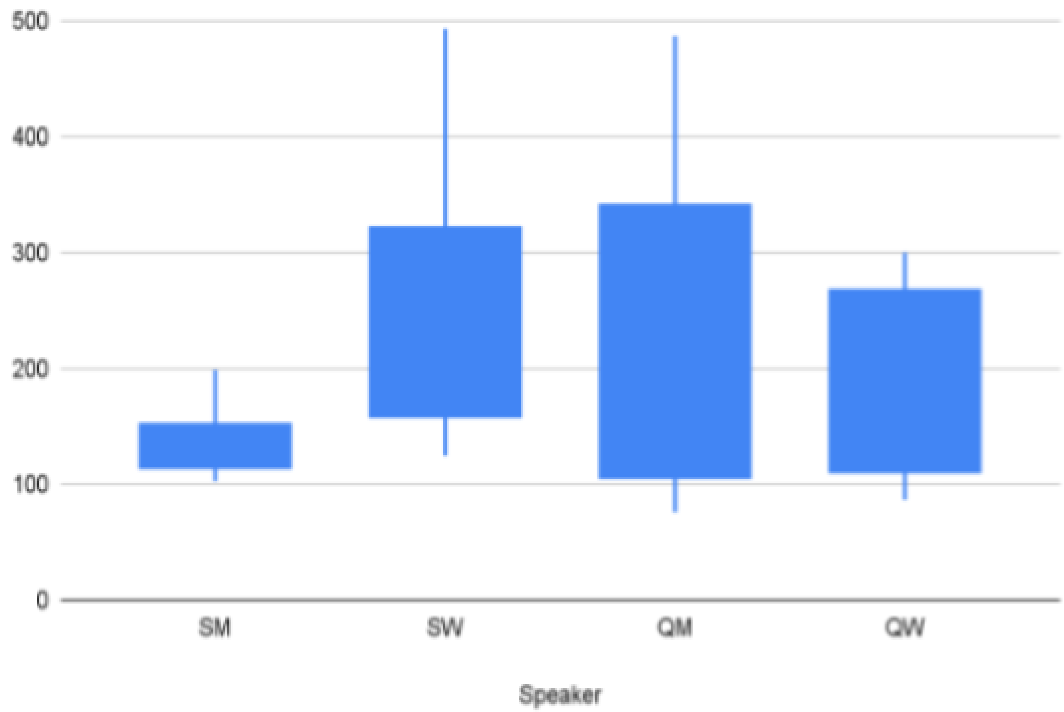

Figure 3: **Pitch Measurements by Group**

Like with vowels, we see some significant results with pitch between groups. When looking at pitch range for each participants, we see that queer men, queer women, and heterosexual women exhibit the largest ranges between the groups (with QM01 having the largest range), while heterosexual men had a relatively small range. When looking at average pitch, like expected, heterosexual men had the lowest mean pitch overall followed by queer men. These results are not surprising as we have to take into consideration the physiological differences between men and women. Despite this, we can clearly see that queer men produced an average pitch higher than heterosexual men, though not close enough to that of women proving the pitch stereotypes associated with this group wrong. When looking at female speakers, we see similar results, were both queer and heterosexual women had very similar average pitch, which once again was expected. However, QW01 had a pitch much lower than the rest of the female speakers and even nearing that of Queer men, which might show some support for the pitch stereotypes associated with queer women.

Lastly, sibilant production was also analyzed and the Center of Gravity (COG) was collected from each participant from 5 different productions of /s/. The average COG can be seen in the chart below:

Participant	Average COG (Hz)
SM01	4923.66
SM02	5738.59
SW01	3759.99
SW02	6585.71
QM01	7639.84
QM02	5168.62
QW01	7349.16
QW02	6607.37

Table 6: **Average COG (Hz) for /s/ Production**

Unlike vowels and pitch, no significant differences were observed in COG of /s/. We can see that COG values were relatively close between men and women with women having higher values overall. QM01 also produced a relatively high COG when compared to the rest of the male speakers and showed more similarities with that of women.

5.5 Discussion of Experiment 1

Experiment one yielded similar results to previous research on this topic. For example, when looking at our results from vowel formants, our data matches that of authors like Katchell et al. (2018) who discovered that lower F1 was seen in heterosexual men. This phenomenon was seen in our results where every vowel production differed in this aspect showing lower F1 values in heterosexual men when compared to queer men (with the exception of /i/). These results also yielded some new information. From the non-normalized data on vowels we discovered that /a/ and /u/ have similar F2 values between queer men and both female groups. This is different from previous research like Pahis (2017) which showed no significant differences between heterosexual and homosexual men when compared to straight women. We also discovered a big similarity in the production of /o/ where queer men and straight women produced almost identical /o/s different from those of queer women and straight men which also had very similar productions to one another. Lastly we also observed a new pattern patternwhere straight women tend to produce higher F2 values for front and mid vowels and lower F2 values for back vowels when compared to queer women. The opposite of this was seen with data from both male groups. Queer men seem to follow the same pattern as straight women while straight men tend to follow the same pattern as queer women. When looking at normalized vowels we also got some interesting results further supporthing the stereotypes that queer men have similar productions to women, which was seen in all five vowels. These results also shine a new light on some of the stereotypes associated with these groups further showing that they may have some significance in queer speech production.

Looking at pitch we also see some results similar to those from previous research. It has been theorized that pitch is the main factor that differentiates queer and heterosexual speakers in terms of speech production. These results seem to further prove this theory. As we saw, the data on pitch shows significant differences between groups supporting data from authors like Barron-Lutzross (2015), Katchel et al. (2018), and Van Dorsel et al. (2013). These results also seem to support some of the stereotypes that are associated with these groups, for example the belief that queer men often have a pitch similar to that of women (which was seen in this data) as well as queer women having a pitch closer to that of men (which was seen in thisd data).

Lastly, what was surprising about these results is that production of sibilants was not a significant factor in differentiating production of speakers. This has also been considered one of the main factors that differentiate these groups and can be seen in many of the research projects previously discussed in this paper. However, one main difference between these is the language (most papers discussed have been done with English populations). This paper focused on Spanish speakers as opposed to English speakers. These results might theorize that production of sibilants may not be as significant when it comes to Spanish as it is with English, supporting one of my theories stated at the beginning of this paper. Before analysis it was theorized that vowel production and pitch would be more significant in Spanish than they were in English, which was seen with this first experiment.

6. Experiment 2

6.1 Perception

To test the second theory of performativity and perceived sexuality, which states that identity is not directly linked to a set group of phonetic features, I ran a second experiment which collected perception data. The purpose of this experiment is to determine which factors and stereotypes influence the perception of sexuality. In this case, I studied whether visual cues affect perception and to what extent these influenced the phonetic cues discovered in experiment one. From the first experiment, we saw that the biggest differences in production were found with vowels and pitch, for that reason, the audio presented in this experiment will contain only those factors. Audios from the first experiment we used and presented to a new set of participants. The main hypothesis for this experiment is that visual cues will override any phonetic cues associated with sexuality and therefore be the determining factor in associating speech to sexuality. In other words, I expect to see a clear divide between participants matches where audios without visual stimuli will be affected by phonetic cues (theory one) while audios accompanied by visual cues will prioritize the visual stimuli over the aural one. If this is not the case and audios with visual cues (matched and mismatched) correctly associate the speech to the sexual orientation, we can conclude that the presence of phonetic cues is actually a big factor in the perception of sexuality.

6.2 Methodology

6.2.1 Participants

The results shown below were collected from a total of 4 participants: female (N=3) male (N=1), all students at the University of California, Berkeley (UCB). The participants' ages ranged from 20-21. Participants were recruited through word of mouth and posts on social media. All participants live in the United States and are Spanish speakers.

6.2.2 Procedure and Materials

Like the first experiment, all data collection had to be done remotely through the UC Berkeley licensed Qualtrics. A survey was created in which participants were presented with a brief introduction of the project followed by consent forms and media release forms. If participants wished to continue with the project, they were presented with a trial audio of the sentence "*Al niño le encanta jugar en la computadora*" ("the kid loves to play on the computer"). This audio served as a trial to understand and learn how to play the audios and answer the questions following the stimulus. Once participants were comfortable with the process, the stimuli were presented. Stimuli were broken into three different groups; the first group consisted of just audio files from four different speakers (one for each group of interest). These audios were presented in the absence of visual stimuli and a series of questions were presented in which participants were asked to rate each voice using a likert scale (1-7) on a series of topics (Appendix D). Some of the groups were borrowed from Gaudio (1994) as they characterized different sexual orientations based on common stereotypes (femenine/masculine, reserved/emotional, etc.). The second group of stimuli consisted of an audio file accompanied by a visual stimuli that matched the sexual orientation of the speaker. Once again, audio files from four different speakers (one for each group of interest) were utilized and participants were asked to rate each voice after listening to it. Lastly, the third group of stimuli consisted of an audio file accompanied by a visual stimuli that differed from the sexual orientation of the speaker (e.g. a gay man's voice with a "stereotypical" straight man depicted in the visual stimuli). All stimuli were presented in a randomized order. Audio files from four different speakers (one for each group of interest) were used and participants were asked to rate each voice after listening to it. Once all stimuli were completed, participants were asked two short questions to learn more about implicit and explicit stereotypes that are common among participants. Once completed, they were redirected to a short socio demographic survey (Appendix B) to learn more about language background, language usage, and other demographic information. Once finished, participants were presented with a thank you message and the survey was concluded. Once data was collected, responses were downloaded to a Macbook Pro 2021 model from Qualtrics and transferred to a university-provided password-protected storage cloud.

6.3 Analysis

Participants were presented with a total of 12 audios plus one for practice: three were from heterosexual men, three from queer men, three from heterosexual women, and three from queer women. As previously mentioned, for each group of audios two of them were accompanied by a visual cue (Appendix C) for which one matched the sexuality and the other mismatched it. Each audio was followed by eight different adjectives which participants had to use to rate the voice heard (Appendix D).

Once results were collected, the average ratings were taken from each participant and these averages were compared to the speakers to determine whether participants were able to match the voice to the correct sexuality (as has been seen in previous research).

6.4 Results

The first set of results are from data collected from aural stimuli only, participants were asked to rate the voices presented to them regarding 8 different characteristics (see Appendix D). There were a total of four stimuli presented that contained only aural cues, one for each group of interest.

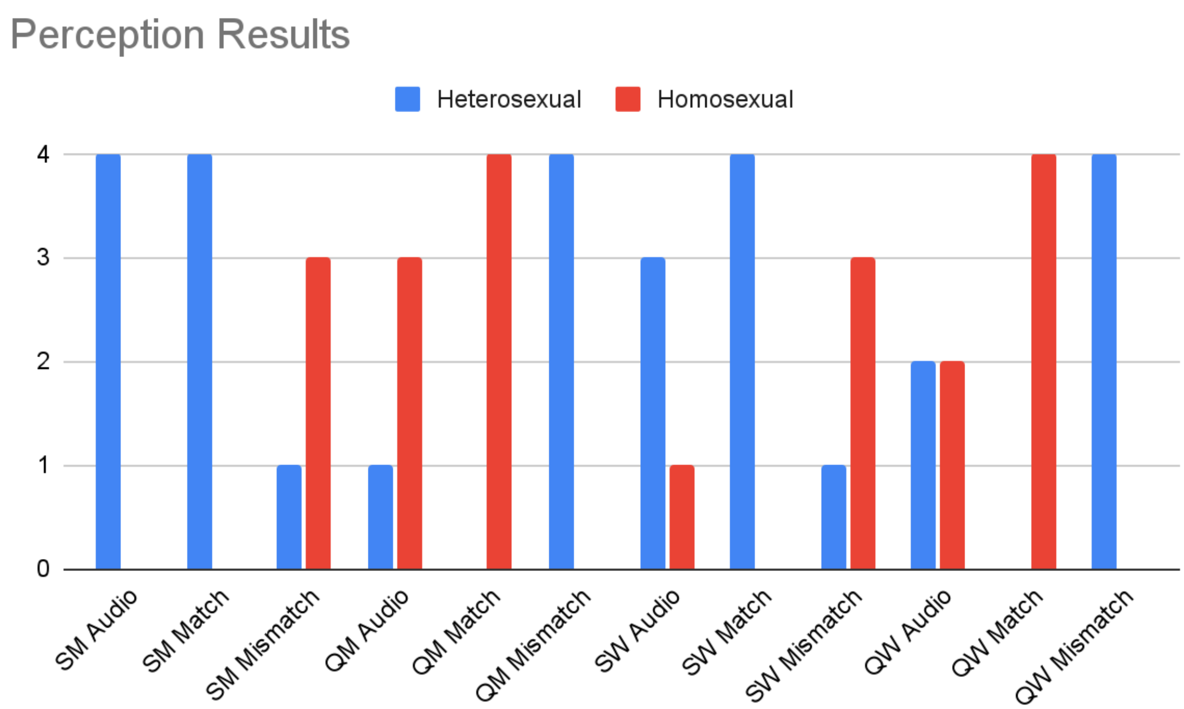

Figure 4: **Perception Ratings**

For these results, only scores on either extreme were considered strong, (in other words, scores of 3, 4, or 5 which were in the middle were considered inconsistent or not significant). Results showed three different patterns, which support the theory I proposed at the beginning of this paper. Like in previous research, participants had relatively high accuracy when rating the voices they heard (audio only). As seen in figure 4, SM, QM, and QW, were mostly rated correctly, with the lowest ratio being 3:1. Participants, however, had a harder time differentiating the voice of QW which were split 2:2 in the ratings. An interesting phenomenon was observed with the introduction of visual cues. For example, if we see the four audios accompanied by a picture that matched the sexuality of the speaker, the ratings correctly identified the sexuality of the speaker with 100% accuracy. When the picture mismatched the sexuality of the speaker (e.g. straight voice with “stereotypical gay man”), however, all voices were rated incorrectly with 3:1 ratios for both straight speakers and 4:0 for both queer speakers. All these ratings also showed very high or very low ratings (either extreme) rather than being inconsistent or closer to the middle of the scale. This pattern was interesting since the same results were observed in both groups including pictures.

This shows that despite sexualities being able to be differentiated from audio alone, acoustic cues are not the most important factor in differentiating them. These results show support for theory two, showing that audio may play an effect on perception of sexuality, however, society and our surroundings may play a larger role.

Data from the remaining seven adjectives used in the Likert scale were mostly inconsistent. With audio only stimuli, participants often rated every voice right in the middle of the scale (scores of 4) not showing any significant information. Some patterns that were observed were that men who were rated heterosexual often received higher ratings in height and masculinity and lower ratings in emotion. The opposite was seen with Queer men beign rated shorter, more affeminate, and more emotional. With female speakers, women rated straight were rated as being nicer, more trustworthy, and more emotional and affeminate than queer women who were rated as being mean, not as trusdtworthy, and more masculine. The same patterns stated above were also seen with the addition of images, however, scores were often higher receiving ratings of 2 or 6 compared to the 2-5 range seen without images. In terms of emotion alone shown in the voice, they were rated in between both extremes, meaning the stereotype that heterosexual voices are less “emotional” and more “reserved”.

6.5 Discussion of Experiment 2

Experiment two showed novel results, some of which had not been studied before. One thing that made this experiment unique was the introduction of images to test whether or not visual cues would be prioritized when determining the sexuality of a speaker over the voice being presented. Prior to the analysis of this data, I theorized that images would be used as the main factor in determining the sexuality of the speaker, meaning phonetic cues would be completely ignored or simply less influential. After seeing the results this was indeed the case. Even those voices that were rated correctly without images were rated incorrectly once the image was added to the stimuli. Something researchers have been theorizing is the belief that phonetic cues do play a factor, however it is not the determining one. This experiment supports that theory. While morphology and semantics were not taken into consideration, when comparing visual and auditory cues, we can conclude that visual cues are prioritized.

7. General Discussion

This project had two main goals that it tried to accomplish: first I wanted to use previous data and knowledge about queer speech (most of which had been done with English speakers) to see if similar patterns could be observed with Spanish speakers. To achieve this I tried to test both of the hypotheses that have been used to describe this phenomenon and as a result two experiments were conducted. The second goal was to determine whether implicit and explicit stereotypes played an important role in determining the sexuality of a speaker. This was tested with the introduction of visual cues in the second experiment which introduced many of the popular stereotypes associated with queer men and women to see what role they would play in this study.

The results collected helped achieve most of the first goal. The first experiment showed that there are phonetic cues that we can use to differentiate between these groups of speakers. Theory one states that speakers are characterized by these different cues, and as we saw, vowels and pitch play a big role and are significantly different between these groups. Despite these findings we also saw that the second theory of performativity and perceived sexuality also played a role in experiment two. We saw that without the presence of visual cues some speakers were correctly identified while some were not. This supports one of the main arguments for this theory which is that not all queer speakers sound the same, nor do all heterosexual speakers; speech instead is a reflection of our surroundings.

The second goal was also achieved, as the visual cues shone a new light on the influence stereotypes play on speech perception. As we saw, the general trend was that visual cues overpowered all the phonetic cues and differences in the speech of speakers, and these were completely ignored. Participants used the images being presented as the main factor in matching the speaker to sexuality and in all cases, the choices matched the image rather than the voice. These results are significant because, once again, they suggest that voice is not the biggest cue that people use to determine or associate people with a sexuality. While it does play a significant role (as we saw with speakers being identified correctly in the absence of images) it is not the main factor.

7.1 Further studies

For future research, something I would like to do is expand the population being studied as well as the amount of participants. This study had many limitations: due to pandemic restrictions everything had to be conducted virtually affecting the audio quality as there was no control over the recording devices or the amount of noise present at the time of recordings. Another limitation was the population chosen. Due to the study being focused only on Berkeley and the surrounding areas, the population of Spanish speakers was not the highest. For future studies, expanding the population and having more control over data collection would probably yield better and more accurate results. Taking into consideration natural speech over read speech might also influence or change the results we saw in this experiment. Something that would also be interesting to include is the presence of other languages or bilingual speakers. Rather than focusing on one language, testing two at the same time (e.g English and Spanish) could be interesting to see whether the knowledge of more than one language affects the way sexuality is perceived. This could be seen since, as we determined with this study, the phonetic cues associated with queer speech differ by language. Spanish showed a higher effect caused by vowels and pitch while English has noticed a big influence from sibilant production.

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10. Appendix

Appendix A: Experiment 1 Story "La Estrella de Sofia"

A Sofía siempre le ha gustado la hora de ir a dormir, porque desde su ventana se pueden ver todas las estrellas que iluminan el oscuro cielo.

– Venga, Sofía, ya es hora de meterte en la cama – dijo su mamá que esperaba para arroparla.

Sofía se metió de un salto en la cama, se tumbó y se acurrucó junto a su osito preferido.

– Mamá, de mayor quiero ser astronauta para poder viajar hasta el cielo en un gran cohete espacial. Y cuando esté allí elegiré la estrella más brillante y me la quedaré solo para mí.

– ¿Y qué vas a hacer tú con una estrella?

– Pintaré las paredes y decoraré los árboles y… así, todo brillará.

– Buenas noches astronauta Sofía. Que sueñes con las estrellas. – dijo mamá mientras apagaba la luz.

Sofía se quedó dormida enseguida, pero algo la despertó. Se levantó de su cama y… ¡no podía creer lo que estaba viendo!

En la ventana le esperaba un cohete y un traje espacial.

Sin dudarlo, Sofía se puso la ropa especial para viajar al espacio y subió al cohete.

– Abróchense los cinturones. Despegamos en 3, 2, 1, 0…Sss ¡Pum!

Y el cohete despegó con destino al cielo estrellado.

Sofía era una gran astronauta y en seguida aprendió a manejar los mandos del cohete.

Voló y voló hasta llegar a las estrellas.
– ¡Cómo brillan! – dijo Sofía.

La luz era tan intensa que tuvo que ponerse gafas de sol.

A lo lejos pudo ver un planeta que brillaba mucho más que Júpiter o Venus.

– Ese debe ser el planeta del que vienen las estrellas – se dijo la niña.

Cogió los mandos del cohete y descendió hasta él.

En el Planeta Brillante todas las estrellas iban y venían muy atareadas y había algunas que se ocupaban de organizar a todas las demás.

– Las estrellas de brillo dorado tienen que ir a la parte derecha del cielo y las estrellas plateadas deberán quedarse cerca de la luna para ayudarla a dar algo más de luz. – decían las organizadoras.

Entonces, Sofía bajó de su cohete y se acercó a una de las estrellas que estaban organizando. – seguro que ellas me sabrán indicar dónde puedo encontrar a la estrella más brillante de todas.

– Hola, soy Sofía y he venido de la Tierra para buscar la estrella más brillante de todas.

La estrella se giró y casi se cae del susto, al ver a una niña en su Planeta Brillante. Cuando al fin se recuperó dijo:

– ¿Y para qué quieres una estrella?

– Pues vera usted. Quiero llevarme la estrella más brillante del cielo para poder pintar las paredes y los árboles y así todo brillará en mi planeta, la Tierra.

– ¿Pero cómo vas a llevarte una estrella? Eso es imposible. ¿No podrías encender una linterna o poner luces de Navidad para que brille tu planeta?

Sofía miró a la estrella extrañada… y después se explicó un poco mejor, por si no la había entendido bien.

– Bueno, las luces de Navidad no pueden estar todo el año encendidas y las linternas necesitan muchas pilas. Además, lo que yo quiero es brillo y purpurina.

La estrella se puso sus gafas para ver bien y sacó unos papeles que llevaba guardados en un maletín morado.

– La ley del Espacio prohíbe que las estrellas salgan del Planeta Brillante, salvo para iluminar el cielo. Pero si quieres puedes quedarte tú a vivir aquí.

– ¿Cómo voy a quedarme aquí? Tengo que volver a mi casa, con mi mamá. – dijo Sofía.

– Haremos una cosa, abre tu mano.

Sofía abrió su mano y la estrella le dio un pequeño saco.

– Sí, eso será suficiente. Ya puedes marcharte Sofía, date prisa que pronto se hará de día.

Sofía montó en su cohete rumbo a la ventana de su casa, algo triste por no haber podido llevarse una estrella.

Entonces, abrió el saco y cual fue su sorpresa al ver que le habían regalado polvo de estrellas.

Desde entonces, cada noche, Sofía abre su saco para pintar con polvo de estrellas las cosas bonitas que hay en el planeta Tierra.

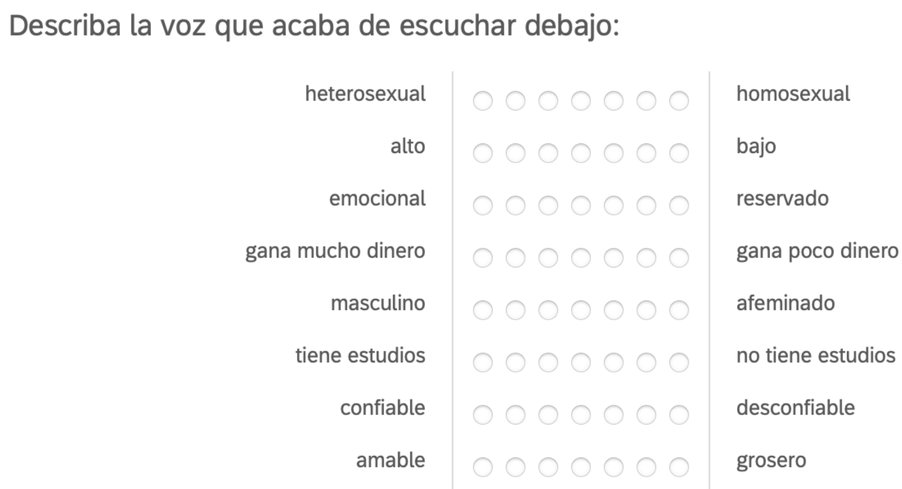
FIN

Appendix B: Sociodemographic Questionnaire

1. Edad ______
2. Género ______
3. Orientación Sexual ______
4. ¿Cuál es tu raza/etnicidad? (selecciona todos los que apliquen):
    a. ____ Indigena de las Americas o nativa de Alaska
    b. ___ Asiatica
    c. ____ Negra
    d. ___ Blanca
    e. ____ Isleña del pacifico
    f. ____ Hispana/Latina
    g. ____ Otra: _________
5. País en el que naciste: __________
6. País en el que creciste: _________
7. País de residencia: _________
8. ¿Qué idiomas hablas y cuál es tu nivel de competencia?
    a. Lectura
    b. Escritura
    c. Hablar
    d. Entendimiento
9. ¿A qué edad aprendiste cada idioma?
10. ¿Qué tan frecuentemente utilizas el español?
11. ¿Dónde utilizas el español?
12. Nivel más alto de educación completado

Appendix C: Experiment 2 Visual Stimuli

Appendix D: Experiment 2 Likert Scale Audio Questions



Appendix E: Individual Vowel Productions (Non-Normalized) by Speaker

Speaker	Vowel	F1	F2
SM01	a	829.37	1448.67
SM01	a	694.25	1428.02
SM01	a	660.57	1503.86
SM01	a	746.37	1522.77
SM01	a	766.76	1504.67
SM01	a	637.01	1234.16
SM01	a	830.88	1393.73
SM01	a	736.4	1607.54
SM01	a	629.66	1285.64
SM01	a	666.54	1498.44

SM01	e	370.84	1991.31
SM01	e	592.61	1681.58
SM01	e	539.96	1593.12
SM01	e	532.22	1709.36
SM01	e	499.43	1662.85
SM01	e	561.77	1287.06
SM01	e	405.19	1666.38
SM01	e	391.54	1960.79
SM01	e	533.85	1500.81
SM01	e	393.37	1226.95
SM01	i	347.26	2237.9
SM01	i	364.04	1998.96
SM01	i	428.14	1919.7
SM01	i	367.35	2180.94
SM01	i	319.46	2010.13
SM01	i	250.2	1973.63
SM01	i	325.53	2036.04
SM01	i	346.23	2099.97
SM01	i	315.09	2144.2

SM01	i	287.14	2114.7
SM01	o	564.64	1267.38
SM01	o	548.14	1121.41
SM01	o	585.21	1309.79
SM01	o	578.07	1194.22
SM01	o	582.69	1235.31
SM01	o	617.81	1320.98
SM01	o	466.12	1538.92
SM01	o	599.83	1248.5
SM01	o	561.58	1405
SM01	o	574.59	1236.97
SM01	u	400.16	666.75
SM01	u	782.97	960.89
SM01	u	541.35	984.98
SM01	u	378.51	1074.56
SM02	a	644.2079545	1466.026746
SM02	a	548.3426866	1644.062717
SM02	a	706.472337	1514.368856
SM02	a	830.7052281	1361.698697

SM02	a	623.4824047	1318.681154
SM02	a	686.818788	1495.868689
SM02	a	518.3353489	1137.69455
SM02	a	747.9178819	1360.808058
SM02	a	628.8439787	1327.089516
SM02	a	720.1145562	1382.294886
SM02	e	429.4752868	1462.396089
SM02	e	489.5203454	1537.394699
SM02	e	496.4242856	1537.177242
SM02	e	480.542359	1589.536763
SM02	e	353.8136222	1299.2034
SM02	e	530.69389	1764.336213
SM02	e	500.2757459	1703.733197
SM02	e	785.3673014	1872.723735
SM02	e	443.2015647	1942.179383
SM02	e	353.8136222	1299.2034
SM02	i	444.9366501	1539.534163
SM02	i	328.6613331	1900.258676
SM02	i	344.0809422	2695.933476

SM02	i	396.0851121	2001.796267
SM02	i	296.4911851	2664.664186
SM02	i	470.0479925	1728.814806
SM02	i	315.2711906	2380.730376
SM02	i	285.3152753	2073.040994
SM02	i	330.702815	2732.337318
SM02	i	355.807542	1852.141906
SM02	o	524.1269696	1271.721843
SM02	o	465.0919297	1138.807387
SM02	o	538.007251	1356.925282
SM02	o	573.6208364	1081.909256
SM02	o	467.4497169	1180.930835
SM02	o	500.4159735	1216.12886
SM02	o	622.4577767	1315.293886
SM02	o	447.0041868	1262.717422
SM02	o	500.4159735	1356.925282
SM02	o	524.1269696	1271.721843
SM02	u	394.4063452	1431.51359
SM02	u	295.2598721	633.9899187

SM02	u	436.4695977	1094.964633
SM02	u	541.35	984.98
QM01	a	689.63	1447.36
QM01	a	494.19	1525.26
QM01	a	663.56	1555.69
QM01	a	629.19	1549.61
QM01	a	444.78	1693.75
QM01	e	428.78	1641.69
QM01	e	481.29	1579.99
QM01	e	427.99	1656.65
QM01	e	421.49	1713.96
QM01	e	428.41	1788.43
QM01	i	325.77	2018.97
QM01	i	375.65	2064.38
QM01	i	350.88	2057.79
QM01	i	379.18	2046.31
QM01	i	344.28	2078.87
QM01	o	397.16	1329.26
QM01	o	412.94	1276.27

QM01	o	461.59	1262.42
QM01	o	557.69	1127.62
QM01	o	569.56	1413.11
QM01	u	365.91	812.4
QM01	u	441.72	785.05
QM01	u	390.62	855.12
QM02	a	733.48	1523.99
QM02	a	733.44	1486.59
QM02	a	540.55	1553.38
QM02	a	761.32	1407.32
QM02	a	740.04	1476.33
QM02	e	476.22	1763.4
QM02	e	415.17	1747.22
QM02	e	401.39	1957.59
QM02	e	426.57	1740.97
QM02	e	556.45	1546.57
QM02	i	378.85	2046.06
QM02	i	367.71	2022
QM02	i	315.38	2647.86

QM02	i	390.86	2314.22
QM02	i	348.32	2067.66
QM02	o	541.7	1020.88
QM02	o	554.09	937.71
QM02	o	378.46	1059.5
QM02	o	598.6	1325.93
QM02	o	552.21	998.29
QM02	u	346.1	851.82
QM02	u	444.21	962.33
QM02	u	353.58	882.8
SW01	a	662.7444376	1857.035288
SW01	a	555.0769072	1837.081754
SW01	a	582.021112	1858.639217
SW01	a	573.2278122	1873.778845
SW01	a	763.9403021	1588.268371
SW01	a	648.8288344	1650.092599
SW01	a	554.8905001	1548.110296
SW01	a	520.845292	1787.100153
SW01	a	757.1205865	1591.793229

SW01	a	611.7775608	1935.165504
SW01	e	304.5597644	2155.70949
SW01	e	431.5916602	2357.580902
SW01	e	540.6004217	1998.725427
SW01	e	416.915289	2168.720806
SW01	e	534.4419846	1791.496166
SW01	e	601.2406076	2101.357202
SW01	e	709.8701817	2045.996738
SW01	e	534.8670517	2109.050215
SW01	e	477.7549476	2072.489388
SW01	e	540.8074734	2112.947012
SW01	i	391.0995875	2779.974199
SW01	i	403.9865445	2919.781736
SW01	i	441.7227579	2844.641152
SW01	i	304.4065553	2671.247166
SW01	i	547.586547	2276.017472
SW01	i	435.0358939	2894.894322
SW01	i	357.1542357	2807.388873
SW01	i	446.7155819	2472.18303

SW01	i	418.2274368	2836.212971
SW01	i	547.586547	2276.017472
SW01	o	560.9839784	1206.316784
SW01	o	563.3709244	1222.155493
SW01	o	533.1709299	1067.973446
SW01	o	281.9420578	931.2907826
SW01	o	610.8420332	1269.570372
SW01	o	634.3650234	1326.223447
SW01	u	286.1648504	1302.484054
SW01	u	346.830038	648.9368817
SW02	a	903.14	1784.18
SW02	a	996.97	1697.32
SW02	a	913.35	1876.13
SW02	a	876.69	1843.01
SW02	a	1015.41	1859.02
SW02	e	503.64	2022.34
SW02	e	543.78	2367.12
SW02	e	449.6	2377.59
SW02	e	462.19	2362.44

SW02	e	425.82	2141.28
SW02	i	327.19	2706.6
SW02	i	396.81	2669.18
SW02	i	395.88	2623.42
SW02	i	372.37	2691.78
SW02	i	433.11	2805.8
SW02	o	466.47	1243.56
SW02	o	520.37	1176.24
SW02	o	512.14	1162.74
SW02	o	544.6	1099.48
SW02	o	574.86	1196.06
SW02	u	390.84	1085.96
SW02	u	366.27	1149.85
SW02	u	488.88	1062.47
QW01	a	591.9561126	1700.173621
QW01	a	683.8410317	1572.651201
QW01	a	643.8733196	1268.615954
QW01	a	673.7225732	1585.149119
QW01	a	633.7390263	1206.435731

QW01	a	653.8760791	1651.151625
QW01	a	797.3440878	1588.233361
QW01	a	640.0933412	1755.461276
QW01	a	688.0209026	1573.433007
QW01	a	700.8431029	1734.581411
QW01	e	708.1375646	1646.191529
QW01	e	554.41913	2311.410858
QW01	e	469.4984227	1927.528315
QW01	e	566.8653882	2143.549363
QW01	e	535.6405199	2396.681127
QW01	e	427.6191035	2460.607214
QW01	e	612.809759	1968.003442
QW01	e	518.8323522	1376.522572
QW01	e	575.6610593	1919.101711
QW01	e	483.7588643	1969.175955
QW01	i	416.4430929	2483.550747
QW01	i	493.3729335	2042.585831
QW01	i	370.5787787	2609.278475
QW01	i	378.5768555	2572.475959

QW01	i	376.0779818	2661.110808
QW01	i	443.7825185	2422.500561
QW01	i	304.4537633	2266.769957
QW01	i	404.9013491	2353.897138
QW01	i	467.6152094	2225.762158
QW01	i	411.6528521	2614.79114
QW01	o	496.782519	1018.948547
QW01	o	504.2108199	1427.132794
QW01	o	593.134089	1110.746015
QW01	o	494.827404	839.2105058
QW01	o	552.7921094	1036.836026
QW01	o	543.1100485	911.6994777
QW01	o	456.4450734	1476.295895
QW01	o	519.390403	884.3400862
QW01	u	427.5927869	843.2012007
QW01	u	449.7930247	921.3322768
QW01	u	318.3657675	823.5897719
QW01	u	438.406412	909.8375643
QW01	u	383.9665847	1092.110139

QW02	a	756.5857906	1732.405327
QW02	a	714.8266214	1636.750942
QW02	a	715.5717136	1752.897696
QW02	a	732.6051009	1742.838361
QW02	a	776.0478472	1415.813261
QW02	a	710.9778412	1781.095601
QW02	a	758.261561	1749.809722
QW02	a	677.1351883	1452.613659
QW02	a	764.8066301	1819.776886
QW02	a	750.6643373	1553.277844
QW02	e	530.7885526	1894.415285
QW02	e	399.6093825	2603.645501
QW02	e	396.0938026	1997.13228
QW02	e	661.0187304	1968.489149
QW02	e	550.4542792	1990.377488
QW02	e	630.7800536	2075.048995
QW02	e	348.6475255	2170.53039
QW02	e	887.2212192	1370.066086
QW02	e	667.4682799	1634.972964

QW02	e	553.0712001	2107.069752
QW02	i	330.4501374	2147.145511
QW02	i	769.7932966	2655.9808
QW02	i	420.3491361	2036.976331
QW02	i	385.7952611	2678.613196
QW02	i	313.8659129	2346.894109
QW02	i	298.3245742	2455.052996
QW02	i	383.5651436	2860.436329
QW02	i	263.2000762	3215.234424
QW02	i	332.5709241	3093.166927
QW02	i	298.3245742	2455.052996
QW02	o	535.7275831	1786.517819
QW02	o	651.2903069	1672.909352
QW02	o	536.0767801	1600.458257
QW02	o	491.7636202	1373.144306
QW02	o	532.8270489	1322.498098
QW02	o	560.7417411	1290.801415
QW02	o	625.419049	1209.972336
QW02	u	334.8437779	1348.612166

QW02	u	380.2489111	1192.886591
QW02	u	426.0270687	1497.448642

Appendix F: Individual Vowel Productions (Normalized) by Speaker

Speaker	Vowel	F1_NORM	F2_NORM
SM01	a	945.058	1650.743
SM01	a	791.09	1627.213
SM01	a	752.712	1713.632
SM01	a	850.48	1735.179
SM01	a	873.714	1714.555
SM01	a	725.866	1406.312
SM01	a	946.778	1588.14
SM01	a	839.12	1831.774
SM01	a	717.491	1464.972
SM01	a	759.515	1707.456
SM01	e	422.568	2269.075
SM01	e	675.272	1916.142
SM01	e	615.278	1815.342
SM01	e	606.459	1947.797

SM01	e	569.095	1894.799
SM01	e	640.131	1466.59
SM01	e	461.709	1898.821
SM01	e	446.155	2234.298
SM01	e	608.316	1710.156
SM01	e	448.241	1398.096
SM01	i	395.699	2550.062
SM01	i	414.82	2277.793
SM01	i	487.861	2187.477
SM01	i	418.591	2485.157
SM01	i	364.021	2290.521
SM01	i	285.1	2248.929
SM01	i	370.938	2320.045
SM01	i	394.525	2392.892
SM01	i	359.042	2443.292
SM01	i	327.193	2409.677
SM01	o	643.401	1444.165
SM01	o	624.599	1277.834
SM01	o	666.84	1492.491

SM01	o	658.704	1360.8
SM01	o	663.969	1407.622
SM01	o	703.988	1505.242
SM01	o	531.139	1753.582
SM01	o	683.5	1422.652
SM01	o	639.914	1600.982
SM01	o	654.739	1409.513
SM01	u	455.978	759.754
SM01	u	892.186	1094.923
SM01	u	616.862	1122.374
SM01	u	431.308	1224.449
SM02	a	753.098	1713.828
SM02	a	641.029	1921.958
SM02	a	825.887	1770.342
SM02	a	971.119	1591.866
SM02	a	728.869	1541.577
SM02	a	802.911	1748.714
SM02	a	605.949	1329.998
SM02	a	874.338	1590.825

SM02	a	735.137	1551.407
SM02	a	841.835	1615.943
SM02	e	502.069	1709.584
SM02	e	572.264	1797.26
SM02	e	580.335	1797.005
SM02	e	561.768	1858.215
SM02	e	413.619	1518.807
SM02	e	620.397	2062.561
SM02	e	584.837	1991.714
SM02	e	918.117	2189.269
SM02	e	518.116	2270.465
SM02	e	413.619	1518.807
SM02	i	520.144	1799.761
SM02	i	384.215	2221.458
SM02	i	402.241	3151.626
SM02	i	463.035	2340.159
SM02	i	346.607	3115.071
SM02	i	549.5	2021.035
SM02	i	368.561	2783.144

SM02	i	333.542	2423.446
SM02	i	386.601	3194.183
SM02	i	415.949	2165.208
SM02	o	612.72	1486.68
SM02	o	543.706	1331.299
SM02	o	628.946	1586.286
SM02	o	670.58	1264.784
SM02	o	546.462	1380.543
SM02	o	585.001	1421.69
SM02	o	727.671	1537.617
SM02	o	522.561	1476.154
SM02	o	585.001	1586.286
SM02	o	612.72	1486.68
SM02	u	461.073	1673.481
SM02	u	345.167	741.153
SM02	u	510.246	1280.046
SM02	u	632.854	1151.471
QM01	a	840.07	1763.097
QM01	a	601.996	1857.99

QM01	a	808.313	1895.058
QM01	a	766.446	1887.652
QM01	a	541.807	2063.236
QM01	e	522.317	1999.819
QM01	e	586.282	1924.659
QM01	e	521.355	2018.043
QM01	e	513.437	2087.855
QM01	e	521.866	2178.57
QM01	i	396.836	2459.401
QM01	i	457.597	2514.717
QM01	i	427.423	2506.69
QM01	i	461.897	2492.706
QM01	i	419.384	2532.368
QM01	o	483.799	1619.234
QM01	o	503.021	1554.684
QM01	o	562.284	1537.813
QM01	o	679.348	1373.606
QM01	o	693.808	1721.375
QM01	u	445.732	989.622

QM01	u	538.08	956.306
QM01	u	475.832	1041.662
QM02	a	870.651	1808.997
QM02	a	870.603	1764.603
QM02	a	641.64	1843.883
QM02	a	903.697	1670.508
QM02	a	878.438	1752.424
QM02	e	565.28	2093.18
QM02	e	492.812	2073.974
QM02	e	476.455	2323.686
QM02	e	506.344	2066.555
QM02	e	660.514	1835.8
QM02	i	449.7	2428.701
QM02	i	436.477	2400.142
QM02	i	374.36	3143.046
QM02	i	463.956	2747.011
QM02	i	413.461	2454.341
QM02	o	643.005	1211.799
QM02	o	657.712	1113.075

QM02	o	449.237	1257.641
QM02	o	710.546	1573.897
QM02	o	655.481	1184.984
QM02	u	410.825	1011.122
QM02	u	527.283	1142.299
QM02	u	419.704	1047.896
SW01	a	683.8	1916.033
SW01	a	572.712	1895.446
SW01	a	600.512	1917.688
SW01	a	591.439	1933.308
SW01	a	788.211	1638.727
SW01	a	669.442	1702.516
SW01	a	572.519	1597.293
SW01	a	537.392	1843.876
SW01	a	781.174	1642.364
SW01	a	631.214	1996.645
SW01	e	314.236	2224.196
SW01	e	445.303	2432.481
SW01	e	557.775	2062.225

SW01	e	430.161	2237.621
SW01	e	551.421	1848.412
SW01	e	620.342	2168.117
SW01	e	732.423	2110.998
SW01	e	551.86	2176.054
SW01	e	492.933	2138.332
SW01	e	557.989	2180.075
SW01	i	403.525	2868.294
SW01	i	416.821	3012.543
SW01	i	455.756	2935.015
SW01	i	314.077	2756.112
SW01	i	564.983	2348.326
SW01	i	448.857	2986.865
SW01	i	368.501	2896.579
SW01	i	460.908	2550.724
SW01	i	431.514	2926.319
SW01	i	564.983	2348.326
SW01	o	578.806	1244.641
SW01	o	581.269	1260.983

SW01	o	550.11	1101.903
SW01	o	290.899	960.878
SW01	o	630.248	1309.904
SW01	o	654.519	1368.357
SW01	u	295.256	1343.864
SW01	u	357.849	669.553
SW02	a	926.136	1829.61
SW02	a	1022.355	1740.538
SW02	a	936.606	1923.901
SW02	a	899.013	1889.937
SW02	a	1041.265	1906.355
SW02	e	516.464	2073.834
SW02	e	557.626	2427.393
SW02	e	461.048	2438.129
SW02	e	473.958	2422.593
SW02	e	436.662	2195.802
SW02	i	335.521	2775.517
SW02	i	406.914	2737.144
SW02	i	405.96	2690.219

SW02	i	381.851	2760.319
SW02	i	444.138	2877.242
SW02	o	478.347	1275.224
SW02	o	533.62	1206.19
SW02	o	525.18	1192.346
SW02	o	558.467	1127.475
SW02	o	589.497	1226.515
SW02	u	400.792	1113.611
SW02	u	375.596	1179.128
SW02	u	501.328	1089.523
QW01	a	649.697	1866.012
QW01	a	750.544	1726.051
QW01	a	706.678	1392.36
QW01	a	739.439	1739.768
QW01	a	695.555	1324.114
QW01	a	717.657	1812.209
QW01	a	875.119	1743.153
QW01	a	702.53	1926.693
QW01	a	755.132	1726.909

QW01	a	769.205	1903.776
QW01	e	777.211	1806.765
QW01	e	608.498	2536.871
QW01	e	515.294	2115.544
QW01	e	622.159	2352.636
QW01	e	587.888	2630.459
QW01	e	469.33	2700.62
QW01	e	672.585	2159.967
QW01	e	569.44	1510.792
QW01	e	631.812	2106.295
QW01	e	530.946	2161.254
QW01	i	457.064	2725.802
QW01	i	541.498	2241.824
QW01	i	406.726	2863.793
QW01	i	415.504	2823.401
QW01	i	412.761	2920.682
QW01	i	487.07	2658.797
QW01	i	334.151	2487.876
QW01	i	444.396	2583.502

QW01	i	513.227	2442.868
QW01	i	451.806	2869.844
QW01	o	545.24	1118.339
QW01	o	553.393	1566.339
QW01	o	650.99	1219.091
QW01	o	543.094	921.069
QW01	o	606.713	1137.971
QW01	o	596.086	1000.629
QW01	o	500.968	1620.297
QW01	o	570.053	970.601
QW01	u	469.301	925.449
QW01	u	493.667	1011.201
QW01	u	349.42	903.925
QW01	u	481.17	998.585
QW01	u	421.42	1198.637
QW02	a	763.947	1749.262
QW02	a	721.782	1652.677
QW02	a	722.534	1769.953
QW02	a	739.733	1759.796

QW02	a	783.599	1429.589
QW02	a	717.896	1798.426
QW02	a	765.639	1766.835
QW02	a	683.724	1466.748
QW02	a	772.248	1837.483
QW02	a	757.968	1568.391
QW02	e	535.953	1912.848
QW02	e	403.498	2628.979
QW02	e	399.948	2016.564
QW02	e	667.45	1987.643
QW02	e	555.81	2009.744
QW02	e	636.918	2095.239
QW02	e	352.04	2191.65
QW02	e	895.854	1383.397
QW02	e	673.963	1650.881
QW02	e	558.453	2127.572
QW02	i	333.665	2168.037
QW02	i	777.283	2681.824
QW02	i	424.439	2056.796

QW02	i	389.549	2704.676
QW02	i	316.92	2369.729
QW02	i	301.227	2478.941
QW02	i	387.297	2888.268
QW02	i	265.761	3246.519
QW02	i	335.807	3123.263
QW02	i	301.227	2478.941
QW02	o	540.94	1803.901
QW02	o	657.627	1689.187
QW02	o	541.293	1616.031
QW02	o	496.548	1386.505
QW02	o	538.011	1335.366
QW02	o	566.198	1303.361
QW02	o	631.504	1221.745
QW02	u	338.102	1361.734
QW02	u	383.949	1204.493
QW02	u	430.172	1512.019