

Does the gay accent exist?

*An acoustic comparison between homosexual and heterosexual Dutch
male millennials*

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Does the gay accent exist?

An acoustic comparison between homosexual and heterosexual Dutch male millennials

Liem, Q.C., supervised by Hamann, S.

ABSTRACT. In response to a perception-based approach employed in previous studies for English speaking gay men, a production-based experiment was conducted, focusing on Dutch gay men. Two groups were compared: Dutch heterosexual and Dutch homosexual men. Natural speech data elicited through informal sociolinguistic interviews were acoustically analyzed in Praat. No evidence was found to conclude that Dutch gay men's speech is distinctive from heterosexual men's speech based on the acoustic features which were compared in this study: skewness of the spectrum and center of gravity of the spectral peak frequency of the fricative /s/, mean pitch, pitch range, intonation (pitch variability over time), speech rate, and articulation rate.¹

INTRODUCTION

The 'gay accent' – does it really exist? Even those without a self-proclaimed *gaydar* often claim to be able to judge whether someone is gay just by hearing the speaker's voice. The widespread cultural stereotype depicts an effeminate voice which includes a high pitch, lisping, over the top intonation, and drawn out vowels as salient markers of homosexuality in men. But is this accent indeed just a stereotype or is there actually something tangible about the way that gay men speak that sets them apart from their straight peers?

A sizeable body of research has gone into identifying and describing the key characteristics of this particular manner of speaking in English. The prevailing stereotype,

which has been reiterated by many researchers, is that gay men sound effeminate or that gay speech is characterized by being imitative of female speech (Travis, 1981; Gaudio, 1994; Munson, DeBoe & White, 2006). But what does this mean? What are the key distinctive features for gay and/or feminine speech?

For example, women's voices have a pitch on average 100-150 Hz higher than male voices (Smyth, Jacobs & Rogers, 2003; Morrison & Rogers, 2000), and Lakoff (1990:204) mentions women's more varied intonational contours. But contrary to the stereotype, Munson & Zimmerman (2006) and Munson & Babel (2007) did not find evidence that gay male speech mimics female speech. They found no overall differences in mean pitch between heterosexual and homosexual men. More extensive

¹ The Dutch version of this Abstract can be found in Appendix A.

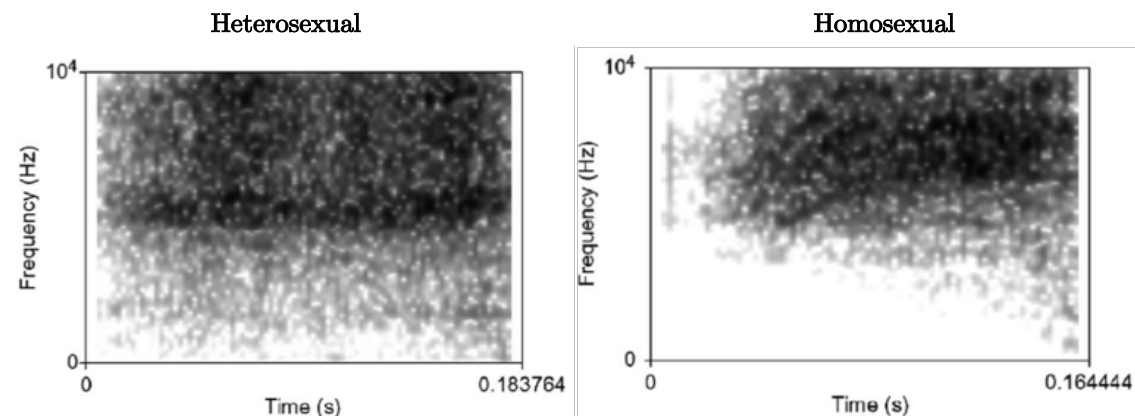


Fig. 1. Spectrograms of the fricative /s/. The spectrogram of a self-identified homosexual man (right) has a more negative skewness (skewness = -1.67) than the spectrogram of a self-identified heterosexual man (skewness = -0.03). (Munson, DeBoe & White, 2006: 215)

investigations regarding pitch and sexual orientation were done by Gaudio (1994), and Smyth, Jacobs & Rogers (2003). They found no evidence for a perceptual correlation between sexual orientation and pitch range or pitch variability. In contrast, Levon's (2007) empirical research showed that listeners were more likely to judge recorded speech stimuli, which were digitally manipulated to feature a wider pitch range, as sounding gay. However, he concedes that the findings are highly contingent and dependent on sociolinguistic factors.

Panfili (2011) examined the relationship between vowel duration and perceived sexual orientation by letting listeners judge a pre-recorded passage. This, however, did not yield a solid correlation.

To investigate the stereotype of the 'gay lisp', Mack & Munson (2010) analyzed listeners' perceptive associations of phonetic variations of the fricative /s/ in English with perceived sexual orientation. They found that a sharper /s/ that was articulated more frontally in the mouth was perceived as 'gayer-sounding'. This particular realization of the /s/ is realized acoustically as a sibilant with an especially high spectral peak frequency, which corresponds to a

more negative skew in the sibilant spectrum (Fig. 1). Linville et al. (1989), Rogers & Smyth (2003), Munson, Jefferson & McDonald (2006), and Munson, DeBoe & White (2006) corroborate the finding that an /s/ produced with a higher peak frequency and thus a more negatively skewed /s/ is perceived as gayer-sounding. This distinctive /s/ appears to be a hyper-articulated /s/, according to Maniwa, Jongman & Wade (2009) and Munson & Zimmerman (2006).

Similar results have been found in Danish. In a perception-based matched guise experiment conducted by Phraao, Maegaard, Møller & Kristiansen (2014), listeners were asked to rate Danish speech samples from two different social registers into which either an alveolar /s/ or a fronted /s/ were spliced on scales of homosexuality and femininity. The results showed that for the modern Copenhagen speech register, listeners rated the speech samples containing a fronted /s/ higher on both the homosexuality and femininity scales compared to the alveolar /s/. Interestingly, the fronted and alveolar /s/ did not receive any significantly different ratings when they occurred in the street language register. As the

fronted /s/ has been found to be indexical of homosexuality in both English and in Danish based on perception, could we expect similar findings in Dutch?

The objective of this research is, ultimately, the same as that of previous researchers. Namely, *verifying* the existence of the gay accent and *identifying* its distinctive characteristics which set it apart from the way heterosexual men speak. As previous researchers mostly relied on perception-based methods, they mainly focused on the identification part. But to answer the question of whether the gay accent actually exists, that is, to verify its existence, we need a different approach – indeed the exact opposite. The experimental procedure discussed in this study features a production-based investigation of recorded gay speech, which was objectively analyzed not by listeners, but with the phonetic analysis software Praat (Boersma & Weenink, 2019), and which was furthermore supported by statistical comparison with heterosexual speech.

In addition to a different experimental approach, the investigation outlined in this thesis will focus solely on native Dutch-speaking men. This is because in contrast to English, there is a surprising absence of research for Dutch on this front. Although no conclusive evidence was found for any pitch differences between heterosexual and homosexual men in English, I want to investigate whether pitch features are distinctive for Dutch gay men. Furthermore, in line with gay male speech being thought of as resembling female speech, I want to investigate whether Dutch gay men speak slower than heterosexual men, as women tend to have a lower speech tempo than men (Weilrich & Simpson, 2014).

In short, by comparing a random group of Dutch homosexual men to a random group of Dutch heterosexual men, can we objectively find any measurable differences in:

- I. the spectral peak frequency of their articulated /s/?
- II. their pitch range and intonation?
- III. their speech tempo?

DATA COLLECTION

Participants

Two sample groups were compared: one consisting of self-identifying homosexual men ($n = 18$, M age = 22.7 years), and the other of self-identifying heterosexual men ($n = 18$, M age = 22.7 years). For the heterosexual group (henceforth HETERO) participants were recruited from various places, mainly in and around P.C. Hoofthuis, a university location of University of Amsterdam. For the homosexual group (henceforth HOMO) participants were primarily recruited via the gay social media app Grindr.

Crucially, none of the recruited participants were made aware of the objective of this research. They were asked if they would like to be interviewed regarding their life as a student in Amsterdam. To prevent the participants from guessing the nature of this investigation, it was only after the interview had concluded that the participant's sexuality could be determined. They were asked to self-identify as homosexual, heterosexual or other. Based on their self-identified sexuality they were assigned to either the HOMO or HETERO group. The recordings of those who did not self-identify as either gay or straight were discarded and were not used for this analysis.

Apart from sexual orientation, all of the participants (Appendix B) in both sample groups shared identical traits:

- (i) male
- (ii) born in the millennial generation (birth year between 1982 and 2000 as defined by the U.S. census bureau)
- (iii) has attended an institution of higher education, i.e. research university or university of applied sciences, which correspond to the Dutch institutions WO or HBO respectively.
- (iv) native speaker of Dutch.

Procedure

The recruited participants were invited to be interviewed in room a quiet room at the P.C. Hoofthuis location of the University of Amsterdam. After gaining their verbal consent, the interviews were audio-recorded.

I employed a number of strategies to elicit natural speech. Firstly, the question with which I started the interviews was the same for each participant: *Kun je iets over jezelf vertellen?* "Can you tell me a something about yourself?" Based on the information provided in their responses, follow up questions were different for each participant in order to create a casual atmosphere in which the participant felt free to talk about the subjects they were most comfortable talking about. By avoiding predetermined questions, and letting the 'conversation' flow organically, I tried to elicit more natural speech from the participants.

Secondly, the interview was, in a deliberate choice, not conducted in a soundproof room. Even though this would have made the recordings more noise-resistant, I feared that the artificial environment would make the

participants feel uneasy. Instead, I chose to conduct the interviews in an ordinary, though somewhat secluded and quiet room.

Thirdly, the interviews were recorded in wave format with a non-intrusive clip-on microphone onto an audio-recording device (Roland Edirol R-1). I chose this recording set-up with the intention of making them forget that they were being recorded, so as to reduce the chance of them monitoring or (sub)consciously altering their speech.

After approximately 5 minutes of recording time I ended the interviews, and I informed the participants about the objective of this research. They were then asked to grant written consent to their recordings being used for this research. Provided the participants gave their written consent, they were asked to fill out a form providing their personal information: age, level of education, native languages, the place where they spent their formative language acquisition years, and most importantly their sexual orientation. It is important to note that the participants were asked to self-report on their sexual orientation. This self-report provided the basis on which the participants were assigned to either the HOMO or HETERO group.

DATA ANALYSIS

Data cleanup

All incidences where I, the interviewer, could be heard were manually cut out of the recordings. The same was done for any long pauses, coughs, feet shuffling, laughter, and other artefacts which could have interfered with the acoustic analyses. The recordings were then passed through a noise reduction filter based on spectral subtraction to remove the background noise (Wempe, 2008; Appendix C).

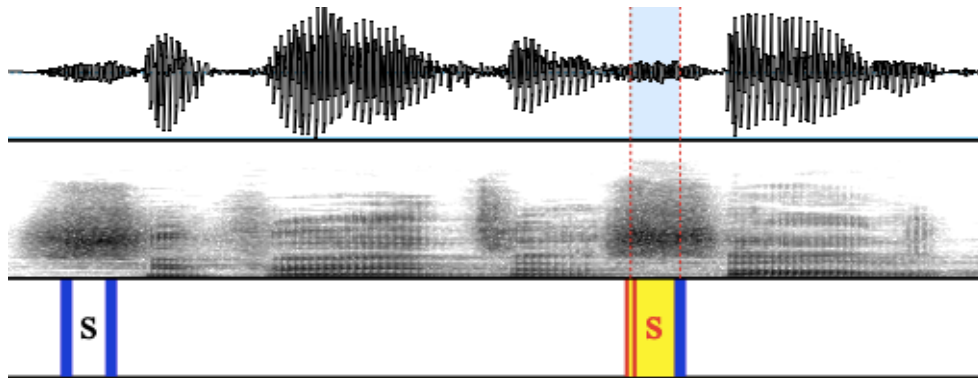


Fig. 2. Labeling of /s/ items in Praat. Top: intensity of speech signal over time. Middle: spectrogram over time. Bottom: /s/ labels. The utterance "super interessant" depicted here was said by a heterosexual participant.

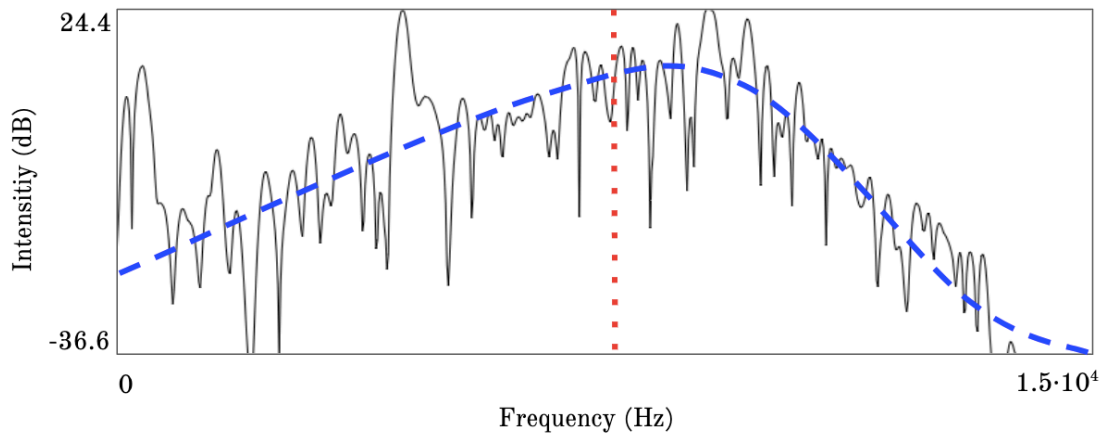


Fig. 3. Spectral slice of an /s/ item articulated by a heterosexual participant. The spectral energy is tilted slightly towards the higher frequencies (skewness -1.16), which is illustrated by the dashed line. This corresponds to a center of gravity of 7804 Hz (indicated by the dotted line), which divides the spectrum in two halves such that the amount of energy in the top half (higher frequencies) is equal to that in the bottom half (lower frequencies).

/s/ spectral peak frequency

Labeling. The phonetic realization of the /s/ is subject to the phonological environment in which it is pronounced. The surrounding phonemes, the location within the syllable, and allophony might all account for micro-variations in pronunciation. To minimize these variations, only those /s/ items which met the following criteria were manually labeled for analysis:

a) /s/ must be located within the onset of the syllable,

- b) /s/ cannot not be part of a consonant cluster,
- c) /s/ cannot not be realized as the allophone [z],
- d) [s] cannot not be an allophone of /z/.

Because the start and end parts of the phonation time of the /s/ should inevitably be influenced by the phonemes directly surrounding the /s/, I paid careful attention to label only the 'core part' of the /s/,

corresponding to roughly the middle 50% of the fricative (Fig. 2).

Measuring. Two measures to determine the phonetic realization of the /s/ were used per /s/ item. Both measures are based on the assumption that "sibilants can be ordered along a one-dimensional auditory continuum of spectral center of gravity" (Boersma & Hamann, 2006: 4). They were automatically calculated in Praat (see script in Appendix D). *Skewness* measures how the distribution of energy is tilted in the spectrum of the /s/ items. A spectrum with a higher spectral peak frequency will be more negatively skewed (Fig. 3). The *center of gravity (COG)* is also used to determine the location of the peak frequency within the spectrum, but it is calculated differently: the COG corresponds to the frequency that divides the spectrum into two halves such that the amount of energy in the top half (higher frequencies) is equal to that in the bottom half (lower frequencies). A sibilant with concentration of high-frequency energy will have a high value for center of gravity (Fig. 3).

The data from each /s/ item were used to calculate an average value for skewness and center of gravity per participant. A more

negatively skewed spectrum and a higher COG are indicative of a an /s/ that is realized with a more frontal place of articulation.

Pitch and intonation

Pitch. The average pitch for both groups was measured automatically in Praat (see script in Appendix E) by measuring the fundamental frequency (F0). Pitch range is a measure of the range of pitches within which the participant's voice phonates during normal conversation. A person with a more monotonous voice will have a smaller pitch range. During a conversation, however, the participant's pitch might be momentarily raised or lowered beyond their neutral pitch range used in everyday conversation. These outliers might in pitch might arise spontaneously without a specific reason, but they might also appear because of conversational artefacts such as expressing certain emotions, exaggeration, emphasis and sarcasm. Because absolute minimum and absolute maximum pitch have a high probability of being outliers as a result of conversational artefacts, I instead chose to use the range between 10% (minimum) and 90% (maximum) pitch as a more robust measure of pitch range.

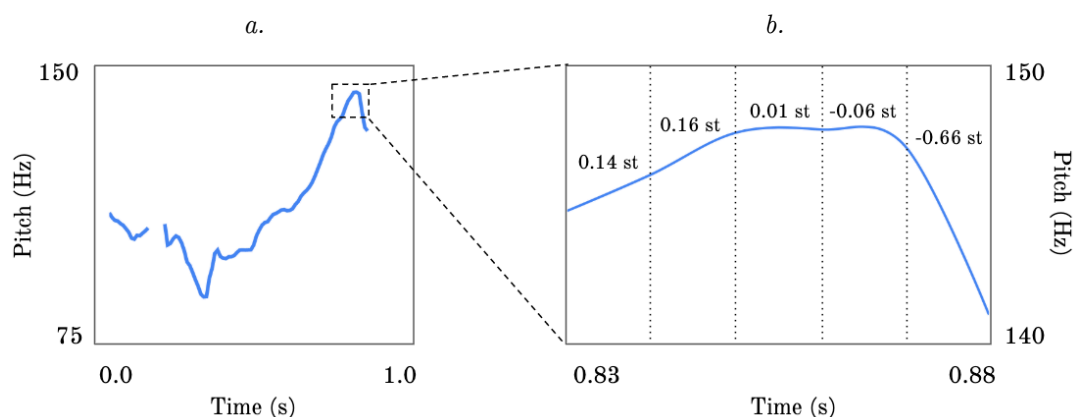


Fig. 4. *a.* Pitch trajectory of the utterance made by a homosexual participant: "zo verbloemen". *b.* The pitch trajectory is divided into 10 ms frames, which are used to calculate the mean absolute slope in semitones per second of phonation time without octave jumps. *st* = semitones

Intonation. The mean absolute slope (MAS) measures the participant's pitch variability over time. Praat calculated the MAS (see script in Appendix E) by dividing each second of phonation time into 10 ms frames, and measuring movement in pitch between each frame. The MAS is calculated by taking the average of the cumulative slopes of rises and falls in pitch of all frames per second of phonation time in semitones without octave jumps (Fig. 4). As this measure calculates absolute slope, no distinction is made between rising or falling slopes, only the absolute difference in pitch. The higher the MAS, the more dynamic the participant's intonation.

Speech tempo

Instead of manually labeling and counting syllables in each recording, I used a Praat script developed by De Jong & Wempe (2009) (see script in Appendix F) to automatically detect, label, and count the number of syllables per unit of time. It does so by measuring peaks in intensity (dB) followed by dips in intensity as potential syllable nuclei (Fig. 5). The output provides two measures of speech tempo: (1)

speech rate: the number syllables per second of duration time, i.e. the entire duration of the recording. And (2) *articulation rate:* the number of syllables per second of phonation time, which is the time in which the participant is actually speaking, excluding any pauses in between (threshold -20 dB).

Statistical analysis

The data from the measurements of /s/ spectral skewness, center of gravity, mean pitch, pitch range, mean absolute slope, speech rate, and articulation rate were collected for both the HOMO and the HETERO groups. These data were compared and tested for significance using a general linear model in R (R Core Team, 2019). For a more comprehensive overview of the statistical tests, see Appendix G.

RESULTS

The results below are grouped into three main categories: /s/ spectral peak frequency, pitch, and speech tempo. A summary of all results can be found in Table 1.

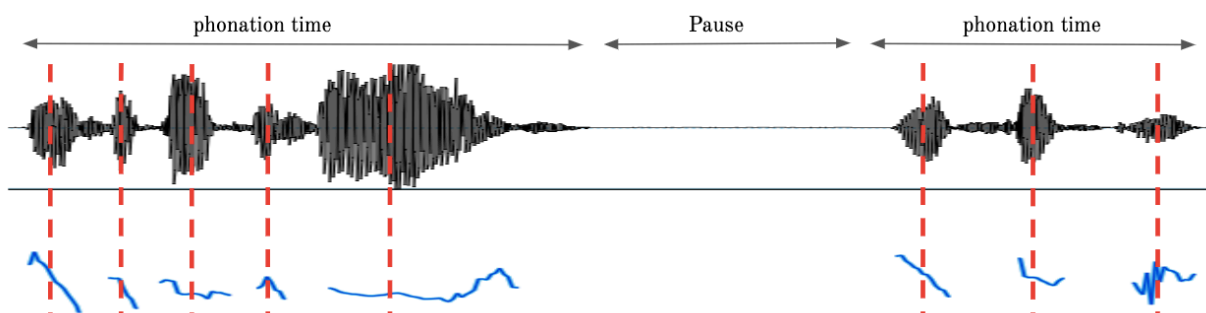


Fig. 5. Schematic illustration of the calculation of speech tempo by the Praat script created by De Jong & Wempe (2009). It automatically detects, labels, and counts the number of syllables per unit of second, measuring peaks in intensity (dB) followed by dips in intensity as potential syllable nuclei. Each dashed line represents a syllable nucleus. Speech rate measures the number of syllables per second of recording time (including pauses), whereas articulation rate measures the number of syllables per second of phonation time. Top: intensity of speech signal over time. Bottom: pitch trajectory over time.

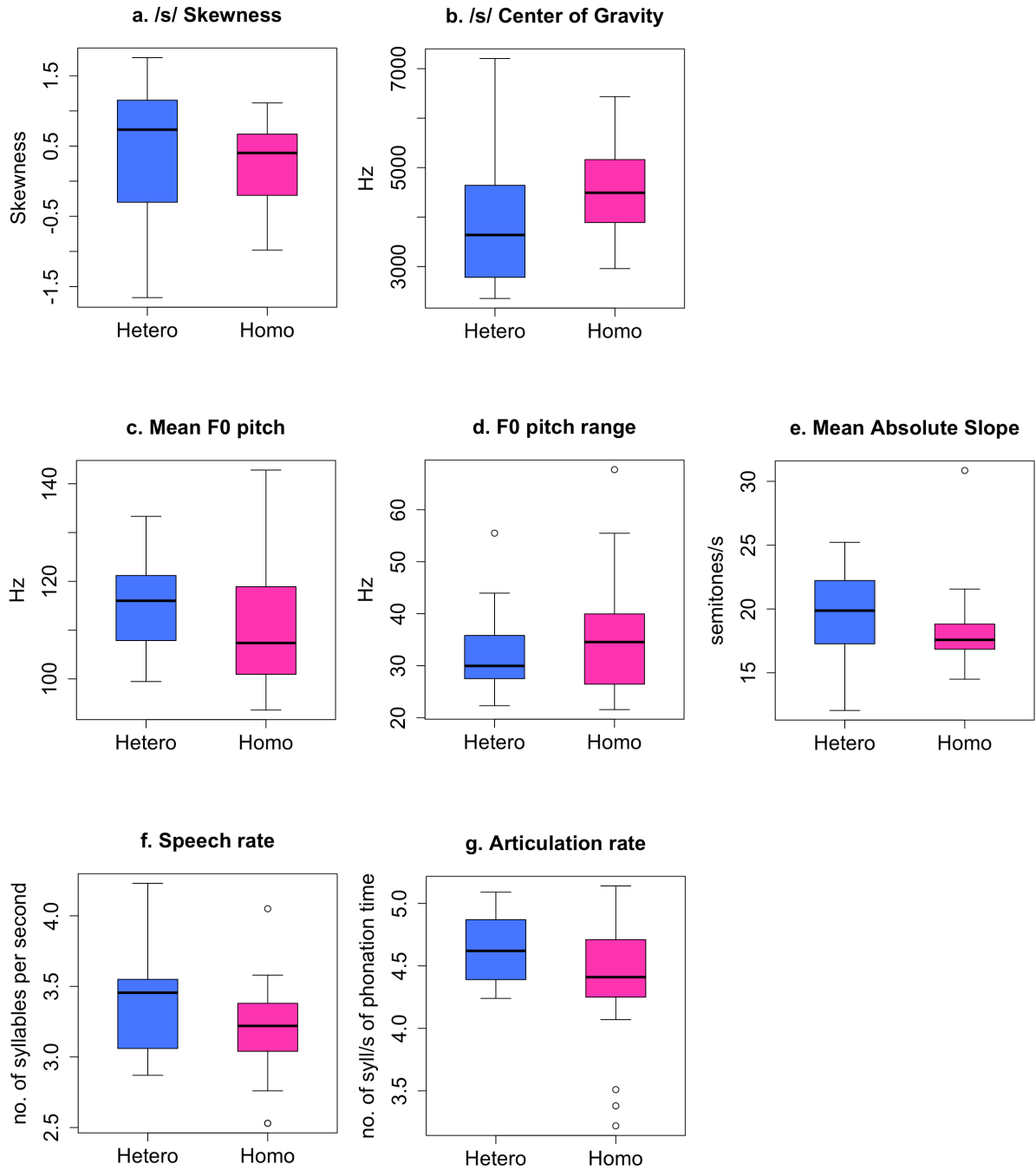


Fig. 6. HETERO–HOMO comparisons for skewness, center of gravity, mean pitch, pitch range, mean absolute slope, speech rate, and articulation rate. The circles beyond the whiskers of the box plots indicate outliers.

/s/ spectral peak frequency

The measured differences between HETERO and HOMO in skewness of the spectrum ($M_{HETERO} = 0.485$, $M_{HOMO} = 0.268$, $t(34) = -0.8$, $p = 0.42$) and center of gravity ($M_{HETERO} = 3954$ Hz, M_{HOMO}

$= 4520$, $t(34) = 1.4$, $p = 0.16$) for the spectrum of the /s/ were not significant (Fig. 6a and 6b).

Pitch and intonation

Fig. 6c and 6d illustrate that mean pitch did not significantly differ between HETERO and HOMO ($M_{HETERO} = 114.8$ Hz, $M_{HOMO} = 111.1$ Hz, $t(34)$

Table 1. Summary of the main results. *st* = semitones, *syll.* = syllables

	HETERO		HOMO		Difference	
	Mean	SD	Mean	SD	Mean	P
/s/ skewness	0.485	0.948	0.268	0.602	-0.217	0.42
/s/ COG (Hz)	3954	1376	4520	977	567	0.16
Mean pitch (Hz)	114.8	10.0	111.1	14.1	-3.7	0.37
Pitch range (Hz)	32.6	8.3	35.8	11.9	3.2	0.35
10% pitch (Hz)	100.1	10.2	95.2	12.5	-5.0	
90% pitch (Hz)	132.7	12.2	131.0	18.1	-1.7	
Mean absolute slope (st/s)	19.30	3.80	18.60	3.61	-0.70	0.57
Speech rate (syll./s)	3.42	0.54	3.19	0.37	-0.23	0.08
Articulation rate (syll./s)	4.63	0.26	4.37	0.38	-0.26	0.08

= -0.9, $p = 0.37$). Nor was a significant effect found for 10%–90% pitch range ($M_{HETERO} = 32.6$ Hz, $M_{HOMO} = 35.8$ Hz, $t(34) = 0.9$, $p = 0.35$).

The mean absolute slope as a measurement for intonation (Fig. 6e) did not show a significant effect ($M_{HETERO} = 19.30$ semitones/s, $M_{HOMO} = 18.60$ semitones/s, $t(34) = -0.6$, $p = 0.57$).

Speech tempo

Neither for speech rate ($M_{HETERO} = 3.42$ syllables/s, $M_{HOMO} = 3.19$ syllables/s, $t(34) = -1.8$, $p = 0.08$) nor for articulation rate ($M_{HETERO} = 4.63$ syllables/s, $M_{HOMO} = 4.37$ syllables/s, $t(34) = -1.8$, $p = 0.08$) did the two groups have significantly different results (Fig. 6f and 6g).

CONCLUSION

A production-based experiment was conducted, comparing Dutch homosexual men with Dutch heterosexual men. Natural speech data elicited through informal sociolinguistic interviews were acoustically analyzed and compared between groups. Between the homosexual group and the heterosexual group no significant differences were found for spectral skewness or center of gravity of the spectrum of the /s/. Thus, I have not been able to find evidence that Dutch gay

men produce a more frontally articulated /s/ than heterosexual men, as was found for their English counterparts. The homosexual and heterosexual men in this study did not significantly differ in respect to mean pitch, pitch range, intonation (pitch variability), speech rate or articulation rate. This is in accordance with the previous studies discussed in the introduction.

Do these findings suggest that the gay accent does not exist in Dutch? Indeed, the lack of conclusive evidence in this study for any phonetic differences between homosexual and heterosexual groups might allude to such a conclusion. However, the relatively small number of participants in this study caused a high degree of statistical uncertainty, which should be taken into account. A follow-up study with larger sample sizes would provide a more statistically robust comparison.

Such a follow-up study should ideally also take into account the participants' regional backgrounds, as regional dialects, and regional variations in pronunciation might have skewed the data. To control for effects of regional accents, I had initially included a fifth requirement for recruiting participants: they

should have spent the formative years of their first language acquisition in the Randstad (a metropolitan area comprising a conglomerate of the four largest cities in the Netherlands (Amsterdam, Rotterdam, Utrecht, and The Hague). Implementing this requirement would have resulted in considerably smaller sample sizes, such that statistical analyses would have become meaningless. Therefore, I decided to expand the requirement to include everyone whose native language is Dutch.

Another issue regarding participants was reliable determination of sexual orientation. The participants were asked to self-report on their sexual orientation. It is important to note that a certain degree of uncertainty comes with self-identification, as it is possible that the participants did not feel comfortable disclosing their sexual orientation. For that reason, they might have given the most unmarked option 'heterosexual'. Even though the subjects for the homosexual group were primarily recruited via the social app Grindr, which clearly has gay users as its target group. Moreover, research suggests that delineating sexuality and sexual identity into three separate and fully exclusive categories (homosexual, heterosexual, and bisexual) might be a distorted representation of reality. Savin-Williams (2014) suggest that sexual identity might be more fluid and might span a spectrum of sexual orientations. The issue remains unresolved (McConaghy, 1999), however, and therefore it was impossible to form truly reliable sample groups.

The sociolinguistic setting might also have a considerable effect: someone might speak very differently in at a party than in a university setting. Homosexuals amongst themselves might also feel a greater sense of freedom to allow themselves to speak 'in a gay manner'

than if they were among heterosexual people. Additionally, depending on the relationship between them, individuals might subconsciously alter their speech to more closely resemble the person they're talking to. In the case of this study, the participants might have converged their speech patterns to resemble mine. This kind of interpersonal accent convergence is called *Speech Accommodation Theory* in the field of sociolinguistics (Giles et al., 1987).

Next, I encountered a major methodological dilemma. The background noise which was found in all recordings negatively affected nearly all my data analyses. However, I had to strike a balance between an ideal recording setting and providing a casual environment in which the participants felt comfortable to speak naturally and in an unmonitored manner. I decided to assign greater importance to eliciting natural speech than to obtaining perfectly clear recordings.

This decision, however, came with the following consequences. For the spectral skewness and center of gravity measurements, the praat script showed difficulties in providing accurate measurements, because it couldn't properly distinguish the background noise from the sibilant sound (which, as a fricative, is also a kind of noise). A similar problem arose for the pitch and speech tempo measurements. The contrast between background noise and phonation time was sometimes unclear, such that Praat's automatic pitch detection couldn't accurately distinguish between silence and phonation time. Likewise, the lack of sufficient contrast between background noise and phonation time also hindered the speech rate script from accurately detecting peaks and dips in intensity. To circumvent these issues, I passed all the participants' recordings through

a noise filter. A substantial improvement indeed, but still some audibly discernible background noise remained.

On a critical note, it is entirely possible that for a study of Dutch gay men, different parameters should have been used. While effects were found in English speaking men for /s/ spectral skewness and center of gravity, the same parameters might not be distinctive for Dutch speaking men. Based on my own intuition, perhaps parameters such as vowel length, prosody patterns or pronunciation of the /r/ could yield more distinctive evidence.

Lastly, some final musings to inspire further research: future researchers interested in this topic might benefit from taking into account the myriad of gay tribes and subcultures in the gay community. It would be interesting to see whether any differences in accent exist between, for example, *twinks* and *bears* (Prestage et al., 2015). Does one subgroup speak with more distinctive features than another? And how does coming out of the closet affect one's accent? Although perhaps exceedingly difficult to execute in practice, it would be interesting to compare the speech features discussed in this investigation in participants before and after coming out of the closet.

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APPENDIX A. Abstract in Dutch

ABSTRACT. Als reactie op eerdere onderzoeken die gebaseerd waren op de perceptie van Engelssprekende homoseksuele mannen, is er in dit onderzoek een productie-gebaseerd experiment uitgevoerd, waarbij de focus ligt op Nederlandse homoseksuele mannen. Twee groepen zijn met elkaar vergeleken: Nederlandse heteroseksuele mannen en Nederlandse homoseksuele mannen. Natuurlijke spraakdata werden via informele, sociolinguïstische interviews uitgelokt en werden vervolgens akoestisch geanalyseerd. Er is geen evidentie gevonden om te concluderen dat de spraak van Nederlandse homoseksuele mannen zich significant onderscheidt van de spraak van Nederlandse heteroseksuele mannen op basis van de scheefheid van het spectrum en het spectraal zwaartepunt van de /s/, de gemiddelde toonhoogte van de stem, toonhoogtebereik, intonatie (toonhoogtevariabiliteit over tijd), spreektempo, en articulatietsnelheid.

APPENDIX B. Participants

List of participants. L1A refers to first language acquisition, WO refers to (research) university, and HBO refers to university of applied sciences.

	SEXUAL ORIENTATION	AGE	PLACE OF FORMATIVE L1A	EDUCATION	OTHER NATIVE LANGUAGES BESIDE DUTCH
G01	HOMO	23	Hengelo	WO	
G02	HOMO	22	De Rijp	WO	
G03	HOMO	27	Amsterdam	WO	Swedish, Spanish
G04	HOMO	22	Hoofddorp	WO	
G05	HOMO	23	Amsterdam	HBO	
G06	HOMO	21	Haarlem	WO	Georgian
G07	HOMO	21	Utrecht	WO	
G08	HOMO	21	Den Bosch	WO	
G09	HOMO	20	Rijswijk	WO	
G10	HOMO	19	Zaandam	WO	
G11	HOMO	22	Amsterdam	WO	English
G12	HOMO	21	Grootebroek	WO	
G13	HOMO	23	Utrecht	WO	
G14	HOMO	25	Den Helder	WO	
G15	HOMO	25	Soest	WO	
G16	HOMO	21	Houten	WO	
G17	HOMO	33	Arnhem	WO	
G18	HOMO	20	Volendam	WO	
S01	HETERO	21	Amstelveen	WO	
S02	HETERO	21	Zaandam	WO	
S03	HETERO	24	Almere	WO	
S04	HETERO	25	Rotterdam	HBO	
S05	HETERO	23	Hilversum	WO	
S06	HETERO	21	Amersfoort	WO	
S07	HETERO	19	Haarlem	WO	
S08	HETERO	21	Almere	WO	
S09	HETERO	19	Zaandam	WO	
S10	HETERO	19	Heiloo	WO	
S11	HETERO	24	Zwanenburg	WO	
S12	HETERO	23	Utrecht	WO	
S13	HETERO	28	Hengelo	WO	English, German
S14	HETERO	20	Haarlem	WO	
S15	HETERO	30	Amsterdam	WO	
S16	HETERO	25	Nijmegen	WO	
S17	HETERO	21	Hoorn	WO	
S18	HETERO	24	Castricum	WO	

APPENDIX C. Noise filter script

Praat script for removing background noise from recordings

Values used:

Maximum Frequency (Hz): 22.000
Filter steps (Hz): 40
Selection of pause with noise only: automatic
Fixed s/n ratio: 30

```
# Noise reducer based on "Spectral subtraction".  
# Uses gauss bandfilters with constant bw.  
# Uses noisy part for suppression level of lower spectral components.  
# By AudiTon (Ton G. Wempe) November 2008  
# Tested in Praat 5.0.40  
# Describing paper to be published.
```

```
form Noise reducer using spectral subtraction  
  comment Uses gauss bandfilters with constant bw.  
  positive Maximum_frequency_(Hz) 22000  
  positive Filter_steps_(Hz) 40  
  comment Uses pause in sound for measuring noise spectrum  
  choice Selection_of_pause_with_noise_only  
  button automatic  
  button manual  
  button fixed s/n ratio  
  positive fixed_s/n_ratio_(ignored_if_not_chosen)_(dB) 30  
endform
```

```
Create Strings as file list: "list", "Data_edited/*.wav"  
numberOfFiles = Get number of strings
```

```
for ifile to numberOfFiles  
  select Strings list  
  fileName$ = Get string: ifile  
  directory$ = "Data_edited"  
  Read from file: directory$ + "/" + fileName$
```

```
# shorten variables  
obj$ = selected$("Sound")  
maxf = maximum_frequency  
nr$ = "'obj$'_nr22k"  
select = selection_of_pause_with_noise_only  
fstep = filter_steps  
win = 1/fstep*1000  
noiseRatio = 'fixed_s/n_ratio'
```

```
sf = Get sampling frequency  
xtr = Get absolute extremum... 0 0 Parabolic  
if maxf > sf/2  
  maxf = sf/2  
  pause Maximum frequency = 'maxf' (limited by sample frequency)  
endif
```

```
# Attenuate low frequencies  
Filter (pass Hann band)... 80 'maxf'-40 40  
Rename... hipassed  
To Intensity... 'fstep' 0 yes  
peakInt = Get maximum... 0 0 Parabolic
```

```
# Extract noise part
```

```

dur = Get total duration
if select = 1
  # expand sound for better distribution of intensity frames
  Create Sound from formula... embed Mono 0 'dur'+0.2 'sf' sin(1000*x)
  Formula... if x>0.1 and x<('dur'+0.1) then Sound_hipassed(x-0.1) else self fi
  To Intensity... 20 0.005 yes
  minpos = Get time of minimum... 0 0 Parabolic
  minpos = minpos-0.1
  plus Sound embed
  Remove
  select Sound hipassed
  Extract part... 'minpos'-0.075 'minpos'+0.075 rectangular 1 no
  Rename... noise_auto
elseif select = 2
  select Sound hipassed
  Edit
  editor Sound hipassed
  pause In sound editor: select part (>'win:0'ms) with noise only.
  Extract selected sound (time from 0)
  endeditor
  durnoise = Get total duration
  # check user selection
  if durnoise < win/1000
    pause The extracted part should be longer than 'win'ms. Correct selection.
    Remove
    editor Sound hipassed
    Extract selected sound (time from 0)
    endeditor
  endif
  Rename... noise_manual
  durnoise = Get total duration
  # check user selection again
  if durnoise < win/1000
    echo No noise part extracted. Program ended.
    exit
  endif
  endeditor
else
  rmsValue = 10^((peakInt-94-noiseRatio)/20)
  Create Sound from formula... noise_fixed Mono 0 2/'fstep' 'sf'
  ... randomGauss(0,'rmsValue')
endif
noise$ = selected$("Sound")

# make spectrum of noise part
Multiply by window... Hanning
nsnoise = Get number of samples
durnoise = Get total duration
# make DFT via resampling (Praat's DFT can be very slow when #samples is prime)
tempsf = 2^ceiling(log2(nsnoise))/durnoise
Resample... 'tempsf' 50
Rename... rawNoise
To Spectrum... yes

# Calculate spectrum modulus and make bins equal to freq. steps
To Ltas... 'fstep'

# convert to lin values
Formula... 10^((self - 94)/20)

# convert to Intensity values
Formula... self * sqrt('fstep')
Rename... noiseInt

# resample total sound for DFT

```

```

# minimum # samples = 2*maxf/sec
minsamp = 2*maxf*dur
select Sound hipassed
newsf = 2^ceiling(log2(minsamp))/dur
Resample... 'newsf' 50
Rename... noisy
To Spectrum... yes

# for use in loop
Copy... filtered
binw = Get bin width
# preset parameter for gauss filter function
asquare = 2*ln(2)/(fstep/binw)^2

# init resulting sound
Create Sound... result 0 'dur' 'newsf' 0

# precalculate variables used in loop
totalwidth = 4.5*fstep
# make odd number of cols to ensure that a col is at centre
numcol = 2*floor(totalwidth/binw/2)+1
midcol = (numcol+1)/2

# estimate number of filter steps
stepcols = round(fstep/binw)
totalcols = maxf/binw
nsteps = floor(totalcols/stepcols)
step1 = round(20/binw)

#pause start loop

for i to nsteps
  # bandfilter total sound
  curcol = step1+stepcols*(i-1)
  select Spectrum filtered
  # multiply by shifted gauss filter
  startcol = curcol-midcol-1
  endcol = startcol+numcol+1
  Formula... if col > startcol and col < endcol then
  ... Spectrum_noisy[]*exp(-'asquare'*(col-curcol)^2) else 0 fi
  To Sound
  Rename... b'i'

  # estimate intensity with window length adapted to freq. step
  To Intensity... 'fstep'*2 0.5/'fstep' yes

  # convert log to lin
  Formula... 10^((self-94)/20)

  # estimate subtract value
  select Ltas noiseInt
  noiseLevel = Get value in bin... 'i'

  # make modifier from filter output intensity
  # avoid negative values after subtraction
  select Intensity b'i'
  Formula... max((self - 4*noiseLevel)/self,1e-6)

  # modify filter output
  Down to Matrix
  To Sound (slice)... 1
  Rename... temp
  Resample... 'newsf' 1
  Rename... modifier
  select Sound b'i'

```

```

    Formula... self * Sound_modifier[]

    # add to current sound sum
    select Sound result
    Formula... self + Sound_b'i'[]

    # cleanup
    select Sound b'i'
    plus Intensity b'i'
    plus Matrix b'i'
    plus Sound temp
    plus Sound modifier
    Remove
endfor

# scale to original peak amplitude
select Sound result
Scale peak... 'xtr'

# restore original sample frequency
Resample... 'sf' 50
Rename... 'nr$'

# cleanup
select Sound result
plus Sound 'noise$'
plus Sound hipassed
plus Intensity hipassed
plus Sound noisy
plus Spectrum noisy
plus Spectrum filtered
plus Sound rawNoise
plus Spectrum rawNoise
plus Ltas noiseInt
Remove
select Sound 'nr$'

Save as WAV file: "datanoisereduced22k/" + nr$ + ".wav"

Endfor

```

APPENDIX D. Skewness and center of gravity script

```
Praat script for measuring the spectral skewness and center of gravity
#Praat script for measuring the center of gravity and skewness

string1 = Create Strings as file list: "sounds", "datanoisereduced22k/*.wav"
string2 = Create Strings as file list: "textgrids", "Textgrids/*.TextGrid"
numberOfFiles = Get number of strings

#column labels
writeInfoLine: "Participant", tab$, "labels", tab$, "CoG_(dB)", tab$, "Skewness"
appendInfoLine: " "

for ifile to numberOfFiles
  #selecting a sound and a textgrid
  select Strings sounds
  sound$ = Get string: ifile
  sound = Read from file: "datanoisereduced22k/" + sound$
  select Strings textgrids
  textgrid$ = Get string: ifile
  textgrid = Read from file: "Textgrids/" + textgrid$

  selectObject: textgrid

  n = Get number of intervals: 1

  totalcog = 0
  totalskew = 0
  numberoflabels = 0

  #measuring COG and skewness per label
  for i to n
    label$ = Get label of interval: 1, i
    if label$ = "s"
      tmin = Get starting point: 1, i
      tmax = Get end point: 1, i
      duration = tmax - tmin
      numberoflabels = numberoflabels + 1
      select 'sound'
      Extract part... tmin tmax Rectangular 1.0 no
      Rename... sibilant
      To Spectrum (fft)
      cog = Get centre of gravity... 2
      totalcog += cog
      skew = Get skewness: 2
      totalskew += skew
      selectObject: "Sound sibilant", "Spectrum sibilant"
      Remove
      selectObject: textgrid
    endif
  endfor
  selectObject: textgrid, sound

  #calculating the average COG and skewness for all labels
  averagecog = totalcog/numberoflabels
  averageskew = totalskew/numberoflabels

  #output per participant
  appendInfoLine: sound$, tab$, numberoflabels, tab$, fixed$ (averagecog, 0), tab$,
  fixed$ (averageskew, 3)

  #cleanup
  removeObject: sound, textgrid
```

endfor

removeObject: string1, string2

APPENDIX E. Pitch script

Praat script for measuring 10%, mean and 90% pitch, and mean absolute slope
directory\$ = "datanoisereduced22k"

```
string = Create Strings as file list: "sounds", directory$ + "/*.wav"  
numberOfFiles = Get number of strings
```

```
writeInfoLine: "Participant", tab$, "min", tab$, "mean", tab$, "max", tab$, "range", tab$,  
"MAS"
```

```
for ifile to numberOfFiles  
  select Strings sounds  
  sound$ = Get string: ifile  
  sound = Read from file: directory$ + "/" + sound$  
  selectObject: sound  
  pitch = To Pitch: 0, 75, 300  
  max = Get quantile: 0, 0, 0.9, "Hertz"  
  mean = Get mean: 0, 0, "Hertz"  
  min = Get quantile: 0, 0, 0.1, "Hertz"  
  range = max - min  
  mas = Get slope without octave jumps  
  
  appendInfoLine: sound$, tab$, fixed$(min, 2), tab$, fixed$(mean, 2), tab$, fixed$(max,  
2), tab$, fixed$(range, 2), tab$, fixed$(mas, 2)  
  removeObject: sound, pitch  
endfor  
  
removeObject: string
```


APPENDIX F. Speech tempo script

Script for measuring speech rate and articulation rate.

```
form Counting Syllables in Sound Utterances
  real Silence_threshold_(dB) -25
  real Minimum_dip_between_peaks_(dB) 2
  real Minimum_pause_duration_(s) 0.3
  boolean Keep_Soundfiles_and_Textgrids no
  sentence Directory datanoisereduced22k
endform

# shorten variables
silencedb = 'silence_threshold'
mindip = 'minimum_dip_between_peaks'
showtext = 'keep_Soundfiles_and_Textgrids'
minpause = 'minimum_pause_duration'

# print a single header line with column names and units
writeInfoLine: "soundname, nsyll, npause, dur (s), phonationtime (s), speechrate (nsyll/dur),
articulation rate (nsyll / phonationtime), ASD (speakingtime/nsyll)"

# read files
Create Strings as file list: "list", "datanoisereduced22k/*.wav"
numberOfFiles = Get number of strings
for ifile to numberOfFiles
  select Strings list
  fileName$ = Get string: ifile
  Read from file... 'directory$'/'fileName$'

# use object ID
soundname$ = selected("Sound")
soundid = selected("Sound")

originaldur = Get total duration
# allow non-zero starting time
bt = Get starting time

# Use intensity to get threshold
To Intensity... 50 0 yes
intid = selected("Intensity")
start = Get time from frame number... 1
nframes = Get number of frames
end = Get time from frame number... 'nframes'

# estimate noise floor
minint = Get minimum... 0 0 Parabolic
# estimate noise max
maxint = Get maximum... 0 0 Parabolic
#get .99 quantile to get maximum (without influence of non-speech sound bursts)
max99int = Get quantile... 0 0 0.99

# estimate Intensity threshold
threshold = max99int + silencedb
threshold2 = maxint - max99int
threshold3 = silencedb - threshold2
if threshold < minint
  threshold = minint
endif

# get pauses (silences) and speakingtime
To TextGrid (silences)... threshold3 minpause 0.1 silent sounding
textgridid = selected("TextGrid")
```

```

silencetierid = Extract tier... 1
silencetableid = Down to TableOfReal... sounding
nsounding = Get number of rows
npauses = 'nsounding'
speakingtot = 0
for ipause from 1 to npauses
    beginsound = Get value... 'ipause' 1
    endsound = Get value... 'ipause' 2
    speakingdur = 'endsound' - 'beginsound'
    speakingtot = 'speakingdur' + 'speakingtot'
endfor

select 'intid'
Down to Matrix
matid = selected("Matrix")
# Convert intensity to sound
To Sound (slice)... 1
sndintid = selected("Sound")

# use total duration, not end time, to find out duration of intdur
# in order to allow nonzero starting times.
intdur = Get total duration
intmax = Get maximum... 0 0 Parabolic

# estimate peak positions (all peaks)
To PointProcess (extrema)... Left yes no Sinc70
ppid = selected("PointProcess")

numpeaks = Get number of points

# fill array with time points
for i from 1 to numpeaks
    t'i' = Get time from index... 'i'
endfor

# fill array with intensity values
select 'sndintid'
peakcount = 0
for i from 1 to numpeaks
    value = Get value at time... t'i' Cubic
    if value > threshold
        peakcount += 1
        int'peakcount' = value
        timepeaks'peakcount' = t'i'
    endif
endfor

# fill array with valid peaks: only intensity values if preceding
# dip in intensity is greater than mindip
select 'intid'
validpeakcount = 0
currenttime = timepeaks1
currentint = int1

for p to peakcount-1
    following = p + 1
    followingtime = timepeaks'following'
    dip = Get minimum... 'currenttime' 'followingtime' None
    diffint = abs(currentint - dip)

    if diffint > mindip
        validpeakcount += 1
        validtime'validpeakcount' = timepeaks'p'
    endif
endfor

```

```

endif
    currenttime = timepeaks'following'
    currentint = Get value at time... timepeaks'following' Cubic
endfor

# Look for only voiced parts
select 'soundid'
To Pitch (ac)... 0.02 30 4 no 0.03 0.25 0.01 0.35 0.25 450
# keep track of id of Pitch
pitchid = selected("Pitch")

voicedcount = 0
for i from 1 to validpeakcount
    querytime = validtime'i'

    select 'textgridid'
    whichinterval = Get interval at time... 1 'querytime'
    whichlabel$ = Get label of interval... 1 'whichinterval'

    select 'pitchid'
    value = Get value at time... 'querytime' Hertz Linear

    if value <> undefined
        if whichlabel$ = "sounding"
            voicedcount = voicedcount + 1
            voicedpeak'voicedcount' = validtime'i'
        endif
    endif
endfor

# calculate time correction due to shift in time for Sound object versus
# intensity object
timecorrection = originaldur/intdur

# Insert voiced peaks in TextGrid
if showtext > 0
    select 'textgridid'
    Insert point tier... 1 syllables

    for i from 1 to voicedcount
        position = voicedpeak'i' * timecorrection
        Insert point... 1 position 'i'
    endfor
endif

# clean up before next sound file is opened
select 'intid'
plus 'matid'
plus 'sndintid'
plus 'ppid'
plus 'pitchid'
plus 'silencetierid'
plus 'silencetableid'

Remove
if showtext < 1
    select 'soundid'
    plus 'textgridid'
    Remove
endif

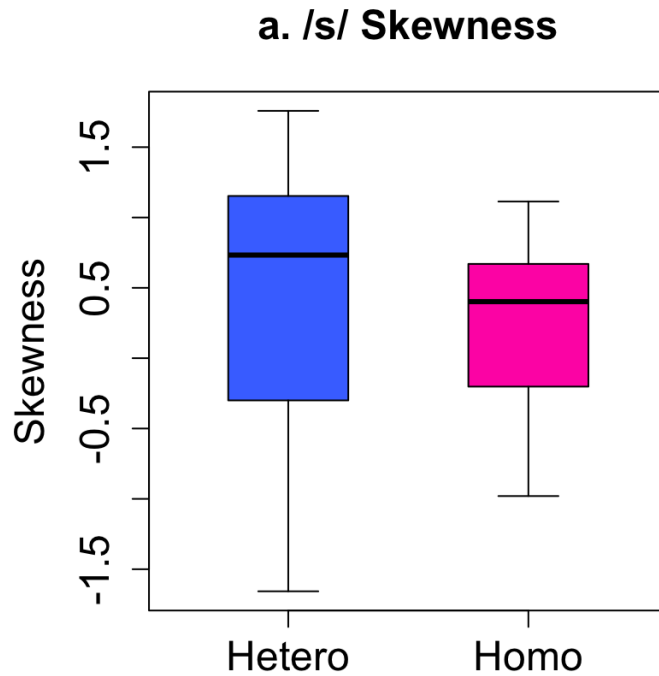
# summarize results in Info window
speakingrate = 'voicedcount'/'originaldur'

```

```
articulationrate = 'voicedcount'/'speakingtot'  
npause = 'npauses'-1  
asd = 'speakingtot'/'voicedcount'  
  
printline 'soundname$', 'voicedcount', 'npause', 'originaldur:2', 'speakingtot:2',  
'speakingrate:2', 'articulationrate:2', 'asd:3'  
  
endfor
```

APPENDIX G. Statistical analyses

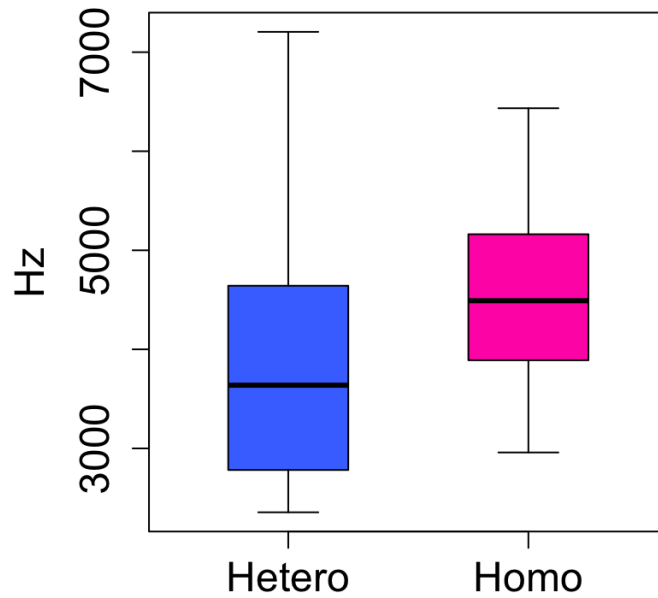
Statistical analyses calculated in R.



```
##  
## Call:  
## lm(formula = Skewness ~ Sexuality, data = dataskewness)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -2.1417 -0.4827  0.1607  0.5143  1.2733   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)          0.3763    0.1324   2.843  0.00751 **   
## Sexuality-Homo+Hetero -0.2167    0.2647  -0.819  0.41868   
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Residual standard error: 0.7942 on 34 degrees of freedom  
## Multiple R-squared:  0.01933,    Adjusted R-squared:  -0.009513   
## F-statistic: 0.6702 on 1 and 34 DF,  p-value: 0.4187
```

```
##              2.5 %    97.5 %   
## (Intercept)          0.1073079 0.6453032   
## Sexuality-Homo+Hetero -0.7547174 0.3212730
```

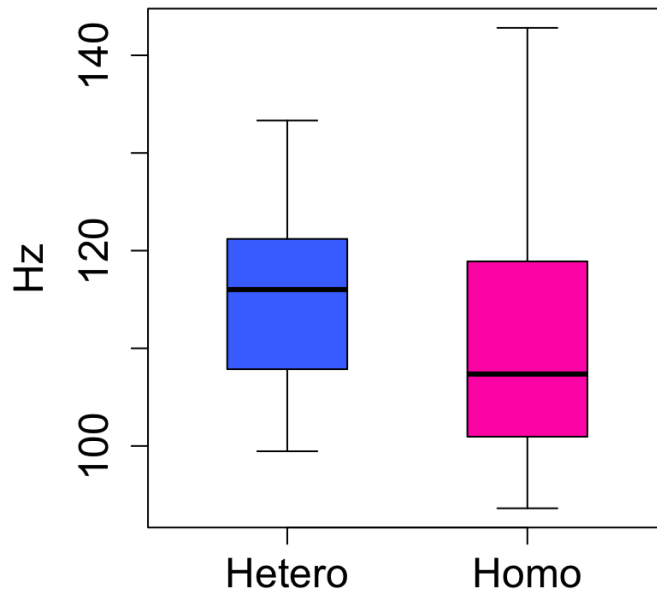
b. /s/ Center of Gravity



```
##  
## Call:  
## lm(formula = COG ~ Sexuality, data = datacog)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -1598.5  -924.9  -149.5    683.2  3251.5   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)          4237.0     198.9  21.306  <2e-16 ***   
## Sexuality-Homo+Hetero    566.9     397.7   1.425    0.163   
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Residual standard error: 1193 on 34 degrees of freedom  
## Multiple R-squared:  0.05639,    Adjusted R-squared:  0.02864   
## F-statistic: 2.032 on 1 and 34 DF,  p-value: 0.1631
```

```
##              2.5 %    97.5 %   
## (Intercept)    3832.8275 4641.117   
## Sexuality-Homo+Hetero -241.3449 1375.234
```

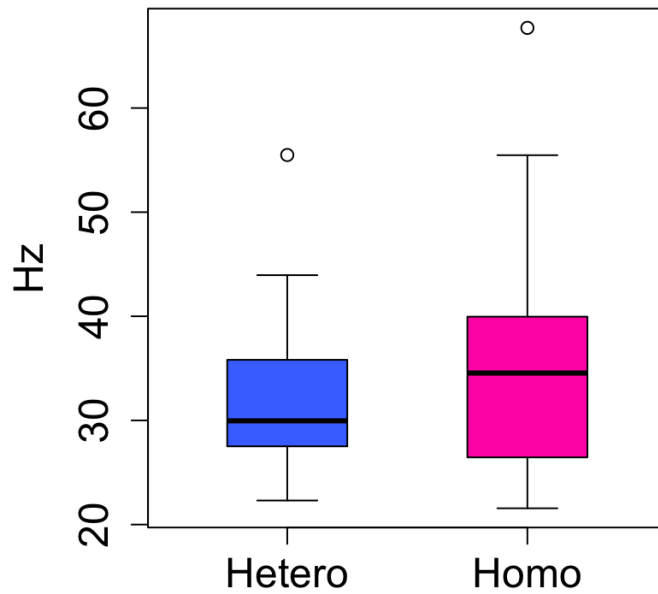
c. Mean F0 pitch



```
##
## Call:
## lm(formula = Mean ~ Sexuality, data = datapitch)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -17.502  -9.632  -0.284   6.741  31.688
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      112.964      2.035  55.502  <2e-16 ***
## Sexuality-Homo+Hetero  -3.683      4.071  -0.905   0.372
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.21 on 34 degrees of freedom
## Multiple R-squared:  0.02351,    Adjusted R-squared:  -0.005212
## F-statistic: 0.8185 on 1 and 34 DF,  p-value: 0.372
```

```
##              2.5 %      97.5 %
## (Intercept)      108.8274 117.099824
## Sexuality-Homo+Hetero -11.9552   4.589648
```

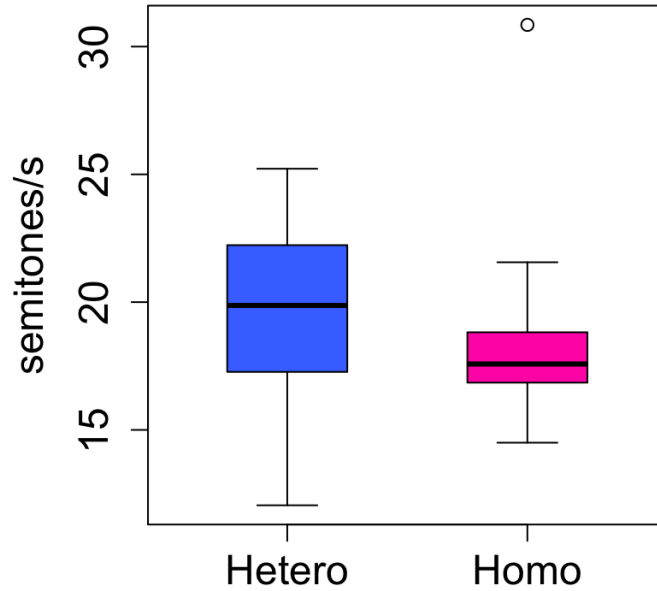
d. F0 pitch range



```
##  
## Call:  
## lm(formula = Range ~ Sexuality, data = datapitchrange)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -14.239  -6.169  -2.158   3.497  31.901   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)      34.193     1.706  20.042 <2e-16 ***   
## Sexuality-Homo+Hetero  3.211     3.412   0.941  0.353      
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Residual standard error: 10.24 on 34 degrees of freedom  
## Multiple R-squared:  0.02539,    Adjusted R-squared:  -0.003278   
## F-statistic: 0.8856 on 1 and 34 DF,  p-value: 0.3533
```

```
##              2.5 %   97.5 %   
## (Intercept)    30.726184 37.66048   
## Sexuality-Homo+Hetero -3.723188 10.14541
```

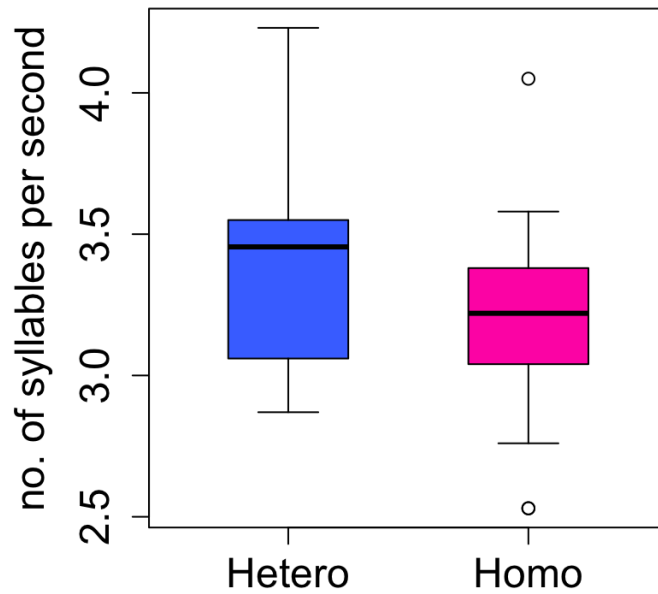

e. Mean Absolute Slope



```
##
## Call:
## lm(formula = MAS ~ Sexuality, data = datamas)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -7.2500 -1.8187 -0.9683  2.3729 12.2517
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      18.9492     0.6176  30.681  <2e-16 ***
## Sexuality-Homo+Hetero -0.7017     1.2352  -0.568   0.574
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.706 on 34 degrees of freedom
## Multiple R-squared:  0.009401, Adjusted R-squared:  -0.01973
## F-statistic: 0.3227 on 1 and 34 DF, p-value: 0.5737
```

```
##              2.5 %    97.5 %
## (Intercept)      17.694002 20.204331
## Sexuality-Homo+Hetero -3.211995  1.808662
```

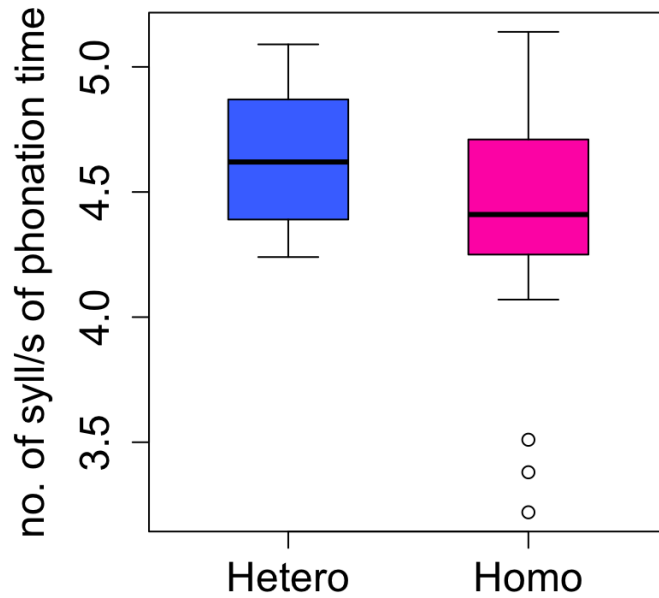
f. Speech rate



```
##
## Call:
## lm(formula = Speech_rate ~ Sexuality, data = dataspeechrate)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.66333 -0.22625  0.02667  0.14917  0.85667
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3.30694    0.06243   52.97  <2e-16 ***
## Sexuality-Homo+Hetero -0.22722    0.12487   -1.82  0.0776 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3746 on 34 degrees of freedom
## Multiple R-squared:  0.08875,    Adjusted R-squared:  0.06195
## F-statistic: 3.311 on 1 and 34 DF,  p-value: 0.07762
```

```
##              2.5 %    97.5 %
## (Intercept)      3.1800641 3.43382476
## Sexuality-Homo+Hetero -0.4809829 0.02653841
```

g. Articulation rate



```
##  
## Call:  
## lm(formula = Articulation_rate ~ Sexuality, data = dataarticulation  
rate)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -1.15111 -0.15361 -0.00111  0.27264  0.76889   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)         4.49861    0.07091  63.445  <2e-16 ***   
## Sexuality-Homo+Hetero -0.25500    0.14181  -1.798   0.081 .      
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Residual standard error: 0.4254 on 34 degrees of freedom  
## Multiple R-squared:  0.08684,    Adjusted R-squared:  0.05998   
## F-statistic: 3.233 on 1 and 34 DF,  p-value: 0.08104
```

```
##              2.5 %    97.5 %   
## (Intercept)         4.3545134  4.64270884   
## Sexuality-Homo+Hetero -0.5431955  0.03319546
```