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Variability in /s/ among transgender speakers: Evidence for a socially grounded account of gender and sibilants

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Abstract: Sibilant consonants are well-established as resources for the negotiation of gender and sexuality, but the origin of these links is less clearly agreed upon. Some researchers have pointed to sex differentiation in the vocal anatomy as a potential cause for gender differences in /s/, though a review of the literature indicates that learned articulatory patterns play a critical role. This article focuses on the spectral qualities of /s/ among 15 English-speaking transgender men and transmasculine individuals. Because their early socialization and physiological development is not normatively aligned with their self-defined gender identities, trans people are well-positioned to illuminate the relative contribution of physiology and identity to the gendered voice. Two analyses are presented, one of which focuses on inter-speaker variation among all 15 participants, and the other of which compares one bilingual speaker's productions of /s/ in English and Spanish. Together, these analyses demonstrate that sex category does not determine the gender-linked acoustic characteristics of /s/. Instead, a more complex, multidimensional framework for gender that distinguishes between gender assignment, role, identity, and presentation is necessary to account for the full range of gendered phonetic styles that speakers can employ and hence to understand the process through which gendered voices arise.

Keywords: transgender, sociophonetics, gender, sex, identity, bilingualism

1 Introduction

As part of the explosion of interest in sociophonetics in recent years, sibilant consonants have come to occupy an important place in the field. Numerous studies have identified /s/ as a resource for the negotiation of identity along axes such as gender, sexuality, class, region, and ethnicity (e.g., Campbell-Kibler 2007, 2011; Levon 2007; Munson 2007; Pharao et al. 2014; Stuart-Smith

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2007). Although sibilants are well-established as indices of gender and gender normativity, the originating cause of this difference is less clearly agreed upon. In much of the phonetically-oriented literature on gender and /s/, physiological differences in female and male vocal anatomy are held up as likely sources of gender differentiation in this sound (e.g., Flipsen et al. 1999; Fuchs and Toda 2010). On the other hand, sociolinguistic research on variation in /s/ associated with identity point to the conclusion that articulatory habits mediate, if not trump, any sex-linked anatomical correlates that might exist. Often, these studies take childhood language socialization as a likely source of socially-learned gender differences in the voice. However, the mutual reinforcements that exist between biology, child socialization, and the intersubjectively forged identities that adults typically express make it difficult to tease apart the contributions of each.

However, certain speaker populations provide a unique perspective on these relationships because their physiology, socialization experiences, and current identity do not align in normative ways. In this study, I center one such group: transgender speakers. The analysis presented here compares the acoustic properties of /s/ as produced by a group of 15 English-speaking transgender men and others on the transmasculine identity spectrum. *Transmasculine* is an umbrella label – i.e. a spectrum of identities – that can be said to include anyone who is assigned female at birth but who does not self-identify with that gender. This includes those who identify as men as well as those who position themselves outside of the female/male binary system all together by identifying as *genderqueer* or *non-binary* (see Bershtling 2014 for more on language and genderqueer identity).

Transgender speakers can inform sociophonetic inquiry into gender in a number of ways; one particularly important contribution is toward our understanding of how biology and social practice exert influence over the gendered voice. The transmasculine individuals in this study could be categorized as members of the same sex: all were assigned female at birth, all developed secondary sex characteristics normatively identified as female during puberty, and all began a regimen of testosterone as hormone replacement therapy around the time they began participation in this study. Testosterone brings about marked masculinization on a number of fronts, including increased body and facial hair, changes in musculature and fat distribution, and, notably, a significant drop in vocal pitch. The fieldwork from which these data are drawn consisted of two years of ethnographic participant-observation and recording in trans communities in the San Francisco Bay Area (2010–2012). The goal of this project was to track changes in the voices of transmasculine people in the first 1–2 years of testosterone in order to capture how pitch changed during this time

and how these changes relate to other elements of the gendered voice, including vowel formant frequencies and the acoustic characteristics of /s/. Despite physiological similarities, there are significant differences in how these individuals experienced their transmasculine identities. I have already pointed to one of these differences, between those who identify as men and those who identify outside of the gender binary. Section 2 of this article provides an in-depth discussion of the framework for conceptualizing gender within many trans communities. This framework, I argue, provides a useful vocabulary for linguists to conceptualize gender as a complex, multi-dimensional aspect of social subjectivity.

A biologically deterministic account of gender differences in /s/ would predict a great deal of similarity across these transmasculine speakers based on their shared sex at birth and similar hormone-induced development in their vocal anatomy at the time of recording (see Zimman 2017 for more on the vocal changes these speakers underwent). A strictly socialization-based account of gender differentiation, on the other hand, might predict similarity based on the shared childhood and adolescent experiences of those assigned female at birth. However, the most striking aspect of these speakers' productions of /s/ is the tremendous variability in the acoustic output, which spans the entire range typically reported for English-speaking women and the entire range typically reported for English-speaking men. This finding undermines any attempt to identify either physiology or socialization as a direct cause of gender differentiation in sibilants. Explaining the differences among these speakers depends instead on recourse to subtle distinctions in gender and sexual identity that nevertheless carry great significance to members of this community. Ultimately, speakers whose early life experiences and physiology is not normatively aligned with their self-defined gender identities help reveal how biological predispositions and socialization experiences are always mediated by individuals' self-understanding and the social practices through which they produce their gender identities (Bucholtz and Hall 2004).

The next section provides a literature review that focuses on evidence for either a social or biological basis for gender differences in /s/ based on previous research in this area. Although sex differentiation in the vocal anatomy continues to prove an enticing explanation for gender-based patterns, the body of research on gender and /s/ as a whole points to the critical importance of socially-learned articulatory habits. Section 3 contains more information about the study from which the data under discussion are drawn, the vocabulary used by members of this community to talk about gender, and a description of methods used in the acoustic analysis. This is followed by a discussion of the findings from this study, which includes two separate

analyses. First, an inter-speaker comparison of the 15 participants in this study illustrates the usefulness of distinguishing between different facets of gender – including gender assignment, identity, and presentation – along with other aspects of identity closely linked to gender, like sexuality. Second, an intra-speaker analysis of one bilingual speaker considers the capacity of individuals to employ different articulatory strategies for sibilants. The different frequency ranges evident in this speaker's productions of /s/ in Spanish and English undermine the possibility that oral anatomy is the direct cause for gender-based differences in /s/. The conclusion of this article includes a brief discussion of the implications of this study for our theorization of embodiment and identity in sociophonetics.

2 Review of the literature

The phonetic characteristics of the voice include some of the most salient sociolinguistic indices of gender. Some of these are intuitively obvious to many non-linguists, such as differences in the pitch ranges used by women and men. But phoneticians have long documented less obviously gendered aspects of the voice, such as the spectral characteristics of /s/. Gender differences in this sound among English speakers have been studied at least as far back as Schwartz (1968), who tested listeners' ability to distinguish speaker gender based on isolated voiceless fricatives produced in laboratory conditions. Listeners in this study showed good accuracy on the sibilants /s/ and /ʃ/ but were not consistently successful at identifying speaker gender based on /f/ or /θ/. Their perceptions were reflected in the acoustic analysis as well, with women's productions showing greater acoustic energy in the high frequencies range of /s/. Since then, numerous studies have reached similar findings in investigations using a variety of analytic methods. One of these is the identification of acoustic peaks in the spectrum, which identifies the highest amplitude frequencies in the spectrum. Peak frequencies for English-speaking women have been reported in the range of approximately 5,500–9,000 Hz, while English-speaking men have been placed in the range of approximately 4,700–8,000 Hz (Fuchs and Toda 2010; Schwartz 1968; Stuart-Smith 2007; Yeni-Komishian and Soli 1981). Another method involves calculating a weighted mean in the form of a center of gravity or centroid. Using this method, women's means appear to range from 6,400–8,500 Hz, while men's range from 4,000–7,000 Hz (Avery and Liss 1996; Fuchs and Toda 2010; Flipsen et al. 1999; Nittrouer 1995; Nittrouer et al. 1989; Stuart-Smith 2007; Tjaden and Turner 1997).

In much of the phonetically-oriented literature on gender, sexual dimorphism in the vocal tract is a first-line explanation for significant gender differences in acoustic output, even if the same findings could be used to support a socially-grounded explanation. As many others writing about /s/ have noted, sex differences in the vocal tract are thought to exist mainly in the posterior region of the vocal tract – particularly in the pharynx – whereas the frequency profile of /s/ is determined primarily by the size of the "front cavity," or space between the tongue constriction and the teeth (Shadle 1985; 1991). Some researchers have proposed that previously undocumented sex differences may exist in the front cavity, which would provide a physiological basis for the observed gender differences in /s/. For example, Flipsen et al. (1999) report that young women and girls as young as nine tend to have a higher center of gravity compared to boys of the same age. Rather than concluding that children may learn to produce /s/ in gendered ways prior to puberty, however, the authors suggest that anatomical differences in the mouth arise earlier than previously thought, causing the gender differences among the 9 year olds.

Fuchs and Toda (2010) investigate the hypothesis that sex-based anatomical traits determine the articulation of /s/ directly through an analysis of both anatomical and acoustic measurements taken from small numbers of English- and German-speaking women and men (6 in each cell). The anatomical measures ended up being less conclusive than might be hypothesized. There was no clear difference in palate length between the women and men, though the authors emphasize a non-significant trend for English-speaking (but not German-speaking) men to have longer palates than their female counterparts. Despite the lack of a consistent anatomical differences between the genders, Fuchs and Toda do report a significant difference between the English- and German-speaking subjects. The fact that the difference between English and German speakers was more significant than any sex or gender difference found in this study calls into question the idea that biological sex, as a binary trait, is the primary driving force behind variation in /s/. Additionally, despite the lack of significant sex-based anatomical differences, there were significant gender-based differences in the acoustics of /s/ for speakers of both languages. One significant anatomical connection that did occur was between palate length and the size of the front cavity, the latter of which is known to be the primary determinant of the acoustic properties of /s/. However, in the absence of data confirming that there is a sex-based difference in palate size, caution is in order when it comes to the conclusion that this correlation is directly connected to gender or sex. Fuchs and Toda conclude that both physiology and socially learned behaviors each contribute toward the production of gender differences in /s/, though their findings could more plausibly be described as lack of evidence for direct anatomical effects.

Of course, even if correlations do exist between anatomy and acoustics within a given population, this does not necessarily mean that the productions of any one individual is caused directly by their own anatomically constrained ability to produce a higher or lower frequency /s/. Indeed, there are at least four sources of evidence that point to the conclusion that articulation can easily override anatomy when it comes to sibilants. First, we know from modeling work done by Shadle (1990) that even very small shifts in articulation can have significant effects on the acoustics of /s/ (p. 193, cited in Stuart-Smith 2007), suggesting that any individual can produce /s/ in a variety of ways that will result in different acoustic output. Second, although gender differences in /s/ are observable in multiple languages, as the other articles of this special issue demonstrate, they do not appear to be as close to universal as are differences in features like fundamental frequency or formant frequencies. Gordon et al. (2002), for instance, compare /s/ productions by speakers of seven disparate, mostly indigenous, languages (Aleut, Apache, Chickasaw, Scottish Gaelic, Hupa, Montana Salish, and Toda) and found gender differences only among the speakers of Chickasaw. Similarly, Heffernan (2004) suggests that sibilants provide a more robust gender marker for Canadian English speakers than for speakers of Japanese. This is especially striking given reports that Japanese has more dramatic gender differentiation in pitch than does American English (e.g., Loveday 1981; Ohara 2001; Yuasa 2008), indicating that it isn't lack of attention to the gender binary that is keeping Japanese speakers from utilizing /s/ to index gender in the same way Canadian English speakers do. Lest one suspect that such differences are driven by biological variation between American and Japanese speaker populations, Ohara (2001) shows that English-Japanese bilinguals treat pitch as a resource for managing gendered identities as they shift between the languages. I will return to the issue of cross-linguistic differences among bilingual speakers when I present results from my own bilingual participant and his variable production of /s/ in Spanish and English.

Third, there is evidence that children begin displaying gender differences in /s/ at a young age (Flipsen et al. 1999), despite the findings of studies like Fitch and Giedd (1999), whose imaging of children's vocal tracts indicates that significant sex differences do not appear to develop until puberty even though gendered phonetic patterns appear before then. Finally, there is considerable variation in the gendered properties of /s/ among speakers of the "same" language or dialect. Stuart-Smith's (2007) study of Glaswegian English reveals that although adult women in Glasgow tended to produce /s/ at a higher frequency than their male counterparts, a different pattern appeared among young adolescents. Middle-class teenage girls patterned with the adult women in terms of the most prominent frequencies in /s/, but the /s/ of working-class teen girls was closer to the adult

men's than to the adult women's or middle-class girls'. Given that working-class and middle-class adolescent girls are more similar to one another physiologically than to adult men, one must turn to articulatory practices to explain these findings. On the other side of the Atlantic, several studies have identified /s/ as one of the most consistent and most salient cues for the perception of sexual orientation among North American English-speaking men (Campbell-Kibler 2011; Levon 2007; Munson 2007; Munson et al. 2006; Zimman 2013; inter alia), which demonstrates that adult men are capable of producing /s/ with a range of frequency profiles. This usually comes in the form of a more negative skew, i.e. a skew toward more amplitude in the higher frequencies even given the same center of gravity. This research underscores the fact that "women" and "men" are far from homogenous groups, and that the intersections of identities based on gender, sexuality, race, class, and other axes of subjectivity produce different constellations of gender-linked linguistic features.

The matter of teasing apart biological and social influences on speech is always challenging at best. Should we heed the words of poststructuralist queer theorists like Butler (1990; 1993), we might conclude that drawing a clear line between nature and nurture is ultimately a hopeless effort because of the ways these domains mutually reinforce one another, acting in a constant feedback loop. This insight is an important one, but this study makes clear that the voices of transgender people can provide special insight on the ways and degree to which embodiment might constrain articulatory production. For normatively gendered cisgender (i.e. non-transgender) women and men, there is a confluence of sex, self-identified gender, and gender socialization throughout the lifetime, which makes it particularly difficult to separate these strands of influence. For transgender people, however, the divergence between early biological development and socialization on the one hand, and identities articulated later in life in the other, can help to clarify the extent to which nuanced aspects of gender identities might override the effects of sexual development or gender assignment at birth.

3 Background and methods

3.1 Background on the study and community

This article derives from a 2 year ethnographic sociophonetic study of English-speaking transmasculine people in the San Francisco Bay Area during their first or second year on testosterone. Between 2010 and 2012, I recorded 15 trans individuals on a regular basis, leading to a body of data consisting of interviews,

read speech, and interactions with other members of participants' communities of practice. Most of the speakers were in the earliest months of hormone replacement therapy when we began working together, though two were in their second year of testosterone, and all experienced a significant drop in vocal pitch as a result (Zimman 2012, 2017). I was able to record 10 of these 15 participants for a full year, but five left the Bay Area before completing the full longitudinal study. At each recording session with these participants, we recorded a reading of Fairbanks' (1960) "Rainbow Passage" in order to have a simple means of tracking change in fundamental frequency and other measures without the effect of broad differences in topic, context, or affect that are typical across interactional contexts (see Smyth et al. 2003 for more on methods and the rainbow passage). Each recording session also included spontaneous speech of some sort, whether in the form of an interview or semi-structured conversation (Alim 2004) with the researcher or in interaction with participants' friends, family, co-workers, etc. In addition to these recording sessions, I engaged in participant-observation within a number of speakers' varied communities of practice. This involved following participants through their daily activities, attending trans community events that often brought my participants together, and seeing the ways interpersonal relationships and institutional forces inform their negotiations of gender.

One of the most important products of ethnographic fieldwork conducted for this study was a sense of how sex, gender, and sexuality are understood by speakers and others in their communities. In the discussion below, I invoke a distinction between several dimensions of gender that are worth introducing now. Because these dimensions can be collapsed for normatively gendered people, gender often appears to be a unitary aspect of identity. However, non-normative gendered identities depends on a distinction between gender assignment, gender identity, and gender presentation. These terms are in use in many transgender communities as well as gender-focused scholarship and activism, and one important conclusion to be drawn from the present study is the usefulness of this multi-dimensional system. *Gender assignment* refers to the gender category an individual is placed into at birth. Those outside of transgender communities often talk about someone's "biological sex" or describe someone as having been "born (fe)male" to reference this aspect of their identity. The notion of gender assignment, however, captures the fact that individuals are not simply born into a gender, but rather receive that gender socially through a process of assignment. It also allows us to recognize that assignment does not arise directly from sex; for instance, an intersex person, whose body is not normatively female or male at birth, will still typically be assigned to one of those

two genders. Conflating gender assignment with sex also suggests that sex is an unchangeable characteristic determined at birth, whereas the changes in trans people's embodiment through hormone therapy, for instance, can be quite significant. This complicates any assumption that trans men can be treated as biologically female or trans women as biologically male (Zimman 2014). Saying that someone was "born (fe)male," naturalizes their gender assignment at birth and treats trans identity not as inborn but as something one develops later in life by deviating from one's original identity.

In transgender communities and the academic fields engaged with them, the phrase *gender identity* generally refers to the gender categories that people claim for themselves. In these terms, someone who sees herself as a woman has a female gender identity regardless of her biology, gender presentation, or perceived gender. In addition to the binary categories of female and male, gender identity also includes non-binary gender identities. People who do not identify as either strictly female or strictly male may use labels like *non-binary* or *genderqueer*, which are themselves umbrella labels suggesting either an incorporation of feminine and masculine qualities, a fluidity between genders, or a rejection of both mainstream categories. Other non-binary identities include *agender*, which may be used by those who do not identify with any gender category at all; *bigender*, which may be used by people who identify with both sides of the gender binary, either simultaneously or in rotation; and *gender-fluid*, which emphasizes movement between genders rather than any particular positionality. Sticking with this degree of nuance, we can also see more complexity in the gender identities of binary-identified trans women and men. Among participants in this study, one important division was between the trans men who saw themselves as simply men, no different from cisgender men, and those who felt that *trans man* is a distinctive gender category with important differences from the unmarked cis male category – an instance of what Bucholtz and Hall (2004) term adequation and distinction.[1] A final difference in the gender identities expressed by participants in this study can be made between the *trans men* and the *trans boys*. This distinction does not mean precisely the same thing

1 In Bucholtz and Hall's (2004) tactics of intersubjectivity framework for the analysis of language and identity, *adequation* and *distinction* are a pair approaches to constructing the relationship between different identities. Some trans men engage in adequation, or the construction of "sufficient similarity" between trans and cis men, which involves emphasizing similarities and downplaying differences. Other trans men engage in distinction, or the construction of salient difference between trans and cis men, which involves emphasizing differences and downplaying similarities. Crucially, neither of these positions regarding the similarity or difference between cis and trans men is truer than the other; both are products of discursive practice.

to all who use these two terms, but the label *trans boy* was adopted by some participants who have a masculine gender identity but who feel uncomfortable affiliating themselves with the word *man*. For some, this discomfort comes from the feeling that *man* is too oppressive a category because of the limitations it places on gender expression, while others felt that manhood is associated with the most privileged gender group and thus did not capture their experience with gendered power.

A final critical distinction is between gender identity and gender presentation. *Gender presentation* or *expression* highlights the semiotic manifestations of gender and the various ways that an identity like "man" can be enacted. Gender expression consists in part of visual elements like clothing choices, hairstyle, and the presence of facial hair, makeup, or other forms of gendered body modification. Bodily hexis, including gesture, gait, posture, and so on, are also semiotic resources for gender presentation. Even the body itself can be read as a part of gender expression – for instance, the display or concealment of skin, muscle mass, or fat in certain parts of the body. And, of course, one of the crucial ways that masculinity and femininity are enacted semiotically is through the voice and linguistic practice more broadly. Cultural norms lead us to expect people who look male-bodied to identify as men, and we expect people who identify as men to have or desire a masculine gender presentation. But gender identity and presentation are not necessarily the same. One might identify as a man but simultaneously have a feminine mode of self-presentation. Likewise, one might identify as non-binary but have a seemingly very normatively masculine style of gender presentation. Zimman (2015) discusses these categories in greater detail.

While self-identification as transmasculine suggests some affiliation with masculinity, the nature of that affiliation varies wildly among the participants in this study. In Table 1, I have summarized my 15 participants' gender identities, gender presentations, and sexual orientations, using their own words provided in interviews and other interactions in which discussions of identity arose either spontaneously or through my prompting. As the table indicates, several of my participants saw themselves as having quite normative enactments of masculinity – an assessment with which I and members of their immediate communities seem to agree. Adam, for instance, reports having a very masculine gender presentation his entire life. From the time he came out as a lesbian at age 19 until he started his transition at 38, he lived as a butch lesbian who also used the word *transgender* as an identifier for several years prior to the start of his transition. Adam is from suburbs north of New York City, where he grew up in an Irish and Italian family with strong ties to their local Catholic community. After years of being visibly queer, Adam told me he

Table 1: Participants' self-described gender identities, presentations, and sexualities.

	Gender		Sexuality	
Speaker	**Identity**	**Presentation**	**Identity**	**Attracted to…**
Ethan	Man	Typical guy	Straight	Women
Joe	Man	Regular guy	Straight	Women
Mack	Man, trans man	Regular guy	Straight	Women
Dave	Man, trans man	Fem	Queer	All genders, esp. masculine people
Carl	Trans man	Nerdy kid	Straight, queer	Women
Adam	Trans man	Conventionally masculine	Queer	Women
Tony	Trans man	Typical guy	Queer	Women & trans men
Jeff	Trans man	Sensitive, spiritual trans guy	Queer	Primarily men
Kyle	Trans man	Blend of queer, outdoorsy & feminist masculinities	Queer	Primarily women, men too since transitioning
Jordan	Trans man	Masculine, androgynous, later fem	Queer	All genders
Elvis	Genderqueer, transgender, avoids labels	Masculine, sensitive guy	Queer	Women & men
James	Genderqueer, trans boy	Mixture of masculine and feminine	Queer	All genders
Pol	Genderqueer, trans boy	Dandy	Queer	Variety of genders
Kam	Genderqueer, trans boy	Fem	Queer	Masculine people
Devin	Genderqueer, transgender, avoids labels	Mixture of masculine and feminine, androgynous	Queer	Primarily men

was somewhat disappointed that his masculinity is "pretty conventional," given his classic dress style and affective reservation – a disappointment that drives him to maintain a strong identity as a trans man rather than simply a man. On the other hand, my participants also included individuals who had quite feminine gender presentations before their transitions, and who in some cases maintained that outward expression of femininity through their transitions. The best example here is Dave, a white, middle-class trans man originally from the San Francisco Bay Area in his early twenties who usually described his gender identity as strictly and simply male. At the same time, Dave strongly identifies as a queer man and describes his gender presentation

as *fem* (specifying that the spelling, for him, takes the masculine form rather than the feminine form *femme*). He indexes this femininity in part through his preference for tight, form-fitting clothing, often in bright colors or flamboyant prints. Dave is small in frame and stands just over five feet, but is usually perceived as male due in large part to his facial hair and low-pitched voice. Although it is low-pitched, Dave's voice is also extremely "queeny," as he puts it. He makes ample use of falsetto voice quality, large excursions in his pitch range that contribute to his engaging and expressive interactional style, and, as the analysis below reveals, he also has among the highest frequency productions of /s/ among the speakers in my study. Among those that fall somewhere between Adam and Dave are participants like James, who blends masculine and feminine stylistic elements as part of his genderqueer identity and expression. James is a 26 year old white, upper class, genderqueer trans boy from Massachusetts who embodies a scruffy, punk aesthetic with simple clothes adorned with hand-modifications like patches, pins and other slogans of anti-authoritarianism. But he blends this rather masculine baseline style, which is enhanced by his unshaven facial hair, with much less normatively masculine accessories like the bright green bandana he had tied around his neck when we first met, the glittery jewelry he habitually wears in his facial and ear piercings, and the variety of toenail polish colors I saw him wear.

A final note about sexuality is useful for interpreting the information in Table 1. I have included information both about the identities that these speakers claim for themselves, which in this case includes *straight* and *queer*, as well as the gender(s) to which they report attraction.[2] Particularly in trans communities, gendered attractions do not necessarily determine sexuality-based identities in normative ways. As Table 1 shows, only men who were exclusively attracted to women described themselves as straight, but the word *queer* was used to cover a wide range of attractions. While Ethan, Joe, and Mack see their attractions to women as heterosexual, Carl, Adam and Tony see their interest in women as queer because they form relationships with queer-identified women, because of their history living as queer women, and/or because they disidentify with the notion of heterosexuality. Carl embodies this tension by simultaneously identifying himself as straight and queer. The remainder of these participants more reliably describe themselves as queer in relation to their interest in genders other than, or in addition to, women.

2 Of course, these are not the full range of potential sexualities inhabited by trans people, who may also identify as gay, lesbian, bisexual, pansexual (attracted to all genders), asexual (attracted to no genders), etc.

There are a few important points to take away from this section before turning to the acoustic analysis. First, people who describe themselves as transmasculine lay claim on an array of gender identities and gender expressions. Second, the layers of identity, presentation, assignment, and embodiment that transmasculine people invoke in talk about gender provide a vocabulary for understanding the multi-dimensional nature of gender, which in turn illuminates the linguistic variation described in the next section. Importantly, none of these aspects of gender – assignment, identity, or presentation – necessarily aligns with the others in predictable ways. But this division is not unique to transmasculine people: even as trans identities bring the dislocations of gender into sharper focus, gender assignment, expression, and identity are elements of gender-normative cis women's and men's experience as well.

A final aspect of this study worth mentioning is my decision to focus on the production of /s/ in read speech – a data source common in phonetics but less often the focus of sociolinguists. Importantly, I do not treat read speech as representative of how these speakers use their voices in other contexts. In some studies, the differences between read speech and casual, spontaneous talk-in-interaction can be a methodological limitation, but in this case it provides a special set of insights precisely *because* of the way read speech calls attention to the act of speaking. In this way, read speech is a kind of performance in the anthropological sense, which is to say it is a genre that opens a space for reflection on social and linguistic norms both for performers and audiences (see, e.g., Bauman and Briggs 1990). For transmasculine individuals in transition, who are already acutely tuned in to the ways their bodies and voices are changing, self-conscious speech creates an opportunity for a distinctly self-conscious performance of gender. That is not to suggest that the voices my speakers use while reading is somehow more artificial than other speaking styles they (or others) might employ. Rather, what I want to emphasize is that the linguistic analysis of performance can bring its own set of insights on the ways sociolinguistic norms and practices are negotiated, resisted, valorized, or otherwise oriented to (see also Zimman 2016). Analysis of everyday vernacular speech can show unguarded moments in which unwanted styles or features come through. But if read speech reflects more intentional enactments of gender the way it has long been known to increase awareness of stigmatized features, particularly those linked to class (as in Labov 1972, inter alia), then analyzing read speech could shed light on the gendered personae participants aim to enact, revealing much about their linguistic goals and desires as well as their linguistic abilities. However, the question of what effect "attention to speech" might have on the gendered characteristics of the voice remains as yet an open one.

3.2 Methods

The acoustic analysis presented below has two parts. The first is an inter-speaker comparison based on a set of 14 word-initial tokens of /s/ occurring in the Rainbow Passage. Each speaker recorded the Rainbow Passage anywhere from 2 to 13 times over the course of their participation in this study; see Table 2 for the total number of recordings and tokens analyzed for each individual.

Table 2: Number of recordings and /s/ tokens per speaker (inter-speaker analysis).

Speaker	Number of recordings	Total number of tokens of /s/
Ethan	4	56
Joe	5	70
Mack	11	154
Dave	11	154
Carl	9	126
Adam	12	168
Tony	10	140
Jeff	3	42
Kyle	13	182
Jordan	2	28
Elvis	9	126
James	8	112
Pol	8	112
Kam	4	56
Devin	13	182

The second dataset, which informs an intra-speaker analysis, includes word-initial tokens of /s/ from a Spanish translation of part of the Rainbow Passage produced by a participant I call Pol, who is a native speaker of Castilian Spanish and British English. His production of /s/ in the Spanish Rainbow Passage will be compared to productions of /s/ in the English Rainbow Passage. Because the Spanish translation's word-initial /s/ tokens all preceded either /u/ (5 tokens) or /o/ (1 token), I only included tokens of /s/ from the English passage that were also followed by back, non-low monophthongs, namely /ʌ/ (5 tokens) and [u] (1 token). Table 3 contains the total number of tokens analyzed in the English and Spanish data for the intra-speaker analysis.

Table 3: Number of recordings and /s/ tokens per speaker (inter-speaker analysis).

Language	Number of recordings	Total number of tokens of /s/
English	8	40 (5 per recording)
Spanish	8	48 (6 per recording)

Recordings were made on a Fostex FR-2LE Field Recorder with an Audio-Technica BP892 headset microphone, at a sampling rate of 44,000 Hz. Prior to analysis, audio files were put through a Hann pass filter to remove sound below 1,000 Hz and above 13,000 Hz, which helped eliminate background noise in some recordings while preserving the range of approximately 4,000–10,000 Hz in which the bulk of acoustic energy for /s/ occurs (Shadle 1990). A long-term average spectrum was constructed for each token of /s/, including the entire segment, save any portion that contained signs of periodicity. Praat's moments analysis function was then used to calculate the four "moments" of center of gravity, standard deviation, skew, and kurtosis. Variation in center of gravity and skew have both been consistently linked to gender and sexuality (e.g., Stuart-Smith 2007; Munson 2007), though the status of standard deviation and kurtosis is less well established. While center of gravity provides a weighted mean frequency, skew represents whether the distribution skews toward lower or higher values. A more negative skew indicates more prominence in the high frequency ranges of /s/, relative to the mean, while a positive skew indicates more prominence in the low frequency ranges. The focus of the inter-speaker analysis below is center of gravity, which provides enough complexity on its own for a full exploration of sex, gender, and sexuality as practiced within these communities. In my intra-speaker analysis I present results from all four acoustic measures.

For statistical analysis of the inter-speaker data, I relied on R's (R Development Core Team 2015) box plotting function, which uses procedures from Chambers (1983) to calculate which boxes have significantly different medians from one another at the 0.05 level. This is represented graphically with notches on the sides of each box, as displayed in Figure 1; boxes with overlapping notches are not significantly different from their neighbors. For the comparative analysis of the Pol's /s/ in Spanish and English, linear mixed effects regressions were conducted, treating each of the acoustic measures (center of gravity, standard deviation, skew, and kurtosis) as the dependent variable in a separate analysis. The repeated measures (one per acoustic

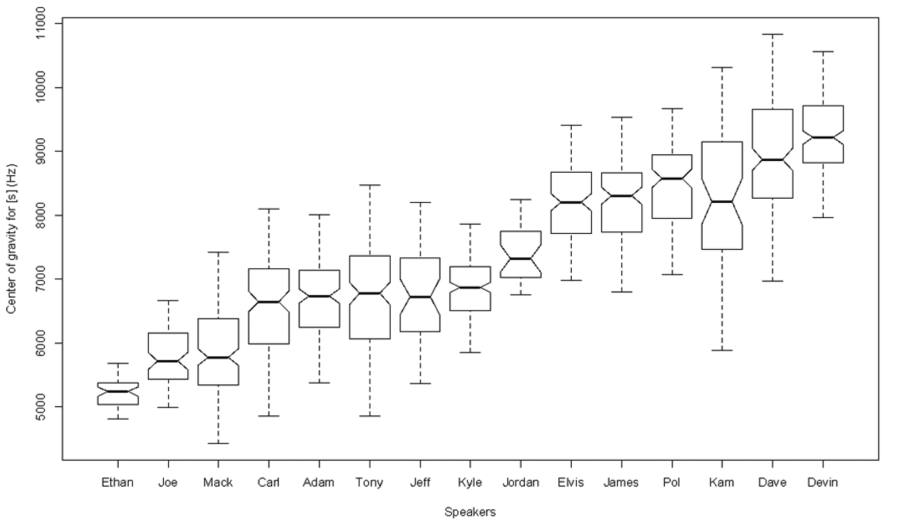

Figure 1: Center of gravity for /s/ for all speakers.

variable) arguably require a Bonferroni correction, providing a new alpha of 0.0125. The independent, fixed-effect variables in these regressions were language and following segment, while the random-effect variable was the recording from which the token was extracted.

4 Results and discussion

4.1 Inter-speaker analysis

Taken as a whole, the most remarkable aspects of this dataset of transgender speakers is the enormous variation in their center of gravity for /s/. In Figure 1, center of gravity (or COG) is plotted for all 15 speakers, who are ordered from lowest to highest mean. As the methods section notes, the notches in this boxplot indicate which speakers' values for /s/ are significantly different from the others in pair-wise comparisons. If the notches of two speakers' boxes overlap (as they do for Joe and Mack, for instance), the difference is not statistically significant, but if they do not over lap (as with Joe and Ethan), there is a significant difference between them. Table 4 provides means for each of these speakers' centers of gravity.

Table 4: Mean centers of gravity for /s/ for all speakers.

Speaker	Total number of tokens of /s/	Mean COG for all tokens
Ethan	56	5226 Hz
Joe	70	5788 Hz
Mack	154	5921 Hz
Dave	154	8905 Hz
Carl	126	6579 Hz
Adam	168	6705 Hz
Tony	140	6727 Hz
Jeff	42	6728 Hz
Kyle	182	6819 Hz
Jordan	28	7338 Hz
Elvis	126	8128 Hz
James	112	8196 Hz
Pol	112	8264 Hz
Kam	56	8267 Hz
Devin	182	9188 Hz
Range of means		**5,226 – 9,118 Hz**

One potential interpretation of these data is that some speakers have been more successful than others in achieving a masculine voice. Yet this argument depends on the assumption that transmasculine people share the same stylistic target, and that this target is a strictly normative masculinity. When we consider the complicated relationships these speakers have with gender, a more compelling explanation emerges, which brings together each of the facets of gender I identified above: assignment, identity, and presentation.

Based on what we know about the acquisition of gendered phonetic traits during childhood, it is important to consider gender assignment here because of the time these speakers spent being seen and treated as girls and women. Assignment is a useful notion because it allows us to refrain from assuming that biological sex is responsible for any aspect of these speakers' voices that distinguishes them from cis men. While the role of biology is of some contention when it comes to /s/, it is clear that language socialization early in life does play some kind of role in producing gender differences in this sound, as the literature review above discusses. Socialization, however, is not a homogenous, unidirectional force. As researchers in socialization have emphasized (Garrett and Baquedano-López 2002; Kulick and Schieffelin 2006), socialization is a dynamic process between interactants. In other words, children – and adults, for that matter – play a crucial role in their

own socialization process. This is particularly important here because trans people describe very different kinds of relationships to their gender socialization early in life. Some of the transmasculine people in this study saw themselves as girls and women prior to transitioning, but others indicated that they never saw themselves as female. The latter group often describe themselves as actively resisting the femininity imposed on them in childhood, even as other trans men may talk about accepting or welcoming femininity when they were younger. One interesting account of how my speakers see their gender assignment and socialization as impacting their voices came from Devin, a 24 year old white middle-class non-binary queer person from the Bay Area who prefers not to use identity labels to describe his gender at all. Devin told me during one of our early meetings that he remembers thinking, as a child, that his voice was not feminine enough and that he should work harder sound like other girls. Devin made reference to this aspect of his socialization while he was giving an account of his own voice. Despite having the most dramatic drop in pitch of any of my speakers (from an average of 169 Hz to 113 Hz over the course of a year), Devin told me that a friend had described him as sounding "like a woman with a deep voice." This was an evaluation that wasn't a problem for Devin, though it would have been for many of the male-identified speakers in this study. This kind of commentary makes it clear that socialization does not end in childhood. To the contrary, the evaluation and sanction of gender presentation continues throughout the lifetime and is often delivered in a particularly blunt manner for trans people in transition, as that Devin's friend's comment would suggest. People do not simply receive socialization in childhood and then act out that socialization throughout the rest of their lives; instead, ongoing socialization experiences continue to shape and reshape speakers' relationships with their voices and other aspects of gender expression. Childhood language socialization, then, can help to explain why many – but not all – of the speakers in this study have centers of gravity within the ranges typically reported for English-speaking women. Indeed, if socialization always "worked" the way it is supposed to, we would not see the kind of gender diversity we find among individuals who have had similar socialization experiences. However, the force of socialization cannot explain all of the variation represented in Figure 1, and we can turn to the other dimensions of gender, along with sexuality, to fill in the gaps.

For speakers like Ethan, Joe, and Mack – who have the three lowest means for center of gravity – the fact that they are the only participants to identify as straight men is undoubtedly significant. These three men – who are all white, between age 40 and 56, and come from working- to lower-middle class families – enact

fairly conventional forms of masculinity and are very comfortable being identified as men. With mean centers of gravity below 6,000 Hz, they are within the norms for American English-speaking men's center of gravity based on the range I cited above (approximately 4,000–7,000 Hz).

The next group of speakers, whose means for center of gravity fall into the range where men's and women's productions have been reported to overlap (6,400–7,000 Hz), can be distinguished in terms of gender identity and sexuality as well. While Ethan, Joe, and Mack self-identify as straight men, the speakers in the middle group – Carl, Adam, Tony, Jeff, Kyle, and, separately, Jordan[3] – identify as queer and prefer to be classified as specifically trans men. For Jeff, the label *queer* refers to his primary attraction to men, but for the others it is a label that they apply to their relationships with women. Most of these queer trans men have relatively conventional gender presentations, as well, compared to some of the speakers I will discuss momentarily. Kyle, however, enjoys blending markers of queer masculinity (e.g., he says he likes to "get cute" with his female partner before they go to a club, referencing his makeup and dancing gear) with his outdoorsy and increasingly athletic lifestyle. In fact, trans men like Kyle who prize their affiliation with queer and distinctively transmasculine identities often expressed concern that they would be mistaken for straight cisgender men, and /s/ can be seen as a potential resource for distinguishing these speakers from straight men like Mack, Joe, and Ethan.

The speakers who do not identify as men and instead use labels like *boy* and *genderqueer* – or avoid labels all together – all have higher centers of gravity than the other two groups I have just described. This includes Elvis, James, Pol, Kam, and Devin. In fact, several of these speakers' mean center of gravity is beyond even the upper end of the range generally reported for English-speaking women (8,500 Hz). All of these individuals distance themselves from hegemonic masculinity in a variety of ways, linguistic and otherwise. This is evident in their non-normative gender expressions which they describe with words like *dandy, queer*, and *androgynous*, and which involve the incorporation of markedly feminine signs like Elvis' turquoise rings, James' sparkly body piercing jewelry, or Kam's lack of interest in binding (i.e. flattening) his chest.

3 Jordan's productions of /s/ put him between the group of queer trans men and the group of non-binary-identified individuals that includes Elvis, James, Pol, Kam, and Devin. This may reflect the context in which I was able to record Jordan, just twice at the very start of his transition, during a time when he was gradually shifting away from a genderqueer identity and toward identification as a trans man.

This leaves Dave, who again provides the clearest demonstration that gender identity and gender presentation are distinct for members of this community. Dave does not identify as genderqueer but instead refers to himself as a man, full stop, who happens to be queer and have a fem gender presentation. His voice is among the most salient means that he uses to constitute his flamboyantly non-normative take on masculinity, for which he mentions Oscar Wilde as a role-model. In this case, Dave's status as having the second highest mean center of gravity among these speakers reflects his gender presentation rather than his gender identity.

4.2 Intra-speaker analysis

The intra-speaker comparison that fleshes out this discussion was motivated by the observation that one speaker, Pol, produces /s/ very differently in his two native languages: Castilian Spanish as spoken in Barcelona and British English acquired primarily through his Cornwall, England-born mother. As of the beginning of his participation in this study, Pol was a 23 year old college student from a working-class family who identified as queer and genderqueer. Despite a fairly prototypical history with gender for a transmasculine person, which includes a life-long history of masculine gender expression, Pol rejects that narrative and instead situates himself outside of the gender binary entirely, describing himself as a trans boy rather than a trans man. His primary goal in pursuing hormone replacement therapy and chest surgery was to move his embodiment to a more ambiguous place rather than to occupy an unambiguously male body. Though clearly masculine in presentation, Pol is also soft-spoken, gentle, kind, and on occasion describes himself as *tenderqueer* – a semi-tongue-in-cheek term used in some genderqueer communities to indicate a sensitive disposition. His dapper sense of style and English accent also set him apart from hegemonic gender norms for American men.

In Spanish, Pol employs a distinctively Iberian low frequency /s/ that has been characterized by phoneticians as apical rather than laminal (Martínez-Celdrán et al. 2003) and/or retracted (Ladefoged and Maddieson 1996). In English, as the inter-speaker analysis above indicates, Pol has a relatively high frequency /s/, with a mean center of gravity of 8,264 Hz across his English dataset. Although the cross-linguistic analysis includes only tokens of /s/ that precede back vowels, as noted above, Pol's mean COG in this subset of data is only slightly lower than the full dataset at 8,112 Hz. In Spanish, however, Pol's center of gravity was much lower, with a mean of 4,846 Hz. Figures 2 and 3 show spectra from a token from each language, selected to be as similar as possible in phonemic environment. These spectral slices plot frequency against amplitude

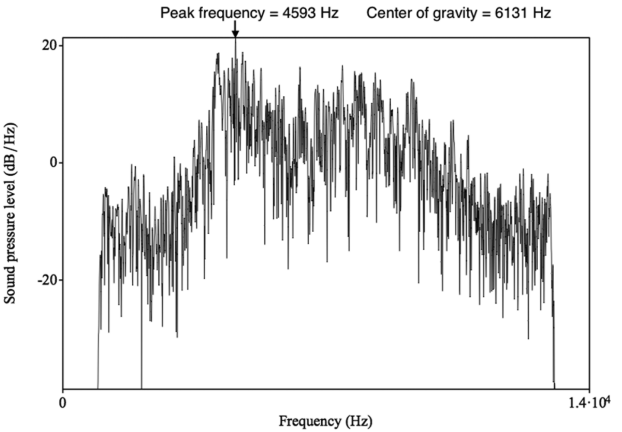

Figure 2: Spectrum for English /s/ in the word *superimposition*.

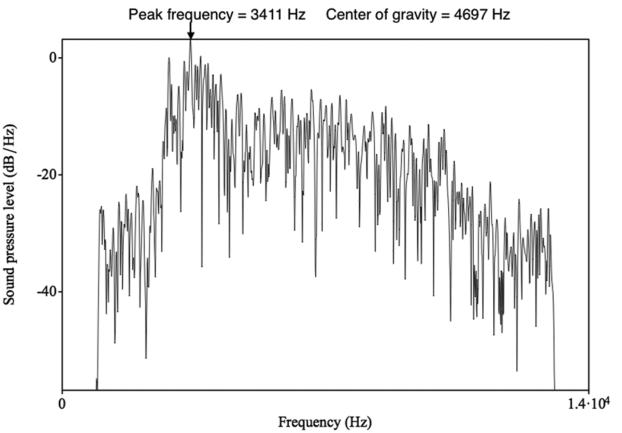

Figure 3: Spectrum for Spanish /s/ in the word *suspendidas*.

such that the most prominent frequencies are represented as peaks. Figure 2 comes from word-initial /s/ in *superimposition* from the English passage. This token has a relatively low center of gravity for the English data at 6,191 Hz and a peak frequency of 4,593 Hz. Figure 3 represents the first segment in the phonologically similar word *suspendidas* ('suspended'), which has a center of gravity of 4,697 Hz and a peak frequency of 3,411 Hz. Peak frequency is indicated with an arrow in each spectrum. The Spanish token is also more positively skewed than the English one because of its relatively lower amplitude in the range of 6,000–7,000 Hz (1.255 for Spanish vs. 0.903 for English).

The difference exemplified in Figures 2 and 3 are also reflected in the linear mixed effects regressions conducted on these data. Four regressions were carried

out, one for each of the acoustic measures (center of gravity, standard deviation, skew, and kurtosis). However, only center of gravity proved to have a statistically significant difference across the two languages. Pol produced /s/ with a significantly lower center of gravity when speaking Spanish ($B = -1513$, $p < 0.000$); there was also a trend toward more positively skewed distributions of energy in /s/ in Spanish, but it did not reach significance ($p = 0.095$). Figure 4 provides a scatterplot for these data, in which English is represented by empty squares and Spanish by filled circles. Clearly, there is very little overlap in center of gravity between these sets of measurements.

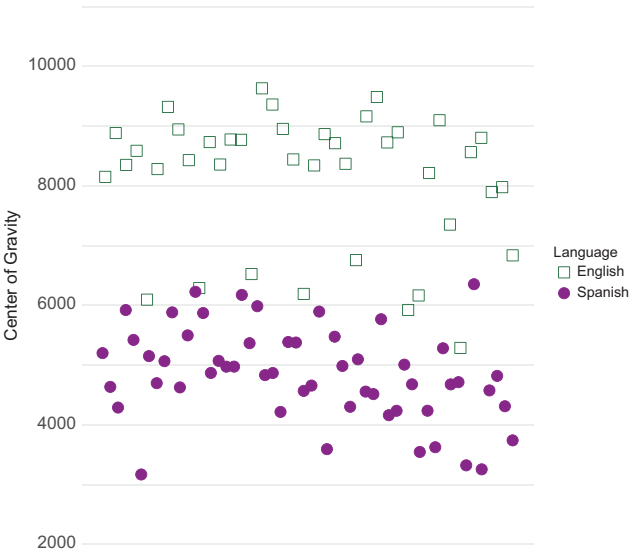

Figure 4: Scatterplot of English and Spanish tokens of /s/.

The difference in center of gravity across Pol's read speech in Spanish and English could be explained in a few different ways. It could be that the difference is essentially language-based, and that any speaker of Castilian and English would display comparable differences in their articulation of /s/. Perhaps Pol produces a high-frequency /s/ relative to other English speakers when he is speaking English and a high-frequency /s/ relative to other Castilian Spanish speakers when he is speaking Spanish. Another possibility is that Pol's high frequency /s/ in English reflects his particular history of acquisition, in which his mother was a primary interlocutor for many of his English-based interactions during childhood. While Pol had access to a full range of Spanish sociolinguistic variation in his childhood, adolescence, and early adulthood in Spain, his options for face-to-face

interactions with native English-speaking models were more narrow until he moved to San Francisco in his early 20's. In this case, it may be that Pol occupies a more typically masculine frequency range for /s/ when speaking Spanish, which would reflect his long history of masculine gender presentation and affiliation with trans and gender non-conforming communities in Spain. Of course, to test either of these hypotheses, we would need to compare Pol's productions of /s/ with those of other speakers from Barcelona.

Whatever the precise cause(s) for the difference between Pol's /s/ in Spanish and in English, he is clearly physiologically capable of producing this sound with a much lower center of gravity than he typically does in English. It is also clear that this difference is articulatory in nature, and cannot reflect a biophysically predetermined frequency range for sibilants. Far from being limited to Castilian Spanish, a low frequency or retracted /s/ has also been documented in certain varieties of English, often with some kind of link to masculinity and/or working-classness (Campbell-Kibler 2011; Stuart-Smith 2007). Given that COG for many of the Spanish tokens in Figure 4 are in the range of 4,000–6,000 Hz, this kind of /s/ may not even be perceived as retracted, particularly when paired with a low-pitched voice (Strand 1999). There is nothing about Pol's vocal anatomy that prevents him from using a lower frequency /s/ in English. Instead, this divergence of /s/ across his languages is, one way or another, a matter of learned articulatory habit.

5 Conclusions

Thanks to the most basic academic contributions of feminist scholarship, many linguists are by now well practiced at distinguishing between sex, as a matter of embodiment, and gender, as a set of social practices. This division, however, has the effect of naturalizing gendered embodiment as an unchanging product of naturally asocial forces while reducing gender's numerous facets to a single dimension of femininity versus masculinity. By focusing on the voices of trans-masculine people, this analysis illustrates the importance of taking a more complex, multi-dimensional approach to gender. The language we use to talk about this aspect of sociality must be complicated to recognize distinctions between gender assignment, identity, and presentation, in addition to sex and sexuality. The variety of gendered phonetic styles employed by the trans people in this study underscore the myriad of ways these aspects of gender can align with one another, each one with its own importance for explaining gendered linguistic practice.

Although sex has an unavoidable role to play in the production of gender differences in the voice, we need a more sophisticated way to approach the

relationship between embodiment and speech. Even if there are broad correlations between anatomical measures and the production of /s/ within a large population of women and men, we must be careful not to assume that these anatomical characteristics are the direct cause of gender differences that we observe in individual voices. The variability in one bilingual speaker's productions of /s/ provides simple yet compelling evidence that oral anatomy does not directly determine how high- or low-frequency a speaker's center of gravity for /s/ will be. The same speaker has the physical capacity to articulate a sound like /s/ in a great many ways, and these articulatory differences appear to have significant acoustic results. While we might be prompted to turn to gender socialization as an alternative explanation for the patterns we find in more normatively gendered populations, socialization always works in concert with (or against) the individual's developing social subjectivity. As the inter-speaker analysis above stresses, this dynamic interplay between self and other demands a consideration not just of biology or gender assignment, but also the gender identities that individuals' claim for themselves and the semiotic expression of those identities in everyday life. An explanation that frames gendered variation in sibilants as a matter of either biology or socialization, or even as both, fails to capture the multifarious systems through which gendered difference is realized.

This degree of complexity in these distinctions may seem unnecessary for those of us who work with cisgender speakers – or, more often than not, speakers who we *assume* to be cisgender. Undoubtedly, transgender speakers provide a perfect opportunity for teasing apart social and biological influences on the gendered voice; however, there are clear applications of this model of gender that can enrich our understanding of cisgender voices as well. For example, Zimman (2013) discusses the importance of considering gender presentation, and not just sexual orientation, in sociophonetic theorizations of perceived sexuality among men. Gender expression is a concept that can help us understand the everyday production of gender through both linguistic and extra-linguistic means. Whatever our community of study, if we hope to account for the full range of voices that speakers produce we need to recognize the limitations of a unitary gender binary and move instead toward a multi-dimensional approach.

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