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Transgender voices: Insights on identity, embodiment, and the gender of the voice

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Abstract

The voice is a highly salient cue in the perception of gender and an important analytic factor in both phonetic and sociophonetic analysis. Although we have a wealth of knowledge about the social construction of gender through language, gender differences in the voice are frequently treated as natural, direct products of sex differentiation. This article focuses on three major areas of insight from studies of transgender people's voices that build on previous evidence that even biologically influenced features of the gendered voice, like pitch, are shaped by sociocultural practice: the identification of features that distinguish voices perceived as female from those perceived as male; the examination of the degree to which the gendered characteristics of the voice can change; and the theorization of where gender differences in the voice come from. Inclusion of trans speakers in the sociophonetic study of the gendered voice requires linguists to be more cautious in the categorization of voices as female or male on the basis of speakers' perceived sex.

1 | INTRODUCTION

The last decade has shown a rapid expansion of interest in and awareness of transgender people's experiences, both within and outside academia. Trans people have long played a significant role in the social sciences because of the way they make the process of acquiring a gender—a process that everyone goes through—more visible (e.g., Garfinkel, 1967). However, linguists have been relatively slow to incorporate these lessons into the study of language. This

article focuses on one particularly important aspect of language when it comes to transgender speakers: the gendered characteristics of the voice.

Vocal cues are often a key factor in the process of categorizing someone's gender, making the voice an enormously important aspect of gender presentation, particularly for those who are transitioning from one gender role, identity, or presentation to another. This has created demand among some trans people—particularly trans women, for reasons to be discussed below—for speech therapy focused on feminizing (or, less often, masculinizing) the voice. Gender differences in the voice are also of great importance to linguists and researchers in allied fields because of the way speaker gender is used to determine, for instance, what kinds of settings should be used in acoustic analysis. Additionally, studying gender and the voice focuses on a site in which the body and cultural processes of socialization and identity construction come into contact with one another. This places the voice at the center of debates about the extent to which gender is a biological versus sociocultural phenomenon. In this sense, the study of trans speakers is not merely addressing the historical exclusion of a highly marginalized group from research in our field but also provides critical insights on our overall understanding of gender differences in the voice. When we limit ourselves to the study of normative speakers—whose embodiment, socialization experiences, and self-articulated gender identities "match" in the expected ways—it is very difficult to tease apart the influence of each of these factors. Analysts are left to speculate about the source of the differences they discover, and such speculations often reinforce the privileging of dominant social groups, such as cisgender people (i.e., those who are not transgender), men, heterosexuals, and White/colonial cultures. By including those whose bodies, life histories, and identities diverge from the norm in various ways, we can ask questions about the influence of each of these forces, bringing us closer to an understanding of why gender differences in the voice exist in the first place.

This article takes a critical perspective on the practice of categorizing voices as "female" or "male" through a focus on transgender speakers. It begins with a brief overview of received wisdom on gender and the voice, which highlights some of the erasures and amplifications that make the picture seem simpler than it truly is. There is also substantial reason to question the naturalization of gender differences in the voice, even before bringing trans speakers into the mix. We can then turn to research on trans voices from both speech pathologists and sociophoneticians organized around a set of three key concerns that drive existing literature in this area: the identification of phonetic features associated with gender, the exploration of the malleability of those features, and the origin(s) of gender differences in the voice.

2 | RECEIVED WISDOM ON GENDER AND THE VOICE

Gender differences in the voice form the backdrop for much research in phonetics broadly and in sociophonetics in particular; they are also of interest to scholars of language, gender, and sexuality. However, these two groups of researchers tend to see gender differently, which leads them to conduct research and interpret findings in different ways. Among researchers who specialize in language, gender, and sexuality, gender is seen as a social construct, that is, a product of social practice that differs over time and across cultures. *Constructivists* recognize that widespread beliefs about gender—including those held by academics—are not universal pictures of "reality," but rather a reflection of a particular cultural framework. Cross-cultural differences in gender norms for women and men provide strong evidence for the constructivist viewpoint, as do differences in the way gender is enacted across different communities within

the "same" culture, particularly as it intersects with race and ethnicity, class, sexuality, and other domains of identity. Gender is potentially fluid and non-binary from this perspective and can be changed and subverted—though not limitlessly—through speakers' exercise of agency. This research often distinguishes between *sex*, in reference to bodily characteristics, and *gender*, in reference to social practices, though both are recognized as social constructs (as in Butler, 1993; Zimman & Hall, 2009; Zimman, 2014). Constructivists tend to see linguistic differences between women, men, or any other gender group as socially learned rather than anatomically determined, at least in the absence of strong evidence to the contrary.

Research that is focused on gender differences in the voice, however, often takes a more *determinist* perspective, in which physiology determines vocal output. Biological sex is frequently the first-line explanation for any difference between women's and men's voices, even when the same results could be interpreted through a constructivist lens. The concepts of sex and gender are often not distinguished, and typically, only two gender categories are recognized despite the fact that human sexual variation encompasses both bodies and identities that fall outside that binary. Yet researchers typically categorize their participants' gender identities based on their own perceptions and assumptions about participants' bodies. *Female* and *male* tend to be treated as homogenous categories, such that intersections with other aspects of identity are rarely considered, and White, middle-class speakers are often treated as representative of women and men in general. For determinists, gender differences in the voice are likely rooted in biological difference rather than socially constructed, at least in the absence of strong evidence to the contrary.

As we will see, trans voices can help shed light on the usefulness of these competing frameworks. Before getting to that point, a brief review of research on gender and the voice is necessary.

2.1 | Determinist perspectives on the voice

The tendency toward biological determinism in research on widely observed gender differences in the voice is driven by the recognition that physiological differences between speakers can have a strong effect on the kinds of voices they are able to produce. Although there are several grounds on which to challenge the determinist view, this research forms a backdrop against which trans voices can be understood and which trans voices are poised to challenge.

For linguists and non-linguists alike, pitch is the most intuitive and salient gender difference in the voice. The primary acoustic measure that reflects a speaker's pitch is fundamental frequency, or F0, which represents the speed at which the vocal folds vibrate. Vocal fold vibration speed depends in part on the mass of the folds, with larger vocal folds producing slower vibration than smaller folds, resulting in a lower F0. This means that the F0 range a speaker can produce is constrained by vocal fold size. The size of the larynx is highly sensitive to testosterone (e.g., Evans, Neave, Wakelin, & Hamilton, 2008), resulting in significant laryngeal growth during typical male puberty (Hollien, Green, & Massey, 1994) or later in life for trans people who take exogenous testosterone (Azul, 2015; Azul, Nygren, Södersten, & Neuschaefer-Rube, 2016 for reviews). Among speakers of American English, average speaking fundamental frequency is generally placed at around 100–120 Hz for men and 200–220 Hz for women (Fitch & Holbrook, 1970; Linke, 1973; Simpson, 2009; Snidecor, 1951; Stoicheff, 1981; Traunmüller & Eriksson, 1995). Determinist approaches tend to see differences in women's and men's F0 as emanating directly, at times exclusively, from sex-based differences in the size of the larynx (e.g., Ohala, 1984 for a particularly determinist account).

Though less consciously salient to most speakers, vowel formant frequencies are another area where women and men typically differ. Formant frequencies, which roughly map onto the concept of vocal resonance, reflect the length of the vocal tract, with longer vocal tracts producing lower resonating frequencies. Because the size of the vocal tract is implicated in formant frequencies, and because women tend to have higher formant frequencies than men, many linguists have supposed that body size is the best explanation for gender differences in formants. However, others have found that height and weight make poor predictors when speakers of the same sex are compared (e.g., Barreda, 2016; Gonzalez & Oliver, 2005), suggesting that the observed physiological differences are driven not by body size but by an increase in the size of the pharynx that accompanies testosterone-driven laryngeal growth.

The articulation of consonants has also been studied from a determinist perspective. Recently, sibilant consonants have been a particularly popular area of study among sociophoneticians interested in gender and sexuality. Studies of voiceless fricatives have drawn connections between femininity and a fronted, high frequency /s/ in multiple languages, including English (e.g., Holmes-Elliott & Levon, 2017; Levon, 2007; Munson, McDonald, DeBoe, & White, 2006; Stuart-Smith, 2007; Zimman, 2015, 2017b), Danish (Pharao & Maegaard, 2017; Pharao, Maegaard, Møller, & Kristiansen, 2014), Mandarin (Li, 2017), and Japanese (Heffernan, 2004). Some studies have suggested that these patterns are rooted in sex differences in the front part of the vocal tract, where /s/ is produced. Fuchs and Toda (2010), for instance, use articulatory measures to directly test whether women and men differ anatomically in ways that could explain the observed gender differences in /s/ (i.e., in the palate or alveolar ridge). Despite a lack of statistically significant results, and despite finding more significant differences between English and German speakers than between women and men in either population, the authors stunningly conclude that both social and anatomical factors play a role in causing gender differences in /s/. Studies of gender differences in voice onset time[1] suggest that women make a bigger contrast between voiced and voiceless stops (Robb, Gilbert & Lerman, 2005), which Whiteside and Marshall (2001) have argued is linked to different phases in cisgender women's hormonal cycles.[2]

Perhaps because we know individuals can do a great deal to alter their prosody, suprasegmental features like intonation, voice quality, duration, rhythm, and amplitude have less often been attributed to physiological differences between the sexes and more often recognized as an element of sociolinguistic style. However, there have been a few exceptions. One is the argument that women make greater use of breathy voice quality than men due to differences in airflow and/or vocal fold thickness (e.g., Klatt & Klatt, 1990). Another is the idea that women make use of a wider pitch range or more distinctive vowels because their voices are "naturally" more difficult to hear or parse auditorily (e.g,. Diehl, Lindblom, Hoemeke, & Fahey, 1996; Ryalls & Lieberman, 1982; see also Henton, 1989 on the question of whether women's pitch range exceeds men's).[3] Notably, many differences reported between women's and men's voices are closely linked to clear speech (Bradlow, Torretta, & Pisoni, 1996).

[1]Voice onset time is a feature of stop consonants that represents the amount of time that passes between the release of the stop and the start of vocal fold vibration. Voiceless stops have a longer voice onset time than voiced stops.

[2]This supposition could be profitably tested with trans populations, which include both those male-identified people who have a cycle similar to cisgender women's as well as those male-assigned individuals who make use of estrogen and/or progesterone therapy, but without cycling in precisely the same way as cis women.

[3]Note the rather tortured logic here: women's voices are naturally harder to understand than men's, and that's why we observe them producing speech that is easier to understand than men's.

2.2 | Constructivist challenges

Despite the wealth of research promoting a determinist perspective on gender and the voice, there is considerable evidence to support a constructivist view. These can be summarized in the following four lessons:

1 *The lesson of linguistic diversity*: Different languages and cultures index gender phonetically in different ways;
2 *The lesson of socialization*: Many gender differences in the voice are acquired in childhood;
3 *The lesson of intersectionality*: Members of the "same" culture and speakers of the "same" language may index gender differently based on other identities they embody;
4 *The lesson of agency*: Speakers have the ability to consciously manipulate the gendered characteristics of their voices.

First, gender differences in the voice vary across languages and cultures, even when it comes to characteristics that clearly have some basis in physiology, such as F0. For example, Japanese-speaking women have been shown to make use of a higher F0 than American English-speaking women, while Japanese men use a lower F0 than their American counterparts (Loveday, 1981; Yuasa, 2008). Although /s/ has been linked to gender in several languages, this connection is not universal; Gordon, Barthmaier, and Sands (2002) compared seven unrelated languages, most of them indigenous, and find gender differences in /s/ for only one (Chickasaw). And even as certain voice qualities are linked to women or men among speakers of some varieties, the opposite association may exist in others. When linguists began studying creaky phonation in English from a sociolinguistic perspective, it was men who were said to make the most use of creak among British English speakers (Henton & Bladon, 1988), whereas in the United States today, it is young women who are most strongly associated with creak.

Another strong piece of evidence for the constructivist approach is the existence of gender differences among prepubertal children. Such differences have been reported for F0 (Hasek, Singh, & Murry, 1980; Ingrisano, Weismer, & Schuckers, 1980; Ferrand & Bloom, 1996) and for formant frequencies (Busby & Plant, 1995; Lee, Potamianos, & Narayanan, 1999; Perry, Ohde, & Ashmead, 2001). With Fitch and Giedd (1999) confirming that children's vocal tracts do not significantly differ by sex before puberty, these differences are best explained as part of the language acquisition and socialization process. Lending further support to a constructivist interpretation, Ferrand and Bloom (1996) also identify gender differences in intonation patterns emerging at the same age that differences in mean F0 appear. Gender differences in /s/ appear in childhood as well, as Flipsen, Shrilberg, Weismer, Karlsson, and McSweeny (1999) demonstrate, though they use their findings to posit a determinist interpretation in which unattested anatomical differences in prepubescent children explain gender differences in /s/.

The concept of intersectionality recognizes that each aspect of a person's identity is necessarily inflected by their other identities, such that gender can never be examined alone but must be understood as intersecting with age, class, race and ethnicity, and other elements of the self (Crenshaw, 1989). This concept helps explain why even individuals who speak the same language and identify with the same gender category may nevertheless index their gender differently. Evidence of intersectionality is especially plentiful in the case of gender differences in /s/. Men who are gay, or perceived as gay by listeners, have been shown to produce a higher frequency /s/ when compared to other men (Munson et al., 2006). Stuart-Smith (2007) finds that gender differences in /s/ intersect with class in Glasgow, with young working-class women

producing a low-frequency /s/ comparable to adult men's /s/ productions, while middle-class girls patterned with adult women. Pharao et al. (2014) examine the intersection of sexuality and immigration among speakers of Danish and show how ideologies about gay men as White and Danish, and about immigrants as socially and sexually repressive, makes listeners less likely to associate a fronted /s/ with gayness when they believe they are hearing an immigrant speaker.

Finally, there is evidence that speakers may be able to exert control over at least some aspects of the gendered voice. For instance, the fact that children can produce higher or lower formant frequencies depending on their assigned gender suggests that they manipulate—i.e., raise or lower—their larynxes in order to make their vocal tracts longer or shorter than they might otherwise be. Evidence about adults' ability to exercise conscious control over gender differences in the voice comes primarily from studies of trans voices, which is the focus of the next section.

Clearly, biology exerts an influence over the gendered voice, particularly when it comes to the size of the larynx. However, even as a person's potential pitch range is constrained by their vocal anatomy, sexual biology alone does not determine which part of that range a speaker will use. There is plentiful evidence that gender differences in the voice are acquired early in life in different ways depending on the norms of a speaker's various communities and how they orient themselves to those norms. However, as we shall see in the next section, there is also considerable evidence of flexibility beyond those early socialization experiences.

3 | RESEARCH ON TRANS VOICES

As the preceding discussion suggests, one of the primary concerns of scholars interested in the gendered voice is the determination of what role biology and socialization play in the production of phonetic gender differences. Differences are often thought to be rooted in biological sex, but gender normative cisgender speakers clearly engage in social practices that enhance anatomical tendencies. Some of these practices may be acquired during childhood, or they may be taken on in adolescence or adulthood as part of a speaker's identity work. However, because all of these factors are typically aligned in the expected ways (i.e., female-assigned bodies go with socialization as a girl and a female gender identity), it is difficult to pry these factors apart. One of the great benefits of centering transgender speakers is that they are uniquely poised to shed light on these questions. Trans bodies may (or may not) start out as normatively female or male, but they are also often modified with hormones, surgery, and other technologies. Trans people typically receive gender socialization based on their assigned sex, but they may or may not respond to that socialization in the normative way. And, of course, trans identities push back against the expectation that certain bodies, or certain socialization experiences, will result in certain kinds of gender identities and expressions.

Before turning to the literature on trans voices, a note about disciplinarity is useful. The majority of research on trans voices has been carried out by speech-language pathologists, in large part because some trans people seek out speech therapy to change their voices. While this literature offers a number of useful insights, it also often reflects problematic ideologies about trans identity. As Zimman (2012a) describes in greater detail, the speech pathology literature on gender and the voice tends to be determinist, assuming that gender differences are primarily or exclusively biological in origin. This leads to an interpretation of trans women as having "male voices" and thus needing training to approximate the "naturally" feminine voices of

cisgender women. Discussions of trans men, by contrast, tend to emphasize the effects of testosterone on the larynx, leading to less research on this population among speech pathologists (though see Adler & Van Borsel, 2006). The literature speech pathologists typically use to characterize what a "female voice" or "male voice" should sound like is decidedly non-intersectional, often relying on data taken from gender normative middle-class White young people (if race, class, and gender normativity are even mentioned) and assuming trans people want to emulate these particular forms of femininity or masculinity. Though deeply problematic in some cases, this literature forms the largest body of knowledge produced on trans voices. Happily, research in recent years has begun to show greater sensitivity to trans people's own concerns and desires (e.g., Davies & Goldberg, 2006; Davies, Papp, & Antoni, 2015; Azul et al., 2016).

The remainder of this section is organized around three core insights offered by the study of trans voices. These include the identification of gender differences in the voice, the examination of their flexibility, and the consideration of their source in the body and/or social practice.

3.1 | What are the features of the gendered voice?

One issue that is of great interest to both speech pathologists and linguists is the identification of phonetic cues that distinguish voices perceived as female from voices perceived as male. Pitch has been the focus of much of the research in this area, including attempts to identify a crossover point—that is, the fundamental frequency at which voices stop being perceived as female and begin being perceived as male or vice versa (Gelfer & Mikos, 2005; Gelfer & Schofield, 2000; Günzburger, 1995; Hancock, Colton, & Douglas, 2014; Spencer, 1988; Wolfe, Ratusnik, Smith, & Northrop, 1990). Although some studies have identified the range of 150–165 Hz as a potential crossover point for trans women (Spencer, 1988; Wolfe et al., 1990; Gelfer & Schofield, 2000), there are notable exceptions. Günzburger (1995) reports that certain trans women in her study were perceived as female despite having F0 means as low as 119–128 Hz. Inversely, Gelfer and Schofield (2000) report that speakers may be perceived as male even with an F0 as high as 181 Hz. These exceptional cases indicate that, despite the salience of fundamental frequency, other features of the voice likely contribute to its perception as female or male.

Reporting on a longitudinal study of trans men and other trans masculine individuals,[4] Zimman (2017a) focuses on the importance of considering multiple phonetic features when characterizing the gendered voice. While F0 may be the easiest way to categorize a voice as female/feminine or male/masculine, the analysis of F0 together with /s/ in this piece underscores that the gendered features of the voice do not always bundle together in normative ways. As is the case with sociolinguistic style more generally, speakers have the ability to combine and recombine stylistic variables in ways that reflect and constitute their complex, intersectional identities. Zimman (2012b, in prep.) describes a parallel perceptual experiment showing that trans speakers' crossover points vary enormously, with some speakers perceived as female even with a mean F0 of 110 Hz and others perceived as male even with a mean F0 of 190 Hz. He finds that both vowel formants and /s/ are significant predictors of how low a trans masculine person's mean F0 has to be before their voice will be categorized as male.

[4]That is, those who were assigned female at birth and self-identify as masculine or male.

The acoustic properties of /s/ have been the focus of sociophonetic studies of trans voices as well. In other work on /s/ among the same trans speakers in the San Francisco Bay Area (Zimman, 2012a, 2017b) and with a larger set of speakers in Portland, Oregon (Zimman, under review), the focus is variability in the production of /s/ and the argument that a finer-grained theory of gender is needed to distinguish not only gender and sex but also gender assignment (the category one is placed in at birth), gender identity (the category one aligns oneself with), gender role (one's socially recognized category), and gender presentation (how one displays gender semiotically). In studies by Podesva and Van Hofwegen (2016) and Hazenberg (2016), trans women and trans men are placed on a continuum in relation to cisgender speakers to illustrate a gender continuum. In contrast to the findings from Zimman's work in major, politically progressive cities with large queer and trans communities, these other researchers find that trans speakers produced /s/ in ways that were more consistently similar to others of the same gender identity (i.e., trans women were similar to cis women and trans men to cis men). Podesva and Van Hofwegen in particular link these findings to the relatively conservative, rural sociocultural setting in which their speakers live. Ultimately, however, the trans women and men collectively fell somewhere between cisgender women and men, illustrating the non-binary nature of the gendered voice.

Prosodic features like intonation, rhythm, and voice quality are often strongly linked to gender in the popular imagination, though these associations are not always borne out in the research. Wolfe et al. (1990) compared the frequency of upward, downward, and level intonational contours among trans women, cis women, and cis men and found that trans women who were perceived as female used a higher number of fluctuations in pitch than those perceived as male. Hancock et al. (2014) similarly conclude that trans women with a larger proportion of upward intonational contours and a larger pitch range were more likely to be perceived as female. This was true despite the fact that there was no gender difference in the intonation of the cisgender women and men recorded as control groups for the study. Günzburger (1993) reports that trans feminine speakers who were asked to produce two types of voices—one “female” and the other “male”—tended to read more slowly and at a lower amplitude in their “female” voice. Gelfer and Schofield (2000) find no significant correlations between perceived gender and types of intonational contours or formant frequencies, though they do identify a non-significant trend toward speakers perceived as women having a larger pitch range than those perceived as men. Certain voice qualities have also been studied in relation to trans voices. Becker, ud Dowla Khan, and Zimman's (2014, 2017) work on creaky voice among speakers in Portland, Oregon, uses a stratified sample of young adults with a variety of gender identities. In keeping with other studies, they find that cisgender women make greater use of creaky voice than cisgender men. However, they also find certain transgender groups also make ample use of creak, particularly transgender men who were not on testosterone (though see Zimman, 2012a, 2013 regarding creak among different sets of trans men on testosterone). Rather than offering a single meaning of creak as feminine or masculine, the authors suggest that different groups may be using creak as part of different strategies, such as accessing a lower pitch range in the case of trans men whose voices are otherwise relatively high pitched.

Attention to features of the gendered voice other than F0 pushes us to consider what we mean when we categorize a voice as “female” or “male.” We know that phonetic indexes of gender are not limited to pitch, but trans people underscore the importance of the array of features that produce a gendered voice and complicate attempts to characterize voices as unambiguously gendered.

3.2 | How flexible is the gendered voice?

Because so much of the research on trans voices is done by speech pathologists, trans speakers' ability to change the gendered properties of their voices has been a major focus. Numerous articles by speech pathologists and practicing speech therapists have described individuals who received vocal feminization therapy, either as explorations of how much change is possible or as evaluations of specific tools or techniques. It is clear that not all speakers experience the same kind of changes, with or without speech therapy, but such changes are demonstrably possible. Mount and Salmon (1988) report an increase in mean F0 from 110 Hz to 210 Hz in a 63-year-old trans woman. Gelfer and Tice (2013) find that the trans women in their study had a higher mean F0 than the cis women used as controls immediately after undergoing vocal training, though these changes levelled off in the long term, placing the trans speakers somewhere between the cis women and cis men to whom they were compared. Despite the assumption in older work that formant frequencies could not be altered because they are determined by the length of the vocal tract (Coleman, 1983), several studies have shown that formants *can* be changed by raising or lowering the larynx (Carew, Dacakis, & Oates, 2007; Davies & Goldberg, 2006; Gelfer, 1999). Carew et al. (2007) report that participants in their study significantly raised the first three formants—F1, F2, and F3—and that most participants were rated by listeners as significantly more feminine after training that focused on resonance.

Research on changes in the voices of trans women tends to focus on the ways speech therapy can assist in vocal feminization. Studies of change in trans men's voices, by contrast, tend to focus on the marked lowering of pitch brought about by testosterone. Studies that track these changes consistently find that fundamental frequency lowers significantly during the first year(s) of testosterone therapy (Adler & Van Borsel, 2006; Cosyns et al., 2014; Damrose, 2009; Nygren, Nordenskjöld, Arver, & Södersten, 2016; Papp, 2011; Van Borsel, De Cuypere, Rubens, & Destaerke, 2000; Zimman, 2012a). Here, too, studies often find variability in how much vocal change occurs, but the general trend is for trans men to reach a pitch range comparable to that of cisgender men (Cosyns et al., 2014; Nygren, et al., 2016). Physiology is generally thought to be directly responsible for these changes, but some of these studies suggest that factors like age, sexuality, gender identity, and race or ethnicity should be investigated more thoroughly in order to see how anatomical changes interact with social processes.

Changes in other gendered characteristics of the voice have been investigated less extensively among trans men. As an exception, Zimman's (2012a) longitudinal study documents changes in /s/ among a few trans masculine speakers, with a much less consistent pattern than that found for F0: toward a higher frequency for some and lower frequency for others. The former is explained in part through reference to speakers' metalinguistic commentary, in which those who adopted a higher frequency /s/ reported feeling less need to constrain their gender presentation because physical changes had led others to perceive them as unambiguously male. Speakers with a lower-frequency /s/, on the other hand, may be influenced by new social pressures or by ongoing shifts in gender identity or expression. In either case, speakers are clearly shifting their articulatory strategies as part of their transition. This need not be a conscious process, however; the trans masculine speakers in this study reported being completely unaware of gender differences in /s/.

The question of malleability of gendered vocal characteristics is, of course, particularly interesting to speech therapists. For those of us who are not in fields that seek methods for changing trans people's voices, however, these observations offer a form of evidence about the source of gender differentiation, which is the focus of the next section.

3.3 | Where do gender differences come from?

The fact that speakers can learn to alter the perceived gender of their voice—including features that are known to be influenced by physiology like F0—undermines the assumption that vocal anatomy is the direct, determining cause of gender differences in the voice. This question is not always an explicit focus in research on trans voices, but such studies typically at least indirectly shed light on the source of phonetic gender differentiation.

From the earliest days of language and gender research, feminist linguists have pointed to gender socialization as the source of female and male voices (Brend, 1975; McConnell-Ginet, 1983; Sachs, 1975). This idea was presented as an important alternative to biological determinism, but trans speakers demonstrate clearly that early life socialization cannot be the only social force shaping the gendered voice. The identities that people come to occupy, which may shift over time, must also be taken into consideration. Zimman (2017b, under review) addresses the supposition that gender differences in /s/ are caused by some combination of sex-based differences in the vocal anatomy (as in Flipsen et al., 1999; Fuchs & Toda, 2010) and childhood gender socialization. Focusing on the diversity of /s/ productions among trans masculine speakers, Zimman (2017b) argues that gender should be understood as a constellation of elements, each of which must be considered separately. Gender identity was a major explanatory factor for how high- or low-frequency a speaker's /s/ would be, with speakers who identified as simply *men* producing a more normatively masculine /s/ than those who identified specifically as *trans men*, who were more normative still than female-assigned speakers who identified as *genderqueer* or *non-binary*. Exceptions to this trend can be explained in terms of *gender expression* (i.e., how gender is expressed outwardly), with more feminine trans men producing /s/ like those of the non-binary speakers. Similar patterns were presented in Zimman's (under review) comparison of trans women, trans men, and non-binary individuals, with the additional factor of *gender role* and history emerging due to the inclusion of a few trans women with quite low frequency /s/ who had spent their adult lives presenting as gender normative straight men before coming to identify as women.

Trans voices also highlight the importance of social stereotypes and language ideologies in shaping gender differences in the voice. Regardless of whether women actually make more use of high rising terminal than men, for instance, the fact that this intonational contour is associated with femininity may be enough for listeners to use it as a cue for gendering a voice, particularly if its gender is otherwise ambiguous. Hancock et al. (2014) offer a particularly strong example of this phenomenon by showing that trans women who use more rising intonation were more likely to be perceived as women even though the cisgender women in the study did not actually make more use of this contour than the cisgender men. Hazenberg's (2012) examination of high rising terminal among Canadian trans people similarly shows that while both trans women and men may hold negative attitudes toward rising intonation on non-questions, its association with femininity gives it a potentially positive function for trans women. Zimman (2016) also considers how trans men's ideologies about the voice—and specifically their agency over their own voices—shapes the phonetic styles they acquire. Like speech therapists, trans masculine speakers on testosterone tend to put emphasis on the physiological changes they undergo and may even stigmatize the process of consciously trying to sound more masculine. This leads many trans men who take testosterone to pay little attention to gendered elements of the voice other than pitch, even as trans women often become highly attuned to resonance, voice quality, and segments like /s/.

As trans men's changing bodies emphasize particularly clearly, sexual physiology itself is more fluid than most discussions of biological sex would suggest (see also Zimman, 2014). Transgender people are able to radically alter their bodies, suggesting that the biological basis for assigning a voice a sex may be more tenuous than ordinarily thought. But it is important to note that cisgender people, too, undergo profound bodily change throughout their lifetimes. This is true in puberty, as well as during the aging process, and is further reflected in choices individuals make about hormonal birth control; hormone replacement therapy after menopause or to treat the new diagnosis of "low T" (low testosterone) in older men; and even pregnancy and exercise. Social practices influence our bodies: certain behaviors are known to change individuals' testosterone levels (Bernhardt, Dabbs Jr, Fielden, & Lutter, 1998) and menstrual cycles are well known to be influenced by others' cycles. To the extent the body shapes vocal production, all of these changes have the potential to bring about changes in the voice as well.

This body of work underscores one of the greatest insights to be gained from studying trans voices. When physiology, socialization experiences, and gender identity are all the same, it is difficult to tease apart the influence of each of these factors and easy to reinforce biological determinism that is frequently used to delegitimize trans identities. With trans people, however, it becomes possible to test our hypotheses about potential links between anatomy and the voice, as well as the strength of those links. It is of great importance, then, that researchers carefully distinguish between different aspects of sex and gender rather than collapsing them into more intuitive, less reflexive categories—even where cisgender speakers are concerned (as in Zimman, 2013).

4 | CONCLUSION

Gender differences in the voice are a linchpin of much phonetic and sociolinguistic research. Although a great deal has been written about the phonetics of gender, there remains much that we do not yet know. The linguistic study of trans voices not only serves to correct the historical exclusion of a marginalized community of speakers but also offers new and unique insights that would be more difficult to discover, if not impossible, through the study of more gender normative populations. Trans speakers reveal how many unchecked assumptions have been woven into the accepted wisdom about how and why women's and men's voices differ. This research should motivate us to be more skeptical of claims about gender and the voice, particularly when they take a determinist perspective.

Trans people emphasize that the body matters, but that its matter is far more complex than tends to be imagined when the focus is on cisgender people. It is insufficient to say that one's larynx directly determines the gender of the voice because speakers generally use only a small range of the voices they are able to produce. With the incorporation of trans voices, bodily sex remains important but can no longer be seen as static, asocial, homogenous, or deterministic. The lessons offered by trans speakers are rarely particular to trans people; they reveal much about how the construction of the voice proceeds, making it crucial to incorporate lessons from trans voices into our studies of cisgender women and men as well.

Trans voices should push us to reconsider the very concept of the gendered voice. In light of the evidence discussed here, what does it mean to have a "female voice" or a "male voice"? Does it mean expressing all elements of the voice in accordance with norms for a particular gender category? If so, this would suggest that not all cis women have female voices and not all cis men have male voices. If not, which precise characteristics determine the gendering of a voice, and where is

the boundary between the possible categories? If F0 must be at a certain level, for instance, do prepubescent boys have female voices? In practice, "(fe)male voice" is used as shorthand for "the voice of a person deemed to be (fe)male"—a circular description of questionable usefulness that rests on researchers' assumptions about their speakers. To the extent we accept that gender is not a simple, natural binary, we must also recognize that the gendered voice is complex, multidimensional, and socially constructed. With rapidly increasing engagement with trans voices among sociocultural linguists, future research promises not only more inclusive and culturally sensitive treatment of trans voices but also new answers to key questions in our field.

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