

Sex, gender, and variability of the vocal tract

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Learning objectives. After reading these notes, you should be able to:

- explain the distinction between sex and gender;
- define major categories of sex and gender;
- identify problems with using a (male) default for vocal tract length; and
- explain how hormones and hormone replacement therapy do and do not affect the acoustic properties of the vocal tract.

1 Sex and gender

Sex is a collection of biological characteristics, such as reproductive anatomy, chromosomes, gene expression, and other biological attributes. These characteristics are usually divided up into two sex categories for humans: **female** and **male**. However, sex is more complex than a simple binary division, since the categories female and male do not neatly partition the space of biological properties. Not all members of a sex share all biological characteristics, and in fact, anyone can have a mixture of characteristics from different sexes, to varying degrees. People are often assigned to sex categories at birth based on observation of superficial attributes.

A related concept is **social gender**, or often just **gender**, which is a sociocultural identity based on how people perceive themselves in relation to various socially constructed roles and traits that are stereotypically linked to sex categories. The adult genders **woman** and **man** are linked to the female and male sex categories, respectively, and someone whose gender corresponds to their assigned sex in this way is called **cisgender** or **cis**.

However, the relationship between gender and sex is not universal or consistent, and it transcends these stereotypes. Someone whose gender does not correspond to their assigned sex in this way is called **transgender** or **trans**. For example, a woman who was assigned female at birth is a cisgender woman, while a woman who was assigned male at birth is a transgender woman. Someone whose gender falls outside the traditional man/woman binary is often called **non-binary**.

There is significant complexity and variation in terminology around sex, gender, and their relationship, especially at the individual level (Gray 2023). The sociopolitical connotations of these terms and concepts are equally complicated and often controversial. For expository purposes, these notes are necessarily simplified (and thus, imperfect), so the discussion here should not be taken as definitive or universally agreed upon. When discussing a particular person's gender, it is best to ask them what terminology they prefer.

Gender is deeply embedded throughout our language use, and thus language is one of the primary means of constructing and affirming gendered identities. This means that language is a central concern to trans people. Though the threat of physical violence looms large for trans people, language serves as the most pervasive ground on which trans identities are delegitimized and through which transphobia is perpetuated. By the same token, language is also the ground on which trans identities can be affirmed, reclaimed, and celebrated.

2 Sex, gender, and vocal tract length

One important reason that sex and gender matter for phonetics is that the resonant frequencies of the vocal tract depend in large part on its length, which correlates in some ways to sex and gender (albeit imperfectly). In phonetics textbooks and courses, a single vocal tract length of 17.5 cm is often used as a default value, because it is a reasonable value for men, and it makes resonant frequencies easier to calculate, since it evenly divides into 35,000 cm/s (a useful approximation of the speed of sound through the mouth). Sometimes, it is even implicitly taken as a general default across humans, if sex and gender are not mentioned.

However, use of this value is somewhat problematic, both historically and empirically, so extra thought and discussion are warranted. Male bodies are already frequently treated as the default in science and society generally, so using 17.5 cm as the default vocal tract length, especially by specifically identifying it as male, perpetuates the implication that male itself is the default (and thus, “normal”) and that everything else is a deviation from the default (and thus, “abnormal”).

Furthermore, singling out 17.5 cm as a default for a male vocal tract length (and a separate shorter length as a female default) treats male and female as homogenous categories. Further, since sex and gender are often conflated, defaults for sex categories are often implied to be representative of gender categories. However, this ignores a significant amount of variation within these categories, and it also excludes bodies and identities that fall outside of these categories. Female and male bodies are much more diverse than single averages can capture, women and men do not align perfectly to female and male, and sex and gender are both much more diverse than binary distinctions.

3 Sex, gender, and pitch

Sex and gender also have a complex relationship with the fundamental frequency (F0) of vocal fold vibration, which partly depends on the mass of the vocal folds: larger vocal tend to vibrate more slowly, resulting in a lower F0, and thus, a lower pitch, while smaller vocal folds vibrate faster, resulting in a higher F0 and higher pitch.

Cross-sex differences in male and female F0 typically arise during puberty, when the greatly increased testosterone production that characterizes male puberty causes a lowering and lengthening of the larynx and a thickening of the vocal folds, increasing their overall mass and thus lowering F0. Hormones are therefore an important contributing factor in determining a speaker’s F0 range.

While cisgender men typically experience this lowering during puberty, transgender individuals who take testosterone-based **hormone replacement therapy (HRT)** will undergo a similar thickening of the vocal folds regardless of their life stage. However, while testosterone HRT thickens the vocal folds, it does not lead to any other changes to the vocal tract; an individual on testosterone will therefore experience a lowering of their F0, but the resonant frequencies of their vocal tract will not be affected.

Estrogen-based HRT, on the other hand, does not lead to any physiological changes to the vocal folds or the rest of the vocal tract. For this reason, many transgender individuals who take estrogen pursue gender-affirming speech therapy to train their voices to more closely align with their gender. They may also work to re-learn their intonation patterns, volume, speech rate, and articulation, all

qualities that have their own gendered associations. Speech therapy is also an option for individuals on testosterone, but due to the characteristic thickening of the vocal folds from the hormone, many such speakers choose not to pursue speech therapy.

4 Sex and gender in phonetics research

Of increasing importance in (socio)phonetic research is the recognition of gender diversity that has not historically been acknowledged in the field until more recently. Recent accounts of the relationship between sex, gender, and the vocal tract have shown that speakers' alignment with certain gendered phonetic styles can vary across time, culture, language, and social group, which is strong evidence for the influence of sociocultural norms even where biology and physiology are clearly also at play. This may be especially true for transgender speakers. Importantly, because what is considered to be a "feminine" or a "masculine" voice varies depending on cultural norms, and it is crucial that acoustic studies also include support for the socially grounded explanations for sex and gender differentiations in the voice.

In short, determining phonetic correlates based on averages of human physiology and sex or gender presents some challenges and does not account for substantial sexual and gender diversity. While biological factors may present some limits on the frequencies a speaker is able to produce, it is by no means fixed and may be subject to change across the lifespan.

Consult Cler et al. 2020, Davies et al. 2015, Murray 2016, and Zimman 2018 for more information on gender diversity and the vocal tract. Note that transgender speakers on estrogen and transgender speakers who do not pursue any hormone therapy at all are underrepresented in the linguistic literature. One exception is in the speech language pathology literature, where transgender women on estrogen are overrepresented.

References

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