The Effects of Speaker Head Posture on Auditory Perception of Vocal Masculinity

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Summary: Objective. The purpose of this study was to investigate the impact of head position on listeners' perception of vocal masculinity.

Methods. Twelve cisgender women were recorded reciting two voiced sentences with varying head positions: baseline, flexed, and extended. Voice samples were cropped and fundamental frequency (f_o) was resynthesized to control for any changes in f_o across conditions. Twelve cisgender adults were recruited as listeners. Listeners were presented with 144 paired comparisons of speaker samples and were prompted to select the sample that sounded more masculine in each presented pairing. Ratings of masculinity were analyzed using Thurstone's law of comparative judgment. A repeated measures analysis of variance (ANOVA) assessed the effects of head positioning, followed by Dunnett's posthoc tests.

Results. The ANOVA showed a statistically significant effect of head position on listener perceptions of masculinity: speech in the flexed position was perceived as statistically more masculine than that in the baseline condition.

Conclusions. The results of this study support the use of head posture manipulation to achieve increased vocal masculinity, which adds to the limited research related to voice masculinization strategies for those seeking gender-affirming voice care.

Key Words: Gender-affirming voice care—Transmasculine—Flexion—Voice.

INTRODUCTION

The gender-diverse community includes those who identify as transmasculine or transfeminine, whose gender expression or gender identity does not match the sex assigned to them at birth. These people may choose to seek gender-affirming services to align their gender expression more closely with their gender identity. The term "transmasculine" refers to those whose gender identity is more masculine-leaning than their assigned sex at birth. Similarly, the term "transfeminine" refers to those whose gender identity is more feminine-leaning than their assigned sex at birth. However, it should be noted that the terms "transmasculine" and "transfeminine" lend themselves toward a more binary view of gender that is not fully representative of the true diversity of gender, and these terms do not reflect the identities of all transgender people.

Gender-affirming voice care services may be sought to help transgender people find stronger correspondence between their gender expression and their voice. Vocal differences associated with gender have historically been documented in cisgender (cis) people (those whose gender aligns with the sex that was assigned to them at birth). Often, cis male voices have a lower average fundamental frequency (f_o),[1] lower formant frequencies,[2] less breathy voice quality,[3] and a smaller range of f_o when speaking[4] compared with cis females. The voices of cis males may also be perceived as "denser" or "heavier" than the voices of cis females.[5] These differences are in large part due to changes that occur to the voice system during male puberty. With male puberty comes significant laryngeal changes and vocal tract lengthening. During this time, the androgen receptors on the vocal folds are sensitive to the influx of testosterone in the body, leading to physical changes, generally resulting in a voice that is perceived as more masculine.[6] By the end of puberty, on average, the person assigned male at birth has a longer vocal tract (the distance from the vocal folds to the lips) and a lower f_o due to vocal folds with greater mass and length compared to those assigned female at birth. However, f_o is a complex process that also relies on factors such as vocal fold tension and tissue stress.[7] Overall, the average postpubescent male will have an average f_o around one octave lower than that of a child (ie, a prepubescent person), whereas the female average f_o will only drop to one-third of an octave.[8]

Historically, gender-affirming voice care therapies have been designed with a focus on transfeminine people because of the minimal changes to the voice while undergoing gender-affirming hormone therapy (GAHT) with estrogen.[9] In fact, published research in voice focusing on transfeminine people outnumbered that focusing on transmasculine people by approximately 3:1 as of 2015,[10] though it is important to note that these data are no longer current. This imbalance in focus reflects the general assumption that transmasculine people who choose to undergo GAHT with testosterone typically experience an adequate level of voice change, more specifically, a sufficient lowering of f_o and/or desired changes to overall voice

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quality. However, not all transmasculine people experience the same voice changes nor to the same degree. One study showed that although the majority of transmasculine people undergoing GAHT with testosterone in the study were satisfied with their voice after 12 months, 24% reported symptoms of vocal fatigue, instability, strain, insufficient lowering, trouble projecting, and being perceived as sounding much younger than their actual age.[11] Furthermore, in a 2000 study,[5] two of the 14 transmasculine participants wished for a "heavier" voice after a year of GAHT with testosterone. Voice satisfaction was also explored by Soderpalm et al[12] who reported that a decrease in f_o through GAHT with testosterone is not always enough to achieve the client's vocal masculinization goals and the need for voice therapy may be underestimated for the transmasculine community. More recently, Azul[10] found that nearly one-third of transmasculine people continued to be misgendered, particularly over the phone, months to years after the start of GAHT. In a meta-analysis, authors in 10 of 15 papers identified a need for effective voice services to employ with the transmasculine population due to voice problems,[10] highlighting the need for voice services regardless of the person's choice to undergo GAHT or not.

Current behavioral treatments for transmasculine clients are limited and evidence is lacking for most current approaches. Two such approaches are targeting a lower f_o[13] and manipulating the vocal tract through treatments such as circumlaryngeal massage and laryngeal reposturing, which have been shown to lower f_o and vowel formants, resulting in a voice being perceived as more masculine following therapy.[14,15] These techniques are designed to decrease paralaryngeal tension and shift the larynx into a lower resting position, thus resulting in a longer vocal tract.[15]

Other current treatments for transmasculine clients include adapting vocal function exercises (VFEs) to target voice masculinization. VFEs include a set program of physiologic exercises consisting of a warm-up, stretch, contracting exercise, and a low-impact adductory power exercise. This protocol can be modified for the voice goals of the transgender client. The results of a recent case study showed that when VFEs were performed at least once per day over a 4-month period, the client demonstrated a smaller pitch range, a lower average f_o, and an increase in his voice-related quality of life.[16] These results suggest that VFEs, when used in conjunction with other therapy approaches, may be beneficial in voice masculinization.

Although some improvements to perceptions of vocal gender and acoustic changes typically associated with increased perceived vocal masculinity have been found through these limited investigations, other interventions are relatively unexplored. One aspect of gender-affirming voice care with limited research is the targeting of other auditory-perceptual impressions of voice, including vocal weight. Vocal weight is described as the perceived heaviness or lightness of a voice.[17] Since the voices of cis males are perceived as having a more "heavy quality" compared with the voices of cis females,[5] a voice may be perceived as having more masculine or feminine qualities with more or less vocal weight, respectively.[17] Anecdotally, vocal weight is an increasingly popular topic of discussion in clinical environments with some clients being introduced to the topic via online platforms. For instance, in May 2024, a search of the terms "transgender vocal weight" on YouTube resulted in 10 videos discussing vocal weight, vocal lightness, or vocal heaviness.

To target the auditory perception of vocal weight, physiologic changes may be made to the vocal folds. Changing the thickness and transverse stiffness of the vocal folds has been shown to affect both f_o and spectral shape cues, which, in tandem, influence gender perception when vocal fold length and vocal tract length are kept consistent.[18] Researchers in a recent study created a synthetic voice using a 3D model with consistent vocal fold and vocal tract length to investigate the impact of altering conditions such as initial glottal angle, vertical thickness, vocal fold longitudinal stiffness, vocal fold transverse stiffness, and subglottal pressure.[18] These physiologic changes directly impacted the spectral shape (the dispersion of acoustic energy across the voice's harmonic frequencies) of the voice signal, an important contributor to gender perception. Reducing thickness (perhaps decreasing the perception of vocal weight) and increasing transverse stiffness of the vocal folds resulted in increased f_o and in the difference between the amplitudes of the first and second harmonics of the voice signal; the resulting voice was perceived as more feminine. Alternatively, increasing thickness (perhaps increasing the perception of vocal weight) and decreasing transverse stiffness resulted in voices being perceived as more masculine, with lower f_o and smaller differences in the amplitudes of the first and second harmonics.[18] However, when the researchers altered the model to create a mismatch between f_o and spectral shape (eg, high f_o paired with low H1-H2 [ie the difference in amplitude between the first and second harmonic of the voice signal, respectively, also referred to as L_1-L_2[19]]), the gender of the speaker was perceived as more ambiguous by listeners.[18] Therefore, although modulation of f_o is often a primary target of voice therapy for the transgender client, this change alone may not be sufficient in altering listener perception of gender. Zhang et al[18] recommended therapies to target both f_o and spectral shape as listeners' perception of weight may be impacted by both the speaker's f_o and the speaker's spectral shape.

Findings by Zhang et al[18] were obtained through generating synthetic voices thus begging the question: how can vocal fold thickness be targeted in a real speaker? One theorized method of targeting vocal fold thickness is through manipulations of head posture, which may lead to changes in listeners' perception of vocal weight and thus speaker's vocal masculinity. For example, physical changes that result from changes in head posture include targeting pharyngeal width,[20,21] the width of the laryngeal tube opening,[22] and the degree of tilt of laryngeal cartilages.[23]

Although not yet studied in the transmasculine community, Knight and Austin[24] investigated acoustic changes, such as f_o and spectral shape due to flexion and extension of the head in a group of trained singers. With head extension, Knight and Austin[24] found that the amplitude of the first (H1) harmonic increased (ie, there was a higher spectral tilt) and vice versa with head flexion. In general, changes in spectral tilt may contribute to changes in voice quality. Auditory-perceptual qualities such as breathiness may be a result of higher spectral slope,[25] but this is inconsistent across studies.[26] For instance, singers were judged to have more singing talent when they presented with higher spectral slopes, which the authors attributed to more "ring" in the voice quality.[27] Overall, although spectral tilt is thought to contribute to voice equality, there is a complex relationship between spectral tilt and specific changes in auditory-perceptual judgments. Regardless, head posture manipulations may be one strategy to target changes to H1 and H2, therefore influencing spectral shape and thus perhaps listener perception of gender. Specifically, the research available would predict that, with extension, the resulting voice may be produced with less vocal weight and thus perceived as more feminine compared with a neutral or flexed posture. In contrast, with flexion, the resulting voice may be produced with more vocal weight and thus perceived as more masculine compared with a neutral or extended posture.

The purpose of this study was to determine the effects of targeting vocal fold thickness via head posture manipulations to influence the perception of vocal masculinity. We tested the hypothesis that unfamiliar listeners would describe voices produced during head flexion as more masculine and voices produced during head extension as more feminine compared with baseline samples.

METHODS

Participants

Study participants included two groups. There was a group of speakers who produced speech under different conditions of head position. There was also a group of unfamiliar listeners who were presented with speech stimuli from the speakers at a later time. All participants completed written consent, in compliance with the Boston University Institutional Review Board.

Speakers were 12 cisgender female adults (M = 24.4 years, SD = 8.6 years, range: 18–50 years) fluent in English. Participants underwent a hearing screening administered by a trained speech-language pathologist. They were presented with pulsed pure tones at octaves from 125 Hz to 8000 Hz and responded to all presented tones at 25 dB or lower in accordance with guidelines from the American Speech-Language-Hearing Association.[28] Participants were also asked about any present neck injuries that would prevent them from being able to extend their head up toward the ceiling for several minutes, thus preventing them from being able to complete the task. Other exclusion criteria included trained singing experience, as singers may have more advanced knowledge about vocal manipulation and breath support than nonsingers. Relatedly, speech-language pathologists or speech-language pathology graduate students were ineligible.

Listeners were 12 cisgender (four male, eight female) adults (M = 28.1 years, SD = 11.2 years, range: 21–61 years). These participants had no history of speech, language, or hearing disorders and were fluent English speakers.

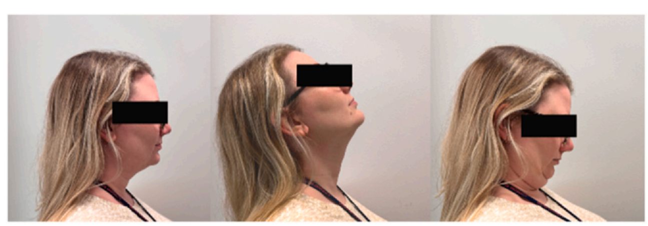
Training protocol

Participants were instructed to both flex and extend their head from their neutral posture (baseline) while producing two all-voiced sentences: "We rode along Rhode Island Avenue" and "I move your mail on my bed over near the wall or by my window." Voiced sentences were used so that recordings could be easily resynthesized after collection to make the median f_o consistent within speakers. Recordings were collected at eight time points in the following order: baseline, head extended, baseline, head flexed, baseline, head extended, baseline, and head flexed. For the extended position, the investigator confirmed that individuals were not extending their heads forward, but rather extended up and tilted backward to visually coincide with the demonstration in Figure 1. For the flexed position, individuals presented varying degrees of posterior placement of the jaw in relation to the cervical spine and degrees of cervical spine elongation; however, all presented with the general position as shown in Figure 1. Participants moved sequentially from one condition to the next with a baseline recording collected between each movement from extended to flexed and flexed to extended (Figure 1).

To elicit baseline samples, participants were instructed to use their typical speaking voice while seated in a neutral posture. For head-extended recordings, participants were asked to extend their head upward as if looking up at the ceiling. For head-flexed recordings, participants were instructed to pull their chin into a tucked posture, as if their chin is moving backward and toward the chest. For head-extended and head-flexed recordings, participants were asked not to try to force their voice back to their typical speaking voice.

Acoustic recordings

Participants wore a unidirectional cardioid headset microphone (Shure SM35 XLR; Shure Incorporated) during



Baseline Extended Flexed

FIGURE 1. Recordings were made as participants moved between head positions.

recordings. The microphone was placed 7 cm from the participant's lips at a 45-degree angle and the acoustic signal was preamplified (RME Quadmic II; Synthax Incorporated), then sampled at 44.1 kHz with 16-bit resolution (MOTU UltraLite-mk3 Hybrid; MOTU, Inc.). The recordings were collected using SONAR Artist (Boston, MA) version 23.10.0 (BandLab Technologies Ltd). After recordings were collected, the audio files were cropped using *Praat* into individual files that contained the two-sentence stimuli with a consistent 300-millisecond pause between them.

Additionally, the recordings were resynthesized in *Praat* to make the median f_o consistent within speakers for voiced sentence samples. The primary motivation in f_o resynthesis was to negate the possibility that the listener's perception of gender is based on f_o and not the speaker's head posture, as f_o has been shown to impact listener gender perception.[5,8] Each participant's median f_o was determined using the *Praat* "Voice Report" function during their second baseline recording and this value was used as a reference. All other recordings were manipulated using the Vocal Tool Kit function in *Praat* by clicking "Process" and "Change Median Pitch and Variation." Then the reference pitch was entered into the "New Pitch Median (Hz)" window. After each adjustment, the resulting median pitch was measured using the "Voice Report" function to confirm accuracy. If the median pitch differed by more than 0.1 Hz from the reference, the value entered into the "New Pitch Median (Hz)" window was adjusted until the measured median pitch matched the reference.

There were 15 possible combinations of the six head postures, however, within-condition comparisons were not included in the final data set (eg, Baseline 2-Baseline 3). The remaining 12 possible pairings were included in the primary listening task (Table 1: Stimuli Combination 1). Baseline recordings one and four were not used due to possible variability in the first and last collected samples. A second stimuli set was used to counterbalance the first stimuli set. The 15 possible pairs were reversed in the second stimuli set so that recording presented first was alternated (Table 1: Stimuli Combination 2).

TABLE 1.
Two Versions of Stimuli Combinations Used in the Listening Task

Stimuli Combination 1	Stimuli Combination 2
Baseline 2—up 1	Up 1—baseline 2
Baseline 2—down 2	Down 2—baseline 2
Baseline 3—up 2	Up 2—baseline 3
Baseline 3—down 1	Down 1—baseline 3
Up 1—baseline 3	Baseline 3—up 1
Up 1—down 2	Down 2—up 1
Up 2—down 1	Down 1—up 2
Up 2—baseline 2	Baseline 2—up 2
Down 1—baseline 2	Baseline 2—down 1
Down 1—up 1	Up 1—down 1
Down 2—baseline 3	Baseline 3—down 2
Down 2—up 2	Up 2—down 2

Listening procedure

The listening task was conducted at an off-site location through the online behavioral research program Gorilla Experiment Builder (gorilla.sc). For the entirety of the task, participants were connected to an investigator via a videoconference call for any questions or troubleshooting. Listeners used their personal computers with headphones and were instructed to set their headphones to a comfortable volume throughout the listening task.

Listeners were then taken to an instructions screen where they were introduced to the task. Participants were instructed both via written instructions and orally to allow both recordings to play all the way through before selecting an answer. Instructions also specified that each recording could be played a maximum of two times.

During the task, listeners were presented with a series of paired comparison samples in a single sitting. All permutations of sample pairings were presented in random order, matched by speaker and task. A 700-millisecond, 500-Hz tone played between recordings to clearly divide the two samples. After listening to both samples, the listener was prompted to select which recording sounded more masculine. Listeners made 144 total judgments and the task took an average of 1 hour and 2 minutes to complete.

Data analysis

Voice masculinity ratings from listening participants were analyzed via Thurstone's law of comparative judgment with case-V simplification.[29] This method converted listener ratings into scale values, placing each sample on a continuum of voice masculinity. Said scale values were calculated using the frequency with which each voice sample was rated as more masculine compared with other samples,[30,31] with higher scale values indicating a voice perceived as more masculine.

Statistical analysis

All statistical analyses were completed using Minitab software (Version 17, Minitab, Inc.). A repeated measures analysis of variance (ANOVA) was used to assess the effects of head posture (baseline, flexed, and extended) and repetition on listener perception of voice masculinity (scale values). Statistical significance was set a priori to an alpha level of 0.05. Effect sizes for the ANOVA were calculated as squared partial curvilinear correlations (η_p^2). Effect sizes of ~0.01 were classified as small, ~0.09 as medium, and > 0.25 as large.[32] Dunnett's posthoc tests were used to evaluate differences in the flexed and extended conditions relative to baseline and were defined according to recommendations specific to speech, language, and hearing sciences[33] as small (0.25), medium (0.55), or large (> 0.93).

RESULTS

The repeated measures ANOVA revealed a significant effect of the head posture ($P < 0.001$) on perceptual

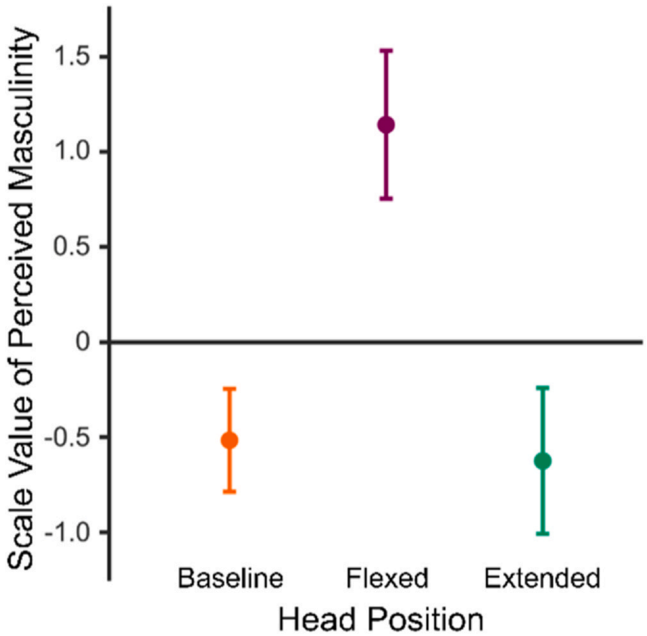


FIGURE 2. Scale values of perceived voice masculinity derived from Thurstone's law for each head posture condition (baseline, flexed, and extended). Error bars represent 95% confidence intervals. Higher scale values correspond to the perception of greater masculinity.

judgments, but no statistically significant effect of repetition ($P = 0.687$). The results of Dunnett's posthoc tests indicated that the scale values of perceived masculinity during the flexed condition were statistically significantly higher (more masculine sounding) than during the baseline condition ($t = 7.60$, $P_{adj} < 0.001$). In contrast, there was no statistically significant difference of the extended posture compared with the baseline posture ($t = -0.50$, $P_{adj} = 0.83$). Scale values for each speaker head condition are shown in Figure 2.

DISCUSSION

This study investigated the impact of speaker head posture manipulation on ratings of voice masculinity by unfamiliar listeners. The results were consistent, in part, with our initial hypothesis: voice recordings with speaker's head flexed resulted in the most masculine ratings by listeners compared with baseline and head extension recordings. However, the difference between the extended and baseline head postures was not statistically significant. Considering that speakers were cisgender females, whose larynges have not been exposed to high levels of testosterone during male puberty, it is possible that the ability to decrease the speakers' vocal masculinity was constrained by their baseline vocal qualities such as breathiness, higher f_o, higher formant frequencies, etc, causing a ceiling effect. For this reason, if the study were to be repeated with speakers whose larynges have been exposed to high levels of testosterone during puberty, we suspect that the result would be reversed (ie, head extended would be significantly less masculine than baseline but no difference would be seen between baseline and flexion).

Since f_o is known to influence listener perception of speaker gender,[5,8] it was controlled for in the present study to remove its potential influence on listener ratings. Thus, these findings demonstrate that the flexed head posture yielded increased perceived masculinity via voice quality changes that were distinct from f_o changes. One way of explaining this result based on the findings of Zhang et al[18] and Knight and Austin,[24] is that with head posture changes, the physical properties of the vocal folds were altered resulting in changes to the spectral shape. Head position has demonstrated changes primarily to the lower harmonics (ie, raising or lowering the amplitudes of harmonic frequencies with extension or flexion below 2 kHz, respectively). These changes may be due to numerous proposed hypothetical processes, including modulations to vocal fold adduction and/or glottal resistance (ie, glottal flow and subglottal pressure).[24] Changes in glottal configuration with head position may have affected spectral tilt or other features of the voice spectrum, and resulted in the increased perception of voice masculinity. Considering it does not yet have any specific acoustic correlates, we cannot interpret our findings as directly related to vocal weight. However, the spectral changes that may have been induced via head flexion in the current work might be correlated with the subjective impression of vocal weight and should be examined in further research.

One alternative possibility is that the head position changes in the current study resulted in changes to the shape of the vocal tract and therefore the vowel formant frequencies. Vowel formants are related to a listener's perception of gender[34–37] and were not controlled for in the current work. Despite this need for caution in interpretation, the present study adds to the limited research regarding techniques to increase masculinization and could provide a basis for further research in the area of vocal weight and the perception of vocal gender.

It can be challenging for clients to identify changes in the perceived gender of their productions as there are no commonly used objective measures or feedback to convey changes in resonance to clients in a clinical setting. Therefore, any cues or techniques to elicit quick changes in the voice signal may be beneficial in helping the client identify targets or explore new qualities that may contribute to their target vocal identity. Cueing the client to alter their head posture could introduce a new technique for masculinization beyond decreasing pitch that may be desirable to the client. Perhaps, this simple task could be used more widely to introduce clients to a quality they may have never previously considered, which could then be facilitated in their typical speech and posture. Moreover, although it would be unrealistic to have the client speak with a chin-tucked posture all the time, it may be a useful gesture to implement during times when the voice is the only indication of speaker gender, for example, over the phone. Finally, cues via head flexion could be used in conjunction with therapy techniques such as laryngeal reposturing.[14,15]

A limitation of this study is that all participants, both speakers and listeners, were cisgender. Cisgender speakers were chosen to account for any potential influence of factors, including past experience with vocal manipulation or familiarity with the task. However, these findings may not be generalizable. Future work should explore if and how a more gender-diverse speaking and listening cohort influence the results of head posture on the perception of vocal gender.

Finally, future studies should explore listeners' perceptions of vocal masculinity when speakers are instructed to alter vocal weight and f_o compared with altering only f_o and/or altering only vocal weight. Finding that a combination of approaches, altering vocal weight and f_o, is most effective in achieving vocal masculinization would provide further support for using a myriad of techniques simultaneously to target vocal masculinization (ie, to address multiple targets) with the goal of accomplishing a client's goals more quickly.

CONCLUSION

This study showed that within a group of cis females, speakers using a flexed head position were rated as the most masculine compared with baseline and head-extended samples, demonstrating that listener perception of speaker masculinity was affected by head posture. However, within the same participant group, listener perception of speaker masculinity was not observed when head-extended samples were compared with baseline and head flex samples. These results add to the limited body of literature related to voice masculinization strategies.

Declaration of Competing Interest

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