The Effect of Biofeedback on the Feminization of Voice in Transgender Women

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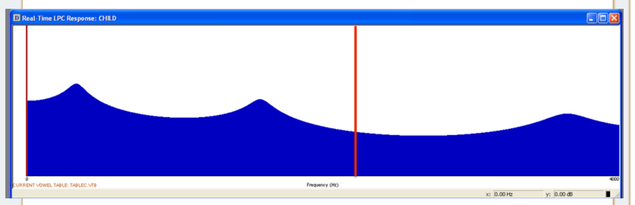
Introduction

- In order to find a voice more congruent with the feminine gender, some transgender women seek voice modification therapy.
- **Voice modification therapy** has typically focused on increasing fundamental frequency (F0) and formant frequencies. [1]
- Research on the efficacy of therapy methods has been limited, particularly in the area of **formant manipulation**.
- Though F0 is the most salient acoustic indicator of gender, raising F0 has yielded neither completely effective nor consistent results in increasing perceived femininity. [2]
  - **Vowel formants** (and specifically the second formant, F2) have been shown to act as important contributors to the perception of gender, **in conjunction with F0**. [3]
- Formant frequencies differ between males and females, with females exhibiting higher average formant frequencies.
- Inspiration for formant matching comes from **visual biofeedback.**



- With biofeedback, a speaker's formants are displayed on a linear predictive coding spectrum in real time.
- The participant uses the external visual information to attempt to alter their vocal quality to match a formant target.

[1] Hancock, A. & Garabedian, L. (2013). Transgender voice and communication treatment: a retrospective chart review of 25 cases. *International Journal of Language & Communication Disorders, 48* (1), 54-65.
[2] Gelfer, M. & Schofield, K. (2000). Comparison of Acoustic and Perceptual Measures of Voice in Male-to-Female Transsexuals Perceived as Female Versus Those Perceived as Male. *Journal of Voice, 14* (1), 22-33.
McNeill, E., Wilson, J., Clark, S., & Deakin, J. (2008). Perception of Voice in the Transgender Client. *Journal of Voice, 22* (6), 727-733.
[3] Carew, L., Dacakis, G. & Oates, J. (2006). The Effectiveness of Oral Resonance Therapy on the Perception of Femininity of Voice in Male-to-Female Transsexuals. *Journal of Voice, 21* (5), 591-603.
Gelfer, M. & Bennett, Q. (2013). Speaking Fundamental Frequency and Vowel Formant Frequencies: Effects on Perception of Gender. *Journal of Voice, 27* (5), 556-566.
Skuk, V. & Schweinberger, S. (2014). Influences of Fundamental Frequency, Formant Frequencies, Aperiodicity, and Spectrum Level on the Perception of Voice Gender. *Journal of Speech, Language, and Hearing Research, 57*, 285-296.
[4] Munson, B. et al. (2015). Gender Typicality in Children's Speech: A comparison of the Speech of Boys with and without Gender Identity Disorder. *Journal of the Acoustic Society of America, 137*(4), 1995-2003.

Objectives

1. Determine whether transgender speakers can use biofeedback to manipulate their F2 frequency to match a target formant frequency typical of female speakers.
2. Assess whether such an acoustic shift influences the speaker's perceived femininity.

Methods

- 11 transgender women and 20 cisgender men participated, forming 2 groups.
- Orientation to biofeedback and training in matching a formant target were provided.
- Speakers produced the words *bud*, *bad*, and *bod* in blocks of nine trials in three conditions to match a target formant frequency.
  - **Shifted-up**: target was scaled up to match a typical female F2 for the vowel in question (experimental condition)
  - **Shifted-down**: target was scaled down by the same amount (control for effects of atypical speech output)
  - **Own**: mean F2 value across speaker's own productions in the baseline phase
- Magnitude of shift was standard across speakers. Shift increment was added/ subtracted from each person's baseline F2.
- Trained graduate students measured F2 at the midpoint of each vowel; F0, F1, F2, and F3 values were extracted at the midpoint.
- Blinded listeners, recruited online through the Amazon Mechanical Turk crowdsourcing platform, rated the gender typicality of each speaker on a **visual analog scale** from "definitely male" to "definitely female". [4]
- Female productions were included for balance.
- Each file was rated by nine unique listeners.

Acoustic Results

- F2 was significantly higher in the shifted-up condition (and lower in the shifted-down condition), relative to the own condition (β = -111.79, *SE* = 26.17, p = 0.02).
- Between groups, F2 was significantly higher in transgender speakers than in cisgender speakers (β = 83.31, *SE* = 26.49, p = 0.004).
- Higher degree of variability of F0, F1, F2, and F3 was found in the transgender group.

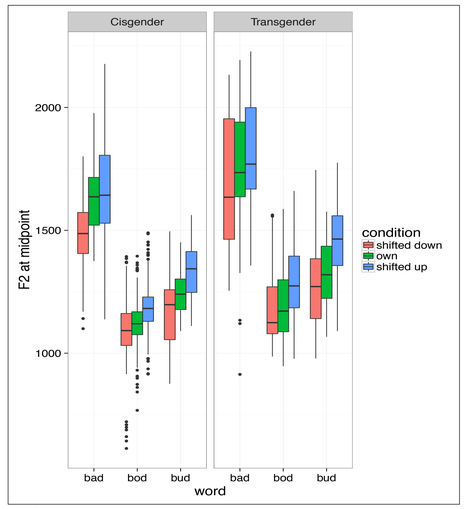


Fig. 1: F2 frequencies of tokens by group, word, and condition

Perceptual Rating

- While the transgender group received significantly higher femininity ratings than the cisgender group (β = 0.16, *SE* = 0.06, p = 0.008), they were still generally perceived as male (below midpoint on VAS rating scale).

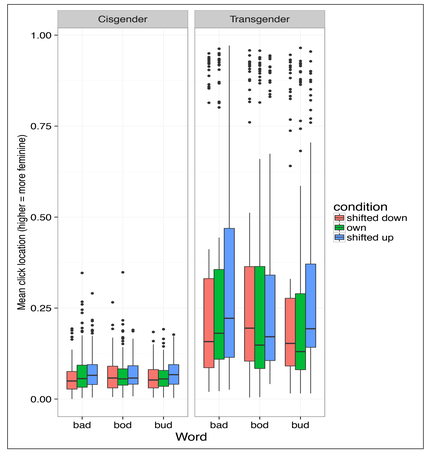


Fig. 2: Perceptual ratings of tokens by group, word, and condition

- Higher F2 frequencies were significantly associated with higher mean femininity ratings (β = 0.02, *SE* < 0.01, p = 0.002), as were higher F0 values (β = 0.05, *SE* = 0.01, p < 0.01).
- There was a significant interaction between F0 and F2 (β = 0.01, *SE* < 0.01, p = 0.001).

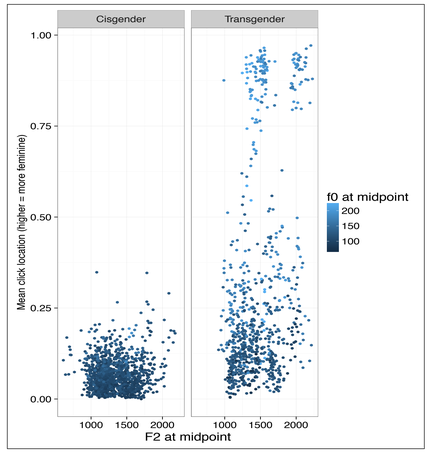


Fig. 3: Perceptual ratings of tokens by group, F2, and F0 (color represents F0, lighter = higher)

Discussion

- Participants successfully used biofeedback to match a shifted F2 target, across vowels and groups.
- Higher F2 values were associated with an increase in the perceived femininity of speech.
- F0 and F2 make a joint contribution to the perception of gender, confirming previous literature.
- Biofeedback might be a useful tool in voice modification therapy for transgender women.
- Larger studies and information about generalization will be essential before strong conclusions can be drawn.