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**.

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 bod, bud, and bad 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 ($\beta = -1.1179, SE = 26.17, p = 0.02$).
- Between groups, F2 was significantly higher in transgender speakers than in cisgender speakers ($\beta = 83.31, SE = 26.49, p = 0.004$).
- Higher degree of variability of F0, F1, F2, and F3 was found in the transgender group.

Perceptual Rating

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

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.