Vocal pitch and intonation characteristics of those who are gender non-binary

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ABSTRACT

Gender identity plays a role in speech production, distinct from the effects of biological sex, including pitch and intonation. Women generally produce higher vocal pitch than men, but this is subject to cultural norms. Women and men also differ in intonation patterns. Transgender men and women tend to pattern according to their gender identity, rather than biological sex, in terms of both vocal pitch and intonation characteristics.

Little is known about the speech of those who do not identify as men or women and instead identify as non-binary. We measured the average vocal pitch and observed intonation patterns of native American English speakers which included 9 non-binary people and compared these to the same measurements of 11 men and 10 women. Non-binary people produced their pitch, as well as their intonation, in ways that are different from both men and women.

Keywords: transgender, non-binary, fundamental frequency, intonation, sociophonetics

1. INTRODUCTION

Vocal pitch (F0 and intonation) are influenced by biological, cultural, and sociological factors, including gender. The voice is one way we perform and perceive gender, and an application of phonetic research is voice-therapy for transgender clients who wish to speak more like their target gender. Little research has examined those who do not identify as male or female and who identify instead under the "non-binary" umbrella. We sought to identify vocal pitch characteristics and intonation styles of non-binary speakers and to compare them to women and men.

2. GENDER AND PITCH

2.1 Effects of Biology and Biological Sex on Pitch

Biological factors such as height/weight, hormones, and vocal tract characteristics contribute to vocal pitch. As we grow, our voices change, and testosterone causes the lowering of male voices during and after puberty. Males, have an average vocal fold length 60% longer than that of females, which causes their voices to be generally lower than that of females [4]. Across language and culture, female norms include a mean pitch of 196-224 Hz, with an average range from 145-275 Hz and male norms include a mean of 107-132 Hz and an average range from 80-165 Hz [3].

2.2 Sociological Factors and Pitch

Beyond biology, gender norms and roles also play an important role in pitch production. In a study which compared Japanese and Dutch speaking women who were cis-gender (meaning they identified with the gender assigned to them at birth), Japanese women produced significantly higher pitch than Dutch women, controlling for biological factors [9]. Higher voices are more desired for women in Japanese society, so the difference was attributed to gender roles.

Research on transgender voices comes primarily from a perception standpoint – how well are transgender people perceived as the gender they identify with? One study examined the perception of gender through voice among MTF (male-to-female) and FTM (female-to-male) speakers, finding that speaking with more downward intonation might help to distinguish speakers as male [6]. In terms of speech production and perception interface, a study looked at MTF speakers before they transitioned and found they showed a higher F2 value for /a/ which correlates with a more feminine voice and also which notably, the listeners found more natural [7]. From the production side, fewer studies have been done. One study involving MTF speakers examined how "spreading the lips wider and bringing the tongue forward" [1] when speaking increases vowel formant frequencies which mirrors cis-female formant frequencies. Overall, perception has been used to inform production in studies involving the intersection of gender and pitch.

2.3 Hypotheses

It was hypothesized that the non-binary speakers will produce their pitch uniquely to men and women and that they will pattern roughly in between the men and women for average F0. It was also hypothesized that

they would combine characteristics of male and female intonation patterns. This is hypothesized because the existing evidence suggest that at least some aspects of F0/intonation are culturally and sociologically, rather than biologically, determined and therefore non-binary speakers will combine and/or reject cultural elements from both gender norms.

3. METHODS & MATERIALS

Native American English speakers between the ages of 18 and 35 were recruited for the study primarily from the Pennsylvania State University and the Philadelphia queer community via email and word-of-mouth. Written consent was waived and no identifying information was collected. Participants were recorded reading the first six sentences of "Rainbow Passage" [5] in a quiet room with minimal background noise whenever possible. After the recording, they completed a survey which included questions related to their gender identity. Their voice recordings were analyzed using Praat for F0; an average F0 was taken for each sentence and then those were averaged for each speaker. Pitch contours are described and a Tone and Break Indices (ToBI) transcription was completed for the first sentence of each recording. Mid-level tones were notated as high (H*) as per previous research [2]. Statistics were computed with SPSS [8].

3.1 Survey Questions on Identity and Expression

The survey questions confirmed that the participants were native speakers of American English and also assessed the following: 1) their gender identity, 2) the sex they were assigned at birth, 3) how strongly they felt they identify with male characteristics (on a scale of 0 to 100), 4) how strongly they felt they identify with female characteristics (on a scale of 0 to 100), 5) how strongly they felt they present or dress masculinely (on a scale of 0 to 100), 6) how strongly they felt they present or dress femininely (on a scale of 0 to 100), and 7) if they had received any psychological, hormonal, and/or voice therapy in regards to gender identity in the past or currently

Questions 3 and 4 regarding characteristics were left up to individual interpretation, but participants were advised that these were characteristics related to identity, and not expression (which was assessed in questions 5 and 6).

3.2 Participants

Of the 30 people who participated, 10 were women (nine cis-women and one trans-woman), 11 were men (six cis-men and five trans-men), and 9 were non-binary (five assigned female at birth and four assigned male at birth).

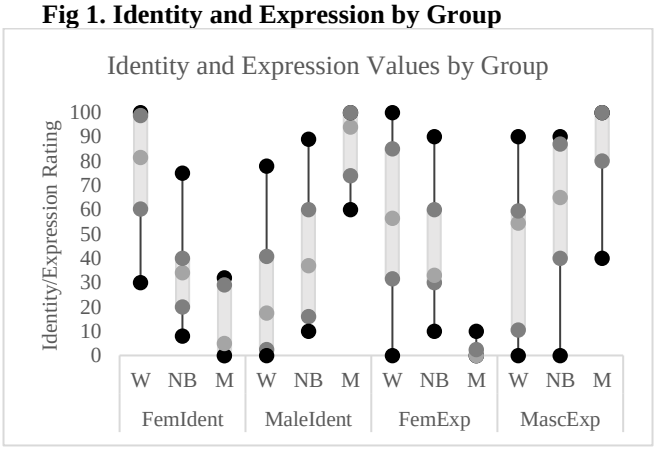
4. RESULTS

4.1 Survey Results

4.1.1 Identity and Expression

The results of female identity/male identity and feminine expression/masculine expression for each group can be observed in Fig 1. Binary participants showed a clear distinction between male and female identity; male participants also showed a clear distinction in gender expression while female participants had a significant component of masculine expression. Women (W) expressed more variation in their identity and expression than men (M). Non-binary (NB) participants had identity and expression values near the midpoint of the scale.

Fig 1. Identity and Expression by Group



4.1.2 Gender therapy

The number of participants who answered "yes" to the questions relating to psychological therapy, hormone replacement therapy (HRT) and voice therapy in regards to gender identity are summarized in Table 1.

Table 1: The number of participants in each group who had received or are receiving gender related therapy

	Women		Men		Non-binary
	Cis	Trans	Cis	Trans	-
Psych	1	0	0	5	5
HRT	0	0	0	5	5
Voice	0	1	0	1	0

All 5 trans-men were receiving or had received psychological and hormone therapy. Half of the non-binary participants had received or were currently receiving psychological and hormone therapy.

4.2 Fundamental Frequency

Descriptive statistics for each of the groups for average F0 are shown in Table 2. Women presented the highest average pitch and men presented the lowest average pitch which was expected given the norms established. The trans-men showed no statistically significant difference for F0 from the cis-men. Additionally, the trans-woman had an average pitch (159.3 Hz) higher than that of the men and non-binary groups; however, she did have the lowest voice of the women.

A one way analysis of variance (ANOVA) for F0 showed a main effect of gender on pitch, $p < .0001$. A multiple comparisons test using the Tukey HSD found that the F0 for women was statistically significantly different from the other two groups. No statistically significant difference was found between the men and non-binary groups (p=.089).

Table 2: Means and standard deviations for average F0 in *Hz*

Gender Identity	*M*	*SD*
Women	198.5	18.3
Non-Binary	144.3	36.7
Men	119.2	18.6

The non-binary participants assigned male at birth had an average F0 of 139.1 Hz and the non-binary participants assigned female at birth had and average F0 of 148.5 Hz. A t-test shows these were not statistically significantly different (p=0.689).

Pearson's correlations were done to look at the relationship between the degree of "female identity" and pitch as well as the degree of "male identity" and pitch. Both of these were significant ($p < .05$). The results are summarized in Table 3. F0 had a large correlation with female identity and a medium negative correlation with male identity.

Table 3. Pearson's R values and P-values for correlations between identity values and pitch

	R-value	p-value
Female identity	.732	<.00001
Male identity	-.491	.0058

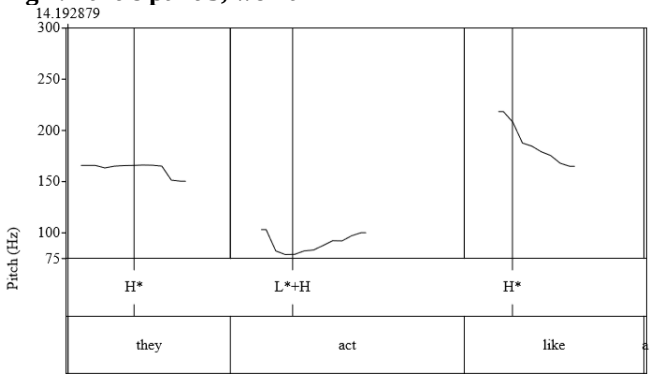
4.3 Intonational Characteristics

Descriptively, the intonation patterns of the women were much more varied with more rises and falls across the whole utterance than men, who primarily show less rising in pitch throughout the utterance and a tendency for a steady drop at the end of the utterance. Those who are non-binary appear to mix these two features. For the majority of the utterance, those who are non-binary have a steady downward intonation – similar to cis-men – but with some moments of rising.

Preliminary results of a ToBI analysis show that the women produce more L+H* and L*+H pitch accents while the men show a higher percentage of level tones with less fluctuation (L* or H*). This is consistent with past research on gender norms [2]. Compared to women, those who are non-binary produce more L* or H* pitch accents. They are also slightly less likely to use L*+H or L+H* pitch accents than woman, but do produce these more often than men. In another contrast to men, they are more likely to switch between L* and H* pitch accents across words (see Fig. 4).

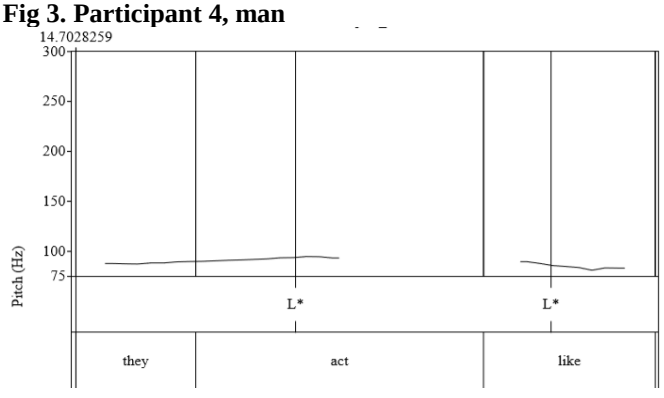
Case examples which highlighted characteristic intonation patterns from each group are shown in Figures 2, 3 and 4.

Fig 2. Participant 3, woman



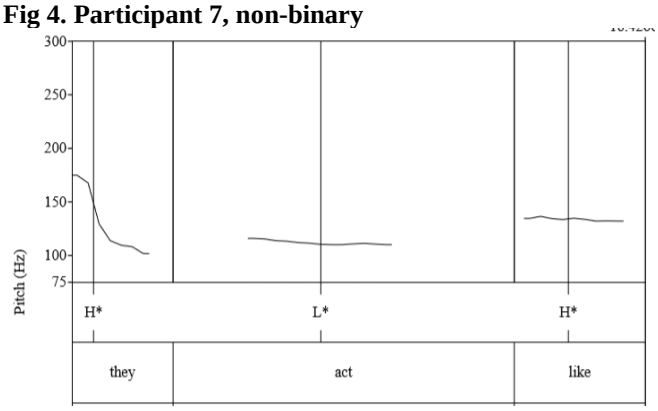
Participant 3 shows characteristic word level prosody of women with a more varied pitch contour and a L*+H "scooping" tone on the word "act".

Fig 3. Participant 4, man



Participant 4 displays a steady continuous low pitch accent across "they" and "act" with little variation and another low pitch accent on "like" which has a slight downdrift (decrease in pitch at the end of the word), characteristic of male intonation.

Fig 4. Participant 7, non-binary



Participant 7 shows an alteration between a H* pitch accent which falls to a L* and then another steady H* tone with some, but not much downdrift at the end of "like". This is unique to the other two intonation curves we have seen and highlights a trend that was noted more often in non-binary participants than in women or men.

5. DISCUSSION

The non-binary group performed pitch significantly differently from the women with an average F0 of over 50 Hz less than that of the women. While not statistically significantly different from the men, the non-binary group did have, on average, a F0 of about 25 Hz higher than the men and thus, was about in the middle of the women and men for F0. The lack of a significant difference between the non-binary participants assigned male at birth and assigned female at birth suggest that the biology itself is not the sole driving factor in pitch production. Results from the Pearson's correlation suggests a moderately positive relationship between female identity and pitch which is stronger than the relationship between male identity and pitch. This could be another reason as to why the non-binary group did not perform significantly differently from the men – they did not have a very high female identity rating. Specifically, non-binary people had near-equal maleness and femaleness, and since femaleness contributes more towards high F0, the same difference in identity ratings between the non-binary and the binary groups would affect the comparison between non-binary people and women more than the comparison between non-binary people and men.

It should be noted that the variation in the women's group cannot be understated. While they all identified as women, they still had much more variation in their identity than men did which impacts pitch production. This is important and lends support to the fact that moving away from strict boxes of gender allows for better description of variability and recognizes the diverse ways in which people can experience gender identity and produce their pitch as a result.

The results for intonation are in line with what was hypothesized. Those who identify as non-binary did not pattern like women nor did they pattern like men. Instead, they patterned with a combination of intonation characteristics, indicating either a mix of feminine and masculine traits or a neutrality – a rejection – of both. This also validates the concept of encoding gender identity in pitch or using it as a form of gender expression.

While differences were seen between the women and men groups for average F0, the average difference was only 80 Hz. This is detectable in speech, but this is not a tremendous difference. Therefore, for the non-binary group, which fell in the middle of those groups, to be statistically significantly different from both of the other two groups would be difficult especially with a limited number of participants.

6. CONCLUSIONS

Non-binary people produce their pitch and vary their pitch in ways that are different from those who are binary. The results of this study, while interesting, should not be taken as generalizations for all those who identify as non-binary. Even within this study, our non-binary participants described their gender identities in various ways including as agender, genderqueer, and genderfluid. While all of these identities fall under "non-binary" they may not all behave similarly which is consistent with the large variability we saw with our non-binary group.

Further research is needed in order to describe the other speech characteristics of those who are non-binary, for example in terms of vowel formants as those have been indicated as showing effects of gender [1] [7].

These results provide important information for speech-language pathology and voice therapy. Because voice therapy is one avenue for binary transgender people who are looking to sound more like the gender they identify as, the same could be true for those who identify as non-binary. Additionally, these results help to lay the groundwork for future linguistic studies that seek to identify vocal pitch characteristics of those who identify under a wide range of gender identities.

7. REFERENCES

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