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ORIGINAL PAPER

Masculine Voices Predict Well-Being in Female-to-Male Transgender Individuals

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Abstract Voices convey important social information about an individual's identity, including gender. This is especially relevant to transgender individuals, who cite voice alteration as a primary goal of the gender alignment process. Although the voice is a primary target of testosterone therapy among female-to-male (FTM) trans people, little research has explored the effects of such changes on their psychological well-being. Here, we investigated how FTMs' vocal gender related to their well-being. A total of 77 FTMs (M_{age} = 25.45 years, SD = 6.77) provided voice samples and completed measures of their well-being and psychological health. An independent group of 32 naïve raters (M_{age} = 22.16 years, SD = 8.21) subsequently rated the voice samples for masculinity. We found that FTMs whose voices sounded more congruent with their experienced gender (i.e., sounded more masculine) reported greater well-being (better life satisfaction, quality of life, and self-esteem; lower levels of anxiety and depression) than FTMs with less gender congruent (i.e., more feminine) voices (β = .48). The convergence between outwardly perceived vocal gender and gender identity brought about through hormone replacement therapy may therefore support greater well-being for FTMs.

Keywords Social perception · Masculinity · Transgender · Voice · Well-being · Gender identity

Introduction

Researchers have described the human voice as an "auditory face" that facilitates social perception (Belin, Fecteau, & Bedard, 2004). Like the face, the voice contains important social information about a person's age, sex, mood, and personality (Belin, Bestelmeyer, Latinus, & Watson, 2011; McAleer, Todorov, & Belin, 2014; Scherer, Koivumaki, & Rosenthal, 1972). Yet unlike the face, which has received a great deal of research attention (Jack & Schyns, 2015; Re et al., 2015; Tskhay & Rule, 2013, 2016), it remains unclear how vocal cues affect people's sense of identity, their interactions with others, and, ultimately, their well-being. This may be especially relevant to transgender (or "trans") individuals,[1] who often augment their voices to better represent their gender identity. Here, we examined how the congruence between vocal characteristics signaling gender and gender identity relates to the well-being of female-to-male transgender individuals (FTMs).

Many trans people experience what we describe as gender incongruence, or a perceived misalignment between the gendered characteristics of their sex assigned at birth and their experienced gender. This misalignment often causes significant distress (gender dysphoria; Zucker, Lawrence, & Kreukels, 2016), prompting

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[1] *Transgender* is an umbrella term subsuming individuals of many gender identities and expressions, typically linked by the common experience of identifying with a gender other than the one assumed by their sex assigned at birth (Lev, 2013). Researchers have used various terms to describe gender and the transgender community, as definitions are in flux (Reisner, Radix, & Deutsch, 2016). In this paper, we use the term *transgender* and *trans* interchangeably to refer to anyone who falls under the transgender umbrella. Further, we use *experienced gender* and *gender identity* to refer to one's subjective feeling of being a man, woman, both, or neither. Finally, we use the term *gender expression* to indicate the social cues and signals that communicate gender information (Collazo, Austin, & Craig, 2013).

many trans people to seek medically supervised gender alignment procedures. Cross-sex hormone replacement therapy (HRT) and gender-affirming surgeries are used to bring physical traits, including the voice, into agreement with the individual's experienced gender.

Such interventions can improve well-being. Trans individuals report experiencing greater violence (Stotzer, 2009), more psychological distress (Bariola et al., 2015; Dhejne, Van Vlerken, Heylens, & Arcelus, 2016), anxiety and depression (Budge, Adelson, & Howard, 2013), suicidality (Clements-Nolle, Marx, & Katz, 2006), and diminished quality of life (Newfield, Hart, Dibble, & Kohler, 2006) compared to cisgender (non-transgender) individuals. Much of this may result from the deleterious effects of social stigma and discrimination that result from negative societal attitudes toward perceived gender incongruence (Başar, Öz, & Karakaya, 2016; Bockting, Miner, Romine, Hamilton, & Coleman, 2013; Hendricks & Testa, 2012; Lick, Durso, & Johnson, 2013; Walch, Ngamake, Francisco, Stitt, & Shingler, 2012). However, evidence suggests that satisfying trans individuals' requests for hormonal and surgical treatment can ameliorate these risks. Though some have criticized the lack of standardized assessment methods and potential physiological risk associated with cross-sex hormone administration (Murad et al., 2010), a wealth of recent research has demonstrated that trans people's quality of life and well-being significantly improve following gender alignment procedures, with particular improvement occurring after hormonal therapy (see Costa & Colizzi, 2016; Heylens, Verroken, De Cock, T'Sjoen, & De Cuypere, 2014; Oda & Kinoshita, 2017; Smith, Madison, & Milne, 2014). This enhancement in well-being following gender alignment may result from increased gender congruence: Trans individuals often report greater affirmation of their gender identity and more fluid social interactions as their gender alignment progressively increases (Davis & Meier, 2014). Whereas past research has explored and documented this relation regarding *visible* changes (Ainsworth & Spiegel, 2010; Van de Grift et al., 2016), none has yet examined parallel effects for *vocal* changes.

As a highly salient gender cue (Sokhi, Hunter, Wilkinson, & Woodruff, 2005; Van Dommelen, 1990), the voice holds a special place in gender expression and identity for trans and other sexual minority populations (McNeill, Wilson, Clark, & Deakin, 2008; Munson, 2007). Both vocal and visual cues interact in perceptions of human gender (Smith, Grabowecky, & Suzuki, 2007); the voice may therefore strongly influence trans people's ability to "pass" as their experienced gender in public, affecting their social lives and core sense of identity. Thus, trans people often augment their voices to become more gender congruent through training or medical intervention. Indeed, regulation of gendered vocal cues is evident even in prepubertal children with non-normative gender identities (Munson, Crocker, Pierrehumbert, Owen-Anderson, & Zucker, 2015). Androgen HRT administered to FTMs can potently masculinize the voice, often producing an overall lowering of speaking pitch compared to natal males (Cosyns et al., 2014; Deuster et al., 2016; Hancock, Childs, & Irwig, 2017). In contrast, male-to-female trans people (for whom estrogen HRT does not alter the voice) must rely on vocal training or laryngeal surgery if they wish to speak in a typically female manner (Bowman & Goldberg, 2006; McNeill et al., 2008).

Recognizing the importance of the voice to the identity and well-being of trans individuals, the Transgender Self-Evaluation Questionnaire (TSEQ), subsequently revised into the Transsexual Voice Questionnaire (TVQ; Dacakis, Davies, Oates, Douglas, & Johnston, 2013), was developed to assess the degree to which trans people experience distress due to vocal properties that may not align with their gender identity. In examining the relation between the TSEQ and vocal femininity in a population of MTFs enrolled in speech therapy, Hancock, Krissinger, and Owen (2011) found that participants' scores correlated with both their own and others' perceptions of their vocal femininity; that is, MTFs with more feminine voices experienced less voice-related distress, and vice versa. Though these results show that gendered vocal characteristics can ameliorate psychological stressors related to the voice, past research has not explored how they relate to well-being beyond voice-specific distress or whether a similar relation exists for FTMs. We therefore sought to determine how vocal gender congruence broadly relates to psychological well-being in an FTM sample.

Past research has typically focused on MTFs, prompting many to address the need for greater representation of FTMs in transgender research and discourse (see Forshee, 2008). This imbalance likely reflects the asymmetric sex ratio in transgender prevalence reported in the literature (see Arcelus et al., 2015; Zucker, 2017 for reviews). However, recent investigations report that adolescents referred to gender clinics in North America and Europe now comprise more individuals assigned female at birth than male (Aitken et al., 2015), suggesting that a demographic change may be occurring in the trans population. In light of the growing proportion of FTM trans individuals, a commensurate increase in research effort is imperative in order to better understand this diverse and understudied population.

Indeed, the only studies of how trans people's voices relate to their well-being have exclusively studied MTFs, despite the dramatic vocal changes that occur through HRT administered to FTMs. Although HRT often produces satisfactory vocal changes in FTMs, studies of long-term androgen therapy have concluded that it is not always unproblematic in all cases (Cosyns et al., 2014). A survey of FTMs found that 88% rated vocal masculinization as equally or more important than sex reassignment surgery and 30% of respondents expressed interest in undergoing speech therapy to alter their voices even *after* HRT (Van Borsel, De Cuypere, Rubens, Destaerke, 2000). A masculine voice therefore constitutes an integral part of gender expression and identity for many FTMs, and likely has significant influence on their psychological well-being.

We therefore investigated the relationship between vocal gender congruence and overall psychological well-being in a sample

of FTMs larger than that used in any existing study on trans voice perception. Overall, we sought to determine whether the psychological benefit of agreement between visible gender characteristics and experienced gender extended to the auditory modality for FTM individuals. Specifically, we wanted to investigate whether masculine-identifying FTMs with more masculine voices experienced greater well-being than masculine-identifying FTMs with more feminine voices. Important control variables included the duration of time on testosterone HRT (which strongly impacts vocal masculinity; see previous) and perceptions of positive affect and attractiveness (known correlates of well-being; Benzeval, Green, & Macintyre, 2013; Umberson & Hughes, 1987). Unlike previous work that only examined voice-specific distress among small samples of MTFs enrolled in voice-therapy programs, we recruited a diverse, nonclinical sample of FTMs by capitalizing on the "video blogging" trend in the trans community (O'Neill, 2014). Further, rather than limiting our investigation to only voice-specific distress, we measured multiple factors of psychological well-being, including depression, anxiety, quality of life, self-esteem, and life satisfaction. Based on previous work demonstrating that MTFs with more feminine voices experience less voice-related distress, we predicted that FTMs with more *masculine* voices would experience greater well-being due to greater vocal gender congruence.

Method

Participants

Targets

We aimed to obtain data from at least 80 participants to serve as targets for the current study, ensuring 80% statistical power at $\alpha = .05$ for a medium effect size ($r = .30$; Cohen, 1992). Anticipating attrition, we invited 215 FTM YouTube video bloggers to participate in an online survey examining masculinity and well-being using YouTube's internal email service. We identified the invitees using relevant search terms in various combinations (e.g., *transman*, *transmale*, *FTM*, *transgender*, and *hormones*) and then navigating to the user's channel where a complete public video set and contact option could be found. Of the 215 individuals originally identified, 134 engaged in the study, 89 of whom returned complete responses. We obtained informed consent from all targets to download and use their videos for research purposes. We eliminated 12 targets because their video blog was inactive ($n = 5$) or their video quality was low ($n = 7$). Thus, our final sample consisted of 77 FTMs ($M_{age} = 25.45$ years, SD = 6.77; ethnicity 73% White, 8% Black, 8% mixed ethnicity, 5% East Asian, 4% Hispanic, and 2% non-disclosed). All were assigned female at birth but identified with a masculine gender at the time of the study and were on testosterone HRT (from which masculinization progresses over the course of 1–2 years; Deuster et al., 2016). They reported the duration of their HRT ($M = 15.21$ months, SD = 6.66) and therefore represented various stages of hormone-induced vocal masculinization. We entered these participants into a draw for a $100 gift card as compensation.

Raters

We recruited a separate group of 32 undergraduate students at the University of Toronto to rate the voice samples ($n_{female} = 19$, $n_{male} = 13$; $M_{age} = 22.16$ years, SD = 8.21; ethnicity: 59% East Asian, 19% South Asian, 16% White, 6% Black) in exchange for partial credit in an introductory psychology course. We based our sample size on the number of raters typically needed to achieve acceptable levels of inter-rater reliability in social perception studies ($n = 30$; e.g., Rule & Tskhay, 2014), as we intended to aggregate their judgments for each target, and obtained informed consent from all participants.

Measures

We used the following published scales to assess different areas of psychological well-being, all with established internal consistency, reliability, and validity (Burckhardt, Anderson, Archenholtz, & Hägg, 2003; Dacakis et al., 2013; Davies & Johnston, 2015; Fydrich, Dowdall, & Chambless, 1992; Pavot & Diener, 2008; Santos, Aguiar, Baeck, & Van Borsel, 2015; Sinclair et al., 2010; Storch, Roberti, & Roth, 2004).

Beck Anxiety Inventory (BAI)

This 21-item self-report questionnaire asks respondents to indicate the occurrence of anxiety symptoms (e.g., "Dizziness or lightheadedness") using a 4-point scale (1 = *not at all*, 4 = *severely*; Beck, Epstein, Brown, & Steer, 1988). Higher scores indicate greater anxiety (here: Cronbach's $\alpha = .95$).

Beck Depression Inventory-II (BDI-II)

This multiple-choice self-report scale assesses symptoms of depression. Each of the 21 subsections assesses a different symptom, and respondents are asked to select the statement that best describes their feelings at the time. For example, the first section evaluates respondents' feelings of "Sadness" using 4 choices (1 = *I do not feel sad* to 4 = *I am so sad or unhappy that I cannot stand it*; Beck, Steer, & Brown, 1996). Higher scores indicate greater depression (here: Cronbach's $\alpha = .81$).

Flanagan Quality of Life Scale (QOLS)

This 15-item scale assesses respondents' satisfaction with their interpersonal relationships, material comforts, and occupational opportunities. Respondents are asked to indicate their degree of

satisfaction in each of 15 domains (e.g., "Intellectual development: education opportunities, etc.") using a 5-point scale (1 = *very dissatisfied*, 5 = *very satisfied*; Flanagan, 1978). Higher scores indicate better quality of life (here, Cronbach's $\alpha = .83$).

Rosenberg Self-Esteem Scale (SE)

This 10-item measure assesses respondents' self-esteem by asking them to indicate how much they agree with statements such as "I feel that I have a number of good qualities" using a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*; Rosenberg, 1965). Higher scores indicate greater self-esteem (here: Cronbach's $\alpha = .98$).

Satisfaction With Life Scale (SWLS)

This 5-item scale assesses respondents' satisfaction with the conditions of their life. Respondents are asked to indicate the degree to which they agree with statements such as, "So far I have gotten the important things I want in my life" using a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*; Diener, Emmons, Larsen, & Griffin, 1985). Higher scores indicate greater life satisfaction (here: Cronbach's $\alpha = .84$).

Transsexual Voice Questionnaire (TVQ)

This 30-item questionnaire assesses the degree of social impairment or distress experienced by trans people specifically due to gender incongruence in their voices. The measure contains statements such as "I feel discriminated against because of my voice" evaluated using a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*; Dacakis et al., 2013), with higher scores indicating greater distress. The scale is principally used in speech and language pathology for MTF patients; as such, we adapted the wording in eight of the 30 items to accommodate our FTM sample (e.g., the item "My voice makes me feel less feminine than I would like" was changed to "My voice makes me feel less masculine than I would like"), as in Hays (2013). Thus, although the TVQ has not been validated specifically within FTM populations, we thought it provided the best means to assess voice-related distress in the present study (here: Cronbach's $\alpha = .94$).

Procedure

The FTM participants recruited from YouTube completed our well-being measures online as well as a self-rating of vocal masculinity ("Right now I would describe my voice as…"; 1 = *very feminine*, 7 = *very masculine*) and questions about basic demographic information (i.e., age, ethnicity, and years of education). We extracted a single speech sample for each target from the audio track of one of their current public YouTube videos, selecting only high-quality samples containing clear, unobstructed speech devoid of background noise. Next, we used a random splicing technique (Van Bezzoijen & Boves, 1986) to mask the targets' speech and to ensure that the raters were not biased by any verbal content, including targets' gender identities, which were often disclosed in the videos. We chose this strategy over other content-masking techniques because previous studies have shown that it does not interfere significantly with judgments of masculinity (Scherer et al., 1972; Van Bezzoijen & Boves, 1986). We prepared the stimuli using Audacity software (Mazzoni & Dannenberg, 2000), removing all silent intervals from each speech sample and all large amplitude peaks in the waveform. We then spliced each track into 200-ms intervals and randomized their order, creating new tracks normalized for speech amplitude and devoid of meaningful content with vocal pitch and resonance preserved. We subsequently trimmed all of the samples to 5-s thin slices (Ambady & Rosenthal, 1992).

Raters listened to each of the 77 5-s vocal samples in random order, rating them for masculinity ("How masculine is this person?" 1 = *very feminine*, 7 = *very masculine*; inter-rater agreement Cronbach's $\alpha = .98$), positive affect ("How happy is this person?" 1 = *not at all happy*, 7 = *very happy*; inter-rater agreement Cronbach's $\alpha = .75$), and attractiveness ("How attractive is this person?" 1 = *not at all attractive*, 7 = *very attractive*; inter-rater agreement Cronbach's $\alpha = .81$) immediately after each clip. The positive affect and attractiveness ratings served as control variables, as previous research has demonstrated that they correlate with both masculinity (Fagot, Leinbach, Hort, & Strayer, 1997; Feinberg, Jones, Little, Burt, & Perrett, 2005; Hess, Adams & Kleck, 2004) and well-being (Benzeval et al., 2013; Umberson & Hughes, 1987). We did not tell the raters that the targets were trans individuals or mention that the study involved gender identity at any point prior to debriefing. All procedures accorded with the approval of the university's research ethics board and with the 1964 Declaration of Helsinki and its later amendments or comparable standards.

Analytic Strategy

Given that we employed multiple predictor and outcome variables, we analyzed the data using structural equation modeling (see Table 1 for descriptive statistics and simple correlations). Before proceeding with the analysis, however, we submitted the variables to a principal axis factor analysis with promax rotation. We expected ratings of vocal masculinity to load onto a Vocal Gender Congruence (VGC) factor along with hormone therapy duration, which has strong masculinizing effects on the voice. We further wanted to establish that the targets' BAI, BDI-II, QOL, SE, and SWLS scores would all load onto a single well-being (WB) factor. We did not have any specific predictions regarding the TVQ scores because the scale contains items directly related to both gender (e.g., "My voice makes me feel less masculine than I would like") and well-being (e.g., "I feel anxious when I know I have to use my voice"). If the TVQ scores loaded onto the VGC factor, we would conclude that the measure better

describes vocal gender congruence (or incongruence), whereas if they loaded onto the WB factor, we would conclude that they better describe general well-being. We also included the attractiveness and positive affect ratings to ensure that they differed from VGC and WB, allowing us to model them as independent predictors of WB. Given the acceptable-to-high levels of inter-rater agreement for ratings of the targets' masculinity, positive affect, and attractiveness noted above, we aggregated these ratings to compute mean scores on each variable for every target.

Horn's parallel analysis (Hayton, Allen, & Scarpello, 2004) revealed that a two-factor solution described the data well, $\chi^2(34) = 1.12, p > .99$ (see Table 2 for factor loadings, variance explained, and rotated eigenvalues). All five well-being measures (BAI, BDI-II, QOL, SE, and SWLS) loaded onto the first (WB) factor, explaining 32% of the total variance. The second (VGC) factor consisted of hormone therapy duration, raters' mean perceived vocal masculinity scores, targets' self-reported vocal masculinity scores, and the TVQ scores, explaining an additional 29% of the total variance. Thus, in this sample, the TVQ seemed to capture targets' concerns with voice-related gender congruence better than their overall well-being. All of the indicators loaded strongly onto their respective factors and displayed minimal cross-loadings. Targets' attractiveness and positive affect scores did not load onto either factor, justifying their roles as independent control variables. The factors correlated moderately, $r(75) = .51, p < .001$.

Following the factor analysis, we estimated latent VGC and WB factors composed of their respective items and regressed the WB factor onto the VGC factor while controlling for vocal attractiveness and positive affect. Because the QOL and SWLS scores tap into similar positive concepts of well-being, we correlated their residual variances in the model. Similarly, because the BAI and BDI measure negative contributions to well-being, we also correlated their residual variances. Finally, we correlated the residual variances of targets' hormone therapy duration and raters' mean masculinity judgments because hormone therapy generates noticeable changes in vocal properties that likely heavily influence perceptions of masculinity (Cosyns et al., 2014; Deuster et al., 2016).

We estimated the model using the maximum likelihood estimator in the lavaan structural equation modeling package (Rosseel, 2012) implemented in R (R Development Core Team, 2008). Because the χ^2 and RMSEA estimates are biased in small samples (Kenny, Kaniskan, & McCoach, 2014), we followed Kline's (2015) recommendation to report the Swain-corrected χ^2, the Swain-corrected χ^2 divided by the degrees of freedom (χ^2/df), and the Swain-corrected Comparative Fit Index (CFI) values to evaluate the model's fit (see also Herzog, Boomsma, & Reinecke, 2007). A nonsignificant Swain-corrected χ^2 value, χ^2/df value lower than 2, and CFI greater than .95 indicate good overall model fit (Hu & Bentler, 1999).

Table 1 Means and zero-order Pearson's product-moment correlations between the predictor and outcome variables

Measure	*M* (SD)	2	3	4	5	6	7	8	9	10	11
Predictor variables											
1. Hormone therapy duration	15.21 (6.66)	−.23*	.79***	−.16	.76***	−.31**	−.41***	.40***	.47***	.37***	−.72***
2. Rater vocal attractiveness	3.62 (0.56)	–	−.11	.35**	−.13	.01	.04	−.22	−.17	−.13	.15
3. Rater vocal masculinity	4.37 (1.20)		–	−.13	.75***	−.29*	−.36**	.39***	.28*	.30**	−.65***
4. Rater vocal positive affect	4.07 (0.44)			–	−.15	.10	.15	−.05	−.00	−.19	.05
5. Self-reported masculinity	4.20 (1.61)				–	−.23*	−.31**	.41***	.44***	.35**	−.78***
Outcome variables											
6. Anxiety (BAI)	13.47 (10.92)					–	.−.75***	−.71***	−.64***	−.85***	.30**
7. Depression (BDI-II)	12.45 (12.20)						–	−.71***	−.64***	−.85***	.40***
8. Life satisfaction (SWLS)	40.61 (9.12)							–	.78***	.75***	−.44***
9. Quality of life (QOLS)	11.25 (5.31)								–	.71***	−.51***
10. Self-esteem (SE)	25.44 (8.86)									–	−.47***
11. Voice-related distress (TVQ)	40.53 (30.14)										–

Hormone therapy expressed in months

BAI Beck Anxiety Inventory; *BDI-II* Beck Depression Inventory; *SWLS* Satisfaction with Life Scale; *QOLS* Flanagan's Quality of Life Scale; *SE* Rosenberg Self-Esteem Scale. *TVQ* Transsexual Voice Questionnaire

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 2 Factor loadings, variance explained, and rotated eigenvalues resulting from the factor analysis of the predictor and outcome variables

Indicator	WB	VGC
Predictor variables		
1. Hormone therapy duration	.01	**.89**
2. Rater vocal attractiveness	− .04	− .18
3. Rater vocal masculinity	− .05	**.86**
4. Rater vocal positive affect	− .05	− .15
5. Self-reported masculinity	− .06	**.92**
Outcome variables		
6. Anxiety (BAI)	− **.80**	.08
7. Depression (BDI-II)	− **.91**	.04
8. Life satisfaction (SWLS)	**.80**	.08
9. Quality of life (QOLS)	**.71**	.13
10. Self-esteem (SE)	**.94**	− .04
11. Voice-related distress (TVQ)	− .07	− **.84**
Variance explained	32%	29%
Rotated eigenvalue	3.52	3.17

Significant item loadings on each factor indicated in bold

Hormone therapy duration expressed in months

BAI Beck Anxiety Inventory; *BDI-II* Beck Depression Inventory; *SWLS* Satisfaction with Life Scale; *QOLS* Flanagan's Quality of Life Scale; *SE* Rosenberg Self-Esteem Scale. *TVQ* Transsexual Voice Questionnaire

Results

All of the individual indicators loaded onto their predicted factors, suggesting they indeed described either vocal gender congruence or well-being, as appropriate. Overall, the structural equation model fit the data well: Swain-corrected $\chi^2 = 54.11$, $p = .03$; $\chi^2/df = 1.46$; CFI = .96. The model revealed that VGC, positive affect, and attractiveness jointly explained approximately 25% of the variance in FTMs' WB. As shown in Fig. 1, the latent VGC factor significantly predicted the latent WB factor ($\beta = .48, Z = 3.77, p < .001$) over and above the influence of vocal attractiveness ($\beta = -.01, Z = 0.10, p = .92$) and positive affect ($\beta = -.09, Z = 0.78, p = .43$) such that greater vocal gender congruence predicted greater well-being.

Discussion

FTMs reported experiencing greater well-being as a function of the congruence between gendered aspects of their voices and their gender identity (i.e., vocal masculinity). Specifically, FTMs exhibited greater life satisfaction, greater quality of life, greater self-esteem, less anxiety, and less depression according to how masculine they and others perceived their voices. These findings parallel those observed in previous studies examining vocal properties in MTFs, for whom greater vocal gender congruence (i.e., vocal femininity) also predicted higher levels of voice-related well-being (Hancock et al., 2011). Our findings join a larger body of literature that supports the benefit of gender alignment procedures for the well-being of trans people (Cohen-Kettenis & Gooren, 1993; Costa & Colizzi, 2016; Davis & Meier, 2014; Keo-Meier et al., 2014; Meier, Fitzgerald, Pardo, & Babcock, 2011). The multiple indicator model we employed allowed us to subsume many positive (e.g., self-esteem) and negative (e.g., anxiety symptoms) variables associated with well-being into one construct. These strong results add further skepticism to the few voices that question the benefits of HRT for trans populations (Murad et al., 2010).

Trans people regularly report experiencing high levels of discrimination, stigma, and hostility that diminish their psychological and physical well-being (Başar et al., 2016; Bockting et al., 2013; Hendricks & Testa, 2012). Research suggests that such negative attitudes toward trans people often stem from cultural intolerance of gender incongruence (Herek, Gillis, & Cogan, 2015; Sjoberg, Walch, & Stanny, 2006; Walch et al., 2012). The present findings help to link these two areas of research by showing that trans individuals whose vocal gender better matches their experienced gender enjoy greater well-being along a broad array of measures that go beyond simple satisfaction with their voices. Our data therefore help to inform the ameliorative efforts provided by increased gender congruence (in this case through hormonally induced vocal masculinization) by demonstrating their scope and magnitude in the daily lives and psychological health of FTMs. Indeed, research shows that gender-affirming medical intervention dramatically improves FTMs' psychological well-being (Davis & Meier, 2014; Newfield et al., 2006), which our results suggest at least partly depends on changes in vocal properties. This comports with the subjective experience

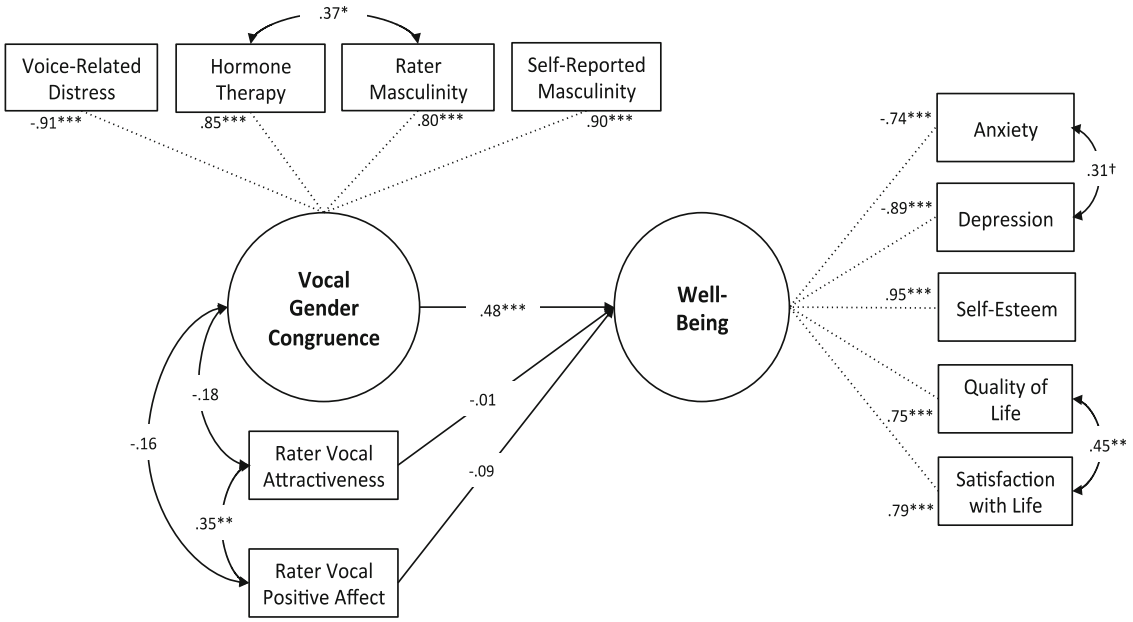

Fig. 1 Structural equation model estimating the contribution of vocal gender congruence to FTMs' psychological well-being. *Note*. Path values represent standardized regression coefficients. Dashed lines indicate relations between individual indicators and their respective latent variables. $^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

of many FTMs, who cite masculinizing their voices as one of the most important goals of the gender alignment process (Van Borsel et al., 2000). To our knowledge, this is the first study to demonstrate this relationship empirically. Notably, one previous study suggested that cisgender individuals' well-being seems not to correlate with perceptions of vocal masculinity/femininity (Sandmann et al., 2014), suggesting that this may be unique to transgender populations, though more investigation is needed.

Previous studies have shown that convergence between *visible* gender characteristics and experienced gender identity relates to higher levels of well-being among FTMs and MTFs (Ainsworth & Spiegel, 2010; Davis & Meier, 2014; Van de Grift et al., 2016). Our results complement these by extending the association to audible gender cues. Yet, future work might seek to explore this in additional and combined modalities; for instance, by investigating how trans people employ gender-typical colognes and perfumes to facilitate perceptions of their gender (by themselves and others), or by examining how the combination and crossing of gender-congruent and gender-incongruent visual and aural cues may compete in impressions of trans' individuals gender and differentially influence their ability to pass (e.g., Freeman & Ambady, 2011; Rudd, 1996; Smith et al., 2007).

Moreover, our findings also show that judgments of masked thin-slice audio clips of trans people's voices can predict meaningful outcomes just as well as standardized speech samples of several minutes in length used in previous work (Hancock et al., 2011). We chose to content-mask our speech samples using a technique that preserves pitch and resonance (which are prioritized in gendered judgments; Coleman, 1976; Scherer et al., 1972), though other vocal cues like prosody and intonation also influence gender perceptions (albeit perhaps to a lesser degree; Günzburger, 1995). Although this did not appear to interfere with our raters' ability to evaluate the speech samples on masculinity (i.e., targets' own self-report of vocal masculinity agreed with raters'), it may have affected ratings of positive affect and attractiveness. We found no evidence that ratings of these measures related to FTMs' well-being, which contrasts with research suggesting that *visual* attractiveness and affect predict greater levels of well-being (Benzeval et al., 2013; Umberson & Hughes, 1987). This suggests that affect and attractiveness do no relate in the auditory modality or that they highly depend on prosodic cues lost in the randomized splicing technique that we employed (Scherer et al., 1972). Thus, whereas future studies might benefit from adopting a thin-slice approach to improve the efficiency of research with trans participants (see Ambady, LaPlante, & Johnson, 2001), such efforts should consider confirming our findings using unmasked standardized speech to disentangle the constraints that each method applies.

Further limitations of the present study include the limited age range of our FTM targets. Because we recruited these participants through YouTube, they represent a fairly narrow age range (75% under the age of 28) of frequent social media users. Older trans adults lack representation in this and other research on well-being despite exhibiting worse physical and mental health than younger trans adults (see Fredriksen-Goldsen, Kim, Shiu, Goldsen, & Emlet, 2014; Orel, 2014; Persson, 2009). Future work should improve upon the current study by examining targets from a broader age spectrum.

We also employed a smaller sample than that used in other investigations of well-being and quality of life among trans individuals due to the constraints of our research question. Because our study principally focused on how social perception impacts the well-being of trans individuals, assuring high-quality, current stimuli was critical. Though our sample size pales to that of large-scale epidemiological studies of well-being (e.g., Rotondi et al., 2012), it achieved respectable levels of power considering the parameters described above and is considerably larger than any existing study on trans voices specifically (e.g., Hancock et al., 2011, 2017).

Moreover, despite observing strong results, our study was somewhat limited by its cross-sectional design. We chose to sample a single time point in the progression of vocal masculinization over a large number of targets in order to draw inferences about how this salient change may affect psychological well-being. Future researchers would benefit from studying a population longitudinally over time to quantify more precisely how, and to what degree, well-being changes as a function of vocal change. Exploration of potential biases introduced by raters' gender identities would also offer a valuable future direction: Our rater pool consisted only of cisgender-identified participants due to ease of recruitment, yet other research groups may wish to investigate the effects of including transgender or mixed-group raters.

In conclusion, we found that increased vocal gender congruence predicts improved psychological well-being outcomes among FTMs. Though understudied in both the social perception and well-being literatures, the voice seems to constitute a key component of gender identity and expression for FTMs with far-reaching influence in their daily lives and psychological health. Better understanding of the importance of gender congruence, and the role of the voice specifically, in the lives of trans people may therefore help to improve the health and well-being of this population.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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