

**Exploring the vocal satisfaction and self-perceived vocal masculinity**

**of**

**transmasculine individuals.**

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by Sidney Gig-Jan Wong

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## Abstract

Minimal research has been conducted on transmasculine individuals due to the prevailing belief that exogenous androgen hormone treatment lowers the f0 to a satisfactory masculine-sounding voice (Van Borsel et al., 2000; T'Sjoen et al., 2006), but it has shown a gender-conforming speaking fundamental frequency does not equate to a gender-affirming voice (McNeill et al., 2008).

The current study explores the vocal satisfaction of transmasculine individuals by employing a global online survey. It identifies psychosocial and communicative effects that may impact this diverse population and aims to place them into the conceptual framework developed by Azul et al. (2017) as feasible in an online survey. The dimensions of the framework include demographic information (e.g. gender identity, binding, smoking etc.), vocal and communicative impacts (e.g. personal, physical, socioeconomic etc.), acoustic measurements (e.g. mean and mode f0), and testosterone history, and self-perceived vocal masculinity.

The current study had methodology-related goals as well, namely to test the efficacy of using acoustic tools such as *Language and Brain and Behaviour Corpus Analysis Tool* (LaBB-CAT; Fromont & Hay, 2017) and *Robust Epoch And Pitch Estimator* (REAPER; Talkin, 2015) within a clinically applied area of research.

The following research questions were explored as part of the study:

- 1) What are the acoustic correlates of masculinity and the socio-cultural construct of the male gender identity?
- 2) What is the relationship between the transmasculine individuals' voice and their quality of life?
- 3) How satisfied are transmasculine individuals with their speech?

The current study found that the vocal satisfaction of transmasculine individuals is not directly predictable from self-perceived vocal masculinity, or from the central tendency measures of the speaking fundamental frequency. Participants' self-perception of both their vocal satisfaction and vocal masculinity was mediated by the individual's self-assigned gender identity label.

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My mum once said to me 「船到橋頭自然直」 (Circumstances change for the better in the face of adversity). I know this to be true.

Kia kaha (stay strong).

## Chapter 1: Introduction

The purpose of this study was to explore the self-perceived vocal masculinity and quality of life in transgender men, trans men, transmasculine people, masculine of centre, tangata ira tane, AFAB (assigned female at birth), male-to-male, and transmasculine individuals' speech (henceforth, transmasculine individuals). The current study investigated vocal satisfaction by exploring many multiple factors (e.g. demographic, vocal and communicative impacts, quality of life, acoustic measurements, and testosterone) which contribute to the vocal use and communicative needs of transmasculine individuals. As discussed in *Chapter 2: Literature Review*, the factors explored correspond closely with those highlighted in the 'Gender-related aspects of transmasculine people's vocal situations' model in Azul (2015: 34) (e.g. presentational factors, attributional factors, normative factors, and diversity) to provide individual-centred framework for researching transmasculine voice. The current study is structured as follows:

- *Chapter 2: Literature Review* provides a comprehensive review of topics relating to transmasculine individuals with significant impacts on their vocal satisfaction (e.g. gender identity, healthcare management, quantifying vocal satisfaction and quality of life). The research questions and associated hypothesis are presented at the end of the chapter.
- *Chapter 3: Methodology* describes the methodology used in the current study to procure these major influencers by analysing questionnaire results and combining this with the acoustic analysis.
- *Chapter 4: Questionnaire Results* summarises the major findings from the questionnaire by providing a demographic profile (e.g. geographic and ethnic distribution, smoking, sexual preferences, gender identity, pronouns, and binding impacts) and the evaluation and satisfaction of voice by assessing the voice and communicative impacts, testosterone use, and intervention techniques employed, and vocal satisfaction.

- *Chapter 5: Acoustic Analysis* compares the acoustic measurements with the results from the questionnaire. Furthermore, a direct comparison is made between the efficacies of Praat (Boersma & Weenink, 2017) and REAPER (Talkin, 2015) for clinical and applied linguistics research on transmasculine individuals.
- *Chapter 6: Discussion* relates the results from the current study to the research questions and hypotheses proposed in *Chapter 2: Literature Review*.
- *Chapter 7: Conclusion* summarises the major findings from the current study, limitations, and future directions.
- *References* include all the research, documents, and software utilised in the current study.
- *Appendix* provides a summary of the questionnaire and responses, speech samples, acoustic measurements, Principal Component Analysis results, script for data visualisation, and a copy of the University of Canterbury Human Ethics Approval and the Ngāi Tahu Consultation & Engagement Group Approval.

## **Chapter 2: Literature Review**

The current chapter provides a comprehensive review of key studies between 1983 and 2017 relating to the vocal satisfaction and quality of life of transmasculine individuals. Section 2.1 discusses topics regarding gender identity such as terminology and definitions (section 2.1.1), a demographic profile of transmasculine individuals (section 2.1.2), and gendered communication (section 2.1.3) and its application to cisgender and transgender individuals. This is followed by a description of the theoretical framework proposed by Azul (2015) in section 2.1.4. Section 2.2 discusses the impacts on vocal satisfaction such as hormone therapy (section 2.2.2) and speech therapy (section 2.2.2) for transmasculine individuals including binding and associated surgeries (e.g. top and vocal) which are discussed in section 2.2.3. Lastly, section 2.3 summarises the current methods to quantify the social satisfaction of transmasculine individuals using the Voice Handicap Index (VHI; section 2.3.1), Transgender Self-Evaluation Questionnaire (TSEQ; section 2.3.2), and Transgender Voice Questionnaire for Male-to-Female (TVQ<sup>MtF</sup>; section 2.3.3), and current research on the vocal satisfaction of transmasculine individuals (section 2.3.4).

### **2.1 Gender Identity**

The current section discusses topics regarding gender identity such as terminology and definitions (section 2.1.1), a demographic profile of transmasculine individuals (section 2.1.2), and gendered communication (section 2.1.3) and its application to cisgender and transgender individuals. This is followed by a description of the theoretical framework proposed by Azul (2015) in section 2.1.4.

#### **2.1.1 Terminology & Definitions**

Definitions in the current study have been taken from the World Professional Association for Transgender Health (WPATH) *Standards of Care for the Health of Transsexual, Transgender, and Gender Nonconforming People* (7<sup>th</sup> Ed; Coleman et al., 2012: 221-222). This document provides best-

practice principles for healthcare professionals who include Speech and Language Pathologists (SLPs) and primary healthcare professionals. Due to the highly sensitive nature of gender identity for reference, some of the terminology relevant to the current study has been presented in Table 1. Note that some definitions were contracted for brevity, for full definitions refer to the glossary of the *Standards of Care* (Coleman et al., 2012: 221-222).

The terminology listed in the *Standards of Care* (Coleman et al., 2012: 221-222) are consistent with those used by health professionals in New Zealand | Aotearoa as established in the document for *Gender Reassignment Health Services for Trans People within New Zealand* compiled by the Counties Manukau District Health Board (CMDHB, 2011), the Human Rights Commission | te Kāhui tika Tangata (HRC, 2008: 12), and Statistics New Zealand | Tatauranga Aotearoa (Stats NZ, 2015a, 2015b). For the sake of brevity, the sample population of the current study will be referred to as ‘transmasculine individuals’. This umbrella term is appropriate as the purpose of the current study is to explore the vocal satisfaction of individuals who were assigned female at birth and identify as ‘masculine of centre’ and wish to speak with a gender affirming voice.

Table 1. *Transgender Terminology* (Coleman et al., 2012: 221-222)

Gloss	Definition
<i>female-to-male</i>	Adjective to describe individuals assigned female at birth who are changing or who have changed their body and/or gender role from birth-assigned female to a more masculine body or role.
<i>gender expression (or role)</i>	Characteristics in personality, appearance, and behaviour that in a given culture and historical period are designated as masculine or feminine (that is, more typical of the male or female social role).
<i>gender identity</i>	A person’s intrinsic sense of being male, female, or an alternative gender.
<i>genderqueer</i>	Identity label that may be used by individuals whose gender identity and/or role does not conform to a binary understanding of gender as limited to the categories of man or woman, male or female.
<i>sex</i>	Sex is assigned at birth as male or female, usually based on the appearance of the external genitalia.
<i>transgender</i>	Adjective to describe a diverse group of individuals who cross or transcend culturally defined categories of gender. The gender identity of transgender people differs to varying degrees from the sex they were assigned at birth.
<i>transition</i>	Period of time when individuals change from the gender role associated with their sex assigned at birth to a different gender role. For many people, this involves learning how to live socially in “the other” gender role; for others this means finding a gender role and expression that is most comfortable for them.

Those who identify as transmasculine individuals may also employ other further terms to describe their gender identity. In two separate demographic studies of the United States and Australia, those who identified as transmasculine individuals also identified with ‘male’, ‘genderqueer’, ‘transgender’, ‘transsexual’ and other gender identity terms (Factor & Rothblum, 2008: 239, del Pozo de Bolger et al., 2014: 398). Terminology that was not taken from the *Standards of Care* (Coleman et al., 2012: 221-222) in Table 1 has been taken from the *Good Practice Guide for Health Professionals* (CMDHB, 2011: 38-39). The additional terminology is presented in Table 2.

Table 2. *Transgender Terminology* (<sup>1</sup>CMDHB, 2011: 38-39)

Gloss	Definition
<i>AFAB</i>	assigned female at birth (c.f.: <i>sex</i> ).
<i>cisgender</i>	a person whose gender identity matches their assigned sex at birth
<i>intersex</i> <sup>1</sup>	a general term used for a variety of conditions in which a person is born with reproductive or sexual anatomy that does not seem to fit the typical biological definitions of ‘female’ or ‘male’.
<i>male-to-male</i>	MtM; someone born with a female or intersex body who has never identified as ‘female’ who has a ‘male’ gender identity.
<i>masculine-of-centre</i>	a person whose gender identity is primarily ‘masculine.’
<i>non-binary</i>	a person whose gender identity is not exclusively ‘masculine’ nor ‘feminine.’
<i>takatāpui</i> <sup>1</sup>	an intimate companion of the same sex. Today used to describe Māori gay, lesbian, bisexual and trans people. It refers to cultural and sexual/gender identity.
<i>tangata ira tane</i> <sup>1</sup>	a Māori term describing someone born with a female body who has a male gender identity.
<i>trans man</i>	(c.f.: <i>female-to-male</i> )
<i>trans person/people</i> <sup>1</sup>	an umbrella term to describe someone whose gender identity is different from their physical sex at birth.
<i>transgender man</i>	(c.f.: <i>female-to-male</i> )
<i>transmasculine</i>	(c.f.: <i>masculine of centre</i> )

The terms listed in Tables 1 and 2 are only a small subset of words to describe transmasculine gender identity. The individuals who identify with these terms have been collectively described as ‘gender nonconforming’, which “refers to the extent to which a person’s gender identity, role, or expression differs from the cultural norms prescribed for people of a particular sex” (Institute of Medicine, 2011; as cited in Coleman et al., 2012: 168). There is also movement towards the de-psycho-pathologisation

of transgender or gender nonconforming individuals (Coleman et al., 2012: 168), which is why the terms ‘Gender Dysphoric’ and ‘Gender Identity Disorder’ are rarely discussed in the current study. Likewise, the term ‘nonconforming’ may insinuate that these individuals are not a part of the norm, this is why the current terminology is shifting towards ‘gender diverse’ and ‘(individuals) on the gender spectrum’.

### **2.1.2 Demographic Profile**

Transmasculine individuals belong to a diverse community of people who share a common gender history. The typical transitioning (or transitioned) transmasculine individual is between the ages of 17-40 years old, possibly a birth-parent of one or more children (Papp, 2011: 48). Factor and Rothblum (2008) conducted a sociological survey of 52 North American female-to-male transmasculine individuals and found that 50% of the respondents exclusively identified as female-to-male (FtM). It was found transmasculine individuals are open to disclosing their gender identity to their family and discussing their gender identities with their parents and siblings (Factor & Rothblum, 2008: 249). Seventy-one percent experienced some sort of discomfort selecting a gendered bathroom (Factor & Rothblum, 2008: 239). In terms of sexual attraction, a large percentage of transmasculine individuals 44% identified as bisexual and 33% identified as lesbian (Factor & Rothblum, 2008: 250). Multiple studies have been conducted to investigate the quality of life of transmasculine individuals (Factor & Rothblum, 2008; Motmans, Meier, Ponnet, & T’Sjoen, 2012; Newfield, Hart, Dibble, & Kohler, 2006; Yerke & Mitchell, 2011), some with a specific focus on mental health (Rotondi et al., 2011; Bariola et al., 2015) and socioeconomic limitations (Dispenza, Watson, Chung, & Brack, 2012; Motmans et al., 2012). A survey conducted by Meier, Pardo, Labuski, and Babcock (2013: 291) found that 43% of 367 North American transmasculine individuals attempted suicide. These are conservative estimates, as a demographic study of 222 Australian Transmasculine population found that 88% were diagnosed with clinical depression and/or anxiety in the last 12 months, 68% had inflicted self-harm, 81% had thought about suicide, and 35% had attempted suicide (del Pozo de

Bolger et al., 2014: 399). This indicates transmasculine individuals experience significant minority stress.

There is a strong social and medical movement towards the de-psychopathologisation of gender diverse individuals (Coleman et al., 2012: 168). Therefore, in some national and subnational entities transmasculine individuals do not need to be ‘diagnosed’ anymore with ‘Gender Dysphoria’ or ‘Gender Identity Disorder’ by a licensed mental health practitioner according to the Diagnostic Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) to identify as ‘transgender’ or ‘transmasculine’ or to receive treatment (CMDHB, 2016: 17).

### **2.1.3 Gendered Communication**

Coleman (1983) provided one of the first reports on the application of acoustic correlates of speaker sex and gender identification of transgender individuals. Coleman (1983: 293) noted that “the gender characteristic most resistant to convincing change is the voice” suggesting voice is a major component in constructing an individual’s gender identity. Oates and Dacakis (1983: 141) described the non-segmental (e.g. f0, intonation, and vocal jitter and shimmer) and segmental (e.g. speech sounds, syntax, vocabulary, and pragmatic language) markers, related to cisgender language and communication. These vocal characteristics are the result of physiological (e.g. hormonal and developmental) and social (e.g. pragmatic and semantic) differences between cisgender females and males and should be considered in the vocal management of transmasculine individuals.

#### *Cisgender Acoustic Differences*

The Source-Filter Theory of speech production was conceptualised by Fant (1971) and has been used to explain how listeners determine acoustic differences in speech. In brief, there are two major acoustic components in speech: the ‘source’ or the sound spectrum generated by the larynx, and the ‘filter’ which modulates this sound spectrum in the vocal tract (Fant, 1971: 16). There are significant anatomical differences between the vocal folds in adult cisgender females and males which affects the ‘source’. Filho et al. (2005: 391) found that the average vocal fold length of an adult cisgender female

was 10.19 mm (full height = 162.4cm) and cisgender male was 15.40mm (full height = 176.4cm). Furthermore, adult cisgender males have a greater vocal fold mass on average (length x height) than adult cisgender females (Hollien, 2014: 403). Due to this increased vocal fold mass in adult cisgender males, the vibrating cycle is slower than for adult cisgender females, resulting in a lower  $f_0$  which is then perceived as a lower pitch (Coleman, 1983: 293).

The resonating cavities (e.g. laryngeal, pharyngeal, oral, and nasal cavities) in the vocal tract act as a 'filter' and modulate the tone produced in the larynx. The acoustic output is formant frequencies and this is auditorily perceived as resonance. There are also anatomical differences in the vocal tract as the mean vocal tract length for an adult cisgender male is 155.4cm and the mean vocal tract length for an adult cisgender female 138.8cm (Fitch & Giedd, 1999: 1514). Due to this added length in the vocal tract, the formant frequencies produced by adult cisgender males are lower than adult cisgender females. These changes develop only in adolescent cisgender males during puberty, when the vocal fold and vocal tract increases in length (Markova et al., 2016; Xue et al., 2010).

In terms of physiological differences, there is a known relationship between testosterone and lower  $f_0$  among cisgender males. Dabbs and Mallinger (1998) compared the salivary testosterone levels and  $f_0$  of adult cisgender men and cisgender women. They found that cisgender males have a mean salivary testosterone level of 9.63 nanograms per decilitre (ng/dL) and a mean  $f_0$  of 99 Hz (compared to 1.78 ng/dL and  $f_0$  of 181 Hz for cisgender women). They found that  $f_0$  decreased as testosterone levels increased in cisgender males ( $r = -0.26$ ), but no significant correlations were found for cisgender females ( $r = 0.11$ ) (Dabbs & Mallinger, 1999; 802). Furthermore, Evans et al. (2008) found that there is a diurnal relationship between testosterone and  $f_0$  in cisgender males. It was found that  $f_0$  increases by approximately 10 Hz from 100 Hz over the course of a 6-hour period as salivary testosterone decreases.

As discussed in section 2.1.2, transmasculine individuals were female bodied at birth (i.e. have oestrogen in their system until menopause/hysterectomy) and many of them also administer testosterone (section 2.2.1) a hormone associated with vocal masculinisation (Dabbs & Mallinger, 1998). The effects of female sex hormone and male sex hormones on the voice vary significantly. For example, Abitbol et al. (1999) conducted a thorough review on the effects of female sex hormones

(e.g. oestrogen and progesterone) on the vocal apparatus of cisgender females. Lack of oestrogen or progesterone has been linked to premenstrual vocal syndrome (Abitbol et al., 1999: 435-439) and menopausal vocal syndrome (Abitbol et al., 1999: 439-441). However, oestrogen and progesterone do not have the same effect on the vocal folds as testosterone (Abitbol et al., 1999: 443).

Of interest to the current study is the role of f0 in distinguishing masculine and feminine voices. Hillenbrand and Clark (2009) conducted a series of experiments comparing the f0 of cisgender males and females. A discriminant analysis was carried out to determine whether masculine and feminine voices can be distinguished using only f0 and formant frequencies (Hillenbrand & Clark, 2009: 1153). It was found that masculine and feminine voices could be distinguished based on f0 and formant frequencies alone. Based on the number of utterances, masculine voices centred around 110-130 Hz and feminine voices were centred 210 Hz (Hillenbrand & Clark, 2009: 1155).

Further studies conducted by Hillenbrand and Clark (2009: 1155-1160) were perception experiments using synthesised recordings of utterances and single syllables respectively. These studies found that increasing the f0 and formant frequencies for masculine voices, or decreasing the f0 and formant frequencies for feminine voices were efficient in changing the perceived gender of the speaker, while altering only f0 or formant frequencies independently were not effective at changing the perceived gender of the speaker (Hillenbrand & Clark, 2009: 1157). The results suggest that both f0 and formant frequencies are integral to discriminating gendered speech.

### *Cisgender Speech Norms*

*Table 3. Speech Norms for Cisgender Female/Feminine and Male/Masculine speech (Davies & Goldberg, 2006: 178)*

Speech Characteristics	Female/Feminine Norms	Male/Masculine Norms
<i>Pitch</i>	mean f0 196-224 Hz	mean f0 107-132 Hz
<i>Formant Frequencies</i>	higher formant frequencies	lower formant frequencies
<i>Intonation</i>	variable intonation, upward glides	level intonation, downward glides
<i>Loudness</i>	68-74 dB	68-76 dB
<i>Breathiness</i>	mildly breathy, softer speech onsets	not breathy, harder speech onsets
<i>Articulation</i>	clear/light	forceful articulation and phoneme reduction
<i>Duration</i>	longer mean duration of phrases, words, and lingering vowels	staccato speech style

F0 and formant frequency as discussed in *Acoustic Differences* is only one aspect of cisgender vocal characteristics. Davies and Goldberg (2006: 178) listed a few English-language speech norms for cisgender female/feminine and cisgender male/masculine speech. These speech characteristics are presented in Table 3 and are shown to contribute to the perception of gender.

In terms of f0 differences between cisgender males and females, studies have shown that f0 is also mediated by vocal attractiveness as younger adolescent cisgender males (11:9±5) found higher-pitched (mean f0 = 216 ± 19 Hz) feminine voices as more attractive, and older adolescent cisgender females found lower-pitched (mean f0 = 137 ± 9) masculine voices as more attractive (Saxton, DeBruine, Jones, Little, & Roberts, 2013: 92). A study conducted by Cartei, Bond, and Reby (2014) on the vocal attractiveness of cisgender males perceived by cisgender females found that perceived vocal masculinity strongly correlated with height, but not testosterone. However, increased levels of salivary testosterone weakly correlated with decreased f0 (Cartei et al., 2014: 571). These studies suggest perceived vocal masculinity is also the product of societal expectations beyond anatomy and physiology as discussed in the previous section.

Cisgender speech norms are observed to vary considerably depending on language, racial or ethnic affiliation, religious affiliation, nationality, or world view. For example, there are significant f0 differences across languages as shown in Table 4 (Traunmüller & Eriksson, 1995).

*Table 4. Cisgender Male/Female f0 Language Comparison (Traunmüller & Eriksson, 1995)*

Language	Cisgender Male f0	Cisgender Female f0	Source
German	129 Hz ( <i>n</i> = 190)	238 Hz ( <i>n</i> = 108)	(Rappaport, 1958)
French	145 Hz ( <i>n</i> = 21)	226 Hz ( <i>n</i> = 21)	(Chevrie-Muller & Gremy, 1967)
French	118 Hz ( <i>n</i> = 30)	207 Hz ( <i>n</i> = 30)	(Boë, Contini, & Rakotofiringa, 1975)
Mandarin Chinese	108 Hz ( <i>n</i> = 2)	184 Hz ( <i>n</i> = 2)	(Chen, 1974)
Swedish	110 Hz ( <i>n</i> = 51)	193 Hz ( <i>n</i> = 141)	(Kitzing, 1979)

#### *Application to Transgender Individuals*

Various studies have been conducted on listener perception of gender within a transgender context (Andrews & Schmidt, 1997; Byrne et al., 2003; Hancock et al., 2015; Hancock et al., 2014; Hardy et

al., 2016; Owen, 2009; Owen & Hancock, 2010; Van Borsel et al., 2009). However, most of these studies were concerned with transfeminine individuals (Byrne et al., 2003; Hancock et al., 2015; Hardy et al., 2016; Van Borsel et al., 2009). The studies discussed in the current section refers to studies which investigates the relationship between perceptual correlates and perceived gender in transfeminine (and to a lesser extent transmasculine) voices.

Andrews and Schmidt (1997) investigated the perceptual and acoustic characteristics of 11 American cisgender male female-impersonators (or ‘crossdressers’ in Andrews & Schmidt, 1997). This study provides valuable insights into how an individual’s self-perception correlates with listener-perception of intended gender identity. The participants were requested to read the *Rainbow Passage* once in their typical masculine style and once in their feminine style (Andrews & Schmidt, 1997: 308). The cisgender male female-impersonators completed a perceptual rating scale (Gelfer, 1999) following the recording to determine the vocal characteristics of their reading styles (Andrews & Schmidt, 1997: 308).

The listener-directed perceptual portion of the study found significant differences between the masculine and feminine speech samples. These perceptual labels were: masculine-feminine, high-low (pitch); melodious-raspy; breathy-full; and animated-monotonous (Andrews & Schmidt, 1997: 309). The masculine style was also perceived to be ‘stronger’ than the feminine style on the strong-weak scale. The acoustic analysis of mean f0 did not identify any significant differences between the masculine and feminine styles of speaking. In one case, the f0 for the feminine speaking style was much lower than the masculine speaking style, but was still perceived as feminine (Andrews & Schmidt, 1997: 311). The authors propose extraneous factors such as loudness, resonance, and prosody (e.g. inflection, rhythm, emphasis) plays a much greater role than f0 in perceived vocal gender than first predicted (Andrews & Schmidt, 1997: 311).

In response to Andrews & Schmidt (1997), Owen and Hancock (2010) investigated the relationship between f0 and semitone range with self- and listener-rated vocal femininity of 20 American transfeminine transgender individuals using a visual analogue scale (VAS). This method was developed in Owen’s (2009) Master’s dissertation and has been used in additional studies (Hancock et al., 2014; Hancock et al., 2015). Speakers were asked to describe *The Waiting Room* (Rockwell, 1937)

picture while they were being recorded. The speakers and a group of listeners were then asked to rate the perceived femininity (0 = Masculine Male, 1000 = Feminine Female) of the speech recording (Owen & Hancock, 2010: 276).

Findings from Owen & Hancock (2010: 276) indicated that speaker-perceived vocal femininity was strongly correlated with mean  $f_0$ . Listener-rated vocal femininity also increased as self-perceived vocal femininity increased (Owen & Hancock, 2010: 279). The findings from Owen and Hancock (2010: 279) suggest there is a strong relationship between self-perceived vocal femininity and listener-perceived vocal femininity. This is consistent with the findings in Andrews & Schmidt (1997). Hancock et al. (2014: 204) investigated the influence of intonation on listener-perceived gender. In contrast to Owen and Hancock (2010) which investigates only transfeminine voices, Hancock et al. (2014) compares transmasculine, transfeminine, cisgender female, and cisgender male speakers.

However, Hancock et al. (2014: 206) did not find a relationship between intonation and perceived gender, indicating intonation as a poor determiner of gender. This is contrary to the current understanding of intonation differences in gendered voices as shown in Table 3 (Davies & Goldberg, 2006: 178). The mean vocal femininity rating was 267 (of 1000) for transmasculine individuals compared to cisgender males who had a mean rating of 88 (Hancock et al., 2014; 206). Further analysis was not carried out on transmasculine individuals as they were indistinguishable from cisgender males; five of the six transmasculine individuals were indistinguishable from the cisgender males for the listeners (Hancock et al., 2014; 206). However, a review of the scores for transmasculine speakers found that their scores were clearly distinct from cisgender males as there was still a mean difference of  $\pm 166$  (Hancock et al., 2014; 206). This suggests transmasculine individuals' voices do differ from the speech of cisgender males.

The findings from Andrews and Schmidt (1997), Owen and Hancock (2010), and Hancock et al. (2014) suggest there is a relationship between acoustic correlates (e.g. mean  $f_0$ ) and perceived vocal gender. These studies do not explore transmasculine voices in detail. A study which finds a relationship between acoustic measures (e.g.  $f_0$ ) and vocal femininity in transfeminine individuals does not automatically translate to transmasculine individuals. These studies also suggest there are

significant speaker and listener effects on perceived vocal femininity (Andrews & Schmidt, 1997; Hancock et al., 2014; Owen & Hancock, 2010). These effects can be expressed through subjective perceptual labels (e.g. melodious-raspy; breathy-full; and animated-monotonous) as in Andrews and Schmidt (1997: 309) or on a VAS such as Hancock et al. (2014) and Owen and Hancock (2010). This further suggests perception studies need to be carried out on transmasculine individuals.

### 2.1.4 Theoretical Framework

Azul (2015) and Azul et al. (2017) conducted a thorough review of peer-reviewed literature on the vocal situation of transmasculine individuals (for definitions used in the current study refer to section 2.1.1). Of the 111 peer-reviewed papers looking at transgender vocal and communicative needs, 76% ( $n = 84$ ) were solely concerned with transfeminine voices (Azul, 2015: 35). Only 32 studies were identified (including bibliographies) that were related to transmasculine individuals (Azul, 2015: 36); 17 were primary research studies.

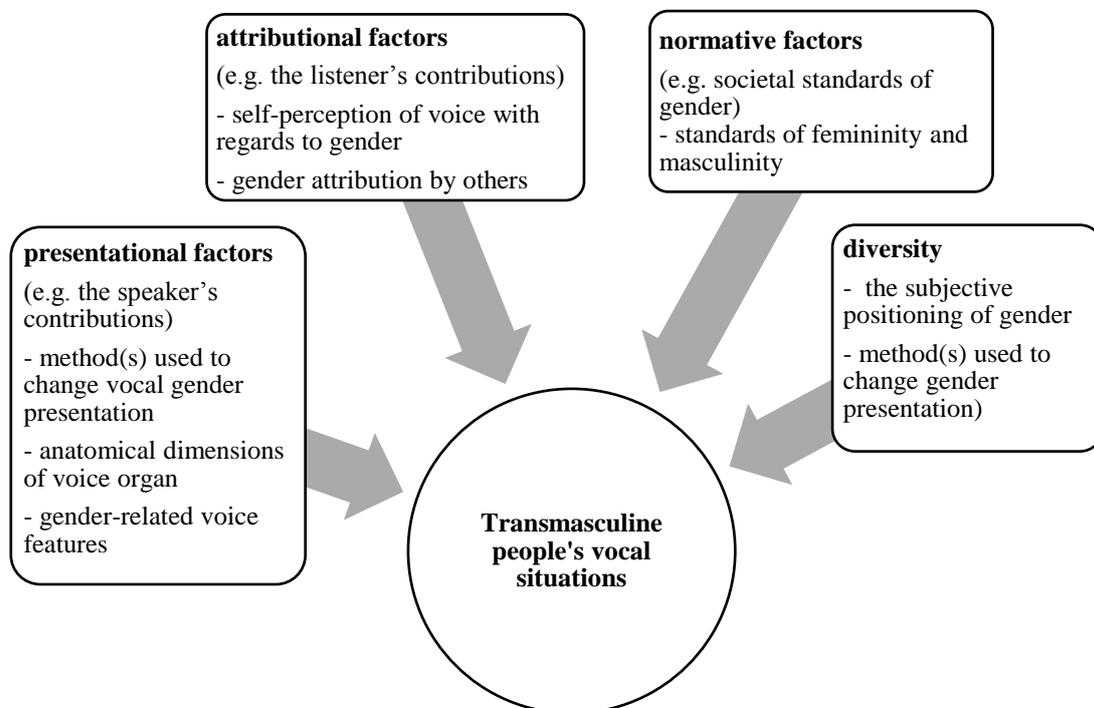


Figure 1. Gender-related aspects of transmasculine people's vocal situations' (Azul, 2015: 34)

Azul (2015: 34) found a number of commonalities between the studies (many of them discussed in the current chapter) and conceptualised the ‘Gender-related aspects of transmasculine people’s vocal situations’ model as shown in Figure 1. This model attempts to organize the content of these studies into four contributing factors which include: presentational factors, attributional factors, normative factors, and diversity (Azul, 2015: 34). Transmasculine individuals are gender diverse; therefore, their speaking voice should be authentic to them and not just based on cisgender speech norms (Davies and Goldberg, 2006: 178). This is why the current model proposed by Azul (2015) is a valuable research to gauge the vocal situation of transmasculine individuals.

The model proposes an individual-centred approach to research by exploring the different aspects of transmasculine voice (Azul, 2015). For example, a number of primary research studies focussed on gender-related vocal features or *presentational factors* such as pitch, resonance, intonation, voice quality, and intensity (Azul, 2015: 41). While these studies explore the acoustic outputs of gender, many of these studies do not consider the self-perception of transmasculine individuals. Only three of the studies investigated self-perception of gender, while six studies investigated listener-attribution of vocal gender (Azul, 2015: 41). Therefore, further studies on transmasculine individuals should aim to explore these factors with reference to Azul’s (2015) Model that contribute to identity-construction. Azul’s (2015) complements the movement towards the de-psychopathologisation of transgender and gender nonconforming individuals (Coleman et al., 2012: 168) (refer to section 2.1.1).

A further review of the current literature on female-to-male transmasculine voice was categorised by subject matter (Azul et al., 2017). Factors identified from existing literature that impact voice function include: hormone treatment; self-guided attempts at changing vocal situation; smoking habits; self-guided changes to voice use; chest binding; changes to outward appearance; changes to posture (slouching); alcohol consumption; professional voice support; psychosocial situation; laryngeal surgery; mastectomy; and anatomy and physiology of voice organ (Azul et al., 2017: 261.e12-261.e15). Furthermore, the following vocal parameters were discussed which indicated the presence or absence of voice problems (Azul et al., 2017: 261.e15). These parameters include: voice quality, pitch/range variability, vocal/control stability, vocal power, vocal endurance, glottal function, singing voice, respiration, muscle tension/posture (Azul et al., 2017: 261.e15-261.e21).

## **2.2 Impacts on Vocal Satisfaction**

The current section discusses the impacts on vocal satisfaction such as hormone therapy (section 2.2.2) and speech therapy (section 2.2.2) for transmasculine individuals including binding and associated surgeries (e.g. top and vocal) which are discussed in section 2.2.3.

The current section will cover some of these factors discussed in Azul et al. (2017), and the implications they have on the vocal satisfaction of transmasculine individuals. The current section aims to describe the healthcare practices that directly influence the vocal satisfaction of transmasculine individuals. Necessary changes to the vocal and physical presentation to conform to transmasculine individual's gender identity can be achieved through services like testosterone therapy, speech and language therapy (SLT), and surgical procedures as summarised in the current section.

### **2.2.1 Hormone Therapy**

As discussed in section 2.1.3, testosterone has a significant influence on the f0 of cisgender males (Dabbs & Mallinger, 1999). Many transmasculine individuals undergo hormone therapy, with a primary desire to masculinise vocal characteristics (Gorton et al., 2005). Wierckx et al. (2014) noted that hormone therapy was effective and carried low risk of side effects and is prevalent among transmasculine individuals. A demographic survey found 88% ( $n = 52$ ) of North American transmasculine individuals were taking hormones indefinitely (Factor & Rothblum, 2008: 242).

There are two types of hormone treatments which are fully subsidised in New Zealand | Aotearoa: 'gonadotrophin releasing hormone (GnRH) analogues/agonists' (also known as 'blockers'), and 'testosterone' cross-hormones (CMDHB, 2011: 22-25). GnRH analogues are a fully reversible hormone treatment and act upon the pituitary gland, suppressing the production of oestrogen (Coleman et al., 2012: 176-177). Many of the effects of testosterone therapy are irreversible, and treatment can begin once oestradiol levels are sufficiently low (through GnRH analogues) in transmasculine individuals (CMDHB, 2011: 26). Testosterone can be administered through intramuscular or subcutaneous injections, oral formulations, sublingual/buccal lozenges, transdermal

patches, and gels (Gorton et al., 2005). The half-life of testosterone in the bloodstream is approximately 70 minutes, therefore, it is necessary for transmasculine individuals to have a continuous supply (i.e. 5mg/day) for successful masculinisation (Gorton et al., 2005).

Positive health effects for transmasculine individuals include growth of facial and body hair, redistribution of body fat to a more typical cisgender male pattern, muscle bulk increase, and lower vocal pitch (Wierckx et al., 2014: 2003). Furthermore, Meier et al., (2011: 292) found that transmasculine individuals who were undergoing hormone therapy reported significantly lower levels of depression than those who were not. Hormone therapy has a positive effect on the mental health of transmasculine individuals. Negative effects of testosterone therapy include polycythaemia (increased red blood cells), oily skin or acne, abdominal pain, headache, weight gain, abdominal lipids, and depression (Coleman et al., 2012: 224-226). Other negative effects include Type 2 diabetes, liver disease, high blood pressure, high cholesterol, heart disease, migraine, sleep apnoea, and epilepsy although some of these effects are reversible (Gorton et al., 2005).

### *Effects on Voice*

Multiple longitudinal studies have been conducted on transmasculine individuals across different language contexts (e.g. Dutch, English, German, and Swedish) where a decrease in mean f0 for most transmasculine individuals following testosterone therapy was found (Cosyns et al., 2014; Deuster et al., 2016; Deuster et al., 2016; Irwig et al., 2017; Nygren et al., 2016; Papp, 2011; Wierckx et al., 2014; Zimman, 2012). In one study the group median f0 was 192 Hz prior to testosterone therapy compared to 108.4 Hz with a range from 100.4 to 166.9 Hz after the 12-month period (in comparison to the control group which had a median f0 of 116.5 Hz with a range from 100.4 to 166.9 Hz) (Deuster et al., 2016a: 962). Irwig et al. (2017: 109) found significant decreases in f0 after 6-months of testosterone therapy in a sample group of seven North American transmasculine individuals.

Cosyns et al. (2014: 1410-1411) found that the mean f0 of transmasculine individuals who have underwent Sexual Reassignment Surgery (SRS) were indistinguishable from cisgender male controls. However, there is evidence to suggest increased vocal satisfaction increases among transfeminine

individuals who have undergone SRS which may account for such a high success rate (Dacakis et al., 2013). This may explain the significant and successful decrease  $f_0$  of all transmasculine individuals in Cosyns et al. (2014: 1410-1411). Furthermore, oophorectomy (total ovary removal surgery) has also shown to influence the mean  $f_0$  of transmasculine individuals (Papp, 2011: 52).

Five of the participants in Papp's (2011: 61) study had a significant decrease in mean  $f_0$  from a habitual speaking  $f_0$  of 170-220 Hz to a pitch floor of 80-100 Hz typical of a cisgender male. However, the habitual speaking  $f_0$  of the participants were almost an octave (6-13 semitones) higher than the pitch floor. This suggests that some transmasculine individuals consciously chose to speak in a higher  $f_0$  (above the  $f_0$  range of a typical cisgender male) even though they now had access to this lower  $f_0$  range. However, many of these studies often mask social performance effects (e.g. listener perceived vocal masculinity) (Cosyns et al., 2014; Deuster et al., 2016; Deuster et al., 2016; Irwig et al., 2017; Nygren et al., 2016; Papp, 2011; Wierckx et al., 2014; Zimman, 2012). This means extra care is needed when interpreting the outcomes of transmasculine voice following testosterone therapy as a lowered  $f_0$  does not necessarily equate to a masculine voice.

However, significant interspeaker differences were also found in many of these longitudinal studies as some participants exhibited more obvious changes to  $f_0$  than others (Deuster et al., 2016a: 964). In a group of 50 Swedish transmasculine individuals, 24% ( $n = 12$ ) sought speech and language therapy because of vocal issues (e.g. vocal fatigue, vocal instability, strain, hoarseness, and difficulties with lowering  $f_0$  or projecting) (Nygren et al., 2016: 766.e30). This suggests testosterone therapy is not entirely unproblematic, and SLT may still be necessary during and following testosterone therapy.

Healthcare providers should warn transmasculine individuals that they may experience vocal changes reminiscent of pubertal adolescent male, including irregularities in pitch (e.g. cracking or squeaking) (Gorton et al., 2005). Wierckx et al. (2014: 2007) noted that 10% of transmasculine participants experienced vocal instability prior to testosterone therapy, this was increased to 40% of participants at 3 months, to 80% of participants at 6 months, and finally a decrease to 60% of participants at 9 and 12 months. Vocal changes are irreversible and may be detrimental to those who use their voices professionally (e.g. public speakers, singers) following testosterone therapy (King et al., 2001: 557, Gorton et al., 2005).

### 2.2.2 Speech Therapy

Speech and language pathologists (SLPs) and therapists (SLTs) work alongside a multidisciplinary team (comprised of psychiatrists/psychologists, plastic surgeons, endocrinologists, gynecologists, urologists, and otorhinolaryngologists etc.) in the management of transgender individuals during their transition (Adler et al., 2006: 139). In the *Standards of Care* (Coleman et al., 2012: 197-199), professionals working in the management of voice and communication therapy should have specialized training in working with transmasculine and gender diverse voices, as well as a basic understanding of transgender health. Furthermore, SLPs should work with the individual to help them adapt and speak in a way that is authentic and congruent with their gender identity (Coleman et al., 2012: 197-199; Davies, Papp, & Antoni, 2015).

In stark contrast with the goals of the WPATH, a sociological survey of 52 American transmasculine individuals conducted by Factor and Rothblum (2008: 241) discovered that 94.1% of transmasculine speakers themselves did not think speech and language therapy was applicable or relevant to their transition. Furthermore, only 2% were considering the possibility of seeing an SLP, and 3.9% were not interested in speech therapy (Factor & Rothblum, 2008: 214). This outcome reflects the body of expert opinion that maintains testosterone therapy provides adequate vocal alteration to the habitual speaking f0 to pass as a cisgender male (as discussed in sections 2.2.1) (e.g. Van Borsel et al., 2000: 439). However, more contemporary research shows that while testosterone therapy will increase vocal cord mass in some individuals, gender specific linguistic features associated with masculine communication involving chest resonance, articulation, and speech rate will not be automatically acquired because of testosterone (Thornton, 2008: 274).

While many SLPs are comfortable with the transgender community; others have indicated they do not have the clinical skills and knowledge to work with transgender individuals (Hancock & Haskin, 2015: 215). Since the 1980's, numerous reviews have been conducted on the speech-therapy considerations in the management of transgender clients (Adler et al., 2006; Davies & Goldberg, 2006; Davies et al., 2015; Oates & Dacakis, 1983; Thornton, 2008). The main role of SLPs working

with transmasculine clients is to assist them in using masculine speech and language norms while maintaining good vocal health (Adler et al., 2006:150).

A number of these studies have been conducted on the therapeutic outcomes of transfeminine transgender individuals (Carew, Dacakis, & Oates, 2007; Dacakis, 2000; Gelfer, 1999; Gelfer & Schofield, 2000; Gelfer & Tice, 2013; Gelfer & Van Dong, 2013; Hancock & Garabedian, 2013; Hancock & Helenius, 2012; Oates & Dacakis, 2015) while studies on transmasculine individuals within an SLP context have been few and far between. Thornton (2008: 273) noted that the most prominent non-segmental feature associated with gendered-speech is speaking f0; with pitch as its auditory perceptual equivalent. Adler and Van Borsel (2006: 150-165) suggested a 10-step programme to alleviate muscle tension (or strain) from using an unnatural and inappropriate male voice as shown in Table 5.

*Table 5. 10-step programme for Transmasculine Clients (Adler et al., 2006: 150-165)*

Steps	
1	Establish an optimum f0 pitch range.
2	Establish abdominal/diaphragmatic breathing patterns.
3	Warm-up exercises to strengthen voice output that lead to easy onset of voice production.
4	Tension-releasing exercises for the jaw and tongue.
5	Use of easy onset for initiation of vocalisation and elimination of harsh glottal attack.
6	Establish progressive relaxation for overall body tension release.
7	Establish postural stabilisation.
8	Establish chest resonance to maintain a believable male pitch level.
9	Evaluation by an otolaryngologist.
10	Treatment of the voice disorder as recommended by the otolaryngologist.

Thornton (2008: 274) listed goals of intervention for transmasculine individuals including the areas of: pitch and intonation (e.g. stabilisation of post-hormonal voice); narrow band of intonation with sharp drop at the end of the utterance; chest resonance (e.g. more chest resonance); speech and language (e.g. more direct speech); and articulation and speech rate (e.g. harsher, clipped articulation of short vowels and omission of final phonemes).

For further information regarding SLP considerations, refer to Oates and Dacakis (1983), Adler et al. (2006), and Davies et al. (2015).

### 2.2.3 Binding & Surgery

The current section provides a summary of chest binding, chest reconstruction (also known as ‘top surgery’), and vocal masculinisation surgery. With reference to the *Standards of Care* (Coleman et al., 2012: 201), hormone therapy should not be a prerequisite to surgery. In a sample population of North American 52 transmasculine individuals, 63% had top surgery, and 32% engage in chest binding (Factor & Rothbum, 2008: 245). The reported findings are similar to a survey of 278 Australian transmasculine individuals who had chest surgery (53%) and engaged with chest binding (89%) (del Pozo de Bolger et al., 2014: 399).

#### *Chest Binding & Top Surgery*

Chest binding is the compression of breast tissue to invoke a flat, masculine looking chest by employing many techniques. Methods of binding include custom- or home-made binders, shirt layering, multiple sports bra, elastic (or other) bandages, athletic compression wear, neoprene compression wear, duct tape or plastic wrap (Peitzmeier et al., 2017: 72). Chest binding have known positive effects on the mental health of transmasculine individuals (Peitzmeier et al. (2017: 68). However, there are also known negative physical health effects due to chest binding. Peitzmeier et al. (2017: 71) conducted a global health survey on chest binding and identified 28 negative health outcomes. 97.2% of the participants who currently bind ( $n = 1800$ ) experienced one of the 28 physical health outcomes, with a prevailing majority of participants experienced some sort of pain e.g. chest or should pain (74%,  $n = 1333$ ); neurological impacts e.g. numbness or light-headedness (41%,  $n = 738$ ); and respiratory impacts e.g. shortness of breath or cough (50.7%,  $n = 914$ ) (Peitzmeier et al., 2017: 71).

These health outcomes have a significant negative impact on speaking, and thus negatively affect the vocal satisfaction of transmasculine individuals. 66.6% of people ( $n = 1800$ ) that currently bind intend to undergo chest reconstruction surgery (Peitzmeier et al., 2017: 69). Chest reconstruction (which equals a double mastectomy) is the partial or total removal of breast tissue (Kääriäinen et al., 2017; Lo Russo et al., 2017; Monstrey et al., 2008; Morrison et al., 2015) with optional nipple and areola

reconstruction. Almost all transmasculine individuals experience positive impacts on their self-confidence, personal and social relationships following surgery (Nelson et al., 2009: 333).

### *Vocal Surgery*

In cases where a lowered fundamental frequency cannot be achieved with androgen hormone or speech therapy, surgical intervention is available for transmasculine individuals (Adler & Van Borsel, 2006; 146). The Isshiki type III thyroplasty is a surgical procedure to lower a patient's pitch by removing cartilage from either side of the thyroid cartilage (Isshiki et al., 1974). The type III thyroplasty procedure has been widely employed to treat cisgender males diagnosed with puberphonia (Chowdhury et al., 2014; García-López, Peñarrocha, & Gavilan, 2010; Hoffman et al., 2014; Li, Mu, & Yang, 1999; Parker, 2008; Slavit, Maragos, & Lipton, 1990; Storck et al., 2011) and has been documented in a transgender context (Morrison et al., 2015; Rosen et al., 2004). Li et al. (1999: 31) reviewed the pre- and post-surgical  $f_0$  of 11 patients with mutational voice disorders. There was a significant decrease of habitual speaking  $f_0$  from 268 Hz to 140 Hz among the sample population, and there were no changes in the habitual speaking loudness dB (Li et al., 1999: 32-33). The Isshiki type III thyroplasty was found to successfully lower the habitual speaking  $f_0$  of cisgender males with mutational voice disorders (Li et al., 1999: 33). However, there are currently no major studies conducted on the surgical outcomes of transmasculine individuals. There are no recommendations provided by the *Standards of Care* (Coleman et al., 2012: 199) regarding vocal health considerations after vocal masculinisation therapy.

## **2.3 Quantifying Vocal Satisfaction & Quality of Life**

The current section summarises the current methods to quantify the social satisfaction of transmasculine individuals using the Voice Handicap Index (VHI; section 2.3.1), Transgender Self-Evaluation Questionnaire (TSEQ; section 2.3.2), and Transgender Voice Questionnaire for Male-to-Female (TVQ<sup>MF</sup>; section 2.3.3), and current research on the vocal satisfaction of transmasculine individuals (section 2.3.4).

Treatments for voice disorders have used objective voice measurements such as shimmer, jitter, and airflow among other components of voice production (Rosen et al., 2004: 1549). These objective measurements only considered the physical wellbeing of a patient, which did not take in to account the psychosocial wellbeing of patients. Psychometric assessments such as the VHI (Jacobson et al., 1997; TSEQ proposed by Davies (Adler et al., 2006: 116), and TVQ<sup>MIF</sup> (Dacakis et al., 2013) are conceptually grounded in the World Health Organisation's (WHO) disablement model (Adler et al., 2006: 116) or the International Classification of Functioning, Disability, and Health (ICF) (Jacobson et al., 1997). The disablement model 'disability' is synonymous with 'activity limitations', and 'handicap' with 'participation restrictions' (Adler et al, 2006: 116-117). Transmasculine individuals may face limitations and restrictions in their day-to-day lives due to the incongruous characteristics of their voice and their gender identities.

The vocal satisfaction of transfeminine individuals have been studied extensively by speech and language professionals either through perception studies (Byrne et al., 2003; Hancock et al., 2015; Hardy et al., 2016; Van Borsel et al., 2009) or using psychometric assessments (i.e. questionnaires) (Dacakis et al., 2013; Dacakis, Oates, & Douglas, 2016, 2017; Hancock, Krissing, & Owen, 2011; Hancock et al., 2009, p. 200; Hedberg, 2014; McNeill et al., 2008; Santos et al., 2015; Schwarz et al., 2017; T'Sjoen et al., 2006). However, only a handful of studies have been conducted on the vocal satisfaction of transmasculine individuals (Deuster et al. 2016a; Deuster et al., 2016b; Hancock et al., 2017; Nygren et al., 2016; T'Sjoen et al., 2008; Van Borsel et al., 2000). As the current study involves using a questionnaire to gauge the vocal satisfaction of transmasculine individuals, the following section will summarise pre-existing studies investigating vocal satisfaction of transgender individuals.

### **2.3.1 Voice Handicap Index (VHI)**

SLPs utilise tools such as the Voice Handicap Index (VHI) to establish the health impacts and social impacts of vocal disorders (Jacobson et al., 1997). The VHI was initially developed by Jacobson et al. (1997) to quantify the psychosocial impacts of voice disorders on patients. The VHI have since been

applied to transgender individuals to understand and detect possible vocal and communicative issues (T'Sjoen et al., 2008).

The initial VHI was composed of 85 items, although this was reduced to 30 following validity testing (Jacobson et al., 1997; 68). Patients evaluated their current vocal situation on a 5-point Likert scale and the total score indicated possible vocal and communicative issues (0-40 = absent to mild; 40-60 = moderate; 60-200 = severe; T'Sjoen et al., 2008: 3). The VHI is also further subcategorised by functional, physical, and emotional limitations (Jacobson et al., 1997: 70). Jacobson et al. (1997: 69) found a moderate correlation ( $r = 0.60$ ) between the VHI score and the severity of vocal dysfunction. Many patients only realised the severity of their condition once they completed the VHI, which indicates that they were unaware of the impact their voice disorder had on their health and wellbeing (Jacobson et al., 1997: 69).

Of interest to the current study, T'Sjoen et al. (2008: 4) applied the VHI on 26 transfeminine individuals and 19 transmasculine, all who took exogenous hormones (T'Sjoen et al., 2008: 3-4). They examined the relationship between vocal disability and venous testosterone levels (T'Sjoen et al., 2008: 4). An additional question was included to see whether they were misgendered over the phone, a scenario specific to transmasculine and transfeminine individuals. The results found that the sample population had a low cumulative score which indicated absent-mild vocal dysfunction (T'Sjoen et al., 2008: 5). T'Sjoen et al. (2008: 6) suggested the low cumulative VHI score was because the VHI was an assessment for vocal disorders and was not a measure of quality of life. This suggested even if transmasculine individuals had a functional voice, their speech might not affirm their gender identity. Both groups indicated they were misgendered over the phone (T'Sjoen et al., 2008: 7).

The VHI had also been studied in conjunction with f0 in transfeminine individuals to gauge vocal satisfaction (McNeill et al., 2008; Robinson et al., 1996). McNeill et al. (2008: 730) conducted a study using the VHI combined with acoustic measurements (e.g. f0) on 12 transfeminine individuals who scored 0- 71 (indicating mild-moderate vocal dysfunction) on the VHI. McNeill et al. (2008: 731) were unable to identify a significant relationship between f0 and vocal happiness. As discussed in section 2.2.2, treatment success is often dependent on sustained change in f0. An increase of f0 within

a feminine-speaking range is considered a necessary and often adequate treatment outcome (Carew et al., 2007; Dacakis, 2000; Gelfer, 1999; Gelfer & Tice, 2013; Gelfer & Van Dong, 2013; Hancock & Garabedian, 2013; Hancock & Helenius, 2012; Oates & Dacakis, 2015).

McNeill et al. (2008: 731) found a moderate correlation between self-perceived vocal femininity and happiness which suggested participants were more satisfied with their voice if they perceived it to be more feminine. Even if the f0 in speech falls within or near the range typical of cisgender female, transfeminine individuals may still not be satisfied with their voice. This result suggests a cisgender conforming f0 range alone does not equate to a gender-affirming voice. This is consistent with the findings discussed in section 2.1.3 (Andrews & Schmidt, 1997; Owen & Hancock, 2010; Hancock et al., 2014) where self-perceived vocal gender greatly impacts vocal satisfaction.

The findings from the above studies (McNeill et al., 2008; T'Sjoen et al., 2008) indicate SLPs should also align their treatment plans regarding transmasculine individuals' self-perception of gender. Therefore, condition-specific psychometric assessment tools should exist for transmasculine individuals as they may not exhibit the same communicative issues as a person with a voice disorder or transfeminine clients do.

### **2.3.2 Transgender Self-Evaluation Questionnaire (TSEQ)**

The Transgender Self-Evaluation Questionnaire (TSEQ) is a self-reporting psychometric assessment to evaluate the vocal and communicative limitations of both transmasculine and transfeminine individuals (Adler et al., 2006: 116). The TSEQ is a modified VHI and individuals are given a score between 0-150 where a lower score indicated fewer limitations (Hancock et al., 2011: 557).

The TSEQ had been applied to a small number of studies, but mainly on transfeminine individuals. (Hancock et al., 2009; as cited in Hancock et al., 2011: 544) investigated the effectiveness of the TSEQ and compared it to the VHI, and the Voice-Related Quality of Life (V-RQOL; Hogikyan & Sethuraman, 1999). The study was conducted on 13 transmasculine individuals and found a strong concurrent validity between the TSEQ with the VHI and the V-RQOL. A study comparing the TSEQ with the VHI in a subset of 32 North American transfeminine individuals found that the TSEQ was

significantly higher when compared to VHI (Hancock, 2017: 115.e5). This suggests the TSEQ is more sensitive to the needs of transfeminine individuals than the VHI.

Hancock et al. (2011) used the TSEQ to investigate the relationship between quality of life and the self- and listener-evaluated perceptions of vocal femininity and likeability for 20 transfeminine individuals. The self- and listener-evaluation of vocal femininity and likeability were recorded on a Visual Analogue Scale (VAS; Hancock et al., 2011: 556). There was significant relationship between the TSEQ and a speaker's self-perceived vocal femininity and vocal likeability which suggest as self-perceived vocal femininity and likeability ratings increase, the quality of life of transfeminine individuals also increases (Hancock et al., 2011: 557). Similarly, TSEQ scores decrease (which translates as an increase in the quality of life) as listener-perceived vocal femininity and likeability increase. These findings are consistent with previous studies which have shown self-perceived vocal gender is a major component in constructing and speaking a gender conforming voice (Andrews & Schmidt, 1997; McNeill et al., 2008; Owen & Hancock, 2010; Hancock, 2017).

However, Hancock et al. (2011: 558) suggested that further validity testing is required on the TSEQ largely due to the absence of a normative control group.

### **2.3.3 Transgender Voice Questionnaire for Male-to-Female Individuals (TVQ<sup>MTF</sup>)**

The Transgender Voice Questionnaire for Male-to-Female Individuals (TVQ<sup>MTF</sup>) evolved from the preliminary TSEQ (Dacakis et al., 2013). Dacakis et al. (2013: 313) acknowledged the widespread use of the TSEQ, and noted the urgent need for a validated psychometric assessment for transfeminine individuals.

The development of the TVQ<sup>MTF</sup> was established in two phases: a systematic review of the TSEQ, and then validity and reliability testing on a sample population (Dacakis et al., 2013: 313). The first phase asked two Australian SLPs and two transfeminine individuals to review the current TSEQ (Dacakis et al., 2013: 314). Dacakis et al. (2013: 314) conducted a thematic analysis on the interviews of 21 transfeminine individuals and found three significant themes that were absent or underrepresented in the TSEQ including: *the effect of emotion and mood on voice, the presence of voice quality problems,*

and *societal responses to voice*. Significant changes were made to the TSEQ which lead to the creation of a preliminary TVQ<sup>MtF</sup>. The second phase of the validation testing and was completed by 29 Australian and six Canadian transfeminine individuals (Dacakis et al., 2013: 315).

Participants were requested to complete the TVQ<sup>MtF</sup> twice following an interval of 2-4 weeks. The findings from the statistical analysis found a high level of internal consistency in the TVQ<sup>MtF</sup> (Dacakis et al., 2013: 316). However, a weak relationship was discovered between the time spent as female role and a lower TVQ<sup>MtF</sup> score which indicates transfeminine individuals who have spent more time presenting as female were more satisfied with their voice. The statistical analysis carried out by Dacakis et al. (2013: 316) was also applied to the Brazilian Portuguese edition of the TVQ<sup>MtF</sup> (Santos et al., 2014: 92; Schwarz et al., 2017).

Hedberg (2014) employed Principal Component Analysis (PCA) to evaluate the validity of the Swedish version of the TVQ<sup>MtF</sup> on 30 Swedish transfeminine individuals, as well as 22 cisgender females with voice disorders, and 30 cisgender females with no apparent voice disorders. The TVQ<sup>MtF</sup> scores were significantly different between transfeminine individuals and cisgender women with no voice disorders, and cisgender women with voice disorders and those without (Hedberg, 2014; as cited in (Dacakis et al., 2016: 125)). However, there were no significant differences between transfeminine individuals and cisgender women (with voice disorders) although differences were found in the response to questions regarding vocal femininity (Hedberg, 2014; as cited in Dacakis et al., 2016: 125).

Dacakis et al. (2017: 143) recruited a further 151 Australian transfeminine individuals to complete the TVQ<sup>MtF</sup>. The purpose of this study was to re-evaluate and validate the TVQ<sup>MtF</sup> (Dacakis et al., 2017: 144). The mean cumulative TVQ<sup>MtF</sup> score for 150 transfeminine individuals was initially 66.59 (Dacakis et al., 2017: 144). This result was consistent with previous validity tests on the TVQ<sup>MtF</sup> (Dacakis et al., 2013; Santos et al., 2014). The PCA conducted on the TVQ<sup>MtF</sup> highlighted two major components that accounted for 60% variance in the psychometric assessment: *vocal functioning* and *social participation* (Dacakis et al., 2017: 145). To date, the TVQ<sup>MtF</sup> is available in several languages including Croatian, Danish, Dutch, Finnish, French, German, Hebrew, Portuguese, Spanish, and Swedish (retrieved from <http://www.shelaghdavies.com/questionnaire/questionnaire.html>).

### 2.3.4 Transmasculine Considerations

A small number of studies were conducted on the vocal satisfaction of transmasculine individuals (Deuster et al., 2016a; Deuster et al., 2016b; Nygren et al., 2016; Hancock et al., 2017; Van Borsel et al., 2000). Van Borsel et al. (2000) explored the vocal issues of 16 Dutch- and French-speaking transmasculine individuals, and further conducted a longitudinal study of two patients undergoing testosterone therapy. The questionnaire looked at the effects of testosterone therapy on vocal satisfaction and the listener-perceived masculinity. 14 transmasculine individuals were satisfied with their current voice, while two subjects wanted a ‘heavier’ voice and to strain their voice when speaking (Van Borsel et al., 2000: 430). They all perceived their voice as more masculine than feminine, although four of the subjects were occasionally addressed as female on the phone (Van Borsel et al., 2000: 431). Three of the 16 subjects were often addressed as female on the street, in a shop or at social occasions (Van Borsel et al., 2000: 438). Van Borsel et al. (2000: 438) argue that non-linguistic features are to blame for these incidents. 14 considered voice as an important aspect of their transition (Van Borsel et al., 2000: 431).

Deuster et al. (2016b: 2129) examined the relationship between time on testosterone and vocal satisfaction, by asking nine German transmasculine individuals questions regarding vocal satisfaction (e.g. “I am satisfied with my voice”) and vocal congruency with gender identity (e.g. “My voice sounds male”). These participants were also a part of a longitudinal study looking at the interaction between time on testosterone and  $f_0$  over a 12-month period (Deuster et al., 2016a: 960) as discussed in section 2.2.1. There were 14 questions in total and participants rated each question on a 7-point Likert scale. The studies found there was a positive relationship between satisfaction with voice and time on testosterone. As time on testosterone increased, the vocal satisfaction increased (‘somewhat disagree’ at 0 weeks, and ‘somewhat agree’ to ‘strongly agree’ at 20-36 weeks and 50-64 weeks) (Deuster et al., 2016b: 2130).

Combined with the findings from Deuster et al. (2016a), Deuster et al. (2016b: 2130) claim that  $f_0$  and time on testosterone are major contributors to vocal satisfaction of transmasculine individuals during the first year of hormone treatment. Further longitudinal studies were carried out, this time on

50 Swedish transmasculine individuals (Nygren et al., 2016: 766.e29). Participants were asked to evaluate four statements on a 7-point Likert scale (1 = never, 7 = always) over the course of 24 months (2 years): “I am perceived as male when speaking on the phone”, “I am satisfied with my voice”, “I am worried that my voice will reveal my native sex”, “I get tired in my throat/voice or hoarse when speaking” (Nygren et al., 2016: 766.e29). Results from the study indicate that as time on testosterone increases, instances of misgendering over the phone decreases, vocal satisfaction increases, and instances of gender history disclosure decrease (Nygren et al., 2016: 766.e29). However, no relationships were found between time on testosterone with vocal and communicative issues which indicates the occurrence of these issues is highly variable.

A third longitudinal study was carried out on seven American transmasculine individuals to investigate the interaction between time on testosterone, acoustic measures, and vocal satisfaction over a 12-month period at three-month intervals (Hancock et al., 2017: 2475). At each visit, participants were recorded reading *the Rainbow Passage* and were also asked to complete three statements taken from the TSEQ; one statement was on a 5-point Likert scale “Currently my voice is...”, and two statements were on a 4-point Likert scale “I feel my voice does not reflect the true me” and “I have to concentrate to make my voice sound the way I want it to sound” (Hancock et al., 2017: 2475). Voice features such as jitter, shimmer, noise-to-harmonic ratio (NHR), and cepstral peak prominence (CPP) were calculated and acoustic measures such as mean f0, f0 range, and semitones were also extracted.

Hancock et al. (2017: 2476) found that the mean f0 of the group after one year on testosterone therapy was within  $\pm 10$  Hz of a cisgender male (approximately 123 Hz or 125.8 Hz according to their normative data). This is expected. The new pitch floor was 91.6 Hz and the pitch ceiling was 576.4 Hz. However, vocal change occurred at different stages for the participants with some following three months of testosterone therapy, and some participants after six months (Hancock et al., 2017: 2476). Furthermore, all participants rated their voice as more masculine following 12-months of testosterone therapy. Counterintuitively, self-perceived vocal masculinity did not correlate with mean f0 or habitual speaking f0 ( $r = 0.47$ ;  $p = 0.28$ ) after a year on testosterone therapy (Hancock et al., 2017: 2479). Further to this, the two participants who had the least mean f0 decrease also rated their voices

as ‘very male’, although their mean f0 was outside of the typical cisgender range. Both transmasculine individuals did not show significant decreases in mean f0 and consistently rated their voices as ‘gender neutral’ throughout the study (Hancock et al., 2017: 2480)

Hancock et al. (2017: 2480) noted the change was unexpected as it was not due to changes in mean f0 and suggested that it could be due to unmeasured voice characteristics such as formant frequencies, a placebo effect, or the participant changed criteria of what constitutes a masculine voice. The findings from Hancock et al. (2017) have implications on the previous studies evaluated so far as vocal masculinity and femininity has been attributed to mean f0 and habitual speaking pitch. This also suggests that some transmasculine individuals are satisfied with a mean f0 that is ‘gender neutral’ or ‘androgynous’ as it complies with their expression of gender identity.

## **2.4 Chapter Summary**

The current chapter provided a comprehensive overview of studies concerning the vocal satisfaction of transmasculine individuals. Little has been done to investigate the interaction between self-perceived masculinity and vocal satisfaction. This is because many scholars such as (Deuster et al., 2016a; Deuster et al., 2016b; Nygren et al., 2016; Hancock et al., 2017; Van Borsel et al., 2000) conclude that a lower f0 (because of testosterone therapy) will provide a desirable masculine voice. Davies et al. (2015: 143) argue that the paucity of research in this area stems from this belief. T’Sjoen et al. (2008: 6) argue testosterone therapy provides adequate vocal adjustments for transmasculine individuals to pass as male. However, these beliefs reinforce the misconception that vocal masculinisation occurs automatically following testosterone therapy (with no regard to masculine speech characteristics not related to f0). On the other hand, transfeminine individuals require active intervention as oestrogen hormone supplements do not have a biological effect on the larynx (Holmberg et al., 2010: 511).

This may explain why studies are more numerous on the voices of transfeminine individuals and studies on transmasculine individuals are few and far between. However, recent studies suggest self-perceived vocal perception has a major influence on the vocal satisfaction (Hancock et al., 2017).

There are numerous factors involved which contribute to the vocal satisfaction of transmasculine individuals with reference to the ‘Gender-related aspects of transmasculine people’s vocal situations’ model conceptualised by Azul (2015).

The vocal satisfaction of transmasculine individuals is under-documented, the current study will expand our understanding of the vocal and communicative needs of this population. Based on the above literature review, the following questions and associated hypotheses will be employed to investigate the vocal satisfaction of transmasculine individuals:

1. How satisfied are transmasculine individuals with their speech?

Hypothesis 1: *A self-perceived masculine voice correlates with a masculine gender identity.*

Hypothesis 2: *Vocal satisfaction increases as self-perceived vocal masculinity increases.*

2. What is the relationship between the transmasculine individuals’ voice and their quality of life?

Hypothesis 3: *Vocal and communicative issues decrease as self-perceived vocal masculinity increases.*

Hypothesis 4: *Self-perceived vocal masculinity increases as time on testosterone increases.*

Hypothesis 5: *Vocal satisfaction increases as time on testosterone increases.*

3. What are the acoustic correlates of masculinity and the socio-cultural construct of the male gender identity?

Hypothesis 6: *A low fundamental frequency ( $f_0$ ) correlates with a masculine gender identity.*

Hypothesis 7: *Fundamental frequency ( $f_0$ ) decreases as time on testosterone increases.*

Hypothesis 8: *Vocal satisfaction increases as fundamental frequency ( $f_0$ ) decreases.*

Furthermore, the current study had methodology-related goals as well, namely to test the efficacy of using acoustic tools such as *Language and Brain and Behaviour Corpus Analysis Tool* (LaBB-CAT; Fromont & Hay, 2017) and *Robust Epoch And Pitch Estimator* (REAPER; Talkin, 2015) within a clinically applied area of research.

## **Chapter 3: Methodology**

The aim of this study was to collect information about the vocal satisfaction and the self-perceived masculinity of transmasculine individuals. As the study was conducted online, participants had the freedom to complete the questionnaire and provide speech sample using their own personal electronic devices (e.g. laptops, desktop computers, tablets, mobile phones etc.). Participants were also notified in advance that providing a speech sample was optional and that they can exit the study at their own volition.

Participants were first presented with information detailing the purpose and aim of the study before they were asked to provide consent to proceed with the data collection. As per University of Canterbury guidelines, all raw unedited data will be stored for a period of 5 years and will be subsequently destroyed. Participants' contact information was stored separately from the speech and questionnaire data, and a copy of the results from this study was sent to those who have indicated they were interested in obtaining a copy of the thesis. This study was approved by the Human Ethics Committee of the University of Canterbury and the Kaiārahi Māori Research team.

### **3.1 Participants**

The participants of this study were recruited online via e-mail and social media. Participants were required to identify or have identified as a transitioning and/or transitioned transgender male or transmasculine individuals. Only participants who were 18 years-old at the time of the study will be included in the analysis of the study.

### **3.2 Inducement**

Participants were offered a chance to win one of two US\$35.00 online vouchers from Amazon.com with funding provided by the University of Canterbury College of Arts. Participants who provided a speech sample were given an extra opportunity to win one of the two online vouchers.

### 3.3 Software

The questionnaire results and the speech samples were collected and housed on the *Language, Brain and Behaviour Corpus Analysis Tool* (LaBB-CAT) which is a browser-based corpus analysis tool designed by Fromont and Hay (2017). The underlying architecture of the transmasculine questionnaire was designed by Robert Fromont from the New Zealand Institute of Language, Brain, and Behaviour. Participants were able to complete the study via the survey link at: <https://labbcats.canterbury.ac.nz/transvoice/elicitation/index.html?task=transvoice>.

The benefit of using LaBB-CAT (Fromont & Hay, 2017) for the purposes of this study was that it allowed for the immediate extraction and analysis of linguistic variables such as acoustic data through a third-party software Praat (Boersma & Weenink, 2017) and *Robust Epoch And Pitch Estimator* (REAPER; Talkin, 2015).

### 3.4 Speech Sample

This study was comprised of an optional speech recording, and the questionnaire proper. All participants were able to choose whether they want to provide a speech sample. Once the microphone was enabled on the participant's personal electronic devices they were prompted to an instruction screen. The speech sample was comprised of four components which included a throat clearing sample, a cough sample, the reading passage "North Wind and the Sun" in a language of their choosing (e.g. English, German, Dutch, French, Russian, Hindi, Traditional Chinese, Simplified Chinese, Japanese, and Korean).

The translations for Aesop's "North Wind and the Sun" were retrieved from Aesop Language Bank (Aesop Language Bank Team, 2010), and were proofread by fluent speakers of the respective languages for clarity and consistency. Examples of the English language version and German language version are in *Appendix* as Example 1 and Example 2. This was followed by a short questionnaire to indicate whether they were binding during the recording. All sound files were saved as a waveform audio file format (.wav).

### 3.5 Questionnaire Design

Participants were redirected to the questionnaire once they completed the speech recording (or if they decided not to provide a speech sample). This current study aimed to incorporate as many of the factors listed in Azul et al. (2017) as feasible in an online survey. Participants were asked to provide a mixture of binary and multivariate responses. Open-ended questions were limited; however, this option was available for questions regarding gender identity or sexual orientation. Tables 6, 7, and 8 presents the questions included in the study. The tables have are out according to the order the questions were asked, the question, the analysis code, type of question, and style of question.

There were 60 questions. The analysis code was the unique text code which was used during the statistical analysis and data visualisation (code for variables are presented as `variable` throughout the current study). Some codes have `scale` placed after the analysis code which indicated that the variables were converted from factors to numerals. Types of questions included scaling (e.g. Likert-scale), multiple choice (multi), binary (e.g. yes/no, true/false), and open textbox questions. Lastly, styles of questions included radio buttons (radio), checkbox (check), and open textbox questions.

The questionnaire was categorised into relevant blocks where each block targeted a specific aspect of the participant's voice. For example, questions one to four in the first block included questions regarding their perception of their voice as shown in Table 6. This block included questions were related to the participant's vocal satisfaction and how they used their voice. Questions 5 to 32 were related to the participant's vocal and communicative factors.

Questions 33 to 40 were only available to participants if they indicated they had taken testosterone as shown in Table 7. The questions in this block included testosterone usage history and how testosterone had affected the participants' voice. If the participant indicated they did not use testosterone, they were redirected to the penultimate block of questions which included questions about vocal intervention methods in questions 41 to 48.

Table 6. Questionnaire Items (Part 1): Question No., Question, Analysis Code, Type, & Style

No.	Question	Code	Type	Style
1	I believe currently my voice is...	current_voice	scaling	radio
2	My IDEAL voice would be...	ideal_voice	scaling	radio
3	I need active use of my speaking voice for	need_speaking_voice	multi	check
4	I need active use of my singing voice for	need_singing_voice	multi	check
5	I have trouble being heard in noisy situations.	inaudible_in_noise	binary	radio
6	The pitch (melody / intonation) of my speaking voice is stable and reliable.	stable_pitch	binary	radio
7	My voice is worse in the evening.	worse_in_evening	binary	radio
8	I have a speaking voice that feels authentic to me.	authentic_speaking	binary	radio
9	The pitch (melody / intonation) range of my voice is restricted.	restricted_pitch	binary	radio
10	I find it easy to be loud at a vocal range that feels authentic to me.	loud_easily	binary	radio
11	People ask "What's wrong with your voice?" or "Do you have a cold?"	people_ask	binary	radio
12	I have to strain to make my voice sound like I want it to.	strain	binary	radio
13	I run out of air and need to take frequent breaths when talking.	frequent_breaths	binary	radio
14	My voice difficulties restrict my personal and social life.	difficulties_restrictive	binary	radio
15	My voice causes me to lose income.	lost_income	binary	radio
16	I hesitate to call people I don't know on the phone because of my voice.	phone_averse	binary	radio
17	I'm consciously trying to change my voice.	consciously_changing	binary	radio
18	I feel self-conscious about how strangers perceive my voice.	self_conscious	binary	radio
19	My voice frustrates me.	frustrated	binary	radio
20	My voice makes me feel masculine.	feels_masculine	binary	radio
21	How often are you perceived as female on the phone?	phone_female	scaling	radio
22	How important is your voice in affirming your gender identity?	identity_importance	scaling	radio
23	Do you feel your current voice matches your current gender identity?	matches_gender_identity	binary	radio
24	Do you feel your current voice matches your current gender expression?	matches_gender_expression	binary	radio
25	Are you satisfied with your present voice?	satisfied	scaling	radio
26	Are you currently living and / or presenting as male?	living_male	scaling	radio
27	Do you normally bind (use any chest binding methods)?	normally_bind	scaling	radio
28	Has your binder ever had the following impact on you?	binder_impact	multi	check
29	In the past 4 weeks to the best of your knowledge, did you snore?	snore	scaling	radio
30	Your voice helps you live / present as male.	helps_present_male	scaling	radio
31	Your voice reflects the true you.	true_you	scaling	radio
32	Have you ever taken testosterone?	testosterone	scaling	radio

Table 7. Questionnaire Items (Part 2): Question No., Question, Analysis Code, Type, & Style

No.	Question	code	Type	Style
33	How long have you been taking testosterone in total?	testosterone_total_time	binary	textbox
34	Have you ever started and stopped using T? If yes, how long were you off T?	testosterone_start_stop	open	textbox
35	During the first year, what method of testosterone therapy did you use the most?	testosterone_therapy	open	radio
36	How quickly did your voice change after the beginning of testosterone use?	testosterone_change_speed	multi	radio
37	Did testosterone change your speaking voice as you expected it?	testosterone_change_expected	scaling	radio
38	If you couldn't achieve sufficient voice change with the help of testosterone, would you consider vocal surgery?	consider_vocal_masculinisation_surgery	scaling	radio
39	Compared to before testosterone, how would you rate your snoring now?	testosterone_snore	binary	radio
40	How did testosterone change your singing pitch range?	testosterone_singing_range	scaling	radio

Table 8. Questionnaire Items (Part 3): Question No., Question, Analysis Code, Type, & Style

No.	Question	Code	Type	Style
41	If you want / wanted to change your voice, please indicate what you would try / tried to achieve	goals	multi	check
42	On average, how many PACKS per DAY did you smoke in the past year?	cigarette_packs_per_day	multi	radio
43	If you couldn't achieve sufficient voice change with the help of testosterone, would you consider vocal surgery?	vocal_surgery	scaling	radio
44	Have you ever worked on masculinising your voice with a speech and language practitioner or voice coach?	slp_coach	binary	radio
45	Have you ever heard of vocal masculinisation surgery?	heard_of_vocal_masculinisation_surgery	binary	radio
46	If you were dissatisfied with your voice, would you consider undergoing vocal masculinisation surgery?	consider_vocal_masculinisation_surgery	binary	radio
47	Tell us about your vocal surgery	vocal_surgery_story	open	textbox
48	What methods of vocal masculinisation would you recommend to a friend wanting to masculinise their voice?	recommended_methods	multi	radio
49	Your age in years	age	open	textbox
50	In which country (or countries) did you live the first 10 years of your life?	country_young	open	textbox
51	In which country do you currently live?	country_now	open	textbox
52	What sex were you assigned at birth?	birth_sex	multi	radio
53	Who do you normally disclose your gender history to?	disclose_to	multi	radio
54	Select your highest level of completed education	ethnicity	scaling	radio
55	Which race(s) or ethnic group(s) do you identify with?	education	open	textbox
56	What pronouns should people use when talking about you?	pronouns	multi	check
57	What people are you sexually attracted to?	sexual_preference	multi	check
58	What word(s) best describe your sexual orientation?	sexual_orientation	open	textbox
59	What word(s) best describe your gender identity?	gender_identity	open	textbox

Questions 49 to 59 were included to gauge demographic information of participants such as age and country of origin, and sensitive questions regarding their gender identity, assigned sex at birth, and sexual orientation.

Following the questionnaire, participants were presented with a debriefing screen and links were provided regarding additional resources and further research into transgender and gender nonconforming individuals. If the participants desired more information about vocal health and surgical procedures for voice masculinisation such as Thyroplasty Type 3, and a link to the online version of the journal article “Voice and Communication Change for Gender Nonconforming Individuals: Giving Voice to the Person Inside” by Davies, Papp, and Antoni (2015) was provided.

### **3.6 Data Analysis**

The data was analysed in R (Gentleman & Ihaka, 2017) via RStudio (RStudio Team, 2016). The correlation coefficient analysis employed R package reshape2 (Wickham, 2009) to consolidate the *r*-values and R packages corrplot (Wei & Simko, 2016) and PerformanceAnalytics (Peterson & Carl, 2014) were used for data visualisation. The transition plots were created using R package Gmisc (Gordon, 2017). The stacked Likert bar plots used R package likert (Bryer & Speerschneider, 2016) for data visualisation. The R packages venneuler (Wilkinson, 2011) and VennDiagram (Chen, 2016) were used to visualise the stacked Venn diagrams and Venn diagrams. Exploratory textual analysis and word cloud data visualisation used R package tm (Feinerer, Hornik, & Meyer, 2008), SnowballC (Bouchet-Valat, 2014), wordcloud (Neuwirth, 2014), RColorBrewer (Fellows, 2014). The R package FactoMineR (Le et al., 2008) was used for Principal Component Analysis and R packages corrplot (Wei & Simko, 2016), ggpubr (Kassambara, 2017), and factoextra (Kassambara & Mundt, 2017) were used for data visualisation. All other data visualisations (e.g. bar plots, box plot, histograms, scatter etc.) used R package ggplot2 (Wickham, 2009).

## Chapter 4: Questionnaire Results

The data was collected over a three-month period from July to October 2017, and over 196 participants have completed the study. Due to the conditions of the Human Ethics Committee application, participants who were under the age of 18 at the time of completing this study and those who indicated their birth sex was male have been excluded from the current study. The responses from the 185 remaining participants have been included in the current analysis.

Section 4.1 analysed the demographic information in the questionnaire. This was subdivided into geographic and ethnic distribution (section 4.1.1), gender identity (section 4.1.2), sexual orientation (section 4.1.3), pronouns used (section 4.1.4), binding habits and impacts (section 4.1.5), and smoking habits (section 4.1.6). Section 4.2 analysed the self-evaluation of voice and vocal and communicative impacts. This was subdivided into self-perception of voice (section 4.2.1), testosterone use (section 4.2.2), and intervention (section 4.2.3). Lastly, section 4.3 analysed vocal satisfaction.

### 4.1 Demographic Information

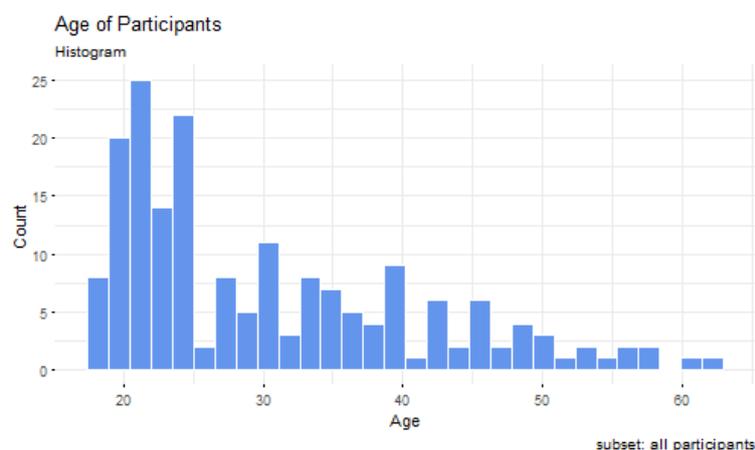


Figure 2. Histogram Age of Participants

The participants came from a diverse educational background as shown in Figure 3 (R package: ggplot2; Wickham, 2009). Most of the participants have studied towards a tertiary qualification such as Certificate/Diploma ( $n = 40$ ), Bachelor ( $n = 54$ ); Masters ( $n = 21$ ), Postgraduate Certificate/Diploma ( $n = 12$ ), and Doctorate ( $n = 9$ ). Three participants and 56 participants completed primary and secondary education respectively. Overall, the participants in the sample population for this study were relatively educated with at least a Bachelors level qualification.

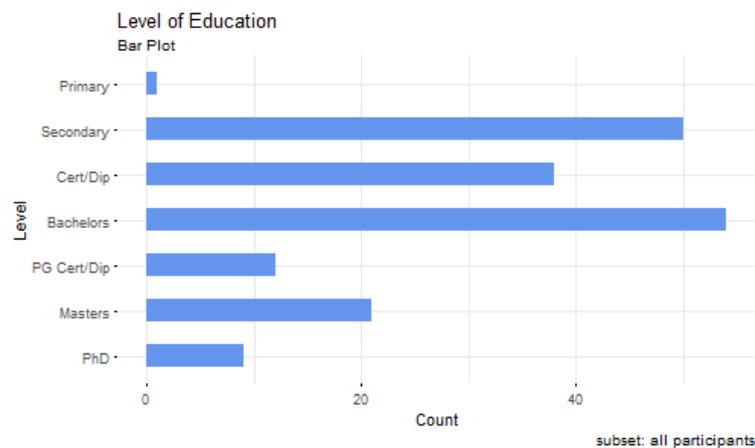


Figure 3. Bar Plot Level of Education

Of the 195 participants, five participants indicated that their birth sex as ‘other’. These individuals indicated they were assigned male at birth. As the study was advertised towards transmasculine individuals, those who were assigned male at birth and identify with a non-binary or transmasculine gender identities were eligible to complete the study. However, the intent of the study was to explore the vocal satisfaction and communicative needs of those who were assigned female at birth; therefore, only participants that noted they were assigned female at birth were included (no participants identified as intersex in the current study).

#### 4.1.1 Geographic & Ethnic Distribution

The purpose of this study was to conduct a global questionnaire to explore the vocal satisfaction and communicative needs of transmasculine individuals. This question was explored through questions 50

(country\_young; “In which country (or countries) did you live the first 10 years of your life?”) and 51 (country\_now; “In which country do you currently live?”). Many of the participants spent their formative years in predominantly English-speaking countries such as the United States ( $n = 55$ ), Australia ( $n = 23$ ), New Zealand ( $n = 14$ ), Canada ( $n = 11$ ), and the United Kingdom ( $n = 11$ ), and predominately German-speaking countries such as Germany ( $n = 31$ ), and Switzerland ( $n = 10$ ). These numbers do not account for the participants who spent their youth in other countries, or currently reside in multiple countries. Other countries and language-areas include Finland, Greece, India, Italy, Denmark, the People’s Republic of China, Malaysia, and Mexico etc. Eighty-six eligible participants provided a speech sample with 71 of the recordings in Standard English and 15 of the recordings in Standard German. This mirrored the distribution of participants who grew up and living in predominately English and German majority speaking countries. Most of participants in this study grew up in economically developed countries. Participants were asked to input their race or ethnic affiliation in a textbox.



Figure 4. Word Cloud of Ethnic/Racial Affiliation

This was explored through question 56 (ethnicity; “Which race(s) or ethnic group(s) do you identify with?”). A word cloud was produced based on the responses through exploratory textual analysis as shown in Figure 4 (R package; tm: Feinerer et al., 2008; SnowballC: Bouchet-Valat, 2014; wordcloud: Neuwirth, 2014; RColorBrewer: Fellows, 2014). Most of the participants identified as

‘white’ ( $n = 87$ ), ‘Caucasian’ ( $n = 37$ ), ‘European’ ( $n = 30$ ). Several participants identified closely with their nationality such as ‘British’ ( $n = 7$ ), ‘Australian’ ( $n = 6$ ), or ‘American’ ( $n = 6$ ). Lastly, a few participants preferred not to disclose their racial or ethnic affiliations and identified with ‘none’ ( $n = 6$ ) or ‘human’ ( $n = 5$ ).

#### 4.1.2 Gender Identity

The next series of demographic questions explored the gender identity of transmasculine individuals. Participants were asked to input words which best described their gender identity in question 59 (`gender_identity`; “What word(s) best describe your gender identity?”). Many participants included multiple terms to describe their gender identity. An exploratory textual analysis was conducted to identify the most significant gender identities in the study. The results of the exploratory textual analysis is shown in Figure 5 (R package; `tm`: Feinerer et al., 2008; `SnowballC`: Bouchet-Valat, 2014; `wordcloud`: Neuwirth, 2014; `RColorBrewer`: Fellows, 2014).

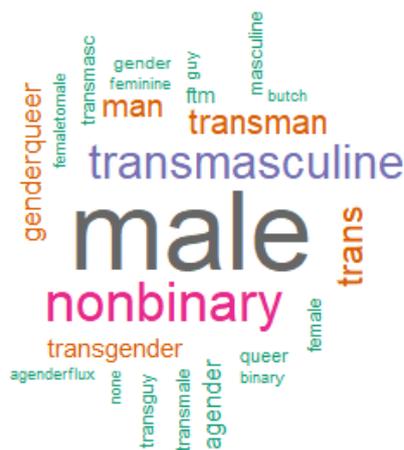


Figure 5. Wordcloud of Gender Identity Terms

A significant number of participants wrote ‘male’ ( $n = 85$ ) and/or ‘man’ ( $n = 16$ ) to describe their gender identity. This was followed by ‘non-binary’ ( $n = 37$ ) and/or ‘transmasculine’ ( $n = 29$ ), and/or ‘trans’ ( $n = 19$ ) and/or ‘transman’ ( $n = 18$ ) and/or ‘transgender’. Another significant group were those

who identified as ‘genderqueer’ ( $n = 14$ ) and/or ‘agender’ ( $n = 10$ ). Only eight participants identified as ‘female-to-male’ (or ‘FtM’). A visible trend among the responses was the number of participants who described their gender identity as some form of maleness. Disclosure of trans-history was optional. In some cases, transmasculine individuals identified as ‘non-binary’ or ‘genderqueer’. The term ‘non-binary’ or ‘genderqueer’ are those who did not fit within the established ideas of sexuality and gender.

The gender identity terms were then manually categorised in to five categories based on the stem of the gender identity terms: ‘non-binary’, ‘trans’, ‘masculine’, ‘male’, and ‘other’. Many participants belonged to more than one category as shown in the five-factor Venn diagram in Figure 6 (R package: VennDiagram; Chen, 2016). There was significant overlap across the different gender identity terms used by the participants. The categories provided a valuable measure for interpreting the questionnaire results. Those who identified as ‘non-binary’ or ‘other’ may not face the exact communicative difficulties as those who used ‘male’ to describe their gender identity.

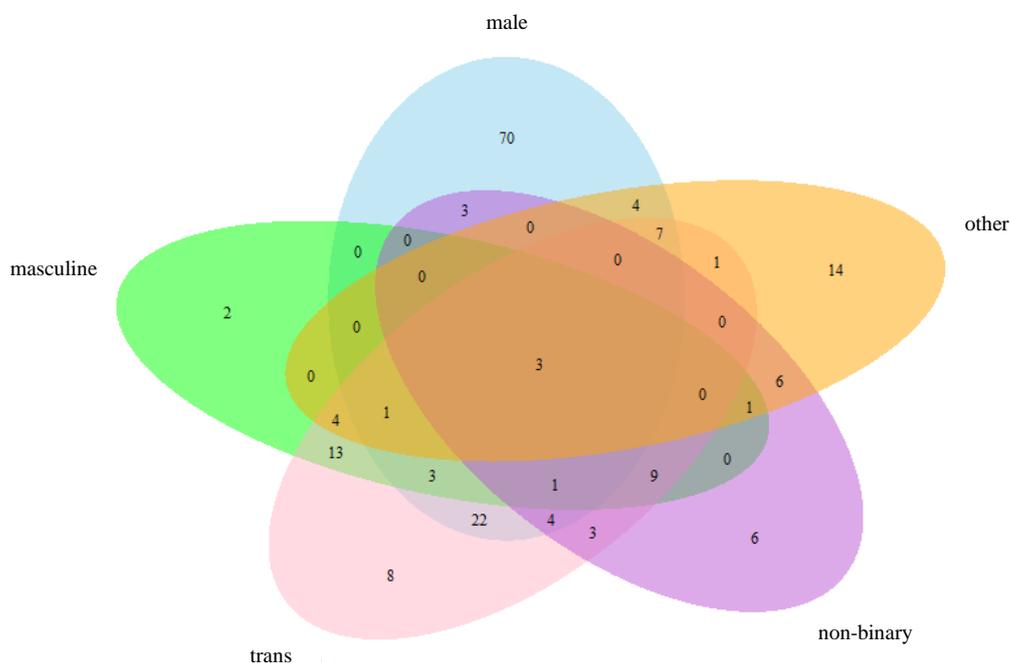


Figure 6. Venn Diagram of Gender Identity Categories

The results from the exploratory text analysis of question 59 coincided with the responses of question 26 (`living_male`; “Are you currently living and / or presenting as male?”). Transmasculine

individuals who currently lived and presented as male full-time numbered 139. Twenty-six participants sometimes lived and presented as male, while 20 participants did not present as male at all in their day-to-day lives.

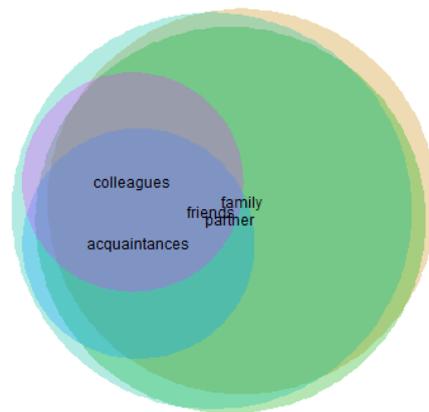


Figure 7. Stacked Venn Diagram of Gender Disclosure

Most participants were willing to disclose their gender history to their family ( $n = 151$ ), partners ( $n = 152$ ), and close friends ( $n = 160$ ); however, many transmasculine individuals withheld this information from acquaintances and colleagues as shown in Figure 7 (R package: `venneuler`; Wilkinson, 2011) which explored question 53 (`disclose_to`; “Who do you normally disclose your gender history to?”).

#### 4.1.3 Sexual Orientation

The next set of questions asked the participants to describe their sexual orientation. This variable was analysed through exploratory textual analysis. Participants were asked to input words in a textbox which best described their sexual orientation in question 58 (`sexual_orientation`; “What word(s) best describe your sexual orientation?”). As shown in Figure 8 (R package; `tm`: Feinerer et al., 2008; `SnowballC`: Bouchet-Valat, 2014; `wordcloud`: Neuwirth, 2014; `RColorBrewer`: Fellows, 2014), many

participants preferred to use the word ‘queer’ ( $n = 54$ ) to describe their sexual orientation. Some participants described their sexual orientation as ‘gay’ ( $n = 34$ ), ‘pansexual’ ( $n = 33$ ), ‘bisexual’ ( $n = 30$ ), or ‘asexual’ ( $n = 17$ ), and a few considered themselves as ‘straight’ ( $n = 18$ ) or ‘heterosexual’ ( $n = 7$ ).

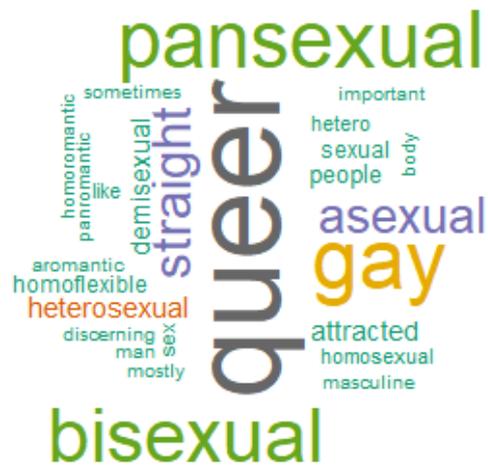


Figure 8. Word Cloud of Sexual Orientation

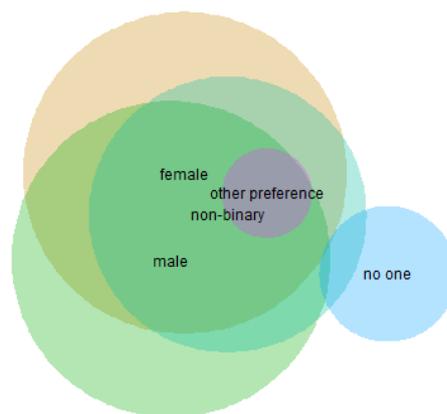


Figure 9. Stacked Venn Diagram of Sexual Orientation

Question 57 (*sexual\_preference*; “What people are you sexually attracted to?”) asked participants to whom they are sexually attracted to. The results revealed an immense amount of overlap, and many participants were sexually attracted to both female-bodied ( $n = 129$ ) and/or male-bodied ( $n = 125$ ) individuals, as well as non-binary ( $n = 95$ ) individuals as shown in Figure 9 (R package: *venneuler*; Wilkinson, 2011). A minority of participants were not sexually attracted to anyone ( $n = 23$ ), and/or provided an alternative answer regarding their sexual orientation ( $n = 10$ ) (e.g. “anyone regardless of their gender”). There were no significant correlations between a participant’s sexual preference and other variables in the current study.

#### 4.1.4 Pronouns

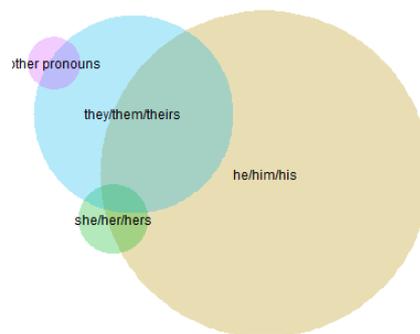


Figure 10. Stacked Venn Diagram of Pronouns Used

In relation to pronoun usage in English, participants were asked to select the preferred 3<sup>rd</sup> person singular pronoun for other people to use when referring to them (question 57, *pronouns*; “What pronouns should people use when talking about you?”). As shown in Figure 10 (R package: *venneuler*; Wilkinson, 2011), participants predominantly selected the masculine pronouns ‘he/him/his’ ( $n = 155$ ), and/or neutral pronouns ‘they/them/theirs’ ( $n = 57$ ), and/or feminine pronouns ‘she/her/hers’ ( $n = 7$ ). In addition to these options available, four participants opted for alternative pronouns such as ‘it/its’, ‘zie/hir’, or prefer for others to use their given names with no pronoun

substitutes. There are positive correlations between participants who prefer to be referred to as ‘he/him/his’ with `gender_identity_male` ( $r = 0.58$ ). Transmasculine individuals who identified as ‘male’ were more likely to use ‘he/him/his’ pronouns, than

#### 4.1.5 Binding

Binding is an area of interest specific to transmasculine individuals. This was explored through question 27 (`normally_bind`; “Do you normally bind (use any chest binding methods)?”). Figure 11 (R package: `likert`; Bryer & Speerschneider, 2016) visualises the impacts of binding on health and activity as explored in question 28 (`binder_impacts`; “Has your binder ever had the following impact on you?”). As per the questionnaire, a significant majority of transmasculine individuals have had chest reconstruction or top surgery ( $n = 89$ ). Most of the respondents always ( $n = 53$ ) and sometimes ( $n = 25$ ) used binders. Eighteen participants did not bind at all.

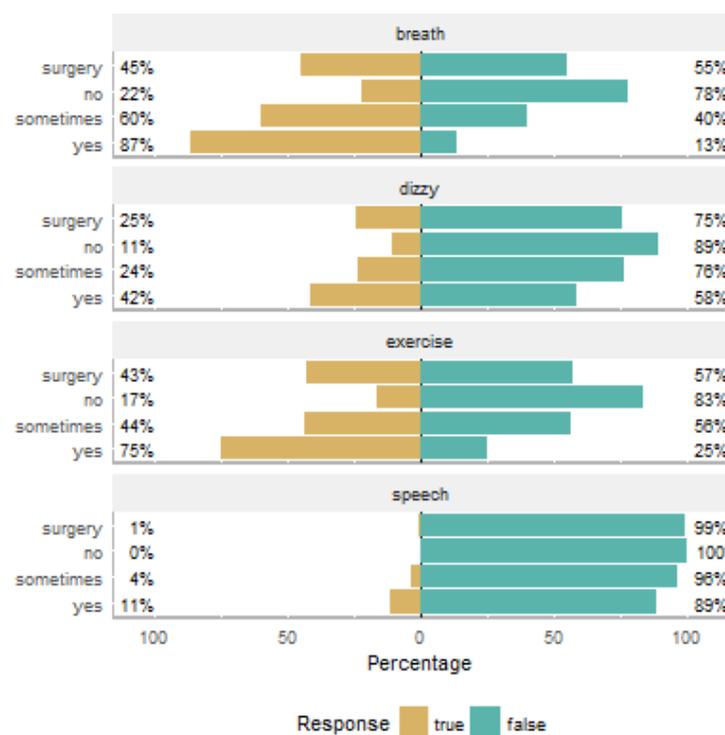


Figure 11. Stacked Column Graph of Binder Impacts

A correlation coefficient analysis was conducted on the binder impacts (excluding participants who have had chest reconstruction or top surgery) and a negative correlation was found between those who bind and those who ran out of breath ( $r = -0.52$ ) and those who often chose not to exercise ( $r = -0.46$ ). This suggested those who used binders ran out breath and were less likely to exercise because of their binders.

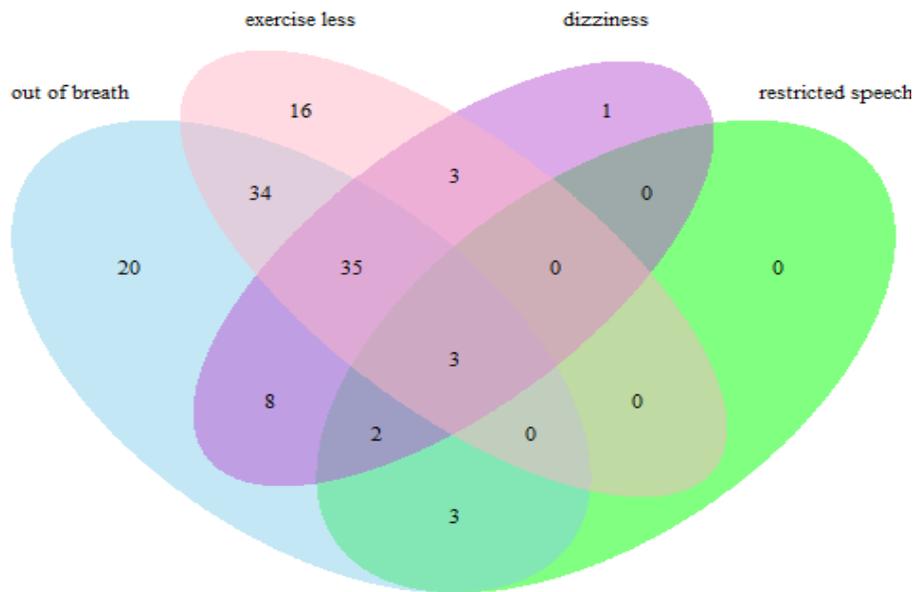


Figure 12. Venn Diagram of Binder Impacts

Figure 12 (R package: VennDiagram; Chen, 2016) summarises the health impacts of binders on a quadruple factor Venn diagram. With reference to Figure 12, participants who run out breath also chose not to exercise ( $n = 34$ ). Participants felt faint or dizzy because of their binders ( $n = 35$ ). A few transmasculine individuals experienced all negative health impacts ( $n = 3$ ) from their binders. Only eight of the participants who were binding ( $n = 78$ ) did not experience any negative health impacts.

#### 4.1.6 Smoking

Participants' smoking habits and cigarette use were explored through question 42 (cigarette\_packs\_per\_day; "On average, how many PACKS per DAY did you smoke in the past

year?”). Most of the participants in the current study did not smoke ( $n = 137$ ), although a few participants smoked either half a pack of cigarettes ( $n = 17$ ) or a full pack of cigarettes ( $n = 11$ ) per day in the last year. Four participants smoked more than a pack of cigarettes per day in the last year, and 16 participants smoked recreationally or less than ten cigarettes per week in the last year.

## 4.2 Self-Evaluation of Voice & Vocal and Communicative Impacts

The current section analysed the self-evaluation of voice and vocal and communicative impacts. This was subdivided into self-perception of voice (section 4.2.1), testosterone use (section 4.2.2), and intervention (section 4.2.3). For the purposes of the current analysis, gendered voices were conceptualised on a spectrum binary where masculinity or male voices lay on one end of the spectrum, and feminine or female voices lay on the other end of the spectrum.

### 4.2.1 Self-perception of Voice

The self-perceived vocal masculinity of transmasculine individual’s and their ideal vocal condition were explored through questions 1 (*current\_voice*; “I believe currently my voice is...”) and 2 (*ideal\_voice*; “My IDEAL voice would be...”). Figure 13 (R package: likert; Bryer & Speerschneider, 2016) is a summary of the current voice and ideal voice of all participants.

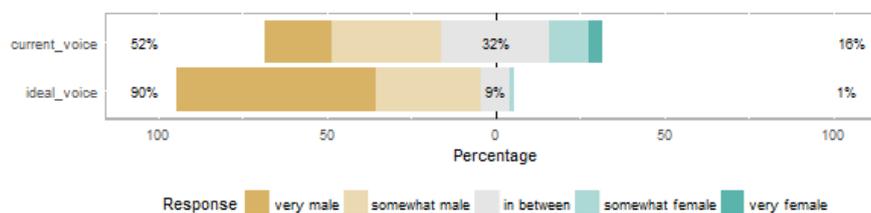


Figure 13. Stacked Column Graph of Current & Ideal Voice Conditions

As shown in Figure 13, most of the participants perceived their voices to be ‘in between that of a female and male’ ( $n = 59$ ) and ‘somewhat male’ ( $n = 60$ ). This was followed by participants who perceived their voices to be ‘very male’ ( $n = 37$ ), ‘somewhat female’ ( $n = 22$ ), and ‘very female’ ( $n = 7$ ). When contrasted with their ideal voice, a clear majority of participants wanted to speak with a

‘very male’ ( $n = 109$ ) and ‘somewhat male’ ( $n = 58$ ) voice. Few participants wanted to speak with a ‘somewhat female’ ( $n = 2$ ) voice and none of the participants wanted to speak with a ‘very female’ voice. There was a positive correlation between current voice and ideal voice ( $r = 0.51$ ): the vocal masculinity of the ideal voice increased as self-perceived vocal masculinity increased. This suggested transmasculine individuals wanted to increase the masculinity of their voices.

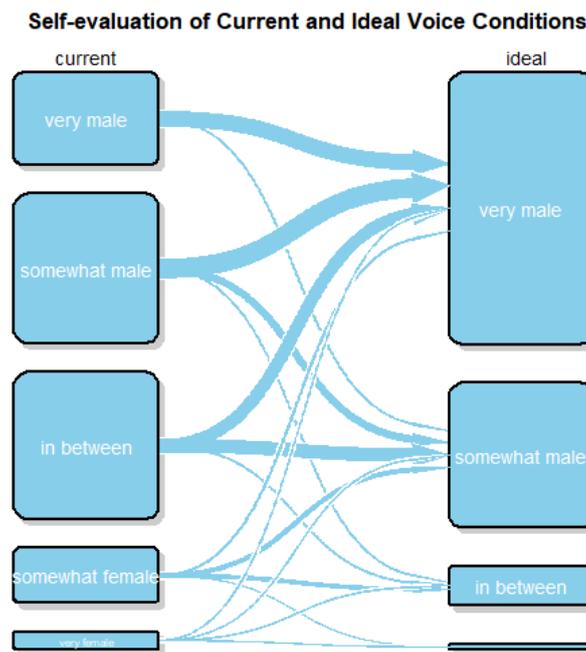


Figure 14. Transition Plot of Current to Ideal Voice

The results from `current_voice` and `ideal_voice` can be visualised using a transition plot as shown in Figure 14 (R package: `likert`; Bryer & Speerschneider, 2016) which supports this claim. Figure 14 visualises the transition from the participants’ current vocal conditions to their ideal vocal conditions. Most of the participants desired to masculinise their current vocal conditions, and only a few individuals wished to neutralise their voices. This suggests some transmasculine individuals who did not identify with a ‘male’ gender identity may not desire to have a ‘very male’ voice. On the other hand, they may want to speak with an androgynous voice that matched their ‘non-binary’ or ‘other’ gender identity. This can be observed in Figure 15 (R package: `likert`; Bryer & Speerschneider, 2016).

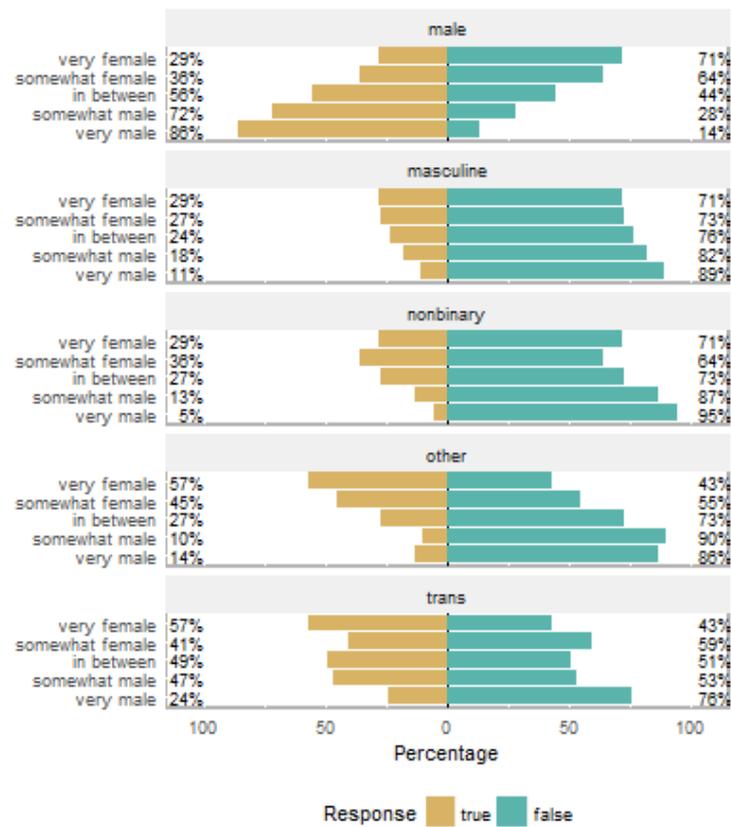


Figure 15. Stacked Column Graph of Ideal Voice & Gender Identity Categories

Figure 15 plotted the transmasculine individuals' `ideal_voice` and `gender_identity` identified in the exploratory text analysis in section 4.1.2. A visual inspection of Figure 15 found that participants who identified as 'male' and/or 'masculine' were more likely to desire a voice that was 'somewhat male' and/or 'very male'. With reference to Figure 15, transmasculine individuals who identified as non-binary desired a voice that was 'in between that of a female and male'. Counterintuitively, the `ideal_voice` for participants who described their gender identity 'trans' was a voice that was 'somewhat male', but not a 'very male' very. This could suggest transmasculine individuals who identified as 'trans' were still in transition and did not want to identify strongly with a 'male' gender identity.

### Voice Congruence with Gender Expression & Gender Identity

Figure 16 (R package: likert; Bryer & Speerschnieder, 2016) explored to what extent the participant’s voice matched their gender expression and gender identity. Participants were asked questions 23 (`matches_gender_identity`; “Do you feel your current voice matches your current gender identity?”) and 24 (`matches_gender_expression`; “Do you feel your current voice matches your current gender expression?”). The results of these questions were grouped based on self-perceived vocal masculinity. As shown in Figure 16, participants who perceived their voices to be ‘somewhat male’ or ‘very male’ indicated that their current voice matched their gender expression and gender identity. Conversely, transmasculine individuals who indicated their voices were ‘in between that of a female and male’, ‘somewhat female’, or ‘very female’ felt their voice did not match their gender expression or gender identity. There was a significant negative correlation with `matches_gender_expression` ( $r = -0.57$ ) and `gender_identity` ( $r = -0.64$ ). This suggests transmasculine individual’s voice no longer matched their gender expression if their self-perceived vocal masculinity decreased.

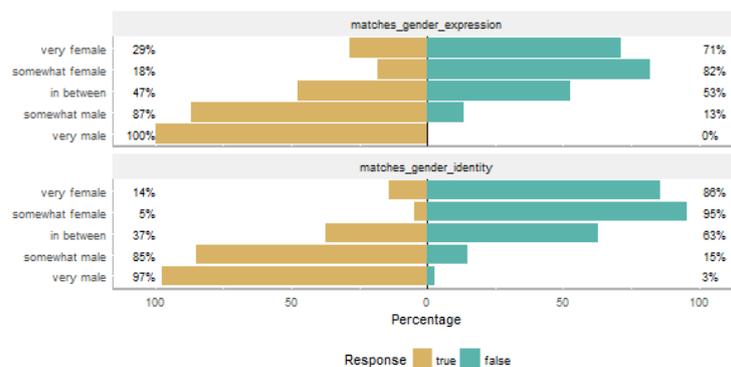


Figure 16. Stacked Column Graph of Current Voice & Gender Identity Congruence

Questions 30 (`helps_present_male`; “Your voice helps you live / present as male.”) and 31 (`true_you`; “Your voice reflects the true you.”) asked transmasculine individuals whether their current voice helped them present as male and asked them whether this reflected their ‘true selves’. As shown in Figure 17 (R package: likert; Bryer & Speerschnieder, 2016), those who perceived their

voices to be ‘somewhat male’ and ‘very male’ rated the highest on the male presentation scale, while those who perceived their voice to be ‘somewhat female’ and ‘very female’ rate the lowest on the male presentation scale. This observation is supported by the significant positive correlation ( $r = 0.81$ ). Furthermore, those who had a ‘somewhat male’ or ‘very male’ voice felt their voices ‘always’ or ‘almost always’ reflected their ‘true selves’.

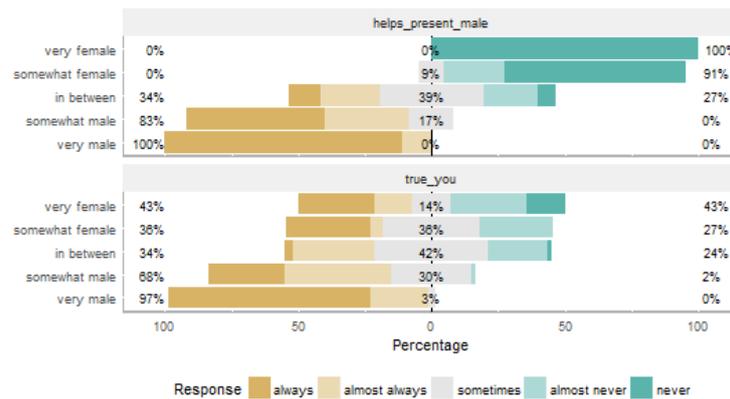


Figure 17. Stacked Column Graph of Current Voice & Gender Expression

### Importance of Voice

Question 22 (`identity_importance`; “How important is your voice in affirming your gender identity?”) found that nearly all participants thought that their voice played an important role in affirming their gender identity. Transmasculine individuals said that their voice was either the most important trait ( $n = 84$ ) or an equally important trait ( $n = 90$ ) alongside physical changes. A small number of transmasculine individuals felt their voice was not at all important in affirming their gender identity ( $n = 7$ ). Figure 18 (R package: `likert`; Bryer & Speerschneider, 2016) indicated the voice was particularly important for participants who identified as ‘male’, while participants who identified with other gender identity terms did not think the voice played an important role in affirming gender identity.

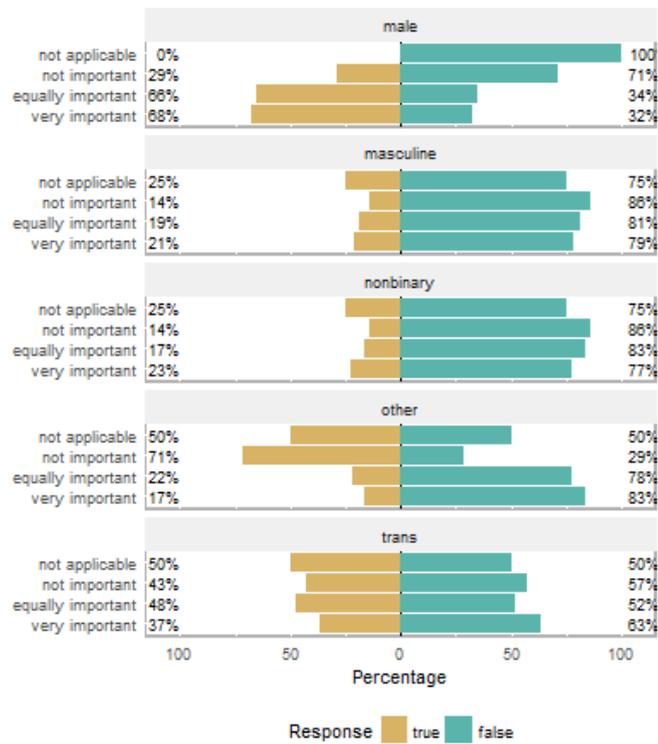


Figure 18. Stacked Column Graph of Gender Identity & Vocal Importance

Based on the above analysis, most participants in this study felt they spoke with a voice that was ‘in between that of a female and male’ or ‘somewhat male’. Participants in this study desired to speak with a more ‘masculine’ voice to match their gender expression and gender identity. A gender affirming voice was also needed for transmasculine individuals to be their ‘true selves’ and to present as male.

#### 4.2.2 Vocal and Communicative Impacts

The following section provided a summary of the vocal and communicative impacts experienced by transmasculine individuals. These factors were grouped manually in to related categories to explore the personal, physical, vocal, and socioeconomic impacts because of transmasculine individuals’ speech. These negative impacts may become vocal and communicative limitations. Three variables discussed earlier (`current_voice`, `matches_gender_expression`, and `matches_gender_identity`) were included in the following analysis as they correlated with the factors below.

*Personal Impacts*

The personal impacts explored in figures 19 (R package: likert; Bryer & Speerschneider, 2016), 20 (R package: PerformanceAnalytics; Peterson & Carl, 2014) and 21 (R package: corrplot; Wei & Simko, 2016) summarises the responses to questions 8 (*authentic\_speaking*; “I have a speaking voice that feels authentic to me”), 17 (*consciously\_changing*; “I’m consciously trying to change my voice”), 18 (*self\_conscious*; “I feel self-conscious about how strangers perceive my voice”), 19 (*frustrate*; “My voice frustrates me”), and 20 (*feels\_masculine*; “My voice makes me feel masculine”). With reference to Figure 19, the different variables were segmented based on the participant’s self-perceived vocal masculinity.

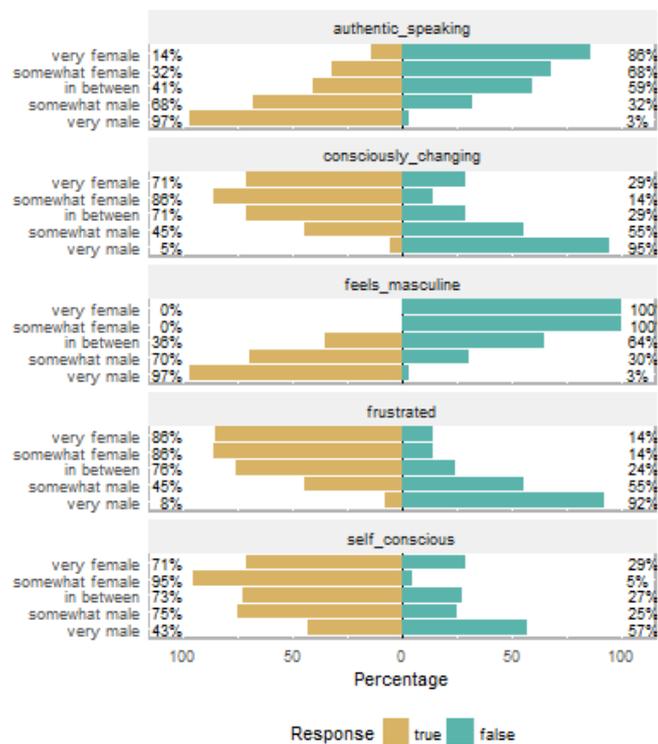


Figure 19. Stacked Column Graph of Current Voice & Personal Factors

The above observations were statistically analysed in a pairwise correlation coefficient analysis. Figure 20 is a correlation matrix with the *r*-value and a simple line graph displayed where the variables intersect. In Figure 21 the size of the circle is relative to the significance of the correlation of

the intersecting variables, where blue signifies a positive correlation and red signifies a negative correlation. There was high covariance among the current group of variables as shown in Figures 20 and 21. Significant negative correlations were found between self-perceived vocal masculinity and the two positive factors: *authentic\_speaking* ( $r = -0.48$ ) and *feels\_masculine* ( $r = -0.63$ ), that is, the more masculine participants self-rated their voice, the more they felt they had an authentic and masculine voice.

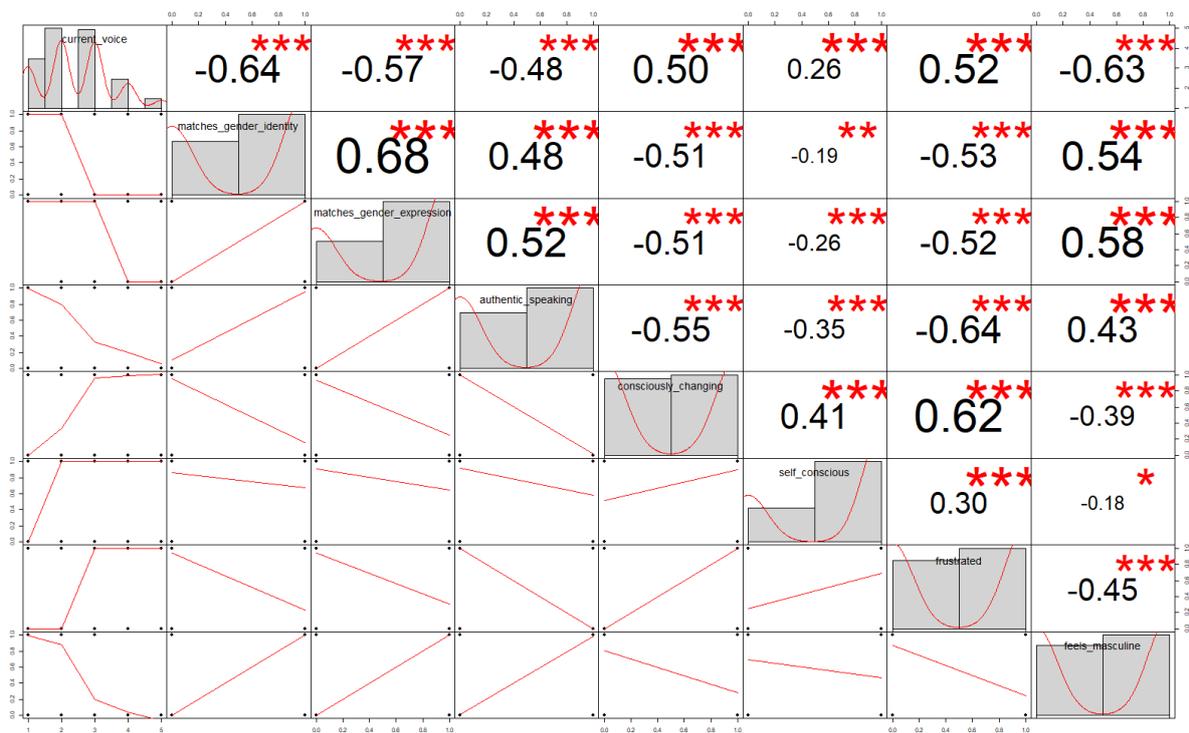


Figure 20. Correlation Matrix of Personal Factors

Both self-rated vocal authenticity and masculinity decreased as participant’s self-perceived vocal femininity increased. Further to this, significant negative correlations were found between *matches\_gender\_identity* with *consciously\_changing* ( $r = -0.51$ ) and *frustrated* ( $r = -0.53$ ), that is, voices which matched the gender identity of the transmasculine individuals who were less likely to consciously change or be frustrated with their voice. These factors were noted earlier as negative factors and decreased as the participant’s current voice conditions were more incongruent with the participant’s gender identity.

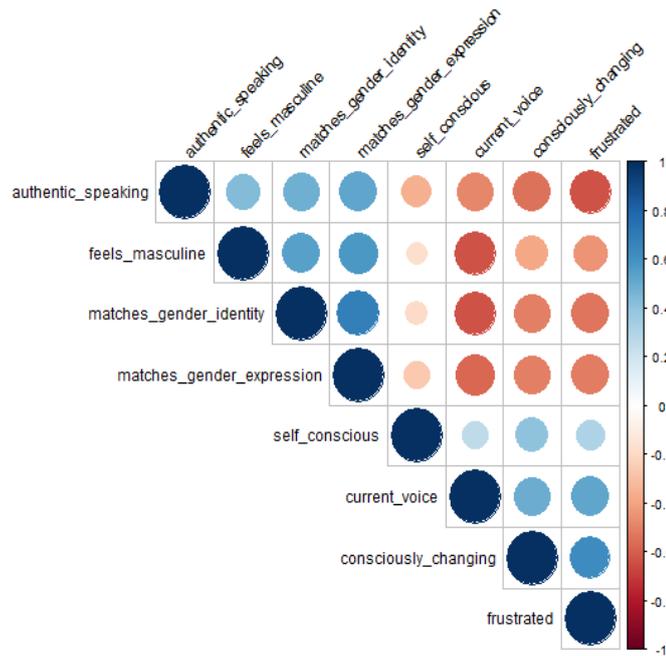


Figure 21. Correlation Plot of Personal Factors

The variables in the current group also correlated significantly with other variables not listed in Figures 20 and 21. The `true_you` variable discussed in the previous section 4.2.1 held significant correlations with `authentic_speaking` ( $r = -0.5$ ) and `frustrated` ( $r = 0.5$ ) which means participants who were more frustrated also find their voice to be less authentic and not a true reflection of themselves

### Physical Impacts

Figure 22 (R package: `likert`; Bryer & Speerschneider, 2016) is a summary of the physical impacts and explored questions 5 (`inaudible_in_noise`; “I have trouble being heard in noisy situations”, 10 (`loud_easily`; “I find it easy to be loud at a vocal range that feels authentic to me”), 12 (`strain`; “I have to strain to make my voice sound like I want it to”), and 13 (`frequent_breaths`; “I run out of air and need to take frequent breaths when talking”).

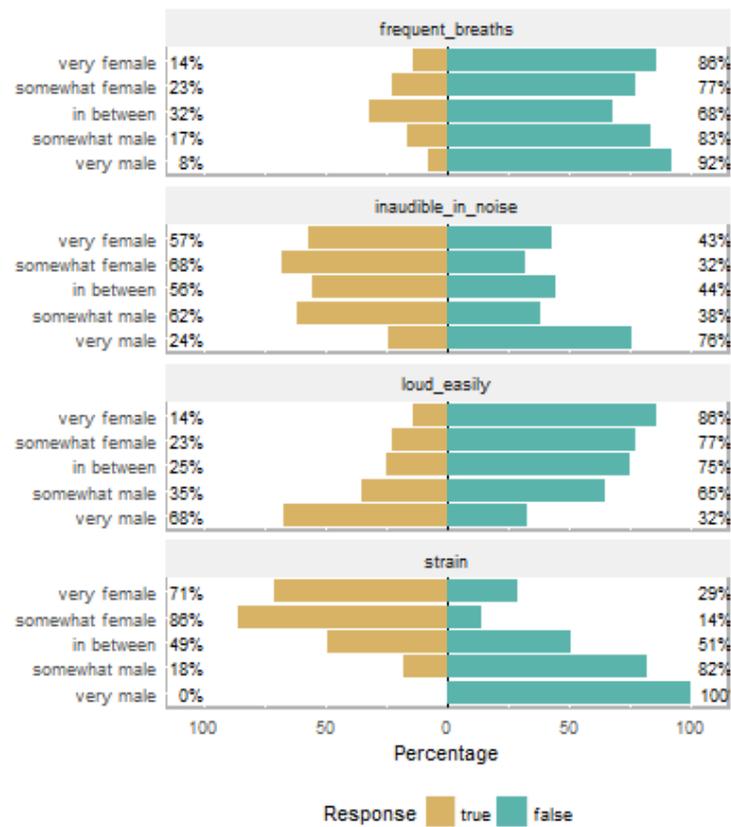


Figure 22. Stacked Column Graph of Current Voice & Physical Factors

Figure 22 visualises the distribution of the physical impacts which differed significantly across different vocal conditions. Most participants did not suffer from breathing difficulties, except for some transmasculine individuals who speak with a voice that is ‘in between that of a female and male’. On the other hand, a significant number of participants found that they were inaudible in noisy environments. Although those who rated their voice as ‘very male’ found this less of an issue as they found it easier to project their voice. Participants who rated their voice as more feminine had more difficulty in speaking loudly, although they experienced less strain than participants who rated their voice as more masculine.

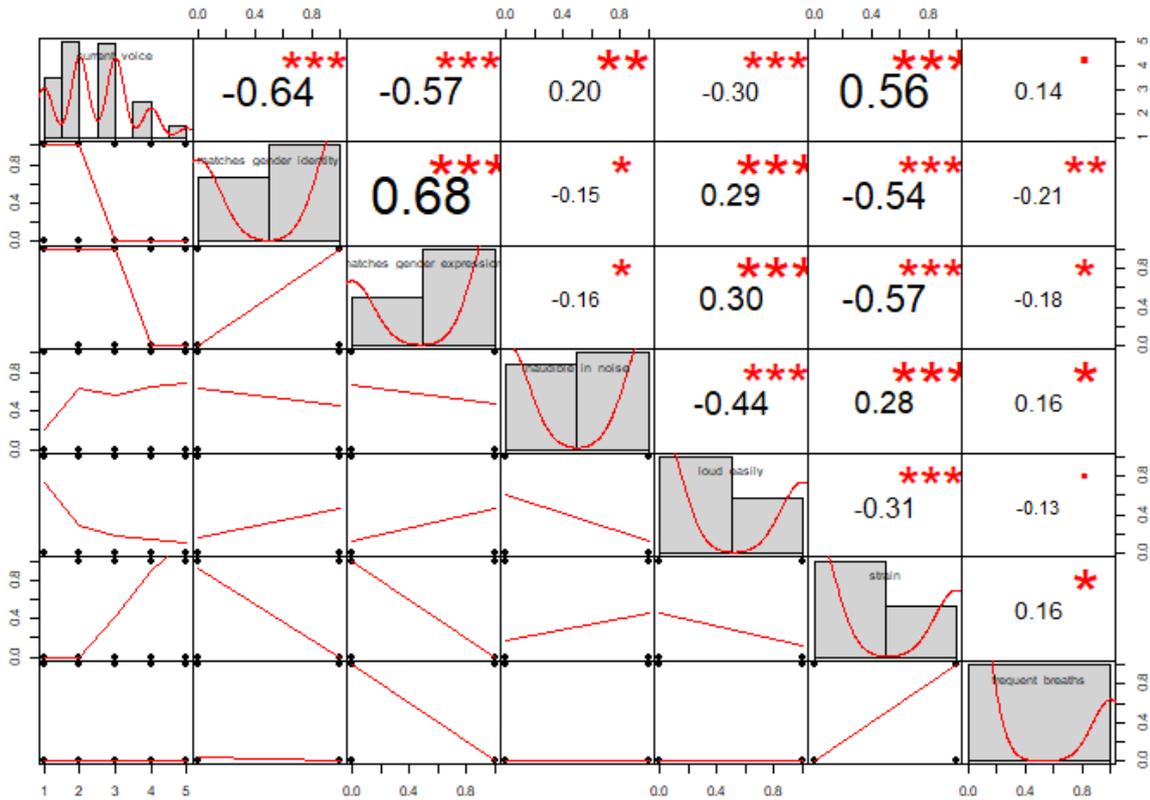


Figure 23. Correlation Matrix of Physical Factors

Statistically, there was little covariance among the variables in the group of physical impacts. However, mildly significant correlations were found between many of the variables according to the pairwise correlation coefficient matrix as shown in Figure 23 (R package: PerformanceAnalytics; Peterson & Carl, 2014) and the visual presentation of the correlation coefficients in Figure 24 (R package: corrplot; Wei & Simko, 2016). The variable `strain` held the most number of significant correlations amongst the group with significant negative correlations with `match_gender_identity` ( $r = -0.54$ ) and `match_gender_expression` ( $r = -0.57$ ), and significant positive correlations with `current_voice` ( $r = 0.56$ ). This means participants experienced less strain when the voice matched their gender identity and gender expression, and strain increased as self-perceived femininity increased. Vocal strain was found to correlate with personal impacts such as `authentic_speaking` ( $r = -0.62$ ), `consciously_changing` ( $r = 0.59$ ), and `frustrated` ( $r = 0.58$ ), and other variables such as `helps_present_male` ( $r = 0.54$ ). This indicates that the more a participant's speaking voice was perceived as inauthentic, the more perceived strain increased. Participants were less likely to

consciously try to change their voice and were less frustrated with their current voice when strain decreased (or vice versa).

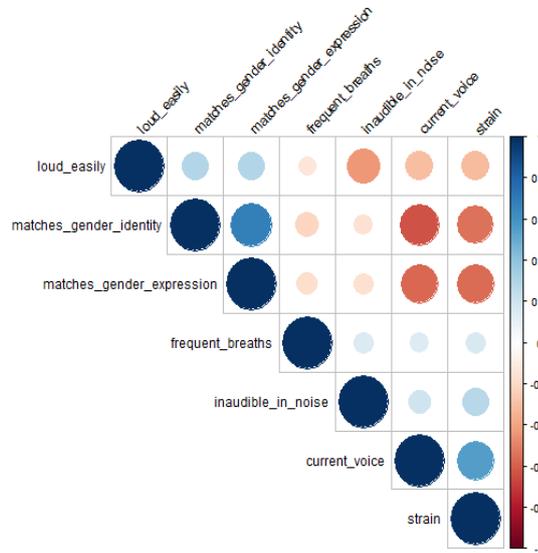


Figure 24. Correlation Plot of Physical Factors

### Pitch-related Impacts

Figure 25 (R package: likert; Bryer & Speerschneider, 2016) is a summary of the pitch-related impacts, and 26 (R package: corrplot; Wei & Simko, 2016) and Figure 27 (R package: PerformanceAnalytics; Peterson & Carl, 2014) are the visualisations of the correlation matrixes. The impacts explored refer to questions 6 (*stable\_pitch*; “The pitch (melody / intonation) of my speaking voice is stable and reliable”), and 9 (*restricted\_pitch*; “The pitch (melody / intonation) range of my voice is restricted”). With reference to Figure 25, the distribution of the answers revealed that transmasculine individuals who had greater self-perceived vocal masculinity were more likely to speak with a stable pitch. Their pitch range were also less likely to be restricted. Conversely, transmasculine individuals who had greater self-perceived femininity were more likely to speak with a

somewhat less stable pitch and more restricted pitch. This observation was expected as discussed earlier in sections gendered communication 2.1.3 and the effects of testosterone therapy 2.2.1.

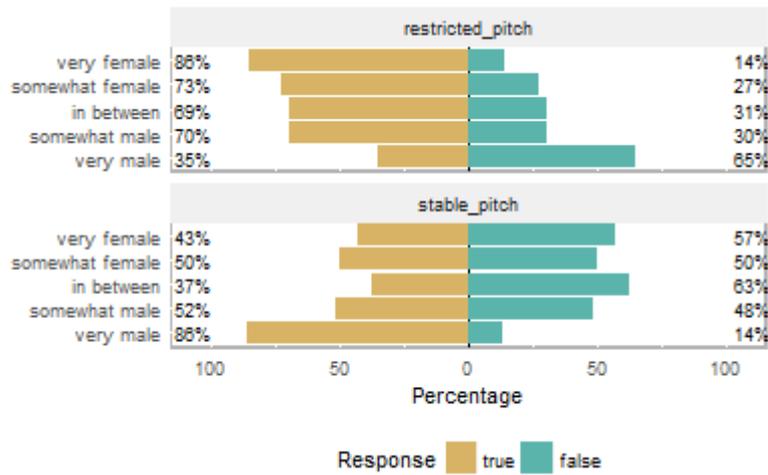


Figure 25. Stacked Column Graph of Current Voice & Pitch Factors

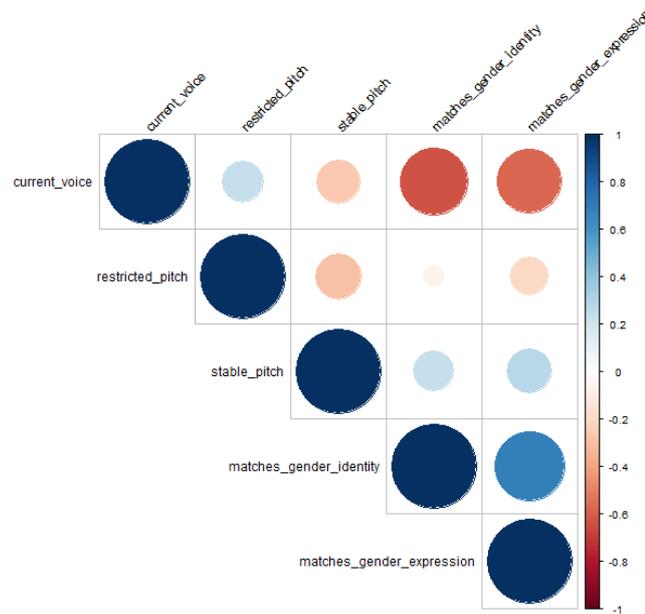


Figure 26. Correlation Plot of Physical Factors

In general, all vocal conditions regardless of their self-perceived vocal gender experienced restrictions to perceived pitch. This indicates that many transmasculine individuals did not speak within a

comfortable pitch range, even if they felt their voices were masculine or authentic. The pairwise correlation coefficient analysis as shown in Figures 26 (R package: corrplot; Wei & Simko, 2016) and 27 (R package: PerformanceAnalytics; Peterson & Carl, 2014) found low correlation between the two variables. Furthermore, the two variables in this group did not significantly correlate with any other variables in the questionnaire. This result was unexpected as pitch differences were one of the most salient ones in terms of feminine and masculine speech characteristics as discussed in 2.1.3. To further investigate the relationship between perceived and actual voice characteristics, an acoustic analysis using fundamental frequency (f0 expressed in Hz) was carried out on the speech data from the reading passages. The results are found in *Chapter 5: Acoustic Analysis*.

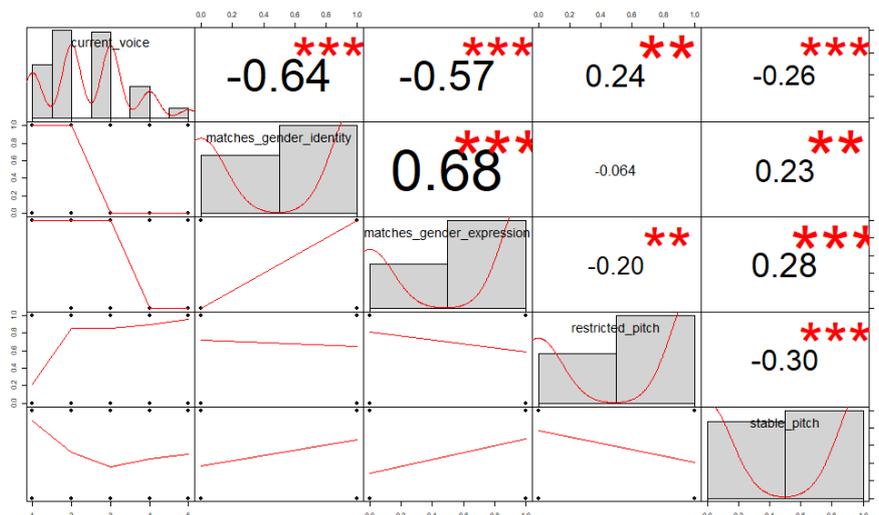


Figure 27. Correlation Matrix of Pitch Factors

### Socioeconomic Impacts

Lastly, Figure 28 (R package: likert; Bryer & Speerschneider, 2016) is a summary of socioeconomic impacts which refer to questions 7 (*worse\_in\_evening*; “My voice is worse in the evening”), 11 (*people\_ask*; “People ask “What’s wrong with your voice?” or “Do you have a cold?””), 14 (*difficulties\_restrictive*; “My voice difficulties restrict my personal and social life.”), 15

(lost\_income; “My voice causes me to lose income”), and 16 (phone\_averse; “I hesitate to call people I don’t know on the phone because of my voice”).

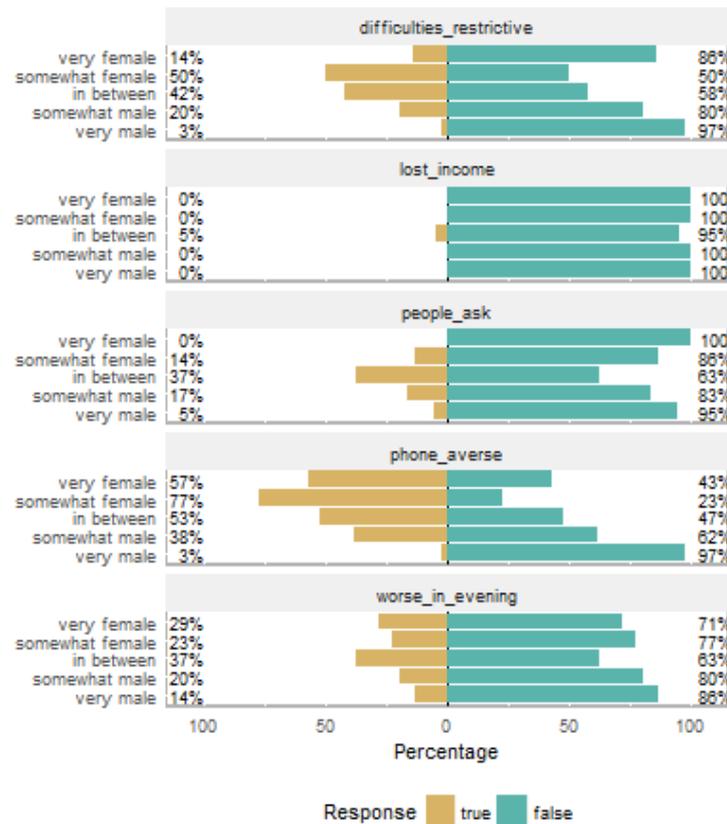


Figure 28. Stacked Column Graph of Socioeconomic Factors

The distribution of the socioeconomic impacts revealed that many of the ‘true’, i.e. negative socioeconomic responses come from participants who perceived their voices as ‘somewhat female’ and ‘somewhat male’. This was particularly telling in the variables `difficulties_restrictive`, `people_ask`, and to lesser extent `lost_income`. A possible explanation for this distribution is that participants who had a voice that did not conform to the extremities of the masculine-feminine spectrum binary could be perceived as gender dissonant by lay listeners. The three variables listed were based on audience and listener feedback. Negative audience feedback may lead to socioeconomic and even psychosocial impacts. Furthermore, participants who did not perceive their voice as ‘very male’ were more likely to be phone averse. A possible explanation could be because they spoke with a non-gender affirming voice. The last question asked transmasculine individuals

whether their voice quality deteriorated over the course of a day. The distribution was similar with the other variables in this group. This meant participants who were less likely to engage socially (i.e. socialise in the evening) because of their voice.

Another possible explanation for why transmasculine individuals who perceived their voices as ‘somewhat female’ or ‘in between that of a female and male’ were more likely to experience significant socioeconomic impacts. This could be because these participants were possibly new users of testosterone, i.e. they were (and still) going through vocal developmental changes. Once a transmasculine individual took testosterone long enough, or once the testosterone had masculinised the participants’ physical appearance enough for them to be confident in their gender identity, these vocal problems should either disappear or become unimportant.

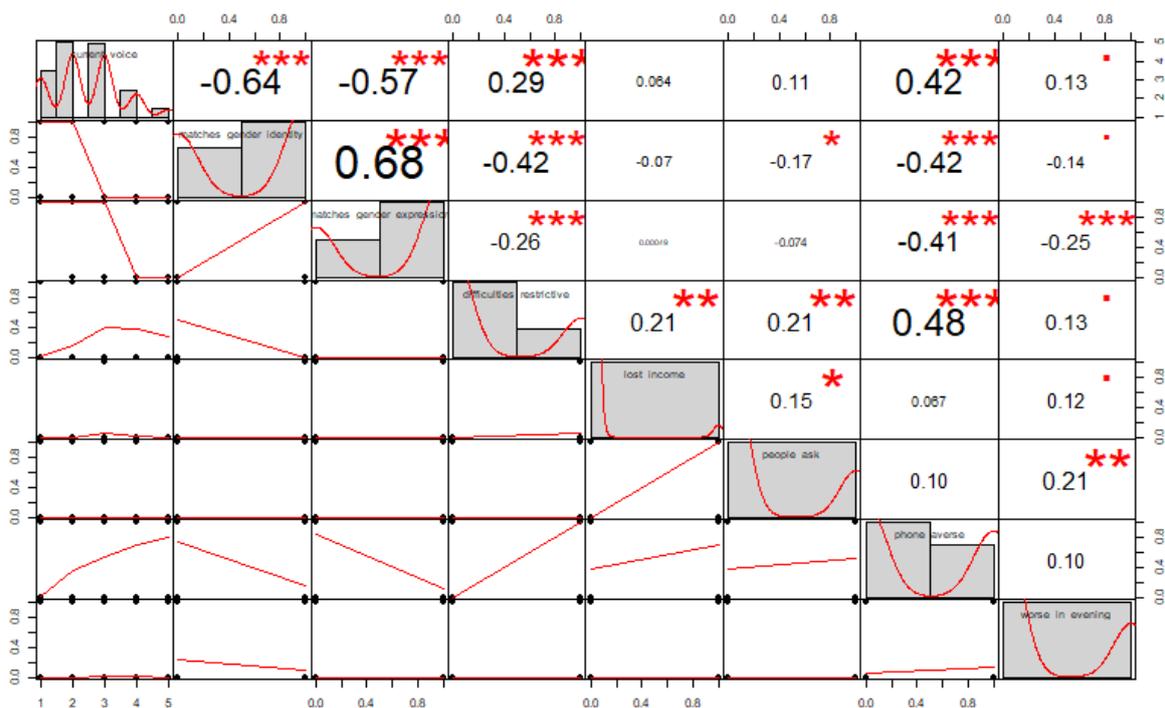


Figure 29. Correlation Matrix of Socioeconomic Factors

There were mild to moderate correlations according to the pairwise correlation coefficient matrix as shown in Figure 29 (R package: PerformanceAnalytics; Peterson & Carl, 2014) and the visual presentation of the correlation coefficients in Figure 30 (R package: corrplot; Wei & Simko, 2016).

There was little covariance amongst the factors, although there were significant interactions between `phone_averse`, `difficulties_restrictive`, and to a lesser extent for `worse_in_evening` with the other variables in the group. For example, `phone_averse` held the strongest correlation with `difficulties_restrictive` ( $r = 0.48$ ). This meant transmasculine individuals became less phone averse as vocal difficulties become less restrictive.

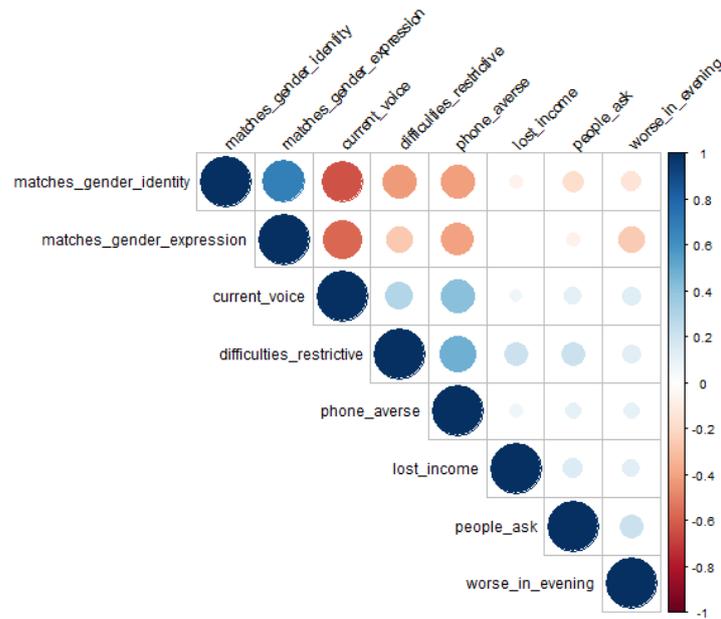


Figure 30. Correlation Plot of Socioeconomic Factors

Likewise, `phone_averse` also held moderate correlations with `current_voice` ( $r = 0.42$ ), and negative correlations with `match_gender_identity` ( $r = -0.42$ ) and `matches_gender_expression` ( $r = -0.41$ ). Participants were more likely to be phone averse if they spoke with a voice that did not match their gender identity or gender expression. This relationship with phone aversion and the control variables parallel a similar interaction between `strain` and `current_voice`, `match_gender_identity`, and `matches_gender_expression`. This indicates vocal strain is significant physical impact and phone aversion is a significant socioeconomic impact on transmasculine individual’s vocal satisfaction.

### Phone (Mis-)Gendering

As discussed in *Socioeconomic Impacts*, `phone_averse` held the most significant correlations as shown in Figure 30. In order to explore this further, question 21 (`phone_female`; “How often are you perceived as female on the phone?”) was included in the questionnaire. Figure 31 (R package: `likert`; Bryer & Speerschneider, 2016) is a summary of participants being (mis-)gendered as female on the phone (‘mis-’ in parentheses as some transmasculine individuals may also identify as ‘female’ so therefore would not experience any distress) grouped by their perceived vocal conditions. Transmasculine individuals who rated perceived their voice to be ‘very female’ or ‘somewhat female’ were ‘almost always’ and ‘always’ perceived as female on the phone. Furthermore, over half of the participants who perceived their voice to be ‘in between that of a female and male voice’ also experienced being perceived as female on the phone. A shift in responses can be observed between participants who rated their voice as ‘somewhat male’ and ‘very male’ where there was a change from ‘sometimes’ and ‘almost never’ for ‘somewhat male’ voices to ‘never’ in ‘very male’ voices.

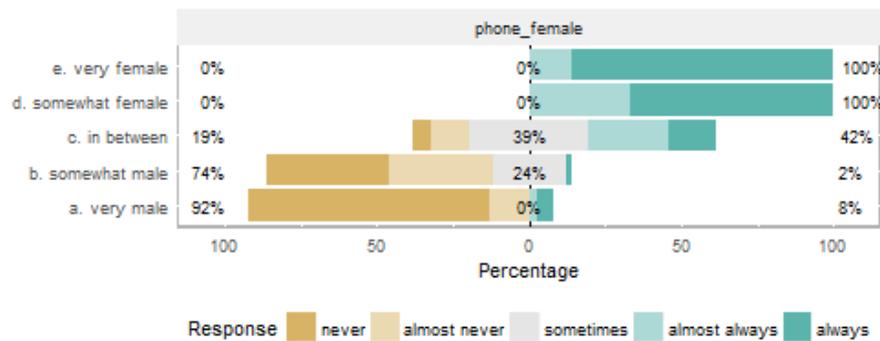


Figure 31. Stacked Column Graph of Current Voice & Phone (Mis-)gendering

There were many statistically significant correlations with phone (mis-)gendering and other variables in the current study. There were significant correlations with the control variables such as `current_voice` ( $r = 0.75$ ), `matches_gender_identity` ( $r = -0.63$ ), and `matches_gender_expression` ( $r = -0.52$ ), and other variables such as `living_male` ( $r = 0.55$ ), `strain` ( $r = 0.51$ ), `helps_present_male` ( $r = 0.81$ ), and `feels_masculine` ( $r = -0.55$ ). This means as the instances of being (mis-)gendered as female on the phone decreased (within the context of this study,

‘never’ being (mis-)gendered as female is the intended outcome), participants were more likely to live (or pass) as the intended male gender identity. Participants were also more likely to perceive their voice as ‘very male’. Furthermore, as the instances of being (mis-)gendered as female over the phone decreased, participants felt their voices were more likely to matched their gender expression and gender expression. Fewer instances of being (mis-)gendered as female on the phone made participants feel more masculine. Thus, `phone_female` is also a significant predictor of vocal satisfaction for transmasculine individuals.

### 4.2.3 Testosterone

The next set of questions asked transmasculine individuals about their history of testosterone therapy. Participants were first asked question 32 “Have you ever taken testosterone?”. The participants who took testosterone were then prompted with questions regarding their testosterone use. Of the 185 participants, 143 participants answered they took testosterone, and 42 participants had never taken testosterone. Eighty-nine percent of participants who identified as ‘male’ ( $n = 110/124$ ) took testosterone, followed by 74% of participants who identified as ‘trans’ ( $n = 61/82$ ), 65% of ‘masculine’ ( $n = 24/37$ ), 62% of ‘non-binary’ ( $n = 23/37$ ), and 51% of those who identified with ‘other’ gender identity terms ( $n = 23/45$ ). Note the total number is greater than 185 as most participants identified with more than one gender identity.

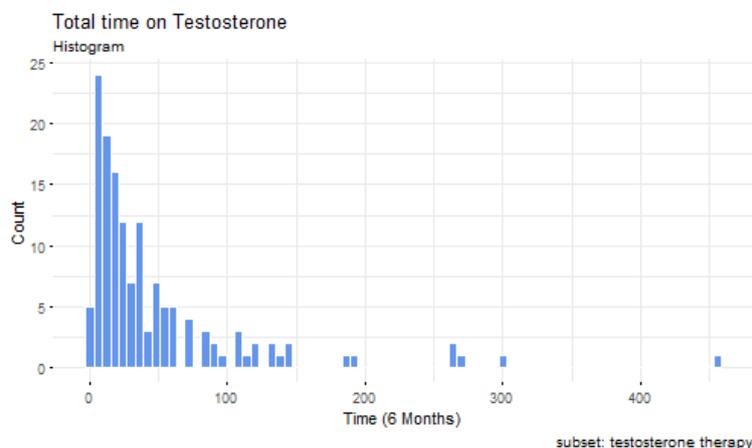


Figure 32. Histogram of Total time on Testosterone

To gauge how long participants were using testosterone, participants were then asked question 33 “How long have you been taking testosterone in total?”. The median time on testosterone was 24 months (2 years) and the mean time on testosterone was 47.44 months (approximately 4 years) (month range = 0.75-456). Figure 32 (R package: ggplot2; Wickham, 2009) is a histogram of the total time participants have been using testosterone in months. The median age of participants who took testosterone was 29 and the mean age was 31.94 (age range = 18-62). Participants who fell within the 1<sup>st</sup> and 3<sup>rd</sup> quartiles were aged 23-39. The demographic information of the participants who took testosterone was similar to the profile of a participant who took this study. Figure 32 included the total time participants took testosterone, excluding time when they have stopped and re-started testosterone therapy due to medical, social, or financial reasons. (This factor was explored in question 34 “Have you ever started and stopped using T[estosterone]? If yes, how long were you off T[estosterone]?”). There was a slightly significant positive correlation ( $r = 0.40$ ) between time on testosterone and the age of the participant as shown in Figure 33 (R package: ggplot2; Wickham, 2009). These variables (i.e. time on testosterone and age) were expressed as a logarithmic transformation as both variables have skewed distribution with a long right tail. Figure 33 plots the geometric means of the two variables.

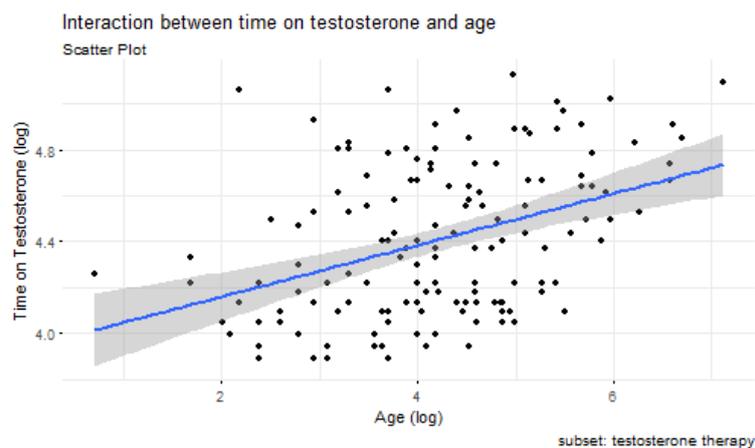


Figure 33. Scatter Plot of Total time on Testosterone (log) & Age (log)

Information on when participants began taking testosterone was not collected. However, information was available on whether participants stopped and re-started testosterone therapy. Nineteen

participants had put testosterone therapy on hold during their treatment history. The median time on hold was six months and the mean time on hold was 22.22 months (approximately 1.86 years). The minimum time on hold was 0 months (or currently on hold) and the maximum time was 240 months (20 years). The transmasculine individual who put their treatment on hold for 240 months (20 years) took testosterone for 54 months (4.6 years). They did not indicate whether they still took testosterone. Figure 34 (R package: ggplot2; Wickham, 2009) is a summary of the most common methods for administering testosterone.

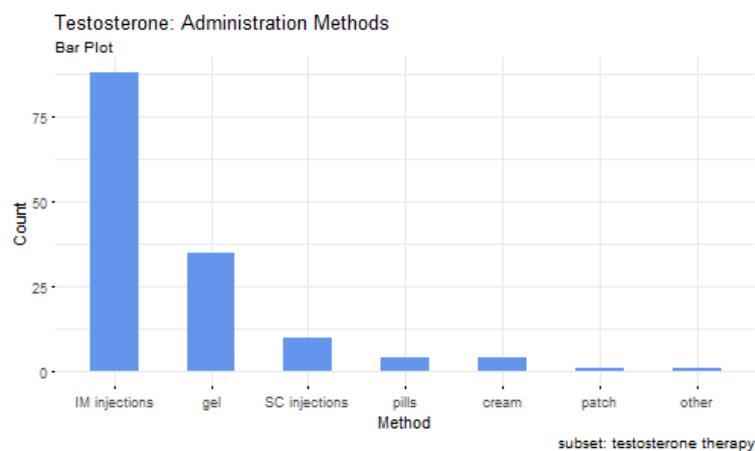


Figure 34. Bar Plot of Testosterone: Administration Methods

Based on Figure 34, the most common administration method for testosterone was intramuscular injections (IM injections;  $n = 88$ ), this was followed by gels ( $n = 35$ ), subcutaneous injections (SC injections;  $n = 10$ ), pills ( $n = 4$ ), creams ( $n = 4$ ), patches ( $n = 1$ ), and other ( $n = 1$ ) methods of administering testosterone such as Axiron which is a topical solution (also a gel). Intramuscular injections are the most prominent method for administering testosterone. Figures 35 (R package: ggplot2; Wickham, 2009) and 36 (R package: ggplot2; Wickham, 2009) summarises participant's self-perceived vocal masculinity group based on testosterone use. Figure 35 summarises the participants who never took testosterone. Most of the participants who never took testosterone perceived their current voice as either 'in between that of a female and male' and 'somewhat female', with some participants reporting their current voice condition was 'very female'.

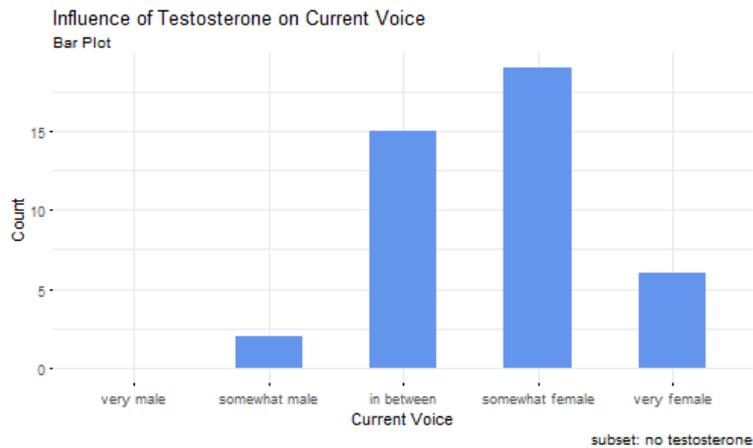


Figure 35. Bar Plot of Current Voice & No Testosterone

Conversely, participants who have taken testosterone rated their voices as more masculine as shown in Figure 36 (R package: ggplot2; Wickham, 2009). Many participants reported their current voice was ‘in between that of a female and male’; however, most participants rated their current voice as ‘somewhat male’ or ‘very male’. This relationship confirms the predicted and well-documented link between testosterone usage and an increase in self-perceived vocal masculinity. Almost no participants who took testosterone indicated their current voice was ‘somewhat female’ or ‘very female’.

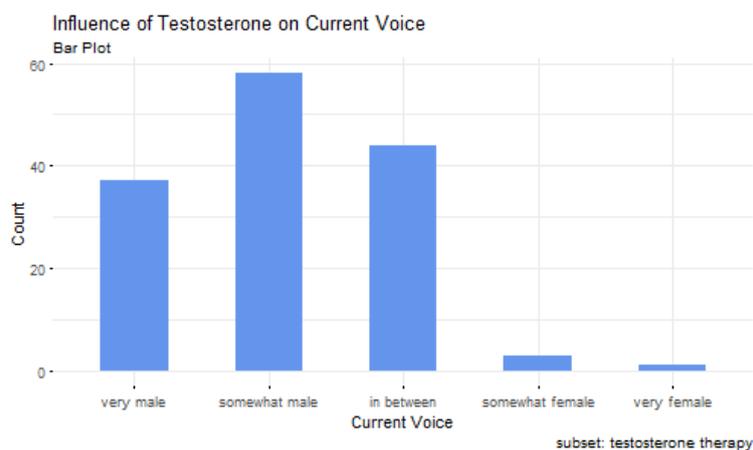


Figure 36. Bar Plot of Current Voice & Testosterone Therapy

Further to this, time on testosterone and the participant’s current voice conditions are presented in Figure 37 (R package: ggplot2; Wickham, 2009). Participants ( $n = 52$ ) who took testosterone longer than 36 months (3 years) were excluded from Figure 37.

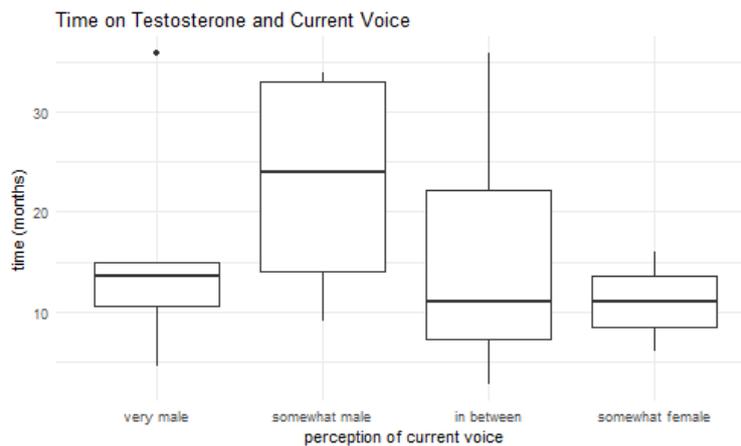


Figure 37. Box Plot of Current Voice & Time on Testosterone

A small number of participants noted their current voice was ‘very male’ following a year of testosterone therapy. Figure 37 indicates that significant changes occur in the first few months of testosterone therapy. Counterintuitively, participants that took testosterone the longest noted their current voice was either ‘somewhat male’ or ‘in between that of a female and male’. In contrast to the participants with a ‘very male’ voice, some participants believed they spoke with a ‘somewhat female’ voice despite the fact they took testosterone for an equal amount of time. Therefore, it is not unreasonable to suggest that either participants follow radically different vocal developmental patterns, or that vocal self-perception is not correlated with the amount of time on testosterone. For further information regarding changes to the speaking fundamental frequency as a function of testosterone, refer to *Chapter 5: Acoustic Analysis*.

The last two figures in this section present transmasculine individuals’ expected vocal change and actual speed of vocal change as shown in Figures 38 (R package: ggplot2; Wickham, 2009) and 39 (R package: ggplot2; Wickham, 2009) respectively. As indicated by Figure 38, most of the participants were realistic on the expected amount of vocal change ( $n = 62$ ). Many participants expected greater ( $n = 35$ ) vocal change or for vocal change to occur faster ( $n = 22$ ). A few participants expected other vocal change ( $n = 21$ ) or no changes at all ( $n = 3$ ). Furthermore, most participants found that their voice changed in a matter of weeks after starting testosterone therapy ( $n = 53$ ), while others found that their voices changed within days ( $n = 18$ ), months ( $n = 39$ ), or a year ( $n = 8$ ) after initiating

testosterone therapy. Many participants found that their voices changed in stages ( $n = 23$ ) while some participants did not experience any voice changes at all ( $n = 2$ ).

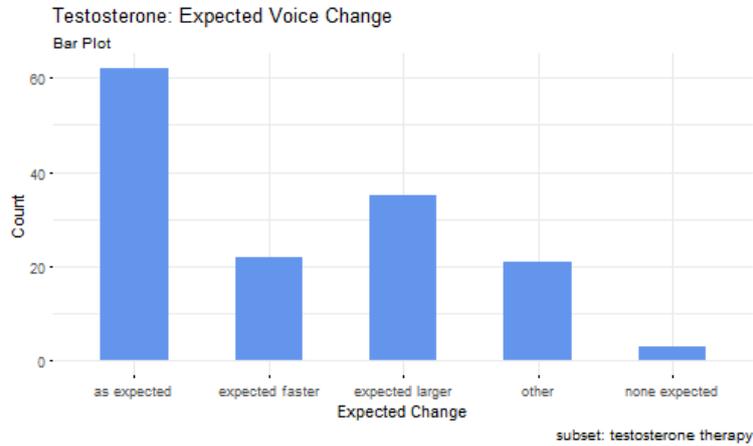


Figure 38. Bar Plot of Expected Voice Change

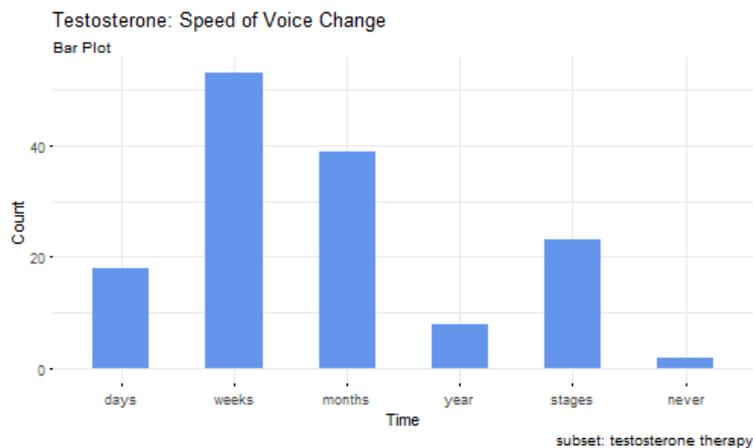


Figure 39. Bar Plot of Speed of Voice Change

As shown in the above analysis, testosterone did have a significant effect on the self-perceived vocal masculinity in transmasculine individuals; however, the magnitude and speed of these effects vary speaker to speaker as shown in Figures 38 and 39. Finally, question 32 “Have you ever taken testosterone?” (`testosterone`) correlated with many previously discussed variables in the current study. For example, there was a significant negative correlation between testosterone use and `current_voice` ( $r = -0.63$ ), `phone_female` ( $r = -0.60$ ), `living_male` ( $r = -0.62$ ), and

helps\_present\_male ( $r = -0.65$ ). This indicates the number of participants who have a ‘masculine’ voice increased as the number of participants who use testosterone increased. Participants were more likely to live and present male, and instances of being (mis-)gendered as female over the phone decreased once transmasculine individuals initiate testosterone therapy. There was also a significant positive correlation between testosterone use and `matched_gender_identity` ( $r = 0.51$ ). This suggests once participants took testosterone, they felt that their voices matched their gender identity.

#### 4.2.4 Intervention

The last series of questions regard current healthcare habits among transmasculine individuals. For example, the questions explored in Figure 40 (R package: `likert`; Bryer & Speerschneider, 2016) were questions 43 “If you couldn’t achieve sufficient voice change with the help of testosterone, would you consider vocal surgery?” (`vocal_surgery`) and 44 “Have you ever worked on masculinising your voice with a speech and language practitioner or voice coach?” (`slp_coach`). The purpose of these questions was to see whether transmasculine individuals were aware of the services available to them. These services are there to help them achieve their desired vocal conditions.

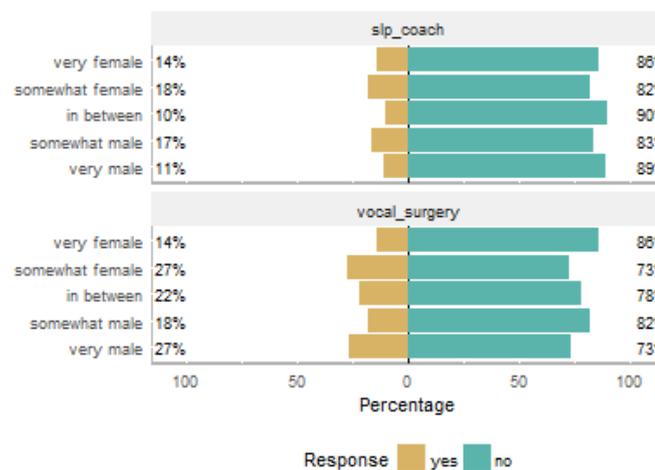


Figure 40. Stacked Column Graph of Current Voice & Intervention Methods

With reference to Figure 40, 160 participants never worked with an SLP to masculinise their voice. Of the 25 participants who have worked with an SLP, one participant noted their current voice was ‘very

female’, four noted their voices were ‘somewhat female’, six participants noted their voices were ‘in between that of a female and male’, ten noted their voices were ‘somewhat male’, and four participants noted their voices were ‘very male’.

This distribution was very similar to `vocal_surgery` where only 41 participants considered vocal masculinisation surgery, with participants who speak with a ‘very male’ ( $n = 10$ ) and ‘somewhat male’ ( $n = 11$ ) in the majority and those who considered their voice as ‘very female’ ( $n = 1$ ) or ‘somewhat female’ ( $n = 6$ ) in the minority. One important finding was that those who perceived their voices as ‘in between that of a female and male’ were more likely to consider vocal masculinisation surgery ( $n = 13$ ) than other vocal conditions. The results from questions 45 “Have you ever heard of vocal masculinisation surgery?” and 46 “If you were dissatisfied with your voice, would you consider undergoing vocal masculinisation surgery?” found that 77% of participants ( $n = 143$ ) never heard of vocal masculinisation surgery and that 63% of participants ( $n = 117$ ) would not consider vocal masculinisation surgery.

Question 48 (`recommended_method`; “What methods of vocal masculinisation would you recommend to a friend wanting to masculinise their voice?”) asked participants what they would recommend to their acquaintances if they asked them for advice to masculine their voice. Participants were able to select from a number of options. Most participants recommended more than one method of vocal masculinisation; therefore, the total number of counts will be greater than the number of participants. For example, nearly all the participants suggested testosterone as the best method to masculine the voice ( $n = 160$ ), while the next most popular method was to see a speech and language professional ( $n = 136$ ). An interesting juxtaposition is that while most participants have not seen a speech and language professional (with reference to Figure 40); the vast majority would suggest seeing an SLP. The recommendation methods are visualised in Figure 41 (R package: `venneuler`; Wilkinson, 2011). Seventeen participants recommended doing nothing, 13 suggested vocal masculinisation surgery, and five participants recommended smoking cigarettes to achieve a more masculine voice. Eighteen participants suggested alternative methods to masculine the voice.

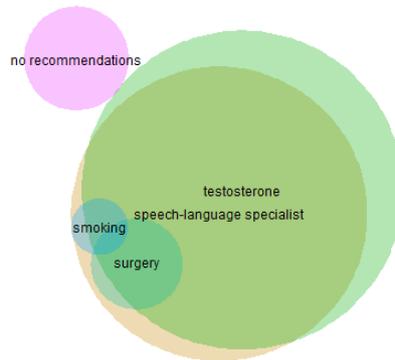


Figure 41. Stacked Venn Diagram of Intervention Recommendation

Twenty-seven participants wrote a description for what they would do to masculinize their voice. Some examples included “breathing and singing exercises”, “consciously changing pitch of their voice”, or “go on YouTube and look up exercises for stretching your vocal chords”. The results of the exploratory textual analysis on the recommendations are visualised in Figure 42 (R package; tm: Feinerer et al., 2008; SnowballC: Bouchet-Valat, 2014; wordcloud: Neuwirth, 2014; RColorBrewer: Fellows, 2014). A prevailing theme was ‘voice’ which occurred seven times. This was followed by ‘singing’ ( $n = 4$ ) and ‘lower’ ( $n = 4$ ). ‘Youtube’ occurred three times out of the 27 written recommendation, which suggests some participants use social media for support.



Figure 42. Word Cloud of Other Recommendations

Figure 43 (R package: likert; Bryer & Speerschneider, 2016) is a summary of Question 41 (“If you want / wanted to change your voice, please indicate what you would try / tried to achieve”) categorised by participant’s current voice conditions. Participant checked the vocal goals that were relevant to them.

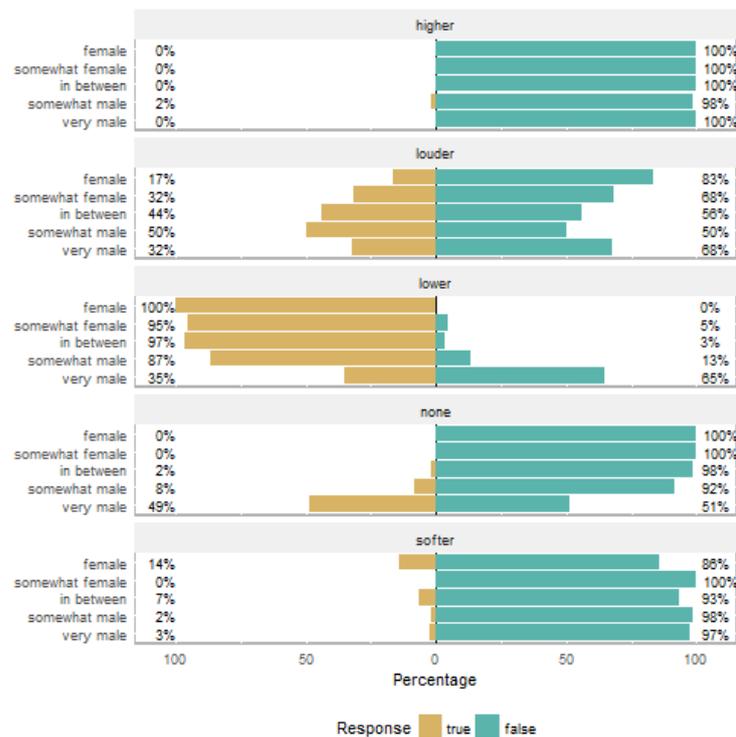


Figure 43. Stacked Column Graph of Current Voice & Goals

Most participants indicated they wanted their voice to be lower ( $n = 150$ ) and louder ( $n = 76$ ), while some participants wanted a softer ( $n = 7$ ) and higher ( $n = 1$ ) speaking voice. It is noteworthy that about a third of the participants who perceived their voice as ‘very male’ wanted their voice to be lower, and over 90% of all the other self-perception groups desired a lower voice as well. Most participants who did not have a ‘very male’ voice wanted their voice to be lower, while participants who were ‘in between that of a female and male’ voice wanted to speak louder. After acquiring a low pitch, loudness was the next major goal (of the changes that was offered to the participants in the questionnaire). Participants who did not want their voice to change typically had a self-perceived ‘very male’ voice ( $n = 24$ ). Thirteen participants indicated they had other vocal goals in mind not

listed in Figure 43. For example, one participant provided a descriptive summary of their vocal situation “without fail, people assume I am female based on [my] voice alone and I think it's because of the way I talk, not just because my voice isn't low pitched. I get more female-sounding the more excited I am and I hate it so much”. Another participant noted “I want a broader range and more reliability, no breaking during sentences or when getting emotional (last one is worst and humiliating)”. This suggests most transmasculine individuals have vocal goals which they hope to achieve.

### 4.3 Vocal Satisfaction

Section 4.2 provides a thorough summary of the questionnaire data. All the variables discussed were known to contribute to vocal satisfaction as listed in Azul et al. (2017). However, how many of these variables actually contributed to the vocal satisfaction of transmasculine individuals? Participants were asked question 25 “Are you satisfied with your present voice?” (satisfied) and indicated whether they were satisfied, somewhat satisfied, or dissatisfied with their current voice.

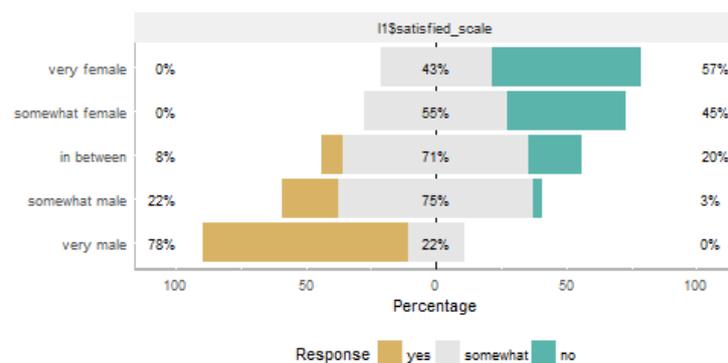


Figure 44. Stacked Column Graph of Current Voice Conditions & Vocal Satisfaction

Forty-seven participants were satisfied with their current voice, while a majority participants were ‘somewhat satisfied’ ( $n = 111$ ). Twenty-eight transmasculine individuals were not satisfied with their current voice. Figure 44 (R package: likert; Bryer & Speerscheider, 2016) plots vocal satisfaction grouped by self-perceived vocal masculinity. Vocal satisfaction increased as self-perceived vocal

masculinity increased ( $r = 0.63$ ), likewise vocal satisfaction decreased as self-perceived vocal femininity increased as shown in Figure 44.

There were a number of participants who were ‘somewhat satisfied’ with their voice in all conditions. There was a significant reduction of participants who were ‘somewhat satisfied’ between the ‘somewhat male’ and ‘very male’ conditions. A likely explanation for this is that participants who were not satisfied with their voice progressively became somewhat satisfied with their voice as vocal masculinity increased. However, the Figure 44 did not account for the transmasculine individuals who were dissatisfied who then became satisfied with their voice. Furthermore, `matches_gender_identity` ( $r = -0.63$ ) and `matches_gender_expression` ( $r = -0.63$ ) increased as vocal dissatisfaction decreased. Participants felt more masculine (‘feels\_masculine’) as vocal dissatisfaction decreased ( $r = -0.63$ ), and `helps_present_male` ( $r = 0.60$ ) and `true_you` ( $r = 0.52$ ) increased as vocal satisfaction increased.

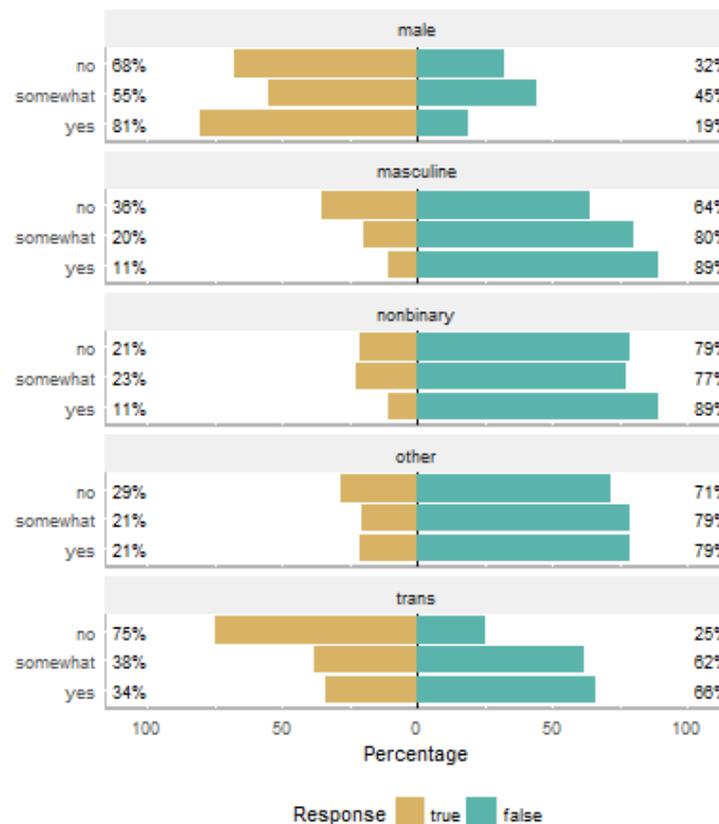


Figure 45. Stacked Column Graph of Gender Identity & Vocal Satisfaction

Figure 45 (R package: likert; Bryer & Speerschneider, 2016) compares the vocal satisfaction between different gender identities. ‘Male’ identified transmasculine individuals were most satisfied with their voice, while ‘trans’ identified transmasculine individuals were least satisfied with their voice (however, this was only proportional to ‘male’ identified participants). This indicates there was a weak relationship between self-perceived vocal masculinity and a masculine gender identity; however, the relationship between vocal satisfaction and other gender identity terms were more difficult to ascertain due to the sheer number of extraneous variables.

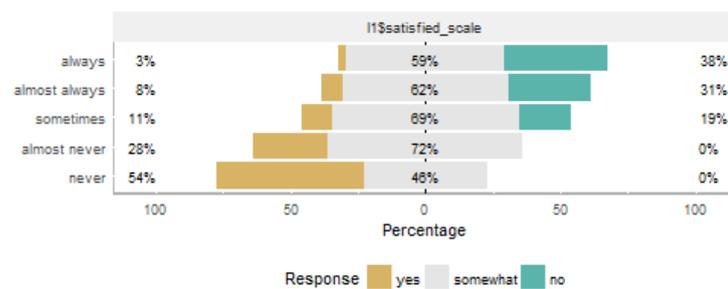


Figure 46. Stacked Column Graph of Phone (Mis-)gendering & Vocal Satisfaction

The `phone_female` variable had a positive correlation with vocal satisfaction ( $r = 0.55$ ), which suggests vocal dissatisfaction decreased when instances of being (mis-)gendered as female on the phone decreased. This can be observed in Figure 46 (R package: likert; Bryer & Speerschneider, 2016). However, participants who remained somewhat satisfied with their voice remained the same no matter how many times they were (mis-)gendered as female on the phone.

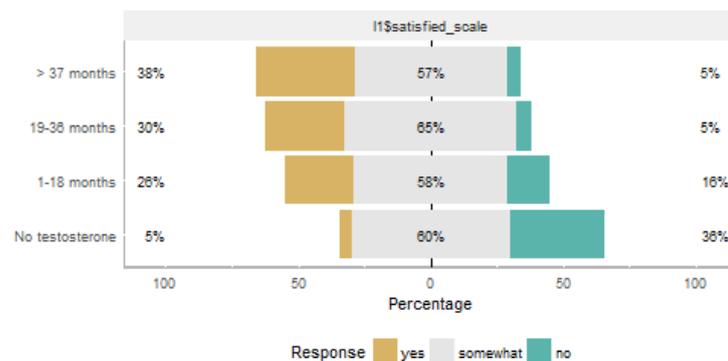


Figure 47. Stacked Column Graph of Time on Testosterone (Groups) & Vocal Satisfaction

This distribution can also be observed in Figure 47 (R package: likert; Bryer & Speerschneider, 2016) where most participants were still only ‘somewhat’ satisfied with their voice following testosterone therapy. The number of participants who were satisfied increased following testosterone therapy; however, some speakers were still dissatisfied after 18 months and after 36 months of testosterone. A significant correlation was not found between time one testosterone and vocal satisfaction.

Table 9 presents the variables with significant correlations with vocal satisfaction. The variables `current_voice`, `feels_masculine`, `phone_female`, `matches_gender_identity`, `matches_gender_expression`, and `helps_present_male` were all correlated with vocal satisfaction. A visual inspection of Figures 44, 46, and 47 (R package: likert; Bryer & Speerschneider, 2016) indicates those who were not satisfied became somewhat satisfied with their voice (either through increased vocal masculinity or time on testosterone); however, there was still a proportion of participants who were not satisfied with their voice. Correlations were observed between vocal satisfaction with other variables such as `strain`, `consciously_changing`, and `frustrated` which are personal and physical factors discussed in section 4.2.2. This suggests vocal dissatisfaction decreased as these physical limitations decreased.

*Table 9. Correlations with Vocal Satisfaction*

variable	(r-value)
<code>current_voice</code>	0.63
<code>authentic_speaking</code>	-0.54
<code>strain</code>	0.55
<code>consciously_changing</code>	0.56
<code>frustrated</code>	0.63
<code>feels_masculine</code>	-0.53
<code>phone_female</code>	0.55
<code>matches_gender_identity</code>	-0.63
<code>matches_gender_expression</code>	-0.55
<code>helps_present_male</code>	0.60
<code>true_you_scale</code>	0.52
<code>goals_na</code>	-0.50
<code>goals_lower</code>	0.51

Based on the above on the above discussion, vocal satisfaction in transmasculine individuals interacted with a number of these factors listed in Table 9. However, a pairwise correlation coefficient

analysis does not demonstrate how these inter-correlated variables contribute to the variance of the participants. Due to the high number of variables in the current study (> 90 variables), a simple Principal Component Analysis (PCA) was carried out using FactoMineR (Le et al., 2008) on the variables with the most covariance. The variables identified as having the most inter-variable covariance were: `authentic_speaking`, `consciously_changing`, `current_voice`, `feels_masculine`, `frustrated`, `gender_identity_male`, `goals_lower`, `goals_na`, `helps_present_male`, `ideal_voice`, `living_male`, `matches_gender_expression`, `matches_gender_identity`, `phone_female`, `pronouns_he`, `pronouns_they`, `recommended_none`, `satisfied`, `strain`, `testosterone`, and `true_you`.

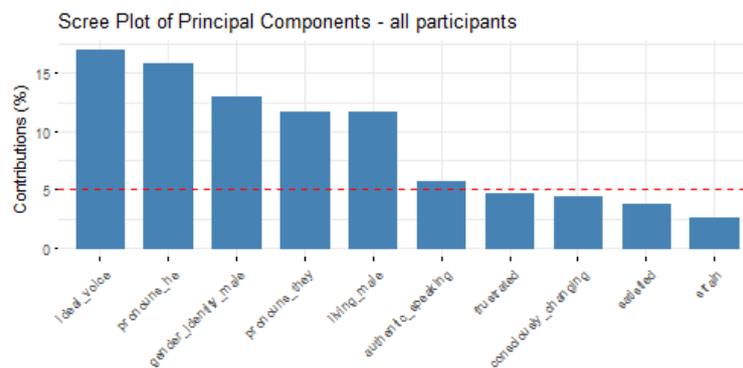


Figure 48. Scree Plot of Principal Components (top 10 variables)

The scree diagram in Figure 48 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) presents the individual variables with the most contribution to all components. The eigenvalues of twenty dimensions are presented in Table 17, and the correlation factor map are presented in Figure 78 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) in the *Appendix*. The variable `ideal_voice` had the highest contribution (>15%) as shown in Figure 78. This was followed by `pronoun_he` (>15%), and `gender_identity_male` (>12.5%).

The eigenvalue for Dimension 1 (Principal Component 1) was 8.4 and contributed to 41.8% of variance (as shown in the scree plot in Figure 79 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) and supporting figures in Table 18 in the

*Appendix*). Variables in the first dimension included `current_voice`, `helps_present_male`, `matches_gender_identity`, and `phone_female`. Dimension 1 is concerned with listener- and self-perception of vocal masculinity and how transmasculine individuals use their voice to express their gender identity. The `phone_female` variable indicates participants use listener feedback to monitor their current vocal masculinity.

The eigenvalue for Dimension 2 (Principal Component 2) was 2.9 and contributed to 14.4% of variance (as shown in the scree plot in Figure 80 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) and supporting figures in Table 19 in the *Appendix*). Variables in the second dimension included `ideal_voice`, `pronouns_he`, `gender_identity_male`, and `pronouns_they`. Dimension 2 is concerned with the aspirations of transmasculine individuals, and their self-perceptions of an ideal voice to express the intended gender identity. The eigenvalue for Dimension 2 was significantly smaller than Dimension 1 which indicates gender identity based on listener feedback is a major contributor to vocal satisfaction.

Lastly, the eigenvalue for Dimension 3 (Principal Component 3) was 1.3 and contributed to 6.5% of variance (as shown in the scree plot in Figure 81 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) and supporting figures in Table 20 in the *Appendix*). Variables in the third dimension included `goals_lower`, `goals_na`, `strain`, `matches_gender_expression`, and `recommended_none`. The variables in Dimension 3 indicate vocal and communicative changes. These modifications include goals, recommendations, and problems relating to the voice.

Based on the PCA, the variables of the current study can be categorised into three major components: Dimension 1 were self- and listener-perceptions of current vocal conditions; Dimension 2 were ideal (vocal or expressive) characteristics of the intended gender identity; and Dimension 3 were vocal and communicative changes. Dimension 1 had the most influence on transmasculine individual's vocal satisfaction, followed by Dimension 2. Dimension 3 contributed the least variance to transmasculine individual's vocal satisfaction. These components can be visualised as a correlation circle as in Figure

49 (R package; FactoMineR: Le et al., 2008; factoextra: Kassambara & Mundt, 2017; ggpubr: Kassambara, 2017) where variables with high covariance are grouped together as clusters.

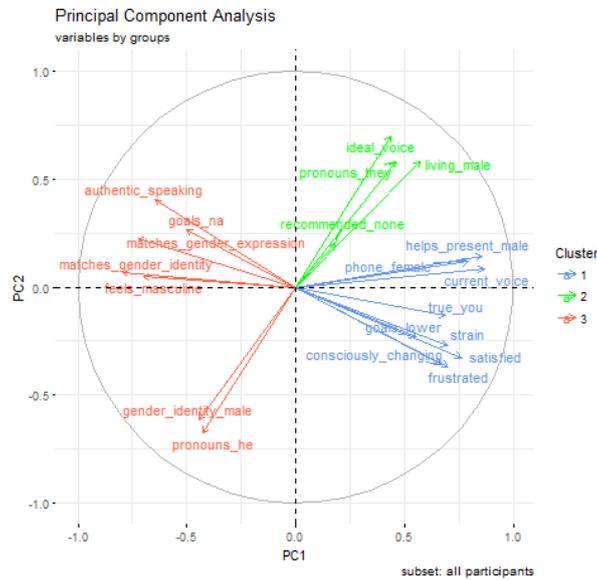


Figure 49. Correlation Circle of Variables by Groups

#### 4.4 Summary of Results

The findings from the questionnaire results indicated that the current sample population of transmasculine individuals were incredibly diverse, in terms of demographic profile, and vocal and communicative needs. Due to the large number of tokens, some of the variables (e.g. `need_speaking_voice`, `need_singing_voice`, and `testosterone_singing_range`) that had low correlations ( $r > 0.5$ ) were excluded from the current analysis (these variables were summarised in the *Appendix*) were removed. Most of the variables discussed in the current chapter influence the vocal satisfaction of transmasculine individuals. A PCA of the most influential variables identified three components that contribute to vocal satisfaction. The results from the current chapter suggest that the vocal and communicative needs of transmasculine individuals should not be dismissed. Even though transmasculine individuals come from a diverse background, they all share the desire to speak with a gender affirming voice.

## Chapter 5: Acoustic Analysis

The current chapter provides an acoustic analysis of transmasculine individuals' mean reading pitch ( $f_0$ ) and how it contributes to their vocal satisfaction. The first part of the acoustic analysis provides a summary of acoustic measurements extracted from Praat via LaBB-CAT. Praat was chosen because this pitch tracker was often used by speech and language professionals and clinicians to analyse objective acoustic measurements (e.g. Cartei et al. (2014), Evans et al. (2008), Hancock et al. (2014), and McNeill et al. (2008) to name a few). Pitch minima, mean, and maxima were collected from the speech samples and analysed according to time on testosterone, participants' self-perceived vocal masculinity, and language contexts.

Substantial inconsistencies were found with Praat' pitch tracking function (Dorreen, 2017). This was particularly evident at the lower frequencies. The current study provided a platform to compare Praat and REAPER within an applied linguistic context. The second part of acoustic analysis used  $f_0$  measurements extracted from REAPER. This has been offered as an alternative to Praat (Dorreen, 2017). The REAPER analysis differed slightly from the Praat analysis as minima and maxima were not included. Mode  $f_0$  was analysed adjacent to mean  $f_0$ . This is because mode  $f_0$  is a central tendency that is a lot less sensitive to outliers than the mean  $f_0$ . The mean  $f_0$  of a speaker is the arithmetic mean of the  $f_0$  measurements, whereas the mode  $f_0$  is the most frequent  $f_0$  measurement (in Hz) of a speaker. The mode  $f_0$  is useful within an applied or clinical context as it calculates the typical 'pitch' of a speaker.

Section 5.1 describes the participants who provided a speech sample. Section 5.2 analysed pitch measurements extracted from Praat. This was subdivided into time on testosterone (section 5.2.1), self-perceived vocal masculinity (section 5.2.2), cross-linguistic analysis (section 5.2.3), and limitations of Praat (section 5.2.4). Section 5.3 analysed pitch measurements extracted from REAPER. This was subdivided into comparing mean and mode  $f_0$  (section 5.3.1), self-perceived

vocal masculinity (section 5.3.2), gender identity (section 5.3.3), and gender identity (section 5.3.4). Lastly, section 5.4 analysed vocal satisfaction.

## 5.1 Participants

The speech samples came from a total of 66 speakers, and were recorded using the participant's personal electronic devices. As discussed in *Chapter 3: Methodology*, participants were asked to read *North Wind and the Sun* in a language of their choice. The recordings were in English ( $n = 50$ ) and German ( $n = 16$ ). The median age of participants in the current section was 29.5, and the mean age was 31.44 (range = 18-58). Participants who were within the 1<sup>st</sup> and 3<sup>rd</sup> quartile were aged 22–37.5. The subset of participants who provided a recording was younger than the participants who only took part in the questionnaire.

Fifty-one participants took testosterone. The median time on testosterone was 15 months (1.25 years) and the mean time on testosterone was 29.53 months (approximately 2.36 years) (range = 0-194). The 1<sup>st</sup> and 3<sup>rd</sup> quartiles of time on testosterone were 4.12-36 months (0.25 – 3 years). Older participants were took testosterone for a longer time than younger participants as shown in Figure 50 (R package: ggplot2; Wickham, 2009). These variables (i.e. time on testosterone and age) were expressed as a logarithmic transformation as both variables had a skewed distribution with a long right tail. Figure 50 plots the geometric means of the two variables.

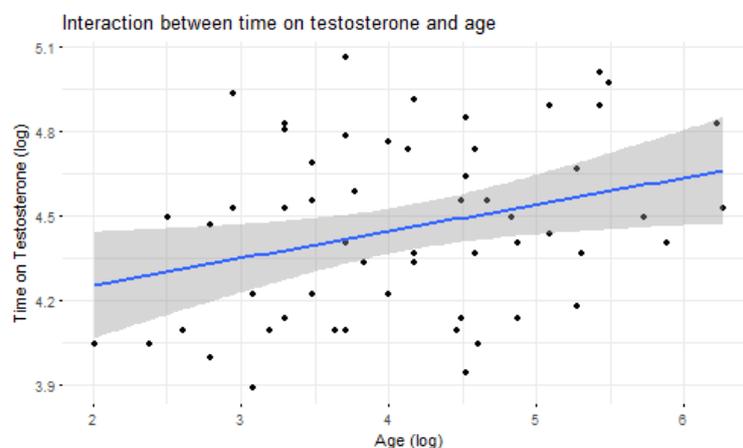


Figure 50. Scatter Plot of Time on Testosterone (log) & Age (log)

The ratio of participants who took testosterone to those who have not taken testosterone was 143:42. This was proportional to the participants who provided a speech sample which was 51:15.

## **5.2 Pitch Analysis with Praat**

The current section analyses pitch measurements extracted from Praat. This was subdivided into time on testosterone (section 5.2.1), self-perceived vocal masculinity (section 5.2.2), cross-linguistic analysis (section 5.2.3), and limitations of Praat (section 5.2.4).

### **5.2.1 Time on Testosterone & f0**

Figure 51 (R package: ggplot2; Wickham, 2009) is a scatterplot of the f0 measurements in Hz on the y-axis and time on testosterone on the x-axis. Participants that took testosterone for more than 36 months or had an f0 maximum greater than 250 Hz were excluded in Figure 51. The cut-off at 36 months coincided with the 3<sup>rd</sup> quartile of the transmasculine participants who provided a voice recording. Furthermore, previous studies have shown for transfeminine individuals that vocal satisfaction increased as time presenting as female increased (Dacakis et al., 2013: 316). This exclusion was placed on the current study to eliminate other influences on vocal satisfaction. Time on testosterone was converted to months, and participants who have not taken testosterone were assigned <1 months to differentiate them from the transmasculine individuals who only began testosterone therapy.

As shown in Figure 51, f0 decreases on all three conditions as time on testosterone increases. There were significant negative correlations between time on testosterone with f0 minima ( $r = -0.60$ ), mean f0 ( $r = -0.64$ ), and f0 maxima ( $r = -0.52$ ). This suggests f0 minima, mean, and maxima decrease as time on testosterone increases, which is in line with previous research outcomes (Cosyns et al., 2014; Deuster et al., 2016; Deuster et al., 2016; Irwig et al., 2017; Nygren et al., 2016; Papp, 2011; Wierckx et al., 2014; Zimman, 2012). In summary, there was a moderate relationship between time on

testosterone and the acoustic measurements extracted from Praat, despite this being a cross-linguistic cross-sectional study.

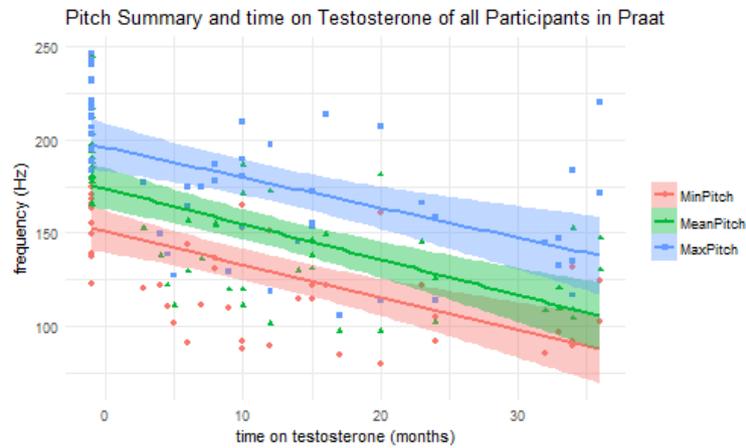


Figure 51. Scatter Plot of Praat Minima, Mean, Maxima & Time on Testosterone

### 5.2.2 Self-perceived Vocal Masculinity

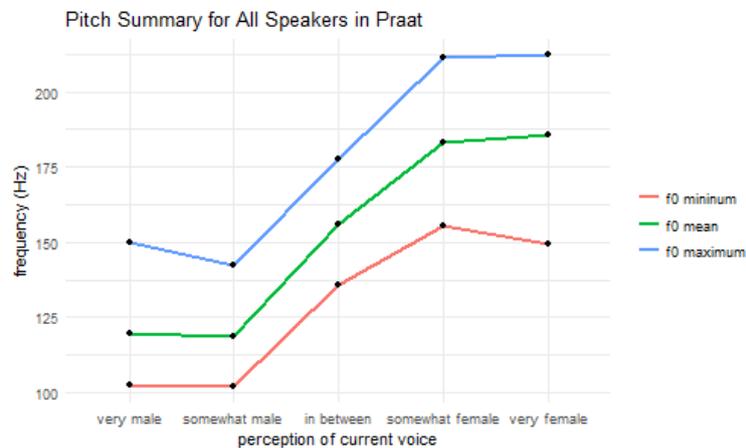


Figure 52. Line Graph of Self-perceived Vocal Masculinity & Praat Minima, Mean, Maxima

Figure 52 (R package: ggplot2; Wickham, 2009) is a summary of the f0 measurements extracted from Praat plotted against the self-perception of the participant's current voice. These measurements were segmented based on the participant's self-perceived vocal masculinity. As shown in Figure 52 - f0 decreased as self-perceived vocal masculinity increased. The distribution of the f0 measurements in

Figure 52 resembled a sigmoid function. The f0 differences between a ‘very female’ and a ‘somewhat female’ were minimal. A participant with an f0 in this range was perceived as feminine. Likewise, the f0 differences between a ‘very male’ and a ‘somewhat male’ voice were negligible. A participant with an f0 in this range was perceived as masculine. Participants who felt they spoke with a masculine voice had the lowest mean f0 combined. Compare this to participants who felt they spoke with a feminine voice had the highest mean f0 combined. The f0 differences (Hz) between each voice condition has been presented in Table 13 in the *Appendix*.

The next lot of analyses explores the relationship between time on testosterone and self-perception of current voice. Figure 53 is a boxplot visualising the interaction of self-perceived vocal masculinity and the total time on testosterone. All participants included in Figure 53 took testosterone for 0-150 months (0-12.5 years). Two participants who took testosterone for over 150 months were excluded from Figure 53. The two participants who took testosterone >150 months took testosterone for 185 (15.4 years) and 194 (16.17 years) and were excluded to constrain the dataset.

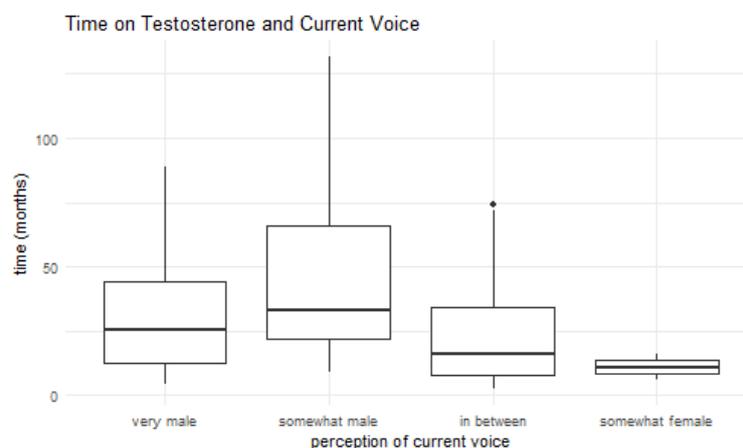


Figure 53. Box Plot of Current Voice & Time on Testosterone

The median time on testosterone for a participant who rated their voice as ‘very male’ ( $n = 11$ ) was 25.5 months (2.125 years) and the mean time on testosterone was 31.45 months (approximately 2.62 years). The median time on testosterone for a participant who rated their voice as ‘somewhat male’ ( $n = 16$ ) was 33 months (1.25 years) and the mean time on testosterone was 47.13 months (approximately 3.93 years). Counterintuitively, participants who rated their voice as ‘somewhat male’

took testosterone for a much longer time than participants who rated their voice as ‘very male’. This means there is no direct relationship between time on testosterone and self-perceived vocal masculinity for the current study, or that the relationship was mediated by e.g. time of commencement of hormone therapy. Compare this to those who rated their voice as ‘in between that of a female and male’ where the median time on testosterone was 16 months (1.33 years) and the mean time on testosterone was 24.62 months (approximately 2.05 years).

### 5.2.3 Cross-Linguistic Analysis

This section compared the acoustic measurements extracted from Praat between English and German. This was to see if there were acoustic differences between English and German and how these differences might affect the current analysis.

#### *English*

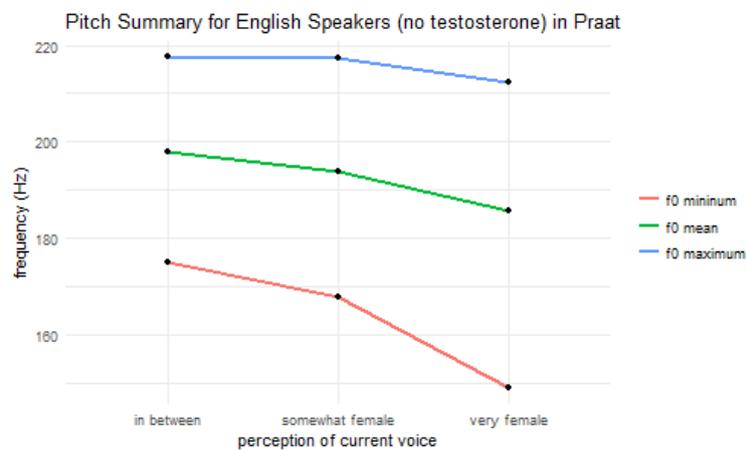


Figure 54. Line Graph of Current Voice & Praat Minima, Mean, Maxima (English) (no Testosterone)

Figure 54 (R package: ggplot2; Wickham, 2009) is based on the analysis of 15 participants who have not taken testosterone. These participants rated their voice as ‘in between that of a female and male’ ( $n = 6$ ), ‘somewhat female’ ( $n = 8$ ), and ‘very female’ ( $n = 1$ ). None of the transmasculine individuals who have not taken testosterone perceived their voice as ‘very male’ or ‘somewhat male’. A small number of transmasculine individuals who have not taken testosterone perceived their own voice as

‘somewhat male’ with reference to section 4.2.3, but again none of the participants who have not taken testosterone perceived their own voice as ‘very male’. The  $f_0$  differences (Hz) between each voice condition has been presented in Table 14 in the *Appendix*.

The median age of an English-speaking participant was 28.50 and the mean age was 30.56. The median time on testosterone was 23 months (1.92 years) and the mean time on testosterone was 40.35 months (3.36 years) (range = 2.75-194 months). The 1<sup>st</sup> and 3<sup>rd</sup> quartiles were 10-47 months (0.83 – 3.92 years). The current study did not ask whether the participants were L1 speakers of English or spoke English as an additional language. Therefore, some of the acoustic measurements were of non-native speakers of English. Participant’s additional language abilities were not collected. Figure 55 (R package: ggplot2; Wickham, 2009) is a scatterplot with  $f_0$  measurements in Hz on the y-axis and time on testosterone on the x-axis.

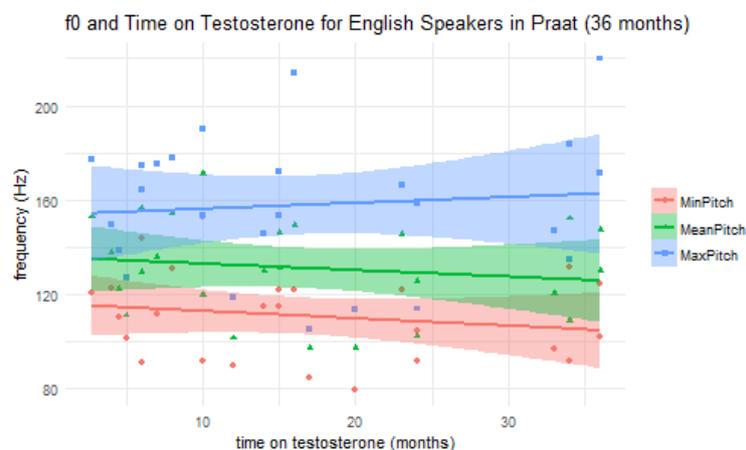


Figure 55. Scatter Plot of Praat Minima, Mean, Maxima & Time on Testosterone (English)

As shown in Figure 55, the  $f_0$  minima and mean  $f_0$  decreased slightly as time on testosterone increased; however,  $f_0$  maxima increased slightly as time on testosterone increased. This might be due to the high variability of  $f_0$  at any given time point; therefore, the effect of testosterone is less apparent. The  $f_0$  of English speaking participants remained relatively constant in the first 36 months of testosterone therapy as shown in Figure 55. Participants who took testosterone >36 months were excluded in order to match the German-speaking transmasculine individuals in the preceding analysis. Furthermore, the mean  $f_0$  was at approximately 130 Hz at the beginning of testosterone therapy. A

possible explanation is that the English-speaking transmasculine individuals used a higher proportion of creak phonation which may account for the low mean f0.

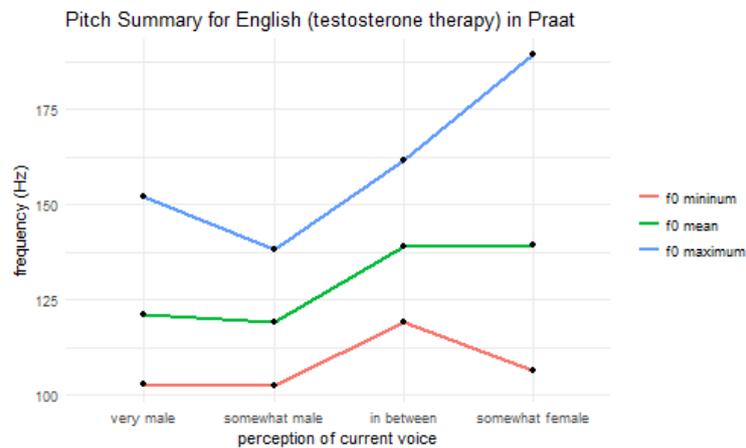


Figure 56. Line Graph of Current Voice & Praat Minima, Mean, Maxima (English) (Testosterone)

The f0 summaries provided in Figure 56 (R package: ggplot2; Wickham, 2009) were consistent to the findings in section 5.2.2. Participants who took testosterone rated their voices as ‘very male’ ( $n = 7$ ), ‘somewhat male’ ( $n = 10$ ), ‘in between that of a female and a male’ ( $n = 16$ ), and ‘somewhat female’ ( $n = 2$ ). The mean f0 of English-speaking transmasculine individuals decreased slightly as self-perceived vocal masculinity increased. The median f0 of an English-speaking transmasculine individual who took testosterone with a ‘very male’ voice was 122.2 Hz and the mean was 121.3 (range = 99.2-146.2 Hz). The f0 differences (Hz) between each voice condition has been presented in Table 15 in the *Appendix*. Although there were perceptual differences between voices, the acoustic difference of masculine and androgynous voices was not as significant.

### German

The median age of a German-speaking participant was 35 and the mean age was 34.19. The German-speaking transmasculine individuals were slightly older than the English-speaking transmasculine individuals by approximately five years. All German-speaking participants took testosterone. The

median time on testosterone was 32.50 months (2.71 years) and the mean time on testosterone was 34.50 months (2.88 years) (range = 8-89 months). The 1<sup>st</sup> and 3<sup>rd</sup> quartiles were 11.50-41.25 months (0.96 – 10.52 years). The German-speaking transmasculine individuals matched the English-speaking participants in terms of time on testosterone. Figure 57 (R package: ggplot2; Wickham, 2009) is a scatterplot with f0 measurements in Hz on the y-axis and time on testosterone on the x-axis. There were moderate negative correlations between time on testosterone with f0 minima ( $r = -0.23$ ), mean f0 ( $r = -0.31$ ), and f0 maxima ( $r = -0.40$ ). This suggested that mean f0 decreased as time on testosterone increased.

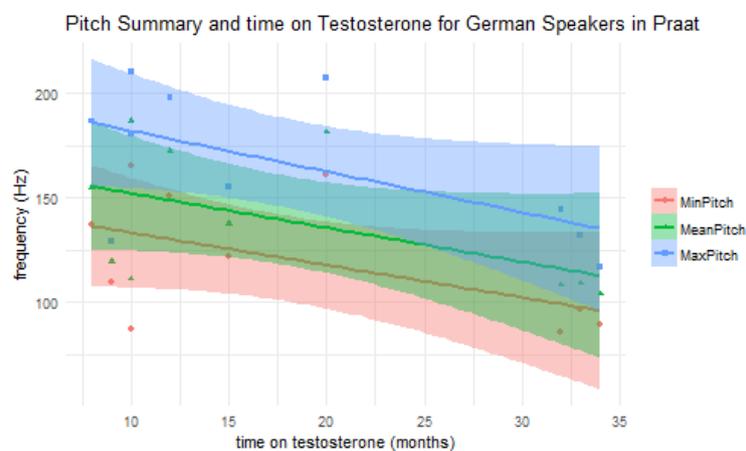


Figure 57. Scatter Plot of Current Voice & Praat Minima, Mean, Maxima (German)

Figure 58 (R package: ggplot2; Wickham, 2009) is based on the f0 measurements and self-perceived masculinity among German-speaking participants. The f0 differences (Hz) between each voice condition has been presented in Table 16 in the *Appendix*. The median time on testosterone for a participant who rated their voice as ‘very male’ ( $n = 4$ ) was 27 months (2.25 years) and the mean time on testosterone was 38.25 months (3.19 years), and for ‘somewhat male’ voices ( $n = 6$ ) the median was 35 months (2.92 years) and the mean was 40.50 months (approximately 3.38 years), and for ‘in between that of a female and male’ voices ( $n = 6$ ) the median was 16 months (1.33 years) and the mean was 26 (2.17 years).

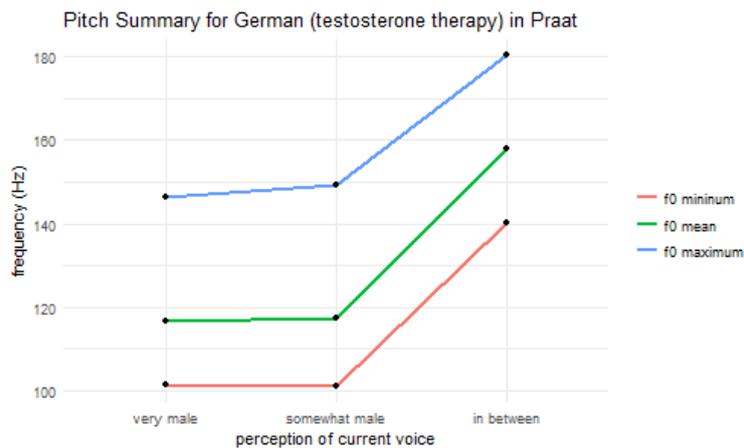


Figure 58. Line Graph of Current Voice & Praat Minima, Mean, Maxima (German)

The median f0 of a German-speaking transmasculine individual who took testosterone with a ‘very male’ voice was 114.8 Hz and the mean was 116.8 (range = 99.8-137.8 Hz). With reference to Figure 58 (R package: ggplot2; Wickham, 2009), the acoustic differences between a ‘very male’ and a ‘somewhat male’ voice were minimal. Participants who spoke with a ‘very male’ voice also inhabited the same f0 range as those who spoke with a ‘somewhat male’ voice. The mean f0 of participants that perceived their voice as ‘in between that of a female and male’ did not converge with those who spoke with a more ‘masculine’ mean f0.

### Summary

By subsetting the current speech data in to separate language groups, it was possible to further analyse the relationship f0 measurements and time on testosterone have on the vocal satisfaction of transmasculine individuals. A significant difference between the English-speaking participants and the German-speaking participants was the distribution of the f0 measurements. German-speaking participants show smaller within-group variability. Furthermore, German-speaking transmasculine individuals who took testosterone had a lower mean f0 than English-speaking transmasculine individuals. One possible explanation for the wide distribution of the English f0 measurements was the number of participants who spoke different varieties of English. For example, English-speaking participant came from the United States ( $n = 15$ ), Canada ( $n = 2$ ), Australia ( $n = 8$ ), New Zealand ( $n =$

7), and Great Britain ( $n = 6$ ). This also included participants who learnt English as an additional language ( $n = 12$ ). Another possibility was Praat's pitch tracking algorithm which often included fifth and octave jumps in intervals of irregular phonation. These downward jumps could artificially lower the mean  $f_0$  if the participants used creaky phonation.

As discussed in section 4.2.3, testosterone may not provide the necessary changes for transmasculine individuals to speak with a cisgender normative masculine voice, and even if the  $f_0$  reaches cisgender male norms, speakers will feel differently about the voice as a function of other vocal or contextual variables, time on testosterone, and individual idiosyncrasies.

#### **5.2.4 Limitations of Praat**

The relationship between  $f_0$  and self-perceived masculinity of voice is not a straightforward correlation as discussed in sections 5.2.2. Voices that were within a 'very male'  $f_0$  range could be self-perceived as 'somewhat male', likewise voices that were within a 'very female'  $f_0$  range could be perceived as 'somewhat female'. Androgynous voices (neither masculine nor feminine) consistently occurred in an  $f_0$  range that was distinctly 'in between that of a female or male' voice. However, some participants who spoke with self-perceived 'somewhat male' or 'somewhat female' voices also inhabited this space. Further to this,  $f_0$  minima and  $f_0$  maxima did not provide a valuable insight into the perceptions of gendered communication as shown in the results.

It is possible that the reason why there were complications in establishing a correlation with vocal masculinity and  $f_0$  was the result of the pitch tracking tool. It has been found that there were substantial inconsistencies with Praat's pitch tracking function particularly at the lower frequencies as discussed earlier. This is problematic as Praat is often used by speech and language professionals and clinicians to extract objective acoustic measurements (e.g. Cartei et al., 2014; Evans et al., 2008; Hancock et al., 2014; McNeill et al., 2008 etc.).

REAPER has been offered as an alternative pitch tracking tool which can accurately estimate glottal closure instants, voicing state, and  $f_0$ . Praat estimates the mean  $f_0$  measurements over the phrase while REAPER estimates  $f_0$  at each glottal closure. For example, the median  $f_0$  measurement

extracted from Praat via LaBB-CAT of the sample population was 137.8 Hz and the mean was 150.7 Hz (range = 88.2-489 Hz). The mean f0 measurement extracted from REAPER was 114 Hz and the mean f0 was 119.1 Hz (range = 78-185 Hz). The mean f0 measurements extracted from REAPER were significantly lower than those extracted from Praat.

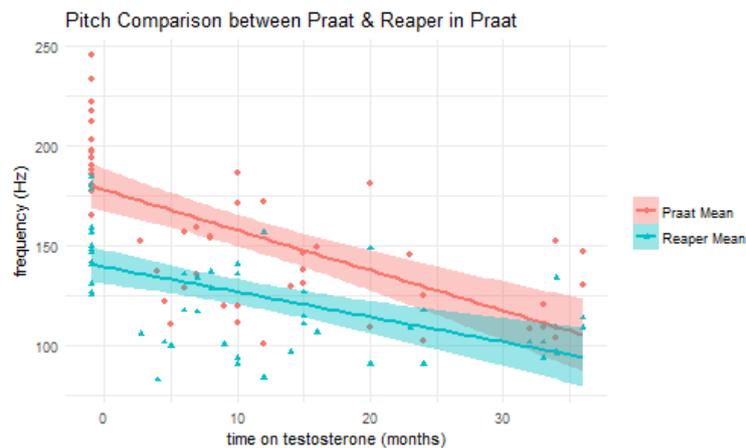


Figure 59. Scatter Plot of Time on Testosterone & Praat/REAPER

Figure 59 (R package: ggplot2; Wickham, 2009) is a scatterplot with the mean f0 from Praat and the mean f0 in REAPER plotted on the y-axis and the time on testosterone on the x-axis. Participants who took testosterone > 36 months were excluded from Figure 59 to be consistent Figures 51, 55, and 57. As shown in Figure 59, REAPER could detect f0 at lower frequencies and the population mean f0 was significantly lower as indicated by the regression line of the mean f0 in Praat (red) and in REAPER (blue). Figure 60 (R package: ggplot2; Wickham, 2009) is a histogram where the difference between the mean f0 between Praat and REAPER per participant was plotted on the y-axis and the counts of the differences were plotted on the x-axis. Most speakers had measurement errors. Most speakers had a mean f0 difference of 10.32-27.10Hz between Praat and REAPER.

Table 10 compares the mean f0 of REAPER and Praat segmented by the self-perceived vocal conditions of the transmasculine individuals. The mean f0 difference between Praat and REAPER was 16.9 Hz and the mean f0 was 23.06 Hz. The minimum mean f0 difference between Praat and REAPER was -5.7 Hz and the maximum mean f0 difference was 126.30 Hz. With reference to the mean f0 measurements extracted from Praat in Table 10, the difference between self-perceived ‘very

male' voices and a 'somewhat male' voice was only 1.1 Hz, and the difference between a 'somewhat male' voice and a voice 'in between that of a female and male' was only 37.2 Hz. This means there is a potential margin of error between a masculine voice and an androgynous voice of  $\pm 16.9$  Hz (median difference) or  $\pm 23.06$  Hz (mean difference). Furthermore, the differences between REAPER and Praat increased as mean f0 increased from a difference of  $\pm 13.7$  Hz to a difference of  $\pm 54.6$  Hz. The potential for measurements errors do not take in to account language differences and time on testosterone.

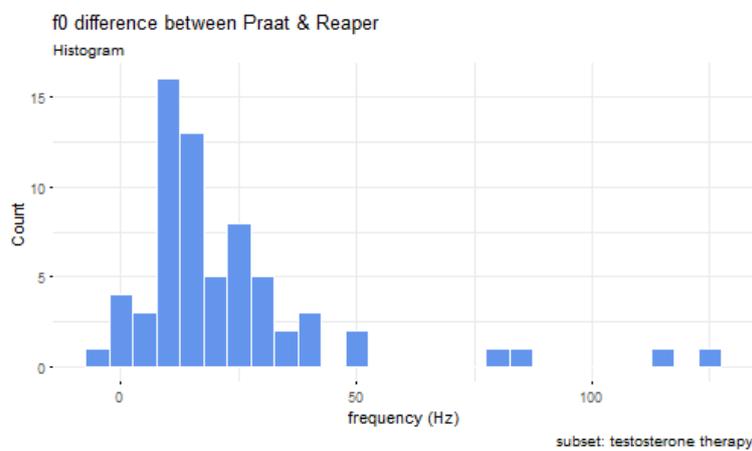


Figure 60. Histogram of f0 difference between Praat/REAPER

Table 10. Self-Perceive Vocal Masculinity & REAPER/Praat Mean

condition	REAPER mean f0 (Hz)	(difference $\pm$ )	Praat mean f0 (Hz)
very male	106	13.7	119.7
(difference $\pm$ )	7.8		1.1
somewhat male	98.3	20.2	118.5
(difference $\pm$ )	30.9		37.2
in between	129.1	26.6	155.7
(difference $\pm$ )	19.1		27.3
somewhat female	148.2	34.8	183
(difference $\pm$ )	17.2		2.6
very female	131	54.6	185.6

As discussed in sections 5.2.3, the mean f0 differences between voice self-perception among English-speaking participants were less apparent than German-speaking participants. However, there were

more English-speaking than there were German-speaking transmasculine individuals. The perceptual difference between a masculine voice and an androgynous voice for English-speaking participants who took testosterone was  $\pm 20$  Hz, whereas the difference for German-speaking participants was  $\pm 40$  Hz in the same condition. This means the potential for measurement errors in Praat for English-speaking participants were more severe.

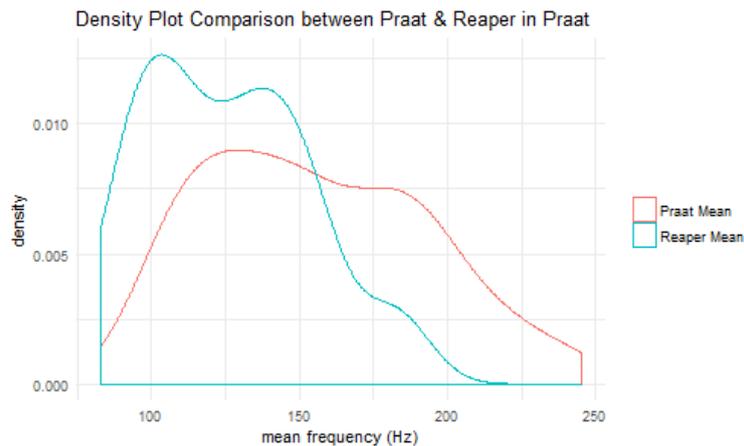


Figure 61. Density Plot of Praat/REAPER mean  $f_0$

Lastly, Figure 61 (R package: ggplot2; Wickham, 2009) is a density plot which compares the mean  $f_0$  between Praat and REAPER. Those who took testosterone for longer than 36 months were excluded. The density of participants who spoke with a particular mean  $f_0$  is on the y-axis and the mean  $f_0$  is on the x-axis. Figure 60 suggests there was a significant difference between the distribution of mean  $f_0$ s in Praat and REAPER. The *blue*-line represented the mean  $f_0$  extracted from REAPER, which reveals a bimodal distribution in Figure 60. The first peak was at 100 Hz, and the second peak was at 140 Hz. Both peaks were within the ranges of what would typically be a ‘masculine’ voice. The first peak indicated many participants employ creak phonation. A third smaller peak at approximately 180 Hz came close to the mean  $f_0$  range of a typically ‘feminine’ voice. On the other hand, the distribution of the Praat mean  $f_0$  measurements indicated by the *red*-line was level between the first peak (at 130 Hz which is within the range of a typically ‘masculine’ voice) and the second peak (at approximately 180 Hz which is within the range of a typically ‘feminine’ voice). This suggests Praat did not detect the spectral difference between creak and modal phonation. Based on the analysis carried out, it is

reasonable to posit there were significant differences between Praat and REAPER measurements. Although Praat is widely used by speech and language professionals, Praat is less accurate at tracking lower frequency ranges which means the frequency output from Praat will be proportionally higher than REAPER. As REAPER is more reliable in detecting creak phonation, acoustic measurements extracted from REAPER will be more valuable for transmasculine individuals.

### 5.3 Pitch Analysis with REAPER

The current section analysed pitch measurements extracted from REAPER. This was subdivided into comparing mean and mode f0 (section 5.3.1), self-perceived vocal masculinity (section 5.3.2), gender identity (section 5.3.3), and gender identity (section 5.3.4).

#### 5.3.1 Comparing Mean & Mode f0

The current analysis investigated the relationship between time on testosterone and f0. Furthermore, the current analysis compared the mean f0 and the mode f0 measurements extracted from REAPER. Figure 62 (R package: ggplot2; Wickham, 2009) is a scatterplot of mean f0 and mode f0 measurements extracted from REAPER and time on testosterone. Participants who took testosterone longer than 36 months (3 years) were excluded from Figure 62 ( $n = 17$ ).

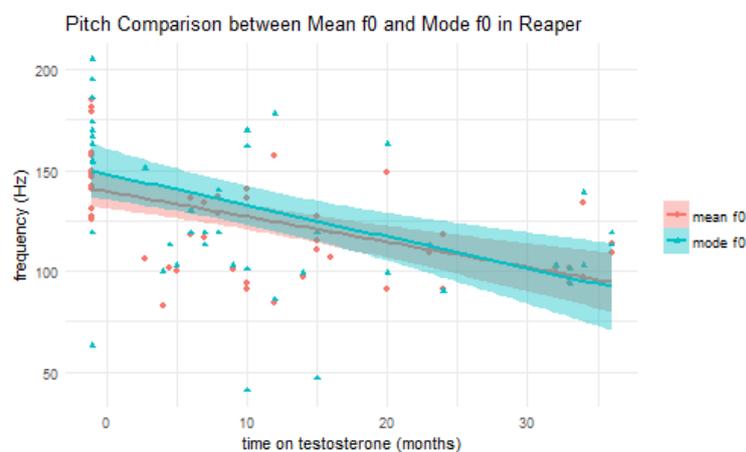


Figure 62. Scatterplot of REAPER mean/mode f0 & Time on Testosterone

As shown in Figure 62, this is consistent with the findings from the Praat analysis in section 5.2.1 where mean  $f_0$  decreased as time on testosterone increased. Furthermore, a finding not apparent in the Praat analysis in section Figure 62 was that the mean  $f_0$  and mode  $f_0$  converge as time on testosterone increased (in months). This is possibly because participants early in the hormonal transition process rely on creaky voice (i.e. irregular low pitched phonation) to artificially lower their speaking pitch which will lower the values of  $f_0$  mean but not  $f_0$  mode (which is a central tendency that is completely immune to outlier). The differences between mean  $f_0$  and mode  $f_0$  were the most apparent in speakers who are yet to take testosterone. While the differences still exist by the second year of testosterone therapy, these differences slowly disappear by the third year on testosterone therapy.

### 5.3.2 Self-perceived Vocal Masculinity & $f_0$

The following section provides a summary of the mean and mode  $f_0$  measurements extracted from REAPER segmented by the participant's current vocal conditions (`current_voice`).

#### *Mean $f_0$*

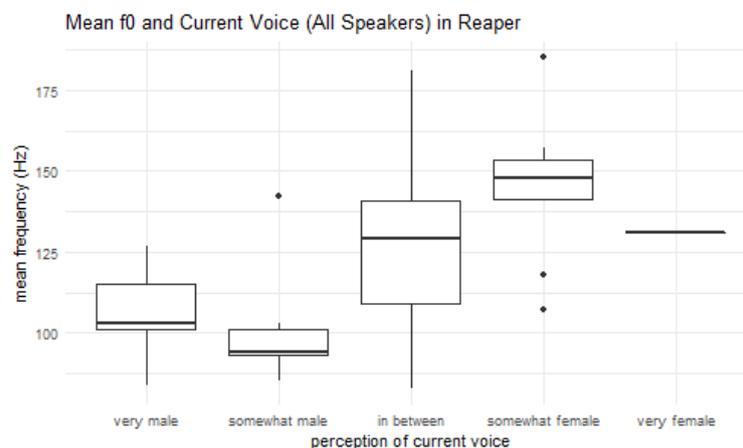


Figure 63. Box Plot of Current Voice & REAPER mean  $f_0$

The purpose of the previous section was to emphasise the effects of an unreliable pitch tracker (e.g. Praat). Figure 63 (R package: `ggplot2`; Wickham, 2009) summarises the mean  $f_0$  measurements of 66 participants grouped by their self-perceived vocal masculinity. Compared with the analysis carried

out in section 5.2.2, the mean  $f_0$  measurements extracted from REAPER were significantly lower than the mean  $f_0$  measurements extracted from Praat. The mean  $f_0$  of a ‘very male’ voice was 106 Hz (range = 84-127 Hz). The mean  $f_0$  of a ‘somewhat male’ voice was 98.25 Hz (range = 85-142 Hz). As per Figure 63, transmasculine individuals who spoke with a ‘somewhat male’ voice had a lower mean  $f_0$  than the transmasculine individuals with a ‘very male’ voice. Compare this to the mean  $f_0$  of a participant who had a ‘very female’ voice that was lower than mean  $f_0$  of participants with a ‘somewhat female’ voice which was 148.2 Hz (range = 107-185).

The findings from the current analysis is very different from the acoustic measurements extracted from Praat as shown in Figure 53 where mean  $f_0$  decreases as vocal masculinity increases. In the case of mean  $f_0$  extracted from REAPER as shown in Figure 63, the mean  $f_0$  of ‘very feminine’ sounding voice was in fact lower than the mean  $f_0$  of a ‘somewhat feminine’ sounding voice, likewise the mean  $f_0$  of a ‘very masculine’ sounding voice had a higher  $f_0$  than the ‘somewhat masculine’ sounding voices. This challenges that notion that self-perceived masculinity is strictly tied to mean  $f_0$ . Furthermore, voices that were rated as ‘in between that of a female or male’ were widely distributed throughout the mean  $f_0$  range.

### Mode $f_0$

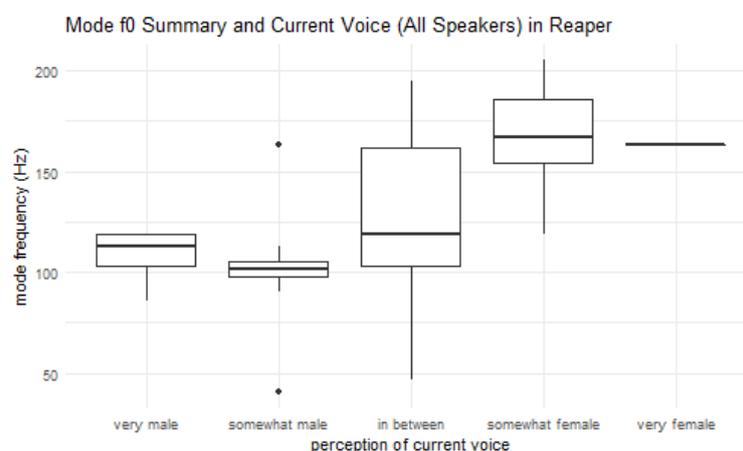


Figure 64. Box Plot of Current Voice & REAPER mean  $f_0$

The purpose of the current section is to compare the clinical efficacy of using mean versus mode to characterise f0 profiles. As discussed at the beginning of this section, the mode f0 has also been offered as an alternative to mean f0 to characterise central tendency in a clinical context (Dorreen, 2017). All mode f0 measurements were extracted from REAPER. The mode f0 measurement can be viewed as the most representative of a participant's speaking f0. Figure 64 (R package: ggplot2; Wickham, 2009) summarises the mode f0 measurements of 66 transmasculine individuals, and their perceptions of their current voice. The median mode f0 of a 'very male' voice was 113 Hz and the mean was 108 Hz, and the median mode f0 of a 'somewhat male' voice was 102 Hz and the mean was 101.7 Hz. This is consistent with previous analyses of f0 in the current study (both Praat mean f0 and REAPER mean f0) which found that the f0 between 'very male' and 'somewhat male' voices were nearly indistinguishable, yet 'somewhat male' voices tend to have a lower f0. The mode f0 of voices that were rated as 'in between that of a female and male' was consistent with the mean f0 which had the greatest distribution of all voice conditions. The mean was 164.5 Hz, and the minimum threshold was 47 Hz and the maximum threshold was 195 Hz.

Participants who have indicated their voices as androgynous overlap with the mode f0 ranges of all other categories. This indicates those who perceive their voices as androgynous do not prescribe to the notion of a having a 'masculine' or 'feminine' voice, nor do they prescribe to the spectral binary. Participants that noted their voices as 'somewhat female' speak on the highest end of the f0 range, the median mode f0 was 167 Hz and the mean was 164.5 Hz.

Lastly, Figure 65 (R package: ggplot2; Wickham, 2009) and Table 11 is a summary of the mean f0 and mode f0 measurements segmented by the current perception of participants. As observed in Figure 65, f0 difference between the mean f0 and mode f0 of participants who spoke with a 'very male', 'somewhat male' voice, or a voice that was 'in between that of a female and male' was very small (approximately 3 Hz as shown in Table 11). There was little f0 variance between the arithmetic mean f0 and the mode f0 in the masculine and androgynous voices. However, there was a significant difference between the mean and mode f0 in feminine voices. Participants who perceived their voices to be 'somewhat female' had a mean f0 of 148.2 Hz and a mode f0 of 164.5 Hz ( $\pm 16.4$  Hz), while participants who perceived their voices to be 'very female' had a mean f0 of 131.0 Hz and mode f0 of

163.0 Hz ( $\pm 32$  Hz). The mean  $f_0$  was lower than the mode  $f_0$  in both conditions, which indicated speakers with ‘somewhat female’ or ‘very female’ voices were attempting to speak with a low  $f_0$  (as the arithmetic mean is sensitive to extreme values, creaky phonation will lower the mean  $f_0$  but does not affect the mode  $f_0$ ).

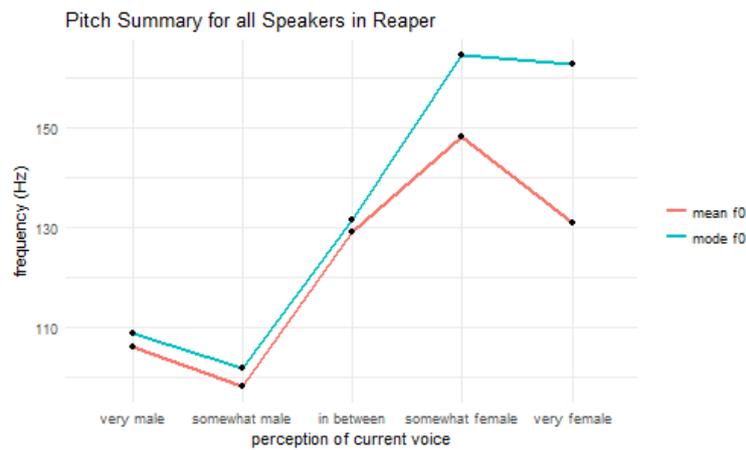


Figure 65. Line Graph Current Voice & REAPER mean/mode  $f_0$

Table 11. Self-perceived Vocal Masculinity & REAPER mean/mode  $f_0$

current voice	mean $f_0$ (Hz)	(difference $\pm$ )	mode $f_0$ (Hz)
very male	106.0	2.9	108.9
(difference $\pm$ )	7.8		7.2
somewhat male	98.3	3.4	101.7
(difference $\pm$ )	30.9		29.9
in between	129.1	2.5	131.6
(difference $\pm$ )	19.1		33.0
somewhat female	148.2	16.4	164.5
(difference $\pm$ )	17.2		1.5
very female	131.0	32.0	163.0

As indicated in the above summary, the mean  $f_0$  and mode  $f_0$  measurements extracted from REAPER are more reliable than those extracted from Praat. REAPER is more sensitive to the lower frequencies. The findings from the current section suggest that mode  $f_0$  is even more reliable than mean  $f_0$  as it is a lot less sensitive to outliers than the mean  $f_0$ . Sections 5.3.3, 5.3.4, and 5.4 will retain the mean and

mode f0 contrast to see how they differ depending on different conditions as most studies on transmasculine individuals have not used mode f0 besides [reference].

### 5.3.3 Gender Identity

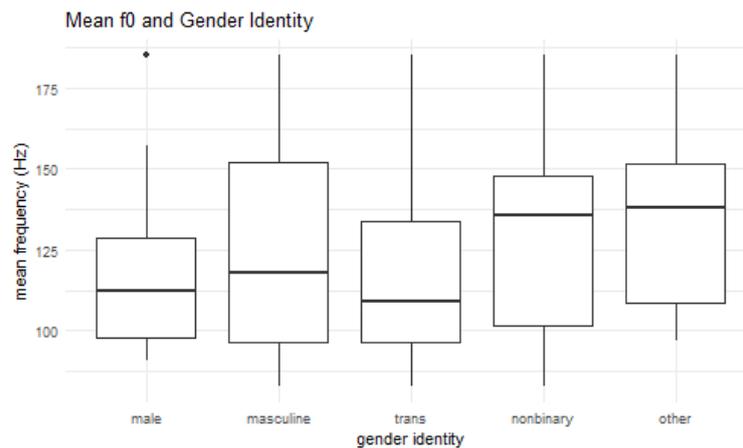


Figure 66. Box Plot of Gender Identity & REAPER mean f0

The following section investigated the interaction between the mean and mode f0 and gender identities. The gender identities were quantified through exploratory textual analysis of the gender identity terms in section 4.1.2. Each gender identity was counted once, which meant a participant who identified as ‘non-binary transmasculine’ with a mean f0 of 120 Hz would contribute towards the ‘non-binary’, ‘masculine’, ‘trans’, and ‘masculine’ subcategories. This method was used to quantify the different transmasculine gender identities in the current study.

Figures 66 (R package: ggplot2; Wickham, 2009) and 67 (R package: ggplot2; Wickham, 2009) are box plots of the mean and mode f0 measurements extracted from REAPER and their associated gender identities. As shown in Figure 66, the mean f0 range for ‘male’, ‘masculine’ and ‘trans’ gender identities were approximately 110 Hz, and the mean f0 range for those who identified with ‘non-binary’ and ‘other’ gender identity terms was approximately 135 Hz. The mean f0 range spans across the mean f0 minima of 90 Hz and mean f0 maxima of 185 Hz. This indicates a mean f0 of 110 Hz

approximated to a more masculine voice, while a mean f0 of 135 Hz was associated with androgynous voice.

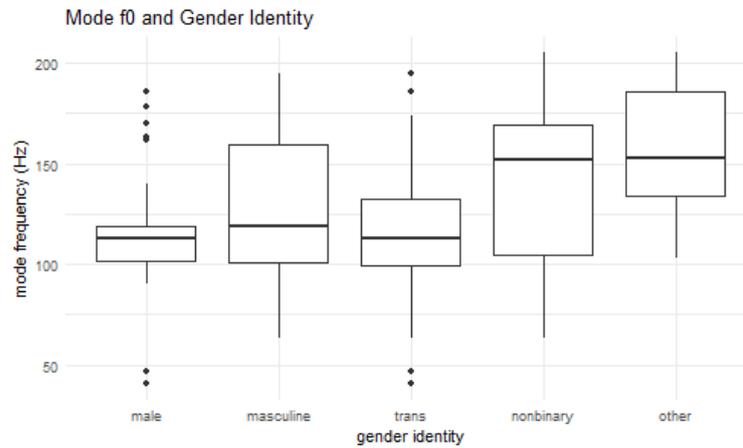


Figure 67. Box Plot of Gender Identity & REAPER mode f0

Compare this with Figure 67 where the mode f0 range for ‘male’, ‘masculine’ and ‘trans’ gender identities were approximately 115 Hz, and the mean f0 range for those who identified with ‘non-binary’ and ‘other’ gender identity terms were approximately 150 Hz. The interquartile ranges were much smaller in terms of frequency range than in the mean f0 comparison, which indicated a tighter clustering of the data points around the central tendency. The mode f0 range spans across the mode f0 minima of 40 Hz and mode f0 maxima of 185 Hz. The acoustic difference between the mean f0 masculine and androgynous gender identities was roughly 35 Hz which corresponds to the perceptual differences between a masculine and an androgynous voice as shown in Table 13 in the *Appendix* as discussed in section 5.1.2.

Participants who identify as more masculine than androgynous were more likely to have a mean f0 of 110 Hz and a mode f0 of 115 Hz as shown in Figures 66 and 67. Participants who identified with a ‘trans’ gender identity were less likely to speak within the masculine f0 range than those who identify as ‘male’ which may indicate they were in transition or were comfortable using an androgynous mean and mode f0.

### 5.3.4 Cross-Linguistic Comparison

The last section compares the mean f0 and mode f0 of English-speaking and German-speaking participants. As discussed in sections 5.2.3, the mean f0 was slightly higher in German-speaking participants than English-speaking participants. This finding is not consistent with Figure 68 (R package: ggplot2; Wickham, 2009) which compares the mean f0 measurements extracted from Praat. However, the acoustic measurements extracted from Praat were consistent with what is known about cross-language f0 means as discussed 2.1.3. The cisgender mean f0 norm for German-speaking cisgender males are slightly higher than English-speaking cisgender males. The mean f0 measurements extracted from REAPER were plotted on the y-axis, and time on testosterone on the x-axis in Figure 68. The mean f0 was relatively high in both language contexts prior to testosterone therapy, although the mean f0 diverge after approximately a year on testosterone therapy.

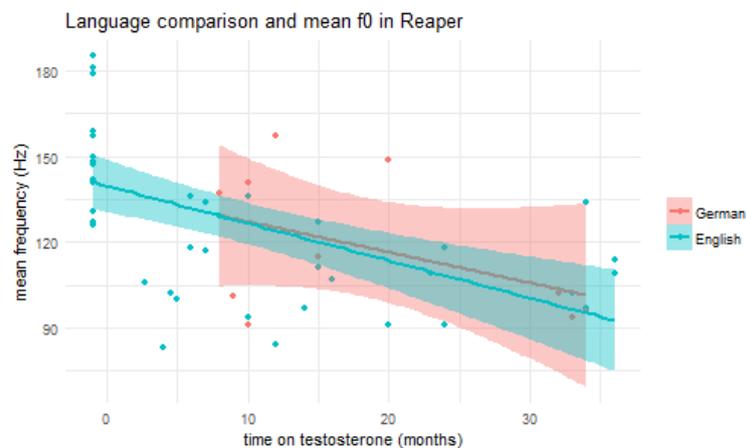


Figure 68. Scatterplot of Time on Testosterone & REAPER mean f0 (language compare)

When the mode f0 was grouped by language context, the German-speaking participants clearly spoke with a higher mode f0 than English-speaking participants as shown in Figure 69 (R package: ggplot2; Wickham, 2009). Once again, this clearly contrasts with the findings previously shown with the Praat mean f0 measurements in sections 5.2.3 and literature on cross-linguistic mean f0 differences as discussed in section 2.1.3 which predicts that German speakers will in general aim for a higher

speaking f0 target because German cisgender males are consistently measured to speak with a higher f0 than English cisgender males.

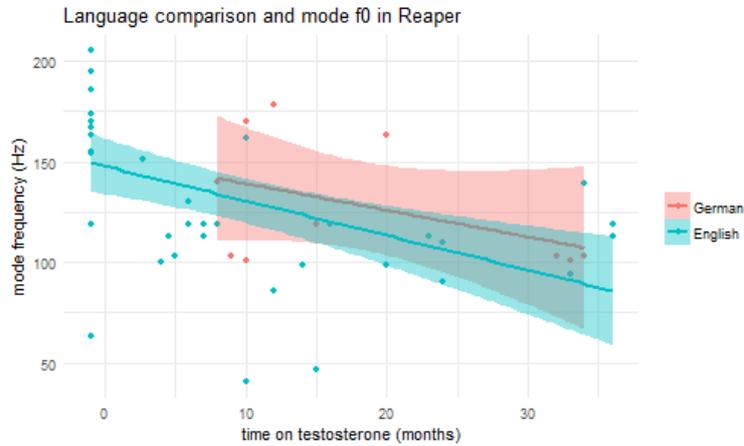


Figure 69. Scatterplot of Time on Testosterone & REAPER mode f0 (language compare)

## 5.4 Vocal Satisfaction

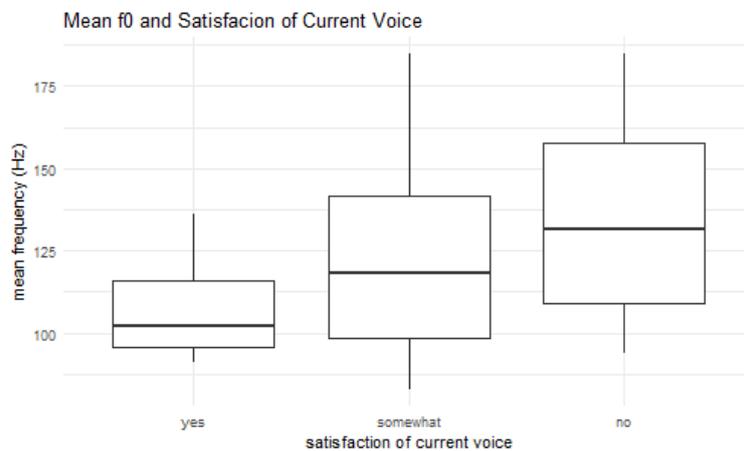


Figure 70. Box Plot of Vocal Satisfaction & REAPER mean f0

Participants who had a lower f0 were overall more satisfied with their current voice. However, what should interest speech and language professionals were the transmasculine individuals who were only somewhat satisfied and not satisfied with their voice. As shown in Figure 70 (R package: ggplot2; Wickham, 2009) the mean mode f0 of transmasculine individuals who were unsatisfied with their

voice spoke within the mode f0 range of those who were satisfied with their voice. Counterintuitively, participants who spoke in the same range should be satisfied with their voice; however, Figure 70 shows that mean f0 is only one aspect that contributes to vocal satisfaction.

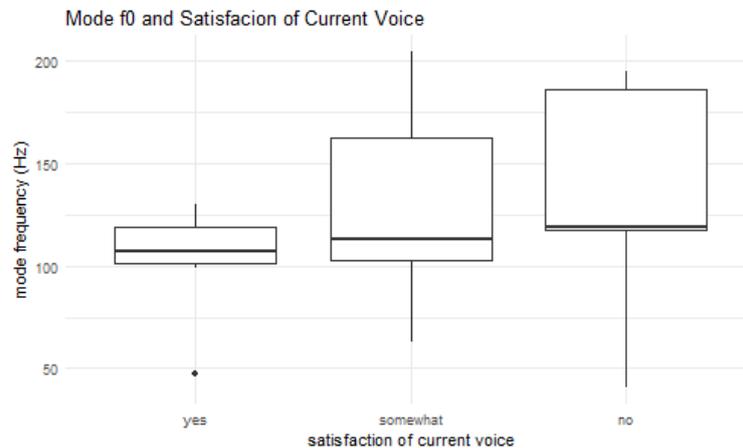


Figure 71. Box Plot of Vocal Satisfaction & REAPER mode f0

The differences between a satisfied and dissatisfied was even less apparent in the f0 range when comparing the mode f0 as shown in Figure 70 (R package: ggplot2; Wickham, 2009). The interquartile ranges (especially the 1<sup>st</sup> quartile and the arithmetic mean) indicated a tight clustering of the data points around the central tendency. This further suggests vocal satisfaction cannot be attributed to f0 alone. Figures 71 (R package: ggplot2; Wickham, 2009) and 73 (R package: ggplot2; Wickham, 2009) are density plots of mean and mode f0 grouped by vocal satisfaction.

Participants who were satisfied with their current voice had a mean and mode f0 of approximately 100 Hz, while participants who were somewhat satisfied had a bimodal distribution with the first peak 100 Hz for mean and modal f0, and the second mode below 150 Hz for mean f0 and above 150 Hz for mode f0. Transmasculine individuals who were not satisfied with their current voice also congregated within the satisfied f0 range at 115 Hz for mean and model f0.

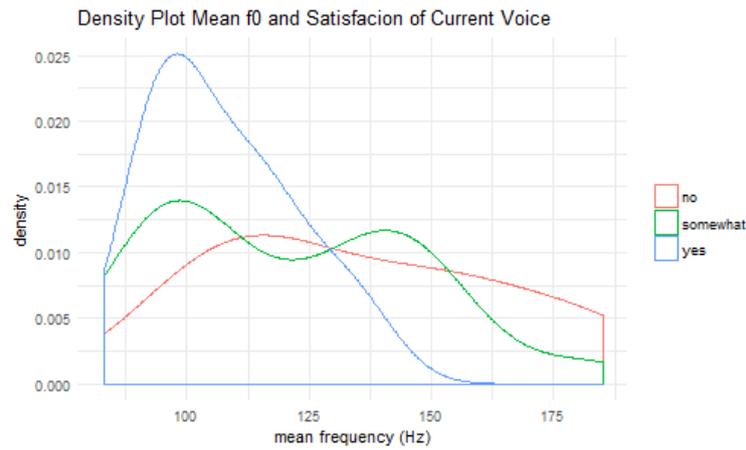


Figure 72. Density Plot of Vocal Satisfaction & REAPER mean  $f_0$

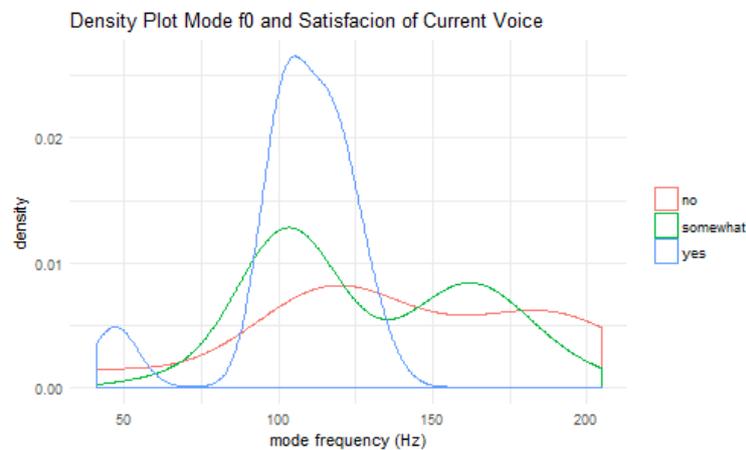


Figure 73. Density Plot of Vocal Satisfaction & REAPER mode  $f_0$

## 5.5 Summary of Results

The current chapter provided an acoustic analysis of transmasculine individuals' mean reading pitch ( $f_0$ ) and how it contributes to their vocal satisfaction. Furthermore, the current chapter aimed to compare the measurement differences between Praat and REAPER on the same dataset. REAPER was more sensitive at detecting lower frequencies. Furthermore, a correlation coefficient analysis did not identify any significant correlations between the Praat acoustic measurements and the results of the questionnaire results from *Chapter 5: Questionnaire Results*. However, significant correlations

were found between the mean f0 and mode f0 measurements extracted from REAPER and the variables in the questionnaire portion of the current study.

*Table 12. REAPER mean/mode f0 Correlations*

variables	mean f0 ( <i>r</i> -value)	mode f0 ( <i>r</i> -value)
current_voice	0.58	0.53
phone_female	0.69	0.61
matches_gender_identity	-0.53	-
living_male	0.64	0.64
helps_present_male	0.71	0.66
testosterone	-0.73	-0.67

As shown in Table 12, there are significant positive correlations between mean f0 and mode f0 with `current_voice`, `phone_female`, `living_male`, and `helps_present_male`. Significant negative correlations were found between mean f0 and mode f0 with testosterone. Although there are more significant correlations with mean f0, mode f0 is a more useful acoustic measure as it is more representative of the central tendency of participants' current vocal situation.

Furthermore, the current chapter found interactions between time on testosterone, participants' self-perceived vocal masculinity, and language contexts. However, section 5.4 found that even if a transmasculine individual spoke within an f0 range that was perceived as masculine (i.e. at 100 Hz), they may not be satisfied with their current voice. Therefore, vocal satisfaction cannot only be attributed to f0.

## Chapter 6: Discussion

The purpose of this study was to explore the self-perceived vocal masculinity and quality of life in transgender men, trans men, transmasculine people, masculine of centre, tangata ira tane, AFAB (assigned female at birth), male-to-male, and transmasculine individuals' speech. The current study consisted of two components: *Chapter 5: Questionnaire Results*, and *Chapter 6: Acoustic Analysis*. The results from the current study will be consolidated with previous literature exploring the vocal satisfaction of transmasculine individuals.

Section 6.1 provides a general discussion of the current study with regards to the factors explored and past literature. This was subdivided into demographic profile of transmasculine individuals (section 6.1.1), vocal satisfaction and theoretical framework (section 6.1.2), healthcare management of transmasculine individuals (section 6.1.3), and applications from the acoustic analysis (section 6.1.4). Section 6.2 responds to the research questions and hypotheses laid out in the summary of *Chapter 2: Literature Review*. Section 6.3 discusses the secondary goals in the current study.

### 6.1 General Discussion

Section 6.1 provides a general discussion of the current study with regards to the factors explored and past literature. This was subdivided into demographic profile of transmasculine individuals (section 6.1.1), vocal satisfaction and theoretical framework (section 6.1.2), healthcare management of transmasculine individuals (section 6.1.3), and applications from the acoustic analysis (section 6.1.4).

#### 6.1.1 Demographic Profile

Based on the demographic analysis in section [number] and its subsection, the typical transmasculine individual who participated in this study:

- is aged between 22 and 37.5
- is of European-descent and resides in a predominately English or German speaking country

- does not smoke
- identifies as queer and are equally attracted to female- and male-bodied individuals
- was born female and identifies as male and prefers ‘he/him/his’ pronouns
- have disclosed their gender history to their family, partner, and friends
- is currently binding and experiencing negative health impacts from the binding techniques

The findings of the current study are consistent to what is already known about transmasculine individuals (Papp, 2011: 48; Factor & Rothblum, 2008; del Pozo de Bolger et al., 2014). This demographic profile indicates the needs of transmasculine individuals are largely dependent on when they choose to transition. For example, the needs of transmasculine individuals who transitioned at earlier stage in life may differ significantly from transmasculine individuals who transition at a later stage in life in terms of hormone therapy, speech therapy, binding, and associated surgeries. Figure 74 (R package: venneuler; Wilkinson, 2011) visualises the gender diversity of transmasculine individuals. Although a majority of transmasculine individuals identify as ‘male’, many more identify as ‘trans’, ‘masculine’, ‘non-binary’, and other gender identity terms. The term ‘female-to-male’ is not as prevalent as in previous studies (Factor & Rothblum, 2008; del Pozo de Bolger et al., 2014). This could be due to the medical implications of ‘female-to-male’ and the current movement towards the de-psychopathologisation of transgender people (Coleman et al., 2012: 168).

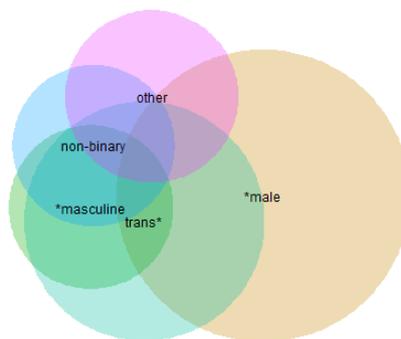


Figure 74. Stacked Venn Diagram of Gender Identity Categories

There was a strong correlation between `current_voice` and `gender_identity` which suggests self-perceived vocal masculinity is a significant predictor of gender identity, or vice versa. Furthermore, `current_voice` held strong correlations with `matches_gender_identity` and `matches_gender_expression`, which further suggests the self-perceived vocal masculinity is a significant contributor to transmasculine individuals' identity, or the other way around.

### **6.1.2 Vocal Satisfaction**

With the aim of exploring the vocal satisfaction and the vocal situation of transmasculine individuals in the current study, a 59 question questionnaire was distributed online via social media. In addition to exploring the demographic data of transmasculine individuals as discussed in section 6.1.1, the current study also explored factors regarding self-perceived vocal masculinity, vocal and communicative issues (e.g. personal, physical, pitch-related, and socioeconomic limitations), and vocal satisfaction. The current study has similar intentions as the VHI (Jacobson et al., 1997, TSEQ proposed by Davies (Adler et al., 2006: 116), and TVQ<sup>MIF</sup> (Dacakis et al., 2013) to quantify vocal satisfaction as discussed in 2.3; however, the questionnaire is not a psychometric assessment. Instead, the current study attempts to explore the factors that were highlighted as significant in Azul et al. (2017, 261.e15-261.e21).

In terms of self-perceived vocal masculinity, 32.4% ( $n = 60$ ) of the participants perceived their current voices to be 'somewhat male', followed by 31.9% ( $n = 59$ ) who perceived their current voices to be 'in between that of a female and male'. Only 20% ( $n = 37$ ) felt their current voice sounded 'very male'. Of interest are the transmasculine individuals who felt their voices were 'somewhat female' (11.9%;  $n = 22$ ) and 'very female' (3.8%;  $n = 7$ ). There is well-known correlation between self-perceived vocal femininity and happiness in transfeminine individuals (McNeill et al., 2008; T'Sjoen et al., 2008). Likewise, vocal satisfaction was found to increase as vocal masculinity increased ( $r = 0.63$ ). This suggests transmasculine individuals were more satisfied with their voice if they were perceived as more masculine.

With reference to the demographic survey conducted by Van Borsel et al. (2000: 430), only two of the 14 subjects wanted to change their voice as the rest were satisfied with their current voice. In the current study however, almost 60% ( $n = 111$ ) of transmasculine individuals were somewhat satisfied with their voice and only 25.4% ( $n = 47$ ) were fully satisfied with their voice. This is a polarising contrast from the findings in Van Borsel et al. (2000: 430), suggesting most transmasculine individuals experience some kind of vocal or communicative limitation. For example, only 18.4% ( $n = 24$ ) are never (mis-)gendered as female on the phone. This contrasts the previously reported 25% of transmasculine individuals who were (mis-)gendered as female on the phone (Van Borsel et al., 2000: 431). However, studies have shown as time on testosterone increases, instances of being (mis-)gendered as female on the phone decreases, vocal satisfaction increases, and instances of gender history disclosure decreases (Nygren et al., 2016: 766.e29). In this current study it was shown that this effect is also dependent on increased self-perceived vocal masculinity as discussed in section 4.2.2.

Van Borsel et al. (2000: 431) reported that all participants in their study felt their voices were more masculine than feminine. However, the current study suggests that most transmasculine individuals felt they have an androgynous voice. 45% ( $n = 84$ ) of transmasculine individuals in the current study thought that their voice was the most important trait or equally important trait 49% ( $n = 90$ ) aspect of their transition. This is comparable to the 87.5% of transmasculine individuals in Van Borsel et al. (2000: 431). Furthermore, Figure 45 section 4.3 indicated transmasculine individuals who identified as 'trans' (either exclusively or alongside other gender identity categories e.g. 'male', 'masculine', 'non-binary', and other terms) were most likely to be dissatisfied with their current voice.

In terms of personal impacts, some participants felt the authenticity of their speaking voice increased as their self-perceived vocal masculinity increased. Whereas participants who felt their current speaking was more 'feminine' did not feel they had a speaking voice that was authentic to them. This distribution also holds true for participants who felt their current voice made them feel masculine. A speaking voice that made participants feel authentic or masculine were positively coded outcomes. These were usually the intended outcomes for transmasculine individuals. However, those who did not identify with either extremes of the gender binary may find a more androgynous voice as being most authentic. Conversely, affirmative responses to `consciously_changing`, `frustrated`, and

self\_conscious increased as self-rated femininity increased. A speaking voice that made participants self-conscious or frustrated and a speaking voice which they needed to consciously change were negatively coded outcomes. These correlated with a voice that did not affirm the speaker's gender identity. Furthermore, vocal strain and fatigue increased as participants' self-perceived femininity increased in terms of physical impacts. This suggests self-perceived vocal masculinity is a good indicator of vocal satisfaction and quality of life for transmasculine individuals. Other negative health impacts will be discussed in section 6.1.3.

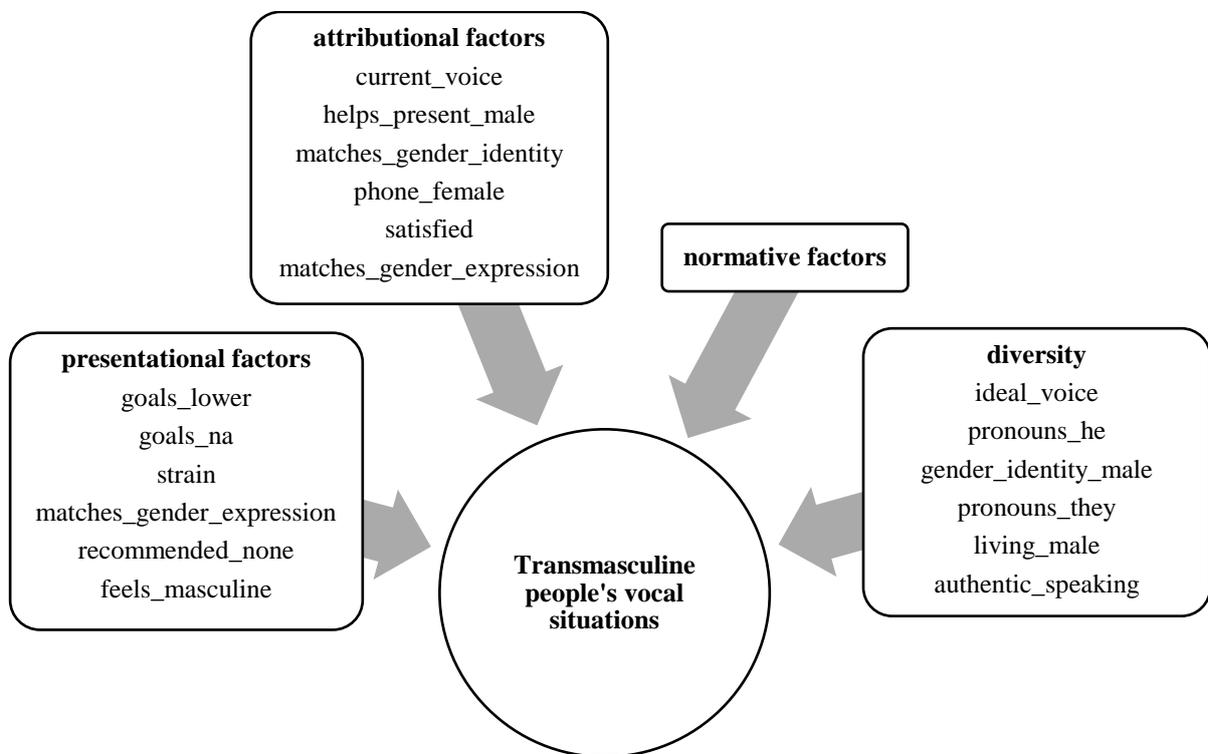


Figure 75. Gender related aspects of transmasculine vocal situations (Azul, 2015: 34)

In order to quantify the variables in the current study, a Principal Component Analysis (PCA) was carried out in section 4.3. Upon closer inspection, the first three dimensions which contributed a cumulative variance of 62.7% of coincide with the factors discussed in the current 'Gender-related aspects of transmasculine people's vocal situations' model proposed by Azul (2015). The factors in the model proposed by Azul (2015) are consistent with the PCA analysis in the current study. The first dimension is 'the self- and listener-perceptions of current vocal conditions' which coincides with

*attributional factors* (e.g. the listener's contributions) (Azul, 2015: 34). The second dimension is 'the ideal (vocal or expressive) characteristics of the intended gender identity' which coincides with *diversity* which accounts the subjective positioning of gender by the speaker (Azul, 2015: 34). The third dimension is 'the vocal and communicative changes' which coincides with *presentational factors* (e.g., the speaker's contributions) which accounts for methods used to change gender identity (i.e. vocal gender) presentation (Azul, 2015: 34). The top six contributing variables from the three dimensions and how they fit within Azul's (2015) research framework are shown in Figure 75. For example, the *attributional factors* such as self-perceived vocal masculinity (as indicated by `current_voice`) can be used to monitor listener feedback (such as `phone_female`).

*Presentational factors* are methods which transmasculine individuals can employ to mitigate vocal gender incongruence for listeners (such as `goals_lower`, i.e. aiming for a lower speaking f0). Variables in the principal component found that many participants do not (or cannot) change the way they speak (as indicated by `goals_na` and `recommended_none`) to combat vocal incongruence with their gender identity. Lastly, the variables in *diversity* denote the aspirations of transmasculine individuals (e.g. `ideal_voice`, `pronouns_he`, `gender_identity_male`, and `authentic_speaking` etc.). Note there were no *normative factors* included in the current study; however, these normative measures are accounted for by the acoustic analysis as transmasculine individual's rate vocal masculinity based on their own ideas of a masculine voice.

### **6.1.3 Healthcare Management**

The current study highlighted a number of vocal and communicative goals of transmasculine individuals (section 4.2.4). These results may be useful for Speech and Language Pathologists (SLPs) and primary healthcare providers who may not have experience interacting with transmasculine individuals. As discussed in section 4.2.4, most transmasculine individuals would recommend to other transmasculine individuals to undergo testosterone therapy (86.5%;  $n = 160$ ) or see an SLP (73.5%;  $n = 136$ ) if vocal masculinisation was not sufficiently achieved. This is an extreme contrast to Factor and Rothblum (2008: 214) who found 94.1% of 52 North American

transmasculine individuals who did not think SLPs were applicable to their transition. However, only 25 participants (13.5%) in the current study would see an SLP to meet their personal vocal and communicative needs. These numbers are somewhat higher than the findings in Factor and Rothblum (2008: 214) who found only 2% were interested in seeing an SLP (compared with 13.5% in the current study). Seventeen participants (9.1%) had no suggestions as to how to achieve vocal masculinisation.

In terms of vocal masculinisation surgery, only a small number of transmasculine individuals have heard of this procedure prior to the current study (22.7%;  $n = 42$ ) and an even smaller number of transmasculine individuals would recommend this procedure to other transmasculine individuals (7%;  $n = 13$ ). Of the 143 participants who were not aware of vocal masculinisation surgery before the current study, 42% ( $n = 49$ ) would reconsider undergoing vocal masculinisation surgery. This is almost three-fold increase of participants that would recommend or consider vocal masculinisation surgery. Transmasculine individuals, who identify as ‘male’, view vocal masculinity as a very important factor to affirm their gender identity more so than those who do not identify as ‘male’.

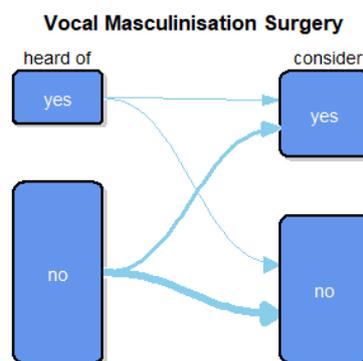


Figure 76. Transition Plot of Vocal Masculinisation Surgery

This claim is supported by the transition diagram Figure 76 (R package: Gmisc; Gordon, 2017). Figure 76 suggests a small number of transmasculine individuals would consider surgery if they knew about the procedure.



*Figure 77. Stacked Venn Diagram of Goals*

In terms of vocal goals, most transmasculine individuals indicated they want their voice to be lower (81%;  $n = 150$ ) and louder (41%;  $n = 76$ ), while a small minority wanted a softer (3.8%;  $n = 7$ ) and higher (0.5%;  $n = 1$ ) speaking voice (refer to Figure 77; R package: *venneuler*; Wilkinson, 2011). This outcome indicates transmasculine individuals do have an assortment of voice goals; however, most participants do not (or cannot) seek professional assistance from SLPs.

SLPs should be aware of behaviours that may impact the vocal health of transmasculine individuals such as chest binding and smoking. These negative health impacts should be highlighted by primary healthcare providers to transmasculine individuals during the initial stages of their transition to mitigate potential negative health effects. For example, chest binding (section 4.1.5) is known to have negative health effects on transmasculine individuals as discussed in Peitzmeier et al. (2017). The health survey of 1800 transmasculine individuals found that 50.7% experienced shortness of breath or maybe (a persistent) cough and 41% felt numbness or light-headed as a result of their binders (Peitzmeier et al., 2017: 71). The current study found that over half of the transmasculine individuals who were chest binding (or had in the past) experienced shortness of breath ( $n = 105$ ), felt light-headed or dizzy ( $n = 52$ ) and could barely speak ( $n = 8$ ) as a result of chest binding. Participants who have had chest reconstruction also noted (historical) impacts from their binders. It is possible that these negative impacts served as further catalyst for the participants to undergo surgery.

The four typical physical complaints found among transitioning and transitioned transmasculine individuals were breathing difficulties (*frequentBreaths*), difficulty in projecting or amplifying their voice at an authentic range (*inaudibleInNoise* and *loudEasily*), and strain (*strain*). Some physical factors may lead to other physical limitations because participants are consciously (or unconsciously) trying to change their voice to match their gender expression and gender identity. Other physical factors that had a direct or indirect effect on speech production could be the result of binders, androgen hormone therapy, or sexual reassignment surgery. As discussed in section 2.2.2, inappropriate management of speaking voice may lead to poor vocal hygiene and speech complications such as tension, strain, and vocal fatigue.

Other impacts such as smoking habits should also be considered in the healthcare management of transmasculine individuals. Azul et al. (2017: 261.e12-261.e15) indicated that cigarette smoking impacted the voice function of transmasculine individuals. Almost a third of the participants smoked cigarettes (26%;  $n = 48$ ) as discussed in section 4.1.6, and five participants recommended smoking cigarettes to achieve a masculine voice as discussed in section 4.2.4. This means 2.7% of participants in the current study recommend smoking as a method of vocal masculinisation. This result is concerning, as smoking is detrimental to health and is a known carcinogen and should not be recommended. These behaviours may have serious implications if they are not managed appropriately by transmasculine individuals, SLPs and primary healthcare providers.

#### **6.1.4 Testosterone Therapy**

Approximately 77% ( $n = 143$ ) of transmasculine individuals taking part in the current study have taken testosterone. This is slightly lower than the findings from the sociological survey of North American transmasculine individuals conducted by Factor & Rothblum (2008: 242). Transmasculine individuals who identify as 'male' are most likely to take testosterone, followed by those who identify as 'trans', 'masculine', 'non-binary', and other gender identity terms. The median age of a participant who has taken testosterone was aged 29 and the median time on testosterone was 24 months. The most common administration method was intramuscular injections.

As discussed in section 4.2.3, transmasculine individuals who have taken testosterone were more likely to perceive their own voice as more masculine, while those who have not taken testosterone do not. This interaction confirms the predicted and well-documented link between testosterone usage and an increase in perceived vocal masculinity (Hancock et al., 2017: 2476). The acoustic analysis indicated an inverse relationship with time on testosterone and  $f_0$ , as documented in numerous studies (Cosyns et al., 2014; Deuster et al., 2016; Deuster et al., 2016; Irwig et al., 2017; Nygren et al., 2016; Papp, 2011; Wierckx et al., 2014; Zimman, 2012). As discussed in section 5.3, this suggests testosterone lowers  $f_0$  in transmasculine individuals. Mean and mode  $f_0$  decreased as time on testosterone increased as shown in Figure 62, this was from a population mean of approximately 150 Hz to 100 Hz following 36 months of testosterone therapy. The population mean  $f_0$  is somewhat higher than the mode  $f_0$  prior testosterone therapy; however, these acoustic measures converge following two years of testosterone.

With reference to Figures 63 and 64, this self-perception of voice varies between speakers as a few speakers who have taken testosterone for nearly year still perceive their voice as ‘somewhat female’ or ‘in between that of a female and male’. Many participants felt that the amount of change that did happen to their voice following testosterone therapy met their expectations (43.4%;  $n = 62$ ), a small subset of transmasculine individuals expected more (24.5%;  $n = 35$ ) or faster (15.4%;  $n = 22$ ) change to their voice following testosterone therapy. These results suggest primary healthcare providers need to provide a realistic timeline of vocal changes to transmasculine individuals when prescribing testosterone. Transmasculine individuals will need to weigh up the risks of testosterone therapy if the primary motive to testosterone therapy is to acquire a ‘masculine’ sounding voice. These negative health impacts are listed in the *Standards of Care* (Coleman et al., 2012: [page]) and Gorton et al. (2005).

Furthermore, significant physiological changes are made to the vocal folds of transmasculine individuals following testosterone therapy. As discussed in section 224-226, these changes approximate those experienced by cisgender adolescent males going through puberty including irregularities in pitch (e.g. cracking or squeaking) (Gorton et al., 2005). With reference to the Source-Filter Theory of speech production proposed by Fant (1971), these changes only affect the vocal fold

or the ‘source’ following testosterone therapy; however, little or no change is observed to the anatomy of the vocal tract or the ‘filter’ in transmasculine individuals. Transmasculine individuals who use their voices in a professional capacity (e.g. public speaking and/or singing) may experience these affects more severely than those who do not.

### **6.1.5 Acoustic Analysis**

The findings from the acoustic analysis indicate that the current sample population of transmasculine individuals speak over/across a very diverse  $f_0$  range. Praat measurements are useful for preliminary and initial analyses of objective acoustic data; however, for consistent and reliable results it is best to employ REAPER as an  $f_0$  analysis tool. As discussed in section 5.2.4, Praat does not track lower  $f_0$  measurements and irregular phonation without manual adjustments to the pitch track, whereas REAPER estimates the  $f_0$  accurately at each glottal closure cycle in an unsupervised manner. The mean  $f_0$  decreases as time on testosterone increases, and these measurements are consistent with the current voice conditions self-rated by participants (Cosyns et al., 2014; Deuster et al., 2016; Deuster et al., 2016; Irwig et al., 2017; Nygren et al., 2016; Papp, 2011; Wierckx et al., 2014; Zimman, 2012).

There were significant systematic differences between mean  $f_0$  and mode  $f_0$ , and variability was found across different language contexts, time on testosterone, and self-perception of current voice. For example, the cross-linguistic comparison found that English-speaking participants had a lower mode  $f_0$  compared to German-speaking participants as discussed in section 5.3.4. This suggests self-perceived vocal masculinity vary considerably depending on language as shown in Table 4 (Traunmüller & Eriksson, 1995). Therefore, transmasculine individuals will map their speech characteristics based on the norms of their linguistic environment.

The findings from Andrews and Schmidt (1997), Owen and Hancock (2010), and Hancock et al. (2014) suggest there is a relationship between acoustic correlates (e.g. mean  $f_0$ ) and perceived vocal gender. Based on the current analysis,  $f_0$  does correlate with self-perceived masculinity as revealed by the Praat and REAPER acoustic measurements. However, participants who felt that they spoke with a ‘very male’ voice or a ‘somewhat male’ voice were in a similar  $f_0$  range. Participants who felt they

spoke with a voice that was ‘in between that of a female and male’ were generally in between the extremities (in some cases these voices were in the feminine or masculine f0 range). This can be observed in Figures 63 and 64 from the f0 measurements extracted from REAPER. Therefore, a voice in the f0 range of an androgynous voice can still be self-perceived as masculine by the speaker. However, a voice in the f0 range of a feminine voice was not typically perceived to be a masculine voice.

A possible explanation for this finding is that f0 is not the only predictor for gendered voices. Hillenbrand & Clark (2009: 1157) suggested that both f0 and formant frequencies are integral to discriminating feminine and masculine voices. Other cisgender speech norms that differentiate feminine and masculine speech among English-speakers include formant frequencies, intonation, loudness, breathiness, articulation, and duration of phonemes as suggested in Davies and Goldberg (2006: 178). These non-segmental features may play a much greater role in self-perceived vocal gender than f0 alone (Andrews & Schmidt, 1997: 311). This suggests f0 is only one aspect among a bricolage of non-segmental features that contribute to self-perceived vocal masculinity. Furthermore, there may be other paralinguistic features not explored in the current study that contribute to the vocal masculinity of transmasculine individuals such vocal attractiveness (Saxton et al., 2013: 92; Cartei et al., 2014: 571).

## **6.2 Research Questions**

The current section responds to the research questions and hypotheses laid out in the summary of *Chapter 2: Literature Review*.

### **6.2.1 Research Question 1**

The first research question was: *How satisfied are transmasculine individuals with their speech?* This research question was explored through hypothesis 1 and 2.

Hypothesis 1: *A self-perceived masculine voice correlates with a masculine gender identity.*

A self-perceived masculine voice does correlate with a masculine gender identity as indicated in the results of section 4.2.1, There is a strong positive correlation between those who identified as ‘male’ and those who currently speak with a ‘very male’ voice, which suggests those who identify as male most likely speak with a ‘very male voice’. Furthermore, there are positive correlations between a self-perceived ‘very male’ speaking voice with `feels_masculine` and `helps_present_male`, which suggests a ‘very male’ speaking voice helps transmasculine individuals present with as male and makes them feel masculine. Furthermore, transmasculine individuals who did not specifically identify as ‘male’ (they identified as ‘masculine’, ‘non-binary’, ‘other’, or ‘trans’) were more likely to speak with an androgynous or feminine-sounding voice.

Hypothesis 2: *Vocal satisfaction increases as self-perceived vocal masculinity increases.*

This hypothesis was found partially correct as most transmasculine individuals want to increase (or keep increasing) the vocal masculinity of their voice (from `current_voice` to `ideal_voice`) whereas some participants want to speak with an androgynous voice. Vocal dissatisfaction decreased as self-perceived vocal masculinity increases. However, a number of individuals who increased in self-perceived vocal masculinity were only somewhat satisfied with their current voice. Therefore, vocal satisfaction does increase as self-perceived vocal masculinity increases although there may be other vocal and communicative limitations that may affect vocal satisfaction.

## **6.2.2 Research Question 2**

The second research question was: *What is the relationship between the transmasculine individuals’ voice and their quality of life?* This research question was explored through hypothesis 3, 4, 5.

Hypothesis 3: *Vocal and communicative issues decrease as self-perceived vocal masculinity increases.*

Vocal and communicative issues largely decrease as self-perceived vocal masculinity increases as indicated in the results of section 4.2.2. Interactions exist between self-perceived vocal masculinity for some of the vocal and communicative factors (e.g. personal, physical, pitch, and socioeconomic), but not all. For example, there is a clear correlation between self-perceived vocal masculinity and personal factors. Personal limitations (e.g. self-conscious or frustration with current speaking voice) decrease while positive personal factors (e.g. vocal authenticity and masculinity) increase as self-perceived vocal masculinity increase. Furthermore, physical limitations (e.g. strain) decrease while positive physical factors (e.g. projecting voice in comfortable/authentic range) increase as self-perceived vocal masculinity increase. The results suggest that if participants are overall satisfied with their voice their quality of life is better; however, vocal and communicative limitations do persist no matter how masculine they sound.

*Hypothesis 4: Self-perceived vocal masculinity increases as time on testosterone increases.*

Self-perceived vocal masculinity does not increase as time on testosterone increases as shown in Figure 37. Participants who have taken testosterone between 0 and 36 months did not show a significant relationship with self-perceived vocal masculinity. Time on testosterone was not a significant predictor to specify whether a participant perceived their voice as ‘very male’, ‘somewhat male’, ‘in between that of a female and male’, or ‘somewhat female’. However, Figures 36 and 37 indicate there is a significant correlation between those who have taken testosterone and those who have not taken testosterone. Those who have taken testosterone rated their voices as more masculine, whereas those who have not taken testosterone rated their voices as more feminine. Therefore, hypothesis 4 is rejected. Time on testosterone does not have a direct effect on self-perceived vocal masculinity, but taking testosterone does have a significant effect on how transmasculine individuals perceive their voice.

*Hypothesis 5: Vocal satisfaction increases as time on testosterone increases.*

As shown in Figure 47, vocal dissatisfaction overall decreases as time on testosterone increases, but the proportions of participants who remain only ‘somewhat satisfied’ with their voice remain the same

no matter how long they have taken testosterone. This outcome suggests participants who were not fully satisfied with their voice were somewhat satisfied following testosterone therapy, and those who were somewhat satisfied become satisfied with their voice. Therefore, vocal satisfaction does increase as time on testosterone increases; however, vocal and communicative limitations remain problematic well into the testosterone therapy and these are unrelated to time on testosterone may persist.

### **6.2.3 Research Question 3**

The third research question was: *What are the acoustic correlates of masculinity and the socio-cultural construct of the male gender identity?* This research question was explored through hypothesis 6, 7, 8.

*Hypothesis 6: A low fundamental frequency (f0) correlates with a masculine gender identity.*

A low fundamental frequency (f0) does correlate with a masculine gender identity. The results discussed in *Chapter 5: Acoustic Analysis* indicate transmasculine individuals were relatively consistent when rating their own voices. A low mean or mode f0 corresponded to a masculine voice ('very male' or 'somewhat male'), a high mean or mode f0 corresponded to a feminine voice ('very female' or 'somewhat female'), while a voice that was 'in between that of a female and male' either fell within the mean and mode of the two spectral extremes, or right across the f0 range based on the perceptual analysis in section 5.3.3. The results from the current study suggest a low fundamental frequency (f0) does correlate with a masculine gender identity. Importantly, the 'somewhat male' and 'somewhat female' categories showed a large amount of misperception on part of the participants, as they each displayed more extreme values than the self-perceived 'male' and 'female' categories did respectively.

*Hypothesis 7: Fundamental frequency (f0) decreases as time on testosterone increases.*

Fundamental frequency (f0) overall does decrease for most speakers as time on testosterone increases based on the acoustic analysis on the mean and mode f0 measurements extracted from REAPER (as

shown in Figure 62). The mean and mode  $f_0$  for the group is approximately 140 Hz and 150 Hz respectively prior to testosterone therapy and converge to a mean and mode  $f_0$  of 100 Hz as time on testosterone increases (in this case following 36 months or 3 years) for the current sample population. While many participants show the  $f_0$  lowering effects of testosterone, many participants still remain significantly above the population regression line for mean and mode  $f_0$  as time on testosterone increases. This indicates  $f_0$  does decrease as time on testosterone increases albeit the speed and magnitude of the changes effects are highly variable depending on the individual.

Hypothesis 8: Vocal satisfaction increases as fundamental frequency ( $f_0$ ) decreases.

As discussed in hypothesis 6, fundamental frequency ( $f_0$ ) corresponds with the self-perceived vocal masculinity and masculine gender identity of transmasculine participants. Furthermore,  $f_0$  does decrease for most speakers as time on testosterone increases as discussed in Hypothesis 7. However, it is not as apparent whether vocal satisfaction increases as fundamental frequency ( $f_0$ ) decreases as the mean and mode  $f_0$  of participants who are satisfied with their voice fall within the same mean and mode  $f_0$  range of those who are somewhat satisfied with their voice, and the mean and mode  $f_0$  differences overlap between those who are somewhat satisfied and not satisfied with their voice as shown in the Figures 70 and 71. Vocal satisfaction does increase as fundamental frequency ( $f_0$ ) decreases; however, there is evidence to suggest there may be other factors involved which may contribute to vocal satisfaction besides  $f_0$ .

### **6.3 Secondary Goals**

The current study had methodology-related goals as well, namely to test the efficacy of using acoustic tools such as *Language and Brain and Behaviour Corpus Analysis Tool* (LaBB-CAT; Fromont & Hay, 2017) and *Robust Epoch And Pitch Estimator* (REAPER; Talkin, 2015) within a clinically applied area of research. The benefit of using LaBB-CAT (Fromont & Hay, 2017) for this study is that it allows the easy consolidation of the questionnaire data and the acoustic data into one database which facilitating the immediate extraction of linguistic variables.

Furthermore, the LaBB-CAT generated transcripts are segmented at the phrase, word, and phoneme level, allowing a fine-grained analysis of materials. A significant benefit of distributing the current study on the online platform of LaBB-CAT was that it was no longer confined to a specific geographic area and participants can complete the study at a time that is convenient to them.

A final benefit of the current underlying architecture of LaBB-CAT is that it can be reproduced to poll transfeminine individuals, and potentially other populations with vocal or communicative needs. Furthermore, it is compatible with third-party acoustic analysis software such as Praat (Boersma & Weenink, 2017) and *Robust Epoch And Pitch Estimator* (REAPER; Talkin, 2015). As discussed in the current study, REAPER is more reliable at pitch-tracking than Praat particularly at the lower frequencies. This is particularly important within a clinical context as objective acoustic measurements are needed to assess clients' vocal habits, including the overuse of creak/fry/glottal pulse register and harsh voice quality.

## Chapter 7: Conclusion

The purpose of this study was to explore the self-perceived vocal masculinity and quality of life transmasculine individuals' speech. To reiterate the findings from the current study, the three research questions and the significant findings are as follows:

1. How satisfied are transmasculine individuals with their speech?

A self-perceived masculine voice does correlate with a masculine gender identity. Vocal satisfaction does increase as self-perceived vocal masculinity increases although there remain other vocal and communicative limitations, such as loudness at an authentic pitch and perceived adequacy of the lowness of the  $f_0$ , that affect vocal satisfaction.

2. What is the relationship between the transmasculine individuals' voice and their quality of life?

Most transmasculine individuals were 'somewhat satisfied' with their voice and only a small number were fully satisfied with their voice. Vocal and communicative issues largely decrease as self-perceived vocal masculinity increases. Vocal satisfaction increases as time on testosterone increases, but vocal and communicative limitations unrelated to time on testosterone may persist. Self-perceived vocal masculinity does not increase as time on testosterone increases. Time on testosterone does not have a direct effect; however, the act of taking testosterone does have a significant effect on how transmasculine individuals perceive their voice.

3. What are the acoustic correlates of masculinity and the socio-cultural construct of the male gender identity?

A low fundamental frequency ( $f_0$ ) does correlate with a masculine gender identity. Fundamental frequency ( $f_0$ ) does decrease for most speakers as time on testosterone increases based on the acoustic analysis on the mean and mode  $f_0$  measurements extracted from REAPER. Vocal satisfaction does increase as fundamental frequency ( $f_0$ ) decreases; however, there is evidence to suggest there may be other factors involved which may contribute to vocal satisfaction besides  $f_0$ .

In summary, the vocal satisfaction of transmasculine individual is not directly predictable from their self-perceived vocal masculinity, or from the central tendency measures of their speaking  $f_0$ , and the observed effects are mediated by the gender identity label the transmasculine individual self-assigns.

#### *Limitations*

There are several limitations to the current study. Firstly, the current study is not a longitudinal study and does not have data regarding the individual effects of testosterone on transmasculine individuals. It is a cross-sectional demographic survey that attempts to explore vocal satisfaction and quality of life of transmasculine individuals abroad. The longitudinal assumptions made in the current study only explore population trends and does not account for the changes happening at the individual level. However, the results from the current do suggest that systemic changes are needed in the management of transmasculine vocal health.

Secondly, the data was not collected under laboratory conditions; therefore, the acoustic measurements extracted may be severely impacted by extraneous factors not accounted for in the current study. These extraneous factors could include faulty equipment or background noise which may affect the quality of the recording. Participants may also be influenced or distracted by their immediate surroundings as the study was conducted online.  $F_0$  as an acoustic measure is relatively stable and REAPER is sensitive to these signals. Furthermore, participants may feel more at ease

providing a speech sample in a familiar environment in contrast to laboratory conditions. However, validation studies should be conducted in the future to compare the acoustic quality of personal recording equipment and speech recorded in laboratory conditions.

Thirdly, there is no control over who participates in a study that is conducted online and there are no guarantees how many people will participate. Furthermore, the study cannot be contained in a specific geographic location without specifying these details beforehand. This limitation can be easily managed by imposing exclusion criteria at the data pre-processing phase.

Lastly, a limitation of the current study is the lack of ethno-linguistic diversity. Nearly all the participants who provided a speech sample came from English-speaking country and some from German-speaking countries even though transcripts were available in a number of languages. However, the current study was able to reach out to over 185 participants in over 15 different countries. The ability to collect data from so many transmasculine individuals across the globe suggests that the lack of diversity to the current study can be mitigated in the future with proper promotion and marketing. Furthermore, the fact that the questionnaire was in English may exclude those who do not speak English as an additional language.

#### *Future Direction*

The current study analysed the questionnaire and acoustic data using descriptive statistics. Many suggestions and improvements should be considered for the future. Firstly, the data will require more nuanced statistical modelling to validate the findings from the current study as there a multitude of influences on transmasculine speech acting as potential variables in the models. For the purposes of the current study, correlation coefficient analysis and a principal component analysis has been carried out on the variables. In future publications mixed effects linear models are proposed to evaluate the statistical significance of the findings from the current study.

Secondly, perception experiments could be carried out on the existing speech samples to quantify listener-perceived vocal masculinity. The current study relies on the self-perceived vocal masculinity of transmasculine individuals to assess the masculinity of the speech. However, previous literature has

shown that listener-perception is a valuable measure of vocal gender particularly for transfeminine individuals as discussed in section 2.1.3. As per the consent form and Human Ethics Application to the University of Canterbury Human Ethics application, many of the participants of the current have provided consent for further acoustic analysis. Findings from the perception study will add to the *attributional factors* in Azul's (2015) model.

Thirdly, compare additional acoustic measures such as formant frequencies, intonation, loudness, breathiness, articulation, and duration of phonemes could be analysed. As discussed in Davies and Goldberg (2006: 178) and in the section 2.1.3, these non-segmental features all contribute to what is perceived as cisgender normative speech. Numerous studies have been conducted on the speech characteristics of transgender female speech and how they compare with transfeminine speech; however, studies on speech characteristics of cisgender male speech are few and far between. Now that there is a corpus of transmasculine speech data that has been segmented at the phonemic level, it is possible to complete these analyses to complement the current study.

### *Final Thoughts*

Coleman (1983: 293) once noted that “the gender characteristic most resistant to convincing change is the voice”. This statement still holds as there is still a lot that is unknown in the area of gendered communication and gendered speech characteristics. This is despite the numerous studies conducted in the last three decades from 1983 to 2017 relating to the vocal satisfaction and quality of life of transgender, and specifically, transmasculine individuals. The findings from the current study suggest that transmasculine speech is influenced by a multitude of factors as discussed in Azul et al. (2017), and that testosterone therapy alone cannot reliably increase the vocal satisfaction of all transmasculine individuals. Every transmasculine individual who participated in the current study helped make one incremental step towards uncovering more of the unknown in this field, and all due credit goes to these brave and courageous individuals.

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## Appendix

### Questionnaire Questions & Responses

1. I believe currently my voice is...

- a. Very much like that of a stereotypical male
- b. Somewhat like that of a stereotypical male
- c. In between that of a stereotypical male and female
- d. Somewhat like that of a stereotypical female
- e. Very much like that of a stereotypical female

response: a b c d e

total (*n*) 37 60 59 22 7

2. My IDEAL voice would be...

- a. Very much like that of a stereotypical male
- b. Somewhat like that of a stereotypical male
- c. In between that of a stereotypical male and female
- d. Somewhat like that of a stereotypical female
- e. Very much like that of a stereotypical female

response: a b c d e

total (*n*) 109 58 16 2 0

3. I need active use of my speaking voice for (check all that apply)

- a. My profession (e.g. teacher, minister, lawyer, salesperson etc.)
- b. Activities outside of work (e.g. coaching, community organisations etc.)
- c. Normal everyday conversation

response: a b c

total (*n*) 125 118 177

4. I need active use of my singing voice for (check all that apply)

- a. My profession (e.g. singer (primary income), student of voice)
- b. Activities outside of work (e.g. choir/chorus, singer/band member (secondary income))
- c. For fun (e.g. in the car / shower, karaoke)
- d. None of the above. I do not sing.

response: a b c d

total (*n*) 4 32 154 28

5. I have trouble being heard in noisy situations.
- a. True (n = 98)
  - b. False (n = 87)
6. The pitch (melody / intonation) of my speaking voice is stable and reliable.
- a. True (n = 99)
  - b. False (n = 86)
7. My voice is worse in the evening.
- a. True (n = 46)
  - b. False (n = 139)
8. I have a speaking voice that feels authentic to me.
- a. True (n = 109)
  - b. False (n = 76)
9. The pitch (melody / intonation) range of my voice is restricted.
- a. True (n = 118)
  - b. False (n = 67)
10. I find it easy to be loud at a vocal range that feels authentic to me.
- a. True (n = 67)
  - b. False (n = 118)
11. People ask "What's wrong with your voice?" or "Do you have a cold?"
- a. True (n = 37)
  - b. False (n = 148)
12. I have to strain to make my voice sound like I want it to.
- a. True (n = 64)
  - b. False (n = 121)
13. I run out of air and need to take frequent breaths when talking.
- a. True (n = 38)
  - b. False (n = 147)
14. My voice difficulties restrict my personal and social life.
- a. True (n = 50)
  - b. False (n = 59)
  - c. Not applicable / no voice difficulties (n = 76)

15. My voice causes me to lose income.
- a. True (n = 3)
  - b. False (n = 182)
16. I hesitate to call people I don't know on the phone because of my voice.
- a. True (n = 76)
  - b. False (n = 109)
17. I'm consciously trying to change my voice.
- a. True (n = 95)
  - b. False (n = 90)
18. I feel self-conscious about how strangers perceive my voice.
- a. True (n = 130)
  - b. False (n = 55)
19. My voice frustrates me.
- a. True (n = 100)
  - b. False (n = 85).
20. My voice makes me feel masculine.
- a. True (n = 99)
  - b. False (n = 86)
21. How often are you perceived as female on the phone?
- a. Always
  - b. Almost always
  - c. Sometimes
  - d. Almost never
  - e. Never
- |           |    |    |    |    |    |
|-----------|----|----|----|----|----|
| response: | a  | b  | c  | d  | e  |
| total (n) | 57 | 32 | 36 | 26 | 34 |
22. How important is your voice in affirming your gender identity?
- a. It was one of the main reasons why I started, or might want to start hormone therapy
  - b. It is as important as other traits (facial hair, fat-muscle ratio etc.)
  - c. Not at all important
  - d. Not applicable
- |           |    |    |   |   |
|-----------|----|----|---|---|
| response: | a  | b  | c | d |
| total (n) | 84 | 90 | 7 | 4 |

23. Do you feel your current voice matches your current gender identity?

a. True (n = 111)

b. False (n = 74)

24. Do you feel your current voice matches your current gender expression?

a. True (n = 123)

b. False (n = 62)

25. Are you satisfied with your present voice?

a. Yes, fully

b. Somewhat, sometimes

c. No, not at all

response: a b c

total (n) 47 110 28

26. Are you currently living and / or presenting as male?

a. Yes, fulltime

b. Yes, sometimes

c. No

response: a b c

total (n) 139 26 20

27. Do you normally bind (use any chest binding methods)?

a. Yes

b. Sometimes

c. No / Never had to

d. Had top surgery / chest reconstruction surgery

response: a b c d

total (n) 53 25 18 89

28. Has your binder ever had the following impact on you? (Check all that apply)

a. I was short on breath.

b. I could barely speak.

c. I chose not to exercise.

d. I got lightheaded or dizzy

e. Not applicable, I don't bind.

response: a b c d e

total (n) 105 8 91 52 61

29. In the past 4 weeks to the best of your knowledge, did you snore?

- a. Most nights.
- b. Some nights.
- c. I didn't snore.
- d. I don't know.

response:	a	b	c	d
total ( <i>n</i> )	37	39	43	66

30. Your voice helps you live / present as male.

- a. Always
- b. Almost always
- c. Sometimes
- d. Almost never
- e. Never

response:	a	b	c	d	e
total ( <i>n</i> )	71	36	35	17	26

31. Your voice reflects the true you.

- a. Always
- b. Almost always
- c. Sometimes
- d. Almost never
- e. Never

response:	a	b	c	d	e
total ( <i>n</i> )	46	52	53	22	12

32. Have you ever taken testosterone?

- a. Yes (*n* = 143)
- b. No (*n* = 42)

33. How long have you been taking testosterone in total? For example if you used T for 3 months and stopped, then started again for another year and a half, you would answer "1 year and 9 months".  
[Textbox provided]

34. Have you ever started and stopped using T? If yes, how long were you off T? For example, if you used T for 3 months and stopped for 6 months, then started again for another year and a half, you would answer "6 months". [Textbox provided]

35. During the first year, what method of testosterone therapy did you use the most?

- a. Gel
- b. Cream
- c. Patch
- d. Pellet
- e. Pills
- f. Intramuscular injections
- g. Sub-cutaneous injections
- h. Other, please specify [textbox provided]

response:	a	b	c	d	e	f	g	h
total (n)	35	4	1	0	4	88	10	1

36. How quickly did your voice change after the beginning of testosterone use?

- a. After some days
- b. After some weeks
- c. After some months
- d. After a year
- e. Changed in stages / a number of stages (stop and go)
- f. It hasn't

response:	a	b	c	d	e	f
total (n)	18	53	39	8	23	2

37. Did testosterone change your speaking voice as you expected it?

- a. I had expected a faster change
- b. I had expected or more marked or larger change
- c. The change was as I expected in both size and time course
- d. I had not expected any change
- e. Other, please specify [textbox provided]

response:	a	b	c	d	e
total (n)	22	35	22	3	21

38. If you couldn't achieve sufficient voice change with the help of testosterone, would you consider vocal surgery?

- a. Yes (n = 68)
- b. No (n = 117)

39. Compared to before testosterone, how would you rate your snoring now?
- a. Much more now than before.
  - b. More than before.
  - c. About the same as before.
  - d. Less than before.
  - e. Much less than before.
  - f. I don't snore.

response:	a	b	c	d	e	f
total ( <i>n</i> )	13	20	57	2	0	51

40. How did testosterone change your singing pitch range? (check all that apply)
- a. My singing pitch range has broadened
  - b. My singing pitch range has narrowed
  - c. I have gained lower notes
  - d. I have lost upper notes
  - e. Not applicable, I never sang.

response:	a	b	c	d	e
total ( <i>n</i> )	17	60	105	104	20

41. If you want / wanted to change your voice, please indicate what you would try / tried to achieve (check all that apply)
- a. Not applicable, I did / do not want my voice to change.
  - b. I want my voice to be higher
  - c. I want my voice to be lower
  - d. I want my voice to be louder
  - e. I want my voice to be softer
  - f. Other, please specify [textbox provided]

response:	a	b	c	d	e	f
total ( <i>n</i> )	24	1	150	76	7	13

42. On average, how many PACKS per DAY did you smoke in the past year?
- a. I do / did not smoke in the past year
  - b. Less than 0.5
  - c. 0.5 – 1
  - d. More than a 1
  - e. Less than 10 cigarettes per WEEK

response:	a	b	c	d	e
total ( <i>n</i> )	137	17	11	4	16

43. If you couldn't achieve sufficient voice change with the help of testosterone, would you consider vocal surgery?
- a. Yes (n = 41)
- b. No (n = 144)
44. Have you ever worked on masculinising your voice with a speech and language practitioner or voice coach?
- a. Yes (n = 25)
- b. No (n = 160)
45. Have you ever heard of vocal masculinisation surgery?
- a. Yes (n = 42)
- b. No (n = 143)
46. If you were dissatisfied with your voice, would you consider undergoing vocal masculinisation surgery?
- a. I had vocal masculinisation surgery
- b. I would consider surgery
- c. I would not consider surgery
- |           |   |    |     |
|-----------|---|----|-----|
| response: | a | b  | c   |
| total (n) | 0 | 68 | 117 |
47. Tell us about your vocal surgery (e.g. where did you have it done, which procedure, etc.) [textbox provided]
48. What methods of vocal masculinisation would you recommend to a friend wanting to masculinise their voice?
- a. Working with a speech specialist
- b. Taking testosterone
- c. Having vocal surgery
- d. Start smoking or smoking more to deepen the voice
- e. Other, please specify [textbox provided]
- |           |     |     |    |   |    |
|-----------|-----|-----|----|---|----|
| response: | a   | b   | c  | d | e  |
| total (n) | 136 | 160 | 13 | 5 | 18 |
49. Your age in years [textbox provided]
50. In which country (or countries) did you live the first 10 years of your life? [textbox provided]
51. In which country do you currently live? [textbox provided]

52. What sex were you assigned at birth?

- a. Female
- b. Other, please specify [textbox provided]

53. Who do you normally disclose your gender history to? (check all that apply)

- a. My family
- b. My partner
- c. Close friends
- d. Acquaintances
- e. Work colleagues
- f. Anyone who asks
- g. No one

response:	a	b	c	d	e	f	g
total ( <i>n</i> )	151	152	160	54	49	73	2

54. Which race(s) or ethnic group(s) do you identify with? [textbox provided]

55. Select your highest level of completed education

- a. Primary/Elementary
- b. Secondary/High School
- c. Certificate / Diploma
- d. Bachelor's
- e. Master's
- f. Postgraduate Certificate / Diploma
- g. PhD

response:	a	b	c	d	e	f	g
total ( <i>n</i> )	1	50	38	54	21	12	9

56. What pronouns should people use when talking about you? (check all that apply)

- a. He/him/his
- b. She/her/hers
- c. They/them/theirs
- d. Other pronouns, please specify [textbox provided]

response:	a	b	c	d
total ( <i>n</i> )	155	7	57	23

57. What people are you sexually attracted to? (check all that apply)
- a. Female-identified people
  - b. Male-identified people
  - c. Non-binary / genderqueer people
  - d. No one
  - e. Other, please specify [textbox provided]

response:	a	b	c	d	e
total (n)	129	125	95	23	10

58. What word(s) best describe your sexual orientation? [textbox provided]
59. What word(s) best describe your gender identity? [textbox provided]

## Speech Samples

*The North Wind and the Sun were disputing which was the stronger, when a traveller came along wrapped in a warm cloak. They agreed that the one who first succeeded in making the traveller take his cloak off should be considered stronger than the other. Then the North Wind blew as hard as he could, but the more he blew the more closely did the traveller fold his cloak around him; and at last the North Wind gave up the attempt. Then the Sun shined out warmly, and immediately the traveller took off his cloak. And so the North Wind was obliged to confess that the Sun was the stronger of the two.*

*Example 1. North Wind and the Sun (English; Aesop Language Bank Team, 2010)*

*Einst stritten sich Nordwind und Sonne, wer von ihnen beiden wohl der Stärkere wäre, als ein Wanderer, der in einen warmen Mantel gehüllt war, des Weges daherkam. Sie wurden einig, dass derjenige für den Stärkeren gelten sollte, der den Wanderer zwingen würde, seinen Mantel abzunehmen. Der Nordwind blies mit aller Macht, aber je mehr er blies, desto fester hüllte sich der anderer in seinen Mantel ein. Endlich gab der Nordwind den Kampf auf. Nun erwärmte die Sonne die Luft mit ihren freundlichen Strahlen, und schon nach wenigen Augenblicken zog der Wanderer seinen Mantel aus. Da musste der Nordwind zugeben, dass die Sonne von ihnen beiden der Stärkere war.*

*Example 2. Nordwind und der Sonne (German; Aesop Language Bank Team, 2010)*

## Acoustic Measurements

Table 13. Praat Minima, Mean, Maxima & Current Voice

current voice	f0 min (Hz)	(difference ±)	mean f0 (Hz)	(difference ±)	f0 max (Hz)
very male	102.5	17.2	119.7	30.2	149.9
(difference ±)	0.4		1.1		7.5
somewhat male	102.1	16.4	118.5	23.9	142.3
(difference ±)	33.6		37.2		35.2
in between	135.7	20.0	155.7	21.9	177.6
(difference ±)	19.8		27.3		34.0
somewhat female	155.5	27.4	183.0	28.7	211.7
(difference ±)	6.3		2.6		0.5
very female	149.2	36.4	185.6	26.6	212.2

Table 14. Current Voice & Praat Minima, Mean, Maxima (English) (no Testosterone)

current voice	f0 min (Hz)	(difference ±)	mean f0 (Hz)	(difference ±)	f0 max (Hz)
in between	175.1	22.8	197.9	19.7	217.5
(difference ±)	7.3		4.0		0.2
somewhat female	167.8	26.1	193.9	23.4	217.3
(difference ±)	18.6		8.3		5.1
very female	149.2	36.4	185.6	26.6	212.2

Table 15. Current Voice & Praat Minima, Mean, Maxima (English) (Testosterone)

current voice	f0 min (Hz)	(difference ±)	mean f0 (Hz)	(difference ±)	f0 max (Hz)
very male	103.1	18.3	121.3	30.6	151.9
(difference ±)	0.4		2.0		13.6
somewhat male	102.7	16.7	119.3	19.0	138.3
(difference ±)	16.6		19.7		23.3
in between	119.3	19.8	139.0	22.6	161.7
(difference ±)	12.9		0.3		27.4
somewhat female	106.4	32.9	139.3	49.8	189.1

Table 16. Current Voice & Praat Minima, Mean, Maxima (German).

current voice	f0 min (Hz)	(difference ±)	mean f0 (Hz)	(difference ±)	f0 max (Hz)
very male	101.5	15.3	116.8	29.6	146.4
(difference ±)	0.3		0.5		2.8
somewhat male	101.1	16.1	117.2	32.0	149.2
(difference ±)	39.0		40.8		31.1
in between	140.2	17.8	158.0	22.2	180.3

## Principal Component Analysis

Table 17. Eigenvalues (Principal Component Analysis)

	Eigenvalue	Variance (%)	Cumulative Variance (%)
Dim.1	8.4	41.8	41.8
Dim.2	2.9	14.4	56.2
Dim.3	1.3	6.5	62.7
Dim.4	1.0	5.1	67.8
Dim.5	1.0	4.8	72.6
Dim.6	0.7	3.3	75.8
Dim.7	0.6	2.9	78.7
Dim.8	0.5	2.6	81.3
Dim.9	0.5	2.4	83.6
Dim.10	0.5	2.3	85.9
Dim.11	0.4	2.1	88.0
Dim.12	0.4	1.9	89.9
Dim.13	0.4	1.9	91.8
Dim.14	0.3	1.6	93.4
Dim.15	0.3	1.5	95.0
Dim.16	0.3	1.4	96.3
Dim.17	0.2	1.2	97.5
Dim.18	0.2	1.1	98.6
Dim.19	0.2	0.8	99.4
Dim.20	0.1	0.6	100.0

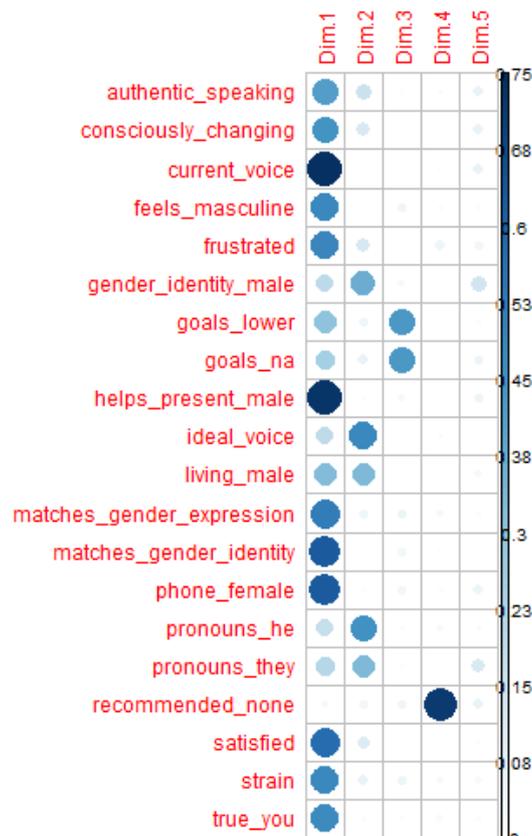


Figure 78. Factor Map (Principal Component Analysis)

Dimension 1

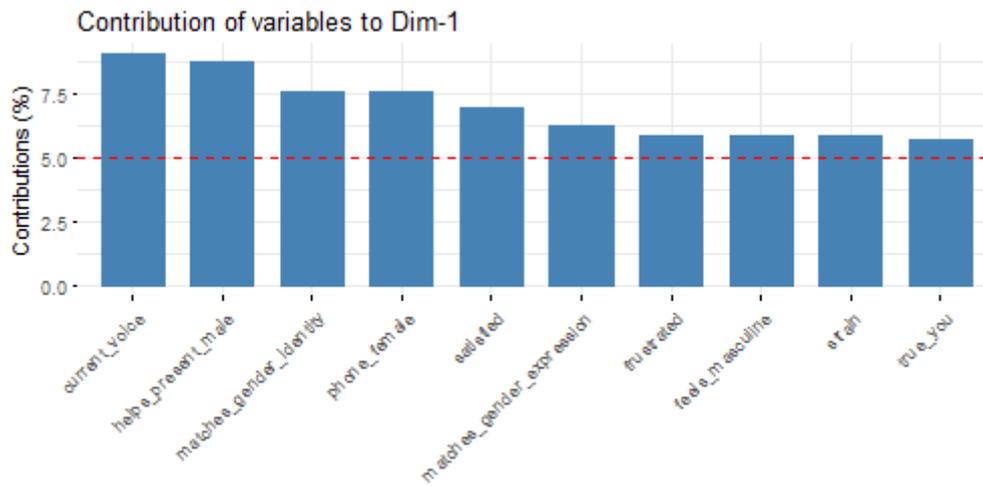


Figure 79. Scree Plot Contributions to Dimension 1 (PC1)

Table 18. Contributions to Dimension 1 (PC1)

Variables	Contribution (%)
current_voice	9.03
helps_present_male	8.77
matches_gender_identity	7.57
phone_female	7.54
satisfied	6.93
matches_gender_expression	6.27
frustrated	5.87
feels_masculine	5.85
strain	5.83
true_you	5.70
consciously_changing	5.34
authentic_speaking	5.01
living_male	3.90
goals_lower	3.67
goals_na	3.00
pronouns_they	2.53
gender_identity_male	2.37
ideal_voice	2.28
pronouns_he	2.16
recommended_none	0.39

Dimension 2

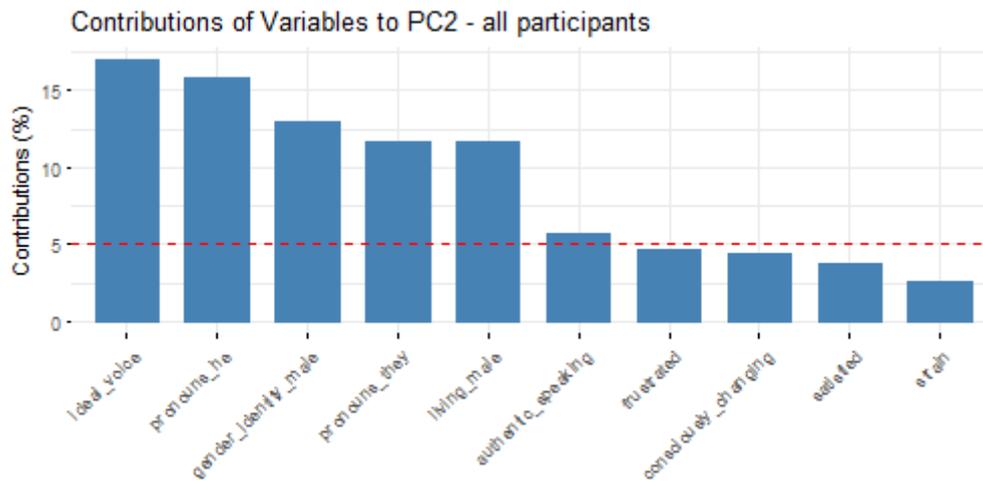


Figure 80. Scree Plot Contributions to Dimension 2 (PC2)

Table 19. Contributions to Dimension 2 (PC2)

Variables	Contribution (%)
ideal_voice	17.00
pronouns_he	15.80
gender_identity_male	13.03
pronouns_they	11.74
living_male	11.73
authentic_speaking	5.65
frustrated	4.69
consciously_changing	4.44
satisfied	3.71
strain	2.54
goals_na	2.43
goals_lower	1.81
matches_gender_expression	1.73
recommended_none	1.39
helps_present_male	0.73
true_you	0.61
phone_female	0.50
current_voice	0.25
matches_gender_identity	0.15
feels_masculine	0.08

Dimension 3

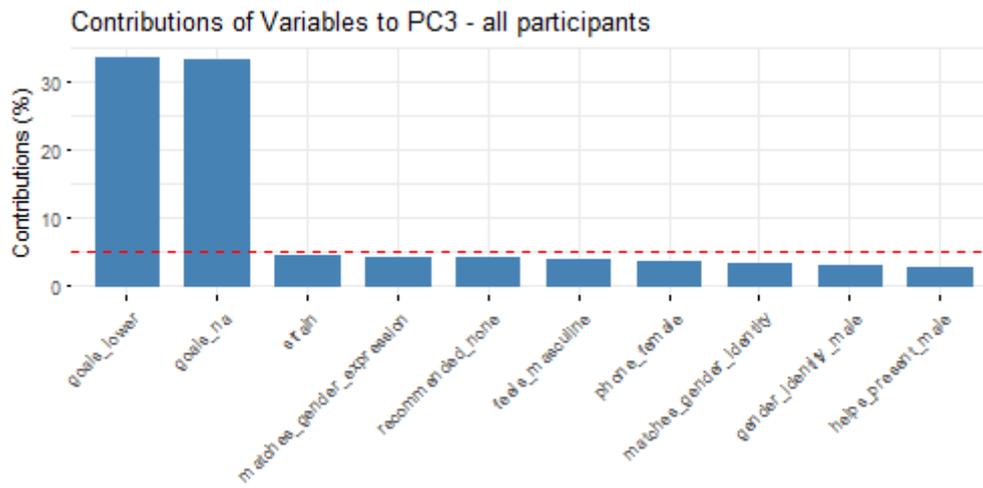


Figure 81. Scree Plot Contributions to Dimension 3 (PC3)

Table 20. Contributions to Dimension 3 (PC3)

Variables	Contribution (%)
goals_lower	33.41
goals_na	33.30
strain	4.26
matches_gender_expression	4.07
recommended_none	3.95
feels_masculine	3.61
phone_female	3.45
matches_gender_identity	3.15
gender_identity_male	2.81
helps_present_male	2.56
pronouns_he	1.58
pronouns_they	1.12
authentic_speaking	0.80
true_you	0.70
satisfied	0.39
frustrated	0.38
ideal_voice	0.33
consciously_changing	0.05
living_male	0.05
current_voice	0.05

## Data Visualisation

### Correlation Coefficient Analysis

```
cor.test(df$var1, df$var2, method=c("pearson", "kendall", "spearman"))

#Correlation Coefficient Multiple Variables
library(reshape2)

a1 <- subset(df, birth_sex_scale == "1" & age >= "18")
a1 <- cor(object[c(1:3)], method = c("pearson", "kendall", "spearman"))
a1.stack <- melt(a1.cor, id.vars=1:3)
a1.stack <- as.data.frame(a1.stack)
a1.cor <- subset(a1.stack, value >= 0.5 | value < -0.5, select=c(Var1, Var2,
value))
a1.cor <- subset(a1.cor, value > -1, select=c(Var1, Var2, value))
a1.cor <- subset(a1.cor, value < 1, select=c(Var1, Var2, value))
write.csv(a1.subset, file = "object.cor.csv")

#correlation plot

library(corrplot)

a1 <- cbind(var1, var2, var3)
a1 <- as.data.frame(a1)

png(filename="a1.corplot.png", width = 600, height = 600, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
a1.cor <- cor(a1)
corrplot(a1.cor, type = "upper", order = "hclust", tl.col = "black", tl.srt = 45)
dev.off()

#correlation matrix

library(PerformanceAnalytics)

a1 <- cbind(var1, var2, var3)
a1 <- as.data.frame(a1)

png(filename="a1.cormatrix.png", width = 1600, height = 1000, units = "px",
pointsize = 12, bg = "white", res = NA, restoreConsole = TRUE)
chart.Correlation(a1, histogram=TRUE, pch=19)
dev.off()
```

### Stacked likert bar plots

```
library(likert)

var1 <- (df$var1)
var2 <- (df$var2)
var3 <- (df$var3)
a1 <- cbind(var1, var2, var3)
a1 <- as.data.frame(a1)
a1[1:3] <- lapply(a1[1:3], factor, levels=1:0)
levels(a1$var1) <- c("true", "false")
levels(a1$var2) <- c("true", "false")
levels(a1$var3) <- c("true", "false")

a1.likert <- likert(a1)
png(filename="a1.likert.png", width = 400, height = 150, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
plot(a1.likert)
dev.off()
```

```

a1.likertgroup <- likert(a1, grouping = df$var4)
png(filename="a1.likertgroup.png", width = 400, height = 150, units = "px",
pointsize = 12, bg = "white", res = NA,
restoreConsole = TRUE)
plot(a1.likertgroup)
dev.off()

```

### Transition Plots

```

library(Gmisc)

png(filename="a1.transition.png", width = 450, height = 500, units = "px",
pointsize = 12, bg = "white", res = NA, restoreConsole = TRUE)
transition_mtrx <- table(df$var1, df$var2)
htmlTable(transition_mtrx, title = "Transitions", ctable = TRUE)
transitionPlot(transition_mtrx, main = "Transitions", box_label = c("var1",
"var2"), cex = 1.2, fill_start_box = "skyblue", type_of_arrow = "gradient",
arrow_clr = "skyblue")
dev.off()

```

### Principal Component Analysis

```

library(FactoMineR)
library(factoextra)
library(corrplot)
library(ggpubr)

a1.m <- df[1:160, 2:21]
head(a1.m[, 1:6], 4)
a1.m.pca <- PCA(a1.m, graph = FALSE) #if no missing values

##eigenvalues
eig.val <- get_eigenvalue(a1.m.pca)
eig.val
write.csv(eig.val, file = "a1.eigenvalue.csv")

##scree plot
png(filename="a1.m.scree.png", width = 500, height = 250, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
plot(fviz_contrib(a1.m.pca, choice = "var", axes = 2, top = 10) + ggtitle("scree
plot"))
dev.off()

##graph of variables
var <- get_pca_var(T3.m.pca)
var

##quality on the factor map
head(var$cos2, 4)
png(filename="a1.m.factor.png")
corrplot(var$cos2, is.corr=FALSE)
dev.off()

##contributions to the PCs
head(var$contrib)
write.csv(var$contrib, file = "a1.m.contrib.csv")

##contributions of variables to PC1
png(filename="a1.m.pcl.png", width = 500, height = 250, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
plot(fviz_contrib(a1.m.pca, choice = "var", axes = 1, top = 10) + ggtitle("PC1"))
dev.off()

```

```

##contributions of variables to PC2
png(filename="al.m.pc2.png", width = 500, height = 250, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
plot(fviz_contrib(al.m.pca, choice = "var", axes = 2, top = 10) + ggtitle("PC2"))
dev.off()

##contributions of variables to PC3
png(filename="al.m.pc3.png", width = 500, height = 250, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
plot(fviz_contrib(al.m.pca, choice = "var", axes = 3, top = 10) + ggtitle("PC3"))
dev.off()

##colour by groups
set.seed(123)
al.m.km <- kmeans(var$coord, centers = 3, nstart = 25)
grp <- as.factor(al.m.km$cluster)

al.m.grps_circle <- fviz_pca_var(al.m.pca, col.var = grp, palette = c("cornflower
blue", "green", "tomato"), legend.title = "Cluster", repel = TRUE)
al.m.grps_circle <- ggpubr::ggpar(al.m.grps_circle, title = "PCA", subtitle = "v",
caption = "subset", xlab = "PC1", ylab = "PC2")
png("al.m.grps_circle.png")
print(al.m.grps_circle)
dev.off()

```

### Stacked Venn Diagrams

```

library(venneuler)

var1 <- (df$var1)
var2 <- (df$var2)
var3 <- (df$var3)
a1 <- cbind(var1, var2, var3)
a1 <- as.data.frame(a1)
a1.stack <- melt(a1, id.vars=1:1)
levels(a1.stack$variable)
levels(a1.stack$variable) <- c("v2", "v3")
a1.stack <- subset(a1.stack, value == "1")
a1.stack$v1 <- as.factor(a1.melt$v1)
a1.stack$value <- NULL

png(filename="a1.stack.png")
plot(venneuler(a1.stack))
dev.off()

```

### Word Clouds

```

library(tm)
library(SnowballC)
library(wordcloud)
library(RColorBrewer)

filePath <- "a1.txt"
a1_text <- readLines(filePath)
a1_docs <- Corpus(VectorSource(a1_text))
inspect(a1_docs)
a1_docs <- tm_map(a1_docs, content_transformer(tolower))
a1_docs <- tm_map(a1_docs, removeNumbers)
a1_docs <- tm_map(a1_docs, removeWords, stopwords("english"))
a1_docs <- tm_map(a1_docs, removeWords, c("x", "y", "z"))
a1_dtm <- TermDocumentMatrix(a1_docs)
a1_m <- as.matrix(a1_dtm)
a1_v <- sort(rowSums(a1_m), decreasing=TRUE)
a1_d <- data.frame(word = names(a1_v), freq=a1_v)
a1_d

```

```

png(filename="4.1.4.a1.wordcloud.png", width = 200, height = 200, units = "px",
pointsize = 12, bg = "white", res = NA, restoreConsole = TRUE)
set.seed(1234)
wordcloud(words = a1_d$word, freq = a1_d$freq, min.freq = 2, max.words=200,
random.order=FALSE, rot.per=0.35, colors=brewer.pal(8, "Dark2"))
dev.off()

```

## Venn Diagrams

```

library(VennDiagram)

df <- read.csv("a1.csv", sep=";", header=T)
a1 <- subset(df, birth_sex_scale == "1" & age >= 18)
grid.newpage()

one <- (a1$var1)
two <- (a1$var2)
three <- (a1$var3)
four <- (a1$var4)
five <- (a1$var5)
area1 <- nrow(subset(a1, one == 1))
area2 <- nrow(subset(a1, two == 1))
area3 <- nrow(subset(a1, three == 1))
area4 <- nrow(subset(a1, four == 1))
area5 <- nrow(subset(a1, five == 1))
n12 <- nrow(subset(a1, one == 1 & two == 1))
n13 <- nrow(subset(a1, one == 1 & three == 1))
n14 <- nrow(subset(a1, one == 1 & four == 1))
n15 <- nrow(subset(a1, one == 1 & five == 1))
n23 <- nrow(subset(a1, two == 1 & three == 1))
n24 <- nrow(subset(a1, two == 1 & four == 1))
n25 <- nrow(subset(a1, two == 1 & five == 1))
n34 <- nrow(subset(a1, three == 1 & four == 1))
n35 <- nrow(subset(a1, three == 1 & five == 1))
n45 <- nrow(subset(a1, four == 1 & five == 1))
n123 <- nrow(subset(a1, one == 1 & two == 1 & three == 1))
n124 <- nrow(subset(a1, one == 1 & two == 1 & four == 1))
n125 <- nrow(subset(a1, one == 1 & two == 1 & five == 1))
n134 <- nrow(subset(a1, one == 1 & three == 1 & four == 1))
n135 <- nrow(subset(a1, one == 1 & three == 1 & five == 1))
n145 <- nrow(subset(a1, one == 1 & four == 1 & five == 1))
n234 <- nrow(subset(a1, two == 1 & three == 1 & four == 1))
n235 <- nrow(subset(a1, two == 1 & three == 1 & five == 1))
n245 <- nrow(subset(a1, two == 1 & four == 1 & five == 1))
n345 <- nrow(subset(a1, three == 1 & four == 1 & five == 1))
n1234 <- nrow(subset(a1, one == 1 & two == 1 & three == 1 & four == 1))
n1235 <- nrow(subset(a1, one == 1 & two == 1 & three == 1 & five == 1))
n1245 <- nrow(subset(a1, one == 1 & two == 1 & four == 1 & five == 1))
n1345 <- nrow(subset(a1, one == 1 & three == 1 & four == 1 & five == 1))
n2345 <- nrow(subset(a1, two == 1 & three == 1 & four == 1 & five == 1))
n12345 <- nrow(subset(a1, one == 1 & two == 1 & three == 1 & four == 1 & five ==
1))

png(filename="a1.venneuler.png", width = 500, height = 400, units = "px", pointsize
= 12, bg = "white", res = NA, restoreConsole = TRUE)
draw.quintuple.venn(area1, area2, area3, area4, area5, n12, n13, n14, n15, n23,
n24, n25, n34, n35, n45, n123, n124, n125, n134, n135, n145, n234, n235, n245,
n345, n1234, n1235, n1245, n1345, n2345, n12345, category = c("var1", "var2",
"var3", "var4", "var5"), lty = "blank", fill = c("skyblue", "green", "pink1",
"mediumorchid", "orange"))
dev.off()

```

## Other Plots

```
library(ggplot2)
library(ggpubr)

#barplot
a1 <- table(df$var1)
a1 <- as.data.frame(a1)
a1 <- subset(a1, Freq >= 1 )
levels(a1$Var1) # inspect levels
a1$Var1 <- factor(education$Var1, labels = c("factor1", "factor2", "factor3"))

png(filename="barplot.png", width = 500, height = 300, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
barplot <- ggplot(a1, aes(x=Var1, y=Freq)) + geom_bar(stat="identity", width=0.5,
fill="cornflower blue") + theme_minimal() + coord_flip() +
scale_x_discrete(limits=c("factor1", "factor2", "factor3"))
barplot <- ggpubr::ggpar(barplot,title = "a1",subtitle = "Bar Plot", caption =
"subset",xlab = "var1", ylab = "Count")
print(barplot)
dev.off()

# boxplot
png(filename="boxplot.png", width = 500, height = 300, units = "px", pointsize =
12, bg = "white", res = NA, restoreConsole = TRUE)
boxplot <- ggplot(df, aes(x = var1, y = var2)) + geom_boxplot() + theme_minimal()
boxplot <- boxplot + scale_x_discrete(name = "var2") + scale_y_continuous(name =
"var1") + ggtitle("var1*var2")
boxplot
dev.off()

#histogram
png(filename="hist.png", width = 500, height = 300, units = "px", pointsize = 12,
bg = "white", res = NA, restoreConsole = TRUE)
hist <- ggplot(df, aes(x=var1)) + geom_histogram(color="white", fill="cornflower
blue") + theme_minimal()
hist <- ggpubr::ggpar(hist,title = "var1", subtitle = "Histogram", caption =
"subset",xlab = "var1", ylab = "Count")
print(hist)
dev.off()

#scatterplot
png(filename="scatterplot.png", width = 500, height = 300, units = "px", pointsize
= 12, bg = "white", res = NA, restoreConsole = TRUE)
scatterplot <- ggplot(df, aes(x = var1, y = var2)) + geom_point()+
geom_smooth(method=lm, aes(fill=var1)) + theme_minimal()
scatterplot <- ggpubr::ggpar(scatterplot, title = "var1*var2", subtitle = "Scatter
Plot", caption = "subset", xlab = "var1", ylab = "var2")
print(scatterplot)
dev.off()
```

## Human Ethics Committee Approval



### HUMAN ETHICS COMMITTEE

Secretary, Rebecca Robinson  
Telephone: +64 03 369 4588, Extn 94588  
Email: [human-ethics@canterbury.ac.nz](mailto:human-ethics@canterbury.ac.nz)

Ref: HEC 2017/12

20 March 2017

Sidney Gig-Jan Wong  
Linguistics  
UNIVERSITY OF CANTERBURY

Dear Sidney

The Human Ethics Committee advises that your research proposal "Self-Evaluation of Masculinity in Transgender Men, Trans Men, Transmasculine People, Masculine of Centre, Tangata ira Tane, AFAB (Assigned Female at Birth), Male-to-Male, and Female-to-Male Transgender Individual's Speech" has been considered and approved.

Please note that this approval is subject to the incorporation of the amendments you have provided in your email of 10<sup>th</sup> March 2017; and the following:

*Please could you send through for our records a copy of the outcome of the Māori consultation once received.*

Best wishes for your project.

Yours sincerely

*R. Robinson*  
pp.

Associate Professor Jane Maidment  
*Chair*  
*University of Canterbury Human Ethics Committee*

## Ngāi Tahu Consultation & Engagement Group Approval

### Ngāi Tahu Consultation and Engagement Group



03/04/2017

Tēnā koe, Sidney

RE: Self-evaluation of masculinity in transgender men, trans men, transmasculine people, masculine of centre, tangata ira tane, AFAB (assigned female at birth), male-to-male, and female-to-male transgender individuals' speech.

This letter is written on behalf of the Ngāi Tahu Consultation and Engagement Group. I/We have read and considered your proposal and acknowledge that this is a worthwhile and interesting project there have been no issues identified.

It is well considered and the researcher is clear about how they ought to take participants' (cultural) needs into account if and when applicable.

Thank you for engaging with the Māori consultation process. This will strengthen your research proposal, support the University's Strategy for Māori Development, and increase the likelihood of success with external engagement. It will also increase the likelihood that the outcomes of your research will be of benefit to Māori communities. We wish you all the best with your current project and look forward to hearing about future research plans.

The Ngāi Tahu Consultation and Engagement Group would appreciate a summary of your findings on completion of the current project. Please feel free to contact me if you have any questions.

Ngā mihi  
Nigel Harris

A handwritten signature in black ink, appearing to read 'Nigel Harris'.

Kaiārahi Māori Research  
Research and Innovation  
Te Whare Wānanga o Waitaha  
Private Bag 4800  
Otautahi Christchurch 8140  
Aotearoa New Zealand  
Phone +64 3 364 2987 ext 45520/6120 cell 0273950134 [nigel.harris@canterbury.ac.nz](mailto:nigel.harris@canterbury.ac.nz)