

Breathy Voice and Fundamental Frequency: Portraying Gender in *The Danish Girl*

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When the Music Changes, You Change Too:

Contemporary Variation in English Dialects



Laura Bisbo

ABSTRACT

This paper investigated how breathy voice and fundamental frequency relate to perceptions of gender and femininity, and how this is portrayed in the movie *The Danish Girl*. The aim of analysing *The Danish Girl* was to investigate whether Eddy Redmayne, who plays the main character, a male-to-female transgender person, uses breathy voice and F0 to portray a transition in gender and femininity in the character. While results were not clear-cut, they indicate that Eddy Redmayne has made alterations to his F0 and amount of breathiness. The investigation of how these phenomena are used in *The Danish Girl* may provide further evidence of how the investigated phenomena are used in real-life, however, it should be acknowledged that *The Danish Girl* shows merely a portrayal of how these phenomena are used by a character and thus does not necessarily represent how females and male-to-female individuals actually use F0 and breathy voice.

Keywords: fundamental frequency; breathy voice; gender; femininity; transgender; When the Music Changes, You Change Too

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Introduction

Listeners infer a great deal of information about speakers from the voice of the speaker alone. This information includes physical characteristics, behavioural traits, and physical states (Podesva and Callier 2015, 174). Stereotypes have a significant role to play in how we perceive the people we encounter, and it is believed that we draw on pre-existing attitudes about social categories when forming our impressions of others (Levon 2014, 539). Gender is some of the most essential information conveyed by the voice. Matar et al. argue, “as soon as a listener hears a voice, the physical features of that voice interact with the listener’s own socioculturally driven perceptual expectations and stereotypes, and a judgment is made about the speaker’s gender” (2016, 1608). Therefore, many studies have been made with the aim of determining just what characteristics of the voice contribute to our perception of gender. Some characteristics that are suggested to be influential to this include pitch, intonation, vocal intensity, resonance, vocal quality and speech rate (Van borsel et al. 2009, 291; Cartei et al. 2012,1). Especially fundamental frequency and breathy voice are two characteristics which have been found to help listeners make judgements of masculinity and femininity in speakers and ultimately be a source for listeners to determine the gender of the speaker (Matar et al. 2016, 1609).

This paper investigates how breathy voice and fundamental frequency relate to the perception of gender, and how this is portrayed in the movie *The Danish Girl*. The movie, which has Eddy Redmayne playing the main character, portrays the transitioning process of Einar Wegener, a biological male, as he realises his true gender identity, and progressively presents himself as more and more feminine throughout the movie. The aim of analysing Eddy Redmayne’s use of breathy voice and fundamental frequency in the movie is to see whether the fundamental frequency and amount of breathiness for Eddy Redmayne change as his character transitions, to portray femininity and a transition from one gender to another, and ultimately a change in sex. *The Danish Girl* was chosen since it deals with gender through the main character, a male-to-female individual, who transitions from male to female throughout the movie, and thus, Eddy Redmayne is playing a character who presents himself as male at the beginning of the movie, and gradually presents himself more and more as a female, meaning that speech from the same individual, but with different gender expressions as well as biological states, can be analysed. However, while the investigation of Eddy Redmayne’s use of fundamental frequency and breathy voice could provide further evidence of how these phenomena are used in real life to express gender, it should be stressed that the movie shows merely a portrayal of a male-to-female individual, and consequently does not necessarily represent how females or male-to-female individuals speak and alter their speech in real life.

The literature review will examine studies of breathy voice and fundamental frequency and their relation to perceptions of gender and femininity. This will include considering studies of male-

to-female individuals, and how these speech characteristics are used by these individuals in order to sound and be perceived as their true gender.

Gender and Transgender

Dacakis et al. comment that gender is by some seen as a binary concept, however, they argue that studies have moved away from asking listeners to rate whether speakers sound female or male to instead asking whether speakers voices contain gender attributes such as femininity and masculinity, and whether specific parameters contribute to these attributes (2012, 166). This seems to represent a shift from looking at gender as a binary concept, to seeing gender on a continuum either from male to female, and or from feminine to masculine. Thus, perceiving an individual as feminine does not guarantee that the individual will be perceived as female; however, that individual is more likely to be perceived as such. Consequently, when looking at gender as a continuum, the terms gender and femininity seem to overlap, and will do so in this paper.

Some individuals who do not seem to fit in in a gender binary agenda are transgender individuals. Bodoïn et al. describes transgender as “an umbrella term that is used to describe people who express their gender in a way that differs from societal norms” (2014, 39). As mentioned previously, one of the key things we infer about speakers from their voice is their gender. Thus, when the voice of a speaker conveys information about their sex that does not align with their gender identity, this can be very problematic (Palmer et al. 2010, 117). It is argued that a fundamental part of male-to-female individuals gaining acceptance of themselves is acquiring a gender congruous voice, since the perception of these individual’s voices has been found to directly correlate with their quality of life (Palmer et al. 2010, 118). Therefore, for male-to-female individuals, voice therapy can be crucial since hormone therapy does not make the male voice sound more feminine. McNeill et al. argue, “in contrast to the female-to-male transgender person whose use of testosterone contributes to physiological changes in the vocal folds that result in a significant decrease in pitch, the use of estrogen by male-to-female transgender persons does not alter pitch, leaving this population more vulnerable to being perceived as their natal, rather than true, gender” (2008, 727). Voice therapy can help transgender individuals alter their speech in specific ways to improve their presentation as the gender which they identify with. Thus, knowing which parameters are perceived as feminine is crucial.

Literature Review

As mentioned previously, when it comes to perceptions of gender and femininity many vocal characteristics have been found to be influential to this including pitch range, intonation patterns, vocal intensity, resonance and vocal quality (Van Borsel et al. 2009, 291). Pitch in particular has been

suggested to be an important factor in listener judgement of voices in regard to femininity and gender (Van Borsel 2009, 291; Andrews and Smith 1997, 308) and, therefore, the primary goal of speech therapy for many male-to-female individuals has been raising their fundamental frequency. However, it has been suggested that breathy voice can be an equally important cue to whether a voice is perceived as feminine or masculine (Dacakis et al. 2012, 167). The following sections explore studies of fundamental frequency and breathy voice and their relations to gender and femininity.

Fundamental Frequency

A higher level of fundamental frequency is generally recognized as a characteristic that distinguishes male and female voices (Van Borsel et al. 2009,291). Hardy et al. report that F0 has been suggested to be the most important acoustic marker of sex in cisgender individuals, and has been found to correlate with higher femininity ratings (2016, 125). Cartei et al. describes F0 as follows, “F0 is based on the rate of vocal fold vibration, which in turn is inversely proportional to the square root of the vocal fold tissue length, men’s F0 (about 120 Hz) becomes on average 80 Hz lower than women’s (about 200 Hz) [...] giving male speakers their characteristically lower pitched voice” (2012, 1). They find however that variation in gender expression cannot be explained entirely by size related difference in the vocal apparatus. They argue,

children’s voice gender can be identified in children as young as 4 years old, despite the fact that the anatomy of the vocal apparatus does not significantly differ between the two sexes until the pubertal age. These observations suggest that children acquire (consciously or unconsciously) gender specific articulatory behaviours during development, and that speakers develop a knowledge of how a “male” or a “female” should sound, with male voices being low-pitched and “deeper”, while female voices being high-pitched and “lighter’.” (2012, 1)

Thus, they suggest that differences in F0 are not only caused by anatomy but are also a learned behavior. Similar findings are reported by Mendoza et al., who comment that speaker’s F0 seems to be a compromise between possible range of F0 and the speaking habit of the individual (1996, 59).

It has been suggested that there is a level of F0 at which a person will be perceived as female; however, this level seems to vary depending on the study. McNeill et al. found that the level of F0 at which a speaker would be perceived as female was above 165 Hz (2008, 727), while Dacakis et al. suggest that it should be above 180 Hz (2012, 166). It is furthermore argued that there is a gender ambiguous range at which an individual can be perceived as either male or female which Hardy et al. find is between 150 to 185 Hz (2016, 125). Thus, there seems to be no agreement about which level of F0 is sufficient to be perceived as female. Nevertheless, Klatt and Klatt found in a study that the

F0 of their participants was remarkably systematic with females mean F0 being 1.7 times higher than the mean F0 for males for each vowel in each sentence analyzed (1990, 828). Thus, while the frequencies required may vary, it is agreed that women generally have higher fundamental frequencies than men.

Hardy et al. investigated how acoustic measures including fundamental frequency of male-to-female individuals' voices were related to perceptions of gender and femininity. They found that F0 was a predictor of femininity ratings; a higher fundamental frequency resulted in higher femininity ratings. However, F0 only explained slightly over half of variance in the femininity ratings, the rest being unaccounted for (Hardy et al. 2016, 130). Similar results were found by Matar el al. 2016, who investigated Lebanese women with Reinke's edema, a condition that causes women to have more "masculine sounding" voices, partially explained by their lowered F0. In their study, they concluded that "[t]he fundamental frequency seems to be the most important factor used by listeners for the judgment of gender in voice in this setting. For F0, higher values related to high-pitched voices are judged as surely feminine, whereas lower values related to low pitched voices are judged as surely masculine independently of the speakers group" (2016, 1615). Thus, F0 was the most important parameter in listener judgement of gender.

As argued previously, F0 is often targeted by clinicians to make male-to-female individuals' voices sound more feminine, and as studies suggest, there seems to be good reason for this since F0 has been found to correlate with femininity ratings. However, a study by McNeill et al. in 2008, found that the correlation between perceived femininity and F0 did not correlate as much for the transgender group as it did for a control group of 25 cis gender participants. They found that with the speech recordings of the cisgender individuals, there was a strong correlation between perceived femininity and F0; however, for the male-to-female individuals the correlation was not as strong. They conclude that F0 alone is not necessarily enough to result in male-to-female individuals' voices to be perceived as feminine to the same degree as it would for a cisgender female (2008, 731-732). Dacakis et al. similarly comment that there is no agreed F0 level at which male-to-female transgender persons will be perceived as feminine, but instead the perception of gender relies on a variety of factors (2012,166). However, they still concluded that "[d]espite the fact that an increase of F0 into the female F0 range may not routinely result in perceptions of the speaker as female, the evidence indicates that this is likely to increase listener perceptions of the voice as containing female attributes" (2012,167). In conclusion, while it seems there is no agreed upon level of F0 where a male will be perceived as female, it is clear that a higher F0 will most often result in speakers being perceived as feminine, though the degree to which F0 correlated to femininity ratings differs for the studies reviewed.

However, F0 is not exclusively related to gender and femininity. Other studies have suggested that F0 can be related to different traits such as competence and sexuality (Levon 2014, 541, 551), as

well as attractiveness (Puts et al. 2011, 111). Furthermore, it is suggested to be associated with the emotions of the speaker (Puts et. al. 2006, 285).

In a study by Puts et al. the fundamental frequency of speech samples of female participants were manipulated, and males were afterwards asked to rate these speech samples. They found that F0 significantly correlated to perceived attractiveness and flirtatiousness (2011, 11). Similarly, Borkowska and Pawlowski comment, “[s]tudies show that voice frequency is negatively related to the attractiveness of men and positively to the attractiveness of women. Men’s preferences for high voices in women have been confirmed in both developed nations and hunter gatherer societies” (2011, 55-56). It is furthermore argued that F0 is connected to the emotions of the speaker, Puts et al. argue, “raised F0 is associated with disparate high-activation emotions such as hot anger, elation, and panic fear, whereas lowered F0 is associated with sadness, boredom, and contempt (low-activation emotions)” (2006, 285). Rodero similarly reports, “emotions carrying a high level of activity, such as joy or fear, tend to be situated in the top end of the frequency spectrum of the speaker. Conversely, sadness and desire tend overall to be formed at the lower end” (2011, 25-26). Thus, it can be concluded that F0 not only conveys information about the gender of the speaker but also the emotional state of the speaker and has been found to correlate with ratings of attractiveness.”

Breathy Voice

Besides fundamental frequency, Podesva and Callier argue that voice quality plays an important role in how listeners identify the gender of a speaker. They define voice quality as “the extragrammatical suprasegmental properties of speech resulting from the configuration of the vocal apparatus” (2015, 173). According to Ladefoged and Gordon different phonation types can be seen on a continuum ranging from breathy voice, through modal, to creaky voice depending on the aperture between the arytenoid cartilages (2001, 384). On this continuum, breathy voice has been suggested to be an important parameter for discriminating between female and male voices (Palmer et al. 2012,117). Ladefoged and Gordon describe breathy voice as follows, “[B]reathy phonation is characterized by vocal cords that are fairly abducted (relative to modal and creaky voice) and have little longitudinal tension” (2001, 384). Like phonation types, breathy voice is usually viewed on a continuum, and can thus be hard to distinguish from modal voice (Ishi et al. 2010, 2).

Breathy voice has been found to alter the voice in terms of acoustics in multiple ways. Hanson et al. argue that breathy voice causes a reduction of the amplitude at mid and high frequencies, as well as introducing a noise component to these frequencies (2001, 453). Similarly, Ishi et al. found that the air escaping through the glottis increases noise around the third formant (2010, 2). According to Klatt and Klatt, the most important acoustic measures of breathiness is “the amount of aspiration noise in the F3 region of the spectrum and relative amplitude of the first harmonic” (1990, 852).

Furthermore, Klatt & Klatt found that fundamental frequency tends to be lower in breathy voice (1990, 823).

Klatt & Klatt found in their study of voice quality variations between genders that female speakers were generally rated by participants as being breathier than males (1990,852). In their acoustic analysis they found that females were in fact significantly breathier than males in terms of the parameters described above (Klatt and Klatt, 1990,852). The findings by Klatt and Klatt of women being breathier than men, in terms of having greater aspiration noise around the third formant, were investigated by Mendoza et al. in 1996, by analysing the speech of Spanish women, and their results corresponded to those of Klatt and Klatt (1996, 64). Another study investigated how naïve listeners rated femininity in breathy and natural speech samples from seven speakers. They found that “the breathy samples always received higher femininity scores than their corresponding normal samples” (Van Borsel et al. 2007, 292). Thus, in this study the same speaker was judged to be more feminine when speaking with a breathy voice as compared to their natural voice. While the speakers in Van Borsel et al.’s study were all cisgender females, a study by Andrews and Smith investigated cross dressers, and their use of breathy voice to increase femininity perceptions, since it is argued by them that voice quality, and particularly breathy voice, is usually addressed by clinicians to make the male voice sound “lighter” (Andrews & Smith, 1997, 308). In the study by Andrews and Smith, they investigated perceptions of crossdresser’s voices when speaking in their feminine voice mode as compared to their typical masculine voice mode. Participants rated the crossdressers’ speech samples on different scales, and it was found that the majority of the speakers were perceived to be breathier when speaking in their feminine mode than in their masculine mode. Ultimately, breathiness was used by the crossdressers to make their voice sound more feminine (1997, 311). However, while it would seem that breathiness has generally been found to be associated with female speakers, a study by Guzman et al. found that male participants in their study, which investigated emotions’ influence on spectral energy distribution, were breathier than the female participants. Consequently, they question the findings of the mentioned studies above. However, they argue that this conclusion should be approached critically since their method was very different from the study by Klatt and Klatt among others. Nevertheless, it is an interesting finding (2013, 129.e8).

Method in general makes studies of breathy voice harder to compare, since the methods used vary widely. Nevertheless, several studies suggest a correlation between breathiness and perceptions of gender and femininity. However, the reasoning for the difference in breathiness that has been reported between males and females differs. Some studies have suggested that the differences are largely due to anatomy, specifically the differences in the larynx between the two sexes. Palmer et al. argue that the perception of breathy voice as a feminine voice characteristic can be contributed to the fact that a more complete glottal closure is expected during phonation for males. Thus, Palmer et al. argue that male-to-female transgender individuals may be challenged by anatomy and physiological

constraints which are imposed by their larynx (2012, 117). However, while anatomy may be a contributing factor to the production differences of breathy voice, Podesva et al. comment that “physical differences merely define the envelope of vocal possibilities rather than determine where within the possible range women and men will fall” (2015, 177). Similarly, Hanson et al. 2001, comment that it is uncertain whether the differences in breathiness are due to anatomy and physiology or social construct. They find that while it is generally believed that women tend to be breathier than men, breathiness can vary not only between genders, but also between individual speakers (2001, 453). It is even suggested that breathiness can vary within single utterances. Klatt & Klatt writes, “while laryngealization and breathiness are not used phonemically in English, our data show clearly that there is considerable variation between speakers of English, and more importantly, there is variation within an utterance on these dimensions” (1990, 821). They furthermore conclude that any individual is likely to be capable of using a wide variety of speaking styles, which may differ in breathiness (1990, 852).

Klatt et al. comment that Swedish women have been found to be less breathy than American women, and thus suggest that it could be restricted to certain nationalities (1990, 825-826). However, Mendoza et al. conclude that “[t]he existence of similar effects in the results of analysis of the speech of Spanish women indicate that this characteristic may not be restricted exclusively to one female nationality subject group. It would be necessary to study this particular aspect in various other subject groups before generalizing this finding” (Mendoza et al. 1996, 64). Thus, this would need more consideration before breathiness can be concluded to be restricted to females of particular nationalities.

In conclusion, it can be argued that breathy voice is indicated to be a feminine voice characteristic and can contribute to individuals being perceived as female. Furthermore, it is argued that variation in breathiness cannot be exclusively attributed to physical differences, as has been suggested by some, since it varies not only between genders but also between individuals and even utterances.

However, as is the case for F₀, breathy voice is not exclusively related to femininity. Ishi et al. write that studies have reported a relationship between different phonation types and information such as emotions and attitudes (Ishi et al. 2010,1). Gobl and Chasaide argue that breathy voice has been found in previous studies to be connected to intimacy and sadness, as well as surprise, happiness and enthusiasm (2003,191), which suggest that breathy voice has not been associated with expressing one emotion in particular, but rather many different depending on the study. However, in their own study of the connection between emotions and voice quality, their results showed some support for a connection between breathy voice and intimacy and sadness, but none for happiness and anger (Gobl and Chasaide 2003, 205). Similarly, Guzman et al. found that emotional states that are characterized by breathy voice include tenderness, sadness and eroticism (2013, 129.e9). Breathiness has also been

associated with attractiveness. Likkarila et al. argue that it is sometimes linked to intimacy and sexual arousal, and conclude that this is why breathy voice in females is argued to be attractive to male listeners (2012, 163). Conclusively, Breathiness is not only related to perceptions of gender, but also several emotional states, as well as attractiveness.

Method

The aim of analysing Eddy Redmayne's use of breathy voice and fundamental frequency in the movie *The Danish Girl* is to see whether the fundamental frequency and amount of breathiness change as his character transitions from presenting himself as male to female.

The Danish Girl is a movie directed by Tom Hoper and was released in 2015. It stars Eddy Redmayne as the main character and is based on the true story of a transgender woman, who was one of the first people to get reassignment surgery in the 1930s. The movie portrays the main character, a biological male, Einar Wegener, as he realizes that his gender identity does not match his biological sex, and his transitioning from presenting himself as male, to presenting himself as a female. Throughout the movie, Eddy Redmayne becomes increasingly more feminine in his portrayal of the character in terms of body language and costume, and so, this paper aims to investigate whether his speech changes with this transition as well. Though, it should be disclaimed that the speech analysed in this study is a *portrayal* of a male-to-female transgender person, and thus does not necessarily represent how females and transgender individuals speak in real-life.

Measures

Only vowels in lexical words were chosen for acoustic analysis in an attempt to get vowels with a sufficient duration. Vowels preceding nasals were excluded as these may be affected by the nasal, which can ultimately affect whether it is breathiness that is measured (Chen 2007, 908). The four scenes were annotated using Praat software (Boersma and Weenink, 2001), and breathy voice and F0 measures were extracted using the VoiceSauce program (Shue, 2010) implemented in Matlab (MATLAB, 2012). Fundamental frequency was measured in hertz and breathy voice via Cepstral Peak Prominence (CPP). CPP was used to measure breathiness in the four speech samples, as studies indicate that this is one of the most accurate measurements of breathiness (Hildebrandt et al. 1994,769). The audio files were obtained from generally available brief YouTube videos.

Four different scenes were analysed. They were chosen to represent 4 different stages of the character's transition from Einar Wegener to Lili Elbe, a transition from a male to a female. Because of difficulty with duration of the vocalic interval and the VoiceSauce algorithm, only 9-13 vowels could be analysed for fundamental frequency in each of the four scenes, with 9 for scene one, 13 for scene two, 12 for scene three and 13 for scene four. For breathy voice the number of vowels analysed

was even more limited, as the issue of duration of the vocalic interval was greater for measuring breathiness, and thus, only 7-12 vowels could be analysed for breathiness that being 7 for scene one, 9 for scene two, 12 for scene three and 8 for scene four. Eddy Redmayne tends to be whispery in many scenes of the movie, including the four scenes chosen, and therefore whispery vowels, which have no voicing, had to be excluded as well. Ultimately this was the case for many vowels, and therefore this is also considered an explanation for the limited vowels analysed.

Scenes

The first Scene was chosen to represent Eddy Redmayne's speech at the point in the movie where his character is not yet aware of his true gender identity, and still presents himself as male. In this scene he is having a conversation with his wife, Gerda, who tells him that she yet again has gotten her period, and thus is not pregnant, which they had been trying for. At the end of the scene, Gerda convinces Einar to pose as a ballet dancer for her painting, which he does very reluctantly.

In the second scene, Eddy Redmayne's character agrees to dress up as a woman in order to act as his own imagined cousin and go to a party with his wife, to both of their amusement. Thus, when Einar is agreeing to this, it seems a joke to both of them. In this scene, Einar dressed as Lili is approached by a man who is trying to flirt with him, and after a conversation in a secluded room he tries to kiss Eddy Redmayne's character resulting in the scene becoming romantic and flirtatious in nature, albeit a very confusing and possibly uncomfortable situation for the character. The character evolves from putting on an act, to realizing that presenting himself as a female feels less like an act to him and more like his true self, leaving him very conflicted. The vowels analysed in this scene are taken from the conversation between Lily and the man.

In the third scene, the character has realized her true gender identity and is now presenting herself as Lili, a female. She is having a conversation with a childhood friend; however, it is uncertain whether this friend is aware of who he is talking to. The friend is a man whom Lili kissed when she was a child, and it seems she might have an interest in, however, that is not explicitly made clear in this scene.

In the fourth scene, Lili has been living as a female for a while and has finally undergone reassignment surgery. She is talking to her wife about her happiness and a dream in which her mother called her Lili, something that makes her very emotional. While Lili is talking about a joyful dream, she seems to show sadness too about the situation she is in, and what she has gone through. In the end of the scene, Lili unfortunately dies from the aftermath of the surgery.

Results for Fundamental Frequency

Eddy Redmayne's mean fundamental frequency in the four scenes is summarised in the figure below.

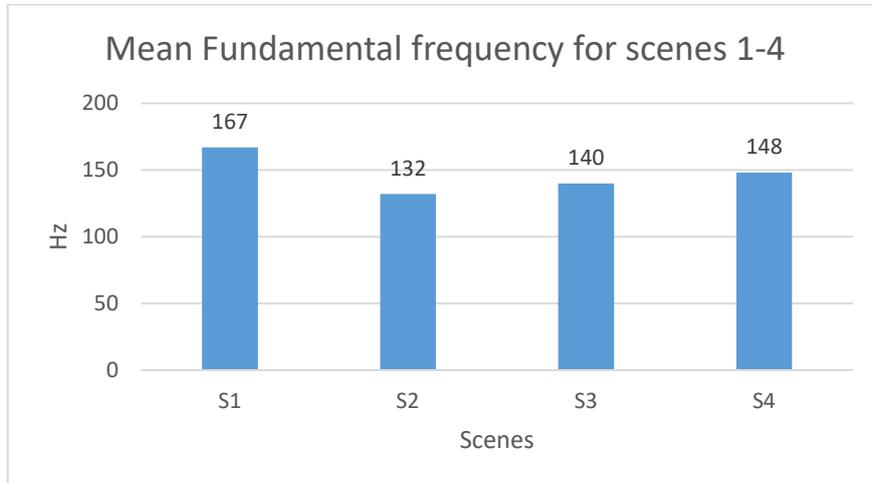


Figure 1. Mean fundamental frequency for scenes 1 to 4

The figure shows that scene one had a F0 of 167 Hz, scene two that of 132 Hz, scene three that of 140 Hz and scene four that of 148 Hz. Thus, the F0 ranged from 132 Hz to 167 Hz between the four scenes, the highest F0 being in the first scene and lowest in the second scene.

F0 in the last three scenes falls under what McNeill et al. have argued to be the borderline range of F0 at 165 Hz at which an individual will be perceived as female (2008, 727); however, the F0 in the first scene falls just over that borderline range with a F0 at 167 Hz, and within what Hardy et al. has termed the gender ambiguous range from 150 to 185 (2016, 125). However, this scene had the least number of vowels analyzed and this should therefore be taken into consideration.

There was great variation in the range of F0 in each scene. The highest F0 and the lowest F0 measured is illustrated in the figure below.

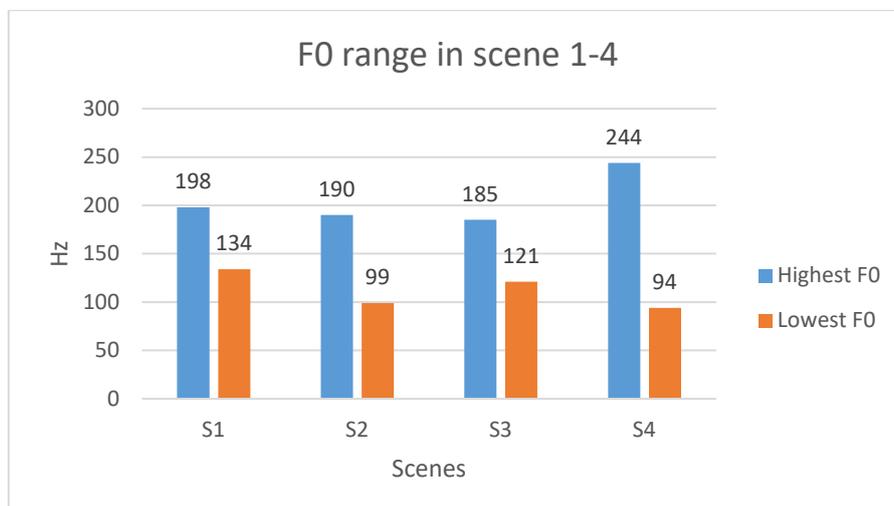


Figure 2. F0 range for scene 1 to 4

For the first scene, the highest F0 was 198 Hz and the lowest 134 Hz, the difference between the two being 64 Hz. For the second scene, the highest F0 was 190 Hz and lowest 99, the difference between the two being 91 Hz. For the third scene, the highest F0 was 185 and the lowest 121, the difference between the two being 64 Hz. For the last scene, the highest F0 was 244 and the lowest 94, the difference between the two being 150 Hz. Conclusively, there is great variation in the range of mean F0 within each scene, however, both the highest mean F0 measured and the lowest mean F0 measured can be found on the fourth scene. Unfortunately, there is not enough data available to control for factors that are possibly causing these big variations, however, this will be discussed in more detail in the discussion section.

Results for Breathy Voice

The CPP mean results are summarized in the figure below.

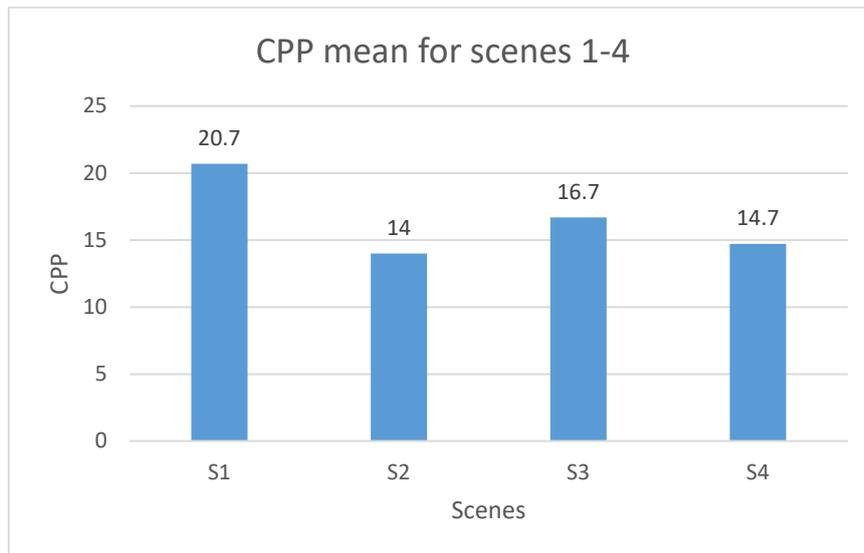


Figure 1. CPP mean for scenes 1 to 4

Scene one shows a CPP mean of 20.7, scene two a CPP mean of 14, scene three a CPP mean of 16.7 and scene four a CPP mean of 14.7. Results show that mean CPP ranges from 14 to 20.7 between the four scenes, the highest being in scene one, meaning that Eddy Redmayne was the least breathy in this scene, and the lowest in scene 2, meaning that he was the breathiest in this scene.

As was reported for the results for F0, there was variation in the range of mean CPP in each scene. The figure below illustrates the highest and the lowest mean CPP measured for the four scenes.

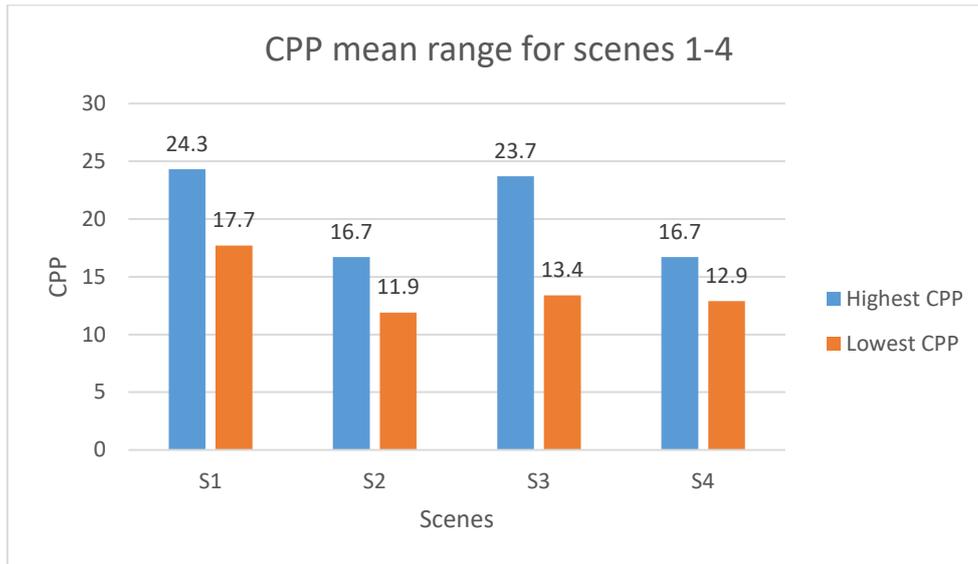


Figure 2. CPP mean range for scenes 1 to 4

Scene one had the highest mean CPP at 24.3 and the lowest at 17.7, the difference between the two being 6.6. Scene two had the highest mean CPP at 16.7 and the lowest at 11.9, the difference between the two being 4.8. Scene three had the highest mean CPP at 23.7 and the lowest at 13.4, the difference between the two being 10.3. Scene four had the highest mean CPP at 16.7 and the lowest at 12.9, the difference between the two being 3.8. Thus, scene three had the most variation in mean CPP within the scene, with a difference in mean CPP of 10.3. However, as was the case for F0, there is not enough data to control for possible factors causing the variation, however, this will be discussed in the next section.

The third figure below shows the mean CPP for each of the four scenes at 25%, 50% and 75% of the vocalic interval.

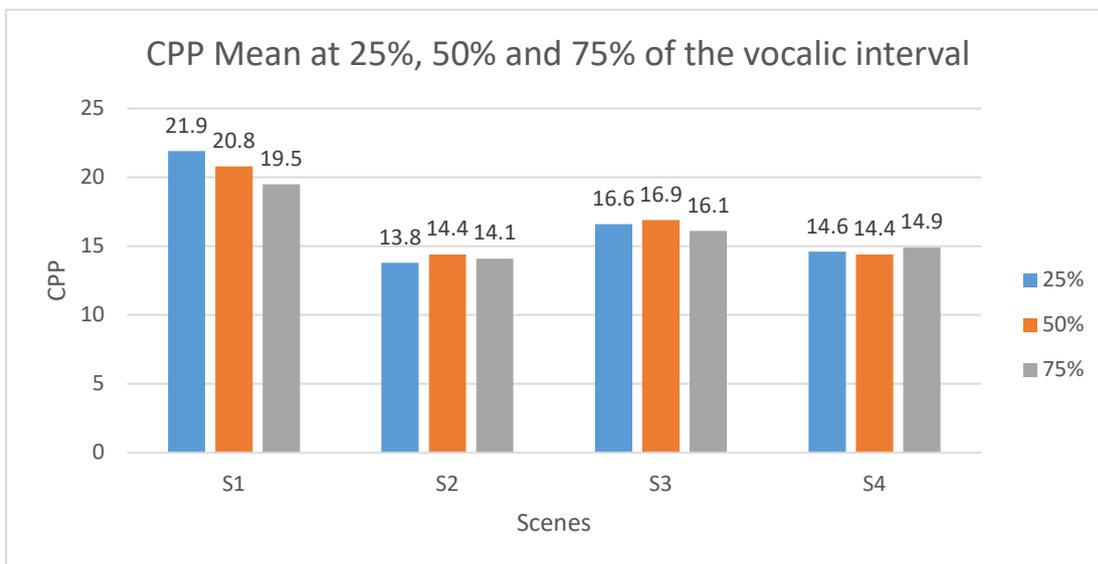


Figure 3. CPP mean at 25%, 50% and 75% of the vocalic interval

Progression of breathiness within the vocalic interval varies between scenes, with none of them sharing the same pattern. For the first scene, Eddy Redmayne was least breathy with a mean CPP of 21.9 at 25 percent of the interval, and the breathiest at 75 percent of the interval with a mean CPP of 19.5. For the second scene, he was the least breathy at 50 percent of the interval with a mean CPP of 13.8, and the breathiest at 25 percent of the interval with a mean CPP of 14.4. For the third scene, he was equally least breathy at 50 percent of the interval with a mean CPP of 16.9, but breathiest at 75 percent of the interval with a mean CPP of 16.1. Finally, for the fourth scene, he was the least breathy at 75 percent of the interval with a mean CPP of 14.9, and the breathiest at 50 percent of the interval with a mean CPP of 14.4. It can be concluded that the ranking of scenes in terms of least breathy and breathiest does not differ depending on which point in the vocalic interval is focused on, except for the 50 percent point of the vocalic interval. Thus, if focus was on 25 percent or 75 percent the ranking of scenes would have been the same, although with slightly different CPP values. The exception is found at the 50 percent point in the interval, where scene two and scene four has the same mean CPP, however, for scene one it represents the highest mean CPP within the interval, while for scene four it represents the lowest within the interval. Nevertheless, no matter at which point of the vocalic interval, scene one is always the one in which Eddy Redmayne is the least breathy, compared to the three other scenes.

Discussion of Fundamental Frequency

Results showed that Eddy Redmayne's F0 is highest in the first scene, which is interesting since this is the only scene in which his character is presenting himself as male and therefore the expectation would be for the F0 in this scene to be the lowest and within a gender normative range. Unfortunately, the first scene also has the least number of analysed vowels, and consequently this might be a contributing factor to the high mean F0, since there was quite a big variation in F0 for the vowels analysed in each scene. It is unknown whether Eddy Redmayne is in general very high pitched, however, if that was the case, you could expect him to be equally high pitched in the following scenes, which he was not to the same extent.

Interestingly, none of the last three scenes in which the character is transitioning to presenting herself as female has a F0 above the borderline range of 165. They are however high compared to the average male F0 which Hancock et al. argue is at 100 HZ (2014, 203), while Cartei et al. finds it to be around 120 Hz (Cartei et al. 2012, 1), however, they are not high enough to fall within the gender ambiguous range, which might have been expected, since the character is in these scenes presenting herself as female. Nevertheless, there was a progression in mean F0 from the second to the fourth scene, with the second scene having a mean F0 at 132 Hz, the third 140 Hz, and the fourth 148 Hz. Thus, there seems to be a slight change in mean F0 as the character becomes more and more aware

of her true gender identity. Therefore, it could be cautiously concluded that Eddy Redmayne uses fundamental frequency to some degree in order to portray a character becoming more feminine.

The second scene has the lowest F0 of the four scenes but is also the scene where Eddy Redmayne is the breathiest. As argued by Klatt and Klatt, breathy voice can result in lowered F0 and therefore there is also the possibility that F0 coincided with breathiness in this scene. This will be discussed later in the discussion for breathy voice.

The results showed great variation in the range of F0 in the different scenes. Unfortunately, there is limited data in this study and it would thus be difficult to control for factors that could be causing the variation; nevertheless, there are different suggestions to what could be causing this variation. Firstly, the variation could be due to vowel quality, or the influence of surrounding segments. Furthermore, sentence type and structure could also have influenced the F0 of the vowels. This could include differences in intonation patterns. Intonation has been argued to differentiate male and female speech, and Hancock et al. found in their study that speakers with a larger pitch range were perceived as female (Hancock et al. 2014, 206). For the four scenes in this study, Eddy Redmayne has the greatest pitch range in the second scene with a 91 Hz difference between the lowest and highest F0 measured, and the fourth scene with a 150 Hz difference between the lowest and highest F0 measured. For the first and third scene this difference was 64 Hz. Thus, the fourth scene is by fair the scene in which he has the greatest pitch range, which makes sense to this argument since this is also the one in which the character can be argued to be the most feminine in terms of presenting herself as her true gender. However, both the first and third scenes have the same pitch range even though the character in the first scene is presenting himself as male, and thus, the variation might not be related to femininity. Another factor that might influence the F0 is the emotional state of the character. *The Danish Girl* is an overall emotional movie and, as argued previously, F0 has been found to be influenced by the emotional state of the speaker (Puts et al. 2006, 285). A last factor which might explain the variation is attractiveness as well as desirability. Studies found that F0 significantly correlated with attractiveness as well as flirtatiousness and desire (Puts et al. 2011, 111; Rodero et al. 2011,11), and several scenes analysed, particularly scene two and three, are arguably flirtatious and or romantic in nature, meaning that this could have influenced the F0.

While these suggestions might help explain the variation, the variation between highest and lowest F0 in each scene as well as the limited number of analysed vowels might indicate that the F0 results are not as reliable as could have been hoped for. Unfortunately, the results are only based on the 9-13 vowels analysed in each scene because of the difficulties encountered with the algorithms extracting the necessary measurements. It seems that VoiceSauce parameter estimation does not function well with running speech and needs longer vocalic intervals to be able to process the speech, at least in this case. Furthermore, the results show variation which femininity alone cannot inconclusively account for, but because of the limited data available in this project, it is difficult to

control for other factors causing the variation. Nevertheless, scene two to four shows increasing F0 which might suggest that Eddy Redmayne used F0 to portray femininity. Either way, there is variation in F0 in all scenes, and thus knowingly or unknowingly, Eddy Redmayne has made alterations of F0 throughout the movie.

Discussion of Breathy Voice

Results show that Eddy Redmayne was the least breathy in the first scene compared to the three others. This is the scene where his character is presenting himself as male, and thus, the results in scene one are in agreement with the literature reviewed, which generally found that females tend to be breathier than males. However, while the F0 gradually rose from the second to the third scene, suggesting a progression as the character transitions, there does not seem to be a similar pattern in regard to breathy voice. However, Eddy Redmayne is breathier in scenes two to four than in the first scene, suggesting that when the character presents herself as female, Eddy Redmayne uses more breathy voice.

As suggested in the F0 discussion, breathiness may have influenced F0. Klatt and Klatt found in a study that breathiness may cause a lowered F0 (1990, 823), and thus, this might explain why Eddy Redmayne in the second scene has the lowest F0 and is simultaneously the breathiest there. However, this would not account for the almost equally low mean CPP in the fourth scene, which had the second highest F0. Nevertheless, it is possible that the two speech characteristics may have influenced each other to some degree.

There was substantial variation in mean CPP for the vowels within each scene, the greatest variation being found in scene three with a difference of 10,3 between the highest and lowest measured mean CPP, and the smallest variation being found in scene four with a difference of 3,8 between the highest and lowest mean CPP. Unfortunately, with the limited amount of data it is uncertain why this variation occurs. However, suggestions for the variation within each scene could be the emotional state of the character. Several scenes are argued to have flirtatious and or romantic feelings involved, and the character is experiencing happiness and sadness as well as various other emotions, some of which are associated with breathy voice. An example could be scene four where Lili is dying and is recalling a dream with what seems to be both sadness and happiness. The expressing of those feelings may have affected the amount of breathiness in the speech of Eddy Redmayne. Breathiness has also been argued to be connected to attractiveness (Likkarila et al. 2012, 163), which may also influence the variation, as the character has encounters with possible romantic interest in some of the scenes. This is particularly the case in scene two in which Lili is, albeit uncomfortable in the situation, flirting with a man who kisses her. A third factor which may be affecting the variation in breathiness could be speaking style. Ishi et al. found that this can affect

breathiness, and that breathiness is for example often found in phrase beginnings. Furthermore, they comment that breathiness can be used to create emphasis and is also found to be used to express “real” feelings, that is, emphasising that the feelings expressed by the speaker are particularly strong (Ishi et al. 2010 9). Thus, these factors might explain the variation in mean CPP found within each scene, however, as was discussed for F0, the variation may also indicate that there was insufficient data, and therefore the results may not be as reliable as could have been hoped for.

The results for mean CPP within the vocalic interval show that there does not seem to be a particular pattern in the progression of mean CPP in the vocalic interval at 25, 50 and 75 percent for the four scenes. Thus, the amount of breathiness at the three different points differs depending on the scene. As mentioned previously, the ranking of the least breathy to most breathy scene does not change whether you look at the mean CPP at 25 percent or 75 percent, however, at the 50 percent of the vocalic interval, scene two and four have the same mean CPP. For scene two that represents the highest mean CPP for the interval, while it in scene four represents the lowest mean CPP. Possible reasons for the variation of breathiness in the vocalic interval between the four scenes could be segmental environment, which Klatt and Klatt argue is likely to influence the breathiness of vowels. They found that breathiness in general increased towards the end of a vowel as well as near voiceless consonant, and was greater in the end of a sentence and in unstressed syllables (1990,846). In the speech analyzed, it was found that Eddy Redmayne was the breathiest at the end of the vocalic interval in scene one and three, which corresponds to what Klatt and Klatt found, namely that their participants were breathier towards the end of a vowel, however, for scene two and four this was not the case. However, the potential confounding effects of the segmental environment were not controlled for in this study, and therefore it cannot be unambiguously concluded whether these factors influenced the results.

It should be acknowledged that there is a possibility that the amount of data in this study is not sufficient to account for the tendencies in the four scenes, causing the variation in CPP, as well as the possibility that there could have been problems with the segmentation. However, the results show a tendency for Eddy Redmayne to be breathier when his character is presenting herself as female as compared to when the character is presenting himself as male. Thus, it would seem that breathy voice was used by Eddy Redmayne to portray a change in the character, presumably gender.

General Discussion

The results indicate that F0 and breathy voice were to some degree changed as the character presented herself as more feminine. There was increased F0 from the second to the fourth scene, suggesting that F0 was used to portray femininity, however, F0 was highest in the first scene, which could be caused by this scene being the one with the least vowels analysed, or it could be caused by any of the other

factors discussed above. Regarding breathy voice, all three scenes where the character is presenting herself as female has a lower mean CPP than the first scene, which had a significantly higher mean CPP, and thus, Eddy Redmayne is breathier for each of these scenes.

While the results suggest that there has been made moderations to both breathy voice and F0 in order to portray a transition from male to female, it should be acknowledged that these are portrayals of what Eddy Redmayne and potentially the director find to be female speech characteristics, and thus, does not necessarily represent how females speak in real life or how male-to-female individuals alter their speech in order to sound more feminine. However, the results correlate to some degree to the literature reviewed, in that F0 and breathy voice relate to perceptions of gender and femininity, and therefore, no matter if Eddy Redmayne consciously or unconsciously altered his voice in the four scenes, the alterations do correspond to what is stereotypically found to be feminine, and what clinicians often recommend male-to-female individuals to alter in order to be perceived as their true gender. Therefore, it seems that Eddy Redmayne uses breathy voice and F0 to portray a transition in gender, whether it be conscious or unconscious.

Conclusion

The literature reviewed in this paper suggests that a higher mean F0 can be seen as a feminine voice characteristic. However, the level of F0 required to be perceived as female is not agreed upon. Nevertheless, it was found that raising F0 is often advised for male-to-female individuals and has been found to cause speakers to be perceived as more feminine. Breathy voice was equally found in many studies to be a factor that contributed to perceptions of femininity. Most studies found that females were in general breathier than males, and thus, this should also be targeted in speech therapy for male-to-female individuals.

The Danish Girl was analyzed with the aim of investigating whether Eddy Redmayne raises his F0 as well as uses more breathy voice as his character transitions from male to female. Results showed that Eddy Redmayne surprisingly had the highest mean F0 in the first scene, the only scene in which his character is presenting himself as male. However, the following three scenes showed that F0 was increasing from the second to the fourth scene, suggesting that it was used to show a transition in gender and femininity. For breathy voice, the results showed that Eddy Redmayne was the least breathy in the first scene, as expected, since this is the scene in which his character is presenting himself as male. The next three scenes all had a lower mean CPP, which suggest that breathy voice was used to show a transition in the character.

However, for both F0 and CPP there was great variation between the lowest value measured and the highest value measured within each scene. Some possible explanations for this includes the emotional state of the speaker and attractiveness, both in regard to F0 and breathy voice. For F0,

intonation patterns, segmental environment as well as sentence type and structure might also have influenced the substantial variation, while the variation in CPP is suggested to potentially be affected by the segmental environment as well as speaking style. Lastly, it was suggested that F0 and CPP may have influenced each other, which could seem to be the case in scene two, which has the lowest F0 as well as the lowest CPP. However, none of these factors were controlled for, and thus, it cannot be concluded whether they were causing the variation or not.

Unfortunately, problems were encountered with VoiceSauce parameter estimation, which meant that many vowels had to be excluded, and thus, only few vowels were actually analyzed for each scene. Consequently, there is the risk that the tendencies found are not completely accurate, and therefore we see the variation within each scene. Nevertheless, it can be concluded that the results show variation in F0 and CPP which indicate that F0 and breathy voice was used by Eddy Redmayne to portray a transition from male to female, whether this be a conscious decision or not.

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