2018

The Influence of Exposure to Unbalanced Sex Ratios on Perceived Vocal Attractiveness

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Presented in Partial Fulfillment of the Requirements of Independent Study Thesis Research

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2017-2018

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Acknowledgements

First and foremost, I would like to thank my advisor, Dr. John Neuhoff, for his guidance, wisdom, and mentorship throughout the Independent Study process. I took Dr. Neuhoff's evolutionary psychology course sophomore year, and it was this class that inspired me to choose my independent study topic. I am extremely lucky to have an advisor who is so knowledgeable in his field. I would also like to thank all of my past and present professors in the Neuroscience and Psychology departments. Their courses have been essential in fueling my interests in neuroscience and continue my education in this field.

I would also like to thank my parents. Without them, the opportunity to attend the College of Wooster would not exist. It is with their endless love and support that I was able to finish this project and succeed at the College for the past three and a half years. You two have always encouraged me to pursue a field that I love and have never doubted my abilities. I am forever thankful for you both.

Finally, thank you to my best friend, Emma Schroeter. You have been my best friend since we met at ARCH in 2014, and I could not imagine being at Wooster without you. The countless taco bell trips and the numerous Taylor Swift songs we have sang together are only some of my favorite memories that I will remember for times to come. Thank you to my other two roommates, Sophia Weiss and Molly Campbell, and all my other friends as Wooster for their love and support throughout the years.

Abstract

The population sex ratio greatly impacts human behavior, especially mating patterns. Recent research shows that visual exposure to unbalanced sex ratios influences perceived facial attractiveness for opposite-sex faces. When opposite-sex faces are scarce in exposure, subsequent opposite-sex faces are rated as more attractive than when they are plentiful during exposure. The current work examines an auditory analog of this effect by exposing listeners to unbalanced ratios of male and female voices and measuring the perceived attractiveness of subsequently presented opposite sex voices. A 2x2 ANOVA was conducted with participant sex and sex ratio exposure as the between-subject factors. Results showed that when participants were in the low-exposure group, ratings of opposite-sex voices were significantly greater than the ratings from participants who were in the high-exposure group. These findings present new evidence that could further explain the effect of unbalanced sex ratios of local populations on mating-related behaviors in humans.

Introduction

Unbalanced Sex Ratio Overview

Evolutionist Charles Darwin first suggested that most sexually producing species procreate at a ratio of 1:1 between males and females. Ronald Fisher notably outlined this proposition in 1930 when he argued that half of an organism's genes come from each biological sex. If there are more females than males in a given population, thus making the sex ratio unequal, the males will be more fertile and will provide a greater contribution to the next generation of offspring. Males will be more represented in the following generations and the sex ratio will adjust itself until it reaches equilibrium. If the sex ratio leans toward either sex, the same process will repeat until a 1:1 sex ratio has been reached (Carvalho et al., 2007).

Population sex ratios can become skewed by three factors: the sex ratio at birth, mortality rates, and migration. The current sex ratio at birth, the number of male births for every 100 female births, is slightly masculine, i.e. the ratio is a little over 1.00. A ratio below 1.00 indicates a more feminine population (Dyson, 2012; Hesketh & Xing, 2006). However, accurate sex ratios are difficult to obtain because of deficient recordings of statistics. Additionally, births at home and births of unwanted/abandoned children often are not registered (Hesketh, & Xing, 2006). Many natural, social, and environmental factors such as family size, parental age, race, various forms of stress, diseases, war, and socioeconomic status affect sex ratios at birth (Hesketh &Xing, 2006).

In particular countries, specifically, countries that are highly patriarchal, the tradition of son preference influences sex ratios. Son preference is not a common theme to all societies; it is typically prevalent in countries in Asia, such as China, South Korea, and India. Son preference is not exhibited by all Asian countries and varies in severity. The concept of son preference

originated from the idea that, traditionally, men are the primary breadwinners, i.e. they have a higher wage-earning capacity and provide for their family. Additionally, men continue the family line and are more likely to be recipients of an inheritance (Hesketh & Xing, 2006). Women are also considered more of a burden economically, as they become members of the husband's family and are not able to care for their parents in old age and illness.

Prenatal sex determination and desire for a small family size has contributed to the imbalanced sex ratios at birth. Technology advances in sex determination have led to sex-selective abortions to ensure that women will give birth to a son. Many Asian countries hold the "small-family culture" mindset, especially countries with larger populations (Dyson, 2012; Hesketh & Xing, 2006). China, notably, is extremely overpopulated. To account for overpopulation, China implemented the one-child policy in 1979, which limited families to only one child. With this policy in place, fertility decreased (Chang, 2008). From 2010-2015, the fertility estimates were measured at only 2.2 births per family, which was a significant decrease from the 5.1 birth estimates in the early 1930s (Chang, 2008; Dyson, 2012).

This one-child policy led to an increased son preference because having sons provided more benefits to a family. However, the drastic decrease in population caused a large gender imbalance, and the sex ratio became more masculine. As an attempt to lower the sex ratio, China implemented a two-child policy, in which families were now limited to two children per family—ideally one boy and one girl. Other Asian countries hold similar beliefs about son preference, in which their sex ratios are also above 1.00 (Hesketh & Xing, 2006; Chang, 2012).

While sex ratios at birth are more masculine due to factors such as son preference and sex determination methods, mortality rates between genders favor females (Hesketh & Xing, 2006). Mortality rates vary between societies and in particular cases, but overall, men consistently die at

younger ages than women. Different patterns and factors exist depending on environment and culture. Men in both the United States and Russia are more susceptible to death between the ages of 18 and 30 because of their inclination to engage in acts of violence. Drug addiction, alcohol consumption, disease, and violence can all affect mortality rates, especially considering men are more likely to engage in risky behaviors than women (Jianakoplos & Bernasek, 1998).

Migration, which is less predictable than mortality rates and sex ratios at birth, also has effects on sex ratios. The sex ratio is less likely to change drastically in large populations; however, smaller populations are more prone to be impacted by migration, but only if the migrants are mainly of the same sex. Sex-selective migration is common in labor professions, but the migration is often short-term. Therefore, the effects of sex-selective migration on sex ratios are often transitory (Dyson, 2012; Hesketh & Xing, 2006).

It is difficult to exactly state the consequences of skewed sex ratios because most consequences are speculative. More consequences will unravel as time passes. It can be conjectured that there will continue to be an excess of males in countries where son preference is still prevalent, in which these males will be less likely to be able to find a viable mate. In these cases where a man is without a mate, it is predicted that these men will become increasingly likely to engage in violent behavior, drug, and alcohol use, and exhibit depressive behaviors (Hesketh & Xing, 2006). However, there is little evidence currently available, and the next two to three decades will accurately show the effects of excess men in populations.

Skewed Ratios and Human Mating Behavior

Sociosexual orientation.

While the consequences of biased sex ratios are still unclear, there is evidence to suggest that unbalanced sex ratios affect core aspects of human mating strategies. The sex ratio theory

suggests that as the sex ratio within a population shift toward one sex, the majority sex will compete with same-sex rivals in order to attract limited potential partners. Additionally, the minority sex can afford to be more selective when choosing possible partners (Moss & Maner, 2016). Traditionally, populations with female-biased sex ratios possess higher levels of promiscuity (Schacht & Mulder, 2015). When the population is female-biased, women are more likely to have uncommitted sex as a strategy to attract a potential mate since men are scarce. However, when men greatly outnumber women in a population, men will compete more with other males, and they will be more inclined to engage in long-term relationships and incur greater financial debt. Therefore, male-biased populations should have lower levels of promiscuity (Schmitt, 2005). Men and women utilize different strategies when approaching and attracting potential mates in order to maximize reproductive success, such as willingness to engage in casual sex, displaying aggression, and intrasexual competition.

Sociosexual orientation, the difference in the willingness to engage in casual sex, is a mating strategy that men and women use differently when attracting mates. Men typically have a more unrestricted sociosexual orientation, in which they are more inclined to seek out casual sex opportunities, while women tend to be more restricted. Men are also more interested having sex with multiple partners compared to women (Malamuth, 1996; Schmitt, 2005) and are more likely to seek out short-term relationships (Laumann, 1994; Schmitt, 2005).

Intrasexual competition.

Another strategy that both men and women use to attract potential partners is intrasexual competition (Buss, 1988; Moss & Maner, 2016). Intrasexual competition involves utilizing both innate and acquired behaviors in order to obtain resources at the expense of their same-sex rivals (Buss, 1988). Essentially, people will use these behaviors to compete with their same-sex rivals

as a mechanism to increase their chances of attracting a mate (Buss, 1988; Moss & Maner, 2016). Men and women value specific traits differently. Men and women both prefer mates who are intelligent and kind. However, men value youthfulness, attractiveness, and fidelity, which reflect their preference for reproductive success. Women, on the other hand, tend to value resources, generosity, and ambition. These preferences reflect their desire for emotional and financial support when raising children. Therefore, both men and women will attempt to show that they possess the desirable qualities of the opposite sex, while simultaneously trying to discredit the same qualities in their same-sex rivals (Miller, 2013).

Intrasexual competition often draws up images of physical confrontation (Buss, 1988). While direct physical combat does occur, intrasexual competition is often not physical, considering that competitors do not even have to meet face to face to engage in competition. Intrasexual competition can also include methods of locating mates (e.g., visiting a place typically occupied by members of the opposite sex); use of effective mate-attracting behaviors (e.g., signaling availability or interest); obtaining resources deemed desirable by the opposite sex (e.g., money, property, and life skills); and altering appearance (e.g., wearing makeup, dieting, fashion choices, and body modifications, such as cosmetic surgery, body piercings, and tattoos) (Buss, 1988).

Aggression as intrasexual competition.

Aggression is also a form of intrasexual competition that both men and women utilize as a mating strategy. By using aggression, both sexes can decrease the number of potential rivals, while increasing the number of mating opportunities (Buss, 1988; Moss & Maner, 2016). Again, aggression does not need to always be physical and can be expressed through words or actions. Between the two sexes, men have been regarded as the more aggressive sex, because in most

mammalian species, males are more aggressive than females (Björkqvist, 2017). Some aspects of aggression in males may be directly or indirectly linked to testosterone (Björkqvist, 2017).While there is a well-established positive relationship between testosterone and aggression in non-human animals, the studies investigating the relationship in humans are inconclusive regarding mating strategies. Testosterone levels vary throughout the lifespan: testosterone rises rapidly during puberty, and it decreases during middle age. This pattern corresponds with physical aggression in males, which is based on the concept of the 'Young Male Syndrome.' This syndrome indicates that males between the ages of 12 and 25 are the principal victims and perpetrators of physical violence (Bjorkvist, 2017; Daly & Wilson, 1990).

Previous research has found that young adult males show higher levels of aggression toward other males (Archer, 2004). Roney, Rahler, & Maestripieri (2003) also found that when men interacted with potential mates, their testosterone levels rose. While the sample size was small, these results provide support for future research (Roney et al., 2003). Additionally, testosterone levels rose when men performed well during a competition, e.g. they won a sporting match (Elias, 1981; Mazur, Booth, & Dabbs, 1992). Finally, other research indicated that testosterone levels fall when a man marries but rises if he divorces (Booth & Dabbs, 1993). Studies have also shown that married fathers have lower testosterone levels than unmarried men (Gray, Kahlenberg, Barrett, Lipson & Ellison, 2001; Storey, Walsh, Quinton, &Wynne-Edwards, 2000). The former studies correspond with the notion that human male aggression is higher when reproductive competition is most intense (Archer, 2004). Therefore, the evolutionary purpose of testosterone appears to be connected to intrasexual competition between males, and the idea that females are attracted to winners. If this were not the case, a selection for this relationship would

not exist. More research needs to be done in order to accurately confirm the relationship between aggression and testosterone when utilizing mating strategies.

Men also use aggression to establish their social dominance. Women tend to be attracted to socially dominant, and socially dominant men tend to be more successful in attracting mates (Moss & Maner, 2016; Sadalla, Kenrick, and Vershure, 1987). Men who are feared and admired (e.g. men who win fights against other men) have attained status and power through acts of aggression. A modern day example is men who win boxing matches and experience a boost in status (Buss & Shackelford, 1997). Testosterone levels showed a low but positive correlation with dominance, which was measured by leadership, toughness, and aggressive dominance. This relationship shows that men with higher testosterone levels were more likely to react aggressively in challenging situations, i.e. securing a mate, especially in a mostly male environment (Archer, 2004).

There is less evidence supporting female-female intrasexual competition as a mating strategy (Moss & Maner, 2016). There are multiple studies investigating women and aggression, but not many linking female-female competition to mating approaches. It is known that women resort more to indirect aggression. Indirect aggression conceptualizes the practice of social manipulation with the intent of psychologically and/or socially harming another person, rather than being physically aggressive toward other women (Bjorkvist, 2017; Campbell, 2013). While the evidence is scarce, women are also thought to show increased levels of female-female competition in a female-prevalent environment (Campbell, 2013; Moss & Maner, 2016). More thorough cross-cultural studies are called for in order to accurately confirm this speculation.

Ultimately, the sex ratio affects displayed acts of aggression. Both men and women are more likely to display acts of unprovoked aggression toward their own sex when they are in the

majority, meaning the majority sex will face greater levels of intrasexual competition. The minority sex will not show many acts of aggression toward same-sex rivals since there are fewer people to compete with for potential mates (Moss & Maner, 2016).

Parental Investment Theory

Triver's parental investment theory aligns with differences in approaches to sociosexual orientation and intrasexual competition. According to his theory, men are typically the sex that invests less in offspring, since they have a large supply of sperm and are free from gestation and lactation (Buss, 1988; Moss & Maner, 2016; Schmitt, 2005). These factors allow men to reproduce at a much faster rate than women can (Wood, Kressel, Joshi, & Louie, 2014). Women tend to invest more since they have a limited number of eggs and are responsible for gestating and nursing infants (Wood et al., 2014). Although some men invest heavily in their own children, across cultures, women usually put more time and effort into raising children because women incur more costs than men do (Buss, 1988; Moss & Maner, 2016; Schmitt, 2005).

In regard to sociosexual orientation, the sex that invests less in an offspring is more likely to engage in casual sex, seek out short-term relationships, and is less choosy in mate choice (Andersson & Iwasa, 1996; Schmitt, 2005). Triver's theory states that women typically invest more than men; thus, they should adopt strategies that lead them to mating opportunities with the best possible mate, i.e. a man who has many resources. In turn, men should adopt a strategy that maximizes copulatory opportunities (Buss, 1988). Therefore, women will limit their promiscuity since they invest more as a parent and will compete with other women to obtain access to resources that men provide, such as protection, financial support, and property. Men will engage in intrasexual competition to find a youthful attractive mate with high reproductive success,

which explains their inclination to engage in casual sex (Buss, 1988; Moss & Maner, 2016; Schmitt, 2005).

Preference for Facial Features

Facial symmetry.

Men and women will also consider both facial and bilateral symmetry when choosing a mate. When searching for a potential partner, women will choose a male who not only will be able to provide resources but will be able to pass on "good genes" to offspring. The good genes sexual selection theory states that individuals will evolve preferences for mates who possess "good genes" that can be passed to offspring to increase their chances of viability (Scheib, Gangestad, & Thornhill, 1999). Symmetry is said to reflect the ability to resist life stressors and indicates good health because it signifies that one can cope with environmental challenges throughout a lifespan (Fink & Penton-Voak, 2002; Fink, Neave, Manning, & Grammer, 2006). Therefore, asymmetry is thought to expose an inability to resist the detrimental effects of stressors during development caused by mutations, toxins, and disease (Scheib et al., 1999). As a result, body symmetry is linked to health and fertility (Møller & Thornhill, 1997; Rhodes et al., 2001; Waynforth, 1998). Specific genetic disorders, such as craniofacial microsomia and Saethre-Chotzen syndrome, can lead to facial asymmetry. Asymmetrical faces have been rated as less healthy than symmetrical faces, which support the belief that symmetry signifies health (Fink et al., 2006; Thornhill & Gangestad, 2006). Lack of symmetry in typically symmetrical traits is referred to as fluctuating asymmetry (FA). Therefore, individuals with high FA should have more mutations and would be less able to resist disease than those individuals with low FA (Scheib et al., 1999). According to these findings, women will seek out mates who possess both

facial and body symmetry in order to produce viable offspring who are capable of enduring environmental and genetic stressors.

Facial attractiveness.

Symmetry is hypothesized to be correlated with attractiveness, meaning that attractiveness may be another possible indicator of health. It has been suggested that attractiveness is positively correlated to both facial symmetry (Grammer & Thornhill, 1994; Jones et al., 2001) and body symmetry (Tovée, Tasker, & Benson, 2000). Specifically, individuals with symmetrical faces have been rated as more attractive compared to individuals with asymmetric faces (Fink et al., 2006; Thornhill & Gangestad, 1994). On the contrary, Scheib et al. (1999) found a relationship of women's attractiveness ratings of faces and symmetry. By presenting only half a face, symmetry cues were removed, which led participants to use cues other than symmetry to judge attractiveness (Scheib et al., 1999). With these results, it can be proposed that attractive features other than symmetry can be used to assess physical condition. Therefore, individuals may not use symmetry as their main cue when evaluating phenotypic quality.

Facial averageness.

Averageness is also hypothesized to relate to attractiveness (Fink &Penton-Voak, 2002; Munoz-Reyes, Iglesias-Julios, Pita, & Turiegano, 2015; Thornhill & Gangestad, 1999). An average face implies that the face does not deviate from the norm. Therefore, an average face is free of any developmental stressors, such as genetic disorders or skin conditions. Averageness is linked to heterozygosity or the presence of different variations of genes on homologous chromosomes. Essentially, high heterozygosity denotes a high amount of genetic variation, while low heterozygosity signifies little genetic variation (Fink & Penton-Voak, 2002; Munoz-Reyes et

al., 2015). Without genetic variation, a population cannot evolve in response to environmental changes. Little genetic variation is, therefore, undesirable because it leads to a risk of extinction (Furlan et al., 2012). Therefore, one may prefer average traits when searching for a mate. However, exact features that contribute to attractiveness, and whether they are products of adaptation, are unclear (Fink & Penton-Voak, 2002).

A previous comprehensive meta-analysis has found a weak correlation between attractiveness and health, but this may be because different cultures have different perceptions of beauty and attractiveness. However, attractiveness is believed to signal health (Rhodes et al., 2001), since symmetric faces are considered more attractive. The connection between attractiveness and symmetry has led to the belief that facial symmetry may partly "stand-in" for facial attractiveness, meaning that the two terms are almost parallel. In humans, men that possess greater symmetry typically have more mating opportunities and attract more sexual partners (Scheib et al., 1999). In comparison to asymmetric men, physically symmetric men report more sexual partners in a lifespan and become sexually active earlier (Fink et al., 2006). Women value facial attractiveness when choosing potential mates (Buss, 1989; Scheib, 1997) and facial attractiveness may be predicted by the degree of symmetry in men's body traits (Gangestad, Thornhill, &Yeo, 1994; Gangestad & Thornhill, 1997). These findings suggest that women use facial attractiveness, a correlate of symmetry when selecting future partners.

Hormone markers and facial preferences.

Hormone markers influence the development of attractive features. In men, testosterone production facilitates the growth of cheekbones, mandibles, and chin, the forward growth of the eyebrow bones, and the lengthening of the lower facial bone (Fink & Penton-Voak, 2002). The higher the testosterone levels, the more prominent, and masculine, these features will be.

Prominent, masculine features imply that lower testosterone production in males will lead to the development of less prominent features. According to the immunocompetence handicap hypothesis, testosterone suppresses functions of the immune system, meaning men who have high levels of testosterone will have weaker immune systems than men who produce lower levels of testosterone (Boonekamp, Ros, & Verlhust, 2008; Fink& Penton-Voak, 2002; Folstad & Karter, 1992). Men with more masculine features (i.e. weak immune system) signify that they have successfully overpowered pathogens, disease, and other health-related markers (Fink & Penton-Voak, 2002). Therefore, only high-quality males, males that pass on heritable benefits, can afford to be masculine (Little Jones, & DeBruine, 2008).

The connection between testosterone and attractiveness in male faces is complex because of the inconsistencies regarding whether women prefer masculine or feminine male faces. Shifts in facial preferences occur across a women's menstrual cycle and can lead to discrepancies in facial preferences (Grammer & Thornhill, 1994; Johnston, Hagel, Franklin, Fink, & Grammer, 2001; O'Toole et al., 1998; Scheib, Gangestad, & Thornhill, 1999). While masculinity may signify health, masculinity in a potential partner also contains multiple costs. Perrett et al. (1998) found that men with more masculine features were perceived as less warm, less honest, and less dominant than men with feminine features (Wood et al., 2014). Higher levels of testosterone in men are also positively correlated with marital instability and lower levels of attachment (Booth & Dabbs, 1993; Burnham et al., 2003). While these traits are not desirable in long-term partners, shifts in preference for masculinity across a women's menstrual cycle may explain why women would seek out men with masculine features as potential mates.

The menstrual cycle affects female's perception of male attractiveness. When women are in their fertile phase (i.e. when women are ovulating), they experience a shift in preference

towards more masculine faces and are more attracted to facial symmetry (Fink & Penton-Voak, 2002; Johnston et al., 2001; Little et al., 2008). Women also report a greater desire to attend social occasions where they might meet a man when they are ovulating (Haselton & Gangestad, 2006). Additionally, women in relationships experience a larger shift in preference than women who are single (Little et al., 2008; Fink & Penton-Voak, 2002), and women in relationships revealed that they feel less committed to their partner when they are most fertile (Haselton & Gangestad, 2006; Little et al., 2008). These shifts in preference represent adaptive trade-offs in mate choice. In essence, females will choose a male with a more feminine face that indicates pro-sociality, warmth, and trust, when they are unlikely to conceive. However, when contraception is likely, they may prefer a more masculine face in order to gain heritable benefits, such as the ability to outlive health stressors.

Hormone markers are also present in females: Women's ratios of estrogen-to-testosterone affect growth of attractive features, such as high cheekbones, full lips, and smaller chin sizes. These feminine features are often preferred by men, in addition to symmetry (Fink & Penton-Voak, 2002; Baudouin & Tiberghien, 2004). However, similar to the relationship between men and testosterone, high doses of estrogen can be harmful to a women's health; therefore, markers of high estrogen doses can indicate the strength of a women's immune system (Fink & Penton-Voak, 2002). Skin condition, which can also be influenced by estrogen, can also hint at mate value. Men prefer women who have skin free of lesions, pimples, warts, and cysts and tend to rate women with smooth skin and relative hairlessness as more attractive as well (Fink, Grammer, & Thornhill, 2001). Smooth skin and hairlessness can be linked to youth since younger women typically possess these characteristics. This explains why men are more

attracted to youthful-looking faces since young women have higher fertility rates than older woman (Fink et al., 2001; Munoz-Reyes et al., 2015).

Sex ratio influences preference for faces.

The sex ratio, the ratio of males to females in a population, influences mate preference for facial attractiveness as well. Hahn, Fisher, Debruine, & Jones (2014) found that when men and women were faced with an effort-based task, in which they had to allocate effort in order to view an attractive face, attractiveness motivation scores were greater for opposite-sex faces rather than own-sex faces. Additionally, the attractiveness motivation scores were greater in the own-sex biased condition compared to the opposite-sex biased condition. Ultimately, when a participant was in the condition in which they were the majority sex, they had more motivation to view attractive faces of the opposite sex. Those who were placed in the opposite-sex biased condition, therefore, had less motivation to view attractive faces since they knew the opposite sex would have to compete for them as mates (Hahn et al., 2014). Male participants' motivation scores were greater than female participants' scores for opposite-sex voices (Hahn et al., 2014), which coincides with the results of Gladue & Delaney (1990). They found that both men and women rated opposite sex customers as more attractive as a bar approached closing time. On average, men rated female customers higher than women rated male customers. Alcohol did not have an effect on attractiveness ratings as ratings did not significantly change as participants became more intoxicated (Gladue & Delaney, 1990).

In women specifically, Watkins, Jones, Little, Debruine, & Feinberg (2012) found that women exhibited a greater increase for symmetry preference when rating the attractiveness of the majority sex compared to when they were rating the attractiveness of the sex that was in the minority. Therefore, altering the sex ratio to favor a particular sex may increase the prominence

of facial cues for mate quality in the favored sex. These two studies provide support that responding voluntarily to faces, depending on whether they were attractive or not, may be adaptive. When evaluating the attractiveness of potential mates and competitors, perceived attractiveness ratings may be susceptible to changes of the sex ratio. These changes in sex ratio might encourage successful allocation of mating effort and effective intrasexual competition (Hahn et al., 2014; Watkins et al, 2011).

Motivation to view beautiful faces.

It is obvious that factors—averageness, symmetry, and hormone markers—interact and effect perceived facial attractiveness. Attractiveness, which indicates beauty, may not only be an honest signal of mate value and genetic quality but also has reward value. According to Charles Darwin, beauty also serves to motivate others to seek out potential mates (Grammer & Thornhill, 1994; Perrett et al., 1988). Motivation to view beautiful faces has been demonstrated by the labor market, in which attractive individuals are more likely to be hired, promoted and earn a higher wage than unattractive individuals (Marlowe, Scheinder, & Nelson, 1996; Frieze et al., 1990). Since there is a strong association between motivation and beauty, neuroanatomy functioning in reward value may be activating by social signals in attractive faces (Aharon et al., 2001). Based on their study, heterosexual males rated both attractive males and females, but only exerted effort when actively viewing pictures of beautiful females. When men were looking at attractive female faces, fMRI results showed activation in reward circuitry in the brain, particularly the nucleus accumbens, indicating that motivation to view beauty is related to brain function. This study was only done in males because women's preference for faces varies across the menstrual cycle. Therefore, it would be difficult to come to a consensus, since their preferences are constantly shifting (Aharon et al., 2001). In addition to beautiful faces, eye gaze is also suggested to have

reward value. Eye contact can suggest interest and focus during social interaction. When participants viewed faces varying in both direction of eye gaze and attractiveness, there was in an increase of brain activity in the ventral striatum. More specifically, when the eye was directed toward viewers, there was a positive relationship between attractiveness and activity in the ventral striatum. Similarly, when eye gaze was directed away from viewers, activity in the ventral striatum decreased as attractiveness decreased. Depending on both eye gaze and, attractiveness can activate regions of the brain associated with reward value, signifying that eye contact with attractive individuals is more rewarding than eye contact with less attractive individuals (Kampe, Frith, Dolan & Frith, 2001).

Vocal Attractiveness

Voice pitch and fluctuating asymmetry.

Both men and women also may take into account a potential mate's voice when evaluating attractiveness, since voices may suggest developmental stability. Hughes, Harrison, & Gallup (2002) found a negative relationship in both sexes between upper limb fluctuating symmetry and attractiveness measured from vocal stimuli. Abend, Pflüger, Koppensteiner, Coquerelle & Grammer (2015) similarly discovered a negative relationship between fluctuating asymmetry and women's vocal attractiveness. When there was a higher rate of asymmetry in the upper and lower limbs, as well in the head and face, women's voices were rated as less attractiveness (Abend et al., 2015). Likewise, Hill et al. (2017) obtained similar results, in which there was a negative correlation between vocal attractiveness and facial FA. More research needs to be done investigating the relationship between FA, especially facial FA, in order to accurately understand whether vocal attractiveness and asymmetry are related.

Mechanics of voice pitch.

Many factors have an effect on voice and its perceived attractiveness. Pitch, the "highness" or "lowness" of a voice, is the voice's most prominent feature (Titze, 2000). Amplitude and formant frequencies influence pitch, but the key influence of pitch is fundamental frequency (F_0), the rate of vocal fold vibrations when speaking or muttering any sound (Johnson & Puts, 2017; Titze, 2000). Individual differences in vocal fold length and thickness account for different variations in voice when speaking, but individuals also consciously and unconsciously adjust their pitch depending on the context (Johnson & Puts, 2017). Some animal species, such as Green Frogs or White Pelicans, purposely use a lower voice pitch to signal aggression (Bee, Perrill, & Owen 2000; Morton, 1977), and humans also deliberately alter their speech in order to convey particular emotions, impressions, or behavior (Johnson & Puts, 2017; Puts et al., 2006). Since voice is a sexually dimorphic trait, varying hormone production can also influence voice changes (Cartei, Bond, & Reby, 2014; Puts, 2005; Puts, Apicella, & Cárdenas, 2012; Puts et al., 2016; Puts, Doll, & Hill, 2014).

Testosterone influences changes in male voices.

During puberty in males, an increased production in androgens leads to the growth of the vocal folds, causing men to have longer (about 60%) and thicker vocal folds than women (Titze, 2000; Puts et al., 2016). Men's vocal folds vibrate at a fundamental frequency half that of females when speaking, meaning that they speak in lower pitches than women do (Puts et al., 2014). Also under the influence of androgens, men typically are taller than women. Their height allows for the development of a descended larynx, which increases the length of their vocal tract and decreases their formant spacing (Gualin & Boster, 1985). On the contrary, women produce less testosterone than men do; therefore, their vocal folds are thinner and shorter, causing them to have a higher pitched voice than men (Gaulin & Boster, 1985; Titze; 2000). Since undergoing

puberty, men's voices change greatly and women's voices do not. Therefore, Ellis (1905) suggests that is unlikely that female voices evolved to attract men, and is emphasized that male voices evolved to attract females, which explains why differences in voice pitch are linked to mating and reproductive success (Puts et al., 2016).

Lower fundamental frequency and height are both perceived as masculine; when women were to rate the masculinity in men, deeper voices positively affected those ratings (Feinberg, Jones, Little, Burt, & Perrett, 2005; Feinberg et al., 2006; Feinberg, DeBruine, Jones, & Perrett, 2008), and tall men, rather than shorter men, are consistently seen as more masculine (Bogaert & McCreary, 2011; Little, Jones, & Burriss, 2007). Women have preferences for male voices with a lower pitch when ovulating and when seeking a short-term, sexual relationship rather than a long-term relationship (i.e. instances when the benefits of choosing a more masculine mate outweigh the costs) (Feinberg et al., 2006; Puts, 2006). Women's preference for a deeper voice relates to testosterone production and genetic quality. Since high testosterone production decreases F_0 while suppressing immune system function (Cartei et al., 2014; Puts, 2006; Puts et al., 2012) women may have developed this preference in order to mate with high quality mates with "good genes" (Puts, Gaulin, & Verdolini, 2006; Puts et al., 2016). Although taller men typically viewed as more masculine, which may suggest that they have a lower-pitched voice, there is an extremely weak, negative correlation between height and F_0 (Cartei et al., 2014). However, Puts et al. (2012) found a significant, negative relationship between height and fundamental frequency. Even though the correlation between size and voice pitch is weak but still significant, the association between the two denotes that low F_0 in men may have evolved as extreme cues of stature and dominance (Puts, 2005). It is important to note that women might not

just prefer one factor, but a combination of factors (height, high testosterone production, and low fundamental frequency), when choosing a potential mate.

Changes in voice and intrasexual competition.

Low F_0 does not only function in mate attraction, it also serves as a component of intrasexual competition, since low F_0 affects how men perceive other men's social and physical dominance. Dominance in males is a fundamental aspect of intrasexual competition because established dominance produces access to resources (Puts et al., 2006). Dominance can exist in two major forms, physical and social. Physical dominance is achieved through aggression or physical threats of aggression, while social dominance can be achieved through leadership, popularity, and persuasion (Henrich & Gil-White, 2001; Puts et al., 2006). In one study, male voices were manipulated to increase masculinity. Female participants rated masculinized female and male voices as more dominant than feminized voices (Feinberg et al., 2005). This experiment investigated females' perceptions of dominance from listening to masculine voices but does not address the relationship of intrasexual competition among males. Puts et al. (2006) found that men altered their pitch when speaking with other male competitors. When participants spoke with a male who they perceived as more dominant than themselves, they raised their F_0. On the other hand, when men spoke with another male competitor whom they viewed themselves as more dominant, they lowered their F_0 (i.e. they spoke in a deeper voice). Puts et al., 2006 also reported a non-significant relationship between low pitch and number of sexual partners in men. Essentially, men who spoke at a lower pitch had more sexual partners in the past year. Although these results were predicted, they were not significant, which indicates that this component from the study should be repeated to confirm a relationship between the two factors. From these findings, it is suggested that a low fundamental frequency may have evolved in men

because of its role in allocation of resources during intrasexual competition and its association with health benefits and genetic quality. Therefore, men with lower voices are viewed as more sexually attractive than men with higher voices (Feinberg et al., 2005; Puts et al., 2006; Puts et al., 2012).

Voice preference for female voices.

There is much greater research on sexual selection on male's voice, but there are still significant findings regarding sexual selection on female voices. Men prefer feminine voices (i.e. voices that are higher in pitch) (Apicella & Feinberg, 2009; Feinberg et al., 2008; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010), especially for short-term, sexual relationships (Jones, Feinberg, DeBruine, Little, & Vukovic, 2008). Breathy voices are also considered as attractive to men. Breathiness is unique to women because of the shortness of their vocal tract (Liu & Xu, 2011).Women also raise their own voice when talking to someone they think is attractive, hinting that high pitch may have evolved to attract potential mates (Fraccaro et al., 2011). Feminine voices that are high pitched may reflect fertility. As a women ages, her pitch decreases, indicating that women's voice has the optimal pitch when she is at her peak reproductive age. Low frequency in women is often associated with older age (Collins & Missing, 2003). It is not unknown that fertility decreases as a women ages. Eggs start to decline around age thirty, which varies for every woman. Women at these prime ages when conception is more likely are said to have more attractive voices than prepubescent girls or postmenopausal women (Röder, Fink & Jones, 2013).

Menstrual cycle and voice changes in women.

The menstrual cycle has a strong influence on women's perceived vocal attractiveness. Women's voice changes little during puberty, but modifications in hormone production are

responsible for changes in voice during pregnancy, menstruation, and menopause (Caruso et al., 2000). Increased estrogen production causes changes during menstruation, such as hoarseness and fatigue (Abitbol et al., 1989; Abitol, Abitbol, & Abitbol, 1999). Premenstrual syndrome (PMS) causes more jitter and less frequency in female voices (Chae, Choi, Kang, Choi & Jin, 2001), and women who use contraceptives had significantly lower jitter and shimmer (Amir, Kishon-Rabin, & Muchnik, 2002). Fertile women, who are ovulating, are said to have more attractive voices (Bryant & Haselton, 2009; Pipitone & Gallup Jr., 2008). Additionally, Pipitone & Gallup Jr. (2009) found that the attractiveness rose as the speaker's risk of conception increased. However, this increase in attractiveness occurred only in women who were naturally cycling (i.e. women who were not on birth control) (Piptone & Gallup Jr., 2008). Women on birth control are less likely to conceive. Since men do not find their voices as attractive as those voices of women who cycle naturally, this finding, along with the suggestion that women's voice lowers in pitch during menstruation (when chances of conceiving are low), may indicate an evolved preference for women who are capable of producing offspring.

Perceiving Sex Ratios

Recent research by Neuhoff (2017) found that listeners can accurately extract sex ratios from vocal stimuli of simultaneous voices talking. Perceived sex ratios depend both on participant sex and age of the voices heard in the voice clips. In the current work, we expect to our findings to align with the results of Neuhoff (2017), in which participants have the ability to distinguish among the varying vocal sex ratios.

The Current Study

The current study examines the influence of biased sex ratios on perceived vocal attractiveness. Attractiveness ratings of both male and female voices were measured after

participants listened to clips of simultaneous voices talking, in which sex ratios were unbalanced. There are currently no published studies investigating the effect of biased sex ratios on the attractiveness of voices. Therefore, the study was modeled after the Hahn et al. (2014) study who studied the influence of biased sex ratios' on facial attractiveness. They hypothesized that participants would be more motivated to view attractive opposite sex, but not own-sex faces, when they were to complete the task in an own-sex biased condition rather than the opposite-sex biased condition. They found that motivation salience was greater for opposite-sex faces in the own-sex biased condition than the opposite-sex biased condition. Our main hypothesis is based on Hahn et al. (2014) findings and additional research on both varying preference for voices and faces and human mating patterns, in which we predict that participants will rate opposite sex voices as most attractive when they are exposed to low opposite-sex biased sex ratios.

Method

Participants. The sample consisted of 222 participants (127 female, 95 male) with a mean age of 33.9 years (*SD* = 7.4 years). All participants reported being heterosexual with normal hearing abilities and were recruited using Amazon Mechanical Turk (MTurk). Each participant was paid $0.30 after completing the study online.

Stimuli. Voice stimuli were gathered from the Buckeye Corpus of Conversational Speech. The corpus contains digitized conversational speech from 40 talkers, stratified for age (under thirty and over forty) and sex. Ten 1.5 s speech tokens were extracted from continuous conversational speech for each of the 20 talkers under the age of 30 (ten male and ten female). Stimuli were selected such that each 1.5 s speech token started with the beginning of an utterance. Individual speech tokens were submitted to Praat (Boersma & Weenink, 1992) for analysis of mean fundamental frequency and amplitude variation. Mean (SD) fundamental

frequency for male and female voices were 124 (54) Hz and 197 (52) Hz, respectively. All speech tokens were equated for overall intensity. Mean amplitude variations (in standard deviations) for each sex were female 8.1 dB and male 8.1 dB. Individual speech tokens were randomly selected into 16 combinations of ten simultaneous voices for each of the six sex ratio levels (0%, 20%, 40%, 60%, 80%, 100%) with the stipulation that no talker could appear more than once in a given combination of voices. The combinations were then digitally mixed and saved as single mp3 files.

Additional voice stimuli used in the attractiveness rating portion of the experiment were gathered from twelve American, The College of Wooster students (six female, six male). The mean age for all twelve students was 20 years old. Each participant read four sentences into a microphone three times. The following sentences were recorded: "The sky is blue," "In the fall, the leaves change color," "December is the 12th month of the year," and "It is a nice day outside." Neutral sentences were chosen to prevent any biased emotion from appearing in the recordings. Every sentence from each participant was analyzed to ensure that sentences were impartial to emotion and free from stutters and irregular pauses. Based on the analysis, the sentence "In the fall, the leaves changed color" was chosen to appear in the final experiment. Therefore, all participants heard six subsequent, recordings of opposite sex voices reading the sentence “In the fall, the leaves change color” aloud. Then, participants rated the attractiveness of each voice in the six recordings.

Procedure. The procedure was approved by The College of Wooster’s Human Subjects Research Committee. After providing informed consent, participants were presented with a computer-generated voice asking them to adjust their volume to a comfortable listening level. To ensure that participants could hear the audio, they were verbally instructed to type a word into a

response box. They were then informed that they would be using a response slider to estimate the proportion of male and female voices when listening to a series of audio clips of voices talking simultaneously. The slider was anchored on the left with “100% Male” and “100% Female” on the right. The center of the scale read “50% Male/50% Female.” Participants could move the cursor along any point on the slider to denote their observed sex ratios. Positions along the scale were recorded on a range from 0-100, but this was not visible to the participants. Each participant was given three practice trials, in which they heard two simultaneous voices at sex ratios of 0%, 50%, and 100%. Following the practice trials, participants were asked three demographic questions about age, sex, and hearing disabilities. After the three practice trials, participants were randomly assigned to either a low-exposure version (randomized sex ratios of 0%, 20%, and 40% opposite sex voices) or a high-exposure version (randomized sex ratios of 60%, 80%, and 100%). There were 48 trials with 10 concurrent voices for each experimental version. Once participants completed estimating sex ratios, they were instructed to rate the attractiveness of six individually- presented opposite sex voices. Each of the six voices was presented in random order, and the same slider mechanism as before was used, but the left side of the scale read “Very unattractive” and the right side read “Very attractive." Again, participants could move the cursor at any point to rate the attractiveness of the voices. Participants were then debriefed upon completion of the study.

Results

Perceived Sex Ratios

As a manipulation check, a one way repeated measures ANOVA with the percentage of opposite-sex voices (low, medium, high) as the within-subjects factor, was conducted to analyze perceived sex ratios. The low, medium, and high levels corresponded to sex ratios within the

low exposure and high exposure groups (0%, 20%, 40% for the low exposure group and 60%, 80%, 100% for the high exposure group). There was a main effect for percentage of opposite-sex voices, $F_{(1, 221)} = 286.65$, $p < .001$ $\eta_p^2 = .565$ that indicated that listeners could distinguish among the varying vocal sex ratios. Mean sex ratio judgments for the low, medium and high levels are displayed in table 1. Additional paired sample t-tests showed that participants discriminated the different vocal sex ratios between the low-high, $t_{(221)} = -18.46$, $p < .001$, low-medium, $t_{(221)} = -14.7$, $p < .001$, and medium-high levels, $t_{(221)} = -14.92$, $p < .001$.

Table 1. Mean sex ratio judgments values (*SD*) in the low, medium, and high levels of percentage to opposite-sex voices.

Percentage of opposite sex voices	Mean (*SD*)
Low	43.96 (11.88)
Medium	52.74 (10.29)
High	64.41 (16,45)

Perceived Attractiveness Ratings

Perceived attractiveness ratings of opposite-sex voices were analyzed using a 2x2 ANOVA with exposure to sex ratios (high exposure, low exposure) and participant sex (female, male) as between-subject factors. Exposure was coded in terms of opposite-sex voices, meaning participants assigned to the high-exposure conditions heard voice clips of sex ratios that mainly consisted of the opposite sex, while participants assigned to the low-exposure condition were mainly exposed to voice clips of sex ratios of their own sex.

Data analysis yielded a significant main effect of exposure, $F_{(1, 221)} = 4.54$, $p < .034$ $\eta_p^2 = .02$, indicating that varying levels of exposure affected attractiveness ratings. Mean perceived

attractiveness ratings for males and females are displayed in table 2. When participants were in the low-exposure group, ratings of opposite-sex voices were significantly greater than the ratings from participants who were in the high-exposure group. The main effect of sex was marginally significant, $F_{(1, 221)} = 3.68$, $p = .056$ $\eta_p^{2 =} .017$, and there was no significant interaction effect observed between sex and exposure, $F_{(1, 221)} = 0.998$, $p = 0.939$ $\eta_p^{2 =} .00$.

Table 2. Mean perceived attractiveness ratings (*SD)* for males and females in high and low exposure conditions.

	Exposure		
Sex	Low-exposure	High-exposure	Total
Female	54.74 (11.94)	51.11 (13.56)	52.97 (12.83)
Male	58.27 13.32)	54.37 (12.34)	56.26 (12.40)
Total	56.20 (12.60)	52.55 (13.50)	54.38 (13.16)

Discussion

The present study first shows that both men and women possess the ability to clearly distinguish between different vocal sex ratios after listening to clips of simultaneous voices talking. These results coincide with Neuhoff (2017). In both studies, listeners were exposed to clips for only 1500 milliseconds. The short amount of exposure time may suggest that detecting the sex ratio of a given environment may come naturally and does not require effort (Neuhoff, 2017).

Additionally, this study offers new evidence that shows the manner in which mating-relating behaviors fluctuate based on the population sex ratio, specifically showing how voice preferences in potential mates change. Consistent with previous research examining the effect of unbalanced sex ratios on motivation scores to view attractive, opposite-sex faces (Hahn et al.,

2014), perceived attractiveness ratings were greater for opposite-sex voices in the low-exposure condition (few members of the opposite sex) compared to the high-exposure condition (many members of the opposite sex). Specifically, male participants assigned to the low-exposure condition rated female voices as more attractive than those men who assigned to the high-exposure condition. Similarly, female participants assigned to the low-exposure condition rated male voices as more attractive than those women who assigned to the high-exposure condition. Both genders adjusted their attractiveness ratings based on the sex ratio, which could promote allocation of mating effort, sociosexual orientation, and intrasexual competition (Hahn et al., 2014; Watkins, 2011).

The main effect of sex was marginally significant. This may be because we had more female than male participants. Future studies could include an equal number of participants of each sex. However, men rated female voices higher than women rated male voices, which correspond with previous findings (Gladue & Delaney, 1990; Hahn et al., 2014). Although facial attractiveness is important to both genders, men emphasize attractiveness in a potential partner more than women do (Buss, 1985; Buss & Barnes, 1986). Women tend to consider additional factors other than attractiveness, such as generosity, ambition, status, and financial standing, in viable mates. Women may also consider similar factors when judging voices for the first time. Tsantani, Belin, Paterson, & McAleer (2016) found that both men and women believed low-pitched male voices to be more trustworthy and dominant than high-pitched male voices, which may explain why women's ratings of men's voices were lower.

Additional factors other than voice could have skewed results, specifically participants' relationship status and differences in the menstrual cycle in female participants. Relationship status is known to influence attractiveness ratings in men. In men, testosterone levels rise and

decline during different life events: testosterone levels rise after divorce, decline during marriage and fatherhood, rise during competitive situations, and decline with age (Booth & Dabbs, 1993; Elias, 1981; Gray et al., 2001; Mazur, Booth, & Dabbs, 1992; Storey et al., 2000). Increased testosterone levels also contribute to a heightened libido in men, particularly an increase in the number of nightly erections, sexual thought and motivations, number of intercourses, and overall sexual satisfaction (Isidori et al., 2005; Skakkebaek, Bancroft, Davidson, & Warner, 1981). Since testosterone levels decrease in aging men, libido decreases as well (Isidori et al., 2005). Although other factors such as age, sleep, physical and mental health, and medication could also influence libido, testosterone still plays an important role (DeLamater & Sill, 2005). Given the correlation between libido and testosterone, men may have rated female voices as more or less attractive based on their relationship status. Particularly, single men and recently divorced men with higher levels of testosterone may have rated voices as more attractive considering they would be motivated to meet a viable mate. On the contrast, men in committed relationships, who have lower levels of testosterone, may also have lower sex drives. Therefore, they may have rated female voices as less attractive, since they are typically not looking to reproduce with another mate.

Female participants' menstrual cycle may have also influenced perceived attractiveness ratings. Women who are ovulating prefer lower-pitched male voices, especially when seeking sexual, short-term relationships (Feinberg at al., 2005; Feinberg et al., 2006; Puts, 2006). Deeper voices are typically seen as masculine (Puts et al., 2006; Puts et al., 2012) Female participants in the ovulating phase of their menstrual cycle may have rated masculine male voices as more attractiveness, since they were fertile, while non-fertile women may have rated masculine voices as less attractive.

To the best of our knowledge, this study is one of the first of its kind to examine the effect of auditory sex ratios on perceived attractiveness ratings of opposite-sex voices. While results for exposure level and sex were significant and marginally significant, respectively, the current work should be repeated to see if future results are consistent. The low-exposure condition contained sex ratios set at 0%, 20%, and 40%, and the high-exposure condition contained sex ratios set at 60%, 80%, and 100%. Future studies could include sex ratios with smaller differences, such as 0%, 10%, and 20%, to see if exposure level still influences perceived attractiveness ratings of voice stimuli. Future works similar to the present study that accounts for menstrual cycle, age, relationship status, and environment could provide even further information on mating behaviors in humans.

Studies regarding sex ratios and behaviors, in general, are important to understand and put meaning behind human behavior. When sex ratio fluctuates, both sexes alter not only their mating patterns, but their behaviors in general. For example, a woman who works in male-dominated environment may feel as if she does not fit in with her male co-workers, which in turn, could negatively affect her self –esteem (Robinson & McIlwee, 1991). Low self-esteem could even lead to engagement in risky behaviors, such as unprotected sex (Gullette & Lyons, 2006). Unprotected sex is more likely to result in a child, which affects the sex ratio at birth. In this hypothetical, but highly possible, case, the biased sex ratio in the workplace influenced feelings and actions that later led a woman to alter her mating behaviors. Skewed sex ratios affect everyday behaviors constantly, and more studies investigating unbalanced sex ratios and changing behavior are needed to ultimately understand human actions.

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