HORMONAL INFLUENCES ON ATTRACTION AND VISUAL ATTENTION TO FACIAL MASCULINITY

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Abstract: Differences in reproductive success caused by competition within and between the sexes have resulted in selective pressures in females to favor specific features in males. Research on women's mate preferences has indicated that women often prefer men that display masculine physical characteristics, likely due to masculinity's association with immunocompetence, resource acquisition, and protection. Traditionally, studies have incorporated a forced choice rating (2afc) where women choose a preference towards a feminine or masculine male face. Findings have consistently shown that masculine faces are preferred and considered attractive, but the hormonal underpinnings of these preferences have been mixed. The current study investigated the ovulatory shift hypothesis, which suggests that women prefer masculine men during peak fertility. The current study used an eye tracking paradigm to measuring women's visual attention to facial masculinity across the menstrual cycle. Estradiol (E) and progesterone (P) were collected to determine if salivary biomarkers influence visual attention to masculine faces during peak fertility in a short- and long-term mating context. Women ($N = 81$) provided saliva samples at three time points throughout their menstrual cycle and were asked to rate and view men's faces that had been manipulated to appear feminine and masculine. Overall, masculine faces were viewed longer compared to feminine faces and this was dependent upon mating context, where women viewed masculine faces longer for a long-term relationship. There was not any evidence suggesting that peak fertility (i.e., high E/P ratio) was associated with viewing facial masculinity, but there was evidence to suggest that hormones were associated with visual attention to men in general. Additionally, women's self-perceived mate value played a significant role in the amount of visual attention displayed to facial masculinity, demonstrating higher visual time to masculine faces as women's self-perceived mate value increased. In line with sexual strategies theory, there was evidence to suggest that mating context, facial masculinity, and mate value are important in mate choice; however, there was no evidence to suggest that women's mate choice was dependent upon fertility status.

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CHAPTER I

HORMONAL INFLUENCES ON ATTRACTION AND VISUAL ATTENTION TO FACIAL MASCUILINITY

Introduction

Sexual selection is a mechanism of evolution that explains the traits that confer fitness advantages in competing for access for members of the opposite sex (intrasexual selection), and the process of choosing members of the opposite sex for mating (intersexual selection) (Andersson, 1994). According to sexual selection theory, members of one sex should be sensitive to cues that advertise important reproductive information about the opposite sex in mate choice. In sexually reproducing species, male ornamentation has evolved due to a variety of factors, such as ecological influences, within-sex competition, and through female choice and mating preferences. In addition, female preferences for exaggerated secondary sexual characteristics have evolved because of indicator mechanisms that signal high heritability and direct phenotypic benefits, such as protection and parental ability (Andersson, 1994). For example, in guppies, male color patterns advertise health and diet, and females show preferences for males that display these color patterns and benefit from the heritable genetic variation of such features (Andersson, 1994). In ungulates, mate choice is dependent on antler size, as large antlers that reflect good condition are preferred by females, and these high-quality traits are more likely to be inherited by offspring (Andersson, 1994). In human males, exaggerated secondary sexual characteristics, such as facial masculinity, are preferred by women (Boothroyd et al., 2013; DeBruine et al., 2006; Marcinkowska et al., 2018b) as it suggests they are "honest signals" that indicate desirable genetic qualities (Little et al., 2011; Rantala et al., 2012; Thornhill & Gangestad, 1999a,b).

Androgens, such as testosterone, are associated with growth of secondary sexual characteristics, however testosterone is also known to be an immunosuppressant (Penton-Voak et al., 2003). Therefore, men who can withstand the immunosuppressant effects of testosterone and advertise these secondary sexual characteristics for mating effort should be preferred by women due to these heritable qualities (Folstad & Karter, 1999, Penton-Voak et al., 2003). Since heritable qualities in men can only be obtained through successful conception, women should have a stronger preference for these sexually dimorphic traits in men during the time of the menstrual cycle where conception is optimal, known as the ovulatory shift hypothesis (Gangestad & Thornhill, 1998; Gangestad & Haselton, 2015). However, ovulation in human populations is concealed to potential mates and to the female herself (Alexander & Noonan, 1979; Alexander, 1990), which may indicate that preferences during peak fertility may not be under direct conscious awareness. Although recent studies (Jones et al. 2019; Marcinkowska et al., 2016, 2018a) using accurate methods in detecting fertility status through hormonal assays have not detected ovulatory shifts, shifts in preferences to sexually dimorphic traits may be more subtle than overt due to concealed ovulation. That is, specifying a preference for masculinity during peak fertility may not be detected using traditional preference tasks that are under conscious control, therefore methods that are sensitive in detecting subtle behavioral changes, such as eye movements, can demonstrate that women display attentional biases towards masculinity. Given the concealed nature of ovulation in human populations (Alexander & Noonan, 1979), women's preferences for masculine traits may be a product of implicit processes that can only be detected using sensitive instruments, such as eye tracking. The study uses an eye tracking paradigm to investigate whether preferences to facial masculinity are influenced by reproductive hormones throughout the menstrual cycle.

CHAPTER II

REVIEW OF THE LITERATURE

Sexual Strategies Theory

According to sexual strategies theory, both men and women have faced adaptive challenges in mate selection (Buss & Schmitt, 1993, 2019). In order to address these adaptive problems, humans have evolved psychological adaptations in response to many facets of mate selection. For women, identifying which men will make good partners has been one of those challenges, as women have had to discern which mates will provide them with indirect benefits in the form of high-quality genes for their offspring, direct benefits in the form of resource protection and status transmission, or a mate who is invested in long-term pair bonding. Since women have more to lose in making a poor mate choice, and given the long, intensive parenting effort of human life histories (Flinn et al., 2007), assessing these features in human mating are important. Women have been known to place premiums on characteristics that signal good genes, such as attraction and health (Buss, 1989; Cashdan, 1996) and characteristics that signal immediate resource transmission and future resource acquisition (Cashdan, 1996). In seeking mates that will provide indirect and direct benefits, women have had to rely on observable physical characteristics to determine which men are advertising cues associated with high quality genes and features associated with direct acquisition of resources. One principle of sexual strategies theory is that women pursuing men with these features would have obtained benefits from seeking such men if searching for men for short-term mating, as pursuing men with these features for long-term relationships would put women and their children at risk for abandonment and increased competition from other women (Buss & Schmitt, 1993, 2019). Since short-term mating requires minimal investment, benefits obtained (i.e., superior genes, resources) would have had to outweigh the costs of not pursuing a mate for a long-term commitment.

Similarly, mating strategies can also be influenced by one's own mate-value or self-perceived attractiveness, as mating strategies are context dependent (Buss & Schmitt, 1993, 2019). Women high on mate-value may be more competitive and better able to acquire high-quality mates (Buss & Shackelford, 2008), such as attracting men with similar levels of physical attractiveness. Studies incorporating individual differences in mate-value have been mixed. High mate value women have shown stronger preferences for masculine men for a long-term mating context (Little et al., 2001), and low mate-value women have shown stronger preferences for masculine men for a short-term mating context (Little et al., 2001) and long-term mating context (Penton-Voak et al., 2003). These results may suggest that high mate-value women may be able to obtain all the desired attributes wanted in a mate, such as high-quality genes and parental investment. In using objective measures of one's own attractiveness in women (i.e., voice pitch), high voice pitch was associated with masculinity preferences (Vukovic et al., 2010), which is consistent with previous research showing self-perceived attractiveness positively related to preferences for masculine voices (Vukovic et al., 2008). Furthermore, in a study examining the desired attributes wanted in a mate, high mate-value women indicated a preference for putative indicators of good genes and parental investment (Shackelford & Buss, 2008). However, studies have also demonstrated that high mate-value women prefer masculinity for short-term mating contexts (Garza & Byrd-Craven, 2020). Taken together, mating strategies have been shown to be context dependent and preferences for masculinity may be driven by one's own mate value.

Immunocompetence-Handicap Hypothesis

The immunocompetence-handicap hypothesis has been used in previous research in testing sexual strategies theory. Sexually dimorphic traits, such as masculinity, are preferred by women because they advertise good genes that are heritable (Thornhill & Gangestad, 1999). Males who display enhanced secondary sexual characteristics are considered by women as high-quality males because they can afford to display these characteristics without suffering reduced fitness from pathogen loads, known as the immunocompetence-handicap hypothesis (Folstad & Karter, 1999; Roberts, Buchanan, & Evans, 2004). Research supporting this prediction has been demonstrated by women's mate preferences for physical characteristics associated with masculinity, such as preferences for upper body strength (Dijkstra & Brooks, 2001; Dixson & Brooks, 2013; Lassek & Gaulin, 2009) and cues (i.e., reduced abdominal fat) signaling immunocompetence (Dixson et al., 2014). Men with physical characteristics that signal upper body strength, as measured by waist to chest/shoulder ratios, are considered more attractive and preferred by women (Braun & Bryan, 2006; Buunk & Dijkstra, 2005; Fan et al., 2015; Frederick & Haselton, 2007; Hughes & Gallup, 2002; Swami et al., 2007). Preferences for these traits are thought to be the result of honest signaling of testosterone, as androgens directly influence muscle mass (Lassek & Gaulin, 2009).

Facial cues are directly observable characteristics that provide women hormonal information about men. Androgen levels are associated with exaggerations of secondary sexual characteristics, such as the brow ridges and jaw (Thornhill & Gangestad, 1996), therefore advertisement of these traits should signal indirect benefits (i.e., good genes) to women because of testosterone's immunosuppression. Studies incorporating direct tests of masculinity preferences have utilized images of men that have been digitally manipulated to enhance sexually dimorphic traits by masculinizing the face shape by 50% (i.e., masculine) or by feminizing the face shape by 50% (i.e., feminine). In these designs, women presented with pairs of masculine and feminine images of the same individual are asked to choose which image is preferable or the most attractive. Using this framework, research has demonstrated that women tend to prefer masculine over feminine faces (Boothroyd et al., 2013; Cornwell & Perret, 2008; DeBruine et al., 2016; Johnston et al., 2001, Little et al., 2008) and find them sexually attractive (Marcinkowksa et al., 2018b). Masculine faces have been associated with immunocompetence (Rantala et al., 2012; Rhodes et al., 2003), disease resistance (Thornhill & Gangestad, 2006), and strength (Windhager et al., 2011). In looking at the role of cortisol and testosterone, testosterone was positively associated with better immune response and attractiveness, however, this was stronger for males with low cortisol (Rantala et al., 2012). Facial masculinity has also been associated with direct benefits, such as protection and resource acquisition (Sell et al., 2009). Men who are masculine display more muscularity, dominance, and physical strength (Fink et al., 2007; Puts, 2010; Windhager et al., 2011).

However, there is a tradeoff between securing a mate with good genes or securing a mate that is willing to invest in offspring (Marcinkowska et a., 2018). Men with masculine features are perceived as less parentally investing (Perret et al., 1998), and more willing to engage in short-term relationships (Boothroyd et al., 2008; Rhodes et al., 2005). In evaluating faithfulness using men's faces, women use masculinity as a cue to indicate unfaithfulness (i.e., lack of commitment) (Rhodes et al., 2013). Studies using body ratio differences as a proxy to masculinity, have shown that men who display masculine body types as indicated by high shoulder to hip ratios, engage in sexual intercourse earlier and have more sexual partners (Hughes & Gallup, 2002). Therefore, preferences for masculinity may be calibrated to maximize the likelihood and need of obtaining indirect (i.e., good genes) or direct benefits (i.e., resources acquisition, protection).

Life History Context/Ecological Conditions

Life history theory describes the trade-offs in the allocation of resources organisms make to somatic, parenting, or reproductive effort with the goal of maximizing fitness (Figueredo et al., 2006). Ecological conditions may influence these tradeoffs by calibrating women's mate preferences as a function of environmental stability. Several studies have suggested that preferences for masculinity are a function of ecological conditions. It is argued that there are selection pressures to pursue fitness maximizing reproductive strategies in responding to environmental cues (Cornwell et al., 2006; Ellis et al., 2003). Depending on the type of environment one is exposed to, sexual strategies may favor early reproduction with less investment or late reproduction with an investment based reproductive strategy (Cornwell et al., 2006). Women who engage in sex early on in development prefer more sexually dimorphic features, such as masculine faces, suggesting a faster-reproductive mating strategy (Cornwell et al., 2006). Unpredictable and unstable environments may shift preferences to exaggerated sexual dimorphic preferences. Preferences for masculine characteristics are stronger in countries where homicide rates are high, indicating a preference for direct benefits where masculinity may be a signal of immediate protection from threats (Brooks et al., 2011; DeBruine et al., 2010; Little et al., 2013). Women with relatively fast life history strategies, as measured by attachment styles and sociosexual orientation, show a preference towards men with characteristics associated with short-term mating (Kruger & Fisher, 2008).

However, preferences for masculinity may reflect a product of a modern novel environment where highly developed environments provide opportunities to discern relationships between facial traits (Scott et al., 2014). Most studies investigating preferences for masculinity have relied on post-industrial populations, therefore, preferences for masculinity may be the result of dense populations where exaggerated sexually dimorphic features are more salient. In a large-scale study of 12 populations that included participants from market economies, pastoralists, foragers, and horticulturalists, women's preferences for masculinity were stronger in urban populations that have lower rates of disease, fertility, and homicide (Scott et al., 2014), which would contradict the immunocompetence-handicap hypothesis. Aggressive indicators associated with masculinity were also stronger in denser populations, perhaps because individuals need to rely on heuristics to discern information from a person in a vast array of social relationships (Scott et al., 2014). A recent study on masculinity preference across different ecological conditions, also supported this finding. Women's preferences for masculinity were stronger in conditions where economic and offspring fitness were optimal, such as in populations with higher human developmental indices (e.g., economic development) (Marcinkowska et al., 2018b), not in more harsh or unpredictable populations, as the immunocompetence-handicap hypothesis would suggest.

Mating Context

According to sexual strategies theory, men and women have evolved psychological mechanisms that underlie their pursuit of both short and long-term mating (Buss & Schmitt, 1993). Women have faced the adaptive problem of finding a mate who is willing to invest, as well as finding a mate with high quality genes. Mating context has been shown to influence women's preferences towards sexually dimorphic characteristics. Research manipulating mating context has traditionally asked women to choose a partner for a short-term relationship (i.e., one-night stand, casual encounter), or for a long-term relationship (i.e., committed relationships). Relying on sexually dimorphic cues can provide women with physical information that is associated with investment (i.e., femininity) or lack of investment (i.e., masculinity) (Perret et al., 1998). In comparing sexually dimorphic facial features as a function of mating context, women have preferred masculine faces for short-term rather than long-term relationships (Little et al., 2002; Little et al., 2011a,b). Short-term relationships require minimal investment, and masculine faces reflect characteristics associated with minimal parental investment, (Perret et al., 1998), therefore, this may alleviate the limitation of pursuing a mate for a long-term relationship (Little et al., 2011a). Additionally, women pursuing masculine men for short-term relationships may capitalize on indirect benefits (i.e., good genes) if conception occurs (Little et al., 2007).

In contrast, studies have also indicated a preference for masculine faces when considering mates for a long-term relationship as a function of environmental harshness. Women that have been assigned to an ecologically safe vs. unsafe condition demonstrate a preference for masculinity when considering men for a long-term relationship. One possible interpretation is that women choose masculine men in safe conditions because safe conditions provide an environment of choosing the highest quality mate (Little et al., 2007). Furthermore, when looking at masculinity as a function of facial hair distribution, masculinity preferences have not been found (Dixson et al., 2018). Women consider unmanipulated (i.e., average) faces as more attractive for short-term and long-term relationships, and feminine faces were preferred for short-term relationships, but not long-term relationships (Dixson et al., 2018). This finding may reflect variation of preferences when including additional profiles of males faces, as opposed to a standard forced choice paradigm (i.e., masculine vs. feminine). It is important to note that using experimentally manipulated mating contexts and a reliance on WEIRD populations may not capture women's preferences that are generalizable to a wider population (Henrich et al., 2010).

Fertility Status

Most studies in masculinity preferences have suggested that men with masculine characteristics are considered attractive and preferable because it is an honest signal of their immunity. However, to capitalize on honest signaling for either indirect or direct benefits women should preferences for masculinity under high conceptive probability. The ovulatory shift hypothesis (Thornhill & Gangestad, 1999) suggests that women should prefer men with high quality genes during optimal times of fertility during the menstrual cycle. In ancestral females, this heightened preference would have been associated with increased reproductive success compared to females who did not exhibit a cyclic shift in preferences (Gildersleeve et al., 2014). It would also indicate that women's preferences would be attenuated outside of the fertile window due to the cost of losing social mates or in choosing the wrong mate (Gangestad et al., 2005). Research into fertility status in women's mate preferences has suggested women prefer men who are symmetrical because of its association with health and immunocompetence (Thornhill & Gangestad, 1999). Women in the high fertility phase display preferences for men with masculine faces compared to women who are at the low fertile phase of the menstrual cycle (Penton-Voak, 2000; Little et al., 2007). However, other studies have not shown an ovulatory shift for preferences to men's masculine characteristics. Women during peak fertility have shown to rate all men as equally attractive, regardless of masculine traits (i.e., waist to chest/shoulder ratios) (Garza et al., 2017; Garza & Byrd-Craven, 2019). Other research on male traits signaling masculinity (i.e., degree of hair distribution) (Gangestad & Thornhill, 2008) has not shown that women shift their preferences for these traits across the fertile period (Rantala et al., 2010; Dixson & Rantala, 2016; Garza et al., 2017).

An inherent problem in research investigating ovulatory shifts in men's mating preferences has been the accuracy of methods used. Traditionally, self-report methods using the calendar method, where women count the days from their previous menstrual period, have been used to dichotomize women into low or high fertility conceptive probability. Meta-analysis research in self-report methods have shown support for an ovulatory shift for cues associated with masculinity and dominance, but that was dependent on relationship context (Gildersleeve et al., 2014). Others (Wood et al., 2014) have been critical of such effects of fertility, citing fertile effects as artifacts of less precise definition of what consists of fertility status. Other critiques of self-report fertility status have been its reliance on between-subjects as opposed to within subjects comparison, and the use of small sample sizes (Gangestad et al., 2016). Researchers have promoted the use of more accurate methods in detecting fertility shifts in women, such as using luteinizing hormone detection kits (i.e., ovulation tests), the estradiol to progesterone ratio (i.e., E/P ratio), and to increase the number of within sample saliva collection for such hormones (Blake et al., 2016; Gangestad et al., 2016).

Nevertheless, the use of precise methods in detecting fertility status have become more common practice. Throughout the menstrual cycle, women experience fluctuations in their levels of estradiol and progesterone. During the pre-ovulatory phase of the menstrual cycle, women experience a rise in estradiol and a decline in progesterone (Roney & Simmons, 2013). By tracking the ratio of estradiol to progesterone, it is possible to determine the increased likelihood of ovulation, and if women's shifts for specific mate preferences were to occur, according to the ovulatory shift hypothesis, they should occur during a rise in the E/P ratio. Findings for hormonal influences in preferences for masculinity have been equivocal. Preferences for masculinity have been associated with increased levels of estradiol (Roney & Simmons, 2008), testosterone (Welling et al., 2007), while others have not found any preferences using luteinizing hormone (Peters et al., 2009). When using the ratio of estradiol to progesterone, findings have also not been supported. The estradiol to progesterone ratio (i.e., E/P Ratio) is a recommended method in detecting fertility status (Gangestad et al., 2016) because during peak fertility estradiol is expected to be higher than progesterone than any other point in the menstrual cycle, therefore higher values are an indicator of increased likelihood of ovulation, while lower values are an indicator of post-ovulation. Recent studies on mate preferences to masculine faces have not revealed a preference during peak fertility as evidenced by the estradiol to progesterone ratio (Marcinkowska et al., 2016, 2018a). Progesterone has shown to be predictive of masculinity preferences as a function of relationship status (Marcinkowska et al., 2018a). Partnered women's progesterone levels were related to a weaker preference for masculinity. Since increased progesterone level are associated with pregnancy (Gilbert, 2000), when progesterone is high, women may direct their attention to parenting instead of honest signals of good genes (Marcinkowska et al., 2018a). Although these studies have relied extensively on preferences tasks, such as choosing which face (i.e., masculine vs. feminine) is preferred, it is not yet understood if there are any hormonal influences in the way that women process these features visually.

Eye Tracking in Masculinity Preferences

Although previous research has depended on women's stated preferences for masculinity, eye tracking has provided researchers with a behavioral measurement of these preferences. Eye tracking is a sensitive gaze contingency technique that provides real-time visual processing, such as implicit and explicit measurements. Eye tracking procedures are advantageous over traditional preference tasks, as they are less susceptible to experimenter expectancy, they correlate with self-reported preferences, and they provide information to smaller features (i.e., regions of interest) that can help investigate the nuances associated with mate preferences (Krupp, 2008). Researchers have used eye-tracking metrics, such as first fixation duration, as an indicator of early-onset processing (Burris et al., 2014) when participants are unaware of their visual processing (Conklin, Pellicer-Sanchez, & Carrol, 2018). Eye tracking metrics, such as dwell time and fixation count, have been used as metrics associated with explicit (i.e., conscious) processing where participants are aware of the regions of interest (ROI) they are viewing. Visual time is a valid measure of sexual interest and arousal, and it can provide insight into the amount of attention to stimuli (Harris et al., 1996). Eye tracking research has been used to investigate sexual preferences and attention to men. In tracking visual attention to male body types varying in muscularity, women focused most of their visual attention to men who were muscular (Dixson et al., 2014). In addition to their viewing time of mesomorphic men, women viewed the abdomen region longer, suggesting that regions of interest associated with health and immunocompetence are important in mate preferences (Dixson et al., 2014). Women viewing men with different waist to chest ratios also showed that the midriff (i.e., abdomen) was a salient area of interest in assessing men's attractiveness (Garza et al., 2017, 2019). Consistent with the immunocompetence-handicap hypothesis (Folstad & Karter, 1999), women consider regions that signal immunocompetence important in making mate choice ratings.

Eye tracking research in women's assessments of sexually dimorphic (i.e., masculine/feminine) faces has been limited. In using both male and female participants in a Chinese sample, Wen and Zuo (2012) showed that participants fixated first at masculine faces, suggesting that masculine features are important in early visual processing. However, since their research combined data from both men and women in tracking their visual movements, it is likely that there were differences in the interpretation of masculine vs. feminine faces (i.e., men may perceive men as dominant/aggressive). In a similar study, albeit using masculinity and attractiveness, Yang et al. (2015) found that masculine faces were preferred for first fixation duration and total visual time, but it was dependent on their level of attractiveness. One study has assessed preferences towards sexually dimorphic faces accounting for hormonal contraceptive use, mating preferences, and partnered status. In using female participants only, Burris et al. (2014) found that women focused their visual attention to feminine rather than masculine faces using visual metrics that account for early stage (i.e., first fixation duration) and late stage (i.e., total dwell time) processing. However, given the differences that exist between Chinese and European populations in masculinity preferences, it can be argued that there are cultural differences in preferences, as both studies using Chinese populations found preferences for masculinity in eye tracking designs, while in a European sample, preferences were for feminine faces. Although not explored, one possible explanation for preferences in the Chinese and European study could be the role of population density. Denser populations may rely on heuristics and exaggerated dimorphic characteristics due to the frequent exchange of social encounters (Marcinkowksa et al., 2018b; Scott et al., 2014).

Given the nuances in detecting ovulatory shifts, one possible avenue to explore in preferences for masculinity would be to follow recommendations by Burris et al. (2014) and investigate visual preference at early (i.e., first fixation duration) and late stages (i.e., total time) of processing as a function of cycle phase. Studies exploring cyclic shifts using eye tracking have been inconsistent, as methods that have been used in detecting fertility have been limited. In using the counting method (i.e., counting the days from the onset of menstruation), Anderson et al. (2010) found that fertile women compared to unfertile women viewed attractive men longer, however, Garza et al. (2017) did not find a main effect for fertility status. Using more precise methods, but limited to tracking progesterone only, Garza & Byrd-Craven (2019) found that women overall view men longer when progesterone was low, which is an indicator of high conceptive probability. It is important to note that masculinity did not moderate the relationship between hormones and visual attention. Research using the forced choice rating (i.e., masculine vs. feminine faces) can incorporate eye tracking while accurately tracking fertility status using both estradiol and progesterone. In addition, aside from using self-report methods of mating context (e.g., Sociosexual Orientation), manipulating a mating context can tap into those underpinnings of preferences that are context dependent throughout the menstrual cycle. Therefore, predictions can be generated to state that women with a high estrogen to progesterone ratio will find masculine men more attractive and show an attentional bias when under a short-term mating context. These types of predictions can answer the question as to women's preferences for masculine men for both indirect and direct benefits.

Current Study

The current study aimed to address issues raised by previous studies investigating the ovulatory shift hypothesis by using an eye tracking paradigm to track women's visual preferences to sexually dimorphic faces. Although recent studies have not found an effect for fertility status using a forced choice task in preferences, the current study addressed if women's visual preferences shift during peak fertility by tracking eye movements across different times of the menstrual cycle. Therefore, this study addressed research questions raised by previous studies and answers whether shifts across the menstrual cycle are detected through eye movements (Burris et al., 2014).

Research questions are as follows:

1) Does fertility status moderate the relationship between sexual dimorphism and attraction/visual attention? It is hypothesized that as estradiol increases and progesterone decreases (i.e., high E/P ratio), women will rate masculine faces more attractive and display an attentional bias towards to masculine faces.

2) Do preferences for masculine features during peak fertility depend on mating context? As a direct test of the sexual strategies theory (Buss & Schmitt, 1993), we investigate if women have evolved psychological mechanisms for short- and long-term mate preferences by tracking visual attention to masculine and feminine faces in these different contexts. Research has suggested that women prefer masculine men for short-term relationships (Little et al., 2002, 2007, 2011), however, tracking progesterone and

estrogen has not been investigated using an eye tracking paradigm. It is hypothesized that women during peak fertility will display an attentional bias to masculine faces when considering men for a short-term relationship.

3) Does self-perceived attractiveness increase attention to masculine features? This question was raised as a method to increase the strength of eye tracking studies investigating preferences for masculine faces (Burris et al., 2014), and to account for individual differences. Therefore, in this study, it is predicted that women with a high perceived mate value may be more competitive for accessing men that display high quality traits. Women will display an attentional bias to masculine features as a function of their self-perceived attractiveness.

CHAPTER III

METHODOLOGY

The study and analysis plan were preregistered on the Open Science Framework (OSF), DOI 10.17605/OSF.IO/7HTVC.

Participants

A G*Power analysis in detecting a small to moderate effect size indicated a sample size of approximately 71 participants. Participants were eighty-one heterosexual women from Oklahoma State University (M_{age} = 19.27, SD_{age} = 2.83) who signed up on the university's SONA system to participate in the three-part study in exchange for course credit. Participants were only allowed to sign up for the study if they were not on any hormonal based birth control, were not pregnant, did not smoke, and identified primarily as heterosexual. The sample demographics were Caucasian (N = 55), African-American (N = 9), Hispanic (N = 5), Native-American (N = 5), Asian-American (N = 4), and Other (N = 2).

Materials

Sexually dimorphic faces. The sexually dimorphic stimuli used were from the London Face Lab, which include a composite of masculinized and feminized faces of the same individual that have been morphed to indicate -50% femininity and +50% masculinity (DeBruine et al., 2017).

Mating context prompts. Two mating context prompts adopted from Jones et al. (2018) were used to connote information on a short-term and long-term relationship. In the short-term-attractiveness test, women were given the following information: "You are looking for the type of person who would be attractive in a short-term relationship. This implies that the relationship may not last a long time. Examples of this type of relationship would include a single date accepted on the spur of the moment, an affair within a long-term relationship, and possibility of a one-night stand." In the long-term-attractiveness test, women were given the following information: "You are looking for the type of person who would be attractive in a long-term relationship. Examples of this type of relationship would include someone you may want to move in with, someone you may consider leaving a current partner to be with, and someone you may, at some point, wish to marry (or enter into a relationship on similar grounds as marriage)."

Sociosexual orientation (SOI-R). The sociosexual orientation (see Appendix A) is a 9-item inventory assessing attitudes towards restricted and unrestricted sexual attitudes and behaviors (Penke & Asendorpf, 2008). Sample items include statements such as, "Sex without love is ok", and participants respond from '1 = strongly disagree' to ‘9 = strongly disagree’. High scores represent attitudes in favor of unrestricted sexuality, while low scores represent attitudes in favor of restricted sexuality.

Mate value inventory. The mate value inventory (see Appendix B) is a 4 - item, 7- point Likert Scale assessing an individual’s self-perceived mate value (Edlund & Sagarin, 2014). The MVI includes statements such as, “Overall, how would you rate your overall desirability as a partner on the following scale?”, “Overall, how would members of the opposite sex rate your level of desirability as a partner on the following scale?”, “Overall, how do you believe you compare to other people in desirability as a partner on the following scale”, and “Overall, how good of a catch are you?”, where respondents choose from, ‘1 = extremely undesirable’, to ‘7 = extremely desirable’.

Sexual Desire. A 9-item sexual desire instrument was used to assess sexual desire throughout the three time sessions in women’s menstrual cycle. Adopted from Pillsworth, Haselton, and Buss (2004), the sexual desire scale presents statements, such as “Relative to other days…how sexy do you feel today?; …how many sexual fantasies have you had today?; and how physically attractive do you feel your body looks today?”. We used this assessment as previous literature has suggested that women’s overall sexual desire changes during peak fertility, rather than a change in sexual desire for extra-pair partners (Jones et al., 2019). By incorporating this instrument, we might be able to determine if visual processing is also influenced by changes in sexual desire.

Hormonal Assays. On the day of salivary analysis, saliva samples were thawed for 1 ½ hrs and then they were centrifuged at 1500rpm’s for 15 minutes. Estradiol and Progesterone were assayed using enzyme linked immunosorbent assays (ELISA) following Salimetrics protocols which required a serial dilution for standards and pipetting samples in duplicates (Estradiol: 100µL, Progesterone: 50µL). The standards for estradiol were 32 pg/µL, 16 pg/µL, 8 pg/µL, 4 pg/µL, 2 pg/µL, and 1 pg/µL, and for progesterone the standards were 2430 pg/µL , 810 pg/µL , 270 pg/µL , 90 pg/µL , 30 pg/µL, and pg/µL. After pipetting each plate, they were set aside for incubation for one hour, then were washed four times using a Bio-Tek plate washer. We added a TMB solution and incubated each assay for 30 minutes in the dark. This was followed by adding 50µL of the stop solution to each well and mixed for three minutes before being read using a Bio-Tek 808lx plate reader using the Gen5 software. The intra and inter-assay coefficient (CV) for progesterone was 6.68% and 5.64%, and 7.52% and 6.15% for estradiol.

Eye tracking metrics. Eye tracking data were recorded using a Tobii X2-60, which is a non-invasive eye tracking instrument that records eye movements at 60 frames per second (60hz). We used three eye tracking metrics, first fixation duration, total visit duration, and number of fixations. First fixation duration was defined as the duration of the first fixation on an interest area (i.e., feminine, masculine face) in milliseconds (ms), and it is often used as an eye tracking metric to indicate saliency upon first view or early-onset processing (Conklin et al., 2008). For late-onset processing, total visit duration and number of fixations were used. Total visit duration measures the duration of time spent on an interest area for each trial, and it is often used as a measure of late-onset or effortful processing (Conklin et al., 2008). The number of fixations (i.e., fixation count) is an eye tracking metric often used to complement total visit duration and it is an alternative method of considering attention (Conklin et al., 2008). The number of fixations is defined as the number of times a fixation is made on an interest area (i.e., feminine, masculine faces). Interest areas were created using the Tobii Lab Pro interest area creator, and we created two interest areas per trial, an interest area encompassing a masculine face and an interest area encompassing a feminine face.

Procedure

Women from Oklahoma State University signed up for the 3-part study using the university's SONA online study sign-up system. The study was announced as, "Attention to Male Images", and it included information as to the requirements in order to be eligible to sign up. A pre-screener was used to only sample participants who were female and primarily identified themselves as heterosexual. They were informed that before each session of the 3-part study, they could not have anything to eat 60 minutes prior to the study, and to choose a timeslot that was consistent throughout the sessions, such as choosing the same time period for each of the three sessions. Following from Marcinkowska et al. (2018a), participants were instructed to choose a time slot that corresponded to the early follicular phase (days 2-8), ovulation (no later than day 20), and luteal phase (last week of their menstrual cycle).

Upon entering the laboratory, participants were given a consent form (see Appendix C), which included information that was addressed on SONA, as well as additional information as to what participants could expect (i.e., demographic questions & surveys). Participants were notified that they would viewing images of men, and their task was to view the images and rate them. They were also informed of the different survey instruments that needed to be completed. Upon consent, participants provided saliva sample through passive drool collection using a saliva collection tube into a saliva collection vial (1.5mL). All participants provided a saliva sample within 1-3 minutes. No participant took over 3 minutes in providing a saliva sample. Once saliva collection was complete, it was stored in a -80°c freezer until the day of salivary analysis.

Participants were then instructed to sit in front of a computer screen where an eye tracking device was magnetically connected to the desktop (Tobii X2-60). The eye tracker was situated within 50cm of the participant to be able to record eye movements adequately. Before beginning the eye tracking study, participants performed a 5-point visual calibration test which consisted of following a red dot randomly across the screen to 5 positions. When complete with the calibration test, their eyes were checked again to ensure that they were centered on the computer screen, and then they were given instructions to the study. Participants were instructed that they were to view images of men and to view the images as they would any image on a computer screen. They were presented with 20 pairs of men for two separate blocks randomly ordered to include a masculinized or feminized version of the same male on either side of the presentation (see figure 1). They viewed each pair for 3000 ms before the screen refreshed and randomly presented another pair. For one block, they were given instructions to view the images of men as if they were looking for a short-term relationship, defined as a relationship that consisted of a one-night stand or casual encounter where no commitment was expected. For the other block, they were instructed to view the images of men as if they were looking for a partner for a long-term relationship, defined as a committed partnership, such as marriage or a relationship lasting month. The use of the mating context prompts was adopted from Jones et al. (2018). For each of the sessions, participants did not view the blocks in the same order. In total, they viewed 80 images per session.

Once complete with the eye tracking portion of the study, participants were instructed to rate the men for their perceived physical attractiveness using a Likert scale where '1 = unattractive' to '7 = extremely attractive'. They provided ratings for men under a short-term and long-term relationship context, in which they viewed each male image sequentially and not in pairs. They then completed a sociodemographic questionnaire which included items about their ethnicity and relationship status, the sociosexual orientation inventory (SOI-R), mate-value inventory, and sexual desire inventory. Participants were dismissed from the study, and were reminded to return for the subsequent parts (i.e., time 2 & 3). They were sent follow-up emails to remind them of sessions 2 and 3. For time sessions 2, participants were instructed to return no later than the 20^{th} day of their menstrual cycle, and for time session 3, they were instructed to return during the luteal phase of their menstrual cycle or the last week before menstruation.

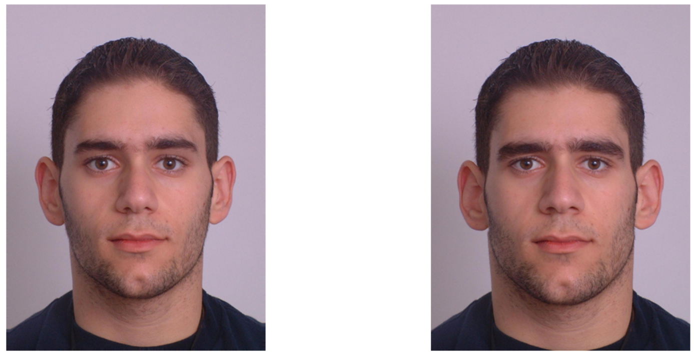

Figure 1. Presentation of a male face depicting a femininized (left) and masculinized (right) version.

CHAPTER IV

RESULTS

Statistical analyses

Data were analyzed using linear mixed-effects models with maximum likelihood using the packages *lme4* and *lmertest* (Bates et al., 2015) in *R* for dependent variables attractiveness, first fixation duration, total visit duration, and fixation count. Linear mixed-effects models are robust multilevel models that account for variation across subjects, trials, and time varying covariates (i.e., estradiol & progesterone). Since participants were asked to rate and view multiple images across multiple time points, linear mixed effects models are recommended for analyzing designs with multiple repeated observations over time. For each session, participants viewed 80 images (i.e., 40 pairs), which totaled 240 images for all three sessions. The mate value inventory and SOI-R were grand mean-centered for interpretation and multicollinearity purposes, and estradiol, progesterone, and E/P ratio were clustered mean centered around subject means to interpret within effects (Brauer & Curtin, 2017). Mating context (i.e., STM, LTM), facial masculinity (i.e., feminine, masculine), estradiol, progesterone, estradiol to progesterone ratio (i.e., E/P ratio), SOI-R, and mate value were entered as fixed factors, and participants and trials were entered as random effects. All models met the assumptions of normality of residuals and we performed qq-plots to test those assumptions. Outliers for visual time were screened at ± 2.50 z-scores from the mean. For all of our analyses, the $R^2_{Marginal}$ (i.e., fixed effects) and $R^2_{\mathrm{Conditional}}$ (i.e., random effects: subjects and trials) are reported for our total effect sizes for our models. $R^2_{Marginal}$ and $R^2_{\mathrm{Conditional}}$ effect sizes are to be interpreted as variance accounted for. All post-hoc analyses were conducted using a Bonferroni correction.

Descriptive statistics

Overall, women's average scores for the SOI-R score were, M = 25.76, SD = 12.36, mate value inventory, M = 20.51, SD = 12.36, and sexual desire inventory, M = 35.26, SD = 12.36. For estradiol and progesterone, we report the average hormone levels across the three sessions in table 1.

Table1. Raw hormone levels for estradiol, progesterone, and E/P ratio across the three sessions.

	Estradiol	Progesterone	E/P Ratio
Session 1	1.64 (1.60)	126 (85.8)	.01(.007)
Session 2	1.45 (.74)	149 (116)	.05 (.34)
Session 3	1.54 (1.05)	145 (93.9)	.01 (.008)

Attractiveness

For attractiveness, the overall variance explained in the model was, $R^2_{Marginal}$ = .05, $R^2_{Conditional}$ = .35. Women who were high on mate value rated all men lower on attractiveness compared to women who were low on mate value, b = -.04, t(3586.12) = 5.43, p < .001. Overall, ratings of attractiveness varied as a function of women's self-perceived mate value, but they were not influenced by sexual dimorphism, mating context, and hormonal levels. There were no other significant main effects or interactions.

First Fixation Duration

First fixation duration was defined as the average duration of the first fixation to a region of interest (i.e., feminine, masculine face), and it is often used as a measure indicating saliency upon first view. The overall variance explained from the model was, $R^2_{Marginal}$ = .02, and $R^2_{\text{Conditional}}$ = .19. There was a significant effect for mate value. Women who were high on mate value had longer first fixation durations compared to women who were low on mate value, b = 3.43, t(1070.03) = 3.86, p < .001. There was a significant effect for women's E/P ratio, b = -31.06, t(11440.29) = -2.25, p = .02. As women's E/P ratio increased their first fixation durations were shorter for all men's faces. Overall, first fixation durations varied as a function of women's self-perceived mate value, but they were not influenced by sexual dimorphism and mating context.

Total Visit Duration

Total visit duration was defined as the average amount of time spent viewing each region of interest (i.e., feminine, masculine face). The overall variance explained from the model was, $R^2_{Marginal}$ = .02, and $R^2_{Conditional}$ = .24. There was a significant effect for facial masculinity, b = 69.12, $t(77.99)$ = 3.48, p < .001. Pairwise comparisons revealed that women viewed masculine faces longer (M = 825, SE = 25) compared to feminine faces (M = 846, SE = 25). A main effect for mating context was significant, b = 85.73, $t(79.43)$ = 4.30, p < .001. Women viewed men longer when considering them for a short-term mating context (M = 891, SE = 25) compared to a long-term mating context (M = 840, SE = 24.9). This was further qualified by a facial masculinity by mating context interaction, b = 66.38, $t(78.75)$ = 2.35, p = .02. There were significant differences when viewing men's faces as a function of mating context, where women viewed masculine faces longer in a long-term mating context (M = 856, SE = 26.8) compared to feminine faces (M = 785, SE = 26.8), see figure 2. There was a significant interaction between mate value and facial masculinity, $F(1, 11534.2)$ = 8.53, p = .003. As women's mate value increased, their viewing time to masculine faces increased as well, b = 5.83, $t(11534.42)$ = 3.07, p =.002, see figure 3. There was a significant interaction between mating context and women's progesterone levels, b = -.39, $t(11539.72)$ = -2.46, p = .01. The interaction suggests that when women's progesterone increases, their visual attention to all men's faces decreases for short-term mating compared to long-term mating contexts, see figure 4. Overall, women viewed masculine faces longer during a long-term mating context. In addition, women's self-perceived mating value moderated the amount of visual attention given to sexual dimorphic faces, and to faces overall when considering mating context.

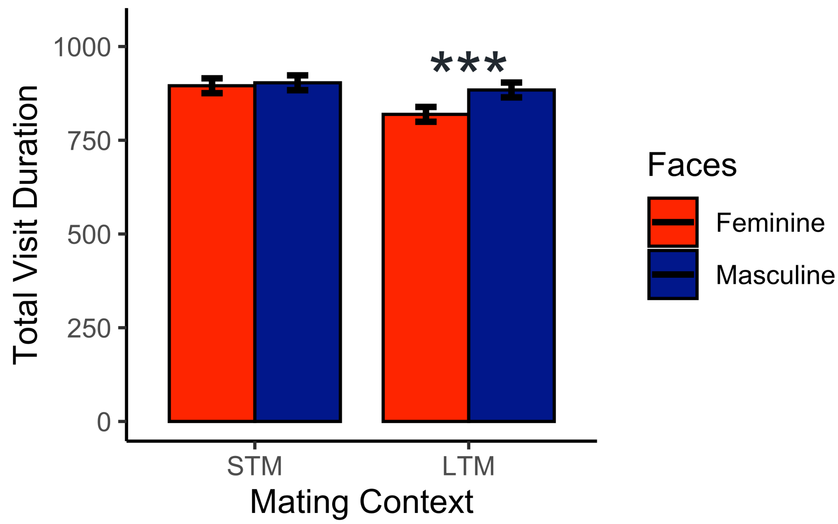

Figure 2. Women's total visit duration in milliseconds as a function of facial masculinity and mating context.

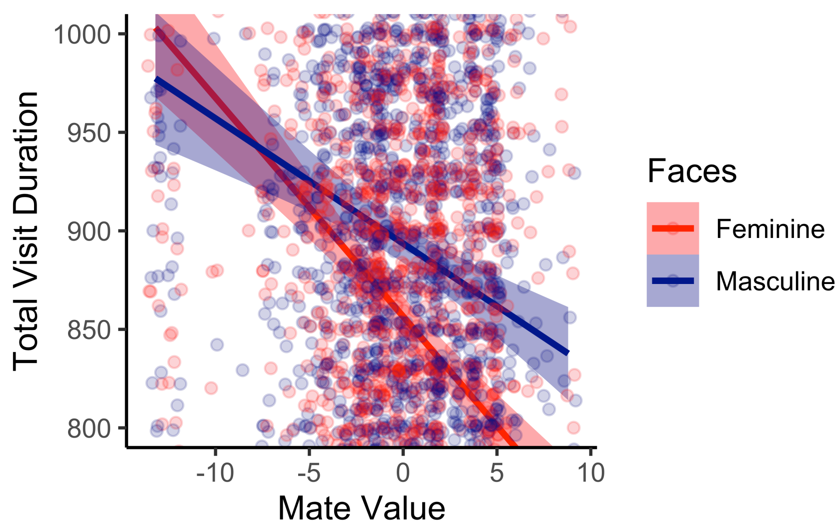

Figure 3. Interaction between women's self-perceived mate value (mean centered) and sexual dimorphism to total visit duration in milliseconds.

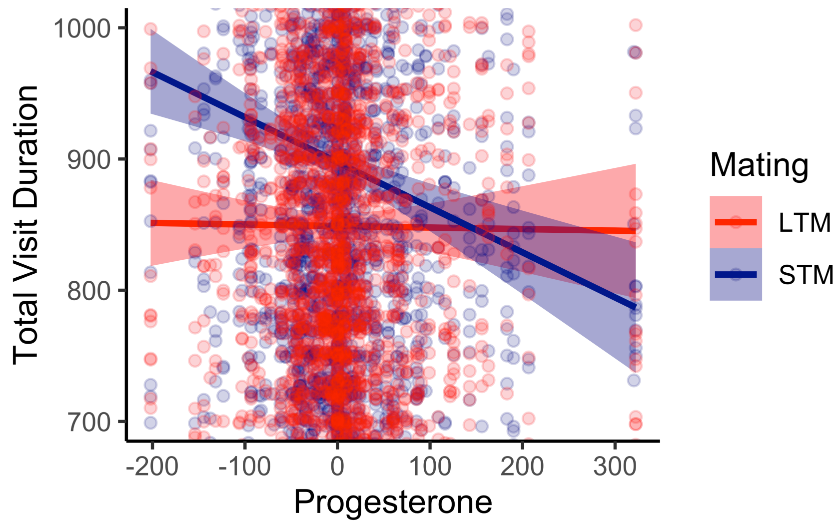

Figure 4. Interaction between women's progesterone levels (mean centered) and mating context predicting total visit duration in milliseconds.

Fixation Count

Fixation count was defined as the number of times a visit (i.e., eye movement) was made into a region of interest (i.e., feminine, masculine faces). The overall variance explained from the model was, $R^2_{Marginal}$ = .01, and $R^2_{\text{Conditional}}$ = .28. There was a significant effect for facial masculinity, *b* = .24, *t*(78.88) = 2.46, *p* = .03. Women made more visual fixations to masculine faces (*M* = 3.14, *SE* = .10) compared to feminine faces (*M* = 2.99, *SE* = 2.99). There was a significant effect for mate value, *b* = - .03, *t*(2778.09) = -3.15, *p* = .01. On average, high mate value women made fewer visual fixations compared to low mate value women. This was further qualified by a mate value by facial masculinity interaction. High mate value women made more visual fixations to masculine faces *b* = .02, *t*(11589.68) = 3.17, *p* < .001, compared to feminine faces, see figure 5.

There was a significant effect for estradiol, $b = .08$, $t(11597.61) = 2.53$, $p = .01$. Women at high levels of estradiol had higher visual fixations to all men compared to when their levels of estradiol were low.

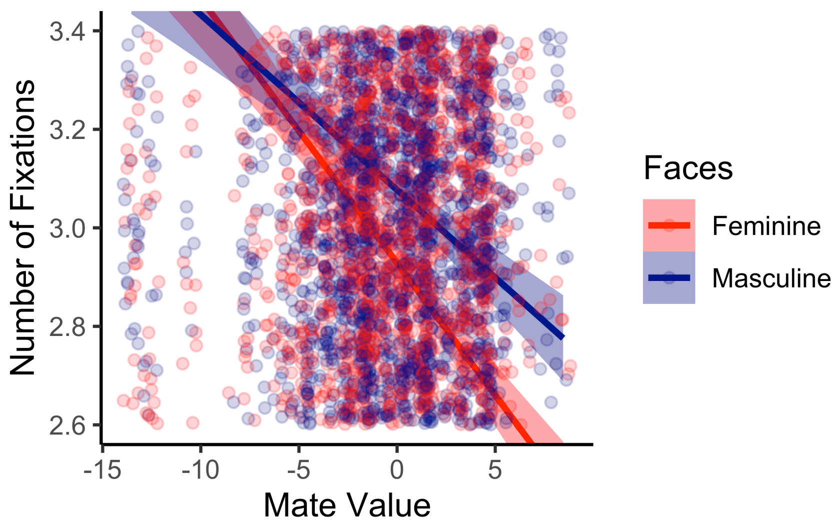

Figure 5. Interaction between women's self-perceived mate value (mean centered) and facial masculinity predicting number of fixations.

CHAPTER V

DISCUSSION

The current study investigated women's visual attention to facial masculinity across their menstrual cycle. Primarily, we tested if women during peak fertility viewed masculine faces longer compared to feminine faces. According to the ovulatory shift hypothesis (Gangestad & Haselton, 2015), women during peak ovulation may demonstrate a stronger preference for sexually dimorphic traits when conception is most optimal. Further, we considered women's preferences to sexually dimorphic faces under a short-term and long-term mating context, as according to sexual strategies theory, throughout ancestral history women have faced adaptive challenges in mate selection (Buss & Schmitt, 1993, 2019). That is, identifying suitable mates who will provide them with immediate resources and mates who are willing to invest long-term.

Our first hypothesis predicted that women during peak fertility would rate masculine faces more attractive and view them longer compared to feminine faces. This first hypothesis was not supported. Masculine faces were not rated more attractive than feminine faces, and there were no interactions with E/P ratio or estradiol and progesterone individually. Our second hypothesis predicted that visual attention to masculine faces would be moderated by mating context, where women during peak fertility would rate masculine faces as more attractive and view them longer during a short-term mating context. The hypothesis was partially supported; however, it was in the opposite direction. Although there were no significant effects for attractiveness, women did view masculine faces longer compared to feminine faces but for a long-term mating context. In addition, there was no support for women during peak fertility (i.e., high E/P ratio) viewing masculine men longer under a short-term mating context. Instead, there was partial support for the association between women's hormones (estradiol, progesterone, and E/P ratio) visual time. When women's E/P ratio was high, they made fewer first fixation durations to all men's faces compared to when their E/P ratio was low. Further, when women's progesterone levels were high, they viewed all men less when considering them for a short-term mating context compared to a long-term mating context. In addition, there were differences in visual fixations when looking at estradiol and progesterone individually. When women's estradiol was high, they made more visual fixations to all men. Lastly, our third hypothesis predicted that attraction and visual attention to sexually dimorphic faces would be moderated by women's self-perceived mate value. This hypothesis was partially supported. Women's self-perceived mate value did not predict attractiveness to masculine faces, but it was negatively associated with attractiveness ratings to all faces rated. Women with higher self-perceived mate value rated all faces lower on attractiveness than women with lower self-perceived mate value. Regarding visual attention, women's mate value was a consistent predictor for all of the eye tracking metrics (i.e., first fixation duration, total visit duration, and fixation count), where women with higher self-perceived mate value had fewer first fixation durations, total visit duration, and number of fixations to all men compared to women with lower self-perceived mate value. However, for both total visit duration and fixation count, the relationships between mate value and eye movements was moderated by facial masculinity. That is, as mate value increased, the differences in eye movements to masculine vs. feminine faces were significant, where high mate value women viewed masculine faces longer and made more visual fixations compared to low mate value women.

The findings of the current study do not support previous work suggesting that facial masculinity influences ratings of attractiveness (Cunningham et al., 1990; DeBruine et al., 2006; Grammer & Thornhill, 1994; Little et al., 2007). Masculine facial characteristics are said to be putative indicators of high-genetic quality due to the immunosuppression effects of testosterone; therefore, only healthy males can afford to signal the high sex-hormone handicap (Folstad & Karter, 1992; Little et al., 2011b; Zahavi, 1975). Masculine faces were not rated higher in attractiveness than feminine faces. This does not imply that facial masculinity is not important in women's mate preferences, as women have shown that their overall preferences to masculinity may be different than what they choose (Flegr et al., 2019). Previous studies have suggested that attractiveness to masculine faces may be influenced by mating context (Little et al., 2011), such as considering a mate for a short- vs. a long-term relationship. In using a mating context prompt, we did not find any differences in attractiveness for women rating men under different mating contexts. Rather, individual differences in self-perceived mate value were the best predictor of attractiveness overall.

In addition to ratings of attractiveness, the current study utilized sensitive gaze recording techniques (i.e., eye tracking) that may be able to capture subtle changes in attention to sexually dimorphic faces as a function of mating context and fertility status. Previous research using eye tracking methods have found that women demonstrate increased visual attention to masculine features, such as masculine bodies (Dixson et al., 2014; Garza & Byrd-Craven, 2019, 2020; Garza et al., 2016, 2017; Pazhoohi et al., 2019) and masculine faces (Wen & Zuo, 2012). Wen and Zuo (2012) demonstrated that first fixation durations were longer for masculine men, however, in the current study there were no first fixation duration differences as a function of facial masculinity, which is consistent with findings from Burris et al. (2014). However, in contrast to Burris et al. (2014), we did find that women's late-onset visual measures (i.e., total visit duration, fixation count) were longer for masculine faces rather than feminine faces. Further, we found that women's total visit duration was influenced by the interaction between facial masculinity and mating context, where women viewed masculine faces longer during a long-term mating context. Given that women were simply viewing paired images of men's faces, visual attention may not necessarily indicate that women found masculine faces more attractive, as demonstrated by the numerical ratings of attractiveness provided. Preferences for masculinity has been linked to women relying on heuristics to discern facial profiles, primarily in societies with high-developed health indices, such as the United States (Scott et al., 2014). It is plausible that women were relying on heuristics to discern facial masculinity, as testosterone levels may be higher in developed societies (Scott et al., 2014). Considering that facial masculinity has been associated with aggression, visual attention to masculine faces could possibly reflect attention to threatening faces or males that are successful intersexually (Mefodeva et al., 2020; Puts, 2010; Scott et al., 2014).

To our knowledge, this study is the first to demonstrate that women view masculine faces longer for a long-term mating context. This finding may be interpreted as women being attentive to features that connote both indirect (i.e., good genes) and direct benefits (i.e., protection, resource acquisition & transmission), which may be ideal attributes in seeking a partner for a long-term commitment. Little et al. (2007) demonstrated similar preferences when using a forced choice technique, where masculine preferences were higher for women considering men for a long-term partnership; however, in their study women were also taking into consideration ecological harshness, a condition not tested in this study. One consistent finding in the current study was women's mate value predicted attraction and visual attention. That is, mate value was negatively associated with ratings of attractiveness and visual attention to all men. However, in late-stage measures of attention (i.e., total visit duration, fixation count), there was more visual attention made to masculine faces compared to feminine faces as mate value increased in women. These findings indicate that high mate value women find salient differences in facial masculinity and it is highlighted by their differences in visual attention to men's faces and in the number of fixations made. This finding points to research suggesting that women high on attractiveness or mate value are more discriminating and may attempt to seek out mates of similar characteristics (i.e., physical features connoting attractiveness). Previous studies have demonstrated that women high on attractiveness prefer men with masculine characteristics (Buss & Shackelford, 2008; Penton-Voak et al., 2003). In line with the current study, eye tracking research has demonstrated that self-perceived attractiveness is a consistent predictor of men's bodily attractiveness and visual attention (Garza & Byrd-Craven, 2020).

The results of the study did not find any evidence suggesting that women during peak fertility prefer masculine faces. The ovulatory shift hypothesis suggests that women shift their preferences to men with putative markers of genetic quality (i.e., masculinity) during peak fertility. However, recent studies have not found robust evidence that women are shifting their preferences to masculine men (Jones et al., 2018; reviewed in Jones et al., 2019; Marcinkowska et al., 2018). The lack of evidence may have to do with the limited number of salivary samples (e.g., 3 in this study) provided and not confirming that ovulation has occurred. Using an eye-tracking paradigm, which is meant to capture subtle movements in visual attention, we did not find evidence that women's preferences to facial masculinity, either by attractiveness ratings or tracking eye movements, were influenced by hormonal fluctuations. That is not to say that such cyclic shifts do not exist, as women's hormone levels did influence visual attention to all men, but it was not dependent on sexual dimorphic features. For instance, women were not visually discriminating toward men for a short-term relationship at a time when conception was unlikely, as indicated by high levels of progesterone. Further, women's early-onset processing (i.e., first fixation durations) to all men's faces were longer when their E/P ratio was high, and they made more visual fixations to all men's faces when estradiol was high. These findings may suggest that increases in women's E/P ratio and estradiol serve to increase attention to men's faces as the stakes are higher in making a poor mate choice. Perhaps, cyclic shifts in women's preferences to men are more strategic and depend on a variety of factors not tested in the current study, such as relationship satisfaction (Marcinkowska et al., 2018a), body muscularity (Frederick & Haselton, 2007), or ecological harshness (Marcinkowska et al., 2018b). One eye tracking study showed that women's progesterone levels were negatively related to viewing men that were manipulated to display different degrees of muscularity (Garza & Byrd-Craven, 2019).

The study includes a few limitations that future studies can investigate and build upon using an eye tracking paradigm. First, although we did collect three time periods across the menstrual cycle, in order to capture true conception probability, research should investigate fertility status by collecting daily salivary samples in addition to luteinizing hormone kits to confirm actual ovulation in women. Second, relying on a non-diverse sample limits what can be tested according to theoretical frameworks proposed in trade-offs made by women. That is, it is unclear if college students are making similar trade-offs in choosing a masculine partner for a short or a long-term relationship. Ecological constraints, such as diverse socioeconomic statuses and different life histories make more salient trade-offs compared to women attending a university. University women have a dense mating pool and are surrounded by cues of safety, where seeking a mate that may demonstrate physical features associated with protection (i.e., masculinity) may not be a priority according to their local ecology. Women have shown to calibrate their preference to facial masculinity when considering ecological constraints whether they are experimental (Little et al., 2007) or actual constraints (Marcinkowska et al., 2018b). Given these differences in life histories that research has shown to influence preferences to facial masculinity, it is unclear if overall preferences to facial masculinity are due to their indications of putative indicators of high-quality genes or successful intrasexual competition (Little et al., 2013; Puts, 2010).

This study contributes to the overall literature on human mate choice. In addition, it adds a different approach in studying the nuanced factors associated with women's cyclic shifts and preferences for sexually dimorphic features. By using an eye tracking paradigm, the overall goal was to determine if the ovulatory shift hypothesis could be supported using real-time measures, such as tracking eye movements to men's facial masculinity. Although there was no strong evidence to suggest that women's visual attention shifted during peak fertility (i.e., high E/P ratio), there were indications that women's hormone levels (i.e., estradiol, progesterone, E/P ratio) predicted visual time to all men's faces. This may suggest these biomarkers play a supportive role in examining men's faces when considering them under a particular mating context. Although, it is very unlikely that women will view the same male with feminine and masculine facial traits in an actual mating context, women do make quick decisions when considering potential mates in a real-world setting, such as in social gatherings, using mobile base dating apps (e.g., Tinder), and in speed dating (Todd et al., 2007).

In summary, women's visual attention to facial masculinity was dependent upon a long-term mating context, and it was further influenced by women's own mate value. According to sexual strategies theory, women may calibrate their mate preferences as a function of their own mate value, and in this study, we find support for women's visual attention becoming more discriminant to masculine faces as mate value increased. We did not find any evidence to suggest that fertility status influenced visual attention to facial masculinity, but there was support that hormones to influence visual attention to all men. This may indicate that there are biological underpinnings to the way that women strategically view men when considering them for a potential mate. Further work is needed to disentangle the role of hormones and their role in the cognitive processes of mate choice. Expanding work on the cognitive processes in mate choice can further the field by understanding the attentional processes in facial evaluations and by considering the biological underpinnings associated in mate preferences.

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APPENDIX A

The revised Sociosexual Orientation Inventory (SOI-R)

Please respond honestly to the following questions:

1. With how many different partners have you had sex within the past 12 months?

0, 1, 2, 3, 4, 5-6, 7-9, 10-19, 20or more

2. With how many different partners have you had sexual intercourse on one and only one occasion?

0, 1, 2, 3, 4, 5-6, 7-9, 10-19, 20or more

3. With how many different partners have you had sexual intercourse without having an interest in a long-term committed relationship with this person?

0, 1, 2, 3, 4, 5-6, 7-9, 10-19, 20or more

4. Sex without love is OK. 123456789

Strongly disagree =1, Strongly agree = 9

5. I can imagine myself being comfortable and enjoying "casual" sex with different partners.

Strongly disagree =1, Strongly agree = 9

6. I do not want to have sex with a person until I am sure that we will have a long-term, serious relationship.

Strongly disagree = 1, Strongly agree = 9

7. How often do you have fantasies about having sex with someone you are not in a committed romantic relationship with?

   1 – never
   2 – very seldom

3 – about once every two or three months 4 – about once a month
5 – about once every two weeks
6 – about once a week
7 – several times per week
8 – nearly every day
9 – at least once a day

8. How often do you experience sexual arousal when you are in contact with someone you are not in a committed romantic relationship with?

    1 – never
    2 – very seldom
    3 – about once every two or three months 4 – about once a month
    5 – about once every two weeks
    6 – about once a week
    7 – several times per week
    8 – nearly every day
    9 – at least once a day

9. In everyday life, how often do you have spontaneous fantasies about having sex with someone you have just met?

    1 – never
    2 – very seldom
    3 – about once every two or three months 4 – about once a month
    5 – about once every two weeks
    6 – about once a week
    7 – several times per week
    8 – nearly every day
    9 – at least once a day

APPENDIX B

Mate-Value Inventory

Overall, how would you rate your level of desirability as a partner on the following scale?

1 = extremely undesirable, 7 = extremely desirable

Overall, how would members of the opposite sex rate your level of desirability as a partner on the following scale?

1 = extremely undesirable, 7 = extremely desirable

Overall, how do you believe you compare to other people in desirability as a partner on the following scale?

1= very much lower than average, 7 = very much higher than average

Overall, how good of a catch are you?

1= very bad catch, 7 = very good catch

APPENDIX C

Oklahoma State University
Department of Psychology

CONSENT TO ACT AS A RESEARCH PARTICIPANT

The purpose of this study is to find out more about the psychological and biological factors contributing to our understanding of attractiveness. By signing below, you are submitting your written authorization for participation in this study.

VOLUNTARY: This study is completely voluntary. You may refuse to answer any questions or choose to withdraw from participation at any time without penalty or loss of benefits to which you are otherwise entitled.

WHAT DO YOU DO? If you agree to participate, you will be asked to participate in three sessions lasting approximately 30 minutes each. The things that may happen during the study are the following:

1. You will be asked questions about your menstrual cycle.
2. You will be asked to submit a saliva sample. Saliva samples will be analyzed for progesterone and estradiol, a hormone that naturally fluctuates throughout the menstrual cycle. Any remaining saliva after the analysis will be discarded.
3. You will be asked to complete the SOI-R, which is an inventory about preferences in sexual relationships.
4. You will be asked to complete the Mate-Value and Components of Self-Perceived Mate Value scale, which are inventories about one's perception of their attractiveness.
5. You will be asked to complete the Mini-K, which is an inventory about one's overall life history.
6. Your eye-movements will be measured as you scan photographs of male faces presented in pairs in the computer screen.
7. You will be asked to rate the attractiveness of each photograph.

COVID-PRECAUTION: Due to COVID-19, we have taken all the necessary steps to reduce any risk of exposure by conducting the following: 1). All equipment in the laboratory has been thoroughly cleaned, 2). All research assistants will be wearing PPE masks, 3). All research assistants will be practicing social distancing, 4). There will only be 1 research assistant at a time with a participant, 5). Saliva collection will be provided by the participant, and research assistants will be wearing gloves when transporting saliva to the wet lab, and 6). The participant is only expected to remove their masks when providing saliva.

RISKS: This project does not involve the experience of stressors greater than those encountered during everyday life or in the course of a routine medical examination. If you begin to experience discomfort or stress during this project, you may end your participation at any time.

BENEFITS: Participating in this project will not result in any direct benefits to you. However, your participation in this research study will help improve our understanding of the psychological and biological factors contributing to our understanding of attractiveness. The experience of participating in this experiment will be educational for the field of Cognitive Science and Evolutionary Psychology.

COMPENSATION: Participants will be compensated 3 SONA credits for completing both sessions.

CONFIDENTIALITY: The records of this study will be kept private. Your answers are completely confidential, and will not be revealed to anyone other than the researchers conducting the study. You will be given an arbitrary number for the purpose of data collection. Only this participant identification number will link you to data you provide. Therefore, your name will not appear on the survey or in the published study itself, maintaining your confidentiality. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. There will be no future use of biospecimens as they will be discarded after analysis and will not be identifiable. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

CONTACTS: If you have any questions about this study you may contact the researchers. They are: 1) Ray Garza, 315 Psychology Building, Department of Psychology, Oklahoma State University, Stillwater OK, 74078, ragarza@okstate.edu; and 2) Jennifer Byrd-Craven, Ph.D., jennifer.byrd.craven@okstate.edu, (405) 744-2914, 116 Psychology Building, Dept. of Psychology, Oklahoma State University, Stillwater, OK 74078. If you have questions about your rights as a research volunteer, you may contact the IRB office, at 223 Scott Hall, Stillwater, OK, 74078, 405-744-3377, or irb@okstate.edu

I have received a copy of this consent document to keep. I agree to participate in the study.

____ __________ ________________

Subject's Signature Age Date

____ ____________

Signature of Investigator/Research Assistant Date

APPENDIX D

Date:
Application Number: Proposal Title:

Principal Investigator: Co-Investigator(s): Faculty Adviser: Project Coordinator: Research Assistant(s):

Processed as: Expedited Category:

09/03/2019
AS-19-95
Attraction to Men and Menstrual Cycle Study

Ray Garza
Jennifer Craven, Ph.D.

Expedited

Oklahoma State University Institutional Review Board

Status Recommended by Reviewer(s): Approved Approval Date: 09/03/2019

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent, and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:
1. Conduct this study exactly as it has been approved. Any modifications to the research protocol

must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.

2. Submit a status report to the IRB when requested
3. Promptly report to the IRB any harm experienced by a participant that is both unanticipated and

related per IRB policy.
4. Maintain accurate and complete study records for evaluation by the OSU IRB and, if applicable,

inspection by regulatory agencies and/or the study sponsor.
5. Notify the IRB office when your research project is complete or when you are no longer affiliated

with Oklahoma State University.

If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

VITA

Ray Garza

Candidate for the Degree of

Doctor of Philosophy

Dissertation: HORMONAL INFLUENCES ON ATTRACTION AND VISUAL ATTENTION TO FACIAL MASCULINITY

Major Field: Psychology

Biographical:

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Completed the requirements for the Doctor of Philosophy in Psychology at Oklahoma State University, Stillwater, Oklahoma in May, 2021.

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Research
Psychophysiological Data Collection and Analysis

Professional Memberships:
Association of Psychological Science
Psychonomic Society
Society for Neuroscience
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