

Offspring Sex, Dominance, and Mating Behavior: Examining Evolutionary Mechanisms in Men and Women

by

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Abstract

Several lines of evidence suggest that parental dominance at conception results in male-biased sex ratios, but no studies have investigated the relationship between dominance and mate preferences in altering offspring sex in humans. Thus, the goals of my dissertation were to examine whether: a) dominance behavior, sexual restrictiveness, self-perceived masculinity and femininity, digit ratios, and hormone levels in men and women who had not yet had children were associated with their predicted sexes of future offspring (Studies 1 and 2); b) predictions for future offspring sex affected men and women's mate preferences for dominance in the opposite-sex (Study 2); c) men and women's predictions for future offspring sex were detectable in their facial characteristics (Study 3); and d) the sex of first-born offspring in actual parents was related to their dominance behavior, facial characteristics, and mate choice. The results of these studies provide partial evidence for the hypothesis that maternal dominance characteristics are related to the probability of male offspring, and that this is related to preferences for dominant male mates. Implications of these findings are discussed in the context of sex determination, parental ability to maximize their reproductive success through offspring, and sexual selection for male dominance and its associated characteristics.

Keywords: Trivers and Willard Hypothesis; Maternal Dominance Hypothesis; testosterone; estradiol; dominance; mate preferences;

Dedication

This dissertation is dedicated to anyone whose path has turned out less straight than she'd planned.

Take heart! I've learned that the deviations are gifts and the detours are blessings.

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List of Acronyms

2D:4D	Digit ratio; ratio of the length of the second digit to the length of the fourth digit of the hand
AD	Aggressive Dominance subscale
BSRI	Bem Sex Role Inventory
D-IPIP	Dominance subscale of the International Personality Item Pool
E ₂	Estradiol
MDH	Maternal Dominance Hypothesis
SAT	Subjective Adjective Test
SD	Social Dominance subscale
SOI	Sociosexual Orientation Inventory
T	Testosterone
TWH	Trivers-Willard Hypothesis
WHR	Waist to hip ratio; ratio of the circumference of the waist to the circumference of the hip

Chapter 1.

Introduction

Seemingly biased offspring sex ratios are commonly observed in our every day lives; families who seem to produce only sons, or only daughters are all around us. Although sex determination is commonly understood to be the product of simple chance, with an equal likelihood of either an X- or Y-chromosome bearing sperm from the father fusing with an X-bearing ovum from the mother, beliefs from folk psychology about our ability to predict or assess the sexes of parents' offspring, such as through observations of parent physical attributes or personality characteristics, pervade human societies. Interestingly, evolutionary theorists have suggested that parents may actually be able to influence the sexes of their offspring, with a bias towards the production of the sex whose reproductive success will benefit most from inheriting parental quality or condition. Thus, our beliefs about the tendency of parents to produce one sex of offspring over the other actually may have some biological foundation: parents who exhibit traits that we associate with being beneficial to sons, or daughters, might actually be more likely to produce that sex. Further, we may have evolved the capacity to perceive some aspect of these processes in ourselves, so as to motivate us to seek mates that would confer sex-appropriate benefits on our future offspring. Although grounded in the available research, these possibilities have not been directly studied. Thus, the goal of this dissertation is to provide an in-depth analysis of the ways in which physiological and psychological characteristics of parents might be involved in variation of their offspring sex ratios.

1.1. Variation in Human Sex Ratios

Although cultural and societal preferences for male offspring are strong and pervasive in some countries (reviewed in Dahl & Moretti, 2008; Hank, 2007; reviewed in

Hesketh & Xing, 2006; Marleau & Saucier, 2002; Ray, Henry, & Urquia, 2012), in most other places, including Canada, the sex ratio of infants at birth remains virtually unchanged at approximately 105-107 males to 100 females (Hesketh & Xing, 2006; Statistics Canada, 2013). This reality alone provides ample evidence of explanations other than chance to account for sex determination; however, several other factors have been identified. During and immediately following wars, for example, many studies have reported spikes in the number of male births recorded (e.g., MacMahon & Pugh, 1954; reviewed in James, 2009). Similarly, skewed sex ratios have been observed in parents with medical conditions (e.g., cancer), parents who have been exposed to environmental toxins, parents who suffer from psychological distress, and parents of specific career orientations (reviewed in James, 1996, 2004, 2008), as well as mothers who are more dominant (Grant, 1990, 1994). Taken together with curious examples in our everyday lives, these results indicate that sex determination in humans is unlikely to be completely random. The problem that remains, then, is determining the exact relationships between the environmental and biological factors that lead to skewed sex ratios.

Statisticians have been interested in classifying sex ratios as well as their deviations from the expected binomial distribution for decades; however, there remains little consensus as to why and how variation occurs. James (2000) explained that variation in the probability of a male (or female) birth likely exists both between (i.e. higher probability of some couples to produce sons, higher probability of some couples to produce daughters) and within couples (i.e. different probability of producing a son (or daughter) with each birth), the latter of which is virtually impossible to measure and analyze by inspection of population ratios. The difficulty in assessing variability within couples is likely why such disparity exists within the literature.

An additional difficulty in interpreting sex ratio variation at the population level is that, especially in modern societies, families are limited in size by parental behaviors associated with whether or not to have additional children (subsequently referred to as 'stopping rules'). For example, Stansfield & Carlton (2007) showed that two-child families with one of each sex are significantly less likely to have a third child than those with two of the same sex, which not only indicates the pervasiveness of parental preferences for offspring sexes, but also demonstrates that such stopping rules can have a dramatic

effect on population-based estimates. Similarly, the decision by most parents in Western countries to only have 2 children largely limits the power of statistical models in their ability to show variation between and within couples compared to chance probability. Large-scale samples are also limited in their ability to reflect other important factors, such as extra-marital conceptions. Thus, although considerable evidence for natural variation in offspring sex ratios exists, statistical limitations as well as human factors such as stopping rules make it difficult, if not impossible to adequately assess the mechanisms behind it. Investigation at the level of the individual or family will therefore be an important step in attempting to make holistic assessments and explanations of sex ratio variation.

1.2. Parental Variation of Offspring Sex: the Trivers and Willard Hypothesis

Evolutionary theory proposes that the ability of individual parents to vary the sexes of their offspring would be adaptive, as it would allow for them to maximize their own reproductive success. Trivers and Willard (1973) predicted that some aspect of parental condition should lead to the differential production of, or investment in, male or female offspring. Specifically, this hypothesis predicts that parents in good condition should produce more sons, as sons who inherited the good condition would be better able to access mates and successfully reproduce than sons who inherited poor condition. In contrast, the Trivers-Willard hypothesis (TWH) would predict that parents in poor condition should produce more daughters, as the mating success of daughters would be less dependent on condition than in sons. In other words by producing the sex of offspring that would benefit most from parental condition, parents could ensure their genes were passed on to successive generations most effectively. Perhaps the most convincing evidence of parental sex ratio bias comes from research investigating social and psychological factors, suggesting an important and potentially functional role for inter- and intra-sexual behavior in altering sex ratios.

1.2.1. Evidence of the TWH in Non-human Animals and Humans

Sex ratio phenomena in a wide variety of mammalian taxa are generally supportive of the TWH (Cameron, 2004), but it is important to note that the data, particularly for primates, has not always been consistent (reviewed in Brown, 2001; Clutton-Brock & Iason, 1986; Hewison & Gaillard, 1999; Hiraiwa-Hasegawa, 1993). One possible reason for the lack of consistency is that Trivers and Willard (1973) failed to provide an explicit definition of 'condition', which has led numerous researchers to focus on physiological characteristics (e.g., body size, nutritional status) rather than behavioral characteristics of parents. In addition, a common limitation in the literature is the timing with which parental characteristics are measured (Cameron, 2004). Specifically, Sheldon and West (2004) have proposed that behavioral measures, such as dominance, or the ability to acquire mates or resources over another individual, prior to conception, are more important indicators of parent condition.

Apart from a few notable exceptions where more female-biased sex ratios were observed (e.g., Simpson & Simpson, 1982; Silk, 1988), many studies investigating maternal dominance in primates have confirmed a male bias in the offspring sex ratios of high-ranking mothers. For example, in a polygynous population of Barbary macaques (*Macaca sylvanus*), Paul and Keuster (1990) found that females with high social rank at conception produced more sons than females with low social rank. In addition, high-ranking females attained greater reproductive success through their sons, who produced significantly more offspring than the sons produced by low-ranking females (Paul & Keuster, 1990; Paul, Kuester, & Arnemann, 1992). Similarly, sons of high-ranking female Rhesus monkeys (*Macaca mulatta*) were significantly more likely to survive to age of reproduction than sons of low-ranking females (Meikle & Vessey, 1988). No differences in survivorship were observed between daughters of mothers of either rank, confirming the predictions of the TWH that mothers in poor condition maximize their reproductive success through the production of daughters.

In humans, both physiological and psychological characteristics of parents have been associated with offspring sex ratio. Parents of sons tend to exhibit characteristics that are associated with male reproductive success. For example, using a large demographic database, Kanazawa (2005) found that parents who were taller and

heavier, traits associated with male reproductive success (e.g., Pawlowski, Dunbar, & Lipowicz, 2000) had more sons than shorter and lighter parents did. In addition, Manning, Martin, Trivers, and Soler (2002) found that parents from two different populations (i.e., Jamaican and British) who exhibited lower (i.e., more masculine) ratios of the 2nd to the 4th digit of their hands (2D:4D) had more sons than daughters. Interestingly, lower 2D:4D in males has also been shown to indicate dominance and masculinity to others (Neave, Laing, Fink, & Manning, 2003) as well as to correlate with self-reported physical attractiveness (Manning & Quinton, 2007), all of which may be considered attractive by females for potential male mates.

Parents of sons also tend to exhibit behaviors that are associated with male reproductive success. For example, Cameron and Dalerum (2009) found that male billionaires, a group typically identified with achievement and status, produced more sons than daughters, and that the sons of billionaires produced more offspring than daughters of billionaires. This finding supports the prediction that parents in 'good condition' can increase their reproductive success through sons. Interestingly, though, they also found that women married to billionaires had higher sex ratios (i.e., more male-biased) than women who were themselves billionaires, and that sex ratios did not differ between men whose money was earned versus inherited, suggesting that biased offspring sex ratio may not be directly related to high personal achievement. One possible alternative is that more dominant women may be more likely to marry billionaires than less dominant women, and thus, offspring sex ratios would tend to be male-biased in this population.

Although relatively fewer studies have investigated characteristics associated with female reproductive success, using retrospective reports by others regarding the attractiveness of mothers and fathers, Kanazawa (2007, 2011) (but see Gelman, 2007) showed that those rated as more physically attractive had more first-born daughters than those rated less physically attractive. Similarly, in a study using facial photographs of mothers, fathers, and their daughters and sons, Cornwell and Perrett (2008) found that ratings by others of mother and father attractiveness were both significant predictors of ratings of daughter attractiveness, suggesting that facial attractiveness is inherited from parent to female offspring. No significant relationships were found between parent

attractiveness and son attractiveness. This makes sense given that males value female physical attractiveness very highly in consideration of a potential mate (see Buss, 2007), which would potentially enhance her reproductive success to a greater degree than it would for males.

It is important to note that TWH did not predict significant associations between condition and female reproductive success, as in populations where males exhibit higher degrees of competition for mates, it is likely to be unaffected by variation in condition. However, in humans, it remains unclear whether males actually do compete more than females for mates. Given that most modern human populations are monogamous, seeking a long-term mate with which to raise offspring, it is likely that both sexes are choosy. More recent theories have included both male and female reproductive success in their models of parental offspring sex ratio variation. Kanazawa (2005) proposed the generalized Trivers and Willard Hypothesis, which posits that any trait or characteristic that varies and is associated with enhanced reproductive success in either males or females, should be higher in parents of males or females respectively. Thus, it may be that parents exhibiting characteristics important for female mating are also important in influencing offspring sex ratios according to TWH.

Taken together, the results of studies that have investigated the association between physiological and psychological characteristics in humans suggest that both parents can potentially enhance the reproductive success (RS) of their children in directions specific to the predictions of Trivers and Willard (1973). Mechanisms through which these characteristics are related to the direct manipulation of sex ratio remain unknown, but interestingly, many of them are hormonally mediated, suggesting an important role for hormones in parental variation of the sex ratio.

1.3. Parental Variation of the Sex Ratio: The Role of Steroid Hormones

Decades worth of studies have been conducted in attempt to explain a mechanism that could influence sex determination. Perhaps the most plausible of these implicate parental hormone levels, which have a fundamental role in many important

reproductive and mating characteristics in men and women. James (1986) proposed that high levels of testosterone (T) and estradiol (E_2) in both the mother and the father increase the probability of a male, and that high levels of gonadotropins (luteinizing hormone, follicle stimulating hormone) increase the probability of a female birth, but has been unable to provide direct evidence of this mechanism. Grant (1998), on the other hand, has proposed that the effects of steroid hormones on sex determination are much more specific, with T levels in the mother, and not the father, directing the probability of male offspring. Several follow up studies have shown that higher maternal T, as measured from bovine follicular fluid obtained during ova maturation, increases the probability of a male embryo (Grant et al., 2005, Grant et al., 2008), and experimentally increased T in birds prior to mating, increases the sex ratio of female offspring (Veiga et al., 2004), confirming that this is indeed a plausible mechanism for biological alteration of sex ratio.

1.3.1. Parental Hormones

The original TWH predicts that both parents should be able to bias their offspring sex ratios. Throughout the past three decades, James (1986, 1996, 2004, 2008) has provided a plethora of epidemiological evidence in support of this theory. For example, lower sex ratios (i.e., female biased) have been shown in populations of women who were treated for infertility with gonadotropins, in populations of men exposed to pesticides that increase gonadotropin levels (reviewed in James, 1996), in populations of men with testicular cancer (who also have high gonadotropin and low T levels), and in populations of men who are professional drivers, professional divers, and pilots (all of whom exhibit low T and high gonadotropin levels) (reviewed in James, 2004). Similarly, higher offspring sex ratios (i.e., male biased) have been shown in populations of women diagnosed with multiple sclerosis (which is associated with enlarged adrenal glands, and subsequently higher T levels) and men and women with human papillomavirus (hypothesized to coincide with increased T levels) (reviewed in James, 2004). Interestingly, significantly lower offspring sex ratios have also been reported in female rodents who developed prenatally in between two other females compared to female rodents who develop prenatally in between two males, the latter of which is exposed to more T (Vandenbergh & Huggett, 1994). Similar results were also obtained in female

spotless starlings (*Sturnus unicolor*), who following experimental implantation of T prior to mating, produced significantly male-biased clutches. Interestingly this bias persisted for three mating seasons, suggesting that the effects of initially high levels of T could have a lasting effect on offspring sex. Thus, exposure to differential levels of gonadotropins, E₂, and T appear to affect offspring sex ratios in both males and females.

Despite the results in support of James' hypothesis, it is important to note that the majority of this evidence comes from correlational work obtained through large database samples of pathological populations. Thus, it is limited by a lack of experimental control and attention to various personal factors that could have influenced the results, and is ultimately limited in its generalizability to otherwise naturally reproducing groups. Similarly, this theory is mute with respect to the biological mechanism through which naturally occurring parental hormones could actually alter offspring sex ratios, particularly for fathers. Although it is possible that paternal hormones could directly alter some component of the reproductive process, such as sperm composition, or chemical composition of the reproductive tract (James, 1997), this has not been directly studied.

1.3.2. Maternal Dominance Hypothesis (MDH)

In contrast to James (1987), the MDH (Grant, 1998) predicts that it is the maternal hormonal environment that is directly responsible for affecting sex ratios at conception. Specifically, the MDH proposes that higher maternal levels of testosterone (T) increase the likelihood of an ovum being fertilized by a Y-bearing chromosome. Grant and Irwin (2008) showed that follicles containing higher levels of T, but not estradiol (E₂), were more likely to later develop into male embryos. Interestingly, though, this was true for subordinate follicles rather than dominant follicles, suggesting that the influence of T takes place early in follicle maturation. In a subsequent study with a larger sample size, Grant, Irwin, Standley, Shelling, and Chamley (2008) replicated this finding, providing additional support for the role of T in altering offspring sex, and the possibility that both genetic and environmental factors exclusive to mothers could be directly involved in this mechanism.

In males, it has been relatively well established that T levels fluctuate in response to social challenge, such as intrasexual competition for territory or mate. Specifically, successful outcomes result in increases in T levels, whereas non-successful outcomes result in decreases in T levels (Wingfield, Hegner, Dufty, & Ball, 1990). The key component to successful outcomes in response to social challenge, though, is behavioral dominance. Dominance facilitates successful competition, which also increases T. Losing a competition, in contrast, reduces T, which in turn reduces dominance. The MDH proposes that although T levels in females are substantially lower than that of males, the relationship between T and dominance works in much the same way. Thus, more dominant women should have higher T and subsequently conceive more sons than daughters, whereas less dominant women should have lower T and subsequently conceive more daughters than sons. Interestingly, dominant mothers have been shown to have more sons than daughters (Akande, 1999; Grant, 1990, 1994), and Grant and France (2001) found that women who scored higher in dominance had higher serum T than those who scored lower, providing support for this prediction. The MDH also adequately explains variation within couples in the probability of a son, because the reliance of dominance on interactions with the environment implies that it, as well as T levels, will be dynamic, changing depending on the mother's current psychological state. Furthermore, variation in women's genetic tendency to produce T (i.e., high, average, low), combined with her current T levels, would both predict the likelihood of a given woman conceiving a son. Interestingly, this also explains how certain couples might only produce one sex compared to the other.

In addition to its elegance in describing the potential mechanism of sex ratio variation, the MDH also proposes a conduit through which mother's traits would beneficially influence her son's reproductive success. Although few studies have directly studied the effects of T in women, there is an abundance of literature providing indirect evidence that maternal T could influence the characteristics of male offspring. First, recent work has shown that T variation in men is related to markers located on the X-chromosome (Ohlsson et al., 2011), suggesting that the production of T in males is at least partially inherited from their mother. Second, various traits that are considered beneficial to males in either intra- or inter-sexual encounters are found in women with higher offspring sex ratios. More dominant women have more sons, and more dominant

men are more successful in their careers (Mueller & Mazur, 1997), and may be considered attractive to females (e.g., Fink, Neave, & Seydel, 2007, but see Perrett et al., 1998). Similarly, women with higher waist-to-hip ratios (WHR), lower (i.e., more masculine) 2D:4D ratios, and taller and heavier bodies, all of which are associated with T, have significantly more sons than daughters (Kanazawa, 2005; Manning, Anderton, & Washington, 1996; Manning et al., 2002; Manning, Trivers, Singh, & Thornhill, 1999; Singh & Zambarano, 1997). It may be, then, that maternal T influences the probability of conceiving a son and maximizes a woman's reproductive success by conferring associated traits on her sons.

1.3.3. Whose Hormones Control Offspring Sex Ratios?

Both James's parental hormone hypothesis and the MDH present interesting and valuable explanations for how parents might bias offspring sex ratios; however, they differ in the relative contribution of fathers in this relationship. Whereas the parental hormone hypothesis suggests that both parents have direct influences on offspring sex, the MDH proposes that this influence is the exclusive domain of the mother. Through the possible provision of genetic markers that influence T production in male offspring, as well as the potential behavioral influence through dominance that could result in epigenetic influences on male behavior, the MDH provides a more comprehensive theory for explaining parental ability to vary the sexes of their offspring. It may be, then, that the evidence in support of paternal T in producing sons is an indirect result. In other words, fathers who produce sons may do so as a result of their being mated to more dominant mothers, rather than having any direct influence on sex ratios themselves. On the other hand, research investigating the role of paternal characteristics, including hormone levels pre-conception, is almost nonexistent, making it difficult to accurately determine the relative contribution of each parent to offspring sex ratio manipulation. Therefore, the potentially important relationships between parental characteristics, mate preferences, and offspring sex ratio in this context warrant further study.

1.4. Human Mating and Offspring Sex Ratio

Human mating behavior involves sexual selection, or the evolution of traits or characteristics through successful mating rather than simple survival (reviewed in Buss, 2007); however, given the potential for parents to bias their offspring sex ratios such that they maximize their own reproductive success, it seems plausible that in doing so, they might also select mates who possess characteristics that would provide additional reproductive benefits to their offspring according to the sex they are likely to conceive. Specifically, given that dominant females may be more likely to conceive sons, these women might select mates showing traits associated with male reproductive success, such as dominance, more often than future mothers of daughters. Similarly, future fathers of sons might prefer traits associated with female dominance more often than future fathers of daughters. This possibility has not been investigated.

1.4.1. Sexual Selection and Mate Preferences

In an early study investigating mate preferences, Buss (1989) found that cross-culturally, there are persistent sex differences in the characteristics that individuals find most important for a potential mate. Whereas males almost always preferred signals of reproductive value, such as youth and physical attractiveness, females almost always preferred signals of the ability to provide resources, such as ambition and status. Trivers (1972) proposed that sex differences in mate preferences were due to differences in parental investment. Specifically, this theory suggests that the more heavily invested sex should be choosier than the less heavily invested sex. In humans, women typically invest more in offspring, both biologically and through parental care, than males do, indicating that they should be choosier. This has been repeatedly confirmed in the literature, with men being more open to casual sexual encounters, multiple partners, and requiring less from potential mates than women (reviewed in Buss, 2007); however, many men do contribute substantially to the care of offspring and thus may exhibit individual differences in their preferences for female mates in the same ways that women do for male mates. Subsequent research has thus been focused on identifying specific traits, or signals of quality, that men and women find particularly attractive in the opposite sex.

Men's mate preferences.

Men's preferences for female mates are relatively well studied, with men generally preferring to mate with women who exhibit signals of high reproductive value, such as youth, attractiveness, and fertility (Burriss, Welling, & Puts, 2011a; Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2003;). For example, men have been shown to prefer an optimal ratio of women's circumference of their waist to their hip, a marker thought to indicate a high ratio of E_2 to T, and thus high potential for reproduction, of approximately 0.70 (Singh, 1994). Similarly, men find women with a more feminine facial appearance to be more attractive (Perrett et al., 1998; Rhodes, Hickford, & Jeffery, 2000); evidence suggests that femininity in the face reflects developmental stability, ideal body weight, and less health problems in women (Hume & Montgomerie, 2001). Other indicators of health and fertility that men have been reported to prefer include large breasts, smaller abdominal depths, and thin waists, all of which may be related to circulating ovarian steroids (Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004; Rilling, Kaufman, Smith, Patel, & Worthman 2009; but see Grillot, Simmons, Lukaszewski, & Roney, 2014). Thus, in making mate choice decisions, men tend to favour females exhibiting traits that signal suitability for the production and care of offspring.

Women's dominance does not appear to affect men's ratings of their attractiveness, either behaviorally (Sadalla, Kenrick, & Vershure, 1987), or as evidenced by female facial appearance (Quist, Watkins, Smith, DeBruine, & Jones 2011). Dominance has been less readily studied in women compared to men, but it appears to be involved in female-female competition. Women have been shown to derogate the reputations of rival women (Rucas, Gurven, Kaplan, & Winking, 2006) and to rate photographs of other women as less attractive when they are in the fertile phase of the menstrual cycle compared to the non-fertile phase, when competition for males might be higher (Fisher, 2004). In addition, most female-female conflicts have been shown to surround a male mate (reviewed in Cashdan, 1997), suggesting that dominance may be a salient behavior exhibited between women, rather than between men and women, in mating contexts. It may be, then, that women's dominance provides an alternative strategy through which mothers of sons gain access to potential male mates.

Although mothers of more sons have been rated less attractive (Kanazawa, 2007, 2011) and found to have higher waist-hip ratios (Singh & Zambarano, 1997), both of which could be markers of higher developmental androgen levels, it is important to note that these results likely represent the extreme tails of the population of all mothers. According to the MDH, women's probability of conceiving a son depends only on her current level of dominance (and T). Thus, a woman who is more likely to conceive a son at the time of engaging in a sexual relationship with a man is not necessarily more likely to be physically unattractive. In fact, Grillot et al. (2014) recently showed that after controlling for the effects of body mass index, women with higher levels of both T and E_2 across the menstrual cycle were rated as more attractive by naïve raters. Assuming women who are more likely to have sons are also higher in T and more dominant, it may be that they are better to stand out from other attractive females, or are more likely to make themselves sexually accessible to male mates.

Early work suggested that women who conceive sons might also be more likely to engage in short-term, non-committed sexual encounters with male partners (Gangestad & Simpson, 1990), making them more attractive, at least temporarily, to male mates. According to theories of sexual selection, the most reproductively successful males (i.e., those with good genes) are least likely to provide paternal investment. In seeking mates, then, a woman who is more likely to conceive a son might be more likely to engage in sexual relationships with such men, regardless of their level of long-term investment, because their reproductive success could in turn, increase her own inclusive fitness by conferring reproductive advantages on her son. Interestingly, naïve raters can accurately perceive whether women are sexually restricted or not simply by viewing their faces (Boothroyd, Jones, Burt, DeBruine, & Perrett, 2008) or interactions with men (Stillman & Maner, 2009), suggesting that men may indeed be able to detect, and display preferences for, individual differences between women. Such differences could be directly related to their offspring sex ratios, but this possibility has not been investigated.

Women's Mate Preferences

Given the relative difference between men and women in terms of their choosiness when it comes to opposite-sex traits, sexual selection for male ornaments

has been the focus of much work in evolutionary psychology. Good genes theory (Trivers, 1972; Zahavi, 1975) predicts that women should prefer men who exhibit traits that signal good genetic quality, as this will ensure that quality genetic material is passed to their offspring. In doing so, however, they may have to trade off certain other beneficial qualities, such as a high degree of parental investment. Thus, it has been proposed that women seek immediate benefits such as good genes when choosing a short-term mate, but prefer signals of long-term investment, such as being a good parent, when seeking a long-term mate (Buss & Schmitt, 1993).

Physical size, strength, and dominance have been associated with male reproductive success and are thus indicative of good genes (reviewed in Puts, 2010). Masculine facial appearance, a T-mediated trait (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak & Chen, 2004), may also signal good genetic quality in men, as high levels of androgens signal resistance to disease and other genetic mutations (Gangestad & Simpson, 2000). Although there is a considerable body of evidence available that shows women prefer such characteristics in men (reviewed in Puts, 2010), this has not been consistently demonstrated. Studies have shown that males who are more dominant have more masculine faces (e.g., Fink et al., 2007), and that more masculine faces are rated as being more dominant (Boothroyd, Jones, Burt, & Perrett, 2007), indicating that masculinity in male faces signals dominance. Whereas several studies have shown that women prefer a more masculine face to a less masculine face (Burriss, Welling, & Puts, 2011b; DeBruine et al., 2006; Johnston, Hagel, Franklin, Fink, & Grammer, 2001), others have shown the opposite result (DeBruine, Jones, Smith, & Little, 2010; Perrett et al., 1998; Rhodes et al., 2000; Scott, Pound, Stephen, Clark, & Penton-Voak, 2010), with women preferring a more feminine one. In addition, Fink et al. (2007) found that women rated the faces of physically stronger men to be more attractive, dominant, and masculine than weaker men, again highlighting differences in preferences for masculinity displayed amongst women. Similar disparity exists for women's preferences for dominant behavior in men. For example, whereas Sadalla et al. (1987) found that females rated a high dominance male depicted in a narrative to be significantly more sexually attractive than a low dominance male target, Snyder, Kirkpatrick, and Barrett (2008) showed that female preferences for dominance depended on context such that it was preferred in physical contexts like athletic

competitions, but not preferred in social contexts like an academic peer group. Variability in women's preferences, therefore, is clearly apparent.

One possible reason for the discrepancy in women's preferences for men's masculine traits, at least in the face, is that although it may signal good genetic quality, it may also provide cues about a man's willingness to invest in offspring. For example, men who were less sexually restricted were rated as having more masculine faces (Boothroyd et al., 2008), indicating that a masculine facial appearance may be related to promiscuity in men. Similarly, masculine male faces were rated as having more negative personality traits, such as less emotional warmth, and a dominant personality (Perrett et al., 1998), suggesting that masculinity in men signals lower relationship quality. Although differences in preferences for men's facial masculinity have been attributed to sexual strategies theory, in which women adopt a short-term mating strategy in order to obtain good genes, and a long-term mating strategy in order to gain long-term material and parental investment (Buss & Schmitt, 1993), there are considerable individual differences in willingness to engage in short-term mating (Simpson & Gangestad, 1991). In addition, most women attempt to gain both good genes and parental investment from one, rather than many men (Buss & Shackelford, 2008), making the generalizability of this theory unclear.

Women have been shown to rate men with more masculine faces as more attractive in situations where they are most likely to adopt a short-term mating strategy, such as when they are most fertile (Penton-Voak et al., 1999). Women also prefer more dominant male qualities, such as physical characteristics (i.e., muscular appearance, Gangestad et al., 2007) and dominant intrasexual behavioral displays (Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004), during the fertile days of their menstrual cycle compared to non-fertile days. However, it has also been shown that women may adjust their preferences for male masculinity depending on their own mate value, suggesting that individual differences in women's own characteristics are important, regardless of mating strategy. For example, Buss and Shackelford (2008) found that women rated by others as more attractive exhibited not only stronger preferences for male genetic quality (i.e., masculinity, attractiveness, physically fit), but also for indicators of financial prospects (i.e. higher income, higher education), parent

quality (i.e., desire for a family, ability to raise children), and relationship quality (i.e., loving partner). Attractive women also prefer more masculine faces (e.g., Little, Burt, Penton-Voak, and Perrett, 2001; Penton-Voak et al., 2003), again suggesting that assessments of other factors influence women's preferences for male mates.

Indicators of male genetic quality and indicators of male parent quality may not be mutually exclusive traits, suggesting that women may not have to trade one for the other in obtaining a long-term mate. In addition, given the apparent individual differences in preferences for masculinity, women's mate choices might be related to the sex of offspring they are more likely to produce. Roney et al. (2006) found that although men's self-reported interest in infants was a significant predictor of women's attributions of their long-term mate quality, facial masculinity was not. However, they also found that the two ratings were not correlated, suggesting that women may evaluate a man's masculinity and parent quality separately. Women, therefore, appear to exhibit differences in their requirement for the parental investment of a potential partner, regardless of how masculine his face appears. Women who are more likely to have sons, then, might prefer more masculine characteristics in a long-term mate, whereas women who are more likely to have daughters might prefer less masculine characteristics in a long-term mate, even though both may still seek men who exhibit traits associated with effective parental investment.

Individual differences in female preferences for a long-term mate remain unresolved. For example, although Cornwell and Perrett (2008) found that other-rated attractiveness of mothers and fathers were correlated, they found no correlation between other-rated attractiveness of mothers and masculinity of fathers, suggesting that more attractive women were not more likely to pair with more masculine men. The researchers also found that although father and son masculinity was positively correlated, mother and son masculinity was not, suggesting that mothers may indeed choose masculine characteristics in male mates according to their future offspring sexes. Similarly, they found that more attractive parents had more attractive daughters, but not sons, again suggesting differential mate preferences depending on the sex of children a couple is likely to produce. These possibilities have never been investigated.

Mate Selection and Offspring Sex Ratio

To my knowledge, no studies have directly investigated the role of potential offspring sex in influencing mate preferences in men and women. In mammals, there is some evidence to suggest that parental dominance influences offspring sex ratio. For example, Helle et al. (2007) randomly mated male and female field voles (*Microtis agrestis*) and found females with higher testosterone and glucose levels had significantly male-biased offspring sex ratios; a parallel but non-significant pattern ($p = .09$) was observed for males with large body size. Given that female testosterone (e.g., Grant & France, 2001) and male body size (reviewed in Puts, 2010) have been associated with dominance, it is plausible that mate pairs characterized by male and female dominance resulted in male-biased litters. Therefore, it is likely that in natural environments, behavior of potential mates in the context of a social environment is assessed according to its relationship to offspring sex.

In humans, women who exhibit characteristics associated with higher offspring sex ratios also prefer more dominant mates. For example, women with optimal waist-to-hip ratios (i.e., more feminine and attractive (e.g., Singh, 1994)) were reportedly more likely to value the provision of resources by mates than women with a higher waist-to-hip ratio (i.e. more masculine and less attractive) (Pawlowski & Jasienska, 2008). Given that women with higher waist-to-hip measurements have more sons than daughters (Manning et al., 1996; Singh & Zambarano, 1997), and that male dominance in faces might be considered a signal of lowered willingness to invest in offspring (Perrett et al., 1998), it makes sense that women who are more likely to produce females would prefer less dominant looking mates. Similarly, women were found to prefer masculine faces more often when their salivary testosterone levels are high compared to when they were low (Welling et al., 2007). Given that testosterone level may be associated with the conception of sons (Grant & France, 2001), this also supports the idea that women who will have sons prefer more dominant mates.

Lastly, a recent study of an extensive database of same and opposite-sex twins has shown that facial masculinity appears to be inherited by both sexes, and is negatively related to attractiveness in females, whereas facial attractiveness is also inherited by both sexes, but negatively related to masculinity in males (Mitchem et al.,

2014), suggesting that highly masculine fathers might produce less attractive daughters whereas highly attractive mothers might produce less masculine sons. Thus, extreme paternal masculinity is unlikely to produce a reproductive benefit for daughters, and extreme maternal attractiveness is unlikely to produce a reproductive benefit for sons. Further investigation of the transmission of facial characteristics that indicate dominance in males and females, as well as their preferences for such characteristics in opposite sex mates, then, will help to identify the importance of offspring sex in determining the exact nature of sexual selection in humans.

1.5. The Face As a Signal of Future Offspring Sex

One possible mechanism through which individuals might evaluate the relative contribution of a potential mate to offspring reproductive success is through their face. Although no studies have investigated the relationship between offspring sex and facial characteristics of parents, there are at least three lines of research suggesting that there may be an important link. First, facial architecture is also thought to reflect steroid hormone levels, with androgens being responsible for bone growth, such as brow ridges and lower jaw development, and estrogens being responsible for the distribution of fats (Johnston et al., 2001), such as in lips. Both of these hormonally influenced facial characteristics are fundamental to reproductive quality in males and females.

Second, physiological characteristics have been previously linked to offspring sex. As described earlier, taller and heavier parents have more sons than shorter and lighter parents (Kanazawa, 2005), and mothers and fathers who were rated as being “very attractive” by an objective third party rater were significantly more likely to have a daughter than a son as their first child (Kanazawa, 2007). These qualities both represent physical qualities, correlates of which are likely detectable in faces.

Third, previous research has identified several personality and behavioral characteristics associated with male and female reproductive behavior that can be accurately identified by observing one’s face. For example, maternal tendencies (i.e. number of children desired, age to have first child) (Law Smith et al., 2011), openness to short-term sexual relationships (Boothroyd, et al., 2008), and dominance (Quist et al.,

2011) have all been correlated with facial features. Similarly, male faces may signal physical strength (Fink et al., 2007), dominance (Mueller & Mazur, 1996; reviewed in Puts, 2010; Valentine, Li, Penke, & Perrett, 2014), openness to short-term sexual relationships (Boothroyd et al., 2008) and interest in babies (Roney et al., 2006). If individuals choose mates based on factors that will maximize their own reproductive success, it is therefore plausible that we have evolved mechanisms for detecting the potential for male or female offspring in the faces of potential mates or competitors.

1.6. Dissertation Overview

Parental ability to influence the sexes of their offspring would present a functional adaptation to a dynamic environment, but if actually taking place, a mechanism that allowed for individuals to recognize the direction of such variation in both themselves and others would provide an additional adaptive benefit such that any offspring produced would receive the best possible heritable benefits from both parents. In humans specifically, an ability to bias offspring sex ratios could systematically relate to mating behavior and preferences, but this possibility has never been investigated. This dissertation presents the results of four studies, each of which was designed to probe specific aspects of the physiological and psychological characteristics of men and women, and how those are related to their predicted and actual sexes of offspring, as well as their preferences for dominance in opposite-sex mates. I collected hormonal, facial, and behavioral data from groups of undergraduate students who had not yet had children, as well as from a group of their parents in order to test the hypothesis that men and women who predict they will, or who already have produced sons are more likely to exhibit and prefer characteristics of dominance. The specific goals of my dissertation were to examine whether: a) dominance behavior, sexual restrictiveness, self-perceived masculinity and femininity, digit ratios, and hormone levels in men and women who had not yet had children were associated with their predicted sexes of future offspring (Studies 1 and 2); b) predictions for future offspring sex affected men and women's mate preferences for dominance in the opposite-sex (Study 2); c) men and women's predictions for future offspring sex were detectable in their facial characteristics (Study

3); and d) the sex of first-born offspring in actual parents was related to their dominance behavior, facial characteristics, and mate choice.

Chapter 2.

STUDY 1: Predictions for Sex of First-born Child Reflect Masculine and Feminine Characteristics in Male and Female Undergraduates

Note: This section is based on the following article, with permission: Palmer-Hague, J. L., Zilioli, S., & Watson, N. V. (2013). Predictions for sex of first-born child reflect masculine and feminine characteristics in male and female undergraduates. *Evolutionary Psychology*, 11, 833-844.

2.1. Introduction to Study 1

Variation in offspring sex ratio has been the topic of considerable interest for decades, but the mechanisms through which it occurs, if at all, remains unknown in humans. The Trivers-Willard hypothesis (TWH, Trivers & Willard, 1973) proposes that parents should vary their offspring sex ratios toward the sex that maximizes reproductive success. Whereas female reproductive success in populations where males compete for access to mates remains relatively stable, male reproductive success depends on ability to access mates. Males in good condition, or those exhibiting traits that facilitate mating, therefore, should produce more offspring than males in poor condition. Through the production of sons, then, parents in good condition could ensure more grand-offspring than parents in poor condition. Parents in poor condition, in contrast, could maximize the number of their grand-offspring through the production of daughters.

Although the TWH has received considerable support in the animal literature, the data are not always consistent (reviewed in Brown, 2001; Clutton-Brock & Iason, 1986; Hewison & Gaillard, 1999; Hiraiwa-Hasegawa, 1993). This is likely because researchers have investigated maternal characteristics thought to reflect physical condition (e.g., body size, nutrition, parity), whereas the most convincing evidence comes from studies

that focused on behavioral traits, namely, dominance prior to conception (Sheldon & West, 2004). For example, in a population of Barbary macaques (*Macaca sylvanus*), Paul and Kuester (1990) found that females with high dominance rank at conception produced more male offspring than females with low dominance rank. In addition, males born to high ranking females produced more offspring than those born to low ranking females (Paul & Kuester, 1990; Paul et al., 1992). Reliance of the TWH on physiological condition as a determinant for sex ratio adjustment, therefore, might be too exclusive. The investigation of heritable environmental influences, such as social rank and resource availability, and their possible associated epigenetic mechanisms, in determining individual offspring sex ratios could be more informative in enhancing our understanding of sex ratio adjustment.

In humans, both physiological and psychological characteristics of parents have been associated with offspring sex ratio. Interestingly, studies have shown a tendency for parents of sons to have characteristics associated with male reproductive success, and for parents of daughters to have characteristics associated with female reproductive success. For example, taller and heavier parents have more sons than shorter and lighter parents (Kanazawa, 2005), and more physically attractive parents have more daughters than less attractive parents (Kanazawa, 2007). Lower (e.g., more masculinized) digit ratios, which are thought to reflect greater exposure to androgens prenatally, have also been associated with higher offspring sex ratios (e.g., more sons than daughters). Manning and associates (2002) found that parents with lower ratios of the 2nd to the 4th digit of their hands (2D:4D) had more sons than daughters. Similarly, Ventura, Gomes, Pita, Neto, and Taylor (2013) found that the 2D:4D ratios of mothers of newborn male infants were significantly lower than those of mothers of newborn female infants, and that T in the amniotic fluid was negatively associated with 2D:4D in the female infants. Lower 2D:4D may indicate dominance and masculinity to others, as women's perceptions of men's facial masculinity and dominance has been shown to correlate positively with their digit ratio (Neave et al., 2003), as well as self-reported physical attractiveness (Manning and Quinton, 2007). Behaviorally, high status males (not females, but see Grant & Yang, 2003) such as billionaires (Cameron & Dalerum, 2009) and past presidents (Betzig & Weber, 1995) have more sons than would be expected by chance. Dominant mothers and less sexually restricted parents (e.g.,

requiring less commitment before engaging in sex, having more sexual partners) also have more sons than daughters (Akande, 1999; Gangestad & Simpson, 1990; Grant, 1990, 1994; Kanazawa & Apari, 2009).

Specific parental physiological and psychological characteristics could have adaptive value for humans. The Maternal Dominance Hypothesis (Grant, 1998) proposes that the conception of one sex or the other is under the control of the mother, where the likelihood of an ovum being fertilized by a Y-bearing chromosome is facilitated by higher maternal levels of Testosterone (T). Behaviorally, the Maternal Dominance Hypothesis suggests that T levels fluctuate with dominance, thus more dominant women should conceive sons than daughters. In fact, Grant and France (2001) found that women who scored higher in dominance had higher serum T than those who scored lower. Fewer studies have examined the effects of T in women, but several studies have shown that women with a higher waist-to-hip ratio (WHR), which is indicative of higher circulating T levels and lower ratings of female physical attractiveness (reviewed in Singh, 2002), have significantly more sons than daughters (Manning et al., 1996; Trivers et al., 1999; Singh & Zambarano, 1997).

In men, testosterone influences a variety of characteristics including facial masculinity (Penton-Voak & Chen, 2004) and dominance (reviewed in Mazur & Booth, 1998) making it plausible that it has similar effects in women. Compared to mothers of daughters, therefore, mothers of sons, could exhibit more masculine or less feminine physical and personality traits, which would in turn influence the manifestation of these traits in their sons. Fathers could exhibit similar sex-of-offspring differences. Specifically, characteristics that enhance male mating success, such as dominance and masculinity, might be more extreme in fathers of sons, which would work to increase their reproductive success by increasing their attractiveness to potential mates and increasing their success in competing with other men for access to mates.

Differences in the expression of masculine or feminine mating characteristics in parents raises the interesting possibility that self-perception of these characteristics, or the presence of some interoceptive cue such as steroid hormone concentration, influences individuals' predictions of their offspring sexes. This possibility remains

unknown. In the present study, we investigated the relationship between sex-of-offspring prediction and the hormonal and personality characteristics of men and women. Specifically, within sexes, we hypothesized that individuals who predict a boy for their first child would exhibit higher dominance scores, sociosexual orientation scores, and T levels, as well as lower digit ratios, and E_2 than those who predicted they would have a girl. In contrast, individuals who predict a girl would exhibit lower dominance scores, sociosexual orientation scores, and T levels, as well as higher digit ratios and concentration of E_2 than those who predict a boy.

2.2. Methods

2.2.1. Procedure

Fifty-one male (mean age = 20.60 years, $SD = 2.03$) and 56 female (mean age = 20.88 years, $SD = 2.74$) undergraduates, naïve to both the purpose and hypotheses of the study, completed a questionnaire package and provided a saliva sample and a photocopy of their hands in exchange for course credit. All study procedures were subject to review and prior approval by the Simon Fraser University Research Ethics Board. All participants provided written informed consent.

2.2.2. Measures

Dominance. We assessed self-reported dominance using the Simple Adjective Test (SAT) (Grant, 1998), a brief, 64-item checklist containing 13 items measuring dominance (e.g., influential, strong, powerful) and 53 filler items (e.g., hopeful, shy, depressed). Participants checked off the items that applied to them and a score out of 13, one for each checked dominance item, was calculated.

Sociosexual orientation. Sexual restrictiveness, or the degree to which an individual is comfortable engaging in sex without commitment, was assessed using the sociosexual orientation inventory (SOI) (Simpson & Gangestad, 1991). The questionnaire involves a series of questions (e.g., “How many different partners do you foresee yourself having sex with during the next five years?”), and statements (e.g., “Sex

without love is OK”) to which the participant must rate their agreement on a 9-point Likert scale. Overall scores were calculated based on participant responses, with higher scores reflecting less restricted orientations and lower scores reflecting more restricted orientations.

Reproductive ambition and preferences. We created a questionnaire based on questions used by Deady, Law-Smith, Sharp, and Al-Dujaili (2006) to assess reproductive ambition and sex-of-offspring prediction and preferences. We asked: “How broody/maternal (or paternal) do you feel compared to others of your age?”, “How important to you is having children?”, “How important to you is having a career?”, “Ideally, how many children would you like to have?”, and “Ideally, at what age would you like to have your first child?”. The first three questions were answered using 7-point Likert scales, and the remaining two were open-ended. We created an overall score indicative of reproductive ambition by adding the responses from the first three questions (the last was reversed scored). Lower scores reflected a lesser tendency/importance for having family than career. The remaining question was analyzed separately. For 3 females and 1 male who did not want children, we replaced their ideal age response with the mean age for their corresponding sex. To assess the sex-of-offspring prediction, we asked, “What sex of child would you predict that you would have first?”. To ensure that predictions were not reflecting simple preferences, we also asked about sex-of-offspring preferences: “If you could only have ONE child, what sex would you prefer to have?” and “Assuming you have more than one child, if you could choose, what would you prefer for the sex of your first-born child?”. Questions were answered in forced choice, male or female.

Salivary hormones. Participants were asked not to eat, drink, smoke, or brush their teeth for one hour prior to the sample collection. We asked about medication use (including hormonal birth control), chronic health or endocrine problems, and menstrual cycle. We collected 3mL of saliva from each participant into untreated polypropylene tubes via passive drool. Each sample was immediately frozen at -20°C for later analysis. Samples were assayed for T and E₂ using enzyme-linked immunoassay techniques at Yerkes National Primate Research Centre at Emory University. The assay range for E₂ was 1-100pg/mL and the inter-assay coefficient of variation was 4.43% at 1.75 pg/mL,

3.67% at 3.95 pg/mL, 0.18% at 14.17 pg/mL, and 8.16% at 30.43 pg/mL. The intra-assay coefficient of variance was 10.5% at 1.84 pg/mL and 12% at 3.78 pg/mL. For T, the assay range was 6.1-600 pg/mL, the inter-assay coefficient of variance was 13.29% at 166.10 pg/mL, and the intra-assay coefficient of variance was 6.7% at 150.49 pg/mL.

Digit ratio. Following removal of rings and jewelry, a thin line was drawn (similar to Bailey & Hurd, 2005) on the proximal creases of the index and ring fingers of participants' left and right hands. A photocopy was taken of both hands together, palms down. The lengths of the 2nd and 4th digits of each hand were measured twice, by two independent raters, from the center of the tip of the finger to the center of the proximal crease, measuring to the nearest 0.05cm using a standard ruler. Due to power outage, scans for 2 males were not collected. One scan was excluded due to poor quality. Inter-rater reliability was $r = 0.99$ for both the right and left hands. An average of the two measurements were taken for each participant and analyzed.

2.2.3. Data Analysis

Preferences and predictions for sex of offspring were compared using Pearson's chi square tests. Within sexes, we compared personality scores, hormone levels, and 2D:4D measurements of individuals who predicted they would have a boy first to those who predicted they would have a girl first using independent samples t-tests. All hypotheses were directional and one-tailed tests were used. Blood contamination or error was suspected for 3 female and 3 male saliva samples. As their values were greater than 3 standard deviations from the mean for their respective sexes, they were excluded from any hormone analyses.

2.3. Results

We found an overall preference for a boy compared to a girl as both an only child ($\chi^2 = 4.57, p < .05$) and as a first-born child ($\chi^2 = 8.49, p < .01$). In contrast, prediction for sex of first-born child did not depend on participant sex ($p > .05$), indicating that predictions did not reflect simple preferences for either males or females. There were also no significant differences between dominance and sociosexual orientation scores, T

and E₂ concentrations, or digit ratios of males and females who preferred a boy compared to a girl for either their only or first born child ($p > .05$), indicating that neither personality or hormone profile influenced general sex of offspring preferences.

2.3.1. Women

Women who predicted that they would have a boy first (Mean \pm SE = 3.60 \pm .48, $n = 30$) scored significantly higher than those who predicted a girl first (Mean \pm SE = 2.36 \pm .39, $n = 25$) on the SAT ($t(53)=1.95$, $p < .05$, one-tailed) (Figure 2.1).

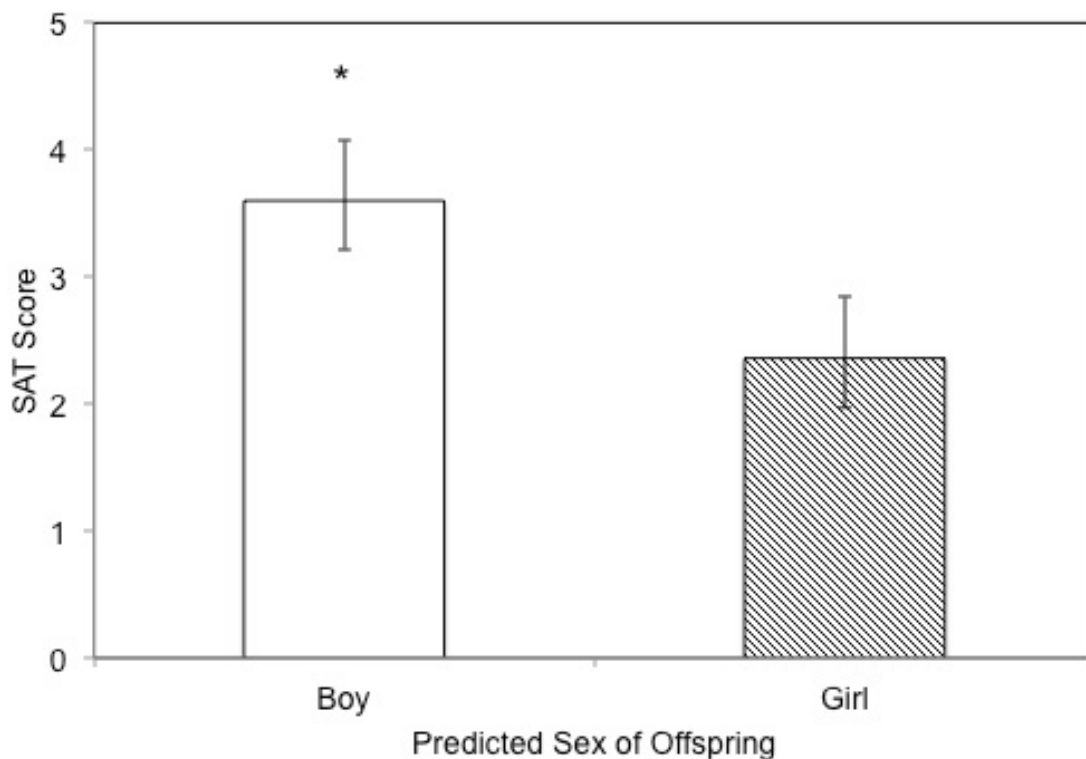


Figure 2.1. Mean (\pm 1 SE) Dominance Scores Obtained by Women Predicting Boy Compared to Girl as First-born Child

Note: * $p < .05$ (one-tailed)

This difference approached significance for the SOI (boy: Mean \pm SE = 42.97 \pm 4.76, $n = 30$; girl: Mean \pm SE = 32.44 \pm 4.42; $t(53) = 1.56$, $p = .06$, one-tailed).

Since hormonal contraceptive use affects both SOI (Oinonen, et al., 2008) and dominance (Grant & France, 2001; Stanton & Edelstein, 2009) in females, we explored these differences in users versus non-users. Significantly higher SOI scores were found for users (Mean \pm SE = 53.00 \pm 6.21, n = 16) compared to non-users (Mean \pm SE = 31.85 \pm 3.49, n = 39) ($t(53)$ = 3.138, p < .01). To ensure that predictions were not dependent on contraceptive use, we separately analyzed the SOI scores of users and non-users who predicted sons compared to daughters. No significant differences were found (p > .05). No significant differences were found between users and non-users for the SAT (p > .05).

No significant differences were observed between women who predicted they would have a boy first and those who predicted they would have a girl for reproductive ambition (p = .47), ideal age to have first child, or T, E₂, or 2D:4D for the right or left hands (all p > .05).

2.3.2. Men

Higher E₂ was found for men who predicted they would have a girl first (Mean \pm SE = 4.02 \pm .18, n = 19) compared to those who predicted they would have a boy (Mean \pm SE = 3.60 \pm .11, n = 29) ($t(46)$ = 2.10, p < .05, one tailed). Similarly, significantly higher (more feminine) 2D:4D (right hand) ratios were found for men who predicted they would have a girl (Mean \pm SE = .97 \pm .01, n = 19) (Figure 2.2) as their first child compared to those who predicted they would have a boy (Mean \pm SE = .95 \pm .01, n = 29) ($t(46)$ = 1.77, p < .05, one-tailed). The same pattern was observed for the 2D:4D (left hand) (girl: Mean \pm SE = .96 \pm .01, n = 19; boy: Mean \pm SE = .94 \pm .01, n = 29; $t(46)$ = -2.05, p < .05, one-tailed) (Figure 2.2).

No differences were observed for T (p > .05). No differences were observed for the SAT, SOI, reproductive ambition, or age to have first child (all p > .05).

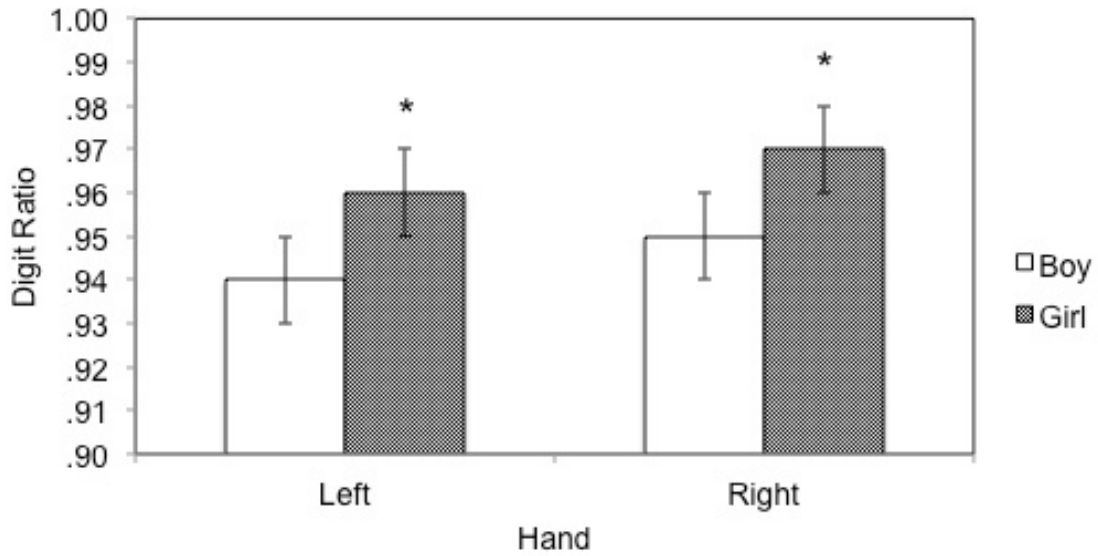


Figure 2.2. Mean (\pm 1 SE) Right and Left Hand Digit Ratios for Men Predicting Boy Compared to Girl as First-born Child

Note: * $p < .05$, one-tailed

2.4. Discussion

The present study examined the relationship between masculine and feminine psychological and physiological characteristics and an individual's prediction of sex for their first-born offspring. Taken together, our results suggest that whatever the mechanism, individuals are somehow sensitive to their own relative masculinity or femininity, and that this alters the predictions they make about their offspring sexes. We found that women who predicted they would conceive a boy were more dominant and less sexually restricted than women who predicted they would conceive a girl. Although we are unable to confirm the accuracy of these predictions, our results are in line with previous studies showing that more dominant and less sexually restrictive women have more sons than daughters (Akande, 1999; Gangestad & Simpson, 1990; Grant, 1990, 1994; Kanazawa & Apari, 2009). These results also agree with the TWH, in that mothers who exhibit characteristics associated with high male reproductive success (in this case, dominant and sexually less restrictive) should produce more sons than daughters.

Males who predicted they would have a girl as their first born exhibited higher salivary concentrations of E_2 as well as higher, or more feminine, 2D:4D ratios, suggesting less exposure to androgens prenatally. To our knowledge, no studies have investigated the relationship between offspring sex ratio and parental E_2 ; however, 2D:4D and offspring sex ratio were negatively correlated in previous research (Manning et al., 2002). It is unclear what effect, if any, higher E_2 might have upon male reproductive success, but 2D:4D has been negatively associated with facial dominance and masculinity as perceived by others (Neave et al., 2003) as well as physical and behavioral aggression (Bailey & Hurd, 2005; Kuepper & Hennig, 2007) in males, suggesting that individuals with a higher 2D:4D exhibit less male-typical behavior than those with a lower one. With regard to the TWH, these results support the idea that fathers who do not exhibit characteristics associated with high male reproductive success (in this case, correlates of high E_2 and 2D:4D ratios) should produce more daughters than sons. In contrast, it could be that fathers of daughters possess characteristics that are more likely to enhance the reproductive success of daughters than sons. Interestingly, women who reported wanting to have more children had higher urinary estrogen levels and more feminine faces than women who reported wanting to have fewer children (Law Smith et al., 2012). Kanazawa (2007) proposed that parental offspring sex ratio should reflect the degree to which parental traits are associated with male or female reproductive success, with parents of sons exhibiting more male-typical traits and parents of daughters exhibiting more female-typical traits. The direct inclusion of femininity measures in future work would enable a test of this hypothesis.

If individuals are able to accurately predict the sex of their offspring prior to ever conceiving a pregnancy, an intriguing possibility that follows is that these predictions affect mating behavior and preferences in line with the TWH. Specifically, women who anticipate that they will have sons might choose mates with characteristics important for male reproductive success, whereas those who anticipate they will have daughters might choose mates with characteristics important for female reproductive success. One possibility is facial preferences. Facial architecture is thought to reflect hormone levels, with androgens being responsible for bone growth, such as brow ridges and lower jaw development, and estrogens being responsible for the distribution of fats (Johnston et al., 2001). In men, high T was associated with a more masculine face, but not

necessarily a more attractive one (Penton-Voak & Chen, 2004), highlighting individual differences in women's preferences. No studies have determined whether facial preferences are related to offspring sex ratio, however, our finding that men who predict they will have a girl rather than a boy have higher E_2 and more feminine 2D:4D ratios suggest that they might also have more feminine or less masculine faces. Whereas some studies have identified an overall preference for masculine features (DeBruine et al., 2006; 2010), others have found that women generally preferred faces with feminine features (Perrett et al., 1998; Rhodes et al., 2000). More attractive women have been found to prefer more masculine faces than less attractive women (Little et al., 2001; Penton-Voak et al., 2003), and mothers and fathers who were rated as being "very attractive" by an objective third party rater were significantly more likely to have a daughter than a son as their first child (Kanazawa, 2007). The inclusion of measures of the predicted or actual offspring sex ratio of both the individual making choices and the target individual in future studies might help to clarify this issue.

Women who predict they would have a son might prefer more masculine faces. Gangestad and Simpson (1990) proposed that less sexually restricted women would be more receptive to mating with reproductively successful men (e.g., those having many sexual partners), as their genes would be beneficial for enhancing the reproductive success of sons. Interestingly, Waynforth, Delwadia, and Camm (2005) found that women with a less restricted sociosexual orientation preferred more masculine male faces than women with a more restricted one. Similarly, Simpson and Gangestad (1992) found that less restricted women placed more emphasis on the attractiveness of partners than those who were more restricted. We did not find an association between male offspring prediction and women's salivary T in our study; however, Welling et al. (2007) found that women preferred a masculine male face more often than a feminine one when their salivary T levels were high, which in combination with Grant and France (2001) who found that women with higher dominance also had higher serum levels of T, suggests that mothers of sons prefer more masculine mates. It is unclear why we did not see an association between dominance and salivary T in our study; however, Grant (1998) suggested that state T is the best predictor of offspring sex close to time of conception. Given the exploratory nature of our study, and that our participants were not actively trying to achieve pregnancy, we did not attempt to control for this possibility.

Future studies, therefore, should examine the relationship between offspring sex ratio – either predicted or actual - and preferences for facial masculinity in male mates, with specific consideration being given to menstrual cycle phase and time to conception.

It is also important to note the possibility that our findings are actually the result of a general self-perception of an individual's masculinity or femininity relative to their own sex. While we did not directly investigate this, the psychological assessment of one's own expression of masculine or feminine characteristics could be important for mating behavior. Individuals who perceive themselves to be more masculine might believe they *should be* more likely to have a son compared to a daughter whereas those individuals who perceive themselves to be more feminine might believe *they should be* more likely to have a daughter than a son. In turn, they might seek mates that fulfill these perceived roles, namely a more masculine or more feminine mate. This possibility should be tested in future studies.

In sum, we found that the personality and hormone profiles of men and women are related to their prediction for sex of future offspring. Despite our relatively small sample of undergraduate students, these individual differences reflect characteristics that could be important for influencing both the reproductive success and mating behavior and preferences of men and women.

Chapter 3.

STUDY 2: Predicted Offspring Sex is related to Women's Preferences for Dominance in Men

Note: This chapter is based on the following article, currently under review: Palmer-Hague, J. L., & Watson, N. V. Predicted offspring sex is related to women's preferences for dominance in men. *Evolutionary Behavioral Sciences*.

3.1. Introduction to Study 2

The results of Study 1 showed that men and women behave as if they may be able to predict the sex of their future offspring, and that these predictions are related to characteristics such as dominance and sexual restrictiveness in women, and E_2 concentrations and digit ratios in men. These results were in line with a large body of research that suggests that parents possessing characteristics associated with male and female reproductive success may be able to bias their offspring sex ratios towards more sons or daughters, respectively, and may have access to interoceptive cues that signal the probable sex of future offspring they will conceive. Such interoceptive cues could potentially influence reproductive behavior, such as mate preferences and selection. These possibilities have not been studied.

Trivers and Willard (1973) predicted that parents could vary their offspring sex ratios in the direction that would most benefit their own reproductive success. Specifically, they predicted that parents in good condition, or those who possessed characteristics associated with high male reproductive success, such as dominance, should produce more sons than daughters. In doing so, their sons would inherit their condition, making them more reproductively successful than a daughter would be. In contrast, parents in poor condition, or those who did not possess characteristics that would benefit reproductive success in a son, should produce more daughters. In doing

so, they would ensure that their genes would be passed on through their daughter, who's reproductive success would be more stable than that of a son. Parental ability to vary offspring sex has been frequently studied in animals, it has not always been demonstrated (reviewed in Brown, 2001; Clutton-Brock & Iason, 1986; Hewison & Gaillard, 1999; Hiraiwa-Hasegawa, 1993), leading researchers to speculate that additional focus on adaptive behavioral mechanisms may be more informative for determining whether condition influences offspring sex (Sheldon & West, 2004).

A number of studies have found support for the Trivers-Willard Hypothesis (TWH) in humans; for example, parents who produce more sons are taller and heavier (Kanazawa, 2005), have more masculine digit ratios (Manning et al., 2002), have more masculine waist-to-hip ratios (mothers, Manning et al., 1996; Singh & Zambarano, 1997), are more open to sex without commitment (Gangestad & Simpson, 1990; Kanazawa & Apari, 2009) are more dominant (mothers, Akande, 1999; Grant, 1990; 1994), and are more likely to be billionaires (fathers, Cameron & Dalerum, 2009) than parents with more daughters. In contrast, parents who produce more daughters are more physically attractive than parents who produce more sons (Kanazawa, 2007, 2011). These results suggest that men and women may actually bias their offspring ratios depending on their own characteristics, but the exact mechanisms through which such alteration takes place remain open for investigation.

The Maternal Dominance Hypothesis (MDH, Grant, 1998) implicates levels of testosterone (T) in women as the key determinant of offspring sex bias, but other hormones, such as estradiol (E_2) in both parents may also be important (see James, 1996). Interestingly, many traits associated with the production of sons are also associated with high T levels, and many traits associated with the production of daughters are associated with high E_2 levels. For example, women with higher T score higher in dominance (Grant & France, 2001) and have higher waist-to-hip ratios (van Anders & Hampson, 2005), whereas women with high E_2 may have a more feminine (i.e., more attractive) facial appearance (Law Smith et al., 2006; Law Smith et al., 2012), and lower waist-to-hip ratios and larger breasts (i.e., Jasienska et al., 2004). In men, high T is related to higher facial masculinity (Penton-Voak & Chen, 2004; Roney et al., 2006) (which may also be considered less attractive to women (e.g., Perrett et al., 1998;

Rhodes et al., 2000, but see Fink et al., 2007; Johnston et al., 2001)) less commitment in long-term relationships (Booth & Dabbs, 1993), and dominance (reviewed in Mazur & Booth, 1998). Thus, hormone levels could provide a plausible indicator of future offspring sex.

In Study 1, we found that when asked to predict the sex of their first-born child, both physiological and psychological characteristics of men and women lined up with their predictions in the direction of the TWH. Specifically, we found that women who predicted they would conceive a son scored higher in behavioral dominance and openness to sexual activity without commitment than women who predicted they would have a daughter. There were no differences between groups in either T or E₂ levels, or digit ratios. In contrast, men who predicted they would have a daughter first had higher salivary E₂ and higher (i.e., more feminine) digit ratios than those who predicted they would have a son, but there were no differences between groups in dominance or SOI. Although preliminary, these results provide evidence for the interesting possibility that there may be pre-conceptive cues about future offspring sex; however, two limitations are worth noting. First, only one brief measure of dominance was used, which limits the reliability of the finding that more dominant women predict sons. Second, men and women may have made predictions about future offspring based on their perceptions of their own masculinity and femininity. In other words, people may have chosen a son because they felt as if they were more masculine and therefore *should* be more likely to have a son, whereas people may have chosen a daughter because they felt as if they were more feminine and therefore should be more likely to have a daughter. These two potential confounds warrant further study.

Despite limitations, the possibility that individuals can access interoceptive cues that signal a bias in their offspring sexes introduces the novel hypothesis that these cues could shape the process of mate selection. In other words, individuals who predict they will have sons might prefer mates with characteristics associated with male reproductive success, as these traits would be conferred on resultant male offspring; likewise, individuals who predict daughters might prefer mates with characteristics associated with female reproductive success. These possibilities have not been studied.

Women who perceive that they will later conceive sons may prefer characteristics of dominance in potential male mates. Research suggests that there is considerable variability in women's preferences for male facial characteristics of dominance, consistent with the hypothesized contribution of a Trivers-Willard type of influence in the process of mate selection. For example, several studies have found that high facial masculinity, which signals dominance in males (Boothroyd et al., 2007; Fink et al., 2007), is not preferable to low facial masculinity (Burriss et al., 2011a; DeBruine et al., 2006; Johnston et al., 2001), but others have shown the opposite result (DeBruine et al., 2010; Perrett et al., 1998; Rhodes et al., 2000; Scott et al., 2010). Dominance in males may increase reproductive success, as more masculine faces signal less willingness to invest in offspring (Perrett et al., 1998) as well as physical strength and dominance (Fink et al., 1997); thus, preference for dominance cues in male faces could be adaptive for future mothers of sons.

Women who predict they will have sons may also prefer mates who exhibit behavioral dominance. Sadalla et al. (1987) reported that females found a high dominance male to be significantly more sexually attractive than a low dominance male target. Importantly, participants did not associate dominance with either aggressive or domineering traits, but they did perceive the high dominance male target to be more promiscuous and less likeable than the low dominance target, suggesting that females associate dominance with other less desirable characteristics and that not all females would choose a high dominance partner. In addition, Snyder et al. (2008) showed that female preferences for dominance depend on context such that it is preferred in physical contexts like athletic competitions, but not preferred in social contexts like an academic peer group, suggesting that context can be influential in determining attractiveness of dominance to potential female mates. Examination of predicted future offspring sex may be informative in clearing up some discrepancy in the research.

Research suggests that men prefer signals of health, fertility, and reproductive potential, such as physical attractiveness and femininity, in potential female mates (Burriss et al., 2011b; Buss, 1989; Hume & Montgomerie, 2001; Jasienska et al., 2003; Perrett et al., 1998; Rhodes et al., 2000; Rilling et al., 2009; Singh, 1994), all of which tend to be associated with the production of daughters. Female dominance has been

less frequently studied, but studies have shown that dominance does not affect ratings of women's attractiveness (Quist et al., 2011; Sadalla et al., 1987), or men's interest in a short-term sexual encounter with them (Brown & Lewis, 2004), suggesting that men's perceptions of women's attractiveness is not dependent on dominance. When choosing a mate, then, men who are more likely to have sons may not exhibit stronger preferences for female dominance than men who are more likely to have daughters. In contrast, men may exhibit individual differences in their preferences for female dominance that are related to the sex of offspring she will produce. These possibilities have not been directly studied.

In the present study, we investigated the relationship between physiological and psychological characteristics, predicted sex of offspring, and mate preferences for dominance in men and women in an attempt to replicate and extend our previous findings. First, we included additional measures of dominance and a measure of psychological androgyny in attempt to confirm previous findings regarding the influence of dominance on predicted sex of offspring. Second, we tested the hypothesis that men and women who predicted they would have sons would exhibit stronger preferences for a dominant mate than men and women who predicted they would have daughters.

3.2. Methods

3.2.1. Participants and Procedure

A total of 132 undergraduates participated in the study in exchange for course credit: 66 males (Mean age \pm *SD* = 20.48 \pm 2.34) and 66 females (Mean age \pm *SD* = 19.91 \pm 2.17) undergraduates (*N* = 132) participated in the study. Participants were ethnically diverse (Caucasian, 33%; Asian, 37%; South Asian, 19%; Middle Eastern, 4%; Other, 7%), which reflects the population in the metropolitan area where the university is located. At the beginning of the test session, participants provided a variety of biodemographic and personal data, and a saliva sample was collected for later analysis. Participants then completed a reproductive preferences questionnaire, a mate preference task using morphed opposite-sex faces, completed a mate preference task using computer generated opposite-sex faces (not analyzed as part of this study), a

psychological questionnaire package, a mate preference task using behavioral vignettes, had a photograph taken of their own face (for use in the larger study), and provided a scan of their hands for digit ratio analysis. All participants provided informed written consent, and study procedures were subjected to prior approval by the Simon Fraser University Office of Research Ethics.

3.2.2. Psychological Questionnaires

Reproductive preferences. Participants completed a reproductive preferences questionnaire (Deady et al., 2006) designed to assess their orientation towards having children and their preferences and predictions for the sexes of their future offspring. Participants were asked to rate the degree to which they agreed with the following questions on a 7-point Likert scale (1 = Not at all, 4 = Not sure/neutral, 7 = Extremely): “How broody/maternal (or paternal) do you feel compared to others of your age?”, “How important to you is having children?”. They were also asked to answer the following open-ended questions: “Ideally, how many children would you like to have?”, and “Ideally, at what age would you like to have your first child?”. To assess preferences and predictions for offspring sex, we asked participants to choose male or female in response to the following questions: “If you could only have ONE child, what sex would you prefer to have?”, “Assuming you have more than one child, if you could choose, what would you prefer for the sex of your first-born child?”, and “What sex of child would you predict that you would have first?”. In order to control for potential influences of cultural or religious backgrounds on reproductive preferences, we also asked participants to rate the degree to which they felt that their religious beliefs and cultural background had influenced their judgments of offspring sex, as well as number of children they would like to have, using the same 7-point Likert scale. All questions were assessed separately.

Dominance. Dominance was assessed using three separate questionnaires: the sociable and aggressive dominance subscales (SD and AD, Kalma, Visser, & Peeters, 1993), a 15-item questionnaire that measures positive and negative interpersonal behaviors related to aggressive and sociable dominance within groups, respectively; the dominance subscale of the International Personality Items Pool (D-IPIP,

<http://ipip.ori.org/ipip/>; Goldberg, 1999), a brief, 11-item measure of dominance used to assess the degree to which a person dominates others in social situations; and the Simple Adjective Test (SAT, Grant, 1998), a 64-item checklist with 13 target items (e.g., influential, strong, powerful) that measure participants' subjective ratings of dominance. A total score was calculated for each scale, with higher scores indicating higher dominance.

Sexual attitudes. The Sociosexual Orientation Inventory (SOI, Simpson & Gangestad, 1991) was used to assess attitudes towards sex without commitment. Participants are asked to answer a variety of questions (e.g., "How many different partners do you foresee yourself having sex with during the next five years?") and indicate their degree of agreement with statements (e.g., "Sex without love is OK") on a 9-point Likert scale. Overall scores were calculated, with higher scores indicating a greater orientation towards less restricted sexual behavior.

Psychological androgyny. The BEM Sex Roles Inventory (BSRI, Bem, 1974) was used to assess the degree to which individuals associate themselves with societal gender roles. It is a 60-item scale containing 20 masculine, 20 feminine, and 20 neutral adjectives for which the participant is asked to rate the degree to which each adjective is like them on a 7-point Likert scale (1-never or almost never true to 7-always or almost always true). Masculinity and femininity scores were calculated based on the ratings given for the masculinity and femininity items, respectively. The masculinity score was then subtracted from the femininity score to obtain a measure of androgyny. Higher scores on the masculinity and femininity scales indicate greater adherence. Androgyny scores close to 0 indicate equal levels of masculinity and femininity, scores less than 0 equal a more masculine gender role, and scores greater than 0 indicate a more feminine gender role.

3.2.3. Mate Preference Tasks

Face preference task. High and low dominance composite faces were created for each sex (i.e., 4 faces total, 2 female, 2 male) (Figure 3.1).



High Dominance



Low Dominance



High Dominance



Low Dominance

Figure 3.1. Composite Male (top) and Female (bottom) Faces Used in Mate Preference Task

The composites were created using photographs from a database of previously collected Caucasian male and female facial stimuli ($N = 66$) (Lundquist, Flykt, & Öhman, 1998) each rated by 327 participants for 15 psychological traits (e.g., happy, fearful, disgusted) including dominance (Oosterhof & Todorov, 2008).

We used Psychomorph software (Tiddeman, Burt, and Perrett, 2001) to create the composites. In brief, this software creates an average face from a series of photographs upon which the researcher has identified key facial landmarks (e.g., jaw line, hair line). High dominance composites were created using the 12 highest rated male¹ and female faces for dominance, and the low dominance composites were created using the 12 lowest rated male and female faces for dominance. A minimum of 12 faces per composite has been suggested in previous research (Law-Smith et al., 2012).

Each participant completed the task with opposite-sex faces. High and low dominance faces were presented digitally, side-by-side on an individual computer screen. Participants were asked to choose which face they preferred for a long- and a short-term mate. The order of these questions was counterbalanced across participants. They were then asked to rate each face, presented individually, for attractiveness/unattractiveness, femininity/masculinity, and submissiveness/dominance using 7-point Likert scales.

Behavior preference task. Opposite sex character vignettes (adapted from Bryan, Webster, & Mahaffey, 2011; Appendix A) were presented as a pencil and paper task. Participants read a description of a dominant and a submissive character and then rated their interest in both a long-term relationship and a one-time sexual encounter with the character using a 7-point Likert scale (1 = not at all interested, 4 =neither interested or not interested, 7 = very interested). Participants were also asked to rate each character for attractiveness, masculinity/femininity, and dominance/submissiveness using 7-point Likert scales as described above. Two task versions for each sex were

¹ Digital error resulted in slightly varied morphological marker placement for 1 high dominance male face.

used in which the presentation of characters was alternated. The two versions were counterbalanced across opposite-sex participants.

3.2.4. Hormone Measurements

Salivary estradiol and testosterone. Testing sessions were held between 1200 and 1600 hours to control for diurnal variation in T concentration. Participants were asked to refrain from eating or drinking, smoking, or brushing their teeth for at least one hour prior to their participation. Upon arrival in the laboratory, they were asked to collect approximately 6mL of saliva via passive drool into an untreated polypropylene tube. Samples were immediately frozen and held at -20°C for later analysis. Samples were analyzed using enzyme-linked immunosorbent assay techniques. On the day of assay, frozen samples were warmed to room temperature and then centrifuged (3000 rpm) for 15 minutes in order separate mucins from the saliva. Samples were then assayed in duplicate using competitive binding immunoassay kits for E_2 and T (Salimetrics Ltd.). The average intra-assay coefficient of variation was 5.01 and 5.40% for E_2 and T respectively, and inter-assay coefficients for low and high control were 4.16% and 4.86% for estradiol, and 8.79% and 6.81% for T. Estradiol concentration was unavailable for one male participant. Steroid levels were in the normal ranges for males (T: Mean \pm SD = 132.20 ± 38.06 pg/mL, E_2 : Mean \pm SD = 2.13 ± 1.05 pg/mL) and females (T: Mean \pm SD = 60.53 ± 22.23 pg/mL, E_2 : Mean \pm SD = $2.62 \pm .85$ pg/mL) (Salimetrics Ltd.).

Digit ratios. The lengths of the second and fourth digits on participants' hands were measured from digital scans obtained using a flatbed scanner. Each scan was saved in .pdf format for later analysis. Two independent raters measured the distance from the proximal crease to the fingertip on the second and fourth digits of the right and left hands for each participant using the Image J software program (<http://imagej.nih.gov/ij/index.html>). Inter-rater reliability was high ($ICC = 0.99$), and so the measurements were averaged for each participant.

3.2.5. Data Analysis

Chi-square, Mann-Whitney U, and independent samples t-tests were used to compare differences between men and women who predicted they would have sons and men and women who predicted they would have daughters on demographic, reproductive attitudes and preferences, psychological, hormone, and digit ratio measures. To determine whether women's dominance was a significant predictor of predicted offspring sex, composite z-scores were calculated from women's SAT and AD scores, and then used as the predictor variable in a binomial logistic regression. Predicted sex of first-born offspring was used as the dependent variable. Mate preferences for facial dominance were then compared separately for men who predicted they would have a son versus a daughter, and women who predicted they would have a son versus a daughter using Chi-square tests. Mixed ANOVAs with face type (high dominance, low dominance) as the within-subjects variable, and predicted offspring sex (son, daughter) as the between-subjects variable were then conducted for participants' ratings for each of masculinity, attractiveness, and dominance. Men and women's interest in a long- and short-term relationship with characters depicted in behavioral vignettes were compared using a series of mixed ANOVAs with character type (dominant, submissive) as the within-subjects variable, and predicted sex of offspring (son, daughter) as the between-subjects variable. Similar analyses were used for participants' ratings of the characters' masculinity, attractiveness, and dominance. A criterion value of $p \leq .05$ was employed for significance tests for all analyses. Because all study hypotheses were formulated *a priori* based on our intent to replicate and extend previous study results, no familywise error rate correction was applied.

3.3. Results

3.3.1. Participant Characteristics and Control Measures

Reproductive preferences. Two participants (1 male, 1 female) did not complete the reproductive preferences questionnaire and were excluded from all further analyses. Table 3.1 shows the reproductive preferences and predictions for the final sample ($N = 130$). Men predicted they would have a son significantly more often than

they predicted they would have a daughter as their first-born ($\chi^2(1, n = 65) = 14.79, p < .01, V = .23$), but they also preferred a son compared to a daughter for both an only ($\chi^2(1, n = 65) = 25.86, p < .01, V = .40$) and first-born child ($\chi^2(1, n = 65) = 21.06, p < .01, V = .32$), suggesting that their predictions may actually reflect preferences. Women also preferred a son compared to a daughter as a first-born child ($\chi^2(1, n = 65) = 14.79, p < .01, V = .23$), but there was no significant differences between their preferences for a son or daughter as an only child, or their predictions for a first-born child ($p > .05$), suggesting their predictions did not reflect preferences.

Table 3.1. Preferences and Predictions for Sex of Future Offspring in Men and Women

	Preference for only one child		Preference for first-born child		Prediction for first-born child	
	Male <i>n (%)</i>	Female <i>n (%)</i>	Male <i>n (%)</i>	Female <i>n (%)</i>	Male <i>n (%)</i>	Female <i>n (%)</i>
Men (<i>n</i> = 65)	53 (82)	12 (18)	51 (78)	14 (22)	48 (74)	17 (26)
Women (<i>n</i> = 65)	26 (39)	39 (61)	48 (74)	17 (26)	38 (58)	27 (42)

Men who predicted they would have a son first did not differ from men who predicted they would have a daughter first with regard to paternal they felt, the importance of having children, the importance of career, preferred age for having first child, or the number of children they would like to have (all $p > .05$). They also did not differ in the degree to which they reported that their culture or religious beliefs had impacted their preferences for offspring sex or number of children they would like to have ($p > .05$).

In contrast, women who predicted they would have a daughter first rated the importance of having a career higher ($Mdn = 7.00$ and 6.00 , respectively, $U = 337.50, Z = -2.57, p = .01, r = .31$), and wanted to have fewer children ($Mdn = 2.00$ and 3.00 , respectively, $U = 361.00, z = -2.22, p = .03, r = .28$) than those who predicted they would have a son first. The two groups did not differ in how maternal they felt, how important having children was to them, or age at which they would like to have their first child. Prediction for first child was not significantly dependent on ethnicity ($p > .05$), but the majority of Caucasian women predicted they would have a son first (73%). However, groups did not differ in the degree to which they reported that their culture influenced

their preferences for offspring sex or number of children they would like to have (all $p > .05$). In addition, there were no significant differences between ethnic groups (collapsed into Caucasian, Asian, Other) on any subsequent measure except for the SOI, where Asian women scored significantly lower than Caucasian women ($p = .02$) and nearly significantly lower than women who were neither Asian nor Caucasian ($p = .06$).

Hormonal birth control and fertility. The majority of women (75%) reported they were not using hormonal birth control. This did not differ significantly between groups ($p > .05$). For women who were not using birth control we determined whether they were in the fertile phase of their menstrual cycle (i.e., 5 days prior to ovulation, and their ovulation day itself, assumed to be 14 days prior to the onset of their next menses) based on self-reported menstrual cycle information, a method frequently used in evolutionary psychology studies (e.g., Perrett et al., 1998; Rantala et al., 2012). Eight (12%) women in our sample were determined to be in the fertile phase; four women were in each of the predicted son and predicted daughter groups.

3.3.2. Part I: Participant Characteristics and Predicted Sex of Offspring

Dominance. Men scored significantly higher than women on the sociable dominance (SD) subscale (Mean \pm SD = 23.43 \pm 5.13 and 21.44 \pm 5.67, respectively, $t(128) = -2.09$, $p = .04$, $d = .37$), and this difference approached significance for the dominance subscale of the IPIP (D-IPIP) (Mean \pm SD = 33.78 \pm 6.55 and 31.68 \pm 5.94, respectively, $t(128) = -1.92$, $p = .06$, $d = .34$) and the Simple Adjective Test (SAT) (Mean \pm SD = 2.95 \pm 2.09 and 2.32 \pm 1.77, respectively, $t(128) = -1.86$, $p = .07$, $d = .33$). There was no difference between men and women on the aggressive dominance (AD) subscale ($p > .05$).

Descriptive statistics, independent t-test results, and effect sizes for men and women who predicted a son first compared to a daughter first are shown in Table 3.2. There were no significant differences between men who predicted they would have a son first and men who predicted they would have a daughter first on any dominance measure (all $p > .05$). In contrast, women who predicted they would have a son first

scored higher than women who predicted they would have a daughter first on both the AD ($p = .03$) and the SAT ($p = .04$) measures. There were no differences between groups on the SD or the D-IPIP ($p > .05$).

SOI and BSRI. Four women (2 predicted son, 2 predicted daughter) and 1 man (predicted son) did not complete the SOI. Two of these women (1 predicted son, 1 predicted daughter) also failed to complete the BSRI. We also excluded one woman's SOI score that was 4 SD above the mean.

Table 3.2. Mean (SD) Dominance Scores for Men and Women by Predicted Sex of First-born Child

	Predicted Offspring Sex		<i>p</i>	<i>d</i>
	Male (<i>n</i> = 48)	Female (<i>n</i> = 48)		
Men				
Dominance Subscale (D-IPIP)	34.02 (6.60)	33.12 (6.58)	.63	.14
Aggressive Dominance (AD)	27.48 (5.36)	25.74 (7.10)	.30	.30
Social Dominance (SD)	23.48 (5.14)	23.29 (5.24)	.90	.04
Subjective Adjective Test (SAT)	3.06 (2.01)	2.64 (2.34)	.49	.20
Women				
	Male (<i>n</i> = 38)	Female (<i>n</i> = 27)		
Dominance Subscale (D-IPIP)	31.84 (5.74)	31.44 (6.32)	.75	.07
Aggressive Dominance (AD)	28.61 (5.15)	25.31 (6.45)	.03*	.58
Social Dominance (SD)	21.71 (5.59)	21.07 (5.86)	.55	.11
Subjective Adjective Test (SAT)	2.71 (1.89)	1.78 (1.45)	.04*	.54

There were no differences between men who predicted a son as their first-born child and men who predicted a daughter as their first-born child on the SOI, BSRI-masculinity, BSRI-femininity, or BSRI-androgyny scales (all $p > .05$). For women, the difference between those who predicted a son as their first-born child and those who predicted a daughter as their first-born child approached significance for both BSRI-masculinity (Mean \pm SD = 4.46 \pm .75 and 4.15 \pm .65, respectively, $t(61) = -1.72$, $p = .09$, $d = .44$) and BSRI-androgyny (Mean \pm SD = .54 \pm 1.06 and .94 \pm .74, respectively, $t(61) = 1.66$, $p = .10$, $d = .44$), but not BSRI-femininity ($p > .05$).

Dominance as an indicator of predicted sex of first-born. The results of a binary logistic regression analysis with composite z-scores for dominance, calculated using individual SAT and AD scores, as the predictor variable, and predicted sex of first-born as the dependent variable, were significant ($-2LL = 81.87$, $\chi^2(1, n = 65) = 6.37$, $p = .01$, $R^2 = .13$), suggesting that women higher in dominance predict sons. The model correctly classified 79% of male predictions and 48% of female predictions, for an overall rate of 66%. After controlling for the effects of self-perceived masculinity by regressing BSRI-scores onto composite dominance z-scores and retaining the standardized residuals, the results of the binary logistic regression with predicted sex of first-born child as the dependent variable and dominance as the predictor variable also approached significance ($-2LL = 82.46$, $\chi^2(1, n = 63) = 2.95$, $p = .09$, $R^2 = .06$). Results are shown in Table 3.3.

Table 3.3. Binary Logistic Regression Analysis for Women’s Predicted Sex of First-born as Dependent Variable.

	<i>B (SE)</i>	<i>Odds Ratio (95% CI)</i>	<i>p</i>
Model 1:			
Dominance Composite z-score	.69 (.29)	1.99 (1.13 – 3.50)	.02
Model 2:			
Residual Dominance Score (Controlled for BSRI-Masculinity)	.46 (.28)	1.58 (.92 – 2.72)	.10

Salivary estradiol and testosterone. One male sample was not analyzed for E₂ due to low saliva volume. In addition, data from 8 participants (5 men, 3 women) were excluded due to current medication use (e.g., antibiotics, antidepressants). One outlier (i.e., > 3SD from mean) for E₂ (male) and one outlier for T (female) were also excluded. Descriptive statistics obtained for the remaining participants are shown in Table 3.4. There were no significant differences between women who predicted a boy and those who predicted a girl for either E₂ or T ($p > .05$). Similarly, men who predicted a son did not differ from those who predicted a girl for E₂ or T ($p > .05$).

Table 3.4. Mean (SD) Salivary Hormone Concentrations

	Estradiol (pg/mL)	Testosterone (pg/mL)
Men ($n = 58, 60$)	2.06 (.95)	133.57 (38.32)
Women ($n = 62, 61$)	2.60 (.84)	58.54 (18.45)
Birth Control Users ($n = 16$)	2.54 (.92)	44.92 (16.37)
Non-users ($n = 46, 45$)	2.62 (.82)	63.38 (16.78)

Digit ratio. There were no significant differences between women who predicted they would have a boy first compared to those who predicted a girl for either right or left 2D:4D ($p > .05$). There were also no significant differences between men who predicted they would have a boy first compared to those who predicted a girl for either the right the left 2D:4D ($p > .05$).

3.3.3. Part II: Predicted Sex of Offspring and Mate Preferences

Two women and one man reported same-sex mate preferences; their data were excluded from further analysis. Due to clerical error, data were unavailable for 1 male on the face preference task, and 1 male and 2 females on the behavior preference task.

Facial preferences.

Manipulation check. For men, there was a significant main effect of face type (high or low dominance) for ratings of attractiveness ($F(1, 61) = 45.45, p < .01, \eta^2 = .43$), and masculinity ($F(1, 61) = 13.62, p < .01, \eta^2 = .18$), with the high dominance face rated more attractive (Mean \pm SD = 4.71 ± 1.30 and) and less feminine (Mean \pm SD = 3.46 ± 1.41) than the low dominance face (Mean \pm SD = 3.17 ± 1.06 and 2.68 ± 1.15 , respectively). There was no significant main effect of face type for dominance ratings ($p > .05$), indicating that men did not perceive the two faces to differ significantly in dominance. Neither the main effect of predicted sex of first-born, or interaction between predicted sex of first-born and face type were significant for dominance, masculinity, or attractiveness (all $p > .05$).

Similarly, significant main effects of face type were observed for women's ratings of dominance ($F(1, 61) = 39.21, p < .01, \eta^2 = .39$), attractiveness ($F(1, 61) = 44.88, p <$

.01, $\eta^2 = .42$), and masculinity ($F(1, 61) = 130.63, p < .01, \eta^2 = .68$), with the high dominance male face rated more dominant (Mean \pm SD = 4.80 \pm 1.47), more attractive (Mean \pm SD = 5.13 \pm .94), and more masculine (Mean \pm SD = 5.82 \pm .99) than the low dominance male face (Mean \pm SD = 3.46 \pm 1.27, 3.59 \pm 1.30, and 3.93 \pm 1.21, respectively). Neither the main effect of predicted sex of first-born, or the interaction between predicted sex of first-born and face type was significant for dominance, attractiveness, or masculinity (all $p > .05$), confirming that despite different mate preferences, perceptions of the faces did not differ between women who predicted sons and women who predicted daughters.

Preferences for facial dominance. Table 3.5 presents potential mate choice (i.e., choice of high vs. low dominance faces) broken down by predicted sex of first-born child and relationship type (short- vs. long-term). Men's preferences for short- and long-term mates were independent of predicted sex of first-born ($p > .05$), with the majority of men in both groups preferring the low dominance face. The face preferences for either relationship-type did not depend on participants' ethnicity ($p > .05$).

Table 3.5. Frequency of Preference for High and Low Dominance Faces for Short- and Long-term Mates

		Short-term		Long-term	
		High Dominance Face	Low Dominance Face	High Dominance Face	Low Dominance Face
Men					
	Son ($n = 46$)	17	29	15	31
	Daughter ($n = 17$)	9	8	7	10
Women					
	Son ($n = 36$)	27	9	18	18
	Daughter ($n = 25$)	13	12	13	12

Note: Relationship between short-term mate preference and predicted sex of first-born for women is significant ($p = .04$)

In contrast, women's preference for a short-term mate was dependent on predicted sex of first-born ($\chi^2(1, n = 63) = 4.43, p = .04, r = .27$), with the majority of women who predicted a boy preferring the dominant face. No relationship was observed for long-term mate preference ($p > .05$). Preferences for either relationship-type did not

depend on ethnicity ($p > .05$), and controlling for the influence of SOI on these preferences did not appreciably affect the results.

Behaviorial preferences.

Manipulation check. Significant main effects were found for character type for women's ratings of dominance ($F(1, 60) = 155.54, p < .01, \eta^2 = .72$), attractiveness ($F(1, 60) = 57.22, p < .01, \eta^2 = .49$), and masculinity ($F(1, 60) = 122.15, p < .01, \eta^2 = .67$). The dominant character was rated more dominant (Mean \pm SD = 6.00 ± 1.07), more attractive (Mean \pm SD = $5.60 \pm .82$), and more masculine (Mean \pm SD = 5.68 ± 1.21) than the submissive character (Mean \pm SD = $2.73 \pm 1.22, 4.35 \pm 1.10$, and $3.82 \pm .89$, respectively). There were no significant main effects of predicted sex of first born ($p > .05$), but the interaction between predicted sex of first-born and character type approached significance for attractiveness ($F(1, 60) = 3.01, p = .09, \eta^2 = .05$), with women who predicted a son rating the dominant character more attractive (Mean \pm SD = $5.86 \pm .87$) than women who predicted a daughter (Mean \pm SD = 5.42 ± 1.55), and women who predicted a son rating the submissive character less attractive (Mean \pm SD = 3.89 ± 0.75) than the women who predicted a daughter (Mean \pm SD = 3.96 ± 1.08). No other interactions were significant ($p > .05$).

For men, significant main effects of character type were found for dominance ($F(1, 61) = 179.29, p < .01, \eta^2 = .75$) and masculinity ($F(1, 61) = 24.82, p < .01, \eta^2 = .29$), but not attractiveness, with the dominant character rated more dominant (Mean \pm SD = $5.68 \pm .90$) and more masculine (Mean \pm SD = 3.86 ± 1.39) than the submissive character (Mean \pm SD = $2.68 \pm .98$ and 2.81 ± 1.49 , respectively). There were no significant main effects of predicted sex of first-born, or interaction effects ($p > .05$).

Preferences for behavioral dominance. For women, there was a significant main effect of character type (dominant, submissive) on interest for a long-term relationship ($F(1, 59) = 38.65, p < .01, \eta^2 = .39$), with greater interest reported for the dominant character (Mean \pm SD = 5.48 ± 1.19) compared to the submissive character (Mean \pm SD = 3.79 ± 1.51). Neither the main effect of predicted sex of first-born or the interaction between interest for a long-term mate and predicted sex of first-born were significant ($ps > .05$). For interest in a one-time sexual encounter, there was a significant

interaction effect ($F(1, 58) = 9.49, p < .01, \eta^2 = .14$), with those who predicted a son reporting greater interest in the dominant character (Mean \pm SD = 5.53 ± 1.28) than those who predicted a daughter (Mean \pm SD = 4.08 ± 1.94) ($t(59) = 3.52, p < .01$) (Figure 3.2). Controlling for SOI had no appreciable effect on these results.

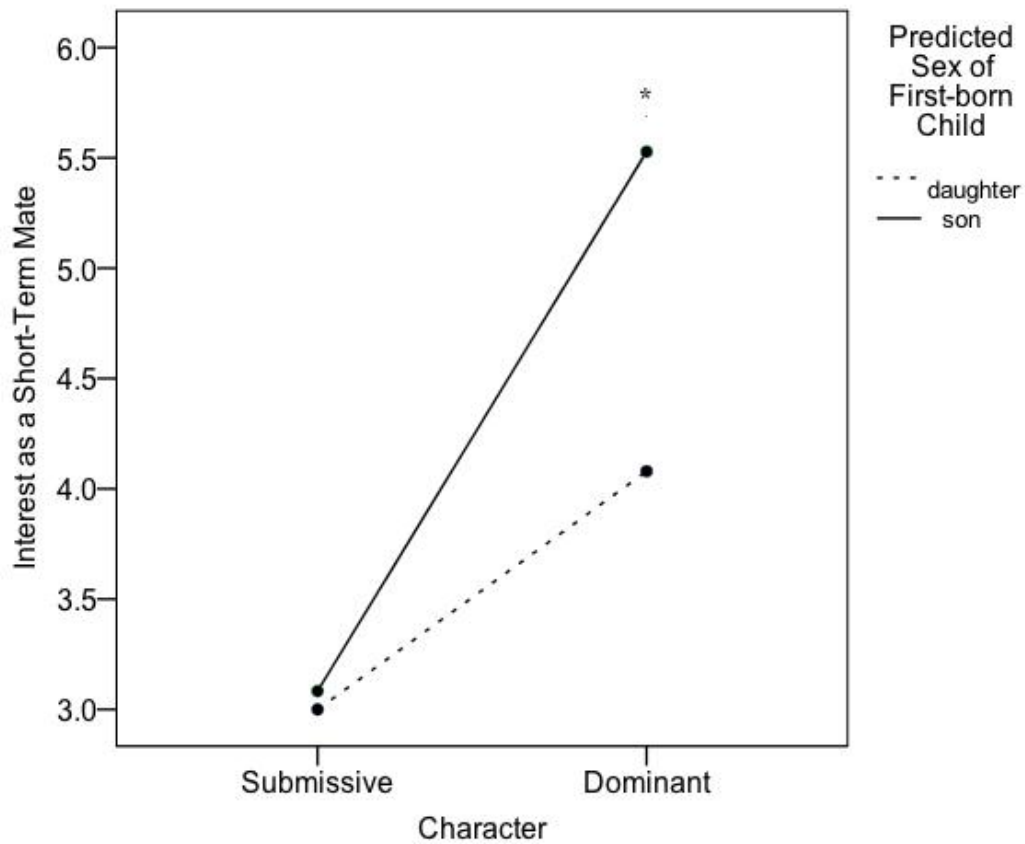


Figure 3.2. Interaction Between Women’s Interest in a Dominant Versus Submissive Character for a One-time Sexual Encounter and Predicted Sex of First-born Child

Note: * $p < .01$

3.4. Discussion

The results of the present study provide additional evidence that there may be interoceptive cues that indicate one's tendency to produce a male or a female offspring, and that this perception may have an adaptive influence on mate preferences. Specifically, we found that for women, dominance is a significant predictor of perception of having a son as a first-born child, with higher dominance increasing the likelihood of a predicted son. We also found that women who predicted they would have a son as their first-born child were more likely to prefer a dominant mate for a short-term mate, both in judgment of the potential mate's face and interpersonal behavior. Interestingly, the relationship between predicted sex of first-born and preference for a dominant mate was independent of perceived masculinity, attractiveness, and dominance in the face, which did not differ between women who predicted they would have a son, and women who predicted they would have a daughter. Taken together these results provide support for the novel hypothesis that women choose mates based on characteristics that will be most beneficial to the reproductive success of their future offspring.

It is worth noting that in contrast to our previous finding that men who predicted a daughter had higher E_2 and more feminine digit ratios, we found no differences between men who predicted they would have a son and men who predicted they would have a daughter on any physiological or psychological measures. This may be attributable to the observation that men's predictions seemed to model their preferences, with the majority of men preferring to have a male offspring. Societal preferences for male offspring have been reported in several studies, particularly in men (e.g., Dahl & Moretti, 2008; Hank, 2007; Marleau & Saucier, 2002), so it is possible that our data reflects this tendency. However, it is also possible that men do not have access to any interoceptive cues for offspring sex, and that modulation of sex ratios is exclusively the domain of the mother. Future research should investigate these possibilities.

This study also provides evidence that the relationship between dominance and predicting a son for a first-born child does not simply reflect differences in self-perceived masculinity. Although the women in our study who predicted they would have a son scored higher in masculinity, they were also more androgynous than women who

predicted they would have a daughter. In addition, controlling for the effects of self-perceived masculinity appeared to have minimal effects on the predictive validity of dominance for influencing women's predictions for first-born child, suggesting that not only do more dominant women tend to give birth to more sons (Akande, 1999; Grant, 1990, 1994), they also appear to *predict* they will have sons, which may in turn influence their mate selection behavior.

Although several factors, such as cycle phase/fertility and women's own attractiveness/mate value (reviewed in Puts, Jones, & DeBruine, 2012), have been demonstrated to resolve the discrepancy in the literature surrounding women's preferences for masculinity and dominance in men, the results of our study suggest that individual differences in mate preferences, particularly for a short-term mate, may actually reflect their perception of the sex of child they will conceive. It has been proposed that women adopt several mating strategies, one of which is to choose mates of high genetic quality for short-term mates and of high parental investment for long-term mates (see Gangestad & Simpson, 2000; Buss, 2007); however, our results suggest that this pattern may differentially ramify in women depending on their self-perceptions regarding sex of future offspring. In other words, women who believe they are more likely to have sons may preferentially seek short-term, dominant mates whereas women who believe they are more likely to have daughters may preferentially seek non-dominant mates for both short- and long-term mates. This would be adaptive in that characteristics of dominance would presumably be of more genetic benefit to sons than daughters. These possibilities warrant additional investigation.

There are at least three limitations to this study worth noting. First, although women using birth control, as well as women who were in the fertile phase of their menstrual cycle were equally distributed amongst groups in our study, we were not able to appropriately investigate the potential effects of menstrual cycle on mate preferences. Future studies should be designed to investigate these factors. Second, we are unable to determine whether the predictions for sex of first-born child made by participants in our study are actually accurate; our analysis probed whether participants' behavior was shaped by their beliefs about first born sex, but it would be fascinating to include an accuracy measure in future studies. Longitudinal studies would be required to confirm

the presence and accuracy of and interoceptive cues for offspring sex. Lastly, our sample was ethnically diverse, which could have introduced variability due to cultural influences regarding attitudes and preferences for offspring sex, as well as characteristics of an ideal mate. Although we did not see any significant association between ethnicity and any of our variables of interest, future research should attempt to control for these factors.

In sum, we provide evidence that there may be interoceptive cues to propensity to produce male or female offspring in women, and that this may lead to differences in preferences for dominance in short-term mates. Women who are more dominant may be more likely to predict they will have a male offspring, which may have a direct influence on their interest in a high dominance male as a potential short-term mate. These relationships warrant confirmation in future research; however, they present the intriguing possibility that women's reproductive qualities may function adaptively to increase their own reproductive success depending on their own offspring sex ratios.

Chapter 4.

STUDY 3: Facial Characteristics in Men and Women who Predict Sons Compared to Daughters

4.1. Introduction to Study 3.

Building on the data presented in Studies 1 and 2, it is reasonable to posit that men and women may have access to interoceptive cues signaling a bias to produce a particular sex of future offspring. Although the exact nature of such cues remains unknown, physiological and psychological characteristics such as steroid hormone concentrations, digit ratio, sexual restrictiveness, and dominance are likely candidates to show a relationship. Indeed, other research has shown that variation in these characteristics is associated with real offspring sex ratios in men and women (Akande, 1999; Grant, 1990, 1994; reviewed in James, 1996; Kanazawa & Apari, 2009; Manning et al., 2002), suggesting that they may indeed provide accurate indicators of an individual's sex-of-offspring bias. Given that both steroid hormone concentrations and characteristics of dominance and sexual restrictiveness affect perceptions of men's and women's faces (Boothroyd et al., 2011; Boothroyd et al., 2008; Fink et al., 2007; Law-Smith et al., 2006; Penton-Voak & Chen, 2004; Quist et al., 2011), it is possible that men's and women's faces differ in predictable ways according to their future offspring sex, and that potential mates may be able to detect or act on these facial cues in some way. These possibilities have not yet been tested.

Parental variation in offspring sex ratio has been theorized to maximize reproductive success (Trivers & Willard, 1973), but the exact mechanisms through which parental variation might take place remain unknown. It has been hypothesized that variation in concentrations of parental E_2 , T, progesterone, and gonadotropins (i.e., LH, FSH) at the time of conception may be responsible for influencing sex determination,

with the former two increasing the probability of a male, and the latter two increasing the probability of a female (reviewed in James, 1996). Although variation in this pattern has been demonstrated in various large databases, including the finding that fathers with testicular cancer (i.e., low ratio of T to gonadotropin) sire more daughters, and that mothers with multiple sclerosis (i.e., high levels of T) bear more sons (reviewed in James, 2004), little is known about how alterations in hormone levels might operate physiologically to alter sex ratios. In contrast, the Maternal Dominance Hypothesis (Grant, 1998) posits that maternal T, which fluctuates with behavioral dominance (Grant & France, 2001), directly affects sex determination. In addition to evidence that shows that more dominant women are more likely to have sons (Akande, 1999, Grant, 1990, 1994), Grant and Irwin (2008) have shown that high levels of maternal T in the follicular fluid surrounding bovine ova increases the probability of it accepting a Y-chromosome bearing sperm. Thus, parental hormone levels at the time of conception may provide important indicators of the tendency for men and women to produce male or female offspring.

One mechanism through which sex ratio variation might be detectable in parents prior to conception is face perception. In men, T levels are positively associated with masculine facial appearance (Penton-Voak & Chen, 2004; Roney et al., 2006), a reliable, T-mediated signal of dominance and physical strength (Fink et al., 2007). Similarly, taller and heavier fathers have more sons (Kanazawa, 2005). More feminine male faces are often considered to be more attractive than masculine male faces (Perrett et al., 1998; reviewed in Puts et al., 2012; but see Johnston et al., 2001), and more attractive fathers have more daughters (Kanazawa, 2007, 2011), again suggesting that hormonal indicators in the faces of men could signal tendency towards male or female offspring. In women, E_2 levels are associated with a feminine facial appearance (Law Smith et al., 2006), attractiveness, and increased maternal tendency (Law Smith et al., 2011), and as with men, more attractive women reportedly have more daughters (Kanazawa, 2007, 2011). The relationship between T and facial characteristics in women has not been directly studied, but dominance is associated with a masculine facial appearance in women (Quist et al., 2011). Furthermore, other indicators of circulating T in mothers, such as higher (i.e., more masculine) waist to hip ratio, and lower (i.e. more masculine) digit ratio, are associated with a greater number of sons,

suggesting that a relationship likely exists. In short, it is plausible that the face may provide a detectable marker of women's tendency to have male or female offspring.

In the present study, we evaluated masculinity/femininity, attractiveness/unattractiveness, and dominance/submissiveness in men's and women's faces according to their predicted future sex of offspring. We also explored whether naïve raters judgments of the sex that men and women were most likely to conceive simply by viewing their faces matched the predictions made by the participants depicted. We hypothesized that women who predicted they would have a son first would be rated more masculine, less attractive, and more dominant than those who predicted a daughter. We also hypothesized that men and women would be more accurate than chance at judging the sexes of men and women's first born offspring by viewing their faces.

4.2. Methods

4.2.1. Face Models and Procedure

Sixty-five male (Mean age \pm SD = 20.49 \pm 2.35 years) and 65 female (Mean age \pm SD = 19.91 \pm 2.91 years) undergraduate participants provided facial photographs and predicted the sex of their first-born offspring as part of a larger study investigating mate preferences. Participants were ethnically diverse (35% Caucasian, 36% Asian, 15% South Asian, 4% Arabic/Middle Eastern, 4%, West Asian/Indian, 7% Other), which is representative of the metropolitan area in which the university is located. Photographs were taken during the test session described in Study 2, where participants were also required to provide information collected from their parents, provide saliva samples for hormone analysis, complete demographic and personality questionnaires, and complete mate preference tasks. All participants provided informed consent, and all study procedures were subject to prior approval by the Simon Fraser University Office of Research Ethics.

Facial photographs. Prior to being photographed, participants were asked to pull their hair from their faces using commercially available hairbands. If applicable, they

were also asked to remove eyeglasses. Participants were asked to sit straight with their feet flat on the floor and keep a neutral facial expression. Photographs were taken under room lighting conditions in a laboratory testing room using a digital camera (Canon Powershot SX130 IS with 12x optical zoom) secured to a tripod placed one meter away from the participant. Photographs were taken manually and zoomed in such that the participant's face filled approximately 40 – 70% of the frame, which was oriented in landscape position. In order to minimize the invasiveness of our study procedure, as well as to maximize ecological validity, no restrictions were placed on participants' use of cosmetics, facial hair, or other facial adornments.

Predicted offspring sex. Participants were asked to predict the sex of their first-born offspring as part of a reproductive attitudes questionnaire. Briefly, they were asked to rate their level of broodiness, desire for children, and desire for career using a 7-point Likert scale, and then to choose either male or female in response to two questions about their preferences for offspring, and ultimately, the sex of child they predict they would have first. Participants were not given any instruction or guidance on how to make these judgments. No participants reported having any existing children.

4.2.2. Face Judgments and Ratings

Participants. Seventy participants rated faces for partial course credit in a psychology course. One male participant failed to respond to more than 10% of the face judgments and was excluded from analysis. The final rater sample consisted of 37 males (Mean age \pm SD = 19.51 \pm 1.68 years) and 32 females (Mean age \pm SD = 20.50 \pm 2.00 years). The raters were also ethnically diverse (30% Caucasian, 35% Asian, 15% South Asian, 7% Arabic/Middle Eastern, 4% West Asian/Indian, 1% Black/African American, and 7% Other). All participants provided informed consent, and all study procedures were subject to prior approval by the Simon Fraser University Office of Research Ethics.

Preparation and presentation of stimuli. Unaltered digital images were presented at a height of 11.4 cm and width of 15.2 cm. Some hair and clothing was visible in the photographs. Faces were presented one at a time with an identification number underneath each one that corresponded to questions presented in paper and

pencil format. Faces were presented in random order, 20 seconds apart, and separated into 2 blocks consisting of 65 photographs each. Participants were given a 5 minute break between blocks.

Rating procedures. Participants completed ratings in groups in a large university classroom, but were not permitted to communicate during the task. Photographs were presented on a large screen at the front of the room using a digital projector. Prior to beginning the ratings, participants were presented with written instructions directing them to rate faces based on their own initial judgments. No written descriptions or definitions of masculinity, attractiveness, or dominance were provided. If a participant recognized an individual in a photograph, they were instructed to check a box identifying this, and not to make ratings for that person.

For each face, participants were asked to first predict the sex of child that the person would have as their first-born child as well as to rate the face for masculinity, attractiveness, and dominance. Participants were asked about the individual's sex of first born in forced choice (male or female), and written as follows: "Based on your impressions of this person, if they were to have a child in the near future, which sex of baby do you think they would have?". Participants were then asked to rate the face for masculinity (1 = very masculine, 3 = neither masculine or feminine, 7 = very feminine), attractiveness (1 = very unattractive, 3 = neither unattractive or attractive, 7 = very attractive), and dominance (1 = very submissive, 3 = neither submissive or dominant, 7 very dominant).

4.2.3. Data Analysis

To determine whether participants could accurately anticipate models' guesses regarding the sex of their future first-born offspring simply by looking at their faces, accuracy and response bias in judgments for sex of offspring were calculated for each participant using Signal Detection Theory (Stanislaw & Todorov, 1999). In the infrequent instance that a participant omitted a response, their total accuracy and bias was calculated without including that item. Mixed ANOVAs with block as the within-subjects variable and sex of rater as the between-subjects variable were conducted to assess

any effects of block order. Overall accuracy scores were compared to chance guessing (.50) using a one-sample t-test.

In order to compare facial characteristics of models average ratings for masculinity, attractiveness, and dominance were calculated for each rater for the faces of women who predicted sons, the faces of women who predicted daughters, the faces of men who predicted sons, and the faces of men who predicted daughters. If a participant omitted a rating, the calculated average for that participant simply excluded the missing value. Averages were then analyzed using a series of mixed-model ANOVAs (separately in women and in men, for masculinity, attractiveness, and dominance) with predicted sex of offspring as the within-subjects variable and the sex of rater as the between-subjects variable.

Ethnicity was collapsed into four groups (Caucasian, Asian, South Asian, and Other) based on the four categories with the highest frequencies. A one-way ANOVA with post-hoc comparison (LSD) was then used to evaluate the effect of ethnicity on face ratings. Linear regressions were used to partition ratings of dominance from the potential influence of ratings of masculinity and attractiveness for males and females. Ethnicity was included in the linear regression for females. Standardized residuals were retained and used for further analyses. Subsequent binary logistic regressions with predicted sex of offspring (dependent variable) and dominance (standardized residual values, predictor variable) were used to assess the role of other-rated facial dominance in the sex of offspring an individual predicts they will have. Significance was set at $p \leq .05$ for all analyses.

4.3. Results

4.3.1. Predicted Sex of Offspring

Men predicted they would have a son ($n = 48$) significantly more often than they predicted they would have a daughter ($n = 17$) as their first-born ($\chi^2(1, n = 65) = 14.79, p < .01, V = .23$). In contrast, the number of women who predicted they would have a son ($n = 38$) did not differ significantly from the number of women who predicted they would

have a daughter ($n = 27$) as their first-born child ($p > .05$). Although women's predicted sex of first-born did not depend significantly on ethnicity ($p > .05$), 50% of the models that predicted a son were Caucasian whereas only 25% of the models that predicted a daughter were Caucasian.

4.3.2. Judgments of Offspring Sex

Ratings from seven participants were excluded from analysis due to not answering any offspring sex questions (1 male), exclusively guessing male offspring (2 females), exclusively guessing male offspring for male faces (2 males, 1 female), and exhibiting extreme bias towards guessing female offspring ($> 3SD$ from group mean, 1 male). Descriptive statistics obtained for accuracy and bias in judgments of sex of offspring in male and female faces is shown in Table 4.1. When overall accuracy scores

Table 4.1. Accuracy (A') and Bias (B') in Participants' Judgments of Offspring Sex

		A'		B'	
		Mean	SD	Mean	SD
Male Faces					
	First Block	.51	.20	-.06	.24
	Second Block	.51	.14	-.05	.18
	Overall	.51	.13	-.03	.11
Female Faces					
	First Block	.51	.16	.05	.14
	Second Block	.43	.18	.07	.26
	Overall	.48	.12	.03	.11
All Faces					
	First Block	.54	.12	.01	.06
	Second Block	.48	.11	< -.01	.05
	Overall	.51	.09	< -.01	.02

Note: A' values range from 0 (None) to 1 (All), and B' values range from -1 (female guessing) to 1 (male guessing), with 0 indicating no bias.

were considered, participants were not significantly better than chance at guessing the offspring sex predictions made by models for male faces, female faces, or all faces

together ($p > .05$). Participants exhibited a slight bias towards guessing female offspring for male faces, and a slight bias towards guessing male offspring for female faces.

A significant order effect was observed for face ratings ($F(1,60) = 8.47, p < .01, \eta^2 = .12$), with higher accuracy scores observed for the first block compared to the second block (Table 1). Neither the main effect of sex of rater, nor the interaction between order and sex of rater were significant ($p > .05$). When analyzed separately, the main effect of order was significant for female faces ($F(1, 60) = 6.69, p = .01, \eta^2 = .10$) but not male faces ($F(1,59) = .02, p > .05, \eta^2 < .01$) (Table 1). No other main or interaction effects were significant ($p > .05$).

4.3.3. Characteristics of Faces

Mean ratings of masculinity, attractiveness, and dominance for men and women's faces are shown in Figure 4.1.

Women. For masculinity ratings, we found a main effect of predicted sex of offspring ($F(1,67) = 170.29, p < .01, \eta^2 = .72$), with women who predicted they would have a son being rated less masculine (i.e., more feminine) (Mean \pm SD = 5.15 \pm .63) than women who predicted they would have a daughter (Mean \pm SD = 4.78 \pm .61). Neither the main effect of rater sex, nor the interaction between predicted sex of offspring and rater sex were significant ($p > .05$). For attractiveness ratings, we also found a main effect of sex of offspring ($F(1,67) = 204.21, p < .01, \eta^2 = .75$), with women who predicted they would have a son being rated more attractive (Mean \pm SD = 4.35 \pm .60) than women who predicted they would have a daughter (Mean \pm SD = 3.79 \pm .62). Neither the main effect of rater sex, nor the interaction between predicted sex of offspring and rater sex were significant ($p > .05$). Lastly, for dominance ratings, we found a main effect of sex of offspring ($F(1,67) = 17.19, p < .01, \eta^2 = .20$), with women who predicted they would have a son being rated more dominant (Mean \pm SD = 4.11 \pm .42) than women who predicted they would have a daughter (Mean \pm SD = 3.94 \pm .46). Neither the main effect of rater sex, nor the interaction between predicted sex of offspring and rater sex were significant ($p > .05$).

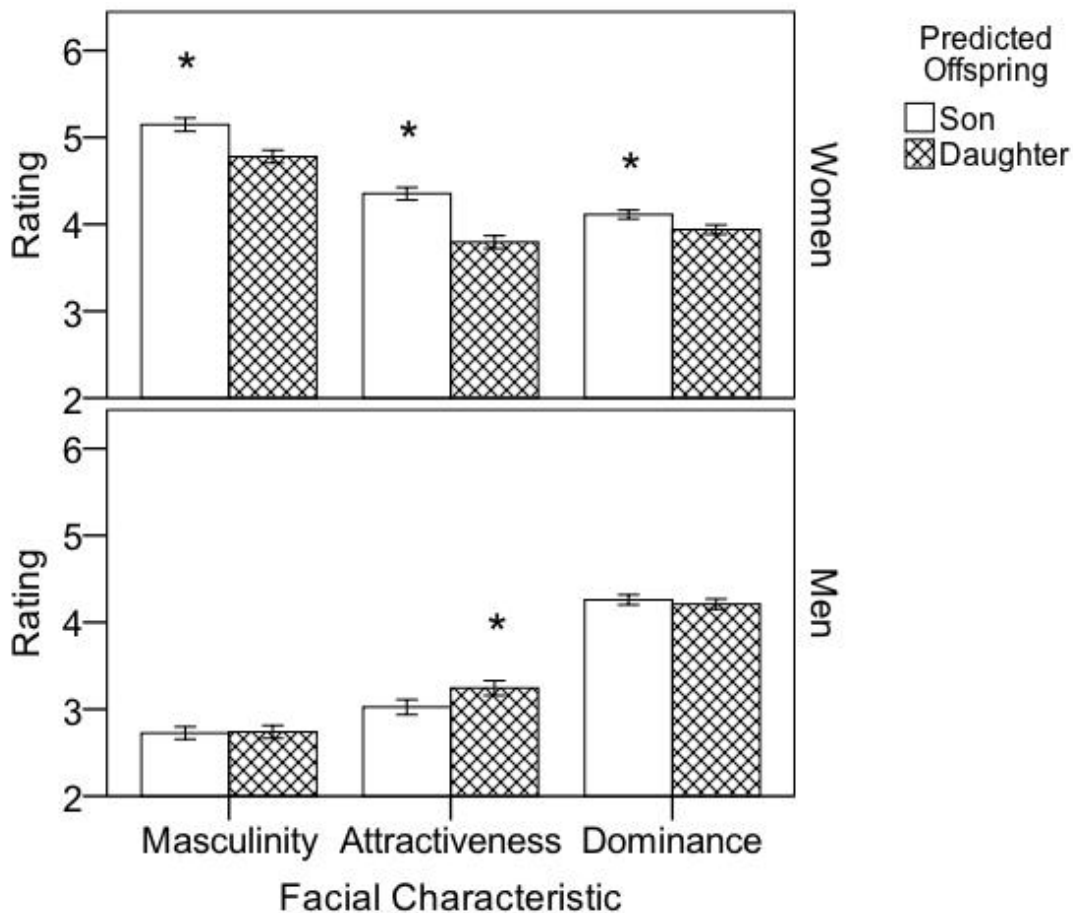


Figure 4.1. Mean (\pm 1 SE) Ratings of Men and Women’s Facial Characteristics Depending on their Predicted Sex of Offspring

Note: * $p < .01$

Men. For men, there was a significant main effect of predicted sex of offspring on attractiveness ratings ($F(1,67) = 29.15, p < .01, \eta^2 = .30$), with men who predicted they would have a son being rated less attractive (Mean \pm SD = $3.02 \pm .71$) than men who predicted they would have a daughter (Mean \pm SD = $3.24 \pm .71$). Neither the main effect of rater sex, nor the interaction between predicted sex of offspring and rater sex were significant ($p > .05$). There were no main effects of sex of offspring or rater sex, nor significant interaction effects between predicted sex of offspring and rater sex, for either masculinity or dominance ratings (all $p > .05$).

4.3.4. Facial Dominance and Predicted Sex of First-Born

Since consistency amongst raters was considerably high for masculinity, attractiveness, and dominance (all ICC > .94), we calculated an average rating across raters for each characteristic for each face and used these values for subsequent regression analyses. Given the high proportion of Caucasian women who predicted they would have a son first, we tested to see whether facial ratings differed by ethnicity. There was no significant effect of ethnicity on ratings of facial masculinity or attractiveness ($p > .05$); however, there was a significant effect of ethnicity on ratings of facial dominance ($F(1, 3) = 5.78, p < .01, \eta^2 = .22$), with Caucasian women rated more dominant than Asian ($p < .01$) and South Asian ($p = .02$) women. No other contrasts were significant.

For women's faces, masculinity and attractiveness were highly correlated ($r(65) = .91, p < .01$), indicating that faces rated as more feminine were also rated as more attractive. There was also a significant correlation between ratings of attractiveness and dominance ($r(65) = .24, p = .05$), indicating that faces rated as more attractive were also rated as more dominant. For men's faces, ratings of masculinity and dominance were significantly negatively correlated ($r(65) = -.81, p < .01$), indicating that faces rated as more masculine were also rated as more dominant. There was also a correlation between ratings of attractiveness and dominance ($r(65) = .34, p < .01$), indicating that faces rated as more attractive were also rated as more dominant. In order to control for these potential effects in determining whether ratings of facial dominance could predict the model's predicted sex of offspring, we ran separate, initial linear regressions for each of ratings for women's and men's dominance (dependent variables) and masculinity and attractiveness as predictor variables. Given the large proportion of Caucasian women who predicted a son compared to a daughter and the finding that Caucasian women were rated as more dominant than Asian or South Asian women, we also included ethnicity (dummy coded as not Caucasian = 0, Caucasian = 1) as a predictor variable in these regressions. Standardized residuals were retained for each regression and used for the following binary logistic regression analyses.

Women's faces. The results of binary logistic regressions performed with predicted offspring sex as the dependent variable, and facial dominance as the predictor variable for women's faces was not significant ($-2LL = 88.22$, $\chi^2(1, n = 65) = .02$, $p = .90$, $R^2 < .01$).

Men's faces. The results of binary logistic regressions performed with predicted offspring sex as the dependent variable, and facial dominance as the predictor variable for men's faces was also not statistically significant ($-2LL = 72.22$, $\chi^2(1, n = 65) = 2.49$, $p = .12$, $R^2 = .06$).

4.4. Discussion

In the present study, we investigated the possibility that the predictions that individual's made for the sex of their future offspring could be detected by naïve raters through viewing their face. We also investigated whether men and women's facial characteristics differed depending on the sex of child they predicted they were more likely to have, and whether ratings of facial dominance were significant predictors of the sex of offspring that an individual would predict they were more likely to conceive. We found no evidence for an ability to detect predicted offspring sex in the faces of models, with rater performance not differing significantly from chance guessing. Interestingly though, we did find evidence to support the possibility that women who predict they will have a son are more attractive, more feminine, and more dominant than women who predict they will have a daughter as their first born child. Men who predicted they would have a daughter were rated as more attractive than men who predicted they would have a son. Although it is important to emphasize that there is no way to verify the accuracy of the predictions made by the participants in our study, these results suggest that although faces may not provide accurate cues of an individual's future sex of offspring, at least for females, they may provide cues of mate quality that vary depending on the sex of child an individual may be more likely to conceive.

The finding that raters were unable to accurately judge the predicted future offspring sex from men's and women's faces suggests that facial characteristics are not

used, at least consciously, as cues of an individual's likelihood of producing a male or a female offspring. However, it is worth noting that of the 65 men who provided photographs in our study, only 17 predicted they would have a daughter as their first-born child. Given that the proportion of male births to female births in Canada is approximately 105:100 (Statistics Canada, 2013), these predictions are unlikely to be accurate and are more likely to be a reflection of a general preference for sons. Thus, if raters were actually able to detect offspring sex in faces, their calculated accuracy would have been affected by initially inaccurate predictions of male participants. Similarly, it is important to acknowledge the role of raters' pre-existing conceptions about sex determination being reflective of an equal probability of an egg being fertilized by an X- or Y-chromosome bearing sperm. Raters of male faces exhibited a slight bias towards guessing female offspring, which is likely a reflection of their tendency to correct their answers for an expected equal distribution of male and female offspring in the faces. Such an effect was also demonstrated for female faces, particularly in the second block where raters' accuracy was significantly lower due to a disproportionate number of predicted male offspring compared to female offspring in faces. The goal of the present study was to explore raters' initial judgments of faces, and thus, we did not provide any explicit explanation or instruction of how faces should be judged. Given the results obtained here, it is likely important for future studies to attempt to clarify or alter the pre-existing ideas that participants' hold about sex determination prior to having them make judgments using faces.

In contrast to our initial hypotheses, we found that women who predicted they would have a son as their first-born child were rated as less masculine and more attractive than women who predicted they would have a daughter first. After controlling for the possible effect of ethnicity on dominance ratings, we did not find evidence for facial dominance as an indicator of the sex of offspring that an individual predicts they will have. This finding is in contrast to previous work that has shown parents of daughters to be more attractive than parents of sons (Kanazawa, 2007, 2011). In addition, parents of sons have been found to be taller and heavier (Kanazawa, 2005) and to exhibit more masculine digit ratios (Manning et al., 2002) and waist-to-hip ratios (Manning et al., 1996; Singh & Zambarano, 1997) than parents of daughters, which would suggest they might also exhibit more masculine facial characteristics. Although we

didn't assess whether the predictions made by women for the sex of their first-born offspring are accurate, the proportion of women who predicted sons was not significantly different from the proportion of women who predicted daughters, suggesting that they did not reflect simple sex of offspring preferences. Women who predict they will have sons may exhibit a bias toward mates exhibiting heritable masculinity and dominance traits, as such traits would likely provide additional benefit to her (predicted male) offspring. One possible explanation for the discrepancy between our results and those of other studies, then, is that potential mothers of sons may be more competitive in attempts to access mates and therefore utilize strategies to appear more attractive and feminine (e.g., wearing make-up, elaborate hairstyles, etc.) than potential mothers of daughters. These possibilities should be tested in future studies.

Men's faces were not perceived to differ in terms of either masculinity or dominance, but for attractiveness ratings, those who predicted daughters were rated higher than those who predicted sons. Interestingly, our results are in line with previous work that has shown that fathers of daughters are rated more attractive than fathers of sons (Kanazawa, 2007, 2011), and that father's attractiveness is correlated with daughter's attractiveness (Cornwell & Perrett, 2008). These results support the theory of 'sexy daughters', or the idea that male attractiveness is selected by female mates for its potential to benefit their female offspring. Another possible explanation for our finding is that men who predict they will have daughters are also more likely to invest heavily in their offspring. Women do not always rate masculine male faces as attractive (reviewed in Puts et al., 2012), which could be because more masculinity in faces signals less kindness, less warmth, and less willingness to invest in offspring. Interestingly, Roney et al. (2006) found that women's judgments of men's attractiveness as a long-term mate were correlated with their interest in infants (i.e., level of parental investment), and that women's judgments of men's attractiveness as a short-term mate were correlated with their masculinity ratings, suggesting that women's evaluations of mate quality are differentially dependent on these two traits. Thus, although we did not see a main effect of rater sex, suggesting that male raters also viewed the faces as more attractive, the men's faces in our sample may have been perceived as equally masculine and dominant, but seen as differentially attractive due to their varying emotional qualities as depicted in their faces. Future studies should attempt to clarify this possibility while also

attempting to ensure that men dissociate their preferences for offspring sex from their predictions.

In contrast to our hypothesis, we did not find facial dominance to be a significant predictor of whether an individual predicted that they would be more likely to have a son or a daughter as their first-born child. There is a large body of theoretical and empirical research to suggest that female dominance positively affects offspring sex ratios, but it is important that these studies focussed on behavioural dominance as opposed to facial cues of dominance. Because we did not explicitly define dominance for our raters, it is possible that their understanding of the characteristic and how it might relate to facial characteristics was unclear. Although we did find that masculinity and dominance were correlated for male faces, which is in line with previous work and thus provides evidence that our sample of raters was typical, we did not see the same correlation for women's faces, suggesting that for women, perceptions of dominance differ. Indeed, the size of the effect of dominance as a predictor of predicted offspring sex for male faces was considerably larger than that for females. Future research, then, should attempt to clarify the definition of dominance in females as well as to determine the perceptions and stereotypes about dominance in women that may affect the way that this characteristic is attributed to others.

There are four major limitations to our study that are worth nothing. First, both our sample of models and our sample of raters was ethnically diverse, which may have altered rater judgments of same-race and other-race masculinity, attractiveness, and dominance. Although previous work has found no effect of ethnicity on ratings of attractiveness (reviewed in Langois et al., 2000) and masculinity (Perrett et al, 1998), it is possible that these differences could have introduced variability to our results. Second, we were not able to control for hairstyles, cosmetic use, facial hair, or other facial adornments, which may have affected ratings of attractiveness, masculinity and dominance. Future studies should attempt to control for these factors while investigating the potential role of future offspring sex in determining an individual's mate quality. Third, although the results of Study 2 suggest that our models were not biasing their judgments for future offspring sex based on their own perceived masculinity or femininity, it is possible that their judgments were based on some pre-existing stereotype of the

characteristics that a mother or father of sons, or daughters, *ought* to possess. Similarly, then, it is possible that the raters in that study utilized similar stereotypes when making their judgments facial characteristics. We are unable to assess the contribution of this possibility to the data presented here; however, the most important focus of future study will be to determine the accuracy of individual's predictions for the sex of their future offspring. This will help to partition out any possible influence of stereotypes or pre-existing beliefs.

In sum, the results of this study provide partial evidence for the hypothesis that the facial characteristics of individuals differ depending on the sex of child they predict they will have in the near future. Women who are more likely to have sons may appear less masculine and more attractive than women who are more likely to have daughters, but future work should investigate different mating strategies in women depending on their predicted offspring sex to determine whether they make adjustments in order to obtain mates that are most likely to genetically benefit their future offspring. In contrast, the faces of men who predict they will have daughters may be considered more attractive, but no more masculine or dominant than the faces of men who predict they will have sons. Such perceptions of attractiveness may reflect a man's willingness to invest in offspring, or the degree of his emotional warmth and kindness. Future work should investigate these possibilities.

Chapter 5.

STUDY 4: Father Dominance Moderates the Effect of Mother Dominance on the Conception of Sons in Contemporary Humans

Note: This section is based on the following article, currently under review: Palmer-Hague, J. L., & Watson, N. V. Father dominance moderates the effect of mother dominance on the conception of sons in contemporary humans. *Evolution and Human Behavior*.

5.1. Introduction to Study 4

Despite considerable empirical interest in human mating behavior, very little attention has been paid to the relationship between offspring sex ratio, parent characteristics, and mate preferences. The results of Studies 1 and 2 suggest that women have presuppositions about the sexes of their future first-born offspring, and that these perceptions are related to both behavioral dominance and preferences for dominance in hypothetical male mates. These findings present the interesting possibility that women's partner preferences may be influenced by unspecified interoceptive cues to offspring sex bias, resulting in attraction to mates who possess heritable characteristics likely to benefit their offspring in sex-specific manner, such as dominance for male offspring. However, the extent to which such behaviour and preferences influence mate selection and offspring sex outside of the laboratory remains unclear.

5.1.1. Dominance and Offspring Sex Ratio in Humans

The Trivers-Willard Hypothesis (TWH, Trivers & Willard, 1973) proposes that parents should maximize their own reproductive success by producing the sex of offspring that will benefit most from their current 'condition'. In other words, if parents are

in 'good condition', they should produce more sons who, through inheritance of this 'good condition', will be more likely to succeed in obtaining mates. Parents in 'poor condition', on the other hand, should be biased toward producing daughters because their reproductive success will be less negatively affected by their condition. The TWH has been studied in a variety of non-human animals, with mixed results (reviewed in Brown, 2001; Clutton-Brock & Iason, 1986; Hewison & Gaillard, 1999; Hiraiwa-Hasegawa, 1993). Sheldon and West (2004) suggested that the lack of consistency is due to excessive focus on physiological characteristics of parents, such as body size and nutrition, rather than on behavioral measures, such as dominance prior to conception.

In humans, a variety of physiological and behavioral characteristics have been associated with offspring sex ratio. For example, taller and heavier parents have more sons than daughters (Kanazawa, 2005; Manning et al., 1996), and more physically attractive parents have more daughters than sons (Kanazawa, 2007, 2011). In addition, Cameron and Dalerum (2009) found that male billionaires, a group typically identified with achievement and status, produced more sons than daughters, and that the sons of billionaires produced more offspring than daughters of billionaires. This finding is in line with the notion that parents in 'good condition' can increase their reproductive success through sons. Interestingly, though, they also found that women married to billionaires had higher sex ratios (i.e., more male-biased offspring) than women who were themselves billionaires, and that sex ratios did not differ between men whose money was earned versus inherited, suggesting that biased offspring sex ratio may not be directly related to high personal achievement. One possible alternative is that more dominant women are more likely to marry billionaires than less dominant women, and thus, offspring sex ratios would be male-biased in this population. In other words, maternal dominance may directly influence offspring sex, whereas paternal dominance may influence offspring sex only indirectly through female mate choice.

The Maternal Dominance Hypothesis (MDH; Grant, 1998) proposes that endogenous maternal T level at the time of conception influences offspring sex. According to the MDH, more dominant women have higher T, which makes their ova more receptive to a Y-chromosome bearing sperm. Interestingly, both Grant (1990,

1994) and Akande (1999) have shown that women who scored higher in dominance were more likely to give birth to sons than daughters. In addition, women with higher T levels scored higher in dominance (Grant & France, 2001), and male embryos were more likely than female embryos to develop from bovine ova contained in follicles with elevated fluid T concentrations (Grant & Irwin, 2005). Because dominance in women can be both stable (i.e., a trait), and variable depending on environment and context (i.e., state), the MDH also explains how the probability of a given women having either a male or female offspring can vary for different conceptions. Thus, maternal dominance may have an important influence on female reproductive behavior.

5.1.2. Dominance, Mating Behaviour, and Mate Preferences in Men and Women

Trivers (1972) predicted that, due to differential costs of reproduction, females should be the choosier sex, requiring considerable investment and quality from potential mates. Indeed, women desire commitment and resources from potential sexual partners (reviewed in Buss, 2007), but the degree to which they value other characteristics, such as dominance, is unclear. Studies of female preferences for masculinity, serving as a signal of male dominance (e.g., Boothroyd et al., 2007; Fink et al., 2007), have yielded mixed results. Whereas several studies have found that women prefer a more masculine face to a less masculine face (Burriss et al., 2011; DeBruine et al., 2006; Johnston et al., 2001), others have shown the opposite pattern (DeBruine et al., 2010; Perrett et al., 1998; Rhodes et al., 2000; Scott et al., 2010). Fink et al. (2007) found that women rated the faces of physically stronger men to be more attractive, dominant, and masculine than weaker men, suggesting that in different contexts, characteristics associated with dominance are considered attractive. Sadalla et al. (1987) found that females rated a high dominance male to be more sexually attractive than a low dominance male target, but Snyder et al. (2008) showed that female preferences for dominance depend on context (i.e., in physical contexts like athletic competitions, but not in social contexts like an academic peer group). Although high conception-risk, greater self-perceived and other-rated attractiveness, and focus on a short-term relationship explain factors involved in female preferences for more masculine mates

(reviewed in Puts et al., 2012), individual differences in preferences for masculinity and dominance, particularly for a long-term partner, remain unresolved.

One possible explanation for variability in attractiveness ratings may be that female mate preferences are influenced by the self-perceived tendency to produce male or female offspring. If a dominant woman was likely to produce sons, then it would make sense for her to choose a mate with characteristics that would most benefit her sons in reproduction, such as those that signal dominance, status, and ability to provide resources. On the other hand, if a woman were to produce female offspring, it would make sense for her to choose a mate with characteristics that would most benefit her daughters in reproduction, such as physical attractiveness or willingness to invest in parenting. Interestingly, more masculine faces are rated less likely to invest in offspring (Perrett et al., 1998), suggesting that individual differences in women's preferences for masculinity could reflect different priorities being given to genetic quality ('good genes hypothesis', Trivers, 1972) compared to parental investment. Sex of offspring, therefore, may be an important mediator of female mate choice.

5.1.3. Assortative Mating and Offspring Sex Ratio

Studies in support of the TWH in humans provide support for mate choice based on characteristics associated with offspring sex (e.g., height and weight for males, physical attractiveness for females), but no studies have directly investigated characteristics of dominance in couples. Two lines of research suggest that there may be a relationship. First, women with a lower waist-to-hip ratio (i.e., more feminine and attractive (e.g., Singh, 1994)) are reportedly more likely to value the provision of resources by mates than women with a higher waist-to-hip ratio (i.e. more masculine and less attractive) (Pawlowski & Jasienska, 2008). Given that women with higher waist measurements have more sons than daughters (Manning et al., 1996; Singh & Zambarano, 1997), and that dominance cues in male faces might be considered a signal of lowered willingness to invest in offspring (Perrett et al., 1998), it makes sense that women who are more likely to produce females would prefer less dominant looking mates. Second, women prefer masculine faces when their salivary T levels are high compared to when they are low (Welling et al., 2007). Given that T level may be

associated with the conception of sons (Grant & France, 2001), this also supports the idea that women who will have sons prefer more dominant mates. These possibilities have not yet been tested.

5.1.4. Facial Characteristics and Future Offspring Sex

In addition to signalling desirable mate characteristics, such as dominance, it is conceivable that some unspecified characteristic of an individual's face may provide a cue as to any bias that he or she has toward future generation of male or female progeny. For reasons pertaining to the TWH and discussed above, perception of this cue could have a direct bearing on mate preferences. Previous research certainly attests to the importance of facial features in the expression of mate preferences. For example, positive predictive relationships have been reported for face ratings and characteristics of masculinity (e.g., Perrett, et al., 1998), dominance (e.g., Quist et al., 2011), and social behavior (Roney et al., 2006). Interestingly, faces also appear to contain cues about hormone levels (Law-Smith et al., 2006; Roney et al., 2006), interest in infants (Roney et al., 2006), and maternal tendencies (Law-Smith et al., 2012), so the idea that the face may also provide a reliable index of a potential mate's prospective offspring sex bias is a plausible one. This possibility has not yet been studied.

5.1.5. Overview of the Present Study

We investigated the facial and behavioral dominance characteristics of men and women in committed, long term relationships based on the known sexes of their offspring. Specifically, we examined facial ratings of mothers and fathers from photographs taken close in time to the conception of first children, as well as composite measures of current behavioral dominance, to test the hypothesis that dominant mothers mated to dominant fathers will have more sons than daughters. In addition, we also explored whether the face is an effective signal relative to offspring sex.

5.2. Method

5.2.1. Parent Participants

Parents were recruited for the study as part of a larger study involving mate preferences in male and female undergraduates ($N = 132$). They completed demographic and behavioral questionnaire packages and provided photographs of themselves. Packages were provided and completed information was returned to the laboratory via their child. A total of 132 mothers and 129 fathers participated. Written informed consent was provided, and the Simon Fraser University Office of Research Ethics approved all study procedures.

Photographs. Mothers and fathers were asked to provide one photograph of themselves from around the time of their marriage or beginning of their relationship. Given the retrospective nature of this request, as well as concern for maintaining ecological validity, we placed minimal restrictions on the photographs collected. Participants were asked to submit photographs where the person was facing forward and not wearing glasses whenever possible. Photographs were collected in digital format via email, or in hardcopy in the laboratory, where they were scanned in to JPG format.

Dominance measures. Mothers and fathers were asked to independently complete the following three behavioral dominance measures: sociable and aggressive dominance subscales (SD and AD, Kalma et al., 1993), one 15-item questionnaire that measures positive and negative interpersonal behaviors related to aggressive and sociable dominance within groups, respectively; dominance subscale of the International Personality Items Pool (D-IPIP, <http://ipip.ori.org/ipip/>; Goldberg, 1999), a brief, 11-item questionnaire assessing the degree to which a person dominates others in social interactions; and the Simple Adjective Test (SAT, Grant, 1998), a 64-item checklist with 13 target items that measures the subjective ratings of feelings associated with dominance.

5.2.2. Face Judgments and Ratings

Rating participants. A total of 79 participants rated parent faces for partial course credit in a psychology class. Data from 6 participants were excluded for the following reasons: misunderstanding task directions ($n = 2$), responses to fewer than 50% of the faces ($n = 1$), and apparent falsification of answers (e.g., repeated pattern of responses throughout) ($n = 3$). The remaining 73 undergraduate participants -- (36 males (Mean age \pm $SD = 20.76 \pm 1.87$ years) and 37 females (Mean age \pm $SD = 20.87 \pm 2.49$)) -- made judgments of offspring sex and ratings of masculinity, attractiveness, and dominance in parents' faces.

Preparation and presentation of stimuli. A total of 243 photographs (121 mothers and 122 fathers) were rated. Age at the time the photograph was taken was available for 118 mothers (Mean \pm $SD = 25.46 \pm 4.11$ years) and 120 fathers (Mean \pm $SD = 28.16 \pm 5.29$ years). Each digital image was cropped to include mostly the participant's face, and re-sized (if necessary) to a height of 12.25 cm and a width of approximately 9 cm. Some hair and clothing was visible in the photographs. Faces were presented one at a time with an identification number underneath each one that corresponded to questions presented in paper and pencil format. Faces were alternated male then female, and presented in 4 blocks of 61 photographs (60 in the final block) with opportunities to take a break in between each block.

Rating procedures. Participants completed ratings in groups in a departmental computer facility, but were not permitted to communicate during the task. Each participant was seated individually at a computer and presented with the faces for rating. Prior to beginning the ratings, participants were presented with written instructions directing them to rate faces based on their own initial judgments and to focus on faces only, rather than hairstyles, jewellery, clothing, or other material items that may or may not be present in the photographs. No written descriptions or definitions of masculinity, attractiveness, or dominance were provided. Participants were able to view each face for as long as they wanted while they made their judgments. In the rare instance that a participant recognized an individual in a photograph, they were instructed to check a box identifying this, and not to make ratings for that person.

For each face, participants were asked to first predict the sex of child that the person would have as their first-born child as well as to rate the face for masculinity/femininity, attractiveness/unattractiveness, and dominance/submissiveness using 7-point rating scales. Sex of first-born child as opposed to sex-ratio or sex of later-born child was chosen as a response measure for two reasons. First, because the photographs were taken as close to the beginning of the parents' relationship as possible, they provided the best measure of mother and father facial characteristics prior to engaging in reproduction, allowing an approximate measure of each parent's preferences at the time of mate choice. Second, the photographs gave a more appropriate measure of parent characteristics at the time of conception of the first-born child than all children, or later-born children.

5.2.3. Data Analyses

Demographic characteristics of parents of first-born sons and first-born daughters were compared using independent-samples t-tests, Mann-Whitney U tests, and chi square tests as appropriate. To determine whether participants could accurately judge the sex of an individual's first-born offspring by looking at their face, accuracy and response bias in judgments for sex of offspring were calculated for each participant using signal detection theory (Stanislaw & Todorov, 1999). If a participant omitted a response, their total accuracy and bias was calculated without including that item. Overall accuracy scores were compared to chance guessing (0.50) using a one-sample t-test. Scores were then analyzed using two mixed-model ANOVAs (one for fathers, one for mothers) with sex of offspring as the within-subjects variable and sex of rater as the between-subjects variable.

In order to compare facial characteristics of parents, average ratings for masculinity, attractiveness, and dominance were compiled separately for faces belonging to mothers of sons, mothers of daughters, fathers of sons, and fathers of daughters. If a participant omitted a rating, it was not included in the calculated average for that participant. Averages were analyzed using mixed-model ANOVAs (one each for masculinity, attractiveness, and dominance for mothers, and one each for masculinity,

attractiveness, and dominance for fathers) with sex of offspring as the within-subjects variable and the sex of rater as the between-subjects variable.

Facial and behavioral characteristics in mothers and fathers were explored with zero-order Pearson correlations. For faces, binary logistic regressions were used to determine the relationships between parental dominance and offspring sex using mother dominance, father dominance, and their interaction as predictors, and sex of first-born child as the dependent variable. Mother and father dominance in faces were first corrected for the effects of attractiveness, masculinity, and age at the time of the photograph using two initial linear regressions (one for mother, one for father) run with the same variables as predictor variables and dominance as the dependent variable (see Cornwell & Perrett, 2008). Standardized residuals obtained from these preliminary analyses were used in the binary logistic regression model.

For dominance behavior, composite z-scores for mother and father dominance were calculated by creating z-scores for each questionnaire, summing the four z-scores for each participant, and then calculating the z-score for the composite. Median splits and subsequent Mann-Whitney U tests were used to assess the difference in sex ratios between high and low dominance mothers and fathers. To determine whether parent behavioral dominance predicted offspring sex ratio, we used a Generalized Linear Model (GLM) with logistic link function and binomial distribution with number of sons as the dependent variable, total number of children as the binomial denominator, and dominance composite score for the mother, dominance composite score for the father, and their interaction as predictor variables. Significance level for all analyses was set to $p \leq .05$.

5.3. Results

5.3.1. Characteristics of Parents

Parents of a male first-born child ($n = 63$) were well matched with parents of a female first-born child ($n = 69$) in demographic characteristics. There were no significant differences between groups in age, ethnicity, marital status, or length of relationship (all

$p > .05$). The majority of couples (first-born son, 73%, first-born daughter, 83%) had at least 2 children.

5.3.2. Facial Characteristics

Mothers' faces. Ratings of mothers' faces for masculinity, attractiveness, and dominance differed significantly depending on the sex of their first-born child, to which the raters were blind. For masculinity, there was a main effect of sex of first born ($F(1, 71) = 41.13, p < .01, \eta^2 = .37$), with mothers of a first-born son being rated as significantly more masculine (Mean \pm SE = $5.01 \pm .07$) than mothers of a first-born daughter (Mean \pm SE = $5.14 \pm .08$). There was no significant main effect of sex of rater or the interaction of sex of first born with sex of rater ($p > .05$).

For attractiveness, there was also a main effect for sex of first-born ($F(1, 71) = 14.09, p < .01, \eta^2 = .17$), with mothers of a first-born son rated as significantly less attractive (Mean \pm SE = $4.02 \pm .06$) than mothers of a first-born daughter (Mean \pm SE = $4.11 \pm .06$). There was also a significant main effect of sex of rater for this measure ($F(1, 71) = 14.44, p < .01, \eta^2 = .17$), with females (Mean \pm SE = $4.29 \pm .09$) rating the faces significantly more attractive than males (Mean \pm SE = $3.83 \pm .09$). The interaction between sex of first-born and sex of rater was not significant ($p > .05$).

For dominance, there was a significant main effect of sex of first-born ($F(1, 71) = 8.04, p < .01, \eta^2 = .10$), with mothers of a first-born son (Mean \pm SE = $4.04 \pm .05$) rated as more dominant than mothers of a first-born daughter (Mean \pm SE = $3.96 \pm .06$). There was also a main effect of sex of rater ($F(1, 71) = 8.18, p < .01, \eta^2 = .10$), with females (Mean \pm SE = $4.14 \pm .08$) rating females as more dominant than males (Mean \pm SE = $3.85 \pm .08$). The interaction between sex of first-born and sex of rater was not significant ($p > .05$).

Fathers' faces. Ratings of fathers' faces for attractiveness and dominance, but not masculinity, differed significantly depending on the sex of their first-born child; again raters were blind to the child's sex. For attractiveness, there was a main effect of sex of first born ($F(1, 71) = 18.85, p < .01, \eta^2 = .21$), with fathers of a first-born son rated

significantly less attractive (Mean \pm SE = 3.47 \pm .07) than fathers of a first-born daughter (Mean \pm SE = 3.56 \pm .07). There was also a significant main effect of sex of rater ($F(1, 71) = 14.44, p < .01, \eta^2 = .17$), with females (Mean \pm SE = 3.35 \pm .10) rating the faces as significantly less attractive than males (Mean \pm SE = 3.68 \pm .10). The interaction between sex of first-born and sex of rater was not significant.

For dominance, there was a significant main effect of sex of first born ($F(1, 71) = 7.06, p = .01, \eta^2 = .09$), with fathers of a first-born son (Mean \pm SE = 3.34 \pm .06) rated as less dominant than fathers of a first-born daughter (Mean \pm SE = 3.40 \pm .06). Neither the main effect of sex of rater or the interaction between sex of first-born and sex of rater were significant ($p > .05$). There were also no significant main effects of sex of first-born or sex of rater, and no significant interaction effect, on ratings of father's masculinity ($p > .05$).

Predicted sex of first-born child. Bias values more than $\pm 3SD$ from the mean were identified for five participants, suggesting that their judgments were biased towards choosing male or female offspring. Data for these participants were excluded. Overall, participants were not significantly better than chance at judging the sexes of people's first born children (Mean accuracy \pm SD = .50 \pm .05, $t(67) = .03, p = .98$). Similarly, there were no significant main effects of sex of parent, sex of rater, or their interaction ($p > .05$).

5.3.3. Parental Facial Dominance and Sex of First-born

Although male and female raters differed for mother and father attractiveness, and mother dominance ratings, we obtained high inter-rater agreement for masculinity, attractiveness, and dominance (all ICCs $> .90$). We therefore calculated an average for each characteristic for each face. These averages were used for all further analyses of facial characteristics.

Zero-order correlations. Mother and father attractiveness were significantly positively correlated ($r = .27, p < .01$). No significant correlations were found for mother

and father facial masculinity ($r = .11, p > .05$), but there was a trend towards significance for mother and father facial dominance ($r = .16, p = .08$).

Parent facial dominance as predictors of sex of first-born. We ran a binary logistic regression with mother dominance, father dominance, and their interaction, as predictor variables, and sex of first-born child as the dependent variable. We first ran 2 linear regressions (one for mother dominance, one for father dominance) to control for the potential effects of masculinity, attractiveness, and age (predictor variables) on ratings of facial dominance (dependent variable). Similar to Cornwell and Perrett (2008), we conducted these preliminary analyses for two reasons. First, facial masculinity, facial attractiveness, and facial dominance are all related and have established influences on mate choice (reviewed in Puts, 2010; Puts et al., 2012). Second, our photographs reflected a broad range of ages in both mothers (19 years) and fathers (28 years), and age was significantly negatively correlated with masculinity and attractiveness in mothers ($r = -.40, p < .01$ and $-.45, p < .01$, respectively). Our final binary logistic regression analyses were run using the standardized residuals for dominance obtained from these initial models.

The results obtained from the binary logistic regression analyses are shown in Table 5.1. The first model with only mother dominance and father dominance included as predictors was not significant ($-2LL = 160.41, \chi^2(2, n = 117) = 1.58, p = .46, R^2 = .02$).

Table 5.1. Binary Logistic Regression Analysis Using Sex of First-born Child as Dependent Variable

	<i>B (SE)</i>	Odds Ratio (95% CI)	<i>p</i>
Model 1			
Mother Dominance	.16 (.19)	1.17 (.80 – 1.71)	.41
Father Dominance	-.18 (.16)	.83 (.57 – 1.22)	.35
Model 2			
Mother Dominance	.19 (.21)	1.21 (.81 – 1.82)	.23
Father Dominance	-.27 (.22)	.77 (.49 – 1.19)	.36
Mother Dominance X Father Dominance	.46 (.21)	1.58 (1.05 – 2.39)	.03

When the interaction between mother and father dominance was added to the model, it approached significance ($-2LL = 154.56, \chi^2(3, n = 117) = 7.45, p = .06, R^2 =$

.08) and accurately predicted 72% of female first-born offspring and 46% of male first-born offspring, yielding an overall classification rate of 60%.

Given our interest in the interaction between mother and father dominance *a priori*, we further explored the mother facial dominance X father facial dominance interaction using simple slopes analyses for binary models (Dawson, 2014), which revealed that the slope for mother dominance was significant when father dominance was high (+ 1 SD) ($t(113) = 2.07, p = .04, d = .39$), but not when it was low (-1 SD) ($p > .05$). A plot of the probability of a first-born son predicted by mother facial dominance as a function of high (1 SD) and low (-1 SD) father dominance is shown in Figure 5.1. These data indicate that when father dominance is high, the probability of a first-born son increases with mother dominance.

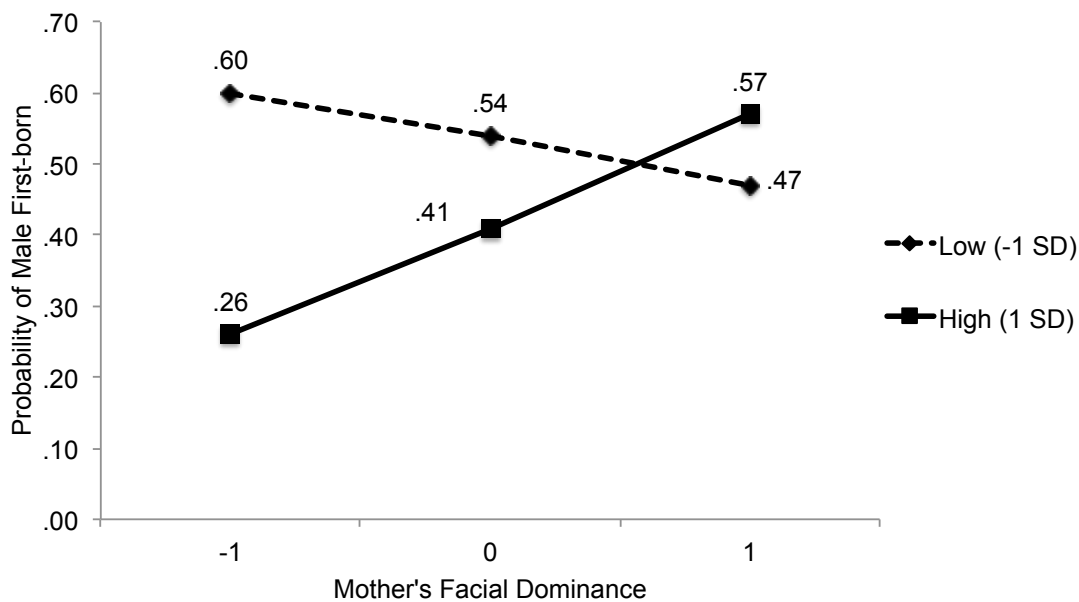


Figure 5.1. Probability of a First-born Son as a Function of Mother and Father's Facial Dominance

Note: Slope for low father dominance is not significantly different from 0; slope for high father dominance is significantly different from 0, $p < .05$ (See text).

5.3.4. Parent Behavioral Dominance and Offspring Sex-ratio

Dominance measures were used to test the hypothesis that parent dominance has a positive influence on the production of sons. Offspring sex ratio (# of sons/# of

children), rather than sex of first-born child was used as the dependent variable in these analyses in an attempt to encompass the influence of trait dominance on the sexes of all of a couple's children. We assumed that current dominance scores would reflect stable (i.e., trait) characteristics of dominance in both mothers and fathers.

One mother failed to complete the SD and AD scales, and one father failed to complete the SAT. These missing values were replaced with the overall means for mothers, and overall mean for fathers, respectively. In order to ensure that behavioral measures were not influenced by pre-existing physiological or mental conditions, we excluded data from an additional 4 mothers (depression, $n = 3$; bipolar disorder, $n = 1$) and 6 fathers (depression, $n = 1$; cancer, $n = 2$; neurological disorders, $n = 3$). Descriptive data obtained from mothers and fathers for the IPIP, SAT, SD, and AD scales are shown in Table 5.2.

Table 5.2. Scores Obtained for Mothers and Fathers on Behavioral Dominance Measures

	Mothers ($n = 128$)	Fathers ($n = 123$)
	Mean (SD)	Mean (SD)
Dominance Subscale (D-IPIP)	31.16 (6.98)	33.78 (7.93)
Social Dominance (SD)	18.46 (5.36)	20.61 (5.50)
Aggressive Dominance (AD)	28.46 (5.93)	30.85 (5.50)
Subjective Adjective Test (SAT)	3.40 (2.45)	4.38 (2.80)

Zero-order correlations. Scores obtained for mothers and fathers were positively correlated for the SAT ($r = .27, p < .01$), SD ($r = .21, p = .02$), and AD ($r = .24, p < .01$). There was no significant relationship between mother and father scores on the DOM ($r = .07, p > .05$).

Parent behavioral dominance as predictors of offspring sex ratio. Since scores obtained for mothers on the IPIP, SAT, SD, and AD were all significantly positively correlated with each other (all $p < .05$) and for fathers, all measures were significantly positively correlated with each other (all $p < .01$) except for the SAT and SD ($\rho = .11, p = .22$), we created composite z-scores for both mother and father dominance.

Mother and father dominance composite z-scores were also positively correlated ($r = .28, p < .01$).

Median split analyses on mother and father composite scores obtained from families with more than one child were performed to examine difference in offspring sex ratios. Mann-Whitney U tests revealed that high dominance mothers ($Mdn = .50$) had significantly higher (i.e., more males) sex ratios than low dominance mothers ($Mdn = .40$) ($U(97) = 920.00, Z = -2.20, p = .03, r = .22$). No difference was obtained between high ($Mdn = .50$) and low ($Med = .50$) dominance fathers ($p > .05$) suggesting that mother but not father dominance had a positive influence on offspring sex ratios.

When mother dominance and father dominance were entered into the binary logistic regression model as predictors of offspring sex ratio, the model was not significant ($-2LL = 254.09, \chi^2(2, n = 118) = 1.54, p = .46, R^2 = .08$). Including the interaction in the model revealed that it was still not significant ($-2LL = 254.09, \chi^2(3, n = 121) = 1.54, p = .67$), indicating that parental dominance did not significantly predict number of sons or daughters produced.

5.4. Discussion

Our results provide partial support for the hypothesis that women select mates who demonstrate heritable qualities that confer sex-specific reproductive advantages on their future offspring. We found significant correlations between parent facial attractiveness and dominance ratings, and between their self-reported dominance characteristics. In addition, ratings of dominance in women's faces predicted their probability of having a son as a first-born child, but only when their partner's face was rated as being more dominant. Mother dominance had no influence on offspring sex when father dominance was low. Similarly, although we found that mothers who scored higher than average in dominance had higher offspring sex ratios than those who scored lower than average, we did not find this relationship for fathers, and neither mother's or father's dominance scores were significant predictors of offspring sex ratio. We also found no evidence that offspring sex could be predicted from facial photographs. Taken together, our results suggest that women's mate selection is influenced by men's

dominance, and that this is related to the sex of their future offspring; however, there may be other factors used in concert with dominance in assessment of male mate quality.

We found a significant interaction between mother and father facial dominance, suggesting that mother dominance is associated with a higher likelihood of male offspring, but only when father dominance is also high. Thus, male dominance appears to be attractive to both mothers of sons and mothers of daughters, despite the assumption that heritable physical characteristics of dominance are more beneficial to sons. The exact reason for this finding is unclear; however, one possible explanation is that women's dominance indicates differences in preferences for parental investment, which may not be causally related to male dominance. Roney et al. (2006) showed that T levels (i.e., indicator of masculinity, or genetic quality) and interest in infants (i.e., indicator of parent quality) were not correlated for men, suggesting that high masculinity does not necessarily reflect low parent quality in male mates. Rather than securing one mate who provides resources while seeking 'good genes' from mates in extra-pair copulations (reviewed in Gangestad & Simpson, 2000), it may be that dominant women require less from long-term mates in terms of direct parental care. Such differences between mothers have not yet been studied. The differential importance that mothers of sons compared to mothers of daughters place on these two qualities in a potential male mate therefore warrants further study.

Another possibility is that selection for attractiveness in female mates is stronger than that of dominance. Female attractiveness and femininity are both highly valued by males, who report even stronger preferences for a feminine face when their T is higher (Welling et al., 2008). Although it is important to note that we did not study behavioural dominance here, our results indicate that men with more dominant faces might prefer women with more attractive, and less dominant looking faces as long-term mates, resulting in a bias toward lower offspring sex ratios. Buss and Shackelford (2008) showed that the most attractive women in their sample had the strongest preferences for male indicators of parent quality, financial investment, and physical attractiveness, suggesting that their own mate value allowed them greater selection in obtaining the ideal male mate. Future studies investigating sexual selection and offspring sex ratios

should include these possible indicators of male and female mate value in order to assess their relative contribution to long-term mate choice.

Given that our sample was comprised of parents of undergraduate students, the majority of whom were middle to upper-middle class, engaged in long-term, committed relationships, and only had 1-2 children, it is possible that we have failed to measure the full range of dominance characteristics in male and female mates. Dominant and masculine looking males are perceived to exhibit less positive qualities, such as warmth, honesty, and willingness to invest in parenting (Perrett, et al., 1998). In addition, Booth and Dabbs (1993) reported that men with higher T were less likely to marry, and when they did, they were more likely to divorce and to have had extramarital partners. Thus, it is possible that the most dominant males, who may be most likely to produce sons, were not adequately represented in our study. Future work should attempt to replicate our findings with males and females prior to mating as well as in different cultural and socioeconomic circumstances.

Our results suggest that dominance behavior is also related to mate selection in accordance with offspring sex. Although parent dominance did not significantly predict couples' offspring sex ratios, our behavioral questionnaires were collected several years after parents had finished having children and were thus less sensitive to detecting a direct influence on offspring sex as they would have been at the time of conception. However, higher sex ratios were observed in mothers with dominance behavior that was higher than the average, suggesting that maternal characteristics influence the sexes of their offspring. It could be argued that parental dominance was the result rather than the cause of having more sons than daughters, but this is unlikely given the relationships that we also observed between offspring sex and facial dominance characteristics closer to conception. In addition, although state dominance might be expected to vary throughout the years in our sample, levels of trait dominance should remain relatively stable and thus provide a proxy for dominance at the time of conception.

Lastly, we found no evidence that the face is an effective prospective indicator of offspring sex. Objective raters were not better than chance at predicting offspring sex from faces. We did not provide raters with any explanation or description of this task

other than to ask them what sex of child they predicted the depicted individual would have as their first-born child, and so it is possible that participants held pre-existing beliefs that the determination of an individual's sex is simply a product of chance (i.e., equal probability of an egg fusing with an X- or Y-chromosome bearing sperm), and answered with little thought. Their detection of differences between masculinity, attractiveness, and dominance in parents of sons and mothers of daughters suggests that they may actually have some ability to detect offspring sex from faces. Thus, the inclusion of more informative instructions might be helpful in making this determination in future studies.

Some final limitations of our study are worth noting. First, although our raters were naïve to the study hypothesis when they made judgments about parent faces, it is possible that the nature of the characteristics we asked them to rate may have influenced their predictions about the sexes of individual's offspring. However, our finding that raters were not better able than chance to predict a person's offspring sex indicates that their ratings were unrelated to any knowledge or bias related to ideas about dominance and the sexes of children that parents might have. Second, the retrospective nature of our study design limited our ability to control the photographs used for parent ratings. Factors such as smiling, make-up, glasses, facial hair, and other adornments were not controlled for, and may have altered the judgments made by participants. Future work might seek to obtain photographs in a more controlled environment. Third, we were not able to assess the possibility of extra-pair copulations and subsequent genetic relationships between fathers and offspring, nor did we assess the sexes of any offspring lost to miscarriage or stillbirth, the latter of which would provide additional information about manipulation of primary offspring sex ratios. These factors should be taken into consideration in future research.

In summary, the present study provides an initial demonstration that when mated to high dominance men, women rated higher in facial dominance are more likely to have a son as a first-born child than women rated lower in facial dominance. In addition, women who are more behaviorally dominant have higher sex ratios than those who are less behaviorally dominant, regardless of the dominance characteristics of their long-term mate. These results provide partial support for the hypothesis that the assessment

of men's long-term mate value is influenced in women by some unspecified interoceptive cues signaling the probability of male versus female future offspring, resulting in preferences for males demonstrating heritable traits of sex-specific reproductive benefit to offspring and thereby enhancing the inclusive fitness of the mother. Future research should seek to identify additional factors that influence women's assessments of mate value, and how these are related to her future offspring sex.

Chapter 6.

General Discussion

6.1. Summary of Main Findings

The primary aim of this dissertation was to provide an in depth analysis of the ways in which physiological and psychological characteristics of parents might be involved in variation of their offspring sex ratios, with particular emphasis on their mating behavior and preferences. To this end, I pursued the following four research objectives:

a) to examine whether dominance behavior, sexual restrictiveness, self-perceived masculinity and femininity, digit ratios, and hormone levels in men and women who had not yet had children were associated with their predictions regarding the sexes of their future offspring (Studies 1 and 2);

b) to examine whether predictions for future offspring sex affected men and women's mate preferences for dominance in the opposite-sex (Study 2);

c) to examine whether men and women's predictions for future offspring sex were reflected in their facial characteristics (Study 3); and

d) to examine whether the sex of first-born offspring in actual parents was related to their dominance behavior, facial characteristics, and mate choice (Study 4).

In Study 1, I conducted a correlational study in which I asked men and women to predict the sex of their first-born child, and then related that prediction to their self-reported dominance behavior, and sexual restrictiveness, as well as their current levels of T and E₂ and their measured digit ratios. I found that women who predicted they would have a son first also rated themselves more dominant and less sexually restricted

than those who predicted they would have a daughter first. In contrast, I found that men who predicted they would have daughter first also had higher levels of salivary E_2 and more feminine digit ratios than those who predicted they would have a son first. These results were in line with previous work suggesting that maternal dominance positively influences the conception of sons (Grant, 1990, 1994; Akande, 1999), but also provided new evidence that offspring sex might be also be influenced by maternal openness to sexual relationships, and both state and trait hormonal profiles in fathers.

Two limitations inherent in Study 1 were that I was unable to assess whether men and women's predictions for their future first-born child's sex were influenced by their self-perceived masculinity and femininity, and that I only used one brief measure of behavioral dominance. In Study 2, I conducted a second correlational study where I asked men and women to predict the sex of their first-born child and then related their prediction to their self-reported dominance behavior, sexual restrictiveness, digit ratios, and hormone levels. This time, however, I also included a measure of psychological androgyny in order to assess participants' adherence to masculine and feminine stereotypes, as well as three additional dominance measures to further clarify the nature of any effects of dominance on offspring sex predictions. In Study 2, I found that women who predicted they would have a son as their first child were again more dominant, but only on two measures, one that measures adjectives associated with a dominant personality, and one that measures aggressive dominance. In addition, although the difference between women who predicted a son and women who predicted a daughter approached significance for higher self-perceived masculinity and androgyny in the former group, controlling for the effect of masculinity had little effect on the relationship between dominance and predicted offspring sex. The results of Study 2 provided no evidence for a relationship between openness to sexual relationships and predicted offspring sex for women, or hormonal characteristics and predicted offspring sex for men. Together, the results of Studies 1 and 2 provided evidence for a positive effect of women's dominance on their perception of whether they will conceive a son as their first-born offspring.

In Study 2, I also tested the hypothesis that women whose self-perceptions suggested to them that they would be more likely to conceive sons would prefer mates

that exhibit traits that would increase the reproductive success of their offspring, such as dominance. I performed an analysis of the relationship between men and women's prediction for the sex of their first-born child and their preferences for dominance characteristics in both the face and behavior of a potential opposite-sex mate. I found that women who predicted they would have a son as their first born child preferred both a dominant male face, and a dominant male character description for a short-term mate significantly more often than women who predicted they would have a daughter. Although there was a general preference for the dominant male character as a long-term mate, I did not find that predicted sex of first-born influenced this preference. In contrast, predicted sex of first-born child had no effect on men's preferences for facial dominance. The majority of men preferred the low dominance female face for both a short- and long-term mate despite that the dominant female face was rated more attractive. In addition, I found no differences in men's dominance ratings for the low- and high-dominance faces. No differences were found for men's short- and long-term mate preferences for the dominant and submissive female character descriptions. Interestingly, these results compliment those previously described for Studies 2 and 3 in that they provide evidence of an adaptive mechanism through which women might enhance their own reproductive success through their offspring; specifically, women who perceive they will produce sons might find more dominant mates attractive, particularly for short-term encounters.

In Study 3, I conducted a quasi-experiment in which participants were asked to guess the sex of first-born child men and women predicted they would have, simply from viewing photographs of their faces. Participants were also asked to rate the faces for masculinity, attractiveness, and dominance. I found no evidence to support the hypothesis that individual's perceptions of the sex of child a man or woman will conceive is observable from their face, but I did find that, in contrast to my hypothesis and results of previous studies looking at actual mothers of sons (e.g., Kanazawa, 2007, 2011; Singh & Zambarano, 1994), women who predicted they would have a son were rated significantly more feminine and attractive than women who predicted they would have a daughter. I also found no effect of predicted offspring sex on facial dominance for women's faces after controlling for the influence of their ethnicity. The reason for these discrepancies is unclear; however, women who produce sons might also exhibit both high E_2 , which positively influences the appearance of facial femininity (Law Smith et al.,

2006), and T, which could positively influence dominance, both facially and behaviorally (Grant & France, 2001), thus concurrently increasing a woman's attractiveness and prediction for male offspring. In fact, Grillot et al. (2014) found that after controlling for body mass index, ratings of women's bodies were positively associated with both E_2 and T, making it possible that the same relationship holds for facial attractiveness and femininity. An alternate possibility is that some variability was introduced by women's cosmetic use, as this has been shown to attenuate the relationship between other-rated facial femininity and attractiveness and hormone levels in women (Law Smith et al., 2006).

Men who predicted they would have a son first were rated as less attractive than men who predicted they would have a daughter, but I found no differences for ratings of masculinity or dominance. These findings were partially in line with previous work that showed that more attractive fathers had more daughters (Kanazawa, 2007, 2011), it is unclear why no differences were observed for dominance or masculinity. The most plausible explanation is that because men's predictions for offspring sex were potentially biased by their preferences, my measurements for men may have been inaccurate. In other words, ratings of men's faces may have actually differed, but because my classification of their predicted offspring sex was potentially biased, I was unable to detect these differences.

Taken together, the results of Study 3 provide partial evidence that differences in physiological characteristics amongst men and women may be related to the sex of child they predict they will produce. Although speculative, such differences could also underlie individual differences in preferences for dominance in potential opposite-sex mates. The major limitation of Studies 1-3 is that I was unable to confirm the accuracy of men and women's predictions for the sex of their first born children. Thus, in Study 4 I utilized photographs of, and self-reported dominance characteristics from, actual mothers and fathers in order to replicate the findings obtained in the previous studies. First, I conducted another quasi-experiment where participants were asked to guess the sex of the first-born child of mothers and fathers from viewing a photograph of their face taken around the time that they had met their mate and started having children. I also asked them to rate each face for masculinity, attractiveness, and dominance. Second, I

conducted a correlational analysis of the actual sex ratios, and self-rated dominance characteristics of mothers and fathers. Although I found no evidence in support of the idea that the sex of a person's future offspring can be accurately determined from their face, I did find that the interaction between dominance ratings of the mother's face and dominance ratings of the father's face significantly predicted the sex of their first-born child. Specifically, I found that when father's dominance was high, the effect of mother's dominance had a positive effect on the probability of the couple having a son, suggesting that men and women's mate preferences are indeed related to the sex of offspring they produce. In addition, I found that mothers who were high in self-reported dominance had higher (i.e., more male-biased) offspring sex ratios than women who were low in self-reported dominance, providing additional support for this hypothesis.

6.2. Theoretical Implications and Further Directions

The work presented in this dissertation provides support for the hypothesis that parental dominance has a positive influence on the conception of sons, but specifically suggests that the influence may operate directly through the mother, and indirectly through the father. These results have important implications for evolutionary psychology, particularly in the context of sexual selection.

6.2.1. Maternal dominance, mate preferences, and offspring sex.

In addition to providing further evidence in support of the hypothesis that more dominant women may be more likely to conceive sons (Grant, 1998), the results obtained in Studies 1 and 2 present the additional possibility that women may be aware of this tendency prior to ever becoming pregnant. In addition to being novel, this finding provides a potential missing link in previous theories of parental ability to vary their offspring sex ratios (Grant, 1998; Trivers & Willard, 1973), which would presumably rely upon an organism being able to somehow assess their current condition, as well as their environment, in order to respond adaptively. Although the existence of such interoceptive cues in women warrants further study to both confirm and elucidate, the possibility that perception of internal qualities, whether physiological or psychological,

that are related to the sex of offspring they would be most likely to produce could potentially have profound and far-reaching influences on their behavior.

Both the TWH and MDH assume that whatever condition is inherited from mother to offspring will directly enhance the reproductive success of that offspring. Thus, characteristics of mothers who have sons should theoretically reflect those that increase reproductive success in men. Given that higher dominance in men leads to higher ratings of attractiveness (Sadalla et al., 1987; Fink et al., 2007); and increased mating success (Hill et al., 2013), mothers should either also possess these characteristics, prefer mates who do, or both. In addition to women who predicted sons in Studies 1 and 2 being more dominant, the results of Study 2 also showed that these women preferred a more dominant face and a more dominant character for a short-term mate compared to women who predicted they would have daughters. Although no preferences were observed for a long-term mate, the results of Study 4 showed that women's ratings of facial dominance predict whether they will have a son as a first-born child when they are mated to men who are also rated as more facially dominant, suggesting that women who are more likely to have sons may indeed choose more dominant long-term male partners.

It is interesting to note that the results of Study 4 suggest that women who are rated low in facial dominance also preferentially mate with men rated high in dominance. Although contrary to my hypotheses, this is not necessarily surprising or at odds with the current state of literature on human mate preferences. Parental investment theory (Trivers, 1972) predicts that women should be choosier when it comes to men, requiring more from them than simple sexual relationships. The results of Study 1, as well as previous work (Kanazawa & Apari, 2009; Gangestad & Simpson, 1990), suggest that women who predict they will have sons may also be less sexually restricted than women who predict they will have daughters. Furthermore, women rated as more attractive have been shown to require more (i.e. physical attractiveness, masculinity, good financial prospect, good partner, good parent) from potential male mates than women rated less attractive (Buss & Shackelford, 2008). Similarly, women whose faces and bodies were rated less attractive preferred more feminine male faces (Penton-Voak et al., 2003). Given that married women who have sons may be more masculine and less physically

attractive than women who have daughters (Study 4; Kanazawa, 2007, 2011), it is possible that women who are more likely to have daughters seek mates who are both dominant and willing to invest in parenting, whereas women who are more likely to have sons are less concerned with paternal involvement in parenting. Alternatively, women who are more likely to have daughters may be more interested in seeking physical protection from male mates, a quality associated with dominance traits in men (reviewed in Puts, 2010). Both of these possibilities warrant further follow-up research.

It is clear from the results obtained in Studies 3 and 4 that female preferences for dominance in male partners may not be related to their ability to detect a man's future offspring sex by viewing his face. The results of Studies 3 and 4 provide no evidence that men and women can assess either a person's predictions about the sex of their future offspring, or their actual offspring sexes, respectively, suggesting either that humans are not consciously aware of such knowledge, or that humans use other facial or behavioral cues to infer the presence of heritable traits that might benefit their future offspring. The influence of dominance behavior on perceptions of a person's offspring sex would be an interesting avenue for future research, as the possibility that individuals make accurate judgments based on parent's behaviour would provide evidence for an adaptive human mechanism for assessing whether a potential mate possesses heritable qualities beneficial to offspring depending on its sex.

Compared to men, little is known about the function of dominance in women. Although the results of previous studies suggest that women may compete with other women regarding looking attractive and getting attention from the opposite sex (Cashdan, 1998; Fisher, 2004), it is also possible that women's dominance is related to more physical competition, such as athletic encounters or outwardly verbal conflicts. Cashdan (2003) found that women with higher androgen levels more often reported exerting verbal aggression, and overtly expressing their competitive feelings compared to women with lower levels. Higher androgen levels were also associated with higher self-regard, as well as higher self-reported leadership ability and popularity with same-sex peers (but not other-rated leadership ability or popularity, see Cashdan, 1995), suggesting that female dominance may serve additional adaptive functions.

In Study 2, women who predicted they would have sons also scored higher on a measure of aggressive dominance as well as a general personality assessment of dominance, both of which support the previous findings that women who have sons may be more overtly aggressive and exhibit overconfidence, both of which are important for male dominance and could therefore influence their sons quality, either through genetic or epigenetic mechanisms. The MDH proposes that women's dominance may serve such an adaptive function, with mothers of sons actually exhibiting more physical types of infant-child interactions (e.g., holding sons above their heads) than mothers of daughters (reviewed in Grant, 1998). Similarly, mother's dominance behavior might influence son's mate preferences for female dominance behaviour. It has been shown in experimental studies with sheep and goats that males prefer to mate with females of the same species of the mother that raised them rather than the mother that genetically produced them (Kendrick, Hinton, & Atkins, 1998). Human males have also been shown to partner with women who exhibit similar facial characteristics to their mothers (Marcinkowska & Rantala, 2012), suggesting a similar mechanism takes place in humans. The influence of dominance on the both parenting behavior and its resultant child behavior also warrants further study.

Grant and France (2001) showed that women who scored higher in dominance also had higher T levels, and Grant and colleagues (2005, 2008) showed that mammalian ova that develop in follicular fluid with higher T levels are more likely to be fertilized by Y-chromosome-bearing sperm and subsequently result in male embryos. However, I found no evidence that T, whether salivary or presumed through digit ratio, mediated the relationship between dominance and predictions for male offspring. Although salivary T has been associated with women's behavior in previous studies, including those involving maternal behavior (Deady, Smith, Sharp, & Al-Dujaili, 2006) and face preferences (Welling et al., 2007), one possible explanation for this discrepancy is that there may be variability between salivary and serum T concentrations in women. For example, Shirtcliff, Granger, and Litkos (2002) showed that salivary estimates of T did not correlate significantly with serum estimates for women, and that the discrepancy reduced the strength of relationship between hormonal measurements and behavioral measurements by 10%. Thus, our salivary concentrations may not have been precise enough to detect a relationship between T and predicted sex of offspring in

our sample. Additional possibilities include considerable variability in women's salivary concentrations of T due to menstrual cycle phase differences, hormonal birth control use, or that some women's predictions for sons were unreliable, both of which would preclude our ability to detect differences between groups. On the other hand, little is known about how, if at all, digit ratio may be related to dominance in women. Although one study showed that women with more masculine digit ratios had more sons (Manning, et al., 2002), this may have reflected high (or even extreme) levels of trait dominance that may not have been present in our relatively small sample. These possibilities should be considered in future investigations.

Taken together, the results for women obtained in Studies 1-4 provide evidence that characteristics such as high dominance and low sexual restrictiveness are related to the predicted conception of sons, and that this may be perceptible in women prior to becoming pregnant. Although I was unable to confirm the accuracy of women's predictions, the data obtained from actual mothers supports this conclusion. Women's perceptions of their own physiological and/or psychological state might also influence their ideas about the attractiveness of potential mates. Indeed, I found that women who predict they will have sons, as well as women who actually do produce sons, prefer to pair with men who exhibit both facial and behavioral dominance, at least for short-term mating encounters. Such preferences may be adaptive in that they could help to increase their own reproductive success through that of their adult sons.

Paternal dominance, mate preferences, and offspring sex. In contrast to my findings for women, the relationship between dominance, offspring sex, and mate preferences in men appears to be indirect, if present at all. The results of Study 1 showed that men who predicted they would have a daughter had higher E_2 levels and more feminine digit ratios, which makes sense given the relationship between E_2 and feminine facial appearance (reviewed in Johnston et al., 2001), as well as the negative relationship between digit ratio and men's perceived dominance (Neave et al., 2003). I was unable to replicate this finding in Study 2. In fact, the results of Study 2 showed that the sex of future child that a man predicts is not related to any physiological or psychological characteristic that I assessed, except for other-rated attractiveness, which was higher in men who predicted they would have a daughter. It could be argued that

any possible results for men in Studies 2 and 3 were diminished by the significant bias for men to predict they would have a son compared to a daughter, possibly reflecting simple preferences for sons, but it is unclear from my data whether this is true. Thus, subsequent results obtained from men in my sample should be taken as preliminary.

The results of Studies 2 and 3 provide support for the hypothesis that men's influence on offspring sex ratios is indirect, taking place predominantly through women who may be more likely to produce sons exhibiting stronger mate preferences for dominant mates. The majority of men in Study 2 preferred the low dominance face for a short- and long-term mate, but rated the high dominance face as more attractive and less feminine than the low dominance face. No differences between faces were observed for men's ratings of dominance. Similarly, men did not exhibit any preferences for either the dominant or submissive character description, and although they rated the dominant character as more dominant and masculine, they did not rate her more or less attractive than the submissive character. Taken together, these results suggest that men may not attend to, or may not exhibit preferences related to, women's dominance as displayed by either faces or behavior descriptions, at least as was investigated here.

In Study 4, male raters perceived the faces of mothers who had sons as more masculine, less attractive, and more dominant than the faces of mothers who had daughters. However, female raters perceived women's faces to be more dominant than male raters did, suggesting a potential sex difference in the perception of facial cues of dominance in women. Similarly, I found that men who were rated high in dominance were partnered with women who were rated as either high or low in facial dominance, suggesting that men may not choose mates based exclusively on this characteristic. It is possible, then, that male mate choice is irrelevant to characteristics of future offspring sex. Alternatively, men may be more sensitive to behavioral than facial dominance, generally preferring attractive mates but exhibiting individual differences in their attraction to dominant behavior in women. An important area for future research, then, will be to investigate men's preferences for women's dominance, as exhibited in various physical (e.g., facial structure) and behavioral phenotypes.

6.2.2. Offspring sex, mate preferences, and sexual selection.

In general, my findings support the idea that maternal dominance is important in the conception of male offspring, and that women who produce sons prefer characteristics of dominance in their partners. However, the women who predicted they would have a male offspring in Study 2 only exhibited preferences for dominance in short-term mates. Similarly, although high mother and father dominance predicted a male offspring in Study 4, low mother and high father dominance also predicted a female offspring in the same study, suggesting that although women who produce sons might seek dominance in short-term mates, they may not do so for long-term mates. These findings have important implications for theories of sexual selection in humans.

Buss and Schmitt (1993) have theorized that given the differences in male and female parental investment and tendencies towards short-term mating, men will be able to obtain a much higher quality female mate if they engage in long-term mating with them (i.e., because she requires more parental investment, but has better reproductive value), whereas women will be able to obtain a mate of higher genetic quality if they engage in short-term mating with them (i.e., because he is unlikely to invest heavily in parenting, but can provide genetic benefits). More recent research has consistently supported this idea for women, in that when considering a mate for short-term engagements, they prefer more masculine mates (i.e., those with indicators of good genes), and when considering a mate for long-term engagements, they do not (i.e., they are looking for indicators of investment) (reviewed in Penton-Voak, 2011). However, it is unclear to what extent women would actually choose to engage in short-term mating strategies and how facial masculinity might actually benefit offspring.

Male facial masculinity has long been thought an indicator of male health and developmental stability (i.e. an indicator of good genes), but Puts (2010) has suggested that male dominance increases success in intrasexual competitions, and female preferences for masculine traits actually reflect preferences for success in competitions rather than preferences for health or attractiveness. Traits associated with dominance (e.g., size, strength) not only increase men's ability to acquire resources such as food and territory, but increase men's mating success (Hill et al., 2013), suggesting that dominance may be a good indicator of male quality. However, discrepancies in women's

preferences for male dominance are well documented, with some studies showing a general female preference for masculine faces (DeBruine et al., 2006; Johnston et al., 2001) and other showing a preference for feminine faces (Perrett et al., 1998; Rhodes et al., 2000). Although some of this variability has been attributed to menstrual cycle variation (e.g., Penton-Voak et al., 1999; but see Wood, Kressel, Joshi, & Louie, 2014), offspring sex may more strongly influence the male characteristics that women consider to be attractive. Assuming that dominance is heritable, women who are more likely to produce sons may prefer dominant male mates compared to women who are more likely to produce daughters, as a dominant son would be more reproductively successful than a dominant daughter or a submissive son.

Preferences for dominance in men may occur in concert with differences in sexual restrictiveness. Individual differences in sexual restrictiveness have been observed (Simpson & Gangestad, 1991), suggesting that not all women will utilize short-term mating strategies. The results presented in this dissertation, as well as by others (Gangestad & Simpson, 1990), suggest that women who produce sons might be more likely to engage in such a strategy. Assuming that males highest in genetic quality are also those who are most likely to engage in a short-term mating strategy (Gangestad & Simpson, 2000), then women who are most interested in obtaining such genetic quality would be required to trade-off parental investment, thus engaging in short-term mating. Given that the genes for facial masculinity, for example, may operate similarly in both male and females, (i.e., Mitchem et al., 2014), and that facial masculinity is negatively associated with facial attractiveness in women (reviewed in Penton-Voak, 2011), it makes sense that individual differences in women's tendency towards, or increased success in, short-term mating with masculine male mates might be associated with the anticipated sexes of their offspring (Study 2), and that this relationship might not be observable in long-term partnered pairs (Study 4). In other words, if indicators of male genetic quality are associated with a tendency towards short-term mating strategy in men, then women who are more likely to produce sons may differentially pursue such a strategy in attempt to increase their reproductive success through the acquisition of such genetic quality for their offspring.

It seems important at this point to clarify that the relationship between maternal dominance, preferences for male dominance, and the conception of sons would not necessarily lead to a runaway process by which only genes for supremely dominant and masculine males and supremely submissive and feminine women would exist in the population. Although speculative, the theory proposed in my dissertation is that because the majority of parents will produce male and female offspring, parental traits selected for at the time of mating will be passed to offspring of both sexes, thus ensuring genetic variability. Mitchem et al. (2014) recently provided evidence that variability in facial masculinity might occur via intralocus conflict between the sexes. They observed a positive genetic relationship between male and female masculinity, but a negative genetic relationship between female attractiveness and male masculinity, suggesting that a beneficial effect of the gene in one sex trades off for a negative effect of the gene in the other. There are also various epigenetic mechanisms that might also operate, such as the influence of E_2 on brain structure, or environmental conditions on the expression of sexually selected traits (reviewed in Jasarevic, Geary, & Rosenfeld, 2012). Both of these possibilities should be approached in future studies.

In summary, the results of my dissertation provide evidence for the existence of a relationship between maternal dominance, mate preferences, and offspring sex, such that heritable parental traits are passed to male and female offspring to increase their reproductive success. This finding has important implications for evolutionary psychology, particularly in the study of sexual selection and should be considered in future studies investigating human mate preferences.

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Appendix.

Character Vignettes Used in Mate Preference Tasks (Chapter 3)

Dominant Character – Kayla (Female) or Mike (Male)

Kayla (or Mike) is a psychology major at her university, where she enjoys most of her classes. She enjoys many extra-curricular activities, including going out to see live music in her spare time. Kayla is also a member of a few on-campus clubs, where she tends to be a leader. She is a “take charge” kind of girl and she is considered by others to be somewhat dominant. In general, Kayla is not afraid to assert her authority when it is required. Because of this, she is considered by her friends to have a powerful influence over others. Kayla has been known to be selfish on occasion, but is usually considerate and sympathetic towards others. She is also a good friend. She enjoys watching movies, reading, hiking, and playing with her dog in the park.

Submissive Character – Kim (Female) or Dean (Male)

Kim (or Dean) is also a psychology major at her university, where she enjoys most of her classes. She enjoys many recreational activities, including going out to see live shows on weekends. Kim is a member of a few on-campus clubs too, where she tends to be more of a follower. She isn't a “take charge” kind of girl and she is considered by others to be somewhat submissive. Although she makes good points, Kim is not very assertive. She also tends to be passive and generally, she yields to her peers when challenged. Because of this, she is not considered by her friends to have much power in social situations. Kim is a good friend. Although she is sometimes selfish, she is usually considerate and sympathetic towards others. She enjoys listening to music, writing, spending time outdoors, and riding her horse at her grandpa's ranch.