Social Perceptions of Men’s Dominance and Variations in Men’s Intrasexual Competitiveness

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Abstract

Dominance plays a central role in human social interaction. Over the years, researchers have learned a lot about how men's dominance is perceived by others, including that people use a variety of perceptual cues when judging men's dominance and that these judgements are typically consistent across observers. However, questions remain concerning what external factors can influence a person's perceptions of other's dominance, and what factors affect individual differences in dominance and competitiveness. This thesis will review the current literature on dominance in men, before presenting three empirical chapters aimed at addressing gaps in the current literature. The first empirical chapter investigates the effects of testosterone and cortisol, on male intrasexual competitiveness, a key dominance behaviour. The study uses a longitudinal design to examine natural fluctuations in hormone levels over time. The study found no evidence of either a within-subject or between subject effect of testosterone, cortisol or their interaction, on intrasexual competitiveness. The second empirical chapter investigated regional variation in sensitivity to cues of dominance across US states. Despite strong theoretical predictions, the results show no compelling evidence that regional variation in population sex ratio influence sensitivity to cues of dominance. The final empirical chapter investigated the influence of transient cues, specifically head orientation on perceptions of dominance and trustworthiness. The results show that while tilting one's head down does reliably increase perceptions of dominance and decrease perceptions of trustworthiness, it appears that cue does not have downstream context contingent effects for leadership judgements.

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Preface

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Author's Declaration

I, Jaimie Stephen Torrance, hereby certify that this thesis has been written by me, and that it is the record of work carried out by me, or principally by myself in collaboration with others as acknowledged, and that it has not been submitted in any previous application for a higher degree.

Date: 16 October 2020

Signature:

Chapter 1 Introduction

Theories based on Darwin's (1871) idea of Sexual Selection, have allowed researchers to understand a variety of phenomenon that could not otherwise be explained by natural selection. For example, there is the textbook case of the peacock's tail, it's large and colorful tail is energetically costly to maintain and serves no obvious survival function, possibly even increasing visibility to predators, and these tails are not present in peahens. The large variety of sexually dimorphic traits among countless animal species, makes little sense from a natural selection standpoint, after all if a trait is beneficial or detrimental to the survival of one sex, why should it be different in the other? Sexual selection theories posit that traits can benefit overall fitness and can be selected for if they help in mating and therefore aid reproductive success. This can occur through intersexual attraction and mate choice (displaying qualities deemed attractive and desirable to the opposite sex), or though intrasexual competition (contests with same sex rivals through threat or force). Consequently, traits that are useful in attracting mates and competing with rivals are inherently valuable and of intrinsic theoretical interest. One such trait of interest is dominance. While there is much we know about "dominance" in human males, and how it operates in a social context, many questions still remain, including what kind of factors can influence our perceptions of men's dominance and what factors can affect men's dominance behaviour. The aim of this thesis will be to outline the current state of dominance research in the introduction, before addressing some important remaining questions in the empirical chapters.

1.1 Why Dominance and Status Matter

1.1.1 Status and social hierarchies

It has long been proposed that humans have developed status seeking behaviors and the accompanying motivational drives because of the evolved survival and reproductive benefits associated with high status (Anderson, Hildreth & Howland, 2015; Barkow, 1975; Kenrick, Griskevicius, Neuberg & Schaller, 2010; Qu, Ligneul, Van der Hurst & Dreher, 2017; von Ruden, Gurven & Kaplan, 2011).

Since it is assumed that not every member of a group can have preferential access to resources simultaneously, this will result in competition between individuals for access, with dominant individuals gaining more access than subordinates. With successive competitions between group members, over time a status hierarchy will form. Here, competitions are social interactions "in which access to something valued is contested between individuals and groups" (Casto & Edwards, 2016, p.21), and status refers to the deference an individual is afforded by others, based on their apparent capabilities (Anderson, Hilldreth & Howland, 2015). Winning in these status competitions signals an individual's dominance (Mazur, 1985).

These resulting social status hierarchies are pervasive in human cultures and integral to social functioning. Although the exact form and structure of these hierarchies varies between cultures (Torelli, Leslie & Kim, 2020), they nonetheless appear to be a universal feature across human cultures (Anderson et al., 2015; Price & Van Vugt, 2014), and they will form spontaneously in both small and large-scale societies (von Rueden, Gurven & Kaplan, 2008; von Rueden, Gurven, Kaplan & Stieglitz, 2014). These hierarchies can be highly structured and formal such as governmental structures, military ranking, or workplace organizations, or they can be entirely informal with very loose structures, such as social groups and clubs (Casto & Mehta, 2019).

One's position within a social hierarchy and thus their associated level of social status is no trivial thing. In fact, from an evolutionary standpoint variation in social status has serious survival and reproductive consequences. High status brings with it, increased influence over group decision-making (Cheng, Tracy, Foulsham, Kingstone & Henrich, 2013), preferential access to important resources (Patton, 2000, 2005) and coalitional support and access to allies (von Ruden et al., 2008; Hehman, Leitner, Deegan & Gaertner, 2015). Additionally there is evidence that status has direct impact on male reproductive success in ancestral environments and modern small-scale societies (Betzig, 1986; Chagnon, 1988; Irons, 1979; von, Rueden, Gurven & Kaplan, 2011; von Ruden & Jaeggo, 2016), similar effects can be seen in modern industrialized societies (Hopcroft, 2006), however usually only after controlling for level of education (Kaplan & Lancaster, 2000; Weeden, Abrams, Green & Sabini, 2006), possibly because of variation in other factors such as contraceptive use. Cross culturally high status in men is consistently seen as attractive and desirable in a potential partner by women (Buss 1989; Shackelford, Schmitt & Buss, 2005), further highlighting the importance of status to men's mating success.

In contrast, having low status can be particularly stressful for individuals when social hierarchies appear stable, with little hope for status improvement (Sheepers & Knight, 2020). Similarly, a loss of status can be highly stressful (Willner, D'Aquila, Coventry & Brain, 1995), and in the case of formal status loss (such as job loss or demotion), can even lead to depression (Mandal, Ayyagari & Gallo, 2011; Stolove, Galatzer-Levy & Bonanno, 2017). It is perhaps not surprising then that status appears to have a profound impact on a variety of health outcomes, with socioeconomic status shown to be a robust predictor of health and general wellbeing particularly in western culture (Demakakos, Nazroo, Breeze & Marmot, 2008; Sapolsky, 2004; 2005).

Evidently status is an important and fundamental factor in life, yet not everyone can hold the coveted high ranks in social hierarchies and enjoy the benefits of the associated status. Some dominant individuals will be better placed to achieve the desirable high-status positions.

1.1.2 What is dominance?

Over the years the term "dominance" has been used by numerous different disciplines in a variety of fields (such as social psychology, personality psychology, anthropology, sociology, behavioural endocrinology etc.), each will often define the term differently and subsequently, it means different things to different people. As such it is important to clarify the meaning of “dominance” for this thesis.

Dominance can be viewed as a psychological trait that drives motivation to achieve and maintain high status (Jackson, 1967). However, dominance can also be seen as the ability to gain influence and achieve goals (Anderson & Kilduff, 2009; Judge, Bono, Ilies & Gerhardt, 2002). Dominance as a behavioural trait is characterized by actions intended to enhance or maintain status (Mazur & Booth, 1998). Therefore, a dominant individual is one who desires high status, acts in a manner targeted at gaining status, and who has (either through psychological or physical advantages) the means to achieve that goal.

Recently, some researches have tried to redefine “dominance”, not as a general concept for all behaviour aimed at achieving and maintaining status, but rather as one potential pathway to status. The dominance-prestige model of status (Cheng, Tracy & Henrich, 2010; Cheng, Tracy, Foulsham, Kingstone & Henrich, 2013; Cheng & Tracey, 2014; Maner, 2017; von Ruden, et al., 2011), defines dominance as a coercive means of gaining status through intimidation and fear, contrasting it with prestige which is defined in terms of gaining status through demonstrations of competence and voluntary deference. While this distinction is interesting and will no doubt play an important role in the discussion of dominance in the years to come, most of the work discussed here in the introduction and in the later empirical chapters, take a more traditional approach to the definition of dominance. This is in part because there is not yet a reliably clear distinction between these two concepts in the wider literature. Many (including this author), have often conceptualized apparent “prestige” related behaviours, under the umbrella term of “dominance behaviours” as they still fall within the broader definition of “actions intended to enhance status”, in line with Mazur and Booth’s (1998) conceptualization of dominance. In fact, in describing the concept of “prestige” some have even referred to it as a “type of social dominance” (Casto, Hamilton & Edwards, 2019 p.238), precisely highlighting the apparent confusion over the distinction. As such this thesis will focus on the more general definition outlined above.

In summary, humans form social hierarchies which determines relative status, which in turn determines a variety of evolutionarily relevant outcomes. One’s position within a social hierarchy can be influenced through various different forms of competition, and dominance can determine success in these competitions.

1.2 The Importance of Dominance Cues

Human history has often been shaped by violent conflict (Bowles, 2009; Keeley, 1996; Manson et al., 1991; Walker, 2001), and anthropological evidence suggests that male-male competition and conflict has been a strong selection pressure (Puts, 2010). However, in most modern societies, violent conflict is not an everyday occurrence for most men, so there must be alternative methods of competition and status challenges. Fernald (2014), notes that in most species social hierarchies are formed through direct physical conflicts (fights) with conspecifics, yet these fights are risky, and the reward may not always outweigh that risk. Therefor individuals are more likely to fight when the potential rewards are high, and avoid conflict with conspecifics they are not likely to beat (Fernald, 2014). Yet even winners can often suffer costs in these conflict interactions, either through costly energy expenditure or direct injury. Therefore strategies for direct conflict avoidance should emerge, such as ritualized conflicts and various forms of status signaling (like visual dominance cues or threat displays) to deter unnecessary conflict (Fernald, 2014). In humans ritualized conflicts can take the form of anything from formal sports competition, to verbal arguments or even staring behaviours. Indeed success in sporting competitions can increase a man's social status, which can lead to higher levels of mating success (Aposolou, 2015; Faurie, Pointer & Raymond, 2004; Shulte-Hostedde, Eys & Johnson, 2008). Yet even losses in these forms of male-male competition can result in status loss, which can be seen with physiological changes, such as differences in changes in hormone levels between winners and losers (Mehta & Josephs 2006; Mehta, Snyder, Knight, & Lasseter, 2015. This is discussed later in section 1.6.1.5). As such being able to adequately assess a rival's dominance prior to engaging in competition is important, as this can inform any decision to engage or not (Sell et al., 2009). Dominance cues are important not just when assessing potential rivals, but also in assessing potential allies too, since a dominant individual may provide advantages in the context of inter-group conflict. Women should be equally as concerned with assessing a man's dominance, since a dominant man with ill-intentions poses a serious risk, but a benevolent dominant man may provide advantages.

1.3 What are the cues to dominance?

This section will focus on outlining research highlighting the most common perceptual cues to dominance in men.

1.3.1 Facial cues

The human face is an important source of social information and is fundamental to fluid social interaction by influencing many social judgments which in turn affect a host of social outcomes (Little, Jones & DeBruine, 2011; Rhodes, 2006). Importantly, dominance is one of the fundamental dimensions on which we judge faces (Oosterhof & Todorov, 2008).

1.3.1.1 Facial masculinity

Human faces are sexually dimorphic, and facial masculinity is characterized by exaggerated sex typical face morphology, such as more pronounced brows, wider jaw, wider chin, and smaller mouth. The craniofacial development that occurs during puberty is the primary cause of these sex differences and seem in part to be dependent upon testosterone exposure during this time (Verdonck et al., 1999).

Research on facial sexual dimorphism in men has often focused on the effect of facial masculinity on ratings of attractiveness and although facial masculinity is sometimes seen to increase ratings of attractiveness, the effect on ratings of dominance is much larger and far more consistent (Puts, Jones & DeBruine, 2012; Scott et al., 2013). In fact ratings of facial masculinity reliably predict perceptions of dominance (Boothroyd, Jones, Burt, & Perrett, 2007; DeBruine, Jones, Little, Boothroyd et al., 2006; Jones et al., 2010; Perrett et al., 1998; Scott et al., 2013; Stirrat & Perrett, 2010; Watkins, Fraccaro et al., 2010; Watkins, Jones, et al., 2010), to the point where cues of masculinity are so inextricably linked to judgments of dominance they are almost used interchangeably (Puts et al., 2012).

There are several reasons that facial masculinity would be associated with perceptions of dominance. For example, facial masculinity consistently increases perceptions of aggressiveness (Lefevre and Lewis, 2013, Stirrat et al., 2012), even across cultures (Scott et al., 2014). Aggressive behaviours are conceptually similar to dominance behaviours, except that aggressive behaviours are intended to inflict harm on others, whereas dominance behaviours are intended more broadly to achieve status (Mazur & Booth, 1998). The two are not mutually exclusive in that a dominant individual can act aggressively to achieve status (Peterson, Sznycer, Sell, Cosmides & Tooby, 2013). It is perhaps not surprising then that men that are perceived as aggressive are also often perceived as dominant (Lefevre and Lewis, 2013). Additionally, facial masculinity seems to correlate with measures of men's overall size, strength and general threat potential (Fink, Neave & Seydel, 2007; Han et al., 2017; Windhager, Schaefer & Fink, 2011).

Considering that facial masculinity has a much stronger effect on perceptions of dominance than on perceptions of attractiveness, it is possible that facial masculinity serves more as a signal of formidability in male intrasexual competition than as a means of attracting mates (Puts et al., 2012). It has been argued that primary function of sexually dimorphic facial structure is to provide protective buttressing for the face during male-male physical conflicts (Carrier & Morgan, 2015; Puts, 2010), in fact it is even argued that most sexually dimorphic male physical features have evolved as armaments to aid in intrasexual conflict (Hill, Bailey & Puts, 2017; Lombardo & Deaner, 2016; Puts, 2010). The general argument posits that since males have faced greater selection pressures for combative competition, and since humans do not posses traditional physiological weapons (such as claws or predominant canines), blunt force trauma to the head is the preferred mode of attack, therefore males should show adaptations for protecting the most vulnerable areas. There does appear to be evidence to support this assertion. It has been noted that the face is by far the most common site of injury resulting from assaults and interpersonal violence (Adi, Ogden & Chisholm, 1990; Brink, Vesterby & Jensen, 1998; Shepherd, Robinson & Levers, 1990). Additionally the most sexually dimorphic areas of the human skull are the areas of the face that show the highest rates of fracture from these interpersonal conflicts, and these are the areas that show the greatest increase in robusticity throughout evolutionary history (Carrier & Morgan, 2014). If this is indeed the case, then greater facial masculinity would mean greater resistance to damaging blows and improved combat longevity, and considering the relation to other cues of threat potential, such as height and strength then facial masculinity could be deemed a valid cue to a man's physical formidability and dominance.

1.3.1.2 Facial width to height ratio

Outside of facial sexual dimorphism, one of the most investigated facial features is the facial width-to-height ratio (fWHR). This fWHR is a measure of relative width of the face compared to the height (measured by the distance between zygions, and the distance between the top lip and brow), such that a larger fWHR represents a wider face. Despite some reports suggesting that there is no overall sexual dimorphism in fWHR (Deaner, Goetz, Shattuck & Schnotala, 2012; Lefevre, Lewis, Bates, Dzhelyova, Coetzee, Deary & Perrett, 2012; Mileva, Cowan, Cobey, Knowles & Little; 2014), a recent meta-analysis would seem to show that fWHR was larger in men than women, albeit with a small effect size (Geniole, Denson, Dixson, Carré, & McCormick, 2015. But see Kramer, 2017). Additionally, unlike facial masculinity, fWHR does appear to be correlated with circulating testosterone levels in men (Lefevre, Lewis, Perrett & Penke, 2013), which may also play a role in dominance behaviour (discussed in section 1.6.1).

There is good reason to believe that fWHR may function as a cue to dominance in men. There is evidence that fWHR is a cue of dominance in other primate species with high fWHR positively associated with status and dominance behaviours in capuchin monkeys, macaques, and bonobos (Altschul, Robinson, Colman, Capitanio & Wilson, 2019; Borgi & Majolo, 2016; Lefevre, Wilson, Morton, Brosnan, Paukner & Bates, 2014; Martin, Staes, Weiss, Stevens & Jaeggi, 2019).

In humans fWHR reliably correlates with dominance perceptions, such that men with a higher fWHR are perceived as more dominant that men with a lower fWHR (Alrajih & Ward, 2013; Geniole et al., 2015; Lefevre & Lewis, 2013; Mileva, et al., 2014; Valentine, Li & Penke, 2014). Additionally fWHR positively correlates to men's self-reported levels of dominance behaviour (Lefevre, Etchells, Howell, Clark & Penton-Voak, 2014), as well as their own self-perceived dominance (Mileva, et al., 2014). Other studies have found men's fWHR to be positively associated with, feelings of power (Haselhuhn & Wong, 2012), as well as dominance related behaviours (Geniole et al., 2015), including achievement striving (Lewis, Lefevre, & Bates, 2012), and exploitative behaviours (Haselhuhn & Wong, 2012; Stirrat & Perrett, 2010).

Similarly fWHR positively correlates with aggressive behaviours (Carré & McCormick, 2008a; Geniole et al., 2015; Haselhuhn, Ormiston & Wong, 2015), and it appears that this association carries over into social judgements, as men with higher fWHR's are perceived as being more aggressive as well (Carré, McCormick & Mondloch, 2009; Geniole, Keyes, Mondloch, Carré & McCormick, 2012; Geniole, Molnar, Carré & McCormick 2014; Lefevre & Lewis, 2013; Short, Mondloch, McCormick & Carré, 2012).

Within sex effects associated with variance in fWHR are not always observed in women, or at least are observed to a lesser extent in women than in men (Carré & McCormick, 2008a; Geniole, et al., 2012; Mileva et al., 2014), leading some to suggest that fWHR may be a more reliable cue of dominance in men than in women (Mileva et al., 2014). Also, it is interesting to note that while studies have found a positive association between fWHR and reproductive success, generally fWHR is negatively correlated with women's assessments of attractiveness (Geniole et al., 2015), once more suggesting that male intrasexual competition may have presented a stronger selection pressure than female choice in the evolution of men's fWHR.

1.3.1.3 Facial coloration

Facial coloration affects a variety of judgments including perceived health, age and attractiveness (Fink, Matts, D'Emiliano, Bunse, Weege, & Röder, 2012; Han et al., 2018; Stephen, Coetzee, Smith, & Perrett, 2009; Stephen, Oldham, Perrett, & Barton, 2012). Of specific importance to assessments of dominance is facial redness. The colour red appears to hold particular connotations of dominance, competitiveness and status for humans in an assortment of contexts (Adams & Osgood; 1973; Little & Hill, 2007; Wiedemann, Burt, Hill, & Barton, 2015). In a variety of animal species redness in males is associated with dominance, aggressiveness and status (Bamford, Monadjem, & Hardy, 2010; Healey, Uller & Olsson, 2007; Iyengar & Starks, 2008). This has been observed in numerous primates, including baboons (Dunbar, 1984), macaques (Rhodes et al., 1997) and mandrills (Setchell & Dixson, 2001; Setchell, Smith, Wickings & Knapp, 2008), with male redness on visible skin corresponding with dominance rank and aggressiveness, and even other males avoiding confrontations with the most red individuals (Setchell & Wickings, 2005). Facial redness in humans, is the result of flow of the oxygenated blood to the periphery, it also appears to be influenced by androgens (Edwards et al., 1941; Jeghers, 1944) and is sexually dimorphic (Frost, 1994, Little et al., 2011). Surprisingly little research has addressed the effects of facial coloration on social perceptions outside of attractiveness judgements, however there is some evidence that facial redness increases perceptions of men's dominance and aggression (Stephen et al., 2012), as well as perceptions of anger (Young, Thorstenson, & Pazda, 2018).

1.3.1.4 Facial hair

One of the most easily identifiable sexually dimorphic facial traits is male facial hair. It's believed that human facial hair serves as a biological marker for postpubescence and sexual maturity in males (Muscarella & Cunningham, 1996), and it has been suggested that it has developed as an exaggerated signal of dominance and potential threat, since it obscures and enhances the apparent size of the jaw and chin (Guthrie, 1970; Dixson, Lee, Sherlock, & Talamas, 2017).

This interpretation would seem to be supported by the evidence, since the effects of male facial hair on women's attractiveness ratings and preferences are highly heterogenous. Some studies find a positive effect of facial hair on attractiveness (Dixson & Brooks; 2013; Janif, Brooks & Dixson, 2014; Neave & Shields, 2008), although this relationship between facial hair and attractiveness is rarely linear (i.e. more beard does not mean more attractive), and other studies even find a negative effect of facial hair on judgements of attractiveness (Dixson & Vasey; 2012). This is probably in part due to societal and cultural shifts, as well as situational and contextual factors, and specific factors such beard length, thickness and distribution affecting judgements of attractiveness

(Dixson & Brooks, 2013; Dixson & Rantala, 2016; Dixson, Tam, & Awasthy, 2013; Janif et al., 2014; Stower et al., 2020).

On the other side however, the effect of facial hair on dominance perceptions appear to be fairly universal, with beards increasing perceptions of men's dominance (Dixson et al., 2017; Neave & Shields, 2008; Saxton, Mackey, McCarty, & Neave, 2016; Sherlock, Tegg, Sulikowski, & Dixson, 2017), as well as perceptions of masculinity (Dixson & Brooks, 2013; Dixson et al., 2017), aggressiveness and status (Dixson & Vasey, 2012). Moreover, beards seem to increase perceptions of dominance independent of other facial cues of dominance, such that even men who lack other facial cues of dominance can increase their apparent dominance to others (Dixson et al., 2017). This is notable since beards do not appear to provide any protective benefit during combat, nor do they seem to signal actual fighting ability, as such it is possible then that beards act as a dishonest signal of dominance, and my instead serve primarily to dissuade conflict though intimidation (Dixson, Sherlock, Cornwell, & Kasumovic, 2018).

1.3.2 Body cues

Throughout human evolutionary history strength is likely to have been a determining factor in men's dominance strategies by affecting their ability to gain and retain resources (Sell et al., 2009), and their ability to maintain social status (Lukaszewski, Simmons, Anderson, & Roney, 2016). Accordingly, attributes that influence physical strength and formidability, will play a central role in dominance behaviours and perceptions.

Men's increased muscle mass is believed to have played a key part in male-male intrasexual competition throughout evolutionary history (Puts, 2010). Although it is often thought that humans have relatively low sexual dimorphism in overall size compared to some other species with high levels of male-male competition, this relatively low dimorphism is mainly attributed to human females having substantial fat stores (Pond & Mattacks, 1987). When comparing fat-free masses on average men are approximately 40% larger than women (Mayhew & Salm, 1990; Lassek & Gaulin, 2009) with around 50–65% more muscle mass than women (Illner *et al.*, 2000; Abe, Kearns & Fukunaga, 2003; Shen *et al.*, 2004).

Subsequently, strength is highly sexually dimorphic with men exhibiting approximately 90% greater upper body strength than women (Lassek and Gaulin 2009).

Consequently, measures of muscularity and upper-body strength seem to play an important role in dominance perceptions. Cross-culturally, men appear to place a great deal of importance on muscularity in their conceptualization of dominance and often desire increased muscularity to increase their apparent dominance to others (Fredercik, Buchanan, Sadehgi-Azar, Paplau, Haselton, Berezovskaya & Lipinski, 2007), and high levels of muscularity increase observers perceptions of men's dominance (Frederick & Hasselton, 2007). Similarly, several putative measures of strength and muscularity seem to reliably increase perceptions of dominance as well. For example, men with a low waist-to-chest ratio (indicating a broad chest and slim waist) are seen as more dominant that men with a higher ratio (Coy, Green & Price, 2014), similar effects are also observed for men with a high shoulder-to-hip ratio (i.e. broad shoulders, narrower hips) (Dijkstra & Buunk, 2001). In addition to measures of muscularity, height (another physical trait associated with strength) affects perceptions of dominance, such that taller men are perceived as more dominant than shorter men (Watkins, Fraccaro, et al. 2010; Stulp, Buunk, Verhulst & Pollet 2015).

Relatedly, increased strength seems to increase men's self-assessed dominance with research showing that men with more upper body strength tend to feel more entitled to better outcomes, and are more likely to decide on aggressive action, and engage in social competition (Gallup, O'Brien, White & Wilson, 2010; Gallup, White & Gallup, 2007; Muñoz-Reyes et al. 2012; Sell et al. 2009, 2016), as well as having an increased sense self-perceived formidability (Kerry & Murray, 2018).

Considering the direct relation between body size and strength, and that stronger and larger men exhibit more dominant and aggressive behaviors, it would appear that these body measures represent valid cues to men's dominance and threat potential.

1.3.3 Vocal cues

Visual physical cues are not the only sources of information people use when making social perceptions, and the human voice carries a wealth of social information, even outside of the linguistic content (Collins, 2000; McAleer, Todorov & Belin, 2014).

In many non-human animals including primates, vocalizations are used by males to attract mates and deter and intimidate rivals (Boseret, Carere, Ball & Balthazart, 2006; Kapusta & Pochroń, 2011; Muller, 2017; Pasch, George, Hamlin, Guillette & Phelps, 2011; Wilczynski, Lynch, O'Bryant, 2005). It also appears that the fundamental frequency, and formant frequencies (the acoustic properties that that make up perceived pitch), predict variation in body size in many species including primates (Fitch & Hauser, 1995; Hauser, 1993; Taylor & Reby, 2010), which in turn influences relative formidability and perceived dominance, meaning that males with deeper vocalizations would be perceived as more dominant and threatening.

In humans, increased levels of circulating testosterone during puberty in males cause the vocal folds (or “vocal cords”) to grow longer and thicker in men than in women (Harries, Hawkins, Hacking, & Hughes, 1998). Males’ larynges also descend during puberty which in turn produces a longer vocal tract and lower more closely spaced formant frequencies (Fant, 1960; Fitch & Giedd, 1999). These morphological changes lead to an overall sex difference in mean voice pitch (or fundamental frequency) between sexes, with women’s voices approximately twice as high as men’s voices, and men having a more monotone voice than women, with less variance in fundamental frequency between utterances (Puts, Apicella & Cardenas, 2012, Titze, 2000). These sexually dimorphic vocal cues such as pitch and timbre can influence perceptions of dominance, such that more masculine voices are consistently perceived as more dominant, than higher pitched more feminine voices (Feinberg et al., 2005; Hodges-Simeon, Gaulin & Puts, 2010; Jones, Feinberg, DeBruine, Little & Vukovic, 2010; Puts, Apicella & Cárdenas, 2012; Saxton et al., 2016; Wolff & Puts, 2010).

Fraccaro and colleagues (2012) noted that although lower more masculine voice pitch was rated as more attractive and more dominant, deliberately lowering voice pitch (i.e. exaggerating cues of masculinity), increased perceptions of dominance but did not affect attractiveness ratings. This would indicate both, that men can deliberately influence how dominant they appear to others, and that people may tend to adopt a low-risk strategy in judging dominance to mitigate the risk of misjudging the formidability of potential threats. The fact that there was no effect on perceptions of attractiveness, indicate that this low-risk strategy could represent a specific adaptation for threat mitigation, rather than a general response bias to deliberately altered pitch (Fraccaro, O'Connor, Re, Jones, DeBruine, & Feinberg, 2012).

Additionally, stranger's assessments of men's fighting ability from voices do not appear to track real world assessments of fighting ability made by familiar peers (Doll et al., 2014), nor do assessments of men's threat potential from voices correlate with actual measure of men's threat potential (Han et al., 2017). It should also be noted that correlations between the acoustic properties of men's voices and individual physical measures of threat potential such as height weight and strength are highly inconsistent (Feinberg et al., 2018; Han et al., 2018; Pisanski et al., 2014; Puts, Jones DeBruine, 2012).

Considering that men can deliberately alter their voice pitch and increase their apparent dominance to others, and that perceptions of dominance from voices do not appear to predict physical formidability or fighting ability, nor do the actual acoustic properties of voices reliably predict measures of threat potential, it would appear that sexually dimorphic vocal cues may not be an honest signal of dominance. Rather these vocal cues might act as a dishonest signal of dominance, and the apparent dominance perceptions may instead be the biproduct of sensory exploitation (Feinberg et al., 2018).

1.3.4 Olfactory cues

Relatively little work has been carried out directly investigating role of olfactory cues in social judgements, however there are some studies that suggest that a man's body odor could influence perceptions of his dominance (Havlíček, Roberts & Flegr, 2005; Sorokowska, 2013; Sorokowska, Sorokowski, & Szmajke, 2012; Sorokowska, Sorokowski, & Havlíček, 2016). Much of the work on body odor perceptions, however, is primarily concerned with attractiveness judgements particularly regarding female preference (i.e. Carrito et al 2017). This is possibly in part because women show superior sensitivity to detecting cues from odor compared to men (Brand & Millot, 2001). Whether or not body odor could be considered a reliable cue to dominance particularly in the context of male-male intrasexual competition is still unclear, especially considering that ratings of dominance from body odor were more accurate when judged by the opposite sex (Sorokowska et al., 2012), perhaps indicating these cues may play a more important role in mate choice than competition.

1.3.5 Transient cues

Much of the research highlighted so far is concerned with relatively invariant and stable cues (like face shape and height), or at least ones that men have little immediate control over (like facial hair and muscle mass). There are however, other cues that influence social judgments that can be highly variable and transient.

Gaze direction is important for fluid social interaction and making social judgements, in part because it carries connotations of intentionality, which in turn informs decisions about future actions (i.e. a threatening gesture made with gaze directed at you, has different implications for you, than if the threatening gesture is made while looking away from you). Consequently, it has been seen that gaze direction moderates the strength of other cues on dominance perceptions, such that perceptions of dominance decrease when the individuals gaze is averted compared to looking straight on (Main, Jones, DeBruine & Little, 2009). Similarly emotional expressions carry with them connotations of intentionality too, as such they can also influence perceptions of dominance, most notably expressions of sadness and fear reduce perceptions of dominance, whereas expressions of anger will increase perceptions of dominance (Hareli, Shomrat & Hess, 2009; Montepare & Dobish, 2003; Zebrowitz, Kikuchi & Fellous, 2007). This makes sense from a survival standpoint; if someone is angry and has ill intentions, it is perhaps better to err on the side of caution when assessing their ability to inflict harm. This relationship between emotional expression and dominance perceptions can be further moderated by the viewing angle of the perceiver, such that angry faces are perceived as most dominant and sad faces as least dominant when viewed from the front, compared to being viewed in profile, again indicating that assessment of intentionality may influence dominance perceptions (Sutherland, Young & Rhodes, 2017).

Tilting the head either up or down is another possible variable cue for dominance judgements, in several animal species, raising the head and chest is a signal of dominance, whereas lowering the head is often a signal of deference and submission, and it has been argued that these actions may serve a similar purpose in humans (Mignault & Chaudhuri, 2003). Some studies have noted that tilting the head up increases perceptions of dominance and masculinity (Bee et al., 2009; Burke & Sulikowski, 2010; Mignault & Chaudhuri, 2003), whereas others have suggested the opposite, finding that tilting the head down increases perceived dominance (Hehman et al, 2013; Toscano, et al., 2018; Witkower & Tracy, 2019). The true direction of this effect is still open for debate, as is the reason for its influence on dominance perceptions, although Witkower and Tracy (2019), do present a convincing argument that tilting the head down creates an illusory “V-shape” in the eyebrows, mimicking the furrowed brow of angry faces. This would coincide with the research previously discussed indicating expressions of anger (and cues to intentionality) influence perceptions of dominance.

1.3.6 Are these judgments accurate?

It is evident from the research outlined above that humans use a variety of cues when assessing the potential dominance of others, particularly men. While some of these cues may be considered “dishonest signals” such as facial hair and voices, due in part to the fact that these can be manipulated, other cues such as height, muscularity and particularly facial cues (excluding facial hair), seem to represent honest signals of men’s dominance and formidability. As noted, facial cues seem to predict real world measure of formidability including height and strength (Fink et al, 2007; Re, DeBruine, Jones & Perrett, 2013; Sell et al., 2009), as well as dominance behaviours, aggressiveness and achievement and status striving (Carré & McCormick, 2008a; Carré, Morrissey, Mondloch & McCormick, 2010; Puts, Welling Burriss, Dawood, 2012; Geniole et al., 2015;

Lewis, Lefevre, & Bates, 2012). In addition, faces also seem to be a valid cue of leadership potential and fighting ability (Doll et al., 2014; Little, Třebický et al, 2015; Třebický et al., 2013; Zilioli, Sell, Stirrat, Jagore, Vickerman & Watson, 2014).

While the accuracy of some social perceptions is perhaps questionable at best, (Olivola & Todorov, 2010; Todorov, Olivola, Dotsch, & Mede-Siedlecki, 2015), the research present here would seem to indicate a degree of accuracy in our perceptions of dominance

1.4 What are the consequences of dominance perceptions?

As noted earlier, form an evolutionary standpoint, the ability to display dominance through cues has survival utility in reducing unnecessary conflicts, however the influence of these cues goes beyond that. Social perceptions are an important part of human interactions, and the perceptions we have about other people influence how we interact with them, meaning they have real world consequences (Olivola, Funk & Todorov, 2014). Perceptions about men's dominance are important in a variety of ways, and in this section, I will highlight some of the key consequences of these dominance perceptions.

1.4.1 Dominance perceptions and mating opportunities

Being able to signal one's own dominance and being perceived by others as dominant may be evolutionarily beneficial by increasing your reproductive fitness through increased mating opportunities.

Displaying cues of dominance can afford an individual deference and status, which brings with it access to valued resources because the men who do so are regarded as both physically and socially dominant by others (Mueller & Mazur, 1996; Swaddle & Reierson, 2002). Additionally, physical cues of dominance may be considered an honest signal of health and good genes (Thornhill & Gangestad, 1999). Since testosterone is thought to be responsible for the development and maintenance of many physical cues of dominance (like facial masculinization, muscle mass, facial hair etc)(Bribiescas, 2001; Hiort, 2002; Richmond & Rogol, 2007), but is also thought to have a negative impact on the immune system (Foo, Nakagawa, Rhodes, & Simmons, 2017), the immunocompetence handicap hypothesis, suggests that only healthy men with "good genes" could afford the cost of displaying these physical cues without suffering as a result of increased parasite stress (Folsatd & Karter, 1992). This would suggest two reasons why dominant looking men would make for attractive mate choices; they can provide good genes to future offspring and can also possibly provide for mother and child with their preferential access to resources.

The evidence would seem to suggest that dominant masculine looking men are often seen as attractive (Buss, 2003; DeBruine et al., 2006; Rhodes, 2006; Perrett et al., 1998). However other studies report that feminine non-dominant looking men are also often seen as attractive (Little et al., 2001; 2002; Welling et al., 2007). It has been proposed that while choosing a dominant looking man as a partner may provide benefits in terms of potential good genes and resources, this may come at a cost of reduced willingness on the man's part to invest time and resources into relationships, since dominant looking men are also often perceived to be less faithful and committed (Boothroyd et al., 2007, Frederick & Haseslton, 2007), thus women are presented with a potential trade-off when choosing a partner (Gangestad et al., 2004; Gildersleeve, Haselton, & Fales, 2014).

Initial theory suggested women should show a preference for dominant masculine looking men in uncommitted short-term relationship contexts, but a preference for non-dominant looking men in long-term committed relationship contexts and that these shifts would track with changes in women's hormone levels across the ovulatory cycle, such that women would prefer dominant masculine looking men when in their most fertile stage of the cycle, in order to maximize conception with men with good quality genes, and would prefer non-dominant committed men at other times (Gangestad et al., 2004; Gangestad & Simpson, 2000; Little & Jones 2012; Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000; Pillsworth & Haselton, 2006). However, recent empirical support for the proposed cyclic shifts in dominance preferences has been lacking across a variety of physiological cues of dominance (Dixson et al., 2018; Jones et al., 2018; Jünger, Kordsmeyer, Gerlach, & Penke, 2018; Jünger et al., 2018; Marcinkowska et al, 2016).

While the exact nature of the relationship between cues of dominance and masculinity and female preferences is equivocal, the fact remains that cues of dominance are still often viewed as attractive (DeBruine et al., 2006; Dixson et al., 2003; Dixson & Rantala; 2016; Nettle, 2002; Swami & Tovee, 2005) and dominance perceptions certainly seem to relate to mating opportunities.

Cross culturally, physiological cues typically associated with dominance and dominance perceptions, such as facial masculinity, vocal masculinity, height, and muscularity are commonly associated with mating outcomes. For example, studies have found that men with more masculine faces tend to have a stronger preference for short-term uncommitted relationships (Boothroyd, Cross, Gray, Coombes, & Gregson-Curtis, 2011; Boothroyd, Jones, Burt, DeBruine, & Perrett, 2008). Additionally it seems like they are also better equipped to pursue their preferred relationships, since men with masculine faces and masculine voices often report earlier age of first intercourse, greater numbers of sexual partners, as well as more short-term relationships and more extra-pair relationships than less masculine men (Hodges-Simeon, Gaulin & Puts, 2011; Hughes, Harrison & Gallup, 2004; Rhodes, Simmons & Peters, 2005). Similarly, men with more muscular and masculine bodies often also report earlier age of first intercourse, more sexual partners and more short term partners (Frederick & Haselton, 2007; Lassek & Gaulin, 2009; Rhodes et al., 2005). Height is another important cue of dominance, and generally speaking, women tend to find taller men more attractive and prefer them as partners (Stulp, Buunk, & Pollet, 2013; Stulp, Buunk, Pollet, Nettle, & Verhulst, 2013), and this seems to be reflect in taller men's mating success (Sear, 2006; 2010; Nettle, 2002).

The evidence presented here would suggest that the supposed heterogeneity in women's preferences for certain dominance cues (most notably facial and vocal masculinity), is yet to be adequately understood. Some have even argued that perhaps female mate choice might have played a lesser role than intersexual competition in the evolution and maintenance of these cues (Kordsmeyer, Hunt, Puts, Ostner, & Penke, 2018; Puts, 2010), which may partially explain the apparent disparity between cues of dominance, attractiveness judgments and mating success. Regardless of the mechanism, it would still appear that cues to dominance play an important role in men's mating opportunities, particularly in terms of overall number and the kinds of relationships they have.

1.4.2 Dominance perceptions and status opportunities

Displaying cues of dominance and being perceived as dominant can often have both direct and indirect effects on status opportunities. For example, facial cues of dominance positively correlated with progression up through the ranks in the military (Mueller & Mazur, 1996), and physical cues commonly associated with dominance such as height have strong positive correlations to general workplace success and income (Judge & Cable, 2004). Whether this is due to the actions of the “dominant” individual leading to success and promotion, or because the individual looked more dominant resulting in greater likelihood of being selected for advancement is unclear. The fact remains however, there appears to be a clear correlation between cues of dominance and attainment of status.

Other studies have shown that the merely being perceived as dominant is enough to influence status opportunities. For instance, in an experimental setting, individuals perceived as more dominant, can receive higher pay awards in managerial positions than those perceived as less dominant (Fruhen, Watkins & Jones, 2015), and in a hypothetical election situation, participants showed preferences for candidates with more dominant sounding voices over those with less dominant sounding voices (Klofstad, 2016; Klofstad & Anderson, 2018). In fact, it appears that social cues are very important for leadership judgements (Ballew & Todorov, 2007; Todorov, Mandisodza, Goren, & Hall, 2005), and these judgments appear to be reflected in real-world voting decisions (Little, Burriss, Jones, & Roberts, 2007).

It is thought that cues of dominance influence status opportunities primarily through access to leadership positions. Biosocial leadership theories suggest that putative leadership preferences reflect the apparent survival and reproductive benefits conferred upon the group by choosing effective group leaders (Spisak, Dekker, Krüger, & Van Vugt, 2012). In this view preference for dominance in leaders may reflect preferences for individual’s wo are capable of pursuing group interests and representing the group against out-groups via formidability, threat and resource acquisition (Van Vugt, Cremer & Janssen, 2007). This potential group benefit from dominant individuals, may help to explain why dominant looking individuals are more likely to be selected for group membership when inter-group conflict is expected rather than in cooperative situations (Hehman Leitner, Deegan, Gaertner, 2015), and why men’s preferences for dominant looking allies increases after a loss (Watkins & Jones, 2016). This effect seems to result in context dependent preferences for leaders. There is now a growing body of research that suggests that dominant looking individuals are preferred as leaders in a wartime context, whereas more trustworthy individuals are preferred as leaders in a peacetime context (Ferguson, Owen, Hahn, Torrance, DeBruine & Jones, 2019; Grabo & Van Vugt, 2018; Laustsen & Petersen, 2017; Little et al., 2007; Little, Roberts, Jones & DeBruine, 2012). The evolutionary-contingency hypothesis (Grabo & Van Vugt, 2018; Van Vugt & Grabo, 2015), suggests that these context-contingent effects of dominance and trustworthiness cues, reflect evolved expectations regarding necessary leadership qualities under varying conditions. This hypothesis suggests that dominance traits would be deemed to be particularly relevant within the domains of conflict or war, and therefore cues to dominance would be particularly salient when judging a potential leader under those conditions.

1.5 What factors influence perceptions of dominance?

So far, this thesis has reviewed research suggesting that humans use a variety of cues in assessing men's dominance, and these assessments influence important social outcomes. Generally speaking, people are fairly consistent in their assessments of dominance, i.e. different people rate the same men similarly (Torrance et al., 2014). This is important because, if assessments of dominance were wildly inconsistent across perceivers, that would indicate a poorly adapted mechanism for assessing threat. However, there are situations in which we would expect some variance in dominance perceptions to exist. Individuals who are at greater risk as a result of misjudging another's dominance, would be expected to show greater sensitivity to cues of dominance. In this section I will be reviewing research on the individual and contextual factors that can influence our perceptions of dominance.

1.5.1 Individual differences

If the function of dominance perceptions in men is primarily for assessing likelihood of success or failure in intrasexual competition (Puts, 2010; Puts, Jones & DeBruine, 2012; Sell et al, 2009), then we might expect to see greater sensitivity to cues of dominance in men who stand to incur greater costs of misjudgment, i.e. the man most likely to lose in a dominance contest. Consequently, researchers have attempted to establish if individual differences in men's own dominance levels influence their perceptions of others dominance. Watkins and colleagues (Watkins, Jones, et al., 2010), found a negative correlation between men's own levels of trait dominance and their assessments of dominance of masculinized male faces. This would indicate that less dominant men were more sensitive to cues of other men's dominance as a means of mediating the potential risk of injury by misjudging a rival's dominance and their related threat potential (Watkins, Jones, et al., 2010).

In addition, when considering men's own height (a putative cue of their relative dominance), taller men showed less sensitivity to cues of other men's dominance than did shorter men (Watkins, Fraccaro, et al., 2010). Similarly, individuals in positions of power and status, tend to underestimate the size of others, whereas individuals in positions of low status tend to overestimate the size of others (Yap, Mason & Ames, 2013). This suggests that men at more risk of incurring injury as a result of misjudging a potential rivals threat potential, may not only be more sensitive to putative cues of dominance, but may actively overestimate threat potential, thus adopting a minimal-risk strategy to threat assessment.

Concurrent with this idea, is evidence that suggests men's own physical strength negatively correlates with their perceptions of other men's dominance, such that stronger men gave lower ratings of physical formidability to potential rivals than did weaker men (Fessler, Holbrook & Gervais, 2014).

Researchers investigating the effects of hormones on social perceptions have noted that through exogenous administration, testosterone acts to increase men's self-perceptions of their own dominance (Welling et al., 2016), as well as increase their preferences for feminine female faces as potential partners (Bird et al., 2016). However, exogenous increases in testosterone did not affect men's perceptions of other men's dominance from facial cues (Bird et al., 2017), nor do baseline testosterone levels seem to affect men's perceptions of other men's dominance from vocal cues (Kandrick et al., 2016).

This is noteworthy because other studies have failed to find any relationship between individual differences in men's own dominance on their perceptions of other's facial cues (Lefevre & Lewis, 2013), and vocal cues (Wolff & Putts, 2010) of dominance. It would seem then, for now, more work is needed in order to fully understand potential individual differences in men's dominance perceptions.

1.5.2 External Factors

It may be adaptively advantageous to poses a perceptual system for assessing dominance, that is flexible and sensitive to situational and contextual changes, in order to optimize decision making, e.g. it may make sense for one individual to engage a potential rival in one situation, but not necessarily in another depending on a variety of factors.

1.5.2.1 Situational factors

Sensitivity to cues of dominance may be dependent upon the situation in which men find themselves when assessing potential rivals. For example, men who find themselves on the losing end of a prior contest, my wish to avoid further status loss by deciding against competing with other rivals that could beat them, and evidence suggests that men who have lost an imagined contest show greater sensitivity to cues of dominance than men who won (Watkins & Jones 2012). This may be a way for men who have recently lost status to mitigate the potential cost of further status loss to more dominant individuals.

Similarly, studies have also shown that men who find themselves in precarious positions or find themselves at a decided disadvantage compared to potential rivals show altered dominance perceptions. Fessler and Holbrook (2013a) noted that men who were tied to chair, or off balance increased their estimates of angry men's size and muscularity (and decreased estimates of their own height) indicating men may be unconsciously able to sense their own vulnerability, which is reflected in their perceptions of potential rivals. It should also be noted, that when one individual is holding a weapon and the other is not, the balance of power and overall odds of success in conflict are shifted in favor of the individual with the weapon, leaving the other deeply disadvantaged and fundamentally subordinate. Research suggests that this shift in dominance dynamic can also be internalized, leading observers to conceptualize weapon holders as generally more dominant and physically imposing than individuals holding innocuous tools (Fessler, Holbrook & Snyder, 2012). These findings point to a tendency for men to overestimate a rival's dominance in situations where they stand a greater chance of losing, thus potentially protecting them from status loss or injury.

Interestingly, just as situational disadvantages seem to increase perceptions of other's dominance, situational advantages seem to decrease dominance perceptions. One study reports, that men who have allies rated single opponents as far less physically dominant (smaller and less muscular) than men who were alone without coalitional support (Fessler & Holbrook, 2013b).

1.5.2.2 Environmental factors

As well as situational variability, there is evidence that men's dominance perceptions of potential rivals is sensitive to other environmental information too. The sex ratio (ratio of males to females) of an environment is one factor believed to influence intrasexual competition in many species (Clutton-Brock, 2007; Mitani, Gros-Louis & Richards, 1996; Monteiro, Vieira & Lyons, 2013), and in an experimentally manipulated female biased sex ratio population, men show greater sensitivity to cues of dominance in other men (Watkins, DeBruine, Feinberg & Jones, 2013). This is perhaps due to the increase in violent confrontations between men in regions with female-biased sex ratios (Barber, 2000; 2009; 2011) (reasons for this are discussed later in Section 1.6.2).

Social learning (the process of learning through observation and imitation), is an important part of development and social interaction in both humans and non-human primates (Bono et al., 2018; Castro & Toro, 2004; Whiten, 2000). People often look to others to gauge an appropriate response to novel situations, and the same is also true when presented with new people. Research has shown that both men and women's judgements of attractiveness can be influenced by social learning from peers, such that potential mates appear more attractive if we have observed peers reacting positively towards them (Hill & Buss, 2008; Jones et al., 2007; Little et al., 2008). This kind of learning based social assessment can be useful if peers have access to information we do not. Considering that observable physical cues of dominance may not always be reliable or honest signals (discusses earlier in Section 1.3.6), it may be beneficial to moderate our assessments of dominance based on the reactions of peers who may have more experience. Consequently, men rate the dominance of male aggressors higher when they observe other peer responders reacting fearfully or intimidated, than when they observe peer responders reacting aggressively themselves (Jones et al., 2011), thus indicating that men will evaluate the reactions of other peers in the environment when assessing the dominance of potential rivals.

1.5.2.3 Contextual factors

Considering that dominance perceptions appear to function (at least in part), to facilitate intrasexual competition between men, particularly with regards to access to mates (Puts, 2010), it is then perhaps not surprising that dominance perceptions seem sensitive to mating related contextual factors.

For example, men's perceptions of their own partners femininity affect their sensitivity to dominance cues in other men (Watkins et al., 2011). Considering men with dominant masculine faces tend to have stronger preferences for more feminine females as partners (Kandrick & DeBruine, 2012), and are more interested in short-term uncommitted relationships (Boothroyd et al., 2008; 2011), and people also perceive dominant looking men to be more promiscuous and interested in short term relationships (Boothroyd et al., 2007, Frederick & Haseslton, 2007; Kruger & Fitzgerald, 2011), combined with the fact that men tend to overestimate women's preferences for other high-dominance men (Kruger & Fitzgerald, 2011), it may be the case that men with more "valuable" partners are more sensitive to dominance cues in potential rivals, because of the perceived increased likelihood of direct competition.

Similarly, men who rated dominant looking masculine male faces as more attractive showed more jealousy towards these men, and showed greater resistance to hypothetically allowing these men to accompany their partners for a weekend (O'Connor & Feinberg, 2012). Also, when imagining a physically dominant man flirting with their partner, shorter men report more jealousy than taller men (Buunk, Park, Zurriaga, Klavina & Massar, 2008), perhaps due to their relative lack of physical dominance and decreased likelihood of success in direct competition. All this indicates a certain degree of context sensitivity to dominance when dealing with potential mating rivals.

The evidence presented in this section shows, that while more work is necessary for researchers to fully understand how individual differences may impact perception of other's dominance, there is already compelling evidence to suggest our perceptual system for assessing dominance is sensitive to a number of environmental, situational and contextual factors.

1.6 What influences dominance behaviour and competition?

This section will focus on highlighting some of the key factors that can influence dominance behaviour and male-male completion that will be explored in the later empirical chapters.

1.6.1 Hormonal factors influencing dominance and competition

While the promise of status and the benefits that confers may be the ultimate drive behind male-male competition, hormonal influences, particularly testosterone have often been proposed as a possible proximal explanation for variation in dominance and status seeking behavior we often observe.

Hormones can impact behaviours through various pathways. Hormones can have either direct effects (where the hormone acts directly on relevant receptors), or indirect effects (where the effects are mediated via other variables); additionally hormones can have either organizational effects (where hormones influence permanent changes at key stages of development), or activational effects (transient effects caused by variation of hormone levels in the bloodstream) (Barry & Owens, 2019).

1.6.1.1 Testosterone and development

Testosterone is the primary steroid hormone responsible for the development and maintenance of masculine phenotypical characteristics, and while found in females, it is produced in far greater quantities in males, as such it is often colloquially known as the "male hormone" (Barry & Owens, 2019). Testosterone is thought to influence male development differentially, at three key stages of life; at the perinatal stage, during adolescence at puberty, and in adulthood (Mazur & Booth, 1998).

During the perinatal stage (in utero and closely following birth), testosterone is believed to be responsible for masculinization of primary sexual physiology and the central nervous system, as well as influencing the development of hormone receptors (Mazur & Booth, 1998). As such it is believed that in later stages of development, testosterone will “activate” these predeveloped structures, so later *activational effects* are the result of interactions between current testosterone levels and the long-term *organizational effects* of perinatal exposure (Mazur & Booth, 1998).

Following the first few months after birth endogenous testosterone levels in males drop considerably, before rising again during puberty (Knorr, Beckmann, Bidlingmaier, & Helmig , 1974; Nottelmann, et al; 1987). During this time testosterone promotes male-typical pubertal development, for example; influencing facial and body hair production, increasing height and muscle mass, genital maturation, and deepening of the voice (Bribiescas, 2001; Hiort, 2002; Richmond & Rogol, 2007).

Following puberty testosterone production peaks on early adulthood before slowly declining with age (Dabbs, 1990). The precise role of testosterone in adulthood is debated in the literature and total consensus is hard to find, however the general notion posits that circulating testosterone levels are relevant to a variety of dominance related behaviours.

1.6.1.2 Testosterone and behaviour

There is convincing evidence of a direct link between testosterone and dominance and status related behaviours in many animal species (Archer, 2006; Wingfield et al., 1990; Wingfield, 2017). Evidence suggest that despite considerable interspecies variation, testosterone regularly acts to facilitate aggressive behaviours in males, specifically when competing for reproductive opportunities (Archer, 1988), with some arguing that the main function of testosterone is to promote reproductive efforts (Hau, 2007).

Much of the initial work on humans had focused primarily on aggressive behaviours (as opposed to more general dominance or status seeking behaviours). Cumulatively however, these studies overall suggest, at best a weak correlation between testosterone and aggression (r = 0.08) (Archer et al., 2005). This would indicate that any behavioural effects of testosterone are likely to be more nuanced, than a simple direct correlation between testosterone levels and aggression.

Given this overall weak correlation of testosterone with aggression, research has shifted towards understanding why might this correlation be so weak, what other possible behavioural paths could testosterone be acting through to promote dominance, and under which conditions this may or may not happen.

1.6.1.3 Challenge Hypothesis

Although initially conceived to account for testosterone variation in seasonally reproducing birds (Wingfield et al., 1990; Wingfield et al., 2006), the challenge hypothesis, has been applied to many other animal species (Hirschenhauser & Oliveira, 2006), including primates (Muller, 2017). A reformulation of the challenge hypothesis has been proposed to apply to humans (Archer, 2006). The basic principles of the challenge hypothesis state that testosterone concentrations will rise in response to cues of competition or status challenges, in order to prepare the individual for competitive or aggressive interactions. It is thought that these surges in testosterone are more adaptive than permanently high levels, since dominant and aggressive behaviours increase the chance of injury (which are better avoided when not necessary), and elevated testosterone may also suppress immune system (Foo et al., 2017) and reduce parental care (Goymann & Flores Dávila, 2017), thus reducing overall fitness. As such, it should be testosterone reactivity (changes in concentrations), rather than baseline testosterone levels that is of theoretical interest. This could help to explain the relatively weak associations noted earlier, indeed newer models of this relationship deemphasize baseline testosterone, instead noting acute changes in testosterone more reliably map variation in human aggression (Carre & Olmstead, 2015). Of course, direct aggression is not the only means of promoting dominance and attaining status.

1.6.1.4 Behavioural paths

Human behaviour is often more complex than most animal models can account for, specifically human status challenges are not always resolved through physical violence and often can take purely psychological or even economic forms (Eisenegger, Haushofer, & Fehr, 2011). As such, testosterone may act to enhance dominance and status, not directly through aggression but by influencing status-relevant social behaviours; e.g. mediating approach-avoidance behaviours, and willingness to engage in intrasexual competition.

Research generally supports this interpretation of testosterone’s role in status-relevant social interactions, for example, salivary testosterone levels are seen to track with attentional vigilance to angry faces (van Honk et al., 1999). Additionally, testosterone administration increased cardiac reactivity (van Honk et al., 2001), as well as amygdala activity (Bos, van Honk, Ramsey, Stein, & Hermans, 2013; Derntl et al., 2009; Goetz et al., 2014; Wingen et al., 2009), in response to angry faces. This suggests that testosterone can act to increase awareness to potential threats and potential status challenges.

It has been proposed that prolonged staring is intended as signals of dominance and gaze-aversion as a signal of submission in both humans and non-human primates, as a way of establishing and maintaining status hierarchies without the need for unnecessary physical aggression (Mazur, 1985; Mazur & Booth, 1998). In line with this model of social gaze behaviour, individuals scoring high on dominance motivations show more prolonged gaze towards angry faces compared to those who scored lower (Terburg, Hooiveld, Aarts, Kenemans, & van Honk, 2011). This suggests that persistent gaze (or reluctance to avert gaze) is a dominance behaviour intended to prevent status loss from potential challenges.

There is now a growing body of evidence linking testosterone with these gaze behaviours. Testosterone administration studies find that exogenous testosterone promotes prolonged eye gaze towards angry faces even outside of consciousness awareness (Terburg, Aarts, & van Honk, 2012), and can reduce submissive eye-gaze aversion in socially anxious individuals (Enter, Terburg, Harrewijn, Spinhoven, & Roelofs, 2012; Terburg et al 2016). This would indicate that testosterone can help indirectly to establish and maintain status hierarchies in social interactions.

When presented with a potential status challenge, individuals can choose to approach the threat in an attempt to maintain dominance, or choose avoidance as a signal of submissiveness (Terberg & van Honk, 2013), and testosterone appears to play an important role in this approach-avoidance process. Evidence from single dose administration studies indicates testosterone can subdue preconscious fear responses (Hermans, Putman, Baas, Koppeschaar, & van Honk, 2006; van Honk, Peper & Schutter, 2005), as well as boost perceptions of one's own physical dominance (Welling at al. 2016), essentially reducing feelings of vulnerability. Similar administration studies also indicate testosterones role in reducing threat avoidance and promoting approach (Enter, Spinhoven, & Roelofs, 2014), decreasing personal distance preference (Wagels, Radke, Goerlich, Habel, & Votinov, 2017), and that this action seems to operate by increasing amygdala reactivity (Radke et al., 2015).

Interestingly testosterone may also act as an analgesic, apparently reducing perceptions of pain in both women (Bartley et al., 2015), and men (Basaria et al., 2015). Thus taken together the evidence suggests that testosterone acts to promote dominance and aids intrasexual competition by increasing awareness to social threats and potential status challenges, prolonging your engagement with these threats and biasing you towards approaching them, as well as potentially providing protective effects should physical competition arise.

There is also more direct evidence for testosterones role in competitive interactions, with research suggesting a direct link to an individual's willingness to compete. For example, a recent study finds that baseline testosterone levels were positively correlated with men's decisions to compete even excluding spite motivations (i.e. competing to boost one's own status rather than to just decrease an opponent's status) (Eisenegger et al., 2017). In addition to this baseline effect, hormone fluctuations can also influence willingness to compete, such that men who's testosterone levels increased following competition were more likely to choose to compete again, than those men who's testosterone did not increase (Carré & McCormick, 2008b), and the extent of this post competition increase was also positively correlated with subsequent willingness to compete (Carré, Putnam, & McCormick, 2009, Mehta & Josephs, 2006).

1.6.1.5 Context and mediating factors

While the evidence presented so far may give the impression that testosterone's role in intrasexual competition is fairly clear, the results across the literature however, are not always consistent and even when they are effect sizes are often relatively small (for more in depth reviews see, Casto & Edwards, 2016; Geniole & Carré, 2018; Ziliolo & Bird, 2017). In order to help understand some of these inconsistencies, researchers have been working to identify the kinds of contexts in which testosterone will effect dominance and status related behaviour, and what other potential mediating factors there might be.

For example, while it was noted earlier that there was an overall weak correlation between testosterone and aggression (r = 0.08) (Archer et al., 2005), recent work suggests that exogenous testosterone can increase aggressive behaviours in impulsive men, or men who already exhibit high levels of trait dominance (Carré at al., 2017). Similarly baseline testosterone levels positively correlated with dominant behaviour in a mating contest, but only in men who scored highly on self-reported dominance, this association was not observed in men who scored low on these self-reports (Slatcher, Mehta, & Josephs, 2011). Another study found that following a victory in competition, subsequent aggressive responses was only predicted by changes in testosterone for men who scored relatively highly on trait dominance (Carré et al., 2009). There is also some evidence suggesting that the effect of testosterone change on aggressive behaviour, is moderated by self-construal, such that there is a stronger positive association in men who are independent over men who are more interdependent (Welker et al., 2017). These findings suggest that testosterone does not affect all individuals equally, but rather may act to boost and maintain competitiveness in men who are particularly concerned with status-seeking and standing out.

Dominance and independence are not the only trait factors that have been found to mediate the effects of testosterone. Other research has also found that competition induced testosterone increases were positively associated with subsequent aggressive behaviours, but only in men scoring relatively low in trait anxiety (Norman et al., 2015). This would indicate that a desire for status alone cannot fully explain testosterone effects, if this can be handicapped by other conflicting psychological traits as well.

Importantly, psychological traits are not the only mediating factors on testosterone effects. The challenge hypothesis discussed earlier, posits that testosterone should increase in response to cues of competition, the biosocial model of status (Mazur, 1985; Mazur & Booth, 1998), is conceptually similar to the challenge hypothesis, except here testosterone response to competition is not universal but rather it is dependent on the contest outcome. In this model; winners should experience an increase in testosterone levels in order to promote and facilitate further competitive behaviours, whereas losers should experience a decrease in testosterone in order to minimize subsequent competition where further status losses may ensue, this is termed the “winner-loser effect”. When it comes to physical competition (i.e. sports), there is substantial support for the prediction that winners experience an increase in testosterone levels, however there is also evidence that losing can lead to increases as well as decreases in testosterone levels, and when it comes to non-athletic competitions the results can be even more mixed (see; Casto & Edwards, 2016 for review). Methodological issues may partially explain this inconsistency (such as collecting post competition samples too early i.e. immediately after the contest, rather than delayed 20-45 mins after contest), yet it is also possible there are other mediating factors too.

Contextual factors; such as the belief that the outcome was either due to skill or due to chance (van Anders & Watson, 2007), or even opponent characteristics like their self-efficacy (van der Meij et al., 2010), or aggressiveness (Carré, Gilchrist, Morrissey, & McCormick, 2010), can moderate the strength of this testosterone response to competition.

There is even some evidence that during competitions where the outcomes are very close (i.e. only-just won or only-just lost), a complete inversion of the winner-loser effect can be see, such that winners showed decreased testosterone relative to losers (Zilioli, Mehta & Watson, 2014). It was argued that this pattern might be the result of the close outcomes creating an unstable status hierarchy, where close winners are in a precarious position of potentially losing their status (thus further competition would be risky), but close losers may feel they have the ability to “grab” status with another opportunity (Zilioli et al., 2014).This would appear to be supported by other work investigating the effects of multiple competitions. Here consecutive losses (establishing a stable hierarchy) resulted in a steep decline in testosterone, but unstable status hierarchies (a combination of a win and a loss) resulted in a boost in testosterone, even more than consecutive victories (Zilioli & Watson, 2014). This formulation of the winner-loser effect would help to explain why in some cases an increase in testosterone is seen after losses, and also why other research had noted that men who’s testosterone increased after a loss were more likely to choose to compete again, than men who’s testosterone decreased after a loss (Mehta & Josephs, 2006), as well as why testosterone increase following a victory only predicted subsequent decisions to compete again if the victory was decisive and not a close victory (Mehta, Snyder, Knight, & Lasseter, 2015).

It would appear then that testosterones response to competition and influence on behaviour, is heavily moderated by a variety of factors including; individual difference in psychological factors (like trait dominance), as well as contextual factors (like hierarchy stability), there is also the possibility of additional physiological mediators too. One possible mediating factor that has gained a lot of interest in the literature is the hormone cortisol

1.6.1.6 Dual Hormone Hypothesis

The possibility that testosterone may interact with other hormones in order to influence dominance and competitive behaviours has been proposed as well. Specifically, the interaction between testosterone and glucocorticoids (namely, cortisol in humans) have gained considerable attention in the literature of the decades. There is reason to believe that cortisol (often considered the “stress hormone”) may play a role in dominance and competitive behaviours. Cortisol is released by the hypothalamic-pituitary-adrenal (HPA) axis, notably, it’s released in response to stress (Dickerson & Kemeny, 2004), and it acts to mediate many of the body’s physiological responses to stress (McEwan, 2019). It has been well established that stress has a central role in the formation and maintenance of social hierarchies and competitive interactions in both human and non-human primates (Sapolsky, 2004, 2005). There is also physiological evidence to suggest a relationship between testosterone and cortisol, testosterone is the end-product of the hypothalamic-pituitary-gonadal (HPG) axis, just as cortisol is the end product of the HPA axis, and there is evidence that these axes may actively modulate each other (Burnstein, Maiorino, Dai & Cameron, 1995; Chen, Wang, Yu, Liu & Pearce, 1997; Viau, 2002), although the exact mode of this modulation is still debated (Grebe, et al., 2019).

The dual hormone hypothesis (Mehta & Josephs, 2010) proposes that testosterone and cortisol interact with each other to influence dominance and status relevant behaviours. Specifically, the hypothesis predicts that testosterone will act to facilitate and enhance status relevant behaviours only when cortisol levels are low. This would mean that high levels of testosterone would only influence dominance and competitive behaviours in men who were not stressed, or at least able to mediate physiological responses to stressors.

Overall, the evidence for the dual hormone hypothesis is relatively mixed (see Casto & Edwards, 2016; and Grebe et al., 2019 for comprehensive reviews). A recent meta-analysis of the current literature on the dual hormone hypothesis provides some support for hypothesis' predictions, indicating the effect of the hormone interaction on status relevant behaviour was significant but not particularly strong ($r = -.61$) (Dekkers et al., 2019). The authors raise concerns however, with inconsistencies in statistical analysis methodologies and potential publication bias, citing these as a need for pre-registered hormone studies (Dekkers et al., 2019). While proponents of the dual hormone hypothesis do acknowledge the relative heterogeneity of results within the literature, they cite multiple potential causes for this disparity, including numerous mediating factors (e.g. trait dominance, contextual factors, sex and gender differences), methodological variations between studies, relatively low power of many studies and high variability in choice of statistical analysis (Knight, Sarkar, Prasad & Mehta, 2020), further suggesting a need for well powered, transparent, pre-registered studies to further investigate hormonal effects on dominance and status relevant behaviours.

1.6.2 Environmental factors influencing dominance and competition

One important environmental factor that is often thought to influence dominance interactions and male-male competition is the relative population sex ratio (number of males in a population relative to number of females). Specifically, it is assumed that when you have more males in an environment you will have increased rates of male-male competition over mates and therefore dominance will play an even more important role in men's reproductive success. This section will look at the theoretical underpinnings of this assumption and examine the evidence for this effect.

1.6.2.1 Sexual selection theories and sex ratio effects on competition

Traditional theories about the operation of sexual selection, provide general predictions about varying levels of within-sex competition as it relates to a population's sex ratio. Theories based on parental investment (Trivers, 1972), propose that the sex that invests more (i.e. more time, energy, proportion of viable gametes) in producing and rising offspring, have an overall reduced potential reproductive rate (Clutton-Brock & Vincent, 1991), this should make them more "choosey" when it comes to mating decisions, meaning the less-investing sex should have to compete more for "access" to the higher-investing sex. In addition, this increased time investment creates a skew in the operational sex ratio (the ratio of sexually active and available males, to sexually active and available females) (Emlen & Oring, 1977). This means the reduced availability of the higher-investing sex becomes a limiting factor on the reproductive success of the less-investing sex, which should in-turn lead to further increased competition among the less-investing sex. In humans, females have higher parental investment than males and as such men should have higher levels of intrasexual competition. This model would then predict that any shift in the actual population sex ratio would alter the relative levels of intrasexual competition, specifically, if a population sex ratio were to be more male-biased, we would expect to see even greater levels of competition in the now abundant sex.

1.6.2.2 Mating markets theory and sex ratio effects on competition

It is often assumed that in male biased populations you should see an increase in rates of violence, however this is not necessarily always the case (Schacht, Rauch & Borgerhoff Mulder, 2014). This assumption is generally based on three points. First, because men are generally more violent and aggressive than women (Archer, 2004; Messner & Sampson, 1991), more men would lead to more violence by a simple fact of increased numbers. Second, unpaired men are more likely than paired men to engage in violence, and when there is a male-biased population, there will be a surplus of unpaired men (Hesketh & Xing, 2006; Hudson & Den Boer, 2002), therefore a male-biased population has a greater proportion of “high-risk” men, that would lead to more violence. Finally, while sexual selection theories would predict an increase in male-male competition in male-based populations, it is often incorrectly assumed that this competition needs to direct and physically violent (Schacht et al., 2014).

In fact, evidence that male-biased sex ratio populations have higher rates of crime is mixed and complex at best, with some studies finding higher rates of violence in male-biased populations (Barber, 2003; Edlund, Li, Yi & Zhang, 2007; Oldenburg, 1992), and other studies finding higher rates of violence in female-biased populations (Barber, 2000, 2009, 2011; Schacht, Tharp & Smith, 2016).

Mating markets theories (Guttentag & Secord, 1983) can provide insight in explaining these conflicting results. Mating markets theories generally assert that in a population, the rarer sex holds greater bargaining power in relationship dynamics, by virtue of having more potential alternative mates, affording them greater ability to pursue their preferred relationship goals, and the more abundant sex must alter their behaviour and expectations to fall in line with the preference of the rarer sex in order to secure a mate. Thus in female-biased populations (when men are rare), men are more likely to pursue short term relationship and be relatively uncommitted, by contrast in male-biased populations (where women are rare), women should be able to choose more committed men, and pursue longer term relationships.

Integrating mating market theories’ predictions, with those of traditional sexual selection theories, can help explain patterning of behaviour observed across varying population sex ratios. For example, although male-male competition may increase in male-biased populations, it appears that this competition is often indirect (non-violent) and primarily focused on accruing economic resources and displaying status (Barber, 2009, Del Giudice, 2012; Griskevicius, Tybur, Ackerman, Delton, Robertson & White, 2012), while demonstrating willingness to commit (Kandrick, Jones & DeBruine, 2015; Schmitt, 2005). Generally speaking, in male-biased populations, men tend to show greater levels of relationship and mating investment (Schacht & Borgerhoff Mulder, 2015), and be less willing to engage in uncommitted sexual relationships (Kandrick et al., 2015; Schacht & Kramer, 2016). Also, in male-biased populations, there tends to be lower rates of teen pregnancies (Barber, 2001), and men are more likely to be in married and committed relationship (Schacht & Kramer, 2016). In addition, it's been noted that the positive effect of socioeconomic status on male marriage status increases in regions with male-biased populations.

Conversely, in female-biased populations relationship commitment tends to decrease and rates of promiscuity increase (Barber, 2009, 2011; Schmitt, 2005), there is also increases in rates if sexually risky behaviour (Green et al., 2012), and men are less likely to be married, instead pursuing short term mating opportunities (Kruger, 2009; Kruger & Schlemmer, 2009). It is this increase in uncommitted sexual relationships and sexual promiscuity that is thought to increase the rates of direct violent competition between men (Del Giudice, 2012; Schacht et al., 2014). So in male-biased populations, where women have greater choice in potential mates, women's preferences for committed, reliable and stable men, may actively reduce the instances of direct violent male-male competition, where as in female-biased populations, where men have more freedom to pursue uncommitted short-term relationships, there is greater opportunity for increased direct (violent) male-male competition, which would result in the observed overall increase in rates of violence in female-biased populations (Barber, 2000, 2009, 2011; Schacht et al., 2016).

It must be acknowledged that female choice and autonomy play an important role in this process, as well as other factors such as relative likelihood and severity of punishment for males who engage in violent or coercive behaviour (Schacht et al., 2014). For instance, in geographic regions where women have relatively low autonomy or where men are unlikely to face severe punishment, you may expect to see an increase in violent behaviour and direct physical competition even if there is a male-biased sex ratio. This may in part explain the variability in results on sex-ratio and rates of violence observed in the literature (Schacht et al, 2014, 2016).

1.7 The Current Studies

This thesis will present 3 empirical chapters investigating factors that influence male intrasexual competition, as well as the factors that influence dominance perceptions. The first empirical chapter investigates the possible effects of testosterone and cortisol on male intrasexual competitiveness, using a longitudinal design to measure natural changes in men's hormone levels over time. The next empirical chapter investigates the effects of environmental factors, specifically the adult sex ratio of the local population, on sensitivity to facial cues of dominance, using a large sample from US states. The final empirical chapter presents a study investigating the effects of head-tilt on perceptions of dominance and trustworthiness, and whether or not these perceptions have downstream effects for judgments of context dependent leadership ability.

Chapter 2 No evidence for associations between men's salivary testosterone and responses on the Intrasexual Competitiveness Scale

Preface

This chapter is adapted from:

Torrance, J. S., Hahn, A. C., Kandrik, M., DeBruine, L. M., & Jones, B. C. (2018). No evidence for associations between men's salivary testosterone and responses on the Intrasexual Competitiveness Scale. Adaptive human behavior and physiology, 4(3), 321-327.

Abstract

Many previous studies have investigated relationships between men's competitiveness and testosterone. For example, the extent of changes in men's testosterone levels following a competitive task predicts the likelihood of them choosing to compete again. Recent work investigating whether individual differences in men's testosterone levels predict individual differences in their competitiveness have produced mixed results. Consequently, we investigated whether men's (N=59) scores on the Intrasexual Competitiveness Scale were related to either within-subject changes or between-subject differences in men's testosterone levels. Men's responses on the Intrasexual Competitiveness Scale did not appear to track within-subject changes in testosterone. By contrast with one recent study, men's Intrasexual Competitiveness Scale also did not appear to be related to individual differences in testosterone. Thus, our results present no evidence for associations between men's testosterone and their responses on the Intrasexual Competitiveness Scale.

2.1 Introduction

Results of several studies suggest that increases in men's testosterone levels due to competitive tasks are associated with increases in their intrasexual competitiveness (reviewed in Zilioli & Bird, 2017). For example, men whose testosterone levels increased after competing against another man on a laboratory task (the Point Subtraction Aggression Paradigm, see Geniole et al., 2017 for a review of this method) were more likely to choose to compete again than were men whose testosterone levels did not increase after competing on the initial task (Carré & McCormick, 2008a). Similarly, the extent to which men's testosterone increases after losing a competitive task against another man is positively related to their willingness to compete again (Carré et al., 2009; Mehta & Josephs, 2006). These effects can be modulated by the decisiveness of the victory (Mehta et al., 2015a) and/or men's aggressiveness (Carré & McCormick, 2008a).

More recently, it has been hypothesized that some associations between testosterone and competition-related behaviors are moderated by cortisol (see Mehta & Prasad, 2015, for a discussion of evidence for this "Dual Hormone Hypothesis"). For example, Mehta et al. (2015b) found that behavior in a competitive bargaining game was predicted by the interaction between changes in testosterone and cortisol in a sample of men and women. When cortisol decreased, testosterone increases led to greater earnings (Mehta et al., 2015b). By contrast, when cortisol increased, testosterone increases led to poorer earnings (Mehta et al., 2015b). Given these results, failure to consider the moderating role of cortisol could explain null and negative results for relationships between testosterone and competition-related behaviors in some studies (Mehta & Prasad, 2015).

The studies described above investigated effects of competition-induced changes in testosterone on competitiveness. Other studies have investigated putative correlations between individual differences in men's competitiveness and testosterone. Results from these studies have been mixed, however. Apicella et al. (2011) found no evidence that men with higher testosterone levels showed greater competitiveness (measured by rate of self-selection into a competitive setting). Arnocky et al. (2018) recently reported that men with higher testosterone scored higher on Buunk and Fisher's (2009) Intrasexual Competitiveness Scale. Buunk and Fisher (2009) defined intrasexual competitiveness as viewing “confrontations with same-sex individuals, especially in the context of contact with the opposite-sex, in competitive terms”.

The aim of the current study was to investigate whether within-subject changes in reported intrasexual competitiveness tracked within-subject changes in men’s testosterone levels. Since we collected these data, Arnocky et al. (2018) published their article. Consequently, we also used our data to test whether men reporting greater intrasexual competitiveness would have higher testosterone levels. Like Arnocky et al. (2018), we assessed intrasexual competitiveness using Buunk and Fisher's (2009) Intrasexual Competitiveness Scale.

2.2 Methods

2.2.1 Participants

Fifty-nine heterosexual men participated in the study (mean age=22.06 years, SD=3.24 years). None of these men were currently taking any form of hormonal supplement or had taken any form of hormonal supplement in the 90 days prior to participation. Participants took part in the study as part of a larger project investigating hormonal correlates of voice and face perception (Kandrik et al., 2016, 2017).

2.2.2 Procedure

Participants completed up to five weekly test sessions, which took place between 2pm and 5pm to minimize diurnal variation in hormone levels (Papacosta & Nassis, 2011). Fifty-five of the participants completed more than one test session, with forty-seven of the participants completing all five test sessions.

During each test session, participants provided a saliva sample via the passive drool method (Papacosta & Nassis, 2011). Participants were instructed to avoid consuming alcohol and coffee in the 12 hours prior to participation and to avoid eating, smoking, drinking, chewing gum, or brushing their teeth in the 60 minutes prior to participation.

In each test session, participants also completed Buunk and Fisher's (2009) Intrasexual Competitiveness Scale (M=2.95, SD=0.98; reliability: Cronbach's alpha=0.86). The Intrasexual Competitiveness Scale is a 12-item questionnaire on which participants indicate how applicable each item is to them using a one (not at all applicable) to seven (completely applicable) scale. Example items include, "I want to be just a little better than other men" and "I tend to look for negative characteristics in men who are very successful". Scores on individual items are averaged to produce an overall score. Higher scores on this scale indicate greater intrasexual competitiveness. The order in which participants provided saliva samples and completed the questionnaire was fully randomized. Like Arnocky et al. (2018), these data were collected as part of a larger project. The project was approved by University of Glasgow's Psychology Ethics Committee.

2.2.3 Assays

Saliva samples were immediately frozen and stored at -32°C until being shipped, on dry ice, to the Salimetrics Lab (Suffolk, UK) for analysis. There they were assayed using the Salivary Testosterone Enzyme Immunoassay Kit 1-2402 (M = 177.5 pg/mL, SD = 42.2 pg/mL, sensitivity<1.0 pg/mL, intra-assay CV=4.60%, inter-assay CV=9.83%) and Salivary Cortisol Enzyme Immunoassay Kit 1-3002 (M = 0.19 µg/dL, SD = 0.11 µg/dL, sensitivity<0.003 µg/dL, intra-assay CV=3.50%, inter-assay CV=5.08%).

Hormone levels more than three standard deviations from the sample mean for that hormone or where Salimetrics indicated levels were outside the sensitivity range of the relevant ELISA were excluded from the dataset (<1% of hormone measures were excluded for these reasons; one cortisol value and four testosterone values). The descriptive statistics given above do not include these excluded values.

For current hormone levels, values for each hormone were centered on their subject-specific means to isolate effects of within-subject changes in hormones. They were then scaled so the majority of the distribution for each hormone varied from -.5 to .5 to facilitate calculations in the linear mixed models. To calculate average hormone levels, the average value for each hormone across test sessions was calculated for each man. These values were then centered on their grand means and scaled so the majority of the distribution for each hormone varied from -.5 to .5. Plots of these values are given in our Supplemental Materials and show no evidence of skew.

2.2.4 Analyses

We used a linear mixed model to test for possible effects of hormone levels on reported intrasexual competitiveness. Analyses were conducted using R version 3.3.2 (R Core Team, 2016), with lme4 version 1.1-13 (Bates et al., 2014) and lmerTest version 2.0-33 (Kuznetsova et al., 2013). Data files and analysis scripts are publicly available at https://osf.io/abqun/.

2.3 Results

The dependent variable was Intrasexual Competitiveness Scale score. Predictors were current testosterone, current cortisol, and their interaction, and average testosterone, average cortisol, and their interaction. No covariates were included in the model. Random slopes were specified maximally following Barr et al. (2013) and Barr (2013). Full model specifications and full results for each analysis are given in our Supplemental Information. Results are summarized in Table 1. There were no significant effects.

	Estimate	Std. Error	df	t	p
Current Testosterone	0.053	0.227	38.280	0.235	0.815
Current Cortisol	0.094	0.216	34.620	0.434	0.667
Current Testosterone x Current Cortisol	2.565	1.566	162.41	1.637	0.103
Average Testosterone	0.389	0.647	60.290	0.601	0.550
Average Cortisol	-0.221	0.865	61.430	-0.256	0.799
Average Testosterone x Average Cortisol	-4.421	3.029	59.540	-1.460	0.150

Table 1. Summary of results for men's hormone levels and reported intrasexual competitiveness.

We also collected and analyzed anxiety questionnaire data. These analyses are reported in the Supplemental Materials and show that men reported greater anxiety in test sessions where their cortisol levels were high.

2.4 Discussion

Our analysis of men's reported intrasexual competitiveness revealed no significant relationships between reported intrasexual competitiveness and men's hormone levels. We found no evidence that within-subject changes in men's reported intrasexual competitiveness tracked changes in men's current testosterone, current cortisol, or their interaction. We also found no evidence that between-subject differences in reported intrasexual competitiveness were related to men's average testosterone, average cortisol, or their interaction. These latter null results are noteworthy because they do not replicate Arnocky et al's (2018) recent finding of a positive correlations between reported intrasexual competitiveness and testosterone level.

There are several limitations to our study that should be acknowledged. First, although previous studies have detected within-subject changes in reported intrasexual competitiveness using the Intrasexual Competitiveness Scale (Buunk & Massar, 2012; Cobey et al., 2013; Hahn et al., 2016), it is possible that it is better suited to detecting hormone-linked individual differences than it is to detecting hormone-linked within-individual differences. Further work investigating changes in competitiveness using other methods may yet reveal hormone-linked changes not apparent in the current study. Second, although we do not replicate Arnocky et al's (2018) results for individual differences in testosterone and intrasexual competitiveness, they had a larger sample that we did (92 men vs 59 men).

Previous research has suggested that women's intrasexual competitiveness increases when their testosterone levels are high (Cobey et al., 2013; Hahn et al., 2016). By contrast, we found no evidence that intrasexual competitiveness tracked changes in men's testosterone levels. These two studies (Cobey et al., 2013; Hahn et al., 2016) used the same Intrasexual Competitiveness Scale as our current study. Further work is needed to establish whether the differences in these results reflect a sex difference in the effects of testosterone on intrasexual competitiveness, a false negative in the current study, or false positives in the studies of women's intrasexual competitiveness. Nonetheless, our null results provide little support for the Challenge Hypothesis of testosterone and competition in men.

In conclusion, we found no evidence that men with higher testosterone levels scored higher on the Intrasexual Competitiveness Scale. Moreover, because we also found no evidence that within-subject changes in scores on this measure tracked changes in testosterone, it is unlikely that the null result is due to testosterone-linked within-subject changes in responses obscuring the between-subject relationship. Of course, these results may not necessarily generalize to other measures of competition in men, which may be related to testosterone in other ways. Further work using a wider range of competition measures would clarify this issue.

Chapter 3 Does adult sex ratio predict regional variation in facial dominance perceptions? Evidence from an analysis of US states

Preface

This chapter is adapted from:

Torrance, J. S., Kandrik, M., Lee, A. J., DeBruine, L. M., & Jones, B. C. (2018). Does Adult Sex Ratio Predict Regional Variation in Facial Dominance Perceptions? Evidence From an Analysis of US States. Evolutionary Psychology, 16(2), 1474704918776748.

Abstract

When the adult sex ratio of the local population is biased towards women, men face greater costs due to increased direct intrasexual competition. In order to mitigate these costs, men may be more attuned to cues of other men's physical dominance under these conditions. Consequently, we investigated the relationships between the extent to which people (N=3586) ascribed high dominance to masculinized versus feminized faces and variation in adult sex ratio across US states. Linear mixed models showed that masculinized faces were perceived as more dominant than feminized faces, particularly for judgments of men's facial dominance. Dominance perceptions were weakly related to adult sex ratio and this relationship was not moderated by face sex, participant sex, or their interaction. Thus, our results suggest that dominance perceptions are relatively unaffected by broad geographical differences in adult sex ratios.

3.1 Introduction

By contrast with previous assumptions, recent research suggests that direct (i.e., violent) competition among men is greater in geographic regions where the adult sex ratio of the local population is more female biased (Schacht et al., 2014 and Schacht et al., 2016). This relationship is thought to occur because the rarer sex, having greater "market value", is better positioned to pursue their sex-typical optimal mating strategy (Pollet & Nettle, 2008). Consequently, in male-biased populations, women have more choice, causing men to invest more effort in indirect competitive strategies that will increase their appeal as long-term partners (e.g., strategies aimed at increasing socioeconomic status and demonstrating willingness to commit to long-term relationships, e.g., Griskevicius et al., 2011; Schacht & Kramer, 2016). Conversely, in female-biased populations, men have more choice and, as such, are better able to pursue short-term mating strategies (Schacht & Borgerhoff Mulder, 2015) and engage in direct (i.e., violent) physical competition while maintaining their appeal as short-term partners to potential mates (Barber, 2009; Schacht et al, 2016).

In order to mitigate the potential costs of greater direct physical competition (e.g., increased risk of injury and/or loss of resources), men may be more attuned to cues of other men's physical dominance under these conditions. Such facultative responses could reduce the opportunity costs that might otherwise be incurred when the adult sex ratio of the local population is more male biased and direct physical competition among men is less intense.

In many non-human animals, sexually dimorphic physical characteristics play an important role in intra-sex conflicts and the formation of dominance hierarchies (reviewed in Emlen, 2008). In humans, several lines of evidence suggest that masculine facial characteristics play an important role in intrasexual competition (reviewed in Puts, 2010). For example, exaggerating male sex-typical characteristics in men's faces reliably increases their perceived dominance and strength (Jones et al., 2010; Perrett et al., 1998) and men with more masculine faces tend to be physically stronger (Fink et al., 2007; Windhager, Shaefer, & Fink, 2011). Masculine characteristics in men's faces might also act to directly protect against impact damage (Carrier & Morgan, 2015). Additionally, multiple studies have now demonstrated that men's faces contain valid cues to their threat potential (Doll et al., 2014; Han et al., 2017; Little, Třebický, Havlíček, Roberts, & Kleisner, 2015).

Since masculine facial characteristics appear to function primarily as a dominance cue (Puts, 2010) and there is greater direct physical competition among men in geographic regions with more female-biased adult sex ratios (Schacht et al., 2014; Schacht et al., 2016), men in geographic regions with more female-biased adult sex ratios may be more likely to ascribe high dominance to masculine men (i.e., be more attuned to cues of men's physical dominance). Such facultative responses could function to mitigate the costs of increased direct competition by allowing men in geographic regions where direct competition is most common to assess potential threats more thoroughly.

Women are thought to place a greater premium on physical dominance of potential mates when direct physical competition among men is higher (Brooks et al., 2011; Watkins et al., 2012), potentially because the benefits of dominance are increased and/or because the costs of aggression are decreased (Brooks et al., 2011). Consequently, women in regions with more female-biased adult sex ratios might also be more attuned to cues of men's physical dominance and therefore more likely to ascribe high dominance to masculine men. Consistent with this prediction, Watkins et al. (2012) reported that experimentally activating (i.e., priming) women's concerns about resource scarcity increased the extent to which they ascribed high dominance to masculine men. However, evidence that priming women with cues of male-male direct physical competition alters their preferences for masculine men is equivocal (Li et al., 2014; Little et al., 2013).

Following recommendations regarding statistical tests for regional differences in human behavior (Pollet et al., 2014), we used linear mixed models to take into account variation in dominance perceptions among individuals within each state (i.e., avoiding the problems associated with aggregating responses across individuals, see Pollet et al., 2014).

3.2 Methods

3.2.1 Participants

A total of 917 heterosexual men (mean age= 23.7 years, SD= 5.91 years) and 2669 heterosexual women (mean age= 22.1 years, SD= 4.90 years) participated in the online study (total N=3586, between the ages of 16 and 40). Online data collection has been used in many previous studies of regional differences in human behavior (DeBruine et al., 2010, 2011; Kandrik et al., 2015; Scott et al., 2014). Participants were recruited by following links from social bookmarking websites (e.g., stumbleupon.com) and were not compensated for participation. Participation took place between 2009 and 2012.

3.2.2 Face stimuli

Stimuli were masculinized and feminized versions of 20 male and 20 female faces from an image set that have been subsequently made publicly available (DeBruine & Jones, 2017).

First, male and female prototype (i.e., average) faces were manufactured using established computer graphic methods that have been widely used in studies of face perception (Tiddeman et al., 2001). Prototypes are composite images that are constructed by averaging the shape, color, and texture of a group of faces, such as male or female faces. These prototypes can then be used to transform images by calculating the vector differences in position between corresponding points on two prototype images and changing the position of the corresponding points on a third image by a given percentage of these vectors (see Tiddeman et al., 2001 for technical details). The male and female prototypes were each manufactured by averaging shape, color, and texture information from 20 faces.

Here, 50% of the linear differences in 2D shape between symmetrized versions of the male and female prototypes were added to or subtracted from face images of 20 young White male adults (age: M=20.3 years, SD=4.1) and 20 young White female adults (age: M=18.4 years, SD=0.7). This process creates masculinized and feminized versions of the individual face images that differ in sexual dimorphism of 2D shape and that are matched in other regards (e.g. identity, skin color and texture). Examples of masculinized and feminized versions of male and female faces are shown in Figure 1. Thus, 40 pairs of images were produced in total (each pair consisting of a masculinized and a feminized version of the same individual): 20 pairs of male face images and 20 pairs of female face images.

Figure 1. Examples of masculinized (left) and feminized (right) faces used in the study.

3.2.3 Procedure

Participants were shown the 40 pairs of face images (20 male and 20 female) and were asked to choose the face in each pair looked more dominant. Participants also indicated whether the more dominant face in each pair looked 'much more dominant', 'more dominant', 'somewhat more dominant', or 'slightly more dominant' than the other face in the pair. The order in which pairs of faces were shown was fully randomized for each participant and the side of the screen on which any particular image was shown was also randomized. This procedure has been used to assess variation in dominance perceptions in many previous studies (e.g., Watkins, Fraccaro et al., 2010).

Following previous studies of dominance perceptions (e.g., Watkins, Fraccaro et al., 2010), responses on the dominance perception test were coded using the following scale (which was centered on chance in the current study):

0.5 to 3.5: masculinized face rated 'slightly more dominant' (=0.5), 'somewhat more dominant' (=1.5), 'more dominant' (=2.5) or 'much more dominant' (=3.5) than feminized face.

-0.5 to -3.5: feminized face rated 'slightly more dominant' (=-0.5), 'somewhat more dominant' (=-1.5), 'more dominant' (=-2.5) or 'much more dominant' (=-3.5) than masculinized face.

3.2.4 Adult sex ratio

Following previous research on regional variation in behavior in the US (Kandrik et al. 2015), estimates of the adult sex ratio (total number of men aged between 15 and 49 years of age divided by the total number of women aged between 15 and 49 years of age) for each US state (plus Washington DC) were obtained from the 2010 US Census Bureau (American Community Survey, 2010; http://factfinder2.census.gov/). Higher values indicate a more male-biased adult sex ratio. Each participant's Internet Protocol (IP) address was used to determine their location. Note that this is relatively accurate at a state level but does not allow for more fine-grained analyses of location.

3.3 Results

We used linear mixed models to investigate the relationship between state-level differences in adult sex ratio and scores on the dominance perception test. Analyses were conducted using R version 3.3.2 (R Core Team, 2016), with lme4 version 1.1-12 (Bates et al., 2014) and lmerTest version 2.0-33 (Kuzenetsova et al., 2013). The dependent variable was scores on the dominance perception test (centered on chance). Independent variables were participant age (centered on mean for sample and scaled), participant sex (effect-coded as male=0.5 and female=-0.5), face sex (effect-coded as male=0.5 and female=-0.5), and the adult sex ratio for each state plus Washington DC (centered on mean for states and scaled). The model included participant age and all possible interactions among participant sex, face sex, and adult sex ratio. The model included random intercepts for each item (i.e., face), state, and participant (nested in state). Random slopes were specified maximally following recommendations by Barr et al. (2013) and Barr (2013). Simulations reported in those studies show that not including these random slopes increases false positive rates to unacceptably high levels. Formulae and the output of this analysis are given in the Supplemental Materials. Our data and analysis files are publicly available at https://osf.io/q46ye/.

	Estimate	Std. Error	df	t	p
Intercept	0.796	0.032	32.8	25.12	<.001
Rater Age	0.025	0.013	3562.4	1.90	0.058
Rater Sex	0.002	0.031	3579.9	0.06	0.953
Face Sex	0.846	0.015	3576.7	55.09	<.001
Adult Sex Ratio	-0.042	0.021	76.4	-1.94	0.056
Rater Sex x Face Sex	-0.006	0.032	26.0	-0.19	0.849
Rater Sex x ASR	-0.046	0.043	1976.7	-1.07	0.283
Face Sex x ASR	0.021	0.021	3583.8	1.00	0.319
Rater Sex x Face Sex x ASR	0.059	0.043	38.7	1.37	0.179

Table 2. Linear Mixed Model output

The intercept was significant (beta=0.80, t=25.1, p<.001), indicating that masculinized faces were judged to be more dominant than feminized faces (M=0.80, SD=1.60). There was also a significant effect of face sex (beta=0.85, t=55.1, p<.001), indicating that the effect of masculinity on dominance perceptions was larger for male (M=1.22, SD=1.46) than female faces (M=0.38, SD=1.62). The effect of masculinity on dominance perceptions tended to be larger in states with more female-biased sex ratios (see Figure 2), but this main effect of adult sex ratio (beta=-0.04, t=-1.94, p=.056), was not significant. The effect of masculinity on dominance perceptions tended to be larger among older participants, but this main effect of participant age was also not significant (beta=0.03, t=1.90, p=.058). No other effects were significant or near significant (all absolute beta < 0.06, all absolute t<1.37, all p>.17). It should be noted within the United States, Washington DC is an outlier on numerous factors including but not limited to adult sex ratio (0.91; mean for all states = 1.01, SD=0.03). Repeating this analysis with Washington DC excluded from the data set showed the same pattern of significant and near-significant results (see supplemental materials).

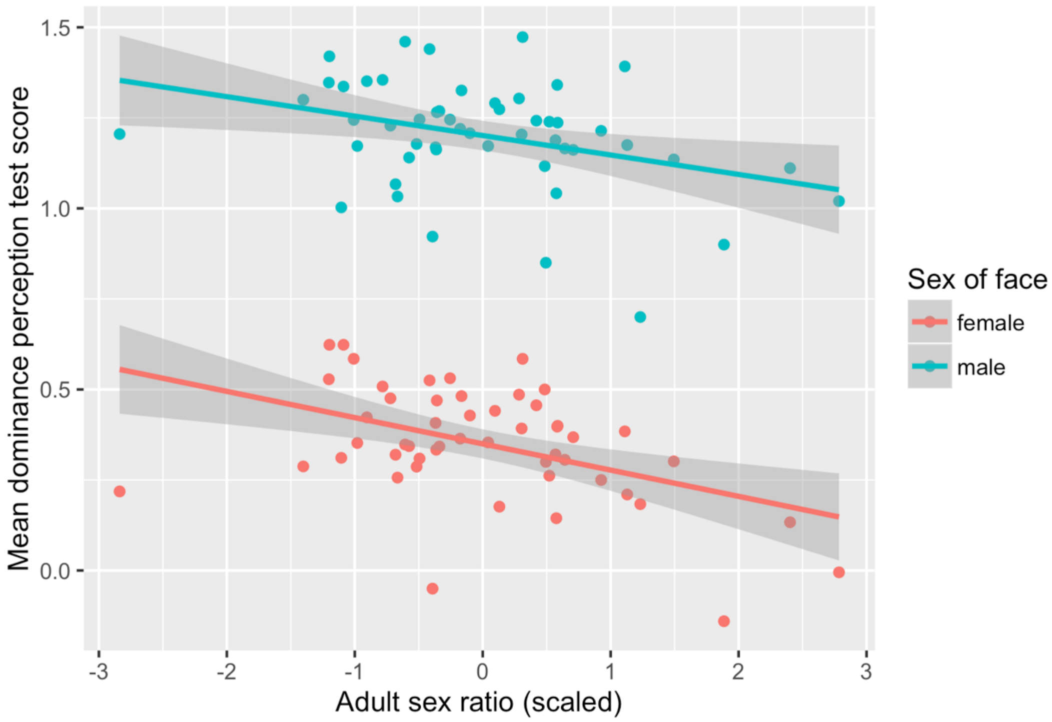

Figure 2. The relationship between adult sex ratio of US states and average scores on dominance perception test for men's and women's faces. On the y-axis, zero equals chance.

3.4 Discussion

Consistent with previous work on dominance perceptions of faces (e.g., Jones et al., 2010; Perrett et al., 1998), masculinized versions of faces were perceived as looking more dominant than feminized versions. Puts (2010) proposed that this tendency to ascribe high dominance to masculinized faces primarily reflects adaptations for identifying particularly formidable men who pose greater threat potential. Consistent with this proposal, we found that identical manipulations of sexually dimorphic aspects of facial morphology produced greater effects on dominance perceptions when applied to images of male faces than when applied to images of female faces.

Although the effect of masculinity on dominance perceptions tended to be larger in states with more female-biased sex ratios, this effect was both weak and non-significant. Thus, despite high power from our large sample size and linear mixed models, our results do not give clear support for the hypothesis that the extent to which people are attuned to facial cues of dominance varies with factors that could influence rates of direct competition, here adult sex ratio (Brooks et al., 2011; Watkins et al., 2012; see also Li et al., 2014). Controlling for other socioecological factors that predict regional variation in responses to facial sexual dimorphism (e.g., urbanization, Scott et al., 2014) may clarify the role of adult sex ratios in face perception. Indeed, since urbanization predicts responses to facial sexual dimorphism (Scott et al., 2014) and urbanization and adult sex ratio are sometimes correlated (e.g., Barber 2000), it remains unclear whether effects of urbanization on responses to sexual dimorphism are mediated by adult sex ratio, effects of adult sex ratio on responses to sexual dimorphism are mediated by urbanization, or urbanisation and adult sex ratio have independent effects on responses to sexual dimorphism[1].

Our results suggest that the tendency to ascribe high dominance to masculinized faces is relatively robust across the range of sex ratios tested in the current study. Of course, more fine-grained analyses (i.e., analyses examining smaller geographic regions) may yet reveal clearer evidence of a link between markers of the intensity of competition among men and dominance perceptions. Further work is needed to address this issue.

In conclusion, we show a large effect of sexually dimorphic facial morphology on dominance perceptions in a large US sample of men and women. The observed effect of facial morphology was particularly pronounced for dominance judgments of men’s faces and weakly negatively related to adult sex ratio. These results, together with those showing that Japanese and White UK participants ascribe high dominance to masculinized faces (Perrett et al., 1998), demonstrate robust effects of sexually dimorphic facial morphology on dominance perceptions.

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[1] We thank the Editor for raising this issue with us. We conducted an exploratory analysis, also suggested by the Editor (David Puts), to test whether a state-level measure of urbanization (from the 2010 census) predicted dominance perceptions in our data. This analysis showed no evidence for any significant effects of urbanization (see supplemental materials for details of this analysis and full results). Nonetheless, we agree this would be a potentially important issue to consider in other samples with a wider range of urbanization and/or adult sex ratios.

Chapter 4 Evidence head tilt has dissociable effects on dominance and trustworthiness judgments, but does have not category-contingent effects on hypothetical leadership judgments

Preface

This chapter is adapted from:

Torrance, J. S., Holzleitner, I. J., Lee, A. J., DeBruine, L. M., & Jones, B. C. (2020). Evidence Head Tilt Has Dissociable Effects on Dominance and Trustworthiness Judgments, But Does Not Have Category-Contingent Effects on Hypothetical Leadership Judgments. Perception, 49(2), 199-209.

Abstract

Previous research has found that physical characteristics in faces that influence perceptions of trustworthiness and dominance have context-contingent effects on leadership perceptions. People whose faces are perceived to be trustworthy are judged to be better leaders in peacetime contexts than wartime contexts. By contrast, people whose faces are perceived to be dominant are judged to be better leaders in wartime contexts than peacetime contexts. Here we tested for judgment-contingent (dominance versus trustworthiness) effects of head tilt (i.e., head-pitch rotation) on person perception and context-contingent (peacetime versus wartime) effects of head tilt on leadership judgments. Although we found that head tilt influenced judgments of trustworthiness and dominance (Study 1), head tilt did not influence leadership judgments (Study 2). Together, these results suggest that the context-contingent effects of physical characteristics on leadership judgments reported in previous work do not necessarily extend to head tilt, even though head tilt influences perceptions of trustworthiness and dominance.

4.1 Introduction

People make inferences about other people's dominance, trustworthiness, and other traits from facial cues (Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015). These inferences have direct effects on real world outcomes, such as decisions about who people choose to associate with and hire (Rhodes, 2006). Similarly, people make judgments about other people's leadership qualities from facial cues (Ballew & Todorov, 2007; Todorov, Mandisodza, Goren, & Hall, 2005). These judgments are made very rapidly (Ballew & Todorov, 2007; Todorov, Mandisodza, Goren, & Hall, 2005) and influence actual voting decisions (Little, Burriss, Jones, & Roberts, 2007; Todorov, Mandisodza, Goren, & Hall, 2005).

Facial judgments of leadership appear to be context-contingent. That is, people judge different types of facial appearance to be better suited to leadership at times of war versus times of peace (Little, et al., 2007). For example, people judge individuals with more dominant looking or masculine faces to be better wartime leaders and those with more trustworthy-looking or feminine faces to be better peacetime leaders (Ferguson, Owen, Hahn, Torrance, DeBruine & Jones, 2019; Grabo & Van Vugt, 2018; Laustsen & Petersen, 2017; Little, Roberts, Jones, & DeBruine, 2012; Re, DeBruine, Jones, Perrett, 2013; Spisak, Homan, Grabo, & Van Vugt, 2012). This is consistent with other work suggesting that dominant looking individuals are more likely to be selected for group membership in situations involving inter-group competition than they are for cooperative situations (Hehman Leitner, Deegan, Gaertner, 2015).

Van Vugt and Grabo (2015) proposed that these context-contingent effects of facial characteristics on leadership judgments reflect evolved stereotypic expectations regarding leadership for different situational context. They suggest this occurs because traits typically associated with dominance would be useful in wartime (i.e., when conflict and aggression may be particularly advantageous in a leader), while traits typically associated with trustworthiness would be relevant in peacetime (i.e., when diplomacy and cooperation may be particularly advantageous in a leader).

The studies described above investigated effects of relatively invariant facial characteristics (e.g., facial shape) on leadership judgments. However, by their very nature, these cues are stable and individuals (i.e., potential leaders) have little-to-no control over their expression. What about cues that can change more rapidly over short periods of times (e.g., seconds)? Might these characteristics also influence leadership judgments and in a context-contingent way? If an important decision such as choosing a leader can be manipulated by cues that are easily controllable, then potential leaders can manipulate the perceptions of those who might choose, potentially undermining their choices.

It has been suggested that head tilt (altering the pitch of one's head up or down, alternatively referred to as 'head pitch rotation'), can function as a dominance display similar to that in primates (Mignault & Chaudhuri, 2003). This similarity to the signals expressed in non-human primates means that head tilt is a likely candidate to influence leadership perceptions under Van Vugt and Grabo's (2015) evolutionary perspective. Several studies have found that tilting a head down increases perceived dominance (Hehman, Leitner & Gaertner, 2013; Toscano, Schubert & Giessner, 2018; Witkower & Tracy, 2019), yet others have suggested the opposite, that tilting up increases dominance and masculinity perceptions (Bee, Franke & André, 2009; Burke & Sulikowski, 2010; Mignault & Chaudhuri, 2003). Consequently, we first investigated the effects of head tilt on perceptions of dominance and trustworthiness (Study 1). We then tested whether the observed judgment-contingent (dominance versus trustworthiness) effects of head tilt on person perception extended to context-contingent (peacetime versus wartime) effects of head tilt on leadership judgments (Study 2).

4.2 Study 1

Study 1 investigated the effects of head tilt on dominance and trustworthiness perceptions.

4.2.1 Methods

One hundred and fifteen participants (44 male; mean age=29.70 years, SD=9.69 years, 65 female; mean age=26.45 years, SD=10.59 years, 6 did not report their sex) were randomly allocated to rate faces for either dominance ("How dominant is this person?"), or trustworthiness ("How trustworthy is this person?") using 1 (not very) to 7 (very) scales. Faces were of 10 adult men and 10 adult women aged between 35 and 45 (mean age=40.2 years, SD=3.44 years), randomly selected from a larger set of images with this age range. Individuals posed front on at a standardized height with direct gaze. Images were collected using a DI3D system (www.di4d.com) using six standard digital cameras (Canon EOS100D with Canon EF 50 mm f/1.8 STM lenses). This allows us to create three versions of the face by manipulating it in 3D space: original (front on), up-tilted (tilted 10 degrees up), and down-tilted (tilted 10 degrees down) versions (see Figure 3). Participants were then presented all 60 images, with trial order being fully randomized. The study was run online at faceresearch.org, with participants recruited by following links to an online face perception study on social bookmarking websites.

Figure 3. Example face stimuli used in the study (from left to right; head tilted down 10 degrees, front on, head tilted up 10 degrees).

4.2.2 Results

Ratings were analyzed using R version 3.5.1 (R Core Team, 2016), with lme4 version 1.1-18-1 (Bates et al., 2014) and lmerTest version 3.0-1 (Kuznetsova et al., 2013). Random slopes were specified maximally following Barr et al. (2013) and Barr (2013). Data files and analysis scripts are publicly available on the Open Science Framework (https://osf.io/sae8t/). The model included face sex, rater sex, head tilt, and judgment as predictors, as well as all possible interactions up to (and including) the four-way interaction among all predictors. Sex of face and sex of rater were included in the models because they have previously been found to have effects on social judgments of faces (Little et al., 2011). All predictors were effect coded (face sex: women = -0.5, men = 0.5; rater sex: women = -0.5, men = 0.5; orientation tilted down = -0.5, front on = 0, tilted up = 0.5; judgment: dominance = 0.5, trustworthiness = -0.5). The six participants who did not report their sex were removed from the data set prior to analyses. A priori power simulations of the study design indicate that this analysis has 100% power at n = 100 and stimulus n = 20 to detect an interaction between head tilt and judgment type (or context, as in study 2) of 0.25 points on the 1-7 rating scale. Full results of this analysis are shown in Table 3.

	Estimate	Std. Error	z	p
Rater Sex	-0.135	0.296	-0.457	0.648
Face Sex	-0.195	0.152	-1.281	0.200
Head Tilt	0.083	0.056	1.474	0.141
Judgment	0.393	0.296	1.325	0.185
R. Sex X F. Sex	0.565	0.092	6.121	<.001
R. Sex X Head Tilt	-0.250	0.113	-2.217	0.027
F. Sex X Head Tilt	-0.209	0.113	-1.848	0.065
R. Sex X Judgement	-0.758	0.593	-1.278	0.201
F. Sex X Judgement	1.289	0.093	13.84	<.001
Head Tilt X Judgement	-0.717	0.113	-6.334	<.001
R. Sex X F. Sex X Head Tilt	-0.084	0.226	-0.372	0.709
R. Sex X F. Sex X Judgement	-0.284	0.184	-1.539	0.124
R. Sex X Head Tilt X Judgement	-0.064	0.228	-0.278	0.781
F. Sex X Head Tilt X Judgement	-0.125	0.226	-0.558	0.577
R. Sex X F. Sex X Head Tilt X Judgement	0.332	0.456	0.728	0.466

Table 3. Results of analysis testing for judgment-contingent (dominance versus trustworthiness judgments) effects of head tilt on person perception.

There was a significant interaction between judgment type and head tilt (beta=-0.72, z=-6.33, p<.001), whereby head tilt had a positive effect on trustworthiness, but a negative effect on dominance (see Figure 4). A significant interaction between face sex and judgment type (beta=1.29, z=13.845, p<.001), indicated that female faces were judged less dominant than male faces and male faces were judged less trustworthy than female faces (see Figure 5). There were no other significant effects or interactions involving judgment type (p>.065).

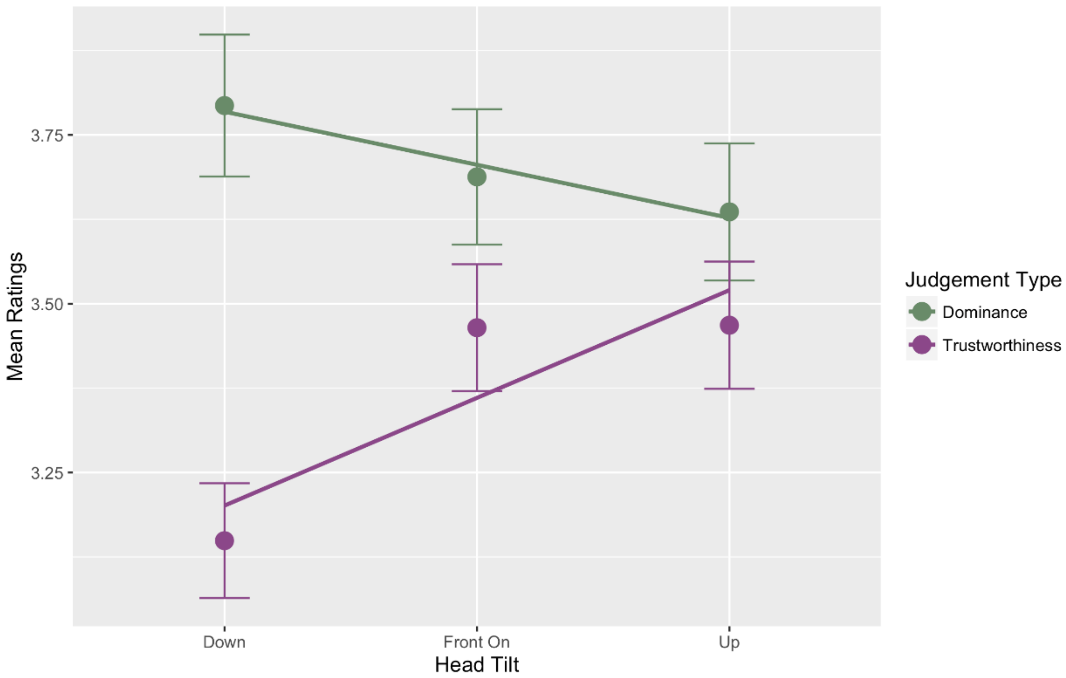

Figure 4. The significant interaction between judgment type (dominance versus trustworthiness) and head tilt in Study 1. Error bars show standard error of the mean. Lines show regression slope.

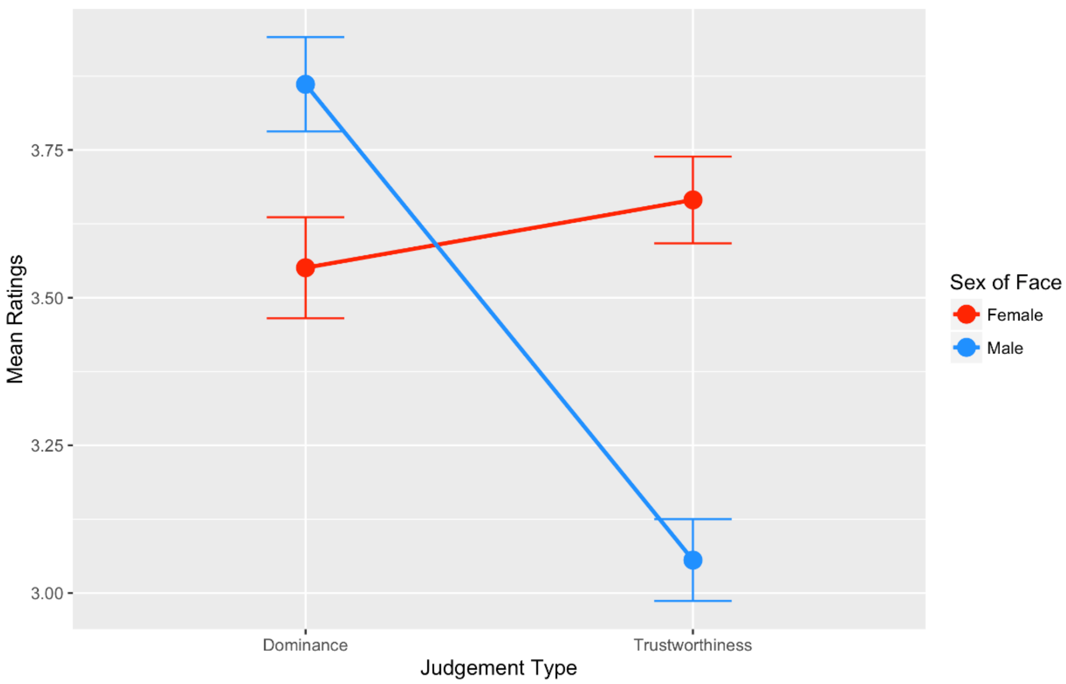

Figure 5. The significant interaction between judgment type (dominance versus trustworthiness) and face sex in Study 1. Error bars show standard error of the mean. Lines show regression slope.

4.2.3 Additional analyses of Study 1

One reviewer asked that we carry out alternative analyses in which dominance and trustworthiness judgments were analysed separately. These analyses can be seen at https://osf.io/zg4ut/ and also show that downward tilt increases dominance perceptions, but decreases trustworthiness perceptions.

4.3 Study 2

In Study 1, we found that tilting the head downward increased dominance perceptions, but decreased perceptions of trustworthiness. Accordingly, in Study 2 we investigated whether tilting heads down increased their perceived leadership ability during wartime, while tilting heads up increased their perceived leadership ability during peacetime. Such results would follow from previous work linking perceptions of dominance to leadership during wartime and perceptions of trustworthiness to leadership during peacetime (Ferguson, et al., 2019; Grabo & Van Vugt, 2018; Laustsen & Petersen, 2017; Little, et al., 2012; Re, et al., 2013; Spisak, et al., 2012).

In 2017 (and before conducting Study 1), we preregistered the prediction that upward-tilted faces would be judged as better leaders in the wartime than peacetime context because upward-tilted faces are perceived to be more dominant (https://osf.io/sae8t/). This prediction was based largely on early studies reporting that upward-tilted faces were perceived as more dominant (Bee, Franke & André, 2009; Burke & Sulikowski, 2010; Mignault & Chaudhuri, 2003). We reconsidered this prediction in light of the results of Study 1 and subsequent work suggesting that downward-tilted faces are perceived to be more dominant (e.g., Toscano, Schubert & Giessner, 2018; Witkower & Tracy, 2019). All other aspects of our methodology and analysis are unchanged from the preregistration.

4.3.1 Methods

The methods and stimuli used in Study 2 were identical to those used in Study 1 except here 101 participants (46 male; mean age=29.49 years, SD=10.11 years, 55 female; mean age=27.87 years, SD=10.77 years) rated 60 faces for leadership on a 1 (very bad leader) to 7 (very good leader) scale. Participants were randomly allocated to rate the faces for either “How good a leader would this person be for a country during a time of war?” or “How good a leader would this person be for a country during a time of peace?”.

4.3.2 Results

Ratings were analyzed as in Study 1, except the variable leadership context (wartime, peacetime) replaced the variable judgment type (dominance, trustworthiness). None of the participants in Study 2 had taken part in Study 1. Full results of this analysis are shown in Table 4.

	Estimate	Std. Error	z	p
Rater Sex	0.491	0.253	1.944	0.052
Face Sex	-0.172	0.210	-0.819	0.413
Head Tilt	0.085	0.057	1.495	0.135
Context	0.330	0.253	1.307	0.191
R. Sex X F. Sex	0.374	0.093	4.004	<.001
R. Sex X Head Tilt	-0.039	0.114	-0.342	0.732
F. Sex X Head Tilt	-0.229	0.114	-2.010	0.045
R. Sex X Context	-0.374	0.505	-0.742	0.458
F. Sex X Context	-0.919	0.093	-9.790	<.001
Head Tilt X Context	0.008	0.114	0.072	0.942
R. Sex X F. Sex X Head Tilt	0.308	0.228	1.350	0.177
R. Sex X F. Sex X Context	0.154	0.187	0.826	0.409
R. Sex X Head Tilt X Context	-0.011	0.228	-0.050	0.960
F. Sex X Head Tilt X Context	0.050	0.228	0.218	0.828
R. Sex X F. Sex X Head Tilt X Context	-0.247	0.456	-0.541	0.589

Table 4. Results of analysis testing for context-contingent (wartime versus peacetime) effects of head tilt on leadership judgments.

There was a significant interaction between rater sex and face sex (beta=0.37, z=4.00, p<.001), whereby women, but not men, tended to rate women to be better leaders than men (see Figure 6). There was also a significant interaction between face sex and context (beta=-0.92, z=-9.79, p<.001), whereby women were judged better leaders in the peacetime than wartime context, while men tended to be judged better leaders in the wartime than peacetime context (see Figure 7). The significant interaction between face sex and head tilt (beta=-0.23, z=-2.01, p=.045) suggested that head tilt had a positive effect on judgments of women's, but not men's, leadership (see Figure 8). Although men tended to give higher ratings than women, this main effect of rater sex was not significant (beta=0.49, z=1.94, p=.052). No other effects were significant or approached significance (p>.135).

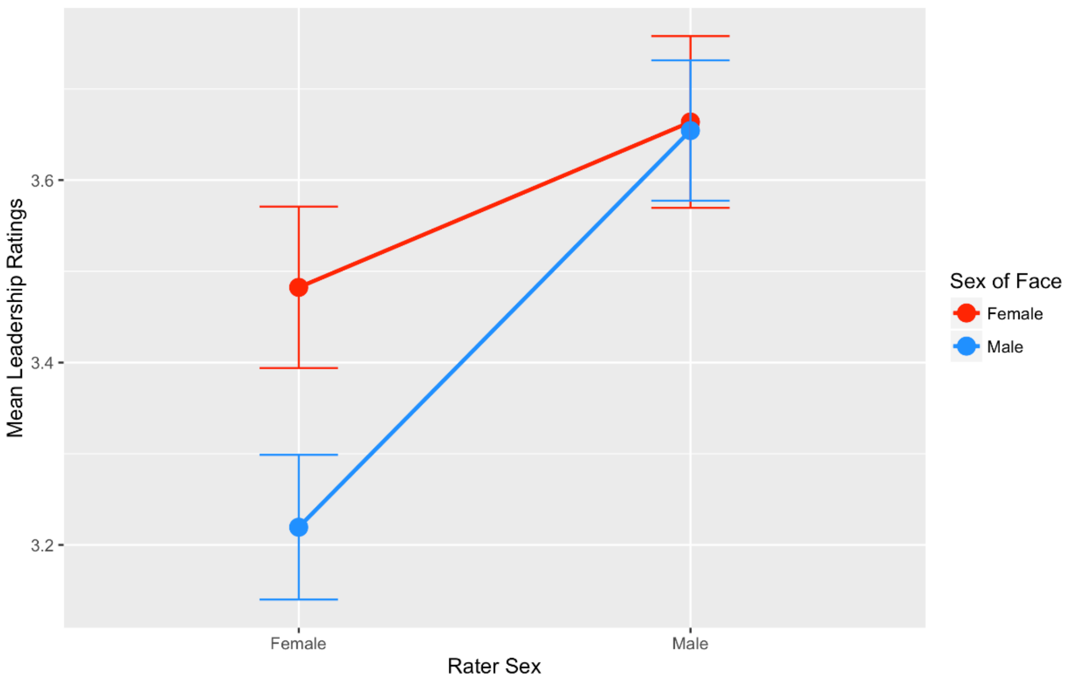

Figure 6. The significant interaction between face sex and rater sex for leadership judgments (Study 2). Error bars show standard error of the mean. Lines show regression slope.

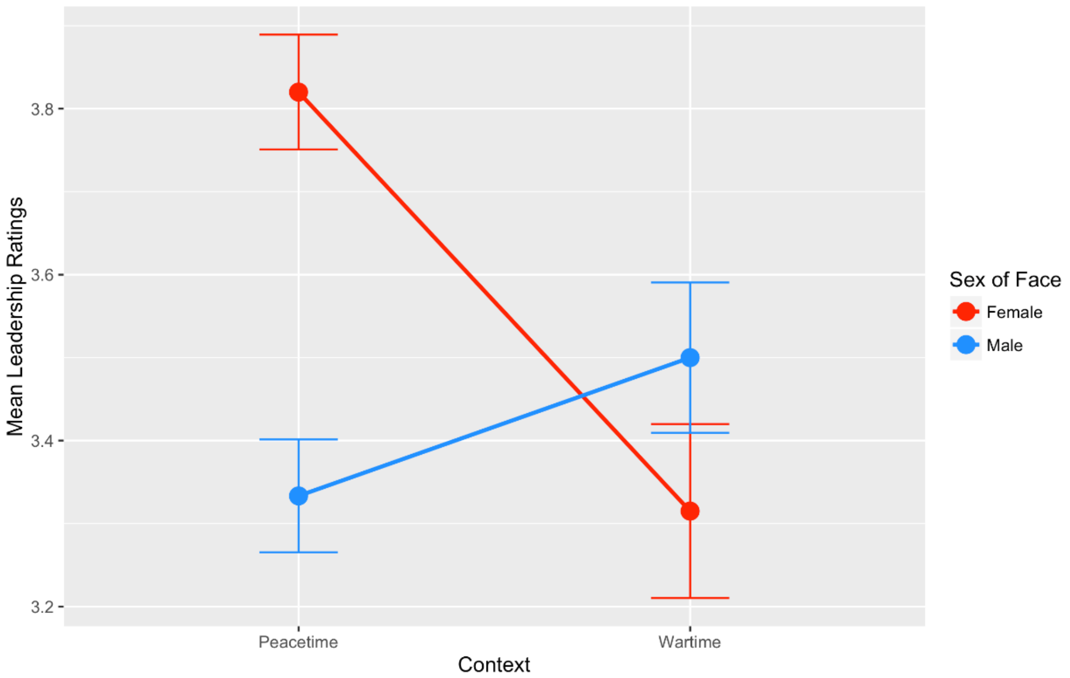

Figure 7. The significant interaction between face sex and context for leadership judgments (Study 2). Error bars show standard error of the mean. Lines show regression slope.

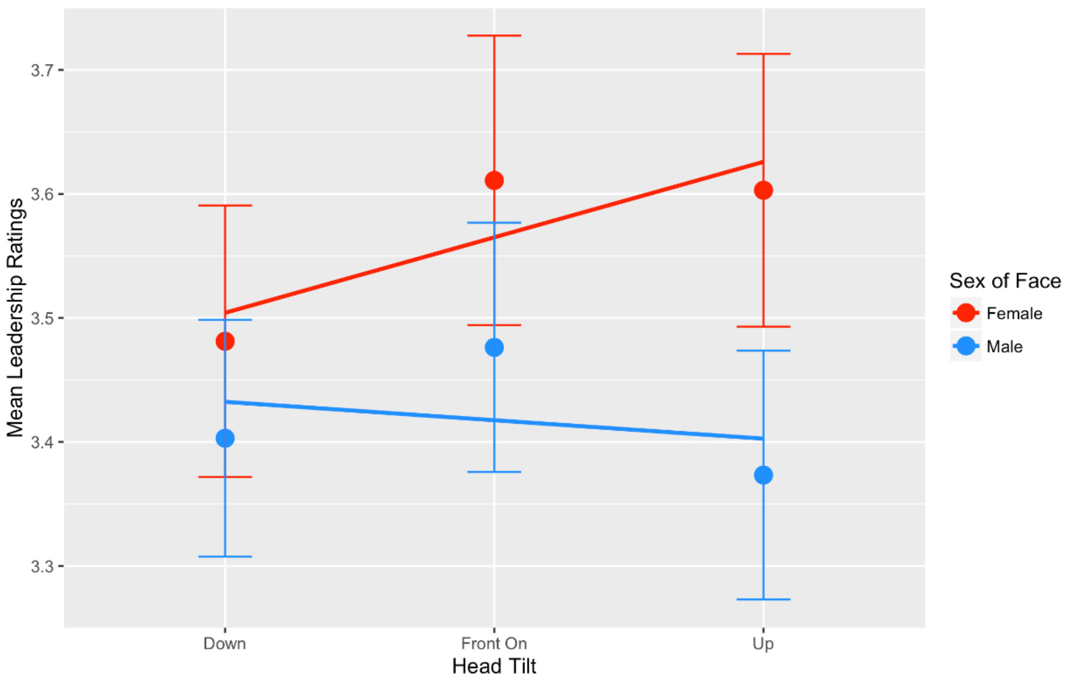

Figure 8. The significant interaction between face sex and head tilt for leadership judgments (Study 2). Error bars show standard error of the mean. Lines show regression slope.

4.3.3 Additional analyses of Study 2

One reviewer asked that we carry out an alternative analysis in which upward tilted faces were excluded from the analysis. This analysis can be seen at https://osf.io/zg4ut/, but also showed no evidence for category-contingent effects of head tilt on leadership judgments.

4.4 Discussion

In Study 1, consistent with some previous research (Hehman, et al., 2013; Toscano, et al., 2018; Witkower & Tracy, 2019), we found that tilting heads down increased perceptions of dominance. In addition, and consistent with research suggesting that dominance and trustworthiness are negatively correlated (Perrett et al., 1998), we also found that tilting heads down decreased perceptions of trustworthiness (Study 1). These effects were relatively subtle, however, and, as a consequence, may not necessarily have much downstream influence on behavior during actual social interactions.

By contrast with previous results for physical characteristics (Ferguson, et al., 2019; Grabo & Van Vugt, 2018; Laustsen & Petersen, 2017; Little, et al., 2012; Re, et al., 2013; Spisak, et al., 2012), we found no evidence that head tilt had context-contingent effects on leadership judgments (Study 2). Importantly, these null results for context-contingent effects of head tilt on leadership perceptions (Study 2) are unlikely to be due to our head tilt manipulation not influencing dominance and trustworthiness perceptions because Study 1 showed clear and dissociable effects of head tilt on both perceived dominance and trustworthiness.

Although we found no evidence that head tilt had context-contingent effects on leadership judgments, we did find that women were judged as better leaders in the peacetime than wartime context, while men were judged as better leaders in the wartime than peacetime context. This is consistent with previous research finding that feminine faces were perceived as better leaders for peacetime than wartime, while masculine faces were perceived as better leaders for wartime than peacetime (Ferguson et al., 2019; Grabo & Van Vugt, 2018; Lausten & Petersen, 2017; Little et al., 2012; Spisak et al., 2012). This context-contingent effect of face sex on leadership judgments suggests that the null result for context-contingent effects of head tilt on leadership judgments was not simply because our testing paradigm was unsuitable to detect context-contingent effects on leadership judgments in general.

It should be noted that the stimuli used in these studies were single 3D images with virtually manipulated pitch (i.e., were individual images manipulated in 3D space), rather than images of the target naturally tilting their head. This method allows for precise control of the head tilt angle, but has some limitations. When an individual tilts their head naturally, there is additional stretching or folding of the skin at points on the face. This does not happen with a virtually tilted head. Secondly, when virtually manipulating head tilt, eye gaze becomes confounded with tilt angle, i.e. when the head is tilted eye gaze is no longer directed. It is possible that the presence or absence of these cues could influence social perceptions. This raises the possibility that the results of Study 1 may not just be due to our head tilt manipulation. However, a recent study by Witkower and Tracy (2019) used both computer generated stimuli and human stimuli with natural head tilt and directed gaze, and found the same pattern of results for the effect of head tilt on dominance perceptions as we saw in the current study (but see Toscano et al., 2018 for evidence that gaze direction i.e. left/ right versus front-on, can qualify effects of head tilt on dominance perceptions). Additionally it should be noted that these possible limitations do not explain why, with identical stimuli and sample sizes, we see an effect of head tilt for dominance and trustworthiness judgments (Study 1) but do not see an effect for leadership judgments (Study 2). Taken together, this information suggests that our null results in Study 2 are not a consequence of our paradigm or stimuli being unsuitable for detecting effects of head tilt on social judgments.

Given the body of research linking cues of dominance and trustworthiness to context-contingent leadership judgments (Ferguson, et al., 2019; Grabo & Van Vugt, 2018; Laustsen & Petersen, 2017; Little, Roberts, Jones, & DeBruine, 2012; Re, DeBruine, Jones, Perrett, 2013; Spisak, Homan, Grabo, & Van Vugt, 2012), it seems unlikely that dominance and trustworthiness are in fact unrelated to leadership judgments in these contexts. The question then remains as to why we find no context-contingent effects of head tilt on leadership judgments when we do see judgment- contingent effects of head tilt. One possible explanation would be that, from an evolutionary standpoint, judgments about trustworthiness and dominance can have immediate consequences (i.e., misjudging these could lead to physical harm), and so you may be more attuned to transient cues that could communicate immediate intent. Leadership judgments however have more long-term consequences; therefore, it may be more beneficial to pay less attention to transient cues and focus on invariant cues that may be more indicative of stable traits. This is speculative, however, and further studies are needed to investigate this issue.

In conclusion, we found that head tilt affected trustworthiness and dominance perceptions, but did not have the context-contingent effects on leadership judgments. However, female faces were judged to better leaders in peacetime than wartime contexts and male faces were judged to be better leaders in wartime contexts than peacetime contexts. That sex of face, but not head tilt, had context-contingent effects on leadership judgments suggests that the well-documented context-contingent effects of physical characteristics on leadership judgments do not necessarily extend to head tilt and, potentially, other changeable facial characteristics.

Chapter 5 General Discussion

5.1 Summary of main findings and contributions

The first study presented in chapter 2, looked to extend the literature on hormone influences on men's dominance and competitive behaviours. The study investigated if differences in men's testosterone levels predicted differences in intrasexual competitiveness. The results from a linear mixed-effects model showed no evidence that either within-subject changes in testosterone, or between-subject differences in testosterone levels, predict intrasexual competitiveness. Specifically, we do not see evidence that men with higher testosterone levels score higher on the Intrasexual Competitiveness Scale, nor do we see increases in men's testosterone levels leading to increases in intrasexual competitiveness. These results then, provide no support for the Challenge Hypothesis, which would predict intrasexual competitiveness to increase when testosterone increases. Similarly, there was no evidence to support Dual-Hormone Hypothesis, as the score on Intrasexual Competitiveness Scale did not track with the interaction of testosterone and cortisol.

Relatively little work in the hormone literature has focused specifically on intrasexual competition, and to the best of our knowledge, at the time, this was the first study investigating men's intrasexual competitiveness, to employ a longitudinal design to look at natural variation in men's hormone levels. Most other studies in the hormone literature have either used single time-point hormone measures (e.g. Arnocky et al, 2018), or induce changes in testosterone levels through various forms of competition (e.g. Carré & McCormick, 2008b). Here we intended to increase ecological validity, by examining natural variations in men's hormone levels, which as of yet has been underexamined in the literature. While the findings presented here in chapter 2 were null results, this still presents the first important step towards integrating this methodology in the study of hormone influence on dominance behaviours.

The study presented in chapter 3 examined potential environmental influences on dominance perceptions. Specifically, this study investigated the possibility that individuals may be more sensitive to cues of dominance (i.e. facial masculinity) in geographic regions where there is increased direct male-male competition (i.e. regions with female biased sex ratios). The results from this study adds to the growing literature that indicates that facial masculinity is used as a cue in dominance perceptions, with increasing facial masculinity reliably increasing perceptions of dominance, and this effect was stronger when judging male faces than female faces. Additionally while the results presented do show a weak effect of adult sex ratio on dominance judgements, and that this effect was in the predicted direction such that individuals in more female bias sex ratio populations show greater sensitivity to cues of dominance, this effect was shy of significance (p=0.056).

While this effect does not reach the threshold of significance, the observed direction of the effect along with recent studies demonstrating increased direct male-male competition in regions with a female biased sex ratio, does raise questions for the traditional model of intrasexual competition and sex ratios, which would predict greater male-male competition in male biased regions. If future work were to build on these findings it could have major consequences for sexual selection theories of male-male competition. This is the only known study to date, that directly investigates the effects of real-world population sex ratio on dominance perceptions. Importantly this study avoids common problems with examining population level differences in behaviour (see Pollet et al., 2014, 2017), by using liner mixed effects models to account for variation among individuals with each state, rather than aggregating across individuals.

The final empirical study presented in chapter 4 examines how changeable transient cues can influence social judgements. Specifically, this study looks at the influence of head pitch rotation (tilting the head up or down), on perceptions of dominance and trustworthiness. This study adds to the emerging literature that suggests these subtle transient cues can have a significant impact on social perceptions. The results indicate that tilting one’s head down increases perceived dominance and decreases perceived trustworthiness. Interestingly, even though the transient cue of head tilt influenced dominance and trustworthiness judgements, there was no evidence that this leads to downstream consequences for context dependent leadership judgements. Conversely, while this transient cue of dominance and trustworthiness, showed no effect on context contingent leadership judgements, there was an effect from the stable cue of face sex, where male faces were judged as better wartime leader and female faces were judged as better peacetime leaders. This is consistent with existing literature demonstrating a context dependent effect of facial sexual dimorphism on leadership judgements. It may well be the case that relatively fundamental social perceptions like dominance and trustworthiness can be influenced by transient cues such as head tilt, whereas judgments of leadership are relatively unaffected by transient cues such as head tilt. To date however, this is the only known study to investigate the effects of transient facial cues on leadership judgements, and further research will be needed to determine if transient cues in general have any effect on leadership judgements.

5.2 Limitations and future directions

While there has been plenty of research investigating the influence of testosterone and cortisol on numerous aspects of dominance and competitiveness, relatively little work has focused directly on intrasexual competitiveness. Previous research using the Intrasexual Competitiveness Scale has suggested that women’s intrasexual competitiveness increases when their testosterone levels are high (Cobey et al., 2013; Hahn et al., 2016), these results were not replicated in the study presented in chapter 2, on men’s intrasexual competitiveness. This discrepancy in results should be addressed, given the body of research on testosterone’s effect on dominance and competitive behaviours in men (discussed in chapter 1), it is unlikely that testosterone would influence intrasexual competitiveness in women but not in men, however a sex difference cannot be ruled out, and further research will be needed to investigate this. It is also possible that the previous results for women may have been false positives (i.e. testosterone levels in fact do not track intrasexual competitiveness in women), or alternatively the results for men in the current study could be a false negative (i.e. testosterone levels in fact do track intrasexual competitiveness in men). Furthermore, it may in fact be the case that the items in the Intrasexual Competitiveness Scale (Buunk & Fisher, 2009) itself are be better suited at measuring women's intrasexual competitiveness than men's, and future work should look to employ other measures of intrasexual competitiveness. Additionally, previous research has indicated that the effects of testosterone changes on dominance and competitive behaviours can be mediated by other psychological trait factors such as trait dominance (Carre et al., 2009, 2017; Slatcher et al., 2011), which was not measured in the current study. It is possible that factors such as trait dominance may have had an undiscovered mediating effect in the current study and as such should be considered in the future.

In chapter 3, the adult sex ratio of the local population was calculated at the state level, allowing for comparison of different sex ratios across states. Choosing states as the population level for analysis was done in order to coincide with maximal accuracy of participant location (trying to locate participants from IP address at a level smaller that state would increase the likelihood of error). However, examining adult sex ratio variation at the state level has its limitations. Notably, even within a state, population density and sex ratio can vary dramatically from county to county. For example, California has an adult sex ratio of 1.03, whereas within California you can see adult sex ratio's as high as 1.76 (in Lassen County), and as low as 0.93 (in Madera County). Since participants location is only logged at the state level, this means the recorded sex ratio may not reflect the true sex ratio of the participants immediate environment. This could prove to be important for any future analysis of population sex ratio effects on dominance perceptions. Considering that the effect observed was in the predicted direction, and the effect fell just short of the traditional level of significance ($p=0.056$), coupled with the fact that a study using experimentally manipulated sex ratio did find a significant effect in the same direction (i.e. a female biased sex ratio lead to in increase in sensitivity to dominance cues, see Watkins et al., 2013), it seems pertinent that further work be done to investigate this effect, potentially utilising a smaller geographic unit (such as county) to more accurately capture the sex ratio of participants immediate environment.

In chapter 4, the face stimuli were created by manipulating the pitch of single high-quality 3D images of real subjects captured from a neutral position. This method has its advantages; it allows for precise control of the head tilt angle, allowing for consistent angle across stimuli, unlike images of subjects naturally tilting their head. In addition, this method generates high quality realistic images, unlike other image generating software (for example, Facegen, or Poser Pro), that allow for precise control but sacrifices realism of the stimuli. There is a limitation to this method in that eye-gaze becomes confounded with head tilt, meaning once the stimuli are tilted eye-gaze is no longer directed towards the observer. While it is unlikely the eye-gaze incongruity is driving the observed effects reported in chapter 4, any future replications of this methodology should look to remove this confound, by obtaining multiple 3D images with subjects gaze fixated at varying angles, allowing for pitch manipulation with directed gaze. It should also be noted that the face stimuli were created using participants aged between 35 to 45, this was done to increase ecological validity, as this age range was deemed more representative of a potential hypothetical leader, than the traditional age range of 18 to 24 common in face perception research. Future work can look to extend this by including a wider range of target ages, and examining the possibility of age dependent effects of head tilt on social perceptions. Additionally, future work should look aim to study cross cultural samples, particularly non-WEIRD samples. While it has been argued that head tilt may serve a similar purpose as it does in many animal species (i.e. to signal dominance or deference), it is important to understand that head tilt can carry a lot of other social connotations as well, which may be influenced by cultural traditions, for example bowing one's head is important in many cultures, but not in others. Any future work should include cross cultural samples before drawing any strong conclusions regarding the underpinnings of head tilts effect on social perceptions. Finally although there was no evidence that head tilt had any context dependent effects on leadership judgements, future work will need to investigate other transient cues such as facial expression, before any conclusions can be drawn with regards to the effects of transient cues in general on leadership judgements.

5.3 Conclusion

In conclusion, the empirical chapters reported in this thesis tested several underlying assumptions in the literature on men's dominance. Chapter 2 found little evidence that reported intrasexual competitiveness tracks changes in men's cortisol and / or testosterone. These null results provide little support for the Dual Hormone Hypothesis, which suggests that men's intrasexual competitiveness is dependent on men's steroid hormone levels. Chapter 3 investigated how environmental factors influence dominance perceptions, finding little clear evidence that regional differences in men's perceptions of facial cues of dominance are robustly predicted by adult sex ratio. These results challenge the results from priming experiments that suggested sex ratio influences dominance perceptions. Finally, Chapter 4 showed that head tilt influences dominance perceptions, consistent with previous research. Together, these results call into question several key assumptions in the literature on human dominance, but that head tilt reliably influences perceptions.

Chapter 6 Appendices

Hormones and Intrasexual Competitiveness Analyses

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```
library(tidyverse)
library(lmerTest)
library(psych)
```

Descriptive statistics and full output for all analyses. This document also includes analyses of reported anxiety levels that are not reported in the main text.

```
# Load Data
data_hormones <- read_csv("hm_intrasexual_comp_anon.csv")
```

6.1 Basic Descriptive Information for Sample

6.1.1 The number of sessions completed per man

```
data_hormones %>%
  group_by(hm_id) %>%
  summarise(
    sessions = n_distinct(date)
  ) %>%
  group_by(sessions) %>%
  summarise(
    n = n()
  )

## `summarise()` ungrouping output (override with `.groups` argument)
## `summarise()` ungrouping output (override with `.groups` argument)

## # A tibble: 5 x 2
##   sessions     n
##      <int> <int>
## 1        1     4
## 2        2     2
## 3        3     2
## 4        4     4
## 5        5    47
```

6.1.2 Mean age for the sample

```
data_hormones %>%
  group_by(hm_id) %>%
  summarise(age = mean(age, na.rm = T)) %>%
  ungroup() %>%
  group_by() %>%
  summarise(
      n = n(),
      mean_age = mean(age, na.rm = TRUE),
      sd_age =   sd(age, na.rm = TRUE),
      se_age =   se(age, na.rm = TRUE)
  ) %>%
  mutate_all(round, 2)
```

```
## `summarise()` ungrouping output (override with `.groups` argument)

## # A tibble: 1 x 4
##         n mean_age sd_age se_age
##     <dbl>    <dbl>  <dbl>  <dbl>
## 1      59     22.1   3.24   0.42
```

6.2 Data Processing

6.2.1 Exclude hormone outliers

```
# calculate means and SDs
test_mean <- mean(data_hormones$test)
test_sd <- sd(data_hormones$test)
cort_mean <- mean(data_hormones$cort)
cort_sd <- sd(data_hormones$cort)

# set values > 3SD from the mean to NA
data_final <- data_hormones %>%
  mutate (
    test = ifelse (test > test_mean + 3*test_sd |
                   test < test_mean - 3*test_sd, NA, test),
    cort = ifelse (cort > cort_mean + 3*cort_sd |
                   cort < cort_mean - 3*cort_sd, NA, cort)
  )

# determine how many values were excluded
data_final %>%
  group_by(hm_id, date) %>%
  summarise(
    t = is.na(mean(test)),
    c = is.na(mean(cort))
  ) %>%
  ungroup() %>%
  select(t:c) %>%
  gather('hormone','na', t:c) %>%
  group_by(hormone) %>%
  summarise(
    'valid' = n() - sum(na),
    'excluded' = sum(na)
  ) %>%
  arrange(hormone)

## `summarise()` regrouping output by 'hm_id' (override with `.groups` argument
)

## `summarise()` ungrouping output (override with `.groups` argument)

## # A tibble: 2 x 3
##   hormone valid excluded
##   <chr>   <int>    <int>
## 1 c         264        1
## 2 t         261        4

# Calculate average hormones for each participant
data_avg <- data_final %>%
  group_by(hm_id) %>%
  summarise(
    avg_test = mean(test, na.rm = TRUE),
    avg_cort = mean(cort, na.rm = TRUE)
  ) %>%
```

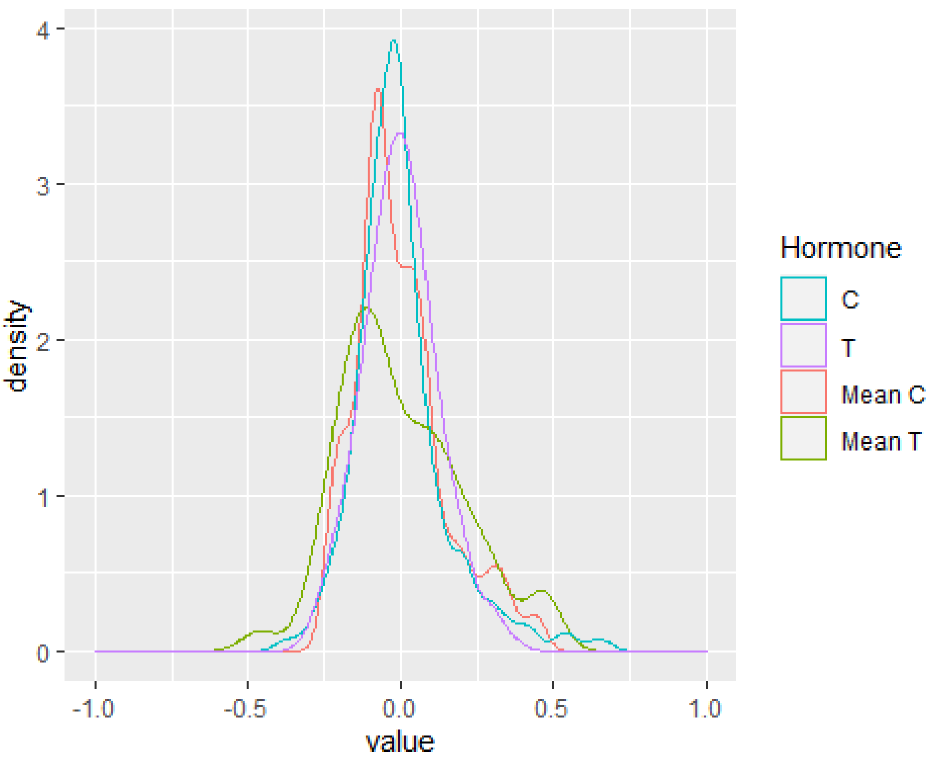
```
  group_by() %>%
  # divide by constants to make range approx -.5 to +.5 for lmer
  mutate(
    avg_test.s = (avg_test - mean(avg_test, na.rm=TRUE)) / 180,
    avg_cort.s = (avg_cort-mean(avg_cort, na.rm=TRUE)) / 0.5
  )

## `summarise()` ungrouping output (override with `.groups` argument)
```

6.2.2 Centre and scale hormones

Centre hormones on subject-specific means, and bring values between -0.5 and 0.5 to facilitate calculations in linear mixed effects models. This graph illustrates that testosterone and cortisol values are not skewed.

```
# centre hormones within-subject
# divide by same constants above to make range approx -.5 to +.5 for lmer
data_scaled <- data_final %>%
  group_by(hm_id) %>%
  mutate(
    test.s = (test-mean(test, na.rm=TRUE)) / 180,
    cort.s = (cort-mean(cort, na.rm=TRUE)) / 0.5
  ) %>%
  ungroup() %>%
  left_join(data_avg, by="hm_id")
```



6.2.3 Mean hormone levels

```
data_scaled %>%
  group_by(hm_id, date, age, test, cort) %>%
  summarise(n = n()) %>%
  ungroup() %>%
  group_by() %>%
  summarise(
      mean_test = mean(test, na.rm = TRUE),
```

```
      sd_test =   sd(test, na.rm = TRUE),
      se_test =   se(test, na.rm = TRUE),
      mean_cort = mean(cort, na.rm = TRUE),
      sd_cort =   sd(cort, na.rm = TRUE),
      se_cort =   se(cort, na.rm = TRUE)
  ) %>% gather("stat", "value", 1:length(.)) %>%
    mutate(value = round(value, 4)) %>%
    separate(stat, c("stat", "hormone")) %>%
    spread(stat, value)

## `summarise()` regrouping output by 'hm_id', 'date', 'age', 'test' (override
with `.groups` argument)

## # A tibble: 2 x 4
##   hormone    mean     sd     se
##   <chr>     <dbl>  <dbl>  <dbl>
## 1 cort      0.188  0.108 0.0066
## 2 test    178.    42.2   2.61
```

6.3 Intrasexual Competitiveness Analyses

6.3.1 Descriptives for Intrasexual Competitiveness Scale

```
data_scaled %>%
  summarise(
    mean = mean(intr_cmpt, na.rm = TRUE),
    sd   = sd(intr_cmpt, na.rm = TRUE),
    se   = se(intr_cmpt, na.rm = TRUE)
  ) %>%
  mutate_all(round, 4)

## # A tibble: 1 x 3
##    mean    sd     se
##   <dbl> <dbl>  <dbl>
## 1  2.95 0.985 0.0607
```

6.3.2 Cronbach's Alpha for Intrasexual Competitiveness Scale

```
horm_alphas <- data_hormones %>%
  select(ICS1:ICS12) %>%
  alpha()

horm_alphas$total$raw_alpha

## [1] 0.8634041
```

6.3.3 Results for LMEM Analysis for Intrasexual Competitiveness Scale

```
model.IC.TbyC <- lmer(intr_cmpt ~ 1 + test.s * cort.s +
                        avg_test.s * avg_cort.s +
                        (test.s * cort.s || hm_id),
                     data = data_scaled, REML = FALSE)

summary.IC.TbyC <- summary(model.IC.TbyC)

summary.IC.TbyC$coefficients %>%
  as.data.frame() %>%
  rownames_to_column(var = "Effect") %>%
```

```
  mutate_if(is.numeric, round, 3) %>%
  rename(p = `Pr(>|t|)`)
```

```
##                    Effect Estimate Std. Error      df t value     p
## 1             (Intercept)    3.035      0.123  59.394  24.634 0.000
## 2                  test.s    0.053      0.227  38.277   0.235 0.815
## 3                  cort.s    0.094      0.216  34.618   0.434 0.667
## 4              avg_test.s    0.389      0.647  60.287   0.601 0.550
## 5              avg_cort.s   -0.221      0.865  61.431  -0.256 0.799
## 6           test.s:cort.s    2.565      1.566 162.409   1.637 0.103
## 7 avg_test.s:avg_cort.s   -4.421      3.029  59.536  -1.460 0.150
```

6.4 State Anxiety Analyses

6.4.1 Descriptives for State Anxiety Scale

```
data_scaled %>%
  group_by() %>%
  summarise(
      mean = mean(st_anx, na.rm = TRUE),
      sd   = sd(st_anx, na.rm = TRUE),
      se   = se(st_anx, na.rm = TRUE)
  ) %>%
  mutate_all(round, 4)
```

```
## # A tibble: 1 x 3
##    mean    sd    se
##   <dbl> <dbl> <dbl>
## 1  36.1  8.81 0.543
```

6.4.2 Results for LMEM Analysis for State Anxiety Scale

```
model.SA.TbyC <- lmer(st_anx ~ 1 + test.s * cort.s +
                        avg_test.s * avg_cort.s +
                        (test.s * cort.s || hm_id),
                      data = data_scaled, REML = FALSE)
summary.SA.TbyC <- summary(model.SA.TbyC)

summary.SA.TbyC$coefficients %>%
  as.data.frame() %>%
  rownames_to_column(var = "Effect") %>%
  mutate_if(is.numeric, round, 3) %>%
  rename(p = `Pr(>|t|)`)
```

```
##                    Effect Estimate Std. Error      df t value     p
## 1             (Intercept)   36.556      0.924  55.499  39.569 0.000
## 2                  test.s    2.968      3.654  45.588   0.812 0.421
## 3                  cort.s    7.100      2.854 146.324   2.488 0.014
## 4              avg_test.s    5.670      4.908  57.793   1.155 0.253
## 5              avg_cort.s   -6.165      6.642  60.254  -0.928 0.357
## 6           test.s:cort.s    1.099     24.559  18.180   0.045 0.965
## 7 avg_test.s:avg_cort.s  -26.526     22.824  56.551  -1.162 0.250
```

ASR and regional variation in facial dominance perceptions

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```
library(tidyverse)

library(lme4)
library(lmerTest)
sessionInfo()
```

6.5 Data Processing

```
data <- read.csv("Regional_dominance.csv")
```

6.5.1 Centre and scale regional and rater predictors

```
to_scale <- data %>%
  select(region_id, asr, violent_crime, urban_per) %>%
  unique() %>%
  mutate(
    asr.s      = (asr-mean(asr))/sd(asr),
    violent.s = (violent_crime-mean(violent_crime))/sd(violent_crime),
    urban.s    = (urban_per-mean(urban_per))/sd(urban_per)
  )

## Warning: package 'bindrcpp' was built under R version 3.3.2

data.s <- data %>%
  left_join(to_scale, by = c("region_id", "violent_crime", "asr", "urban_per"))
%>%
  mutate(rater_age.s = (rater_age-mean(rater_age))/sd(rater_age))
```

6.5.2 Effect code sex

Turn data to long format & effect code stimulus sex (men = 0.5 women = -0.5)

```
data.long <- data.s %>%
  gather(trial, rating, female_1:male_20) %>%
  separate(trial, into=c("face_sex", "face_id")) %>%
  mutate(
    rater_sex.e = recode(rater_sex, "male" = 0.5, "female" = -0.5),
    face_sex.e = recode(face_sex, "male" = 0.5, "female" = -0.5)
  )
```

6.5.3 Reverse code DV to masculinity

```
# ratings are 1=pref masculine, 7 = pref feminine
# reverse for both male and female stimuli

data.all<-data.long %>%
  mutate(
    rating_masc=7-rating,
    rating.c=rating_masc-3.5
  ) %>%
  select(
```

```
    user_id,
    rating.c,
    rater_age,
    rater_age.s,
    rater_sex,
    rater_sex.e,
    face_id,
    face_sex,
    face_sex.e,
    region_id,
    asr.s,
    violent.s,
    urban.s
  )
```

6.5.4 Exclude DC

```
data.no.dc <- data.all %>%
   filter(region_id != "DC")
```

6.6 Main Analyses

6.6.1 Sex ratio: with DC

```
## Sex ratio only
model.asr<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_sex.e*asr.s
               + (1 + face_sex.e || region_id:user_id)
               + (1 + rater_sex.e:face_sex.e || region_id)
               + (1 + rater_sex.e:asr.s || face_id),
               data.all, REML = FALSE)
summary(model.asr)
```

```
## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula: rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * asr.s +
##     ((1 | region_id:user_id) + (0 + face_sex.e | region_id:user_id)) +
##     ((1 | region_id) + (0 + rater_sex.e:face_sex.e | region_id)) +
##     ((1 | face_id) + (0 + rater_sex.e:asr.s | face_id))
##    Data: data.all
##
##       AIC       BIC    logLik  deviance  df.resid
##  494630.9  494788.8 -247299.4  494598.9    143424
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1147 -0.4559  0.0778  0.5775  4.5409
##
## Random effects:
##  Groups              Name                   Variance  Std.Dev.
##  region_id.user_id   (Intercept)            0.5885709 0.76718
##  region_id.user_id.1 face_sex.e             0.4535606 0.67347
##  region_id           (Intercept)            0.0001824 0.01351
##  region_id.1         rater_sex.e:face_sex.e 0.0012381 0.03519
##  face_id             (Intercept)            0.0150970 0.12287
##  face_id.1           rater_sex.e:asr.s      0.0006520 0.02553
##  Residual                                   1.6632483 1.28967
## Number of obs: 143440, groups:
## region_id:user_id, 3586; region_id, 51; face_id, 20
##
## Fixed effects:
```

```
##                                 Estimate Std. Error         df t value
## (Intercept)                    7.958e-01  3.168e-02  3.300e+01  25.122
## rater_age.s                    2.542e-02  1.339e-02  3.562e+03   1.898
## rater_sex.e                    1.860e-03  3.126e-02  3.580e+03   0.059
## face_sex.e                     8.459e-01  1.536e-02  3.577e+03  55.089
## asr.s                         -4.169e-02  2.149e-02  7.600e+01  -1.940
## rater_sex.e:face_sex.e        -6.068e-03  3.155e-02  2.600e+01  -0.192
## rater_sex.e:asr.s             -4.596e-02  4.279e-02  1.977e+03  -1.074
## face_sex.e:asr.s               2.095e-02  2.102e-02  3.584e+03   0.997
## rater_sex.e:face_sex.e:asr.s  5.890e-02  4.299e-02  3.900e+01   1.370
##                               Pr(>|t|)
## (Intercept)                     <2e-16 ***
## rater_age.s                     0.0578 .
## rater_sex.e                     0.9526
## face_sex.e                      <2e-16 ***
## asr.s                           0.0560 .
## rater_sex.e:face_sex.e          0.8490
## rater_sex.e:asr.s               0.2829
## face_sex.e:asr.s                0.3191
## rater_sex.e:face_sex.e:asr.s    0.1785
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) rtr_g. rtr_s. fc_sx. asr.s  rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.034
## rater_sex.e  0.237 -0.138
## face_sex.e   0.000  0.000  0.000
## asr.s        0.097 -0.029  0.071  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.468  0.000
## rtr_sx.:sr.  0.034 -0.035  0.191  0.000  0.448  0.000
## fc_sx.:sr.s  0.000  0.000  0.000  0.189  0.000  0.066   0.000
## rtr_s.:_.:.  0.000  0.000  0.000  0.067  0.000  0.194   0.000  0.448
```

6.6.2 Sex ratio: without DC

```
model.asr.no.dc<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_sex.e*asr.s
                + (1 + face_sex.e || user_id)
                + (1 + rater_sex.e:face_sex.e || region_id)
                + (1 + rater_sex.e:asr.s || face_id),
                data.no.dc, REML = FALSE)
summary(model.asr.no.dc)
```

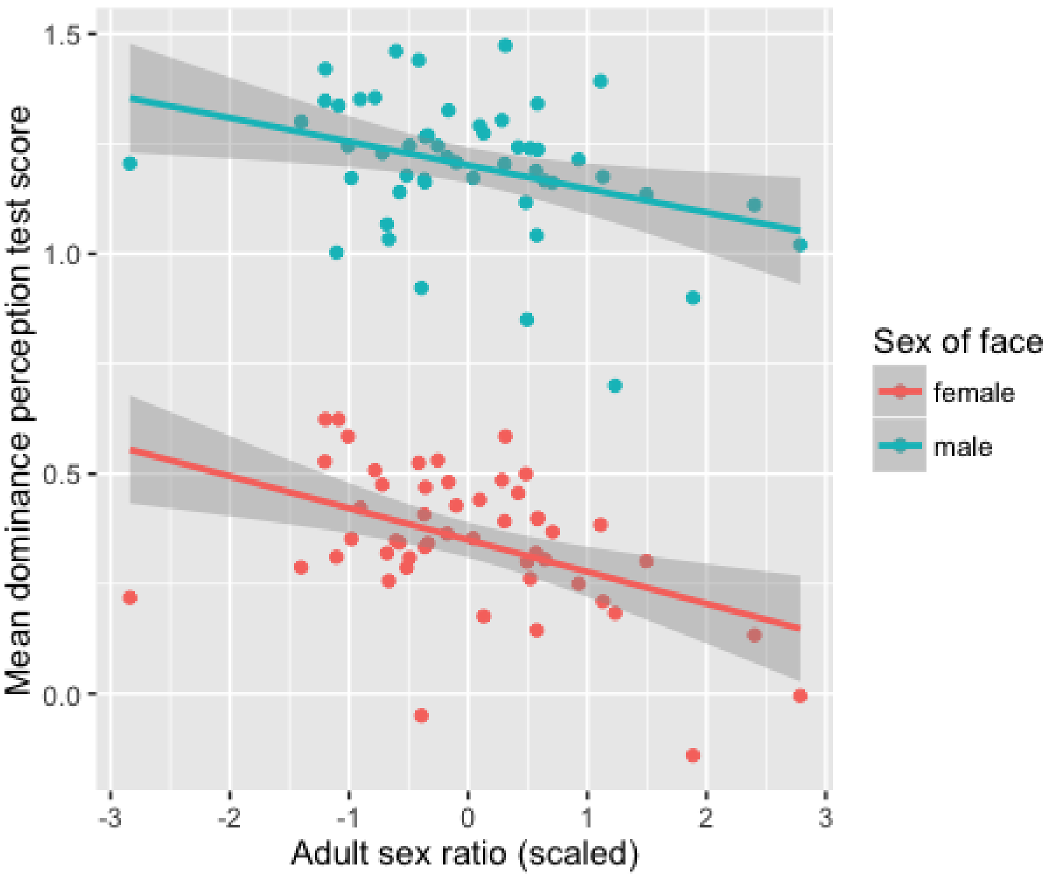
```
## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula: rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * asr.s +
##     ((1 | user_id) + (0 + face_sex.e | user_id)) + ((1 | region_id) +
##     (0 + rater_sex.e:face_sex.e | region_id)) + ((1 | face_id) +
##     (0 + rater_sex.e:asr.s | face_id))
##    Data: data.no.dc
##
##       AIC       BIC    logLik  deviance  df.resid
##  492062.7  492220.6 -246015.3  492030.7    142664
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1142 -0.4560  0.0779  0.5771  4.5398
##
## Random effects:
##  Groups      Name                   Variance  Std.Dev.
##  user_id     (Intercept)            0.5902203 0.76826
##  user_id.1   face_sex.e             0.4530970 0.67312
```

```
##  region_id   (Intercept)           0.0002125 0.01458
##  region_id.1 rater_sex.e:face_sex.e 0.0002104 0.01451
##  face_id     (Intercept)           0.0150337 0.12261
##  face_id.1   rater_sex.e:asr.s      0.0008876 0.02979
##  Residual                          1.6638021 1.28988
## Number of obs: 142680, groups:  user_id, 3567; region_id, 50; face_id, 20
##
## Fixed effects:
##                                Estimate Std. Error         df t value
## (Intercept)                   7.956e-01  3.166e-02  3.300e+01  25.130
## rater_age.s                   2.622e-02  1.346e-02  3.547e+03   1.948
## rater_sex.e                   8.423e-04  3.131e-02  3.561e+03   0.027
## face_sex.e                    8.462e-01  1.535e-02  3.553e+03  55.127
## asr.s                        -4.316e-02  2.247e-02  6.600e+01  -1.921
## rater_sex.e:face_sex.e       -4.626e-03  3.085e-02  2.200e+01  -0.150
## rater_sex.e:asr.s            -2.593e-02  4.469e-02  1.866e+03  -0.580
## face_sex.e:asr.s              2.072e-02  2.187e-02  3.566e+03   0.948
## rater_sex.e:face_sex.e:asr.s  3.557e-02  4.392e-02  2.800e+01   0.810
##                              Pr(>|t|)
## (Intercept)                    <2e-16 ***
## rater_age.s                    0.0515 .
## rater_sex.e                    0.9785
## face_sex.e                     <2e-16 ***
## asr.s                          0.0591 .
## rater_sex.e:face_sex.e         0.8822
## rater_sex.e:asr.s              0.5619
## face_sex.e:asr.s               0.3434
## rater_sex.e:face_sex.e:asr.s   0.4248
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) rtr_g. rtr_s. fc_sx. asr.s  rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.034
## rater_sex.e  0.238 -0.139
## face_sex.e   0.000  0.000  0.000
## asr.s        0.091 -0.040  0.065  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.478  0.000
## rtr_sx.:sr.  0.030 -0.031  0.177  0.000  0.445  0.000
## fc_sx.:sr.s  0.000  0.000  0.000  0.176  0.000  0.060   0.000
## rtr_s.:_.:.  0.000  0.000  0.000  0.060  0.000  0.177   0.000  0.455
```

6.6.3 Plot

Mean Dominance perception score against ASR by state

```r
data.all %>%
  group_by(region_id, face_sex, asr.s) %>%
  summarise(mean_rating = mean(rating.c)) %>%
  ungroup() %>%
  ggplot(aes(asr.s, mean_rating, colour=face_sex)) +
  geom_point() +
  geom_smooth(method="lm") +
  xlab("Adult sex ratio (scaled)") +
  ylab("Mean dominance perception test score") +
  labs(colour="Sex of face")
```




```
ggsave("figure2.png", width=6, height=4)
```

6.7 Other models with alternative predictors

6.7.1 Urbanization: with DC

```
model.urban<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_sex.e*urban.s
                + (1 + face_sex.e || region_id:user_id)
                + (1 + rater_sex.e:face_sex.e || region_id)
                + (1 + rater_sex.e:asr.s || face_id),
                data.all, REML = FALSE)
summary(model.urban)
```

```
## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula:
## rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * urban.s +
##     ((1 | region_id:user_id) + (0 + face_sex.e | region_id:user_id)) +
##     ((1 | region_id) + (0 + rater_sex.e:face_sex.e | region_id)) +
##     ((1 | face_id) + (0 + rater_sex.e:asr.s | face_id))
##    Data: data.all
##
##       AIC       BIC    logLik  deviance  df.resid
##  494635.2  494793.2 -247301.6  494603.2    143424
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1161 -0.4562  0.0778  0.5777  4.5405
##
## Random effects:
##  Groups              Name                   Variance  Std.Dev.
##  region_id.user_id   (Intercept)            0.5890052 0.76747
##  region_id.user_id.1 face_sex.e             0.4537996 0.67365
##  region_id           (Intercept)            0.0003106 0.01762
##  region_id.1         rater_sex.e:face_sex.e 0.0011167 0.03342
##  face_id             (Intercept)            0.0151000 0.12288
##  face_id.1           rater_sex.e:asr.s      0.0006531 0.02556
##  Residual                                   1.6632482 1.28967
## Number of obs: 143440, groups:
## region_id:user_id, 3586; region_id, 51; face_id, 20
##
## Fixed effects:
##                                Estimate Std. Error        df t value
## (Intercept)                   8.038e-01  3.282e-02  3.900e+01  24.490
## rater_age.s                   2.502e-02  1.342e-02  3.584e+03   1.864
## rater_sex.e                  -2.193e-03  3.558e-02  3.578e+03  -0.062
## face_sex.e                    8.351e-01  1.754e-02  3.575e+03  47.620
## urban.s                      -5.112e-03  1.950e-02  9.100e+01  -0.262
## rater_sex.e:face_sex.e       -2.367e-02  3.555e-02  6.700e+01  -0.666
## rater_sex.e:urban.s           2.110e-02  3.809e-02  3.586e+03   0.554
## face_sex.e:urban.s            1.725e-02  1.888e-02  3.584e+03   0.913
## rater_sex.e:face_sex.e:urban.s  1.911e-02  3.850e-02  3.500e+01   0.496
##                              Pr(>|t|)
## (Intercept)                    <2e-16 ***
## rater_age.s                    0.0624 .
## rater_sex.e                    0.9509
## face_sex.e                     <2e-16 ***
## urban.s                        0.7938
## rater_sex.e:face_sex.e         0.5078
## rater_sex.e:urban.s            0.5797
## face_sex.e:urban.s             0.3610
## rater_sex.e:face_sex.e:urban.s   0.6229
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) rtr_g. rtr_s. fc_sx. urbn.s rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.011
## rater_sex.e  0.269 -0.104
## face_sex.e   0.000  0.000  0.000
## urban.s     -0.268 -0.071 -0.237  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.494  0.000
## rtr_sx.:rb. -0.136 -0.022 -0.505  0.000  0.446  0.000
## fc_sx.:rbn.  0.000  0.000  0.000 -0.510  0.000 -0.250   0.000
## rtr_s.:_.:.  0.000  0.000  0.000 -0.247  0.000 -0.495   0.000  0.446
```

6.7.2 Urbanization: without DC

```
model.urban.no.dc<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_sex.e*urb
an.s
                + (1 + face_sex.e || region_id:user_id)
                + (1 + rater_sex.e:face_sex.e || region_id)
                + (1 + rater_sex.e:asr.s || face_id),
                data.no.dc, REML = FALSE)
summary(model.urban)

## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula:
## rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * urban.s +
##     ((1 | region_id:user_id) + (0 + face_sex.e | region_id:user_id)) +
##     ((1 | region_id) + (0 + rater_sex.e:face_sex.e | region_id)) +
##     ((1 | face_id) + (0 + rater_sex.e:asr.s | face_id))
##    Data: data.all
##
##       AIC       BIC    logLik  deviance  df.resid
##  494635.2  494793.2 -247301.6  494603.2    143424
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1161 -0.4562  0.0778  0.5777  4.5405
##
## Random effects:
##  Groups              Name                   Variance  Std.Dev.
##  region_id.user_id   (Intercept)            0.5890052 0.76747
##  region_id.user_id.1 face_sex.e             0.4537996 0.67365
##  region_id           (Intercept)            0.0003106 0.01762
##  region_id.1         rater_sex.e:face_sex.e 0.0011167 0.03342
##  face_id             (Intercept)            0.0151000 0.12288
##  face_id.1           rater_sex.e:asr.s      0.0006531 0.02556
##  Residual                                   1.6632482 1.28967
## Number of obs: 143440, groups:
## region_id:user_id, 3586; region_id, 51; face_id, 20
##
## Fixed effects:
##                                 Estimate Std. Error         df t value
## (Intercept)                    8.038e-01  3.282e-02  3.900e+01  24.490
## rater_age.s                    2.502e-02  1.342e-02  3.584e+03   1.864
## rater_sex.e                   -2.193e-03  3.558e-02  3.578e+03  -0.062
## face_sex.e                     8.351e-01  1.754e-02  3.575e+03  47.620
## urban.s                       -5.112e-03  1.950e-02  9.100e+01  -0.262
## rater_sex.e:face_sex.e        -2.367e-02  3.555e-02  6.700e+01  -0.666
## rater_sex.e:urban.s            2.110e-02  3.809e-02  3.586e+03   0.554
## face_sex.e:urban.s             1.725e-02  1.888e-02  3.584e+03   0.913
## rater_sex.e:face_sex.e:urban.s 1.911e-02  3.850e-02  3.500e+01   0.496
##                               Pr(>|t|)
## (Intercept)                     <2e-16 ***
## rater_age.s                     0.0624 .
## rater_sex.e                     0.9509
## face_sex.e                      <2e-16 ***
## urban.s                         0.7938
## rater_sex.e:face_sex.e          0.5078
## rater_sex.e:urban.s             0.5797
## face_sex.e:urban.s              0.3610
## rater_sex.e:face_sex.e:urban.s  0.6229
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Correlation of Fixed Effects:
##              (Intr) rtr_g. rtr_s. fc_sx. urbn.s rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.011
## rater_sex.e  0.269 -0.104
## face_sex.e   0.000  0.000  0.000
## urban.s     -0.268 -0.071 -0.237  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.494  0.000
## rtr_sx.:rb. -0.136 -0.022 -0.505  0.000  0.446  0.000
## fc_sx.:rbn.  0.000  0.000  0.000 -0.510  0.000 -0.250   0.000
## rtr_s.:_.:.  0.000  0.000  0.000 -0.247  0.000 -0.495   0.000  0.446
```

6.7.3 Violent crime: with DC

```
model.violentCrime<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_sex.e*vi
olent.s
                + (1 + face_sex.e || user_id)
                + (1 + rater_sex.e:face_sex.e || region_id)
                + (1 + rater_sex.e:violent.s || face_id),
                data.all, REML = FALSE)
summary(model.violentCrime)

## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula:
## rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * violent.s +
##     ((1 | user_id) + (0 + face_sex.e | user_id)) + ((1 | region_id) +
##     (0 + rater_sex.e:face_sex.e | region_id)) + ((1 | face_id) +
##     (0 + rater_sex.e:violent.s | face_id))
##    Data: data.all
##
##      AIC       BIC    logLik  deviance  df.resid
##   494634.2  494792.1 -247301.1  494602.2    143424
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1168 -0.4561  0.0774  0.5772  4.5401
##
## Random effects:
##  Groups      Name                   Variance  Std.Dev.
##  user_id     (Intercept)            0.5887241 0.76728
##  user_id.1   face_sex.e             0.4536370 0.67353
##  region_id   (Intercept)            0.0003934 0.01983
##  region_id.1 rater_sex.e:face_sex.e 0.0010804 0.03287
##  face_id     (Intercept)            0.0150793 0.12280
##  face_id.1   rater_sex.e:violent.s  0.0000000 0.00000
##  Residual                           1.6633327 1.28970
## Number of obs: 143440, groups:  user_id, 3586; region_id, 51; face_id, 20
##
## Fixed effects:
##                                    Estimate Std. Error         df t value
## (Intercept)                       8.004e-01  3.167e-02  3.300e+01  25.276
## rater_age.s                       2.485e-02  1.339e-02  3.567e+03   1.855
## rater_sex.e                       3.819e-03  3.081e-02  3.581e+03   0.124
## face_sex.e                        8.452e-01  1.514e-02  3.573e+03  55.829
## violent.s                         2.360e-02  2.392e-02  3.460e+02   0.987
## rater_sex.e:face_sex.e           -1.069e-02  3.095e-02  2.300e+01  -0.345
## rater_sex.e:violent.s             5.959e-02  4.722e-02  3.579e+03   1.262
## face_sex.e:violent.s             -2.889e-02  2.341e-02  3.567e+03  -1.234
## rater_sex.e:face_sex.e:violent.s -5.015e-02  4.725e-02  1.240e+02  -1.061
##                                   Pr(>|t|)
## (Intercept)                         <2e-16 ***
## rater_age.s                         0.0636 .
## rater_sex.e                         0.9014
## face_sex.e                          <2e-16 ***
## violent.s                           0.3245
## rater_sex.e:face_sex.e              0.7330
## rater_sex.e:violent.s               0.2070
## face_sex.e:violent.s                0.2172
## rater_sex.e:face_sex.e:violent.s    0.2906
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##              (Intr) rtr_g. rtr_s. fc_sx. vlnt.s rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.031
## rater_sex.e  0.239 -0.135
## face_sex.e   0.000  0.000  0.000
## violent.s   -0.038 -0.010 -0.062  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.482  0.000
## rtr_sx.:vl. -0.032  0.015 -0.090  0.000  0.499  0.000
## fc_sx.:vln.  0.000  0.000  0.000 -0.089  0.000 -0.064   0.000
## rtr_s.:_.:.  0.000  0.000  0.000 -0.064  0.000 -0.081   0.000  0.501
```

6.7.4 Violent crime: without DC

```
model.violentCrime.no.dc<-lmer(rating.c ~ 1 + rater_age.s + rater_sex.e*face_se
x.e*violent.s
                + (1 + face_sex.e || user_id)
                + (1 + rater_sex.e:face_sex.e || region_id)
                + (1 + rater_sex.e:violent.s || face_id),
                data.no.dc, REML = FALSE)

summary(model.violentCrime.no.dc)
```

```
## Linear mixed model fit by maximum likelihood t-tests use Satterthwaite
##   approximations to degrees of freedom [lmerMod]
## Formula:
## rating.c ~ 1 + rater_age.s + rater_sex.e * face_sex.e * violent.s +
##     ((1 | user_id) + (0 + face_sex.e | user_id)) + ((1 | region_id) +
##     (0 + rater_sex.e:face_sex.e | region_id)) + ((1 | face_id) +
##     (0 + rater_sex.e:violent.s | face_id))
##    Data: data.no.dc
##
##       AIC       BIC    logLik  deviance  df.resid
##  492065.9  492223.8 -246017.0  492033.9    142664
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1171 -0.4558  0.0780  0.5770  4.5395
##
## Random effects:
##  Groups      Name                   Variance  Std.Dev.
##  user_id     (Intercept)            5.906e-01 7.685e-01
##  user_id.1   face_sex.e             4.529e-01 6.730e-01
##  region_id   (Intercept)            3.784e-04 1.945e-02
##  region_id.1 rater_sex.e:face_sex.e 1.149e-12 1.072e-06
##  face_id     (Intercept)            1.501e-02 1.225e-01
##  face_id.1   rater_sex.e:violent.s  0.000e+00 0.000e+00
##  Residual                           1.664e+00 1.290e+00
## Number of obs: 142680, groups:  user_id, 3567; region_id, 50; face_id, 20
##
## Fixed effects:
##                                    Estimate Std. Error         df t value
## (Intercept)                       8.010e-01  3.162e-02  3.300e+01  25.332
## rater_age.s                       2.545e-02  1.346e-02  3.548e+03   1.891
## rater_sex.e                       1.933e-03  3.088e-02  3.564e+03   0.063
## face_sex.e                        8.445e-01  1.513e-02  3.567e+03  55.798
## violent.s                         2.607e-02  2.884e-02  2.120e+02   0.904
## rater_sex.e:face_sex.e           -7.358e-03  3.027e-02  3.567e+03  -0.243
## rater_sex.e:violent.s             1.706e-02  5.674e-02  3.542e+03   0.301
## face_sex.e:violent.s             -3.434e-02  2.806e-02  3.567e+03  -1.224
## rater_sex.e:face_sex.e:violent.s  6.215e-03  5.613e-02  3.567e+03   0.111
##                                  Pr(>|t|)
## (Intercept)                        <2e-16 ***
## rater_age.s                        0.0586 .
## rater_sex.e                        0.9501
## face_sex.e                         <2e-16 ***
## violent.s                          0.3672
## rater_sex.e:face_sex.e             0.8079
## rater_sex.e:violent.s              0.7637
## face_sex.e:violent.s               0.2211
## rater_sex.e:face_sex.e:violent.s   0.9118
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Correlation of Fixed Effects:
##              (Intr) rtr_g. rtr_s. fc_sx. vlnt.s rt_.:_. rt_.:. fc_.:.
## rater_age.s -0.030
## rater_sex.e  0.240 -0.136
## face_sex.e   0.000  0.000  0.000
## violent.s   -0.022  0.009 -0.053  0.000
## rtr_sx.:f_.  0.000  0.000  0.000  0.491  0.000
## rtr_sx.:vl. -0.026  0.007 -0.059  0.000  0.508  0.000
## fc_sx.:vln.  0.000  0.000  0.000 -0.058  0.000 -0.054   0.000
## rtr_s.:_.:.  0.000  0.000  0.000 -0.054  0.000 -0.058   0.000  0.518
```

6.7.5 Additional Analysis

In addition to the main research question of this project we investigated potential individual differences in the extent to which men and women ascribed high dominance to masculinized versus feminized versions of faces, by state using violent crime rates as the independent variable. We predicted that people would ascribe high dominance to masculinized versus feminized versions of faces to a greater extent in states where violent crime rates were higher.

Violent crime statistics (number of violent crimes per 100,000 people) were obtained from the 2013/2014 report of the US Social Science Research Council's Measure of America Project (http://www.measureofamerica.org/measure_of_america2013-2014/). Data provided in this report are for 2010.

We repeated the analyses described in the main manuscript, this time with violent crime rates (centered on mean for states and scaled) in place of the independent variable adult sex ratio. This analysis also showed a significant intercept (beta=0.80, t=25.3, p<.001), a significant effect of face sex (beta= 0.85, t=55.8, p<.001), and a near-significant trend for participant age (beta=0.02, t=1.86, p=.064). No other effects were significant or near significant (all absolute beta<0.06, all absolute t<1.27, all p>.20). Repeating this analysis with Washington DC excluded from the data set showed the same pattern of significant and near-significant results.

Additionally, adult sex ratio and violent crime rates were significantly negatively correlated when Washington DC was included in the dataset (r=-.30, N=51, p<.001), but not when Washington DC was excluded from the dataset (r=-.11, N=50, p=.44). The difference between these correlations reflect Washington DC's status as an outlier for both adult sex ratio (0.91; mean for all states=1.01, SD=0.03) and violent crime rate (1244; mean for all states=371, SD=179).

Head Tilt and Social Perceptions

6.8 Head Tilt And Dominance / Trustworthiness (Study 1)

JSTorrance

06/09/2019

.e denotes 'effect coded', _c denotes 'centered', _s denotes 'scaled'

6.8.1.1 Load Data

```
dat <- read.csv("DOM_TRUST_ANON.csv")
```

6.8.1.2 Descriptives

```
DescStats <- dat %>%
  group_by(sex) %>%
  summarise(Count= n(), MeanAge = mean(age), AgeSD = sd(age))

## `summarise()` ungrouping output (override with `.groups` argument)

JudgeN <- dat %>%
  count(sex, judgement) %>%
  spread(judgement, n)

UniqueN <- dat %>%
  select(user_id) %>%
  unique()%>%
  summarise(Count = n())

knitr::kable(DescStats, digits = 2)
```

sex	Count	MeanAge	AgeSD
female	65	26.45	10.59
male	44	29.70	9.69
na	6	27.87	6.85

```
knitr::kable(JudgeN)
```

sex	dominance	trustworthiness
female	32	33
male	22	22
na	3	3

6.8.2 Tidy dataset

6.8.2.1 Remove participants w/ unreported Sex, and centre age on sample mean

```
data <- dat %>%
  filter(sex!="na") %>%
  mutate(age_c = age - mean(age))
```

6.8.2.2 Turn Data into long format, and add effect coding

Effect code participant (rater) sex, and face sex (women = -0.5, men = 0.5); Head Tilt (down = -0.5, neutral = 0, up = 0.5); and judgement type (trustworthiness = -0.5, dominance = 0.5)

```
data.long <- data %>%
  group_by(user_id) %>%
  gather(trial, rating, female_09328358_m10:male_90280196_p10) %>%
  separate(trial, into=c("face_sex", "face_id", "head_tilt")) %>%
  mutate(sex.e = recode(sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(face_sex.e = recode(face_sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(head_tilt.e = recode(head_tilt, "p10" = 0.5, "m10" = -0.5, "neutral" =
0)) %>%
  mutate(judge.e = recode(judgement, "dominance" = 0.5, "trustworthiness" = -0.
5))
```

optimise data for ordinal modelling

```
data.long.o <- data.long %>%
  ungroup() %>%
  mutate(rating.o = as.ordered(as.integer(data.long$rating)))
```

6.8.3 Omnibus Model w/ Dominance & Trust coded as conditions

```
model.omni.o <- clmm(rating.o ~ 1 + sex.e*face_sex.e*head_tilt.e*judge.e
                + (1 | user_id)
                + (1 | face_id)
                + (0 + face_sex.e:head_tilt.e| user_id)
                + (0 + sex.e:head_tilt.e:judge.e| face_id), data.long.o, Hess =
TRUE)
summary(model.omni.o)
```

```
## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: rating.o ~ 1 + sex.e * face_sex.e * head_tilt.e * judge.e + (1 |
##     user_id) + (1 | face_id) + (0 + face_sex.e:head_tilt.e |
##     user_id) + (0 + sex.e:head_tilt.e:judge.e | face_id)
## data:    data.long.o
##
##  link  threshold nobs logLik    AIC      niter       max.grad cond.H
##  logit flexible  6540 -10424.09 20898.19 4533(27313) 3.60e-03 3.2e+03
##
## Random effects:
##  Groups  Name                      Variance  Std.Dev.
##  user_id face_sex.e:head_tilt.e    1.565e-11 3.956e-06
##  user_id (Intercept)               2.242e+00 1.497e+00
##  face_id sex.e:head_tilt.e:judge.e 2.402e-02 1.550e-01
##  face_id (Intercept)               1.054e-01 3.246e-01
## Number of groups:  user_id 109,  face_id 20
##
## Coefficients:
##                                       Estimate Std. Error z value Pr(>|z|)
## sex.e                                 -0.13537    0.29649  -0.457   0.6480
## face_sex.e                            -0.19512    0.15233  -1.281   0.2002
## head_tilt.e                            0.08319    0.05644   1.474   0.1405
## judge.e                                0.39266    0.29653   1.324   0.1854
## sex.e:face_sex.e                       0.56528    0.09235   6.121 9.28e-10
## sex.e:head_tilt.e                     -0.25029    0.11288  -2.217   0.0266
## face_sex.e:head_tilt.e                -0.20851    0.11283  -1.848   0.0646
## sex.e:judge.e                         -0.75796    0.59311  -1.278   0.2013
## face_sex.e:judge.e                     1.28937    0.09313  13.846  < 2e-16
## head_tilt.e:judge.e                   -0.71676    0.11315  -6.334 2.38e-10
## sex.e:face_sex.e:head_tilt.e          -0.08402    0.22558  -0.372   0.7096
## sex.e:face_sex.e:judge.e              -0.28366    0.18431  -1.539   0.1238
## sex.e:head_tilt.e:judge.e             -0.06360    0.22831  -0.279   0.7806
## face_sex.e:head_tilt.e:judge.e        -0.12595    0.22558  -0.558   0.5766
## sex.e:face_sex.e:head_tilt.e:judge.e   0.33240    0.45645   0.728   0.4665
##
## sex.e
## face_sex.e
## head_tilt.e
## judge.e
## sex.e:face_sex.e                      ***
## sex.e:head_tilt.e                     *
## face_sex.e:head_tilt.e                .
## sex.e:judge.e
## face_sex.e:judge.e                    ***
## head_tilt.e:judge.e                   ***
## sex.e:face_sex.e:head_tilt.e
## sex.e:face_sex.e:judge.e
## sex.e:head_tilt.e:judge.e
## face_sex.e:head_tilt.e:judge.e
## sex.e:face_sex.e:head_tilt.e:judge.e
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2  -2.6845     0.1713 -15.676
## 2|3  -1.1780     0.1669  -7.059
## 3|4   0.1765     0.1660   1.063
## 4|5   1.3943     0.1666   8.370
## 5|6   2.7875     0.1696  16.433
## 6|7   4.4420     0.1846  24.064
```

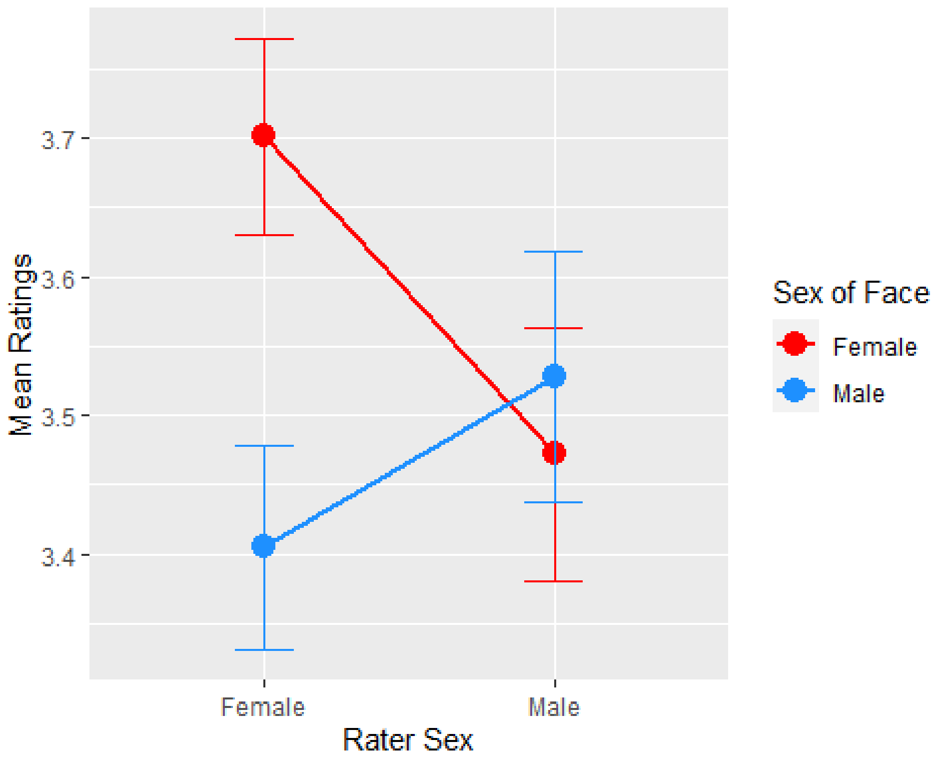
Data for interaction plots

```
plot.data <- group_by(data.long, user_id, face_sex, head_tilt, sex, judgement)
%>%
  summarise(rating.m = mean(rating,na.rm = TRUE)) %>%
  ungroup() %>%
  filter(sex != "na", !is.na(head_tilt)) %>% # removes empty factor categories
  select(user_id, rating.m, head_tilt, face_sex, sex, judgement)

## `summarise()` regrouping output by 'user_id', 'face_sex', 'head_tilt', 'sex'
(override with `.groups` argument)

## Warning: `fun.y` is deprecated. Use `fun` instead.
```

6.8.4 Plot of Rater Sex and Face Sex Interaction

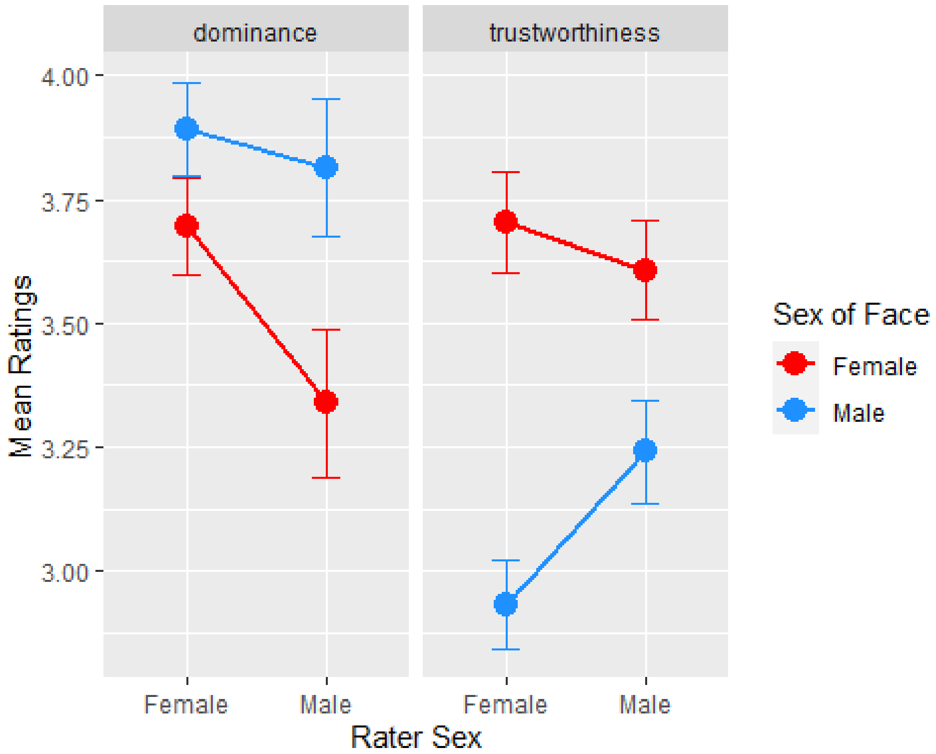
####Plot not presented in manuscript

```
## `geom_smooth()` using formula 'y ~ x'
```



####Alternative version of Rater Sex and Face Sex Interaction plot split by judgement type to facilitate interpretation ####Plot not presented in manuscript

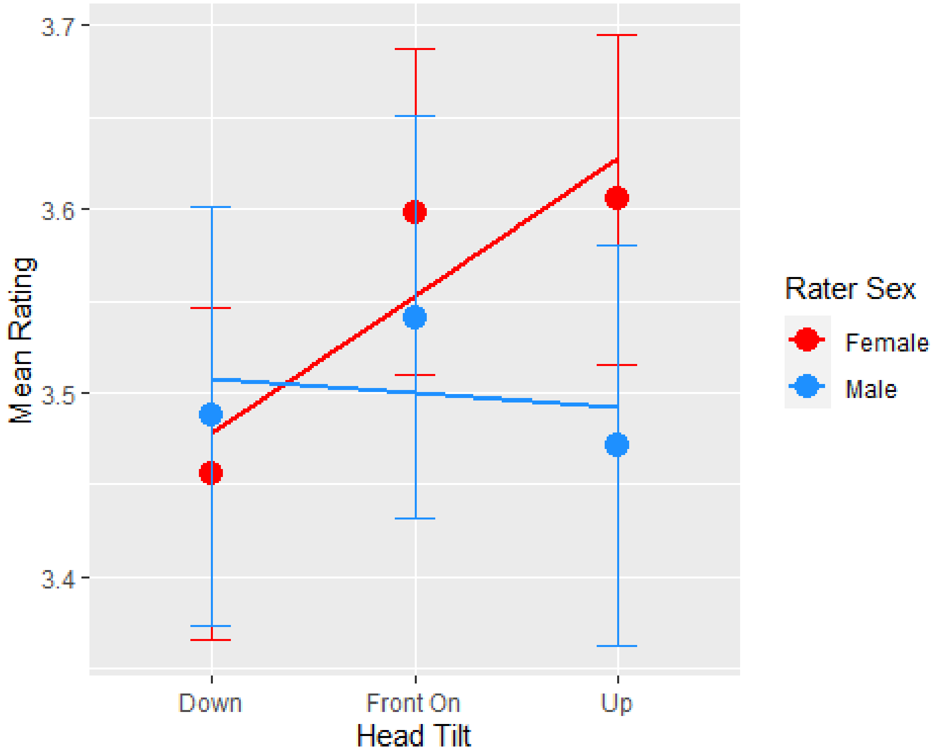
```
## `geom_smooth()` using formula 'y ~ x'
```



6.8.5 Plot of Head Tilt and Rater Sex Interaction

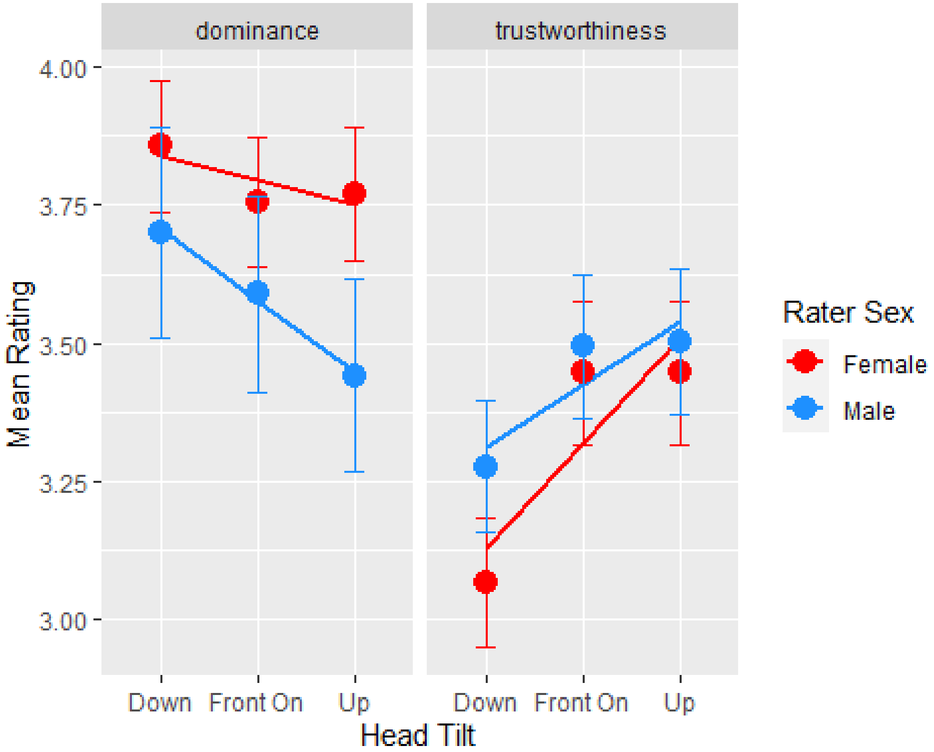
####Plot not presented in manuscript

```
## `geom_smooth()` using formula 'y ~ x'
```



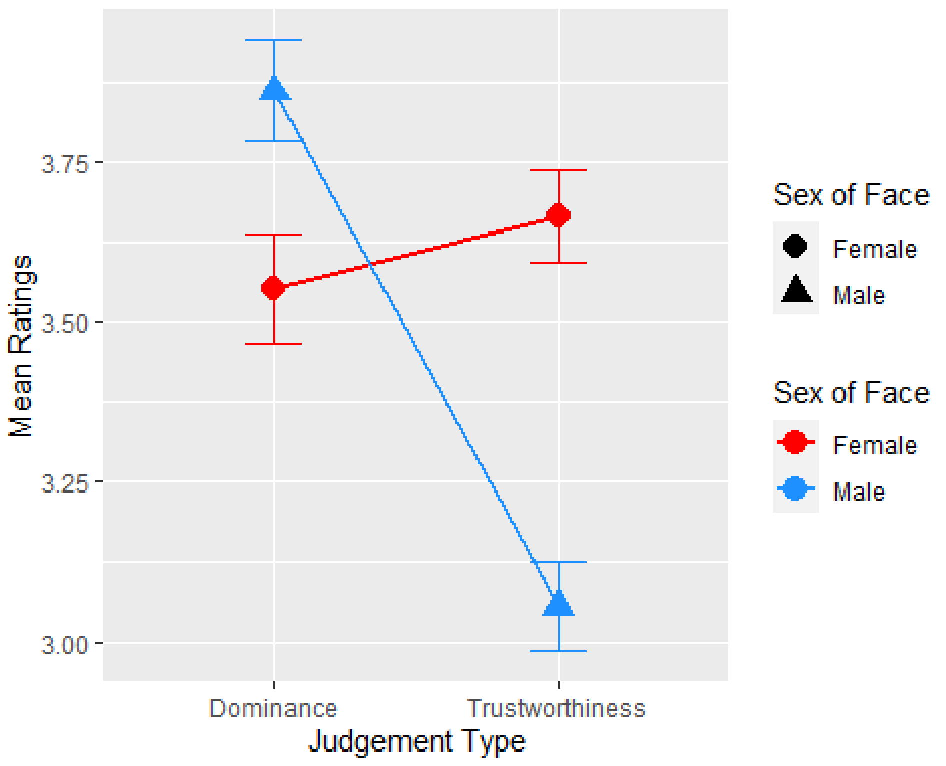
####Alternative version of Head Tilt and Rater Sex Interaction plot split by judgement type to facilitate interpretation ####Plot not presented in manuscript

```
## `geom_smooth()` using formula 'y ~ x'
```



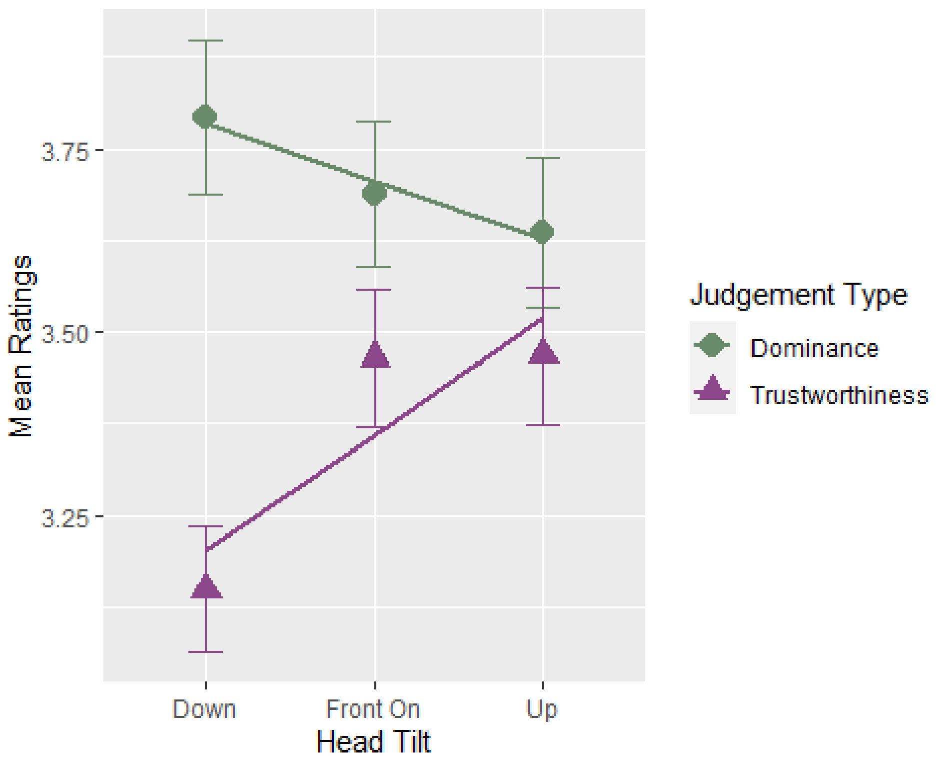
6.8.6 Plot of Face Sex and Judgement Type Interaction

```
## `geom_smooth()` using formula 'y ~ x'
```



6.8.7 Plot of Head Tilt and Judgement Type Interaction

```
## `geom_smooth()` using formula 'y ~ x'
```



6.9 Head Tilt And Leadership (Study 2)

JSTorrance

06/09/2019

.e denotes 'effect coded', _c denotes 'centered', _s denotes 'scaled'

6.9.1.1 Load Data

```
data <- read.csv("HEADTILT_LEADERSHIP_ANON.csv")
```

6.9.1.2 Descriptives

```
DescStats <- data %>%
  group_by(sex) %>%
  summarise(Count= n(), MeanAge = mean(age), AgeSD = sd(age))

## `summarise()` ungrouping output (override with `.groups` argument)

ContextN <- data %>%
  count(sex, context) %>%
  spread(context, n)

knitr::kable(DescStats, digits = 2)
```

sex	Count	MeanAge	AgeSD
female	55	27.87	10.77
male	46	29.49	10.11

```
knitr::kable(ContextN)
```

sex	peace	war
female	27	28
male	23	23

6.9.2 Tidy dataset

6.9.2.1 Turn Data into long format, and add effect coding

Effect code participant (Rater) sex, and face sex (women = -0.5, men = 0.5); Head Tilt (down = -0.5, neutral = 0, up = 0.5); and context (war = -0.5, peace = 0.5)

```
data.long <- data %>%
  group_by(user_id) %>%
  gather(trial, rating, female_09328358_m10:male_90280196_p10) %>%
  separate(trial, into=c("face_sex", "face_id", "head_tilt")) %>%
  mutate(sex.e = recode(sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(face_sex.e = recode(face_sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(head_tilt.e = recode(head_tilt, "p10" = 0.5, "m10" = -0.5, "neutral" =
0)) %>%
  mutate(context.e = recode(context, "peace" = 0.5, "war" = -0.5))
```

optimise data for ordinal modelling

```
data.long.o <- data.long %>%
  ungroup() %>%
  mutate(rating.o = as.ordered(as.integer(data.long$rating)))
```

6.9.3 Ordinal Model

```
model.o <- clmm(rating.o ~ 1 + sex.e*face_sex.e*head_tilt.e*context.e
                + (1 | user_id)
                + (1 | face_id)
                + (0 + face_sex.e:head_tilt.e| user_id)
                + (0 + sex.e:head_tilt.e:context.e| face_id), data.long.o, Hess
= TRUE)
summary(model.o)
```

```
## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: rating.o ~ 1 + sex.e * face_sex.e * head_tilt.e * context.e +
##     (1 | user_id) + (1 | face_id) + (0 + face_sex.e:head_tilt.e |
##     user_id) + (0 + sex.e:head_tilt.e:context.e | face_id)
## data:    data.long.o
##
##  link  threshold nobs logLik   AIC      niter       max.grad cond.H
##  logit flexible  6060 -9988.62 20027.24 4232(22060) 1.21e-02 8.0e+02
##
## Random effects:
##  Groups  Name                        Variance  Std.Dev.
##  user_id face_sex.e:head_tilt.e      1.744e-10 1.321e-05
##  user_id (Intercept)                 1.537e+00 1.240e+00
##  face_id sex.e:head_tilt.e:context.e 0.000e+00 0.000e+00
##  face_id (Intercept)                 2.096e-01 4.578e-01
## Number of groups:  user_id 101,  face_id 20
##
## Coefficients:
##                                       Estimate Std. Error z value
## sex.e                                  0.49099    0.25260   1.944
## face_sex.e                            -0.17193    0.21001  -0.819
## head_tilt.e                            0.08529    0.05704   1.495
## context.e                              0.33019    0.25260   1.307
## sex.e:face_sex.e                       0.37428    0.09347   4.004
## sex.e:head_tilt.e                     -0.03905    0.11405  -0.342
## face_sex.e:head_tilt.e                -0.22931    0.11411  -2.010
## sex.e:context.e                       -0.37481    0.50511  -0.742
## face_sex.e:context.e                  -0.91934    0.09391  -9.790
## head_tilt.e:context.e                  0.00827    0.11404   0.073
## sex.e:face_sex.e:head_tilt.e           0.30812    0.22818   1.350
## sex.e:face_sex.e:context.e             0.15421    0.18674   0.826
## sex.e:head_tilt.e:context.e           -0.01151    0.22807  -0.050
## face_sex.e:head_tilt.e:context.e       0.04970    0.22813   0.218
## sex.e:face_sex.e:head_tilt.e:context.e -0.24660    0.45623  -0.541
##                                       Pr(>|z|)
## sex.e                                   0.0519 .
## face_sex.e                              0.4130
## head_tilt.e                             0.1349
## context.e                               0.1912
## sex.e:face_sex.e                      6.23e-05 ***
## sex.e:head_tilt.e                       0.7321
## face_sex.e:head_tilt.e                  0.0445 *
## sex.e:context.e                         0.4581
## face_sex.e:context.e                   < 2e-16 ***
## head_tilt.e:context.e                   0.9422
## sex.e:face_sex.e:head_tilt.e            0.1769
## sex.e:face_sex.e:context.e              0.4089
```

```
## sex.e:head_tilt.e:context.e              0.9598
## face_sex.e:head_tilt.e:context.e         0.8276
## sex.e:face_sex.e:head_tilt.e:context.e   0.5888
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2 -2.42205    0.16744 -14.466
## 2|3 -1.06884    0.16422  -6.509
## 3|4  0.07184    0.16355   0.439
## 4|5  1.34488    0.16423   8.189
## 5|6  2.62294    0.16723  15.684
## 6|7  4.10407    0.17960  22.851
```

Data for interaction plots

```
plot.data <- group_by(data.long, user_id, face_sex, head_tilt, sex, context) %>
%
  summarise(rating.m = mean(rating,na.rm = TRUE)) %>%
  ungroup() %>%
  filter(sex != "na", !is.na(head_tilt)) %>% # removes empty factor categories
  select(user_id, rating.m, head_tilt, face_sex, sex, context)
```

```
## `summarise()` regrouping output by 'user_id', 'face_sex', 'head_tilt', 'sex'
(override with `.groups` argument)
```

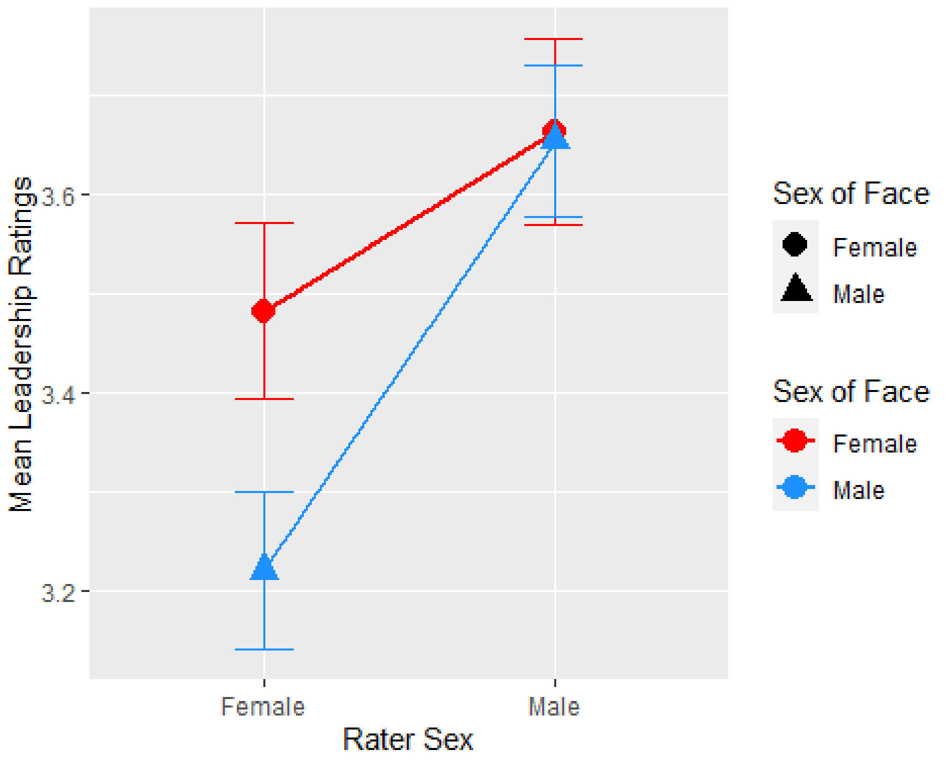
```
## Warning: `fun.y` is deprecated. Use `fun` instead.
```

```
## <ggproto object: Class ScaleDiscrete, Scale, gg>
##     aesthetics: shape
##     axis_order: function
##     break_info: function
##     break_positions: function
##     breaks: waiver
##     call: call
##     clone: function
##     dimension: function
##     drop: TRUE
##     expand: waiver
##     get_breaks: function
##     get_breaks_minor: function
##     get_labels: function
##     get_limits: function
##     guide: legend
##     is_discrete: function
##     is_empty: function
##     labels: Dominance Trustworthiness
##     limits: NULL
##     make_sec_title: function
##     make_title: function
##     map: function
##     map_df: function
##     n.breaks.cache: NULL
##     na.translate: TRUE
##     na.value: NA
##     name: Judgement Type
##     palette: function
##     palette.cache: NULL
##     position: left
##     range: <ggproto object: Class RangeDiscrete, Range, gg>
##         range: NULL
##         reset: function
```

```
##         train: function
##         super:  <ggproto object: Class RangeDiscrete, Range, gg>
##     rescale: function
##     reset: function
##     scale_name: manual
##     train: function
##     train_df: function
##     transform: function
##     transform_df: function
##     super:  <ggproto object: Class ScaleDiscrete, Scale, gg>
```

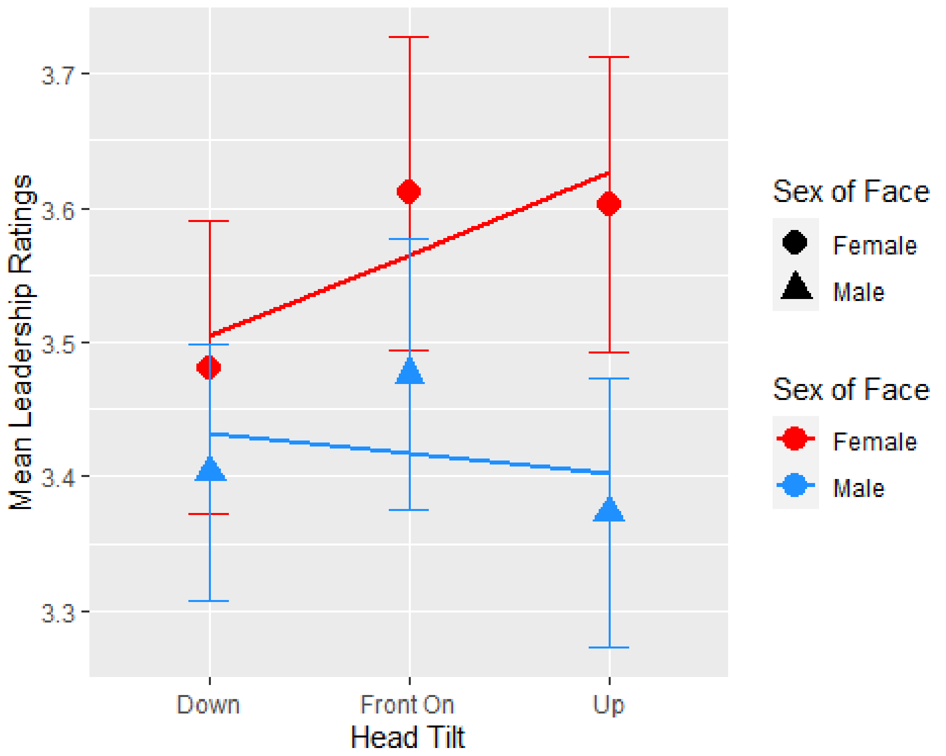
6.9.4 Rater Sex and Face Sex Interaction

```
## `geom_smooth()` using formula 'y ~ x'
```



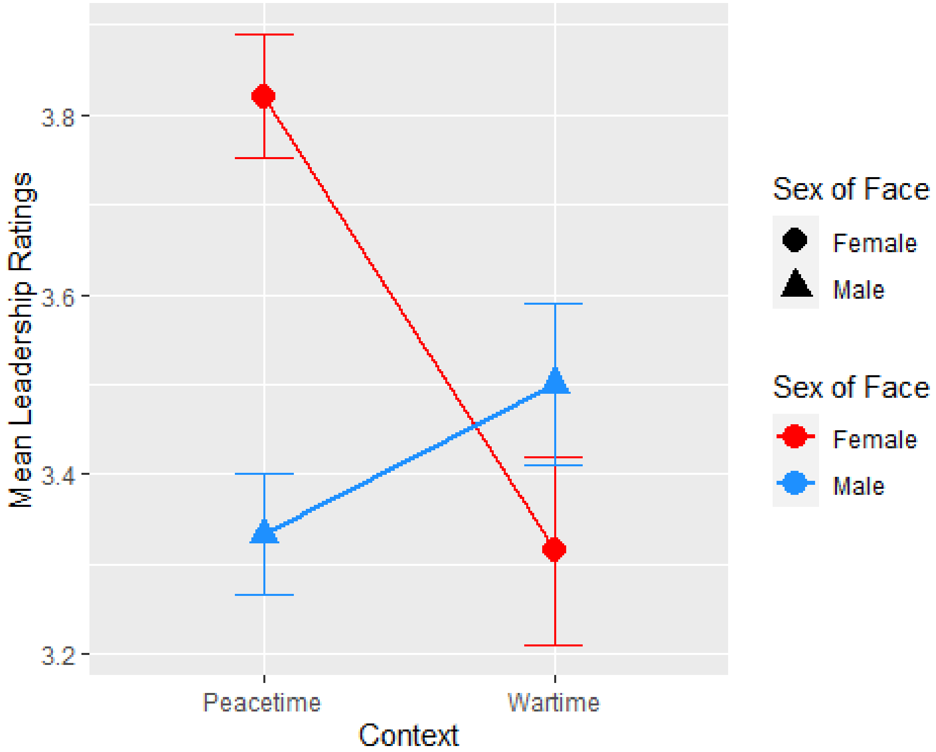
6.9.5 Face Sex and Head Tilt Interaction

```
## `geom_smooth()` using formula 'y ~ x'
```



6.9.6 Face Sex and Context Interaction

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10 Head Tilt And Leadership (Additional Analyses)

JSTorrance

06/09/2019

.e denotes 'coded', _c denotes 'centered', _s denotes 'scaled'

6.10.1.1 Load Data

```
dat_L <- read.csv("HEADTILT_LEADERSHIP_ANON.csv")
dat_DT <- read.csv("DOM_TRUST_ANON.csv")
```

6.10.2 Additional analysis for Study 1 - unpacking effects of Head Tilt on Dominance and Trustworthiness individually

6.10.2.1 Tidy dataset

6.10.2.1.1 Remove participants w/ unreported Sex, and centre age on sample mean

```
data_DT <- dat_DT %>%
  filter(sex!="na") %>%
  mutate(age_c = age - mean(age))
```

6.10.2.1.2 Turn Data into long format, and add effect coding

Effect code participant (rater) sex, and face sex (women = -0.5, men = 0.5); Head Tilt (down = -0.5, neutral = 0, up = 0.5); and judgement type (trustworthiness = -0.5, dominance = 0.5)

```
data.long1<-data_DT%>%
  group_by(user_id)%>%
  gather(trial, rating, female_09328358_m10:male_90280196_p10)%>%
  separate(trial, into=c("face_sex", "face_id", "head_tilt"))%>%
  mutate(sex.e = recode(sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(face_sex.e = recode(face_sex, "male" = 0.5, "female" = -0.5))%>%
  mutate(head_tilt.e = recode(head_tilt, "p10" = 0.5, "m10" = -0.5, "neutral" =
0))%>%
  mutate(judge.e = recode(judgement, "dominance" = 0.5, "trustworthiness" = -0.
5))
```

optimise data for ordinal modelling

```
data.long.o1 <- data.long1 %>%
  ungroup() %>%
  mutate(rating.o = as.ordered(as.integer(data.long1$rating)))

data.dom.o <- data.long.o1 %>%
  filter(judgement=="dominance")

data.trust.o <- data.long.o1 %>%
  filter (judgement=="trustworthiness")
```

6.10.3 Ordinal Model w/ Dominance

```
model.dom.o<-clmm(rating.o ~ 1 + sex.e*face_sex.e*head_tilt.e
                  + (1 | user_id)
                  + (1 | face_id)
```

```
                + (0 + face_sex.e:head_tilt.e| user_id)
                + (0 + sex.e:head_tilt.e| face_id), data.dom.o, Hess = TRUE)
summary(model.dom.o)

## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula:
## rating.o ~ 1 + sex.e * face_sex.e * head_tilt.e + (1 | user_id) +
##     (1 | face_id) + (0 + face_sex.e:head_tilt.e | user_id) +
##     (0 + sex.e:head_tilt.e | face_id)
## data:    data.dom.o
##
##  link  threshold nobs logLik   AIC      niter       max.grad cond.H
##  logit flexible  3240 -5237.72 10509.44 1887(11312) 1.74e-02 7.0e+02
##
## Random effects:
##  Groups  Name                   Variance  Std.Dev.
##  user_id face_sex.e:head_tilt.e 1.953e-10 1.397e-05
##  user_id (Intercept)            2.607e+00 1.615e+00
##  face_id sex.e:head_tilt.e      2.758e-11 5.252e-06
##  face_id (Intercept)            3.144e-01 5.607e-01
## Number of groups:  user_id 54,  face_id 20
##
## Coefficients:
##                                Estimate Std. Error z value Pr(>|z|)
## sex.e                          -0.51576    0.45351  -1.137  0.25543
## face_sex.e                      0.46056    0.25937   1.776  0.07578 .
## head_tilt.e                    -0.26600    0.08089  -3.288  0.00101 **
## sex.e:face_sex.e                0.41017    0.13199   3.108  0.00189 **
## sex.e:head_tilt.e              -0.26412    0.16154  -1.635  0.10206
## face_sex.e:head_tilt.e         -0.29588    0.16153  -1.832  0.06699 .
## sex.e:face_sex.e:head_tilt.e  0.06577    0.32291   0.204  0.83860
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2 -2.76349    0.26787 -10.316
## 2|3 -1.31006    0.26177  -5.005
## 3|4  0.02263    0.26035   0.087
## 4|5  1.11270    0.26074   4.267
## 5|6  2.52481    0.26372   9.574
## 6|7  4.11200    0.27652  14.871
```

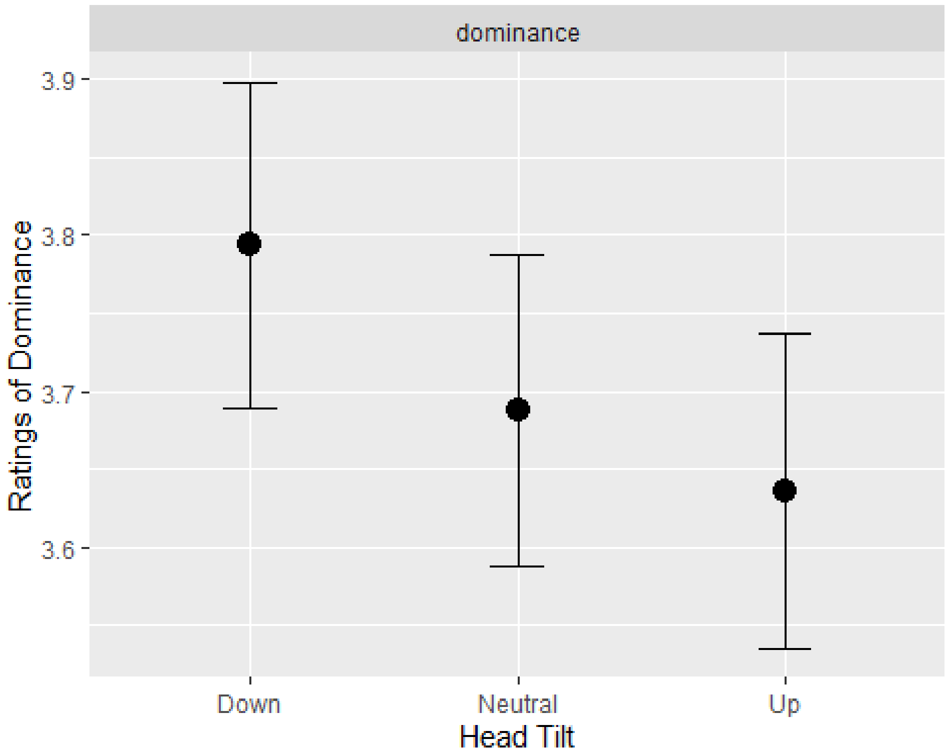
Data for interaction plots

```
plot.data <- group_by(data.long1, user_id, face_sex, head_tilt, sex, judgement)
%>%
  summarise(rating.m = mean(rating,na.rm = TRUE)) %>%
  ungroup() %>%
  filter(sex != "na", !is.na(head_tilt)) %>% # removes empty factor categories
  select(user_id, rating.m, head_tilt, face_sex, sex, judgement)

## `summarise()` regrouping output by 'user_id', 'face_sex', 'head_tilt', 'sex'
(override with `.groups` argument)

## Warning: `fun.y` is deprecated. Use `fun` instead.
```

6.10.3.1 Dominance Judgement Plots

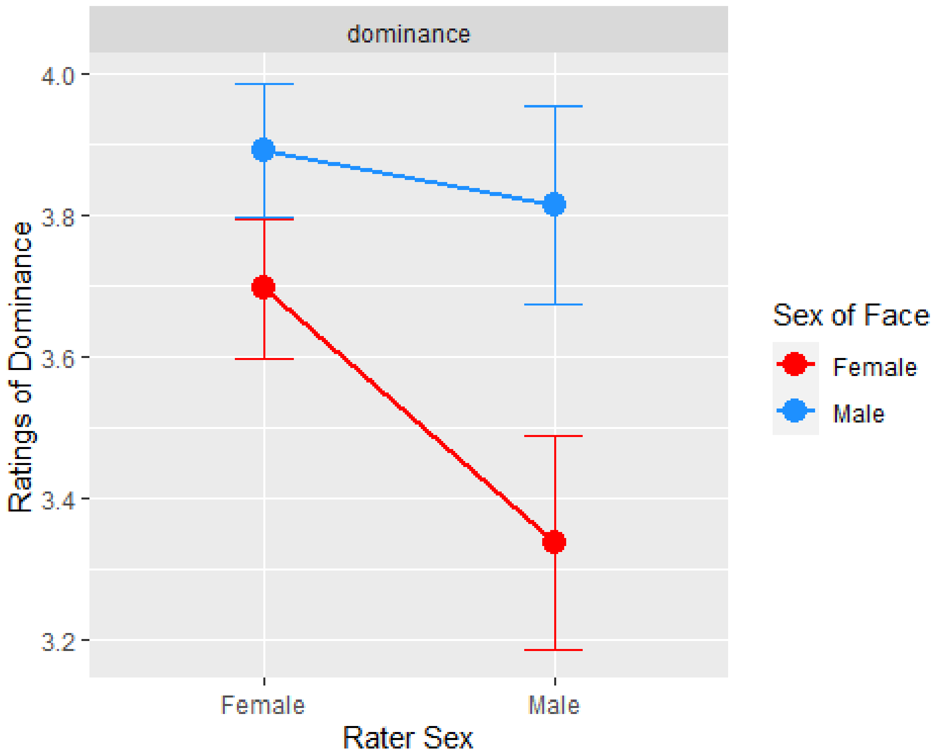
6.10.3.1.1 Plot of Head Tilt Main effect

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10.3.1.2 Plot of Rater Sex and Face Sex

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10.4 Ordinal Model w/ Trustworthiness

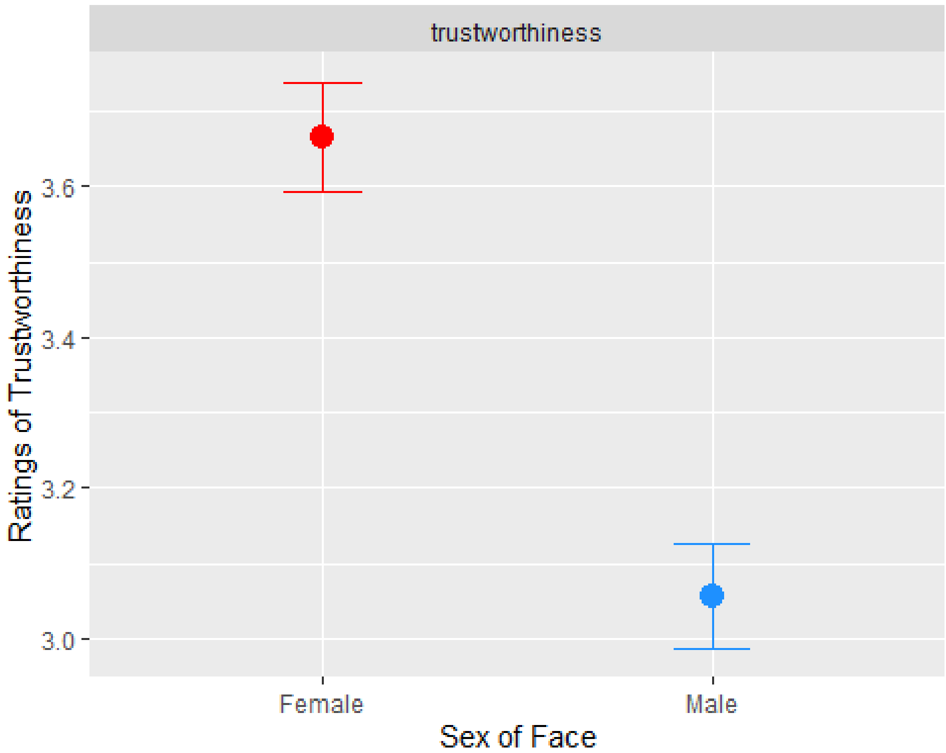
```
model.trust.o <- clmm(rating.o ~ 1 + sex.e*face_sex.e*head_tilt.e
                      + (1 | user_id)
                      + (1 | face_id)
                      + (0 + face_sex.e:head_tilt.e| user_id)
```

```
                + (0 + sex.e:head_tilt.e| face_id), data.trust.o, Hess = TRUE)
summary(model.trust.o)

## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula:
## rating.o ~ 1 + sex.e * face_sex.e * head_tilt.e + (1 | user_id) +
##     (1 | face_id) + (0 + face_sex.e:head_tilt.e | user_id) +
##     (0 + sex.e:head_tilt.e | face_id)
## data:    data.trust.o
##
##  link  threshold nobs logLik   AIC     niter       max.grad cond.H
##  logit flexible  3300 -4963.15 9960.30 2018(12132) 3.26e-03 5.1e+02
##
## Random effects:
##  Groups  Name                   Variance  Std.Dev.
##  user_id face_sex.e:head_tilt.e 1.742e-09 4.174e-05
##  user_id (Intercept)            2.264e+00 1.505e+00
##  face_id sex.e:head_tilt.e      9.888e-02 3.145e-01
##  face_id (Intercept)            4.118e-01 6.417e-01
## Number of groups:  user_id 55,  face_id 20
##
## Coefficients:
##                              Estimate Std. Error z value Pr(>|z|)
## sex.e                         0.25897    0.41955   0.617  0.53708
## face_sex.e                   -0.95773    0.29460  -3.251  0.00115 **
## head_tilt.e                   0.50713    0.07994   6.344 2.24e-10 ***
## sex.e:face_sex.e              0.78961    0.13028   6.061 1.35e-09 ***
## sex.e:head_tilt.e            -0.24357    0.17388  -1.401  0.16128
## face_sex.e:head_tilt.e       -0.17901    0.15900  -1.126  0.26024
## sex.e:face_sex.e:head_tilt.e -0.23830    0.34758  -0.686  0.49297
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##     Estimate Std. Error z value
## 1|2  -2.7779     0.2622 -10.594
## 2|3  -1.1388     0.2565  -4.440
## 3|4   0.3440     0.2555   1.346
## 4|5   1.8355     0.2571   7.140
## 5|6   3.3683     0.2635  12.785
## 6|7   5.3592     0.3052  17.559
```

6.10.4.1 Trustworthiness Judgement Plots

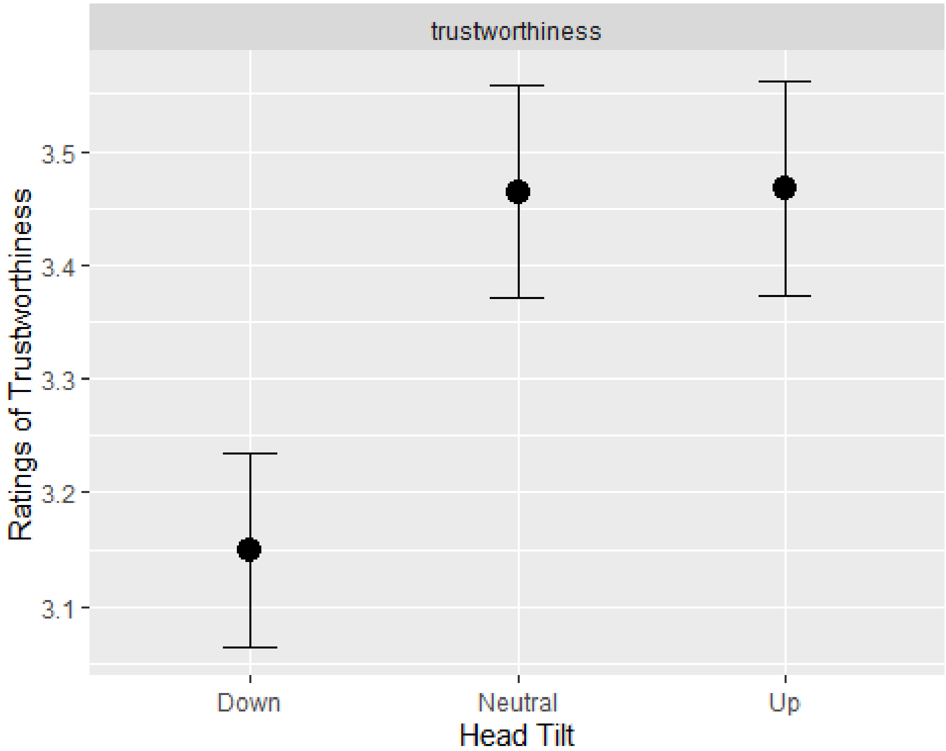
6.10.4.1.1 Plot of Main effect of face sex

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10.4.1.2 Plot of Head Tilt Main effect

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10.4.1.3 Plot of Rater Sex and Face Sex

```
## `geom_smooth()` using formula 'y ~ x'
```

6.10.5 Additional analysis for Study 2

Rerunning the analysis without the head tilt up condition.

6.10.5.1.1 Turn Data into long format, and add effect coding

Effect code participant (Rater) sex, and face sex (women = -0.5, men = 0.5); Head Tilt (down = -0.5, neutral = 0, up = 0.5); and context (war = -0.5, peace = 0.5)

```
data.long2<-dat_L%>%
  group_by(user_id)%>%
  gather(trial, rating, female_09328358_m10:male_90280196_p10)%>%
  separate(trial, into=c("face_sex", "face_id", "head_tilt"))%>%
  mutate(sex.e = recode(sex, "male" = 0.5, "female" = -0.5)) %>%
  mutate(face_sex.e = recode(face_sex, "male" = 0.5, "female" = -0.5))%>%
  mutate(head_tilt.e = recode(head_tilt, "p10" = 0.5, "m10" = -0.5, "neutral" =
0))%>%
  mutate(context.e = recode(context, "peace" = 0.5, "war" = -0.5))
```

optimise data for ordinal modelling and filter out the head up condition

```
data.long.o2 <- data.long2 %>%
  ungroup() %>%
  mutate(rating.o = as.ordered(as.integer(data.long2$rating)))

data.long.o.noup <- data.long.o2 %>%
  filter(head_tilt!="p10")
```

6.10.5.2 Ordinal Model w/out head tilt up

```
model.o2<-clmm(rating.o ~ 1 + sex.e*face_sex.e*head_tilt.e*context.e
               + (1 | user_id)
               + (1 | face_id)
               + (0 + face_sex.e:head_tilt.e| user_id)
               + (0 + sex.e:head_tilt.e:context.e| face_id), data.long.o.noup,
Hess = TRUE)
summary(model.o2)

## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: rating.o ~ 1 + sex.e * face_sex.e * head_tilt.e * context.e +
##     (1 | user_id) + (1 | face_id) + (0 + face_sex.e:head_tilt.e |
##     user_id) + (0 + sex.e:head_tilt.e:context.e | face_id)
## data:    data.long.o.noup
##
##  link  threshold nobs logLik   AIC      niter       max.grad cond.H
##  logit flexible  4040 -6585.80 13221.61 3693(25354) 5.51e-03 6.0e+03
##
## Random effects:
##  Groups  Name                        Variance Std.Dev.
##  user_id face_sex.e:head_tilt.e      13.9025  3.7286
##  user_id (Intercept)                  1.6990  1.3034
##  face_id sex.e:head_tilt.e:context.e  0.7678  0.8762
##  face_id (Intercept)                  0.2651  0.5149
## Number of groups:  user_id 101,  face_id 20
##
## Coefficients:
##                                       Estimate Std. Error z value
## sex.e                                  0.53963    0.27375   1.971
## face_sex.e                            -0.14553    0.24448  -0.595
## head_tilt.e                            0.34034    0.11544   2.948
## context.e                              0.28778    0.27370   1.051
## sex.e:face_sex.e                       0.52097    0.16447   3.168
## sex.e:head_tilt.e                     -0.01664    0.23064  -0.072
## face_sex.e:head_tilt.e                 0.02265    0.43939   0.052
## sex.e:context.e                       -0.47766    0.54733  -0.873
## face_sex.e:context.e                  -1.24232    0.16509  -7.525
## head_tilt.e:context.e                 -0.11062    0.23061  -0.480
## sex.e:face_sex.e:head_tilt.e           0.71563    0.87900   0.814
## sex.e:face_sex.e:context.e             0.09487    0.32848   0.289
## sex.e:head_tilt.e:context.e           -0.17655    0.50119  -0.352
## face_sex.e:head_tilt.e:context.e      -0.84573    0.87891  -0.962
## sex.e:face_sex.e:head_tilt.e:context.e -0.52510    1.80105  -0.292
##                                       Pr(>|z|)
## sex.e                                  0.04870 *
## face_sex.e                             0.55167
## head_tilt.e                            0.00320 **
## context.e                              0.29306
## sex.e:face_sex.e                       0.00154 **
## sex.e:head_tilt.e                      0.94247
## face_sex.e:head_tilt.e                 0.95889
## sex.e:context.e                        0.38282
## face_sex.e:context.e                  5.27e-14 ***
## head_tilt.e:context.e                  0.63144
## sex.e:face_sex.e:head_tilt.e           0.41556
## sex.e:face_sex.e:context.e             0.77272
## sex.e:head_tilt.e:context.e            0.72464
## face_sex.e:head_tilt.e:context.e       0.33593
## sex.e:face_sex.e:head_tilt.e:context.e  0.77063
## ---
```

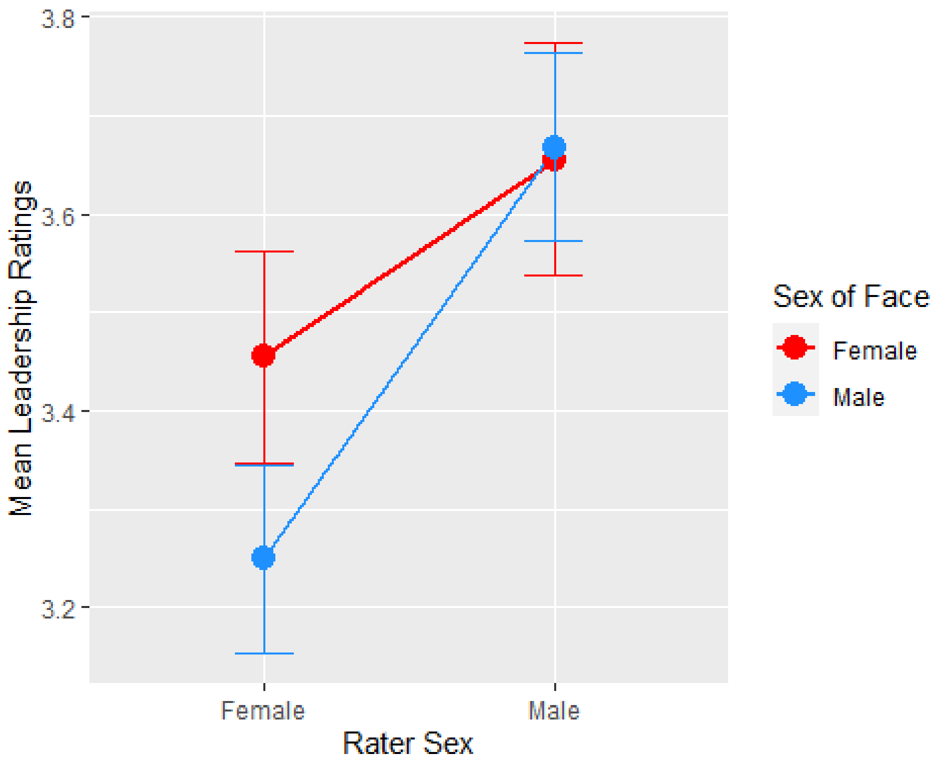
```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##      Estimate Std. Error z value
## 1|2 -2.696957   0.187107 -14.414
## 2|3 -1.253530   0.181659  -6.900
## 3|4 -0.007617   0.180354  -0.042
## 4|5  1.343524   0.181232   7.413
## 5|6  2.675059   0.185603  14.413
## 6|7  4.163748   0.202418  20.570
```

6.10.5.2.1 Data sorting for new interaction plots

```
data.long.noup <- data.long2 %>%
  filter(head_tilt!="p10")


plot.data.new <- group_by(data.long.noup, user_id, face_sex, head_tilt, sex, co
ntext) %>%
  summarise(rating.m = mean(rating,na.rm = TRUE)) %>%
  ungroup() %>%
  select(user_id, rating.m, head_tilt, face_sex, sex, context)

## `summarise()` regrouping output by 'user_id', 'face_sex', 'head_tilt', 'sex'
(override with `.groups` argument)
```

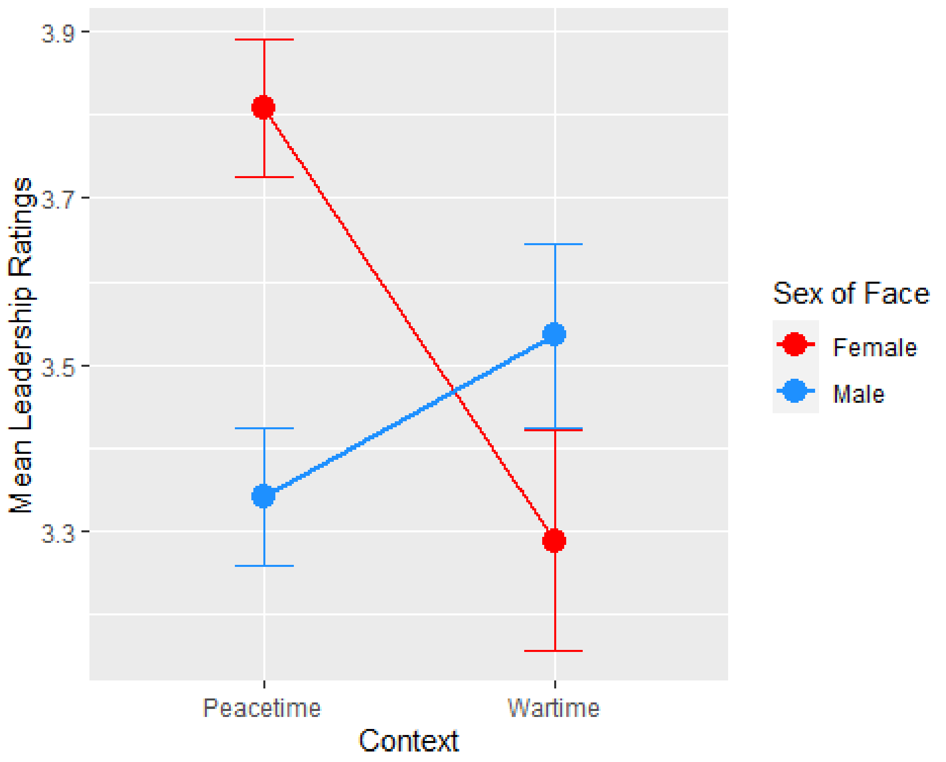
6.10.5.3 Rater Sex and Face sex Interaction w/out UP

```
## `geom_smooth()` using formula 'y ~ x'
```



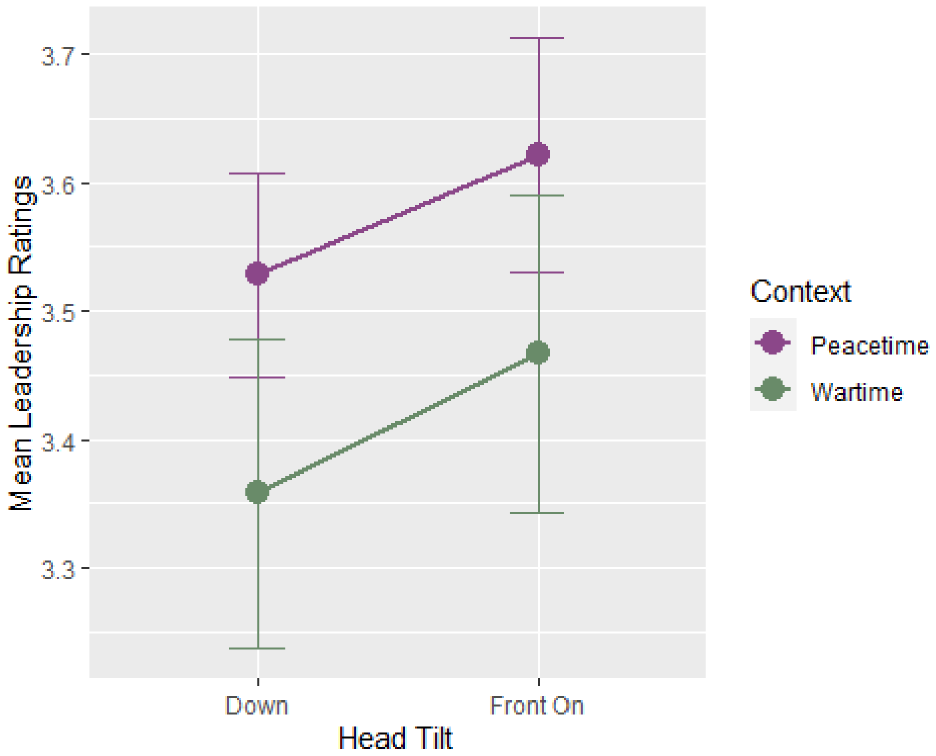
6.10.5.4 Face sex and Context Interaction w/out UP

```
## `geom_smooth()` using formula 'y ~ x'
```



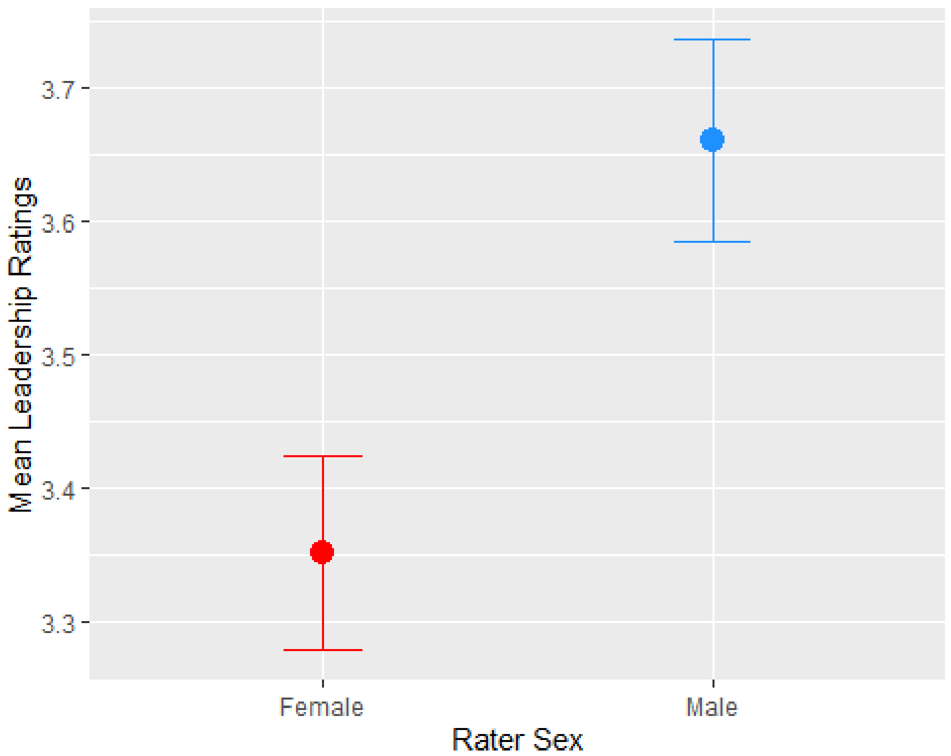
6.10.5.5 NON-SIGNIFICANT Context and Head Tilt Interaction w/out UP

```
## `geom_smooth()` using formula 'y ~ x'
```



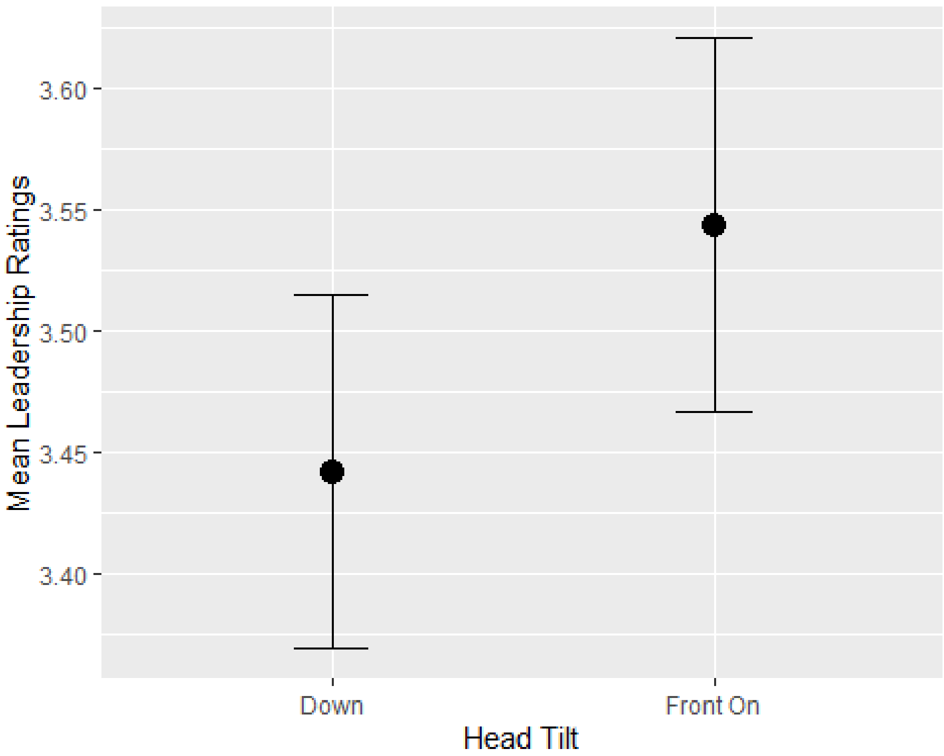
6.10.5.6 Rater Sex Main Effect w/out UP

```
## `geom_smooth()` using formula 'y ~ x'
```



6.10.5.7 Head Tilt Main effect w/out UP

```
## `geom_smooth()` using formula 'y ~ x'
```



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