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INVESTIGATING BIASES IN ADULT FACE RECOGNITION BEHAVIOR

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Abstract

People use the structure of the human face to form social impressions. These social dimensions of face processing have direct relevance for motivating social behavior, like selecting and competing for potential mates. Therefore, men and women may be differentially sensitive to the visual information relevant to these dimensions. For example, structural characteristics of faces that convey dominance (e.g., signals of physical strength) may be especially relevant for males when considering behavior related to intrasexual mate competition. In contrast, structural characteristics of faces that convey attractiveness (e.g. signals of youth or fertility) may be especially relevant for females when considering behavior related to intrasexual mate competition. In what follows, I evaluated several hypotheses related to the own-gender bias (OGB) in face recognition (i.e. superior recognition for faces of one's own sex). First, I predicted that priming males to attend to dominance cues in other male faces would induce heightened sensitivity to male faces in a subsequent face recognition task. Second, I also tested the prediction that priming females to attend to attractiveness cues in other female faces would instigate heightened sensitivity to female faces in the same face recognition task. Finally, I predicted that the relationship between priming cues and the OGB would be influenced by relationship status and satisfaction, mate guarding, and individual differences in one's own attractiveness and dominance.

Adult male and female participants were tested in a series of face processing tasks including perceptual sensitivity to detect facial attractiveness, dominance, and likeability, as well as a face recognition task. In addition, participants completed questionnaires related to their relationship status and provided physical measures of attractiveness and dominance. Participants were randomized into one of three conditions and completed either an attractiveness, dominance, or likeability perceptual trait judgment task prior to a face recognition task. I predicted that only those men in the dominance condition should experience an OGB, whereas the women in the attractiveness condition should experience an OGB. No modulation in recognition performance was expected for participants in the likeability condition.

Results indicate that, across all three conditions, all participants exhibited greater recognition performance for female faces than male faces, but women in particular exhibited greater accuracy than men for female faces, regardless of condition. When evaluating inverse efficiency, however, this female superiority effect was not present. In addition, all participants exhibited lower perceptual thresholds (i.e. greater sensitivity) to detect each trait in male faces than in female faces. Finally, men's own dominance was inversely related to their sensitivity to detect dominance in male faces, and women's own attractiveness influenced their sensitivity to detect likeability, but not attractiveness, in other women's faces. These findings are discussed in the context of previous literature examining the OGB in face recognition.

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DEDICATION

"It may be that the gulfs will wash us down:
It may be we shall touch the Happy Isles,
And see the great Achilles, whom we knew.
Tho' much is taken, much abides; and tho'
We are not now that strength which in old days
Moved earth and heaven, that which we are, we are;
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield."

- Alfred, Lord Tennyson

While writing this dissertation, I have relied on my family's love and undying support. Therefore, I dedicate this work to the following individuals:

For my husband, Javier Motta-Mena. I could never repay him for the sacrifices he has made in order to help me finish my degree. Javier has been by my side through every single second of this dissertation and of my graduate school career. It has been with his encouragement and confidence in me that I was able to finally cross the finish line. Without him, the road would have been a lonely place.

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1 Introduction

1.1 Sex as variable of interest is underappreciated in psychological research

There is growing interest in understanding the influence of biological sex and sex hormones on human cognition, behavior, and visual perception (Del Giudice et al., 2016; Grabowska, 2017; McCarthy, Arnold, Ball, Blaustein, & De Vries, 2012; McEwen & Milner, 2017; Motta-Mena & Puts, 2017; Motta-Mena & Scherf, 2016). Most recently, the National Institute of Mental Health concluded that there is a scarcity of research examining sex differences at a neurobiological and mechanistic level, as well as a need for more neuroscientists to incorporate sex as a variable in experimental designs (National Institute of Mental Health, 2011). In addition, sex differences have been described as "underappreciated" in both biomedical (McCarthy, 2016) and cognitive sciences (e.g. in the visual system; Vanston & Strother, 2017), particularly given the prevalence of sex-linked disorders (e.g., autism, schizophrenia) that are associated with atypical visual function (e.g. Whyte & Scherf, 2017).

Sex differences in behavior have been documented in multiple cognitive domains such as spatial cognition (in both humans, Cornoldi & Vecchi, 2004; Maccoby & Jacklin, 1974; and rats, Tolman, 1948) and verbal fluency (e.g. remembering a list of previously encoded words; for review, see Ullman, Miranda, Travers, & Becker, 2008). Favoring males, differences have been observed on tests of mental rotation (Collins & Kimura, 1997) and embedded figures (Witkin, Dyk, Fattuson, Goodenough, & Karp, 1962). In contrast, differences favoring females have been reported in tests of verbal fluency (Herlitz, Nilsson, & Bäckman, 1997; but see Hyde & Linn, 1988) and episodic memory, particularly when the items to be remembered include words (Hill, Grut, Wahlin, Winblad,

& Bäckman, 1995), stories (Hultsch, Masson, & Small, 1991), or faces (Herlitz & Yonker, 2002), an advantage reportedly attributed to women's superior general episodic memory (e.g. Lewin, Wolgers, & Herlitz, 2001; but see Pauls, Petermann, & Lepach, 2013). However, much of the empirical work on the reported female advantage in face memory is largely inconsistent.

1.2 The reported female OGB in face recognition is inconsistent

Evidence supporting the reported female advantage in face recognition has been summarized in a number of meta-analyses, but the conclusions emerging from these analyses are conflicted. For instance, in one meta-analysis of 131 effect sizes from 96 studies of sex differences in face recognition, the authors concluded a selective advantage in women *only* for female faces (Herlitz & Lovén, 2013), an effect that has been referred to as the *own-gender bias* (OGB) in face recognition (whereby one exhibits enhanced recognition for faces of their own sex). Critically, this analysis only included studies that a) explicitly tested for an OGB or differences as a function of sex, and b) were not tests of short-term recognition (i.e., short intervals between each encoding trial and recognition trial, ranging from milliseconds to seconds). As a result, Herlitz & Lovén (2013) excluded several studies that reported no sex differences in memory for faces (e.g. Godard & Fiori, 2010), an OGB in men (McKelvie, Standing, Jean, & Law, 1993), and no interactions between stimulus sex and participant sex (Maner et al., 2003) from the analysis.

Separately, an earlier meta-analysis of 128 eyewitness identification and facial recognition studies came to a different conclusion. In this review of 960 experimental conditions and 16,950 subjects, the researchers concluded that a) stimulus sex does *not* reliably influence facial identification performance, and b) *both* men and women have better recognition memory for faces of their own sex (i.e., men and women both exhibit an OGB in face recognition; Shapiro & Penrod, 1986). Critically, this OGB in both sexes reflects a similar pattern of behavior across both sexes, not a behavior that is unique to women, as has been suggested previously in the literature. Given these conflicting reports, the inferences from both of these meta-analyses fail to converge onto a consistent pattern of findings regarding the reported sex differences in face recognition, or with respect to a female advantage in face recognition.

In addition to these inconsistent findings, some evidence suggests that reported sex differences in face recognition can be easily attenuated with simple task modifications. For example, in one eyetracking study, additional exposure time to faces during encoding significantly increased men's accuracy during recognition, and men and women's recognition memory became matched (Heisz, Pottruff, & Shore, 2013). Importantly, in this study, males made fewer fixations than females did, suggesting that men may have gathered less perceptual information to establish a memory representation for the newly learned faces than women did in the same amount of time (thereby leading to poorer performance than the women). In support of this theory, when the authors controlled for the number of fixations made during encoding, the sex difference in recognition memory was no longer observed. This finding is critical, as it suggests that any sex differences that may be present in face recognition may manifest at the encoding stage, and furthermore are not particularly robust in nature.

Finally, in our own work, we have failed to replicate the OGB in face recognition performance in either women or men in two independent samples of healthy young adults (nearly 180 participants combined; Picci & Scherf, 2016; Scherf, Elbich, & Motta-Mena, 2017). In these studies, the samples included an equal number of male and female participants and had robust power to detect potential biases. The first of these two studies investigated biases in face recognition abilities across four developmental groups (children, early and late puberty adolescents, and adults; Picci & Scherf, 2016). There was no OGB for either male or female participants in any of the developmental groups. Importantly, the children (ages 6-8 years) did evince the predicted female Caregiver Bias (i.e., better recognition of adult female compared to adult male faces). The second study was a large-scale investigation of the influence of biological sex on the behavioral and neural basis of sex on face recognition abilities (Scherf et al., 2017). Using a standard task of unfamiliar face recognition (i.e., Cambridge Face Memory Task long form; Russell et al., 2009), we found no sex differences in face recognition ability and no OGB in recognition performance of either men or women.

Therefore, the presence of a consistent OGB, particularly for women, is not a stable finding in the literature. Rather than interpret these inconsistencies as a core challenge to the validity of the notion of an OGB, I suggest that an interesting way to interpret this inconsistency is to ask whether the presence or absence of an OGB in face recognition behavior varies as a function of sex and context together.

1.3 Theories regarding the OGB in recognition are post-hoc and tenuous

Importantly, the existing literature offers very little in the way of a theory for predicting *why* there would be sex differences in memory for faces – and why women are expected to consistently outperform men specifically in tasks of face recognition.

According to one view, sex differences in face recognition may be due, at least in part, to evolutionary pressures reflecting a history in which males and females faced different challenges related to survival and reproduction (Buss, 1995). For example, in most mammals, females tend to be the primary caregivers, which is a role requiring careful interpretation of infants' nonverbal expressions in the service of recognizing and responding to infant needs (i.e. the primary caretaker hypothesis; Babchuk et al. 1985). Such skills, in theory, increased offspring survival, thereby leading to sexual selection of putatively greater social interest in, and skills related to, interpreting facial cues and nonverbal expressions in females specifically.

In support of this theory, researchers argue that infant girls have stronger preference than infant boys to look at faces (Connellan et al. 2001), and that females are also more social than males from infancy (Simpson et al., 2016). This purported innate female interest in, and preference for looking at, faces is thought to be the foundation for the sex differences that appear early in development in face recognition (e.g., Herlitz & Lovén, 2013). Women's early bias for looking at faces is thus ostensibly strengthened by reciprocal interactions with other females, which leads to perceptual expertise for own-sex faces. However, this line of thinking fails to explain why males would not also develop an expertise for faces of their own sex, particularly given that facial cues provide a plethora of information relevant for *both* sexes to detect in navigating social relationships.

In addition, there is a body of literature demonstrating that the tendency for recognition performance to be higher for female faces is a main effect, whereby *both* boys and girls exhibit superior recognition for female faces early in development (Macchi Cassia, Bulf, Quadrelli, & Proietti, 2014; Picci & Scherf, 2016; Quinn et al., 2008; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), unless the caregiver is a male (Quinn et al., 2008), in which these children tend to have a bias for remembering *male* faces. This growing body of literature demonstrates that this is a ‘caregiver bias’ (e.g. Picci & Scherf, 2016), whereby both *both boys and girls* exhibit better recognition memory for faces of the same sex as their primary caregiver. Thus, this early face recognition bias is actually a female face bias for *both* sexes, not a selective OGB for females.

Despite the lack of a coherent, theoretical argument for expecting sex differences or the presence of an OGB in face recognition, several researchers have ruled out potential mechanisms underlying these purported sex differences. For example, sex differences in memory for faces do not appear to be related to general intelligence (Herlitz & Yonker, 2002), superior general recognition abilities (Goldstein & Chance, 1971; Ryan & Gauthier, 2016), the ability to verbally label faces (Lewin & Herlitz, 2002), or the quality of contact with same-sex individuals (N. Wolff, Kemter, Schweinberger, & Wiese, 2014).

Therefore, these data do not support a model in which children have an early bias in face recognition that is inextricably tied to the sex of the primary caregiver, which then morphs into an asymmetric OGB in adult females but not adult males (Scherf & Scott, 2012).

Taken together, the current work on sex differences in face recognition suggests that further evidence is necessary to understand a) whether a general, pervasive female advantage exists in face recognition memory, and if not, b) the contexts under which this advantage emerges, and c) whether this advantage may be reliably elicited with specific social task demands.

1.4 Using a developmental task approach to test sex differences in face recognition

To fully understand how biases may emerge in face recognition, one must adopt a more functional approach. I argue that a visual system that is consistently and specifically tuned to remember own-sex faces is not an adaptive one. What would be the functional reason for this kind of visual organization, and why would it be disproportionally organized this way in women and not men? Stable, persistent biases such as the female OGB are unlikely to help individuals successfully navigate the challenges of their social world. Instead, I posit that a core reason underlying the discrepancies regarding the influence of sex on face recognition is that researchers have not considered that the OGB in face recognition may be highly dependent on the age-appropriate *developmental tasks* of the individual.

Specifically, age-appropriate developmental tasks/goals are expected to induce changes in the needs for face processing developmentally (Motta-Mena & Scherf, 2017; Picci & Scherf, 2016; Scherf, Behrmann, & Dahl, 2012; Scherf & Scott, 2012). For example, the social developmental tasks of childhood involve learning self-mastery while still depending on primary caregivers. In contrast, the social developmental tasks of adolescents involve acquiring independence from parental figures, forming confiding friendships, and exploring romantic partnerships with peers. Finally, young adults are immersed in romantic and sexual relationships with peers, whom they are evaluating for long-term romantic relationships in order to begin forming families. These differential social developmental tasks are expected to shape the emergence and plasticity of biases in face recognition, and in particular, the OGB.

Using this theoretical framework, I build on previous work employing the developmental task model to understand biases in face processing, which argues that face-processing biases reflect the computational goals of the perceptual system that have been shaped by social developmental tasks (Motta-Mena & Scherf, 2016; Picci & Scherf, 2016; Scherf et al., 2012; Scherf & Scott, 2012). Specifically, the social, emotional, and contextual environment of an individual shapes the specific tasks that are relevant for a particular developmental period. In turn, these contexts shape face-processing biases differentially as a function of the different developmental tasks.

There is converging evidence from our lab to support the notion that face-processing biases are related to the computational goals of the perceptual system and emerge in order to resolve these developmental tasks. For example, relative to adolescents in early puberty, adolescents in late puberty exhibit greater sensitivity to those facial expressions that are relevant for the romantic and sexual relationships that they are beginning to navigate (Motta-Mena & Scherf, 2016). In addition, adolescents begin to evince a *peer bias* in face recognition (that is, greater recognition memory for faces of their own pubertal group) specifically as a function of pubertal development, and not age (Picci & Scherf, 2016). This evidence suggests that the computational goals of the visuoperceptual system change to retune face processing behaviors in response to changes in the developmental tasks of an individual.

Given the developmental importance of mate selection and competition in adulthood, I propose that these contexts are highly relevant for face recognition behavior. Importantly, though the developmental goals are largely similar for both men and women, the ways in which this particular goal is navigated and accomplished may manifest slightly differently in men and women. That is, men and women compete for mates in uniquely different ways (Campbell, 2004; Puts, Gaulin, & Verdolini, 2006; Simpson et al., 1999). Specifically, men report more jealousy when a rival is high in social dominance, physical dominance, and social status (Dijkstra & Buunk, 2002), whereas women tend to report more jealousy when a rival is high in physical attractiveness (Dijkstra & Buunk, 2002). This phenomomena occurs because, over the course of human history, behaviors that have enabled individuals to fend off and gain an advantage over same-sex competitors in order to succesfully obtain mates (i.e., intra-sexual competition) have been shaped by sexual selection (Darwin, 1871; Buss, 1988). Intrasexual competition mechanisms are likely relevant for face recognition behavior because heterosexual men and women are motivated to seek potential mates (opposite-sex faces) and also fend off potential competitors (same-sex faces), which could influence the OGB depending upon the context. In other words, intrasexual competition may be elicited in specific contexts, which may shape sex-specific responses, like the OGB in face recognition.

In other words, a perceiver evaluating a face in the service of assessing its potential threat is expected to encode the face differently than a perceiver evaluating a face in the service of assessing its potential as a romantic/sexual partner. In what follows, I detail precisely how I predict differences in an individual's age-appropriate *developmental tasks* are likely to drive differences in face recognition behavior. Considering precisely how developmental tasks develop and change throughout the lifespan will inform how biases such as the OGB may emerge in recognition behavior, particularly given that an individual's developmental tasks are expected to bias their attention, memory, and inferences.

In what follows, I present a novel theoretical framework for investigating sex differences in the behavioral basis of *face recognition*. I hypothesize that sex differences in behavior are driven by biases that emerge in the service of achieving evolutionarily adaptive developmental tasks (i.e. related to survival, mate competition, and reproduction). In other words, rather than considering the OGB a stable trait of face recognition, I argue that it can be reliably and flexibly elicited in some social contexts, and reliably dampened in others.

1.4.1 A functionalist approach to understanding sex differences in face recognition

I argue that visual perception in general, and social perception in particular, should be construed as highly constructive and sensitive to an individual's goals and contexts. This theoretical approach draws on Gibson's ecological theory (Gibson, 1979), and suggests that attention is adaptively tuned – selectively focusing on the features of the environment that are most important for accomplishing specific goals (McArthur & Baron, 1983; Zebrowitz, Leslie; Montpare, 2010; Zebrowitz, 2017). Applying this theory to face processing suggests that humans process faces in the service of acquiring goal-relevant facial cues and information that facilitate specific social behavior, such as acquiring a romantic partner (i.e. a mate) or identifying a same-sex individual that may be a potential threat for a mate (i.e. a competitor).

Critically, this perspective is not completely novel; it builds on existing theoretical models that emphasize the dynamic and reciprocal relationship between the *physical* characteristics of the observer (i.e. sex, race, age) and that of the target during face perception (Adams, Albohn, & Kveraga, 2017; Adams, Garrido, Albohn, Hess, & Kleck, 2016; Freeman & Ambady, 2011; Hehman, Sutherland, Flake, & Slepian, 2017). I extend this foundational work by proposing that differences in the perceiver's *developmental tasks* interact with characteristics of the face to be remembered (e.g. sex) to drive biases during face recognition.

A careful analysis and consideration of precisely *what kind* of facial information individuals are perceiving in order to interact effectively with their social environment is a fruitful approach for evaluating precisely *how* people perceive and navigate their social environment (e.g. do heterosexual men and women remember opposite-sex faces better if they are primed to view them as potential mates?). Given uniquely different contexts and specific task demands, it is plausible that men and women can – and do – exhibit different biases in face processing. Using this approach, we can begin to establish a theoretical framework from which to make predictions about different goals can drive cognitive biases, which in turn can influence differences in perception and behavior.

1.4.2 Can visual input cues/priming enhance memory for faces?

A functional approach to visual perception and face processing necessitates employing an evolutionary perspective. Evolutionary psychologists assert that the human mind has been designed to help us navigate important adaptive challenges that were faced by our human ancestors (e.g. Buss, 1989). An interdisciplinary approach which integrates theories of social perception with evolutionary hypotheses would help bridge the two disciplines of cognitive science and evolutionary science,and suggest fundamental ways in which proximate factors guide the modern expression of adaptive psychological mechanisms.

Mating competition occurs across species, and exists whenever the use of a resource, including a mate, makes the resource unavailable to others (Andersson, 1994;

Buss, 1988; Walters & Crawford, 1994). Competition over mates can take multiple forms, including physical aggression or threats to exclude same-sex competitors from mating opportunities, as well as the expression of anatomical and behavioral traits to attract mates (for review, see Motta-Mena & Puts, 2017).

Evolutionary theories suggest that men and women are designed to solve different mating-related strategies (Trivers, 1972), which lead to differences in mate preferences and competition. Such differences in mate preferences and competition are explained, at least in part, by sexual selection theory. Specifically, due to the relative asymmetry in parental investment between men and women, heterosexual women should theoretically compete with other women for mates that provide resources, while heterosexual men should compete with other men for mates that appear attractive, fertile, and healthy (Buss, 1989; Conroy-Beam, Buss, Pham, & Shackelford, 2015; Trivers, 1972).

Following this idea, can certain visual input cues such as attractive faces (which are related to pursuing an individual for sexual or romantic relationships) lead to memory enhancement for faces of potential romantic or sexual partners (i.e. biases in face recognition) in the service of accomplishing age-appropriate developmental tasks related to reproduction and competition. Indeed, there is evidence to support this notion that certain input cues from the face can induce unique behavioral (and in some cases, endocrine) changes in the perceiver. Evaluating the effect of viewing certain kinds of faces (e.g. attractive faces) on people's basic cognitive processes could lend support to the idea that visual stimuli such as faces might be able to induce biases in human perception and social relationships.

For example, in one experiment evaluating the "cognitive consequences of viewing attractive faces", Olson & Marshuetz (Olson & Marshuetz, 2005) employed a priming task to evaluate whether viewing attractive faces would enhance memory for positive words. Participants viewed a rapidly presented face followed by a black screen with a white word, and were required to ignore the face stimulus and instead attend to and classify the words (e.g. laughter) as "good" or "bad". The authors argued that if attractive faces bias subsequent processing, then reaction times for "good" words preceded by attractive faces should be faster than when the same words are preceded by unattractive faces. Thus, the strength of this study is in its design as a within-subjects experiment. Planned comparisons revealed that participants responded faster to positive words when they were preceded by attractive male and female faces (700 ms) than when they were preceded by unattractive faces (753 ms). This differentiation in the behavioral data was not present when positive words were preceded by inverted attractive and unattractive faces, suggesting that attractive faces either induce positive emotions or bring to mind positive labels (e.g. "good") that in turn speed categorization of positive words. This finding hints at the possibility that attractive faces may also enhance memory for attractive stimuli.

To ascertain that this effect was face-specific (that is, due to the attractiveness of faces and not judging attractiveness more generally), the authors evaluated the same question in a separate sample of 18 students, but with houses as a comparison category of stimuli. In the comparison condition, there were no RT differences when positive words were preceded by previously-rated attractive houses as compared with unattractive houses, suggesting that the cognitive bias in the first experiment was due to attractive processing of *faces* specifically. However, a more compelling comparison condition would have involved relevant stimuli for college students that have the same degree of valence as faces (e.g. perhaps sports team logos/rivalries, or food items).

In addition, in a priming study examining the influence of attractive faces on declarative memory (Baker, Sloan, Hall, Leo, & Maner, 2015), 58 participants were randomly assigned to view 10 opposite-sex faces that were either highly attractive or average in attractiveness while listening to a male voice recite a story. Participants were told to pay attention to the story as well as the faces, which were each presented for 7 seconds during the 70-second duration of the audio presentation of the story. Their evidence suggests that men who viewed attractive opposite-sex faces while listening to the story remembered more details than men who viewed average faces. This effect was also present for women, but did not reach statistical significance. This pattern of results suggests that viewing attractive *opposite sex* faces may enhance memory in men, but not necessarily in women. Further, these findings lend credence to the hypothesis that visual input cues are capable of inducing differences in men and women’s memory for faces in uniquely different ways.

To evaluate whether mating cues influence encoding, retrieval, or both, Baker et al. (2015) followed up in a second experiment, and presented the same opposite-sex faces and story to a separate group of 220 participants. In the follow-up study, the order of presentation was altered to identify the exact stage of processing that was affected by the presentation of attractive faces (i.e. mating cues). Participants either viewed attractive faces prior to the story (*encoding* enhancement condition), after the story (*retrieval* enhancement condition), or not at all (no enhancement condition). Unlike Heisz et al.

(2013), who argue that sex differences occur at encoding (based on an eyetracking study where women made more fixations than men), Baker et al. (2015) found that participants who viewed attractive opposite-sex faces prior to *retrieval* remembered significantly more details than participants in the other two conditions, regardless of participant sex. Thus, based on this set of findings, exposure to highly attractive opposite-sex faces (i.e. mating cues), appears to lead to enhanced memory for faces for both men and women.

Thus far, these findings hint at the distinct possibility that visual cues specifically related to mating and reproduction can lead to important differences in men and women's recognition performance for male and female faces. This work highlights the notion that in order to evaluate whether biases may be induced in recognition behavior as a function of the sex of the face, one must additionally consider a) the attractiveness of the face, and b) whether these faces provide information about relationship potential or threat potential.

1.4.3 Can a "mating response" be elicited with certain cues from potential mates?

Given the evidence that certain input cues (e.g. those related to sexual or romantic relationships) can lead to memory enhancement, would it also be possible to induce *behavioral* changes in participants using visual input cues related to mate competition and attraction?

In one study, 39 college-aged males were randomly assigned to engage in conversation with a male or female confederate prior to completing a battery of psychological measures (Roney, Mahler, & Maestripieri, 2003). Both male and female confederates were explicitly directed to engage in a "friendly but natural conversation with the participant". Men who interacted briefly with a female confederate showed a significant increase in testosterone over baseline levels and were rated as having expressed more polite interest and display behaviors than men who had a brief interaction with a male confederate. Thus, merely changing the sex of the confederate that participants encountered induced the emergence of courtship-like behavior (i.e. more polite interest and display behaviors), that was associated with a distinct hormonal reaction. This suggests that visual input cues can not only enhance memory for positive stimuli, but perhaps also induce important behavioral changes (and therefore potentially recognition memory).

This work suggests a model of mate attraction mechanisms in which input cues from potential mates can prime those psychological representations that facilitate certain courtship tactics (i.e. attitudes that emphasize wealth, ambition, and social status). In a another study of 142 high school students, males who were visually exposed to potential mates (e.g. attractive women, either in person or in photographs) produced self-descriptions that more closely matched putative female mate preferences (i.e. higher valuations of material wealth and social status, and personality trait descriptions indicating high extraversion) than men in control conditions (Roney, 2003). Specifically, young men who were exposed to young women prior to completing a battery of psychological questionnaires placed greater importance on “Dressing well” and “Being physically attractive” than young men who were not exposed to young women. Thus, exposure to “mating cues” (i.e. attractive faces) facilitates the expression of specific behaviors that support the accomplishment of those goals related to the stimuli. In other words, presenting images of attractive females leads young men to change their behavior in such a way that enables them to be able to pursue (and impress) a potential mate.

Finally, in a recent eyetracking study by Gillath and colleagues (Gillath, Bahns, & Burghart, 2017) with 105 heterosexual graduate students (36 males), researchers evaluated whether the way people look at others changes as a function of the perceiver's goal for the relationship (potential friend vs mate), or as a function of the perceiver's gender. Participants examined full-body photos of 10 men and 10 women (all matched on attractiveness ratings) with no time limit. After each image was cleared from the screen by the participant, participants rated the potential of the individual in the image as either a friend or a romantic/sexual partner. Results from this experiment suggest that people looked at the head and chest more when rating individuals in the images as potential mates, and looked at the legs and feet more when rating individuals in the images as potential friends, regardless of participant gender. These findings suggest that relevant goals and participants' own gender may affect the way people visually scan their environment, and search for information that is relevant for their goals (Gillath et al., 2017). I expect, therefore, that manipulating input cues for men and women is likely to lead to differences in face recognition behavior for male and female face stimuli.

Finally, Maner and colleagues (Maner, Gailliot, Rouby, Miller, & Valli, 2007) explored the possibility that attentional biases are guided by psychological states associate with mating. Maner et al. (2007) integrated theories of motivation and social cognition within the meta-theoretical framework of evolutionary psychology and emphasize the adaptive nature of social cognition to evaluate the cognitive processes underlying face processing behavior. Maner et al. (2007) employed a dot-probe visual cueing task across three experiments to induce participants to either seek a mate or guard a mate (described further below) and evaluated a hypothesized increase in attentional adhesion (i.e. longer fixation times to either attractive same- or opposite-sex faces). Here, a functionalist perspective yielded the following hypotheses: A mate search motive was expected to increase attentional adhesion to physically attractive members of the *opposite* sex in the service of seeking a potential mate, while a mate guarding motive would increase attentional adhesion to physically attractive members of the *same* sex in the service of monitoring potential competitors.

To prime a mate search motive, Maner et al. (2007) had 121 participants (59 men, 65 women) write about 4-5 instances in which they felt sexually and romantically aroused. A control condition required participants to describe a time in their life when they felt “very happy”. Following this prime, participants completed a dot-probe cueing task that included 60 target photographs of highly attractive men and women, as well as average-looking men and women (15 in each category). The dot-probe task used in this study thus assessed attentional *disengagement*, or how efficient participants are at shifting attention *away* from a stimulus, but the outcome variable was how long participants left their attention on the face stimuli. In the experimental paradigm, participants viewed a target face for 500 ms in one quadrant of the computer screen (Maner et al., 2007). The photo then disappeared, and simultaneously, a shape (either circle or square) appeared in either a) the same location as the picture, or b) in a different quadrant (thus requiring participants to shift their attention away from the face). Participants were required to categorize the shape as quickly as possible with a button-press. Thus, on attentional shift trials, participants were required to shift their attention away from the quadrant with the face presentation, and to a different point on the screen. The primary variable of interest was the response latency between the appearance of the object and the participant’s response, which provided a measure of attentional adhesion. Higher scores indicated greater adhesion to attractive opposite-sex faces (i.e. “mate searching” behavior). Results indicate that participants who were primed with feelings of sexual arousal (but not general feelings of happiness) looked at opposite-sex faces longer. This set of findings has important implications for understanding the cognitive processes underlying mate selection and relationship maintenance, and how these processed may influence the way humans view opposite-sex faces during face recognition.

In a separate study, Maner et al. 2007 evaluated processes involved in mate guarding (i.e. guarding against reproductive threats posed by intrasexual rivals). Jealousy is strongly linked with mate guarding, and promotes behavioral responses in individuals in the service of guarding one’s mate from potential competitors (Sabini & Silver, 2005). Thus, using a priming procedure to induce feelings of jealousy, the authors expected to induce actions in participants that were aimed at guarding one’s mate from potential intrasexual competitors (i.e. greater attention to same-sex targets). Participants were instructed to think of their current romantic partner (or someone toward whom they had romantic feelings) and envision a scenario where they observed that person flirting with someone else. Results from this manipulation revealed that the jealousy procedure significantly increased attentional adhesion to attractive same sex targets (rather than opposite-sex targets as in the previous manipulation). In particular, female participants attended more to attractive same-sex targets than male participants.

In short, inducing sexual arousal (i.e. a mate *search* prime) prompted both men and women to gaze at attractive *opposite-sex* targets (i.e. potential mates) for a longer period of time compared to same-sex targets. In contrast, inducing jealousy (i.e. a mate *guard* prime) drove increased attention to *same-sex* targets (i.e. intrasexual competitors) in both men and women (Maner et al., 2007). This pattern of results suggests that visual input cues may be capable of non-consciously priming specific cognitive states, which in turn facilitate the accomplishment of goals related to mating, reproduction, and/or intrasexual competition. This line of work lays the groundwork for the current project, and in what follows, I propose that manipulating the mating goals of the *perceiver* can influence biases related to sex in face recognition behavior.

1.5 Intrasexual vigilance as one mechanism by which the OGB is elicited

The central thesis of this dissertation is that biases in face recognition are dynamic and context-dependent. In particular, contexts related to evaluations of potential mates and competitors are reliable contexts that are expected to drive sex differences in behavior across species. This is just one example of the kind of context that is expected to influence this type of bias as there may be others. Thus, the core hypothesis herein is that inducing humans to think about same-sex individuals as competitors is expected to lead to enhanced processing of same-sex faces, thereby leading to better memory for same-sex faces in face recognition behavior (i.e. the OGB).

Given the literature demonstrating that certain input cues can prime cognition related to mating, the next question naturally involves the other side of the coin. Can certain input cues prime cognition that are related to competition, whereby perceivers' awareness of competitors (rather than potential mates) is heightened? Critically, identifying candidate input cues for priming cognitive mechanisms related to mate selection and competition would only make functional sense only if they reliably indicate the relative threat posed by competitors in same-sex faces (e.g. for females, attractiveness in female faces).

Several lines of research have demonstrated that presenting certain input cues can prime information-processing goals at a subconscious level (e.g. Chartrand & Bargh, 1996), and even physical behaviors (e.g. men exposed to a female confederate express more positive facial cues than unexposed men; Roney, Hanson, Durante, & Maestripieri, 2006), related to mating behavior and cognition. For instance, men appear to be able to detect subtle facial cues of women's fertility, which can reportedly influence men's mating cognition and behavior (Miller & Maner, 2010). However, it is unclear which facial cues may indicate women's fertility (e.g. skin coloration, texture, or brightness), as shifts in the female confederate's fertility appeared to influence only the male participants' evaluations of her attractiveness, and not females' (but see Krems, Neel, Neuberg, Puts, & Kenrick, 2016; Necka, Puts, Dimitroff, & Norman, 2015; Puts et al., 2013 for evidence to suggest that women are sensitive to cues of fertility in other women).

Evolutionary perspectives would argue that whatever traits are particularly valued in men and women are likely to receive preferential cognitive processing (e.g. greater attention) by members of the opposite sex (Maner, DeWall, & Gailliot, 2008). Thus, one might expect that where men might be attuned to physical attractiveness, women might be attuned to social dominance in men. Members of one's own sex that possess these desirable qualities thus represent threatening intrasexual rivals (Dijkstra & Buunk, 2002). Specifically, men report more jealousy when a rival is high in social dominance, physical dominance, and social status (Dijkstra & Buunk, 2002).

In addition, some work suggests that men tend to monitor potential competitors in their environment. For instance, less dominant men (compared to more dominant men) are more sensitive to visual and vocal cues of dominance in other men (Watkins, Fraccaro, et al., 2010; Watkins, Jones, & DeBruine, 2010). However, Wolff & Puts (2010) employed rigorous methodology and provide evidence to the contrary, suggesting that that men's attentiveness to *vocal* masculinity is unmediated by the dominance of the listener. Collectively, these findings fail to converge, but nevertheless underscore the possibility that men’s perceptual system is, at least in part, adaptively tuned for detecting dominance in other men in the service of navigating social hierarchies.

In two separate experiments employing rapidly-presented visual arrays of males and females, observers selectively attended to male (but not female) targets displaying signs of social dominance (i.e. by adding business attire; Maner et al. 2008). Critically, however, the samples in each of these two experiments were not sex-balanced (110 women and 37 men in experiment 1; 29 women and 18 men in experiment 2). Thus, to the extent that these results would stand with a sex-balanced sample, this pattern of results suggests that observers vigilantly attend to others who are relevant to their own reproductive success.

Men also tend to value those physical features in women that are related to fecundability, such youthfulness, vitality, and an ideal body-shape (Conroy-Beam et al., 2015; J. Townsend & Wasserman, 1998; Waynforth & Dunbar, 1995). In addition, when asked to spontaneously mention relevant characteristics about a rival that might attract their partner, women tend to report more jealousy when a rival is high in physical attractiveness (Dijkstra & Buunk, 2002). As such, women tend to compete with other women for mates by advertising qualities that are valued by men (e.g. beauty, clothing choice, and sexual exclusiveness; Durante, Li, & Haselton, 2008; Haselton & Gangestad, 2006), and by derogating rivals (e.g. through gossip and devaluing other women; for review, see Campbell, 2004; Fisher, 2004) rather than via direct displays of dominance, as in men. Thus, intrasexual competition in women may elicit a different dynamic among women than intrasexual competition in men.

Some evidence suggests that women actively monitor the presence of potential competitors in their environment, particularly given that women in the fertile phase of the cycle are typically rated by men to be more attractive than women in the luteal phase (Bobst & Lobmaier, 2012; Puts et al., 2013; Roberts et al., 2004). For example, across four experiments in which women in relationships were shown photographs of other women taken during either the fertile or non-fertile phase, women reported intentions to socially avoid fertile (but not non-fertile) women – but only when their own partners were highly desirable (Krems et al., 2016). In addition, women have also been shown to withhold more resources from another woman in a Dictator game, keeping more for themselves, when both women were in the late follicular (fertile) phase of their ovulatory cycles (Necka et al., 2015). Taken together, these findings support the notion that *visual cues* from potential mates and competitors are critical for motivating behaviors related to mate attraction and competition in women.

Critically, however, while men and women may have evolved specialized adaptations for evaluating competitors, it is also possible that this ability reflects adaptations for discriminating between individuals more generally (e.g. trustworthiness). In other words, the judgments participants are making in these tasks may conceivably related to cues that are not related to the outcome variable (e.g. looking less "trustworthy" rather than looking “more fertile” per se). At the very least, behaviors related to intrasexual competition in women appear more likely to be engendered in the presence of an attractive or fertile female competitor (Krems et al., 2016; Necka et al., 2015). Whether similar behaviors emerge in men in the presence of a dominant competitor is unclear.

In summary, the motivation underlying the strategies by which men and women individuate and recognize faces may be fundamentally different as a function of the visual information they prioritize when viewing same-sex faces. Given the appropriate context and age-appropriate social developmental tasks (e.g. acquiring a mate; Scherf, Behrmann, & Dahl, 2012), an individual may be more motivated to encode and recognize a same-sex face when evaluating the face as a potential competitor. Thus, an OGB in face recognition could represent an example of a behavior resulting from cognition related to opposite-sex mate choice and mate guarding or same-sex contest competition.

1.6 Individual differences in face recognition abilities

In addition to understanding how such a complex system as face recognition is influenced by biological sex, it is critical to evaluate human sexual dimorphism in order to truly understand how an individuals’ own attractiveness or dominance may influence behavior. Sexually dimorphic traits such as hand grip strength, bicep circumference, and waist-hip ratio (WHR) are traits that affect attractiveness and perceptions of dominance, and also predict mate preferences and behaviors related to competition for mates. Thus, understanding why and how men and women look different can elucidate how one’s own appearance mediates biases in face recognition.

Hand grip strength has been positively correlated with ratings of men’s facial dominance, masculinity, and attractiveness in a sample of 32 college-age male participants and 79 college-age female raters (Fink, Neave, & Seydel, 2007), even after controlling for the men's age and body weight. In other words, the faces of physically stronger men (i.e. those with higher hand grip strength) were rated as more dominant and masculine, further suggesting that men may be sensitive to men's faces in the service of evaluating their physical dominance (e.g. Buss, 1989). In addition, men's assessments of dominance/formidability in other men is highly correlated with their actual upper-body strength (Sell et al. 2009). Thus, given its correlation with ratings of dominance, hand grip strength can serve as a proxy for actual dominance in men. In addition, hand grip strength is also associated with self-reported aggressive behaviors, promiscuity, and age at first sexual intercourse in contemporary college-age males, but not females (Gallup, White, & Gallup, 2007) suggesting that physical strength predicts success in male intrasexual competition (i.e. dominance) more generally.

The size of the biceps/brachii muscle also also correlates strongly with upper body strength and, albeit weakly, with aggression (Archer & Thanzami, 2009; Wolff & Puts, 2010) and thus also serves as a robust proxy for dominance in men. Given these findings, the degree to which a male is physically dominant is expected to play a significant role in the emergence of the OGB in face recognition. Specifically, more dominant men (as measured by greater biceps circumference and hand grip strength) are predicted to be a) less sensitive to dominance in male faces, and b) less likely to experience an OGB than less dominant men. Note that this prediction is specifically for those males who are in a context which is expected to induce a male OGB (e.g. after evaluating male faces on dominance; see section 1.7 for more detail regarding this prediction).

In contrast, more attractive women are predicted to be more likely to experience an OGB in face recognition than less attractive women. Given assortative mating (where 9s tend to mate with 9s, 6s with 6s, etc.), attractive women should experience an OGB in the service of guarding a mate that is (presumably) also high in value (measured with relationship satisfaction questionnaire). On the other hand, if an attractive female has a partner low in mate value, she is not expected to experience an OGB to the same degree as a woman with a partner high in mate value.

One method of objectively evaluating women's attractiveness typically employed in the literature is a low waist-hip ratio (WHR), which is the ratio of the narrowest part of the waist to the widest part of the hips (Björntorp, 1991; D Singh, 1993). Ratings of women's body attractiveness correlate highly with ratings of facial attractiveness (Thornhill & Grammer, 1999), and women with more feminine faces and lower WHR tend to generate the greatest perceived threat to female observers (Fink, Klappauf, Brewer, & Shackelford, 2014). While men tend to prefer a gynoid pattern of body fat distribution across a wide variety of societies (Dixson, Vasey, et al., 2011; Dixson, Dixson, Bishop, & Parish, 2010; Dixson, Dixson, Morgan, & Anderson, 2007; Dixson, Grimshaw, Linklater, & Dixson, 2011; Dixson, Sagata, Linklater, & Dixson, 2010; Marlowe, Apicella, & Reed, 2005; Devendra Singh, Dixson, Jessop, Morgan, & Dixson, 2010; J. J. Snodgrass, Sorensen, Tarskaia, & Leonard, 2006; Sugiyama, 2004), there is considerable cross-cultural and individual variability in men's preferences for overall body fat (Cashdan, 2008). As a result, it may be important to consider the role of body mass index (BMI; Wheatley et al., 2014) in evaluating women's attractiveness in conjunction with WHR.

Why would a certain WHR in women be attractive for men? The evidence in support of an underlying endocrine mechanism is mixed. One study in 119 women ranging from 24 to 37 years of age suggests that a gynoid pattern of fat distribution (large breasts, a narrow waist, and large hips) is correlated with higher levels of both estradiol and progesterone, which would indicate higher fecundability (Jasieńska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004). However, a separate study using a smaller sample size (33 women), a narrower age range (18-20 years), and rigorous methods found no such relationship (Grillot, Simmons, Lukaszewski, & Roney, 2014), even with the same analysis as Jasienska et al., and even when controlling for BMI. In contrast, in a study of 500 women visiting a fertility clinic across multiple timepoints, each 0.1 increase in WHR was associated with a 30% decrease in the probability of conception per cycle (Zaadstra et al., 1993).

Finally, a recent preprint (Jones et al., 2017) employing a Bayesian analysis with latent multivariate modeling in a sample size twice as large as that in Jasienska et al. (2004) did not replicate any of the hormone-attractiveness relationships in a sample with a more restricted age range, and instead suggests that there is no relationship between salivary estradiol and progesterone and WHR (Jones et al. 2017). In addition, salivary estradiol and progesterone were also unrelated to a second measure of women's attractiveness – facial attractiveness – thereby partially replicating findings from Puts et al. 2013. Thus, it is unclear whether women's WHR is reliably correlated with endocrine measures related to fertility. Nevertheless, given the high correlations between facial attractiveness and body attractiveness, the current study employs WHR as a proxy for women’s own attractiveness in addition to considering the potential effect of BMI on women’s perceptions of other female faces.

1.7 Understanding biases in recognition as a function of developmental task

Evaluating individual differences in measures of a) men’s physical dominance, and b) women’s physical attractiveness as they relate to face recognition behavior may reveal uniquely different cognitive biases. This work provides a cognitive model of mate competition in men and women that buids on the developmental task model discussed previously (Scherf et al. 2012; Scherf & Scott, 2012). With the developmental task model, I posit that age-appropriate developmental tasks and goals influences adult biases in face recognition behavior. Specifically, new developmental tasks over the course of development induce changing needs for face processing (e.g. evaluating faces for long-term relationships, or for potential threat as competitors), which are expected to shape the emergence and plasticity of biases in face processing behavior. For example, young adults must navigate increasingly complex romantic and sexual relationships, and in particular, the fleeting nature of “hookups” or uncommitted relationships, and how they differ from committed relationships (Garcia, Reiber, Massey, & Merriwether, 2013). As adults navigate these relationships and begin to understand how same-sex indivudals may represent competitors, biases related to one’s own sex expected to emerge in the service of navigating social hierarchies and relationship maintenance.

Critically, men and women are not predicted to have different visual experiences of a face; that is, they are not expected to *perceive* faces differently in order to fulfill a particular developmental task. Researchers and individuals supporting the theoretical framework surrounding cognitive penetrability (in which cognitive biases are expected to alter an individual's visual experience of the world; e.g. Lupyan, 2015) may argue that men and women have fundamentally different *visual experiences* of the social world, given the documented sex differences in behaviors and developmental tasks related to survival and sexual reproduction. However, participant ratings of masculinity, dominance, aggression, and attractiveness from facial photographs tend to be highly correlated and largely consistent across sex (Geniole & McCormick, 2015; Wang, Hahn, DeBruine, & Jones, 2016; Han et al., 2017).

Ratings such as these suggest that, at a perceptual level, men and women do not have a fundamentally different visual experience when viewing and rating facial photographs on traits such as aggression, masculinity, or attractiveness. Rather, given particular task demands and contexts, the nature of the information that men and women attend to is expected to change as well.

2 Project goals

This is one of the first studies to consider biases in face recognition behavior as the product of a dynamic interaction between the sex of the observer, the sex of the face to be recognized, and the developmental tasks of the perceiver. To date, biases in face recognition, including the OGB, have been regarded as fixed, stable traits within the perceptual system. Here, I provide the first test of whether and to what extent such biases can be manipulated and induced. That is, given that men monitor same-sex males in order to keep track of potential competitors, I posit that an OGB may be reliably elicited in men if they are first visually primed to detect facial dominance in other male faces. This priming is expected to induce heightened sensitivity to male faces, and expected to manifest in enhanced recognition specifically for male, and not female, faces (i.e. the Dominance condition in the following experiment). Relatedly, an OGB may be reliably elicited in women if they are first visually primed to detect facial attractiveness in other female faces (i.e. the Attractiveness condition in the following experiment). This priming is expected to induce heighted sensitivity to female faces and manifest in enhanced recognition specifically for female, and not male faces. Evaluating traits that are not directly related to reproductive goals or mate competition (e.g. likeability) are not expected to prime heighted sensitivity to opposite- or same-sex faces.

I aim to evaluate the dynamic, interactive nature of participant sex and the sex of the face to be remembered in face recognition. This is critical for the process of examining whether there are specific, ecologically-relevant conditions under which an OGB can reliably be elicited in face recognition. The inconsistencies in the existing literature lead me to address several primary goals.

In the following experiment, I evaluated the extent to which the presence of same-sex competitors may drive enhanced recognition for own-sex faces in both men and women. Specifically, this work focuses on understanding how biases related to judgments of attractiveness and dominance influence memory for same- and opposite-sex faces in a subsequent face recognition task. In addition, I evaluated the extent to which individual differences in one's own dominance and attractiveness (measured by physical strength, bicep circumference, BMI, and waist-hip ratio), as well as relationship status and satisfaction motivated dfferences in recognition behavior. In this way, I tested how characteristics of the perceiver interacted with the characteristics of the face to be remembered, and how the OGB could emerge as a function of this interaction within specific contexts.

The first goal is to evaluate whether the OGB in face recognition behavior may be reliably elicited in a sample of typically developing healthy female adults as a function of an *attractiveness* prime (with males in the same condition serving as one control group, and females without the prime serving as second control group). The second goal is to evaluate whether the OGB in face recognition behavior may also be elicited in a sample of typically developing healthy male adults as a function of a *dominance* prime. In this condition, the females judging facial dominance first are not expected to exhibit an OGB in their face recognition behavior, given that women tend to evaluate competitors primarily based on cues related to attractiveness (and not necessarily dominance).

The third goal is to investigate whether the effect of the attractiveness prime or dominance prime on inducing an OGB in women or men, respectively, may be moderated by one's own attractiveness (measured using waist-hip ratio and BMI as a proxy in women) or dominance (measured using hand grip strength, height, and bicep circumference in men).

The final goal is to evaluate whether relationship satisfaction, jealousy, and ratings of physical dominance, prestige, and attractiveness may influence participants' recognition performance for female or male faces.

For instance, one can imagine that women may be more motivated to be mindful of other attractive women when in committed relationships with low rates of satisfaction, as attractive women represent alternatives to an unhappy relationship. Similarly, mate guarding may also occur when women are satisfied in their relationships, but are worried that their partner might not be (e.g. if they perceive themselves as lower in mate quality than their partner). On the other hand, attractive women could also pose less of a threat for women who are highly satisfied with their relationships with higher rates of mutual trust. Given the prediction regarding assortative mating (where 9s tend to mate with 9s, 6s with 6s, etc.), attractive women should experience an OGB in the service of guarding a mate that is (presumably) also high in value (measured with relationship satisfaction questionnaire). On the other hand, if an attractive female has a partner low in mate value, she is not expected to experience an OGB to the same degree as a woman with a partner that is high in mate value.

Overall, this work informs current literature on the complexity of how a perceiver's sex and developmetnal tasks may interact with the sex of the observed face in a context-dependent, dynamic way rather than in a fixed, stable way (as has been suggested in the literature). This work builds on existing models of visual perception and face processing, but applies them to face recognition in a novel way that emphasizes the importance of mate competition in adult men and women in face processing. With this model, I posit that directing adults to make explicit judgments about dominance (in men) or attractiveness (in women) engages hyperawareness of same-sex individuals as competitors, which facilitates enhanced memory for same-sex faces in a face recognition task.

This novel theoretical framework delivers multiple testable hypotheses and detailed predictions about the nature of the OGB in face recognition. Ultimately, this work can inform the way we think about the influence of sex on behavior – as well as the interactive nature of sex in face recognition – by investigating how memory for faces responds to contextual changes. This work will lay a foundation for subsequent studies investigating developmental changes in the dynamic interaction between the sex of the perceiver as well as the sex of the face to be perceived in both typically developing individuals, as well as those with autism or schizophrenia (who experience deficits in face processing behavior).

2.1 Predictions and competing hypotheses

1. The OGB in face recognition behavior may be reliably elicited in a sample of typically developing healthy female adults as a function of an *attractiveness* prime (with males in the same condition serving as one control group, and females without the prime serving as second control group).

2. The OGB in face recognition behavior may also be elicited in a sample of typically developing healthy male adults as a function of a *dominance* prime. In this condition, the females judging facial dominance first are not expected to exhibit an OGB in their face recognition behavior, given that women tend to evaluate competitors primarily based on cues related to attractiveness (and not necessarily dominance).

3. More dominant men are expected to be less sensitive to dominance in other male faces, and similarly experience a male OGB to a lesser degree than less dominant men. A competing hypothesis may suggest a curvilinear relationship, where men who are extremely high or low in dominance will not experience an OGB at all, but men in the average will, and to a greater degree than men in the extremes.

4. More attractive women are expected to experience an OGB to a greater degree than less attractive women. On the one hand, given assortative mating (where 9s tend to mate with 9s, 6s with 6s, etc.), attractive women should experience an OGB (i.e. greater recognition memory for female faces) in the service of guarding a mate that is

(presumably) also high in value. An alternative hypothesis, however, would be that a woman that is high in attractiveness does not need to compete with other, less attractive women, and therefore will not experience an OGB.

4. Relationship satisfaction, jealousy, and ratings of physical dominance, prestige, and attractiveness may influence participants' recognition performance for female or male faces. On the one hand, one can imagine that women may be sensitive to other attractive women when in committed relationships with low rates of satisfaction, as attractive women represent alternatives to an unhappy relationship. On the other hand, mate guarding may also occur when women are satisfied in their relationships, but are worried that their partner might not be (e.g. if they perceive themselves as lower in mate quality than their partner). Attractive women could also pose less of a threat for women who are highly satisfied with their relationships with higher rates of mutual trust. On the other hand, if an attractive female has a partner low in mate value, she may not experience an OGB to the same degree as a woman with a partner that is high in mate value. Given the exploratory nature of these analyses, each of these predictions merit equal consideration.

3 Method

3.1 Participants

The sample included 360 typically developing, heterosexual adults (age range = 18-35 years; 180 males, M = 19.59, SD = 2.43; 180 females, M = 19.96 $S.D.$ = 2.88) that passed the screening criteria (out of 471 individuals that were initially screened). Table 1 shows the distribution of eligible participants by age and sex in each experimental condition. Age was not different between sex $t(358) = -1.286$, $p = 0.199$, between experimental conditions, $F(2,357) = 2.341$, $p = 0.098$, or between sex, within each condition (Attractiveness: $t(118) = -.516$, $p = 0.607$; Dominance: $t(118) = 0.030$, $p = 0.976$; Likeability: $t(118) = -1.818$, $p = 0.072$). In addition, a univariate analysis of variance with sex and condition as the between subjects factors and age as the within-subjects factor revealed no main effect of sex, $F(1,354) = 1.667$, $p = 0.198$, no main effect of condition $F(2,354) = 2.345$, $p = 0.097$, and no interaction between sex and condition, $F(2,354) = 0.978$, $p = 0.377$. As such, all comparisons were between age-matched participants.

This sample size was determined *a priori using the* G*Power 3 statistical power analyses software (Faul, Erdfelder, Lang, & Buchner, 2007). To provide 80% power to detect a moderately-sized (d = .5) three-way omnibus interaction among the within-subjects factors of participant sex (male, female), and between-subjects factors of condition (attractiveness, dominance, or likeability), and stimulus sex (male, female) from a repeated-measures ANOVA with a significance level of $p < .05$, required 120 participants in each of the 3 conditions (totaling 360 participants).

Participants were recruited largely via print advertisements, Penn State's StudyFinder, and the PSU Psychology Department undergraduate subject pool. Participants provided informed consent prior to participating in the experiment. All participants were self-reported to be exclusively heterosexual (i.e. were screened out if they reported being anything other than heterosexual or preferring the opposite sex predominantly or exclusively), and had no 1) current or lifetime neurological or psychiatric disorders in themselves, 2) history of autism or other pervasive developmental disorder (PDD) in themselves or first-degree relatives, 3) history of loss of consciousness; 6) sensory impairments such as vision or hearing loss, or 7) history of abnormal developmental milestones. The exclusion of subjects with a history of any psychiatric disorder or autism in first-degree relatives was aimed at excluding those individuals with genetic loading for disorders that are known to disrupt face-processing behavior. All the experimental procedures were reviewed and approved by the Internal Review Board at Penn State University.

3.2 Materials

3.2.1 Face Stimuli

Databases. The stimuli for these experiments were created using young adult faces from several databases, including the Radboud Face Database (RaFD; Langner et al., 2010; Caucasian and Moroccan faces), FaceGen database (Oosterhof & Todorov, 2008; computer-generated faces), NimStim (Tottenham et al., 2009), Karolinska face database (Lundqvist, Flykt, & Öhman, 1998), NIMH-ChEFS (Egger et al., 2011), and JimStim (Tanaka, Campbell, Hagen, & Xu, 2016).

3.2.2 Trait Evaluation Task Stimuli

For the trait evaluation tasks (figure 5a), three male and female faces were selected from the FaceGen database (Oosterhof & Todorov, 2008). These faces were created using a mathematical algorithm designed to predict facial features, which increase or decrease each face attribute (i.e. attractiveness, dominance, or likeability) by adjusting face shape and reflectance (Oosterhof & Todorov, 2008).

This algorithm generates vectors in face space, based on participant ratings of real faces, which can later be used to edit features related to different attributes in the positive and negative direction (for more details, see Todorov, Dotsch, Wigboldus, & Said, 2011). For example, previous findings suggest that masculine shape makes male faces unattractive, and only masculine reflectance makes them attractive (Oh, Dotsch, Porter,

& Todorov, 2017; Said & Todorov, 2011). Thus, a 100% attractive male face is one in which shape is in the negative direction (feminine) and reflectance is in the positive direction (darker; figure 2a). By contrast, a 100% attractive female face is one in which both shape and reflectance are in the negative direction (lighter and more feminine; figure 2b).

Once the base vectors in face space were generated, they were subsequently used to transform features in positive and/or negative directions. The +1 SD transformed faces were considered to be the 100% attractive (figure 2a-b), dominant (figure 3a-b), or likeable (figure 4a-b) face relative to the original faces (for more details on this procedure based on face space, see Todorov et al. 2011). These +1 SD faces were morphed with the 0% attractive, dominant, or likeable faces using the Face Mixer in Abrosoft FantaMorph 5 Deluxe (Version 5.4.0, www.fantamorph.com) to produce versions of each trait that were 1, 2, 3, 4, 6, 8, 11, 16, 27, 32, 45, 64, and 91% (of 1 SD) versions of each face (for more details on this morphing procedure, see Motta-Mena & Scherf, 2017).

3.2.3 Face Identity Recognition task

For the recognition task, the stimuli consisted of 30 grayscaled photographs of faces with neutral and happy expressions presented on a black background (figure 5b). Photographs were acquired from several face databases, including the NimStim (Tottenham, et al., 2009), Karolinska (Lundqvist, et al., 1998), NIMH-ChEFS (Egger, et al., 2011), and JimStim (Tanaka, Campbell, Hagen, & Xu, 2016). Luminance was standardized across images. Skin blemishes and scars were edited to eliminate any potential cues for recognition. The stimuli included 5 male and 5 female target identities, and 5 male and 5 female distractor identities. There were two images of each target identity, one presented at encoding and a separate image presented at test. Together with the 10 distractor images (all smiling), this resulted in a total of 30 images. The ethnic distribution of the stimuli reflected the ethnic distribution of the town from which participants were recruited.

3.3 Measures

Prior to completing any of the computer tasks, participants were first screened to determine their eligibility for the full study.

3.3.1 Autism Quotient

Potential participants completed the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) as part of the screening tools. The AQ is a 50-item self-report questionnaire that assesses social skills (e.g., “I find it hard to make new friends") and restricted/repetitive interests (e.g., “I am fascinated by dates”) as an index of broader autism phenotype traits in individuals. Responses on the AQ were coded based on a 4-point scale so that total scores ranged from 50 - 200 (Hoekstra, Bartels, Cath, & Boomsma, 2008; Rhodes, Jeffery, Taylor, & Ewing, 2013). Higher scores indicate the presence of more autistic traits. Given that individuals with high rates of autism-like traits typically also have impaired face processing, individuals who scored above 109 on the AQ were not eligible for the full study due to high autism-like symptomology (see Whyte & Scherf, 2017).

3.3.2 General Medical History and Sexual Preference Survey

This screening questionnaire was a general medical history survey that asked participants about current and past psychiatric or psychological disorders in themselves as well as in first-degree relatives (i.e. biological mother, father, and siblings). In addition, this questionnaire included a 2-item sexual preference survey in which participants provided a self-report assessment of their sexual preference and sexual orientation. The sexual preference question asks about the sex of the individual's preferred sexual partner on a scale of 1-6 (1- women exclusively, 2-women predominantly, 3- both women and men, 4- men predominantly, 5- men exclusively, 6 - other). The sexual orientation question asks participants to self-report their orientation using one of four labels, including: 1-heterosexual, 2-homosexual, 3-bisexual, or 4-other. Participants completed this questionnaire after signing the screening consent. Participants were required to report as preferring the opposite sex predominantly or exclusively, and exclusively heterosexual to be considered eligible for the full study (as in Scherf, Elbich, & Motta-Mena, 2017).

3.3.3 Adult Symptom Inventory

The Adult Symptom Inventory is a checklist of behaviors that tend to be characteristic of different psychiatric disorders (twenty in total). Participants read each prompt and responded with either “Never”, “Sometimes”, “Often”, or “Very Often”. There are twenty groups of behaviors, each corresponding to a different psychiatric diagnosis such as Generalized Anxiety Disorder (GAD) or Schizophrenia. Example items for GAD include “I worry a lot about bad things that could happen”, “I have trouble getting myself to stop worrying”, and “I have trouble keeping my mind on what I am doing.” If participants responded with “Often” or “Very often” for more than half of the items in any one group of behaviors, they were deemed ineligible for the full study.

3.3.4 Perceived Relationship Quality Components Questionnaire

Once each participant completed the computer tasks, they then completed a modified version of the Perceived Relationship Quality Components questionnaire (PRQC; Fletcher, Simpson, & Thomas, 2000). The PRQC contains six subscales, each measuring a distinct component of relationship quality: satisfaction, intimacy, trust, passion, commitment, and love (see appendix C). As in previous work, only the first item within each subscale was presented to participants (for a total of six items in the questionnaire), given that responses to the questions within each subscale are highly correlated with each other, and thus redundant with the first question within each subscale (Fletcher et al., 2000).

The PRQC is measure of global perceived relationship quality, and asks questions such as “How dedicated are you to your relationship?” and “How happy are you with your relationship?” (figure 5c). Participants completed two versions of this questionnaire, one version from their own perspective (PRQC-Self; e.g. “How dedicated are you to your relationship?”) and one asking the participant from their partner’s perspective (PRQC-Partner; e.g. “How dedicated is your partner to your relationship?”). Scores on the PRQC range from 1 to 7, with 7 indicating higher levels of commitment and satisfaction. Responses were summed and averaged across the six questions.

3.3.5 Scale for Three Types of Jealousy

This questionnaire measures three types of jealousy (Buunk, 1997; see appendix C): reactive jealousy (the degree to which a person would be upset if their partner would engage in certain intimate behaviors with a third person), preventive jealousy (the degree to which one was inclined to prevent even innocent, superficial contact between the partner and members of the opposite sex), and anxious jealousy (refers to the frequency of worrying over the potential sexual and intimate contact of the partner with someone of the opposite sex).

Participants responded from 1 (not at all) to 5 (extremely) for each of the 15 items (e.g. “I am concerned that my partner finds someone else more attractive than me”). Participants completed two versions of this questionnaire, one version from their own perspective (Jealousy-Self; e.g. “I am concerned that my partner will find someone else more attractive than me.”) and one from their partner’s perspective (Jealousy-Partner; e.g. “My partner is concerned that I will find someone else more attractive than them.”) The scores were summed across each type of jealousy (α = .85) following previous work, and range from a possible 15 to 75 (α = .85; Buunk, 1997), with higher scores indicating higher rates of jealousy. Previous research using this measure has linked women’s reported relationship jealousy and intrasexual competitiveness with hormonal indices, suggesting that reported relationship jealousy and intrasexual competitiveness may be highly related behaviors (Cobey et al., 2012; Cobey, Pollet, Roberts, & Buunk, 2011).

3.4 Experimental Procedures

All computer tasks were conducted on a MacBook Pro computer (12-inch monitor) using MATLAB with Psychophysics Toolbox (Brainard, 1997) and PsychoPy, Psychophysics software in Python (Peirce, 2007). Figure 1 illustrates the experimental design, including the randomization protocol for each experimental condition, as well as the tasks included within each condition.

Prior to beginning the experiment, participants were screened for eligibility for the study. Upon completing the screening consent and questionnaire, participants were randomly assigned to one of 3 between-subject conditions: attractiveness, dominance, or likeability. Following randomization, participants completed a face trait evaluation task (either Attractiveness, Dominance, or Likeability depending on the condition; Figure 5a), followed by a face recognition task (Figure 5b), a relationship questionnaire (Figure 5c), and a series of ratings about their own and partners' physical dominance, attractiveness, and prestige. After the computer tasks were completed, participants completed several physical measures.

The Attractiveness condition was designed to engage female intrasexual competition mechanisms prior to face recognition and subsequently induce an OGB in female face recognition. The males in this condition were included to test the specificity of the effect with respect to participant sex. In this condition, women (and not men) were expected to remember more female faces than male faces.

The Dominance condition was designed to engage male intrasexual competition mechanisms prior to face recognition and subsequently induce an OGB in male face recognition. The female participants in in this condition were included to test the specificity of the effect with respect to participant sex. In this condition, men (and not women) were expected to remember more female faces than male faces.

Finally, the Likeability condition was included as a control condition. While it is possible that individuals may evaluate potential partners on their "Likeability" (and thereby categorize likeability as a trait that represents mating cues), judging faces on Likeability is not expected to prime mating motives as strongly (or at all) as exposure to explicit mating cues such as attractiveness or dominance. In this condition, there were no expected modulations in recognition behavior as a function of observer or stimulus sex.

3.4.1 Trait Judgment Tasks

The trait evaluation tasks were designed to measure the minimum amount of perceptual information (i.e., perceptual threshold) necessary to detect each face trait. It was a 2-alternative forced-choice fixed step-size perceptual staircase procedure (Cornsweet, 1962) The code for this perceptual staircase procedure has been previously published (Motta-Mena & Scherf, 2016). This staircase procedure has been made publicly available for use (https://nyu.databrary.org/volume/272), but note that this code from Motta-Mena & Scherf (2016) employs a different paradigm and stimuli (see Motta-Mena & Scherf, 2016 for more details).

Prior to each task, participants were provided definitions of each trait. Attractive (figure 2) was defined as “pleasing, appealing, or good-looking”. Dominance (figure 3) was defined as “strong”, and “more likely to win in a physical fight”. Likeable (figure 4) was defined as “pleasant, friendly, or agreeable.” Each participant was randomized into one of the three conditions and judged only one face attribute (see *General Procedures* for more details). Each version of the task (attractiveness, dominance, or likeability) began with 6 practice trials in which each of the 100% trait faces was paired with the 0% face. Participants identified, “Which face is more attractive [dominant, likeable]?” and were required to respond correctly on each practice trial prior to beginning the experiment.

After the practice, on each trial, participants saw a pair of faces on either horizontal side of a central fixation. Participants decided “Which face is more attractive [dominant, likeable]?” with a button press. The pair of stimuli included the 0% face and one of the morphed trait faces (e.g., 32% dominant face). The position of the stimuli was counterbalanced across trials. The first trial included the 0% and the 64% morph (see

Figure 2a-b). After each trial, a threshold was calculated based on the participant's response. The staircase procedure involved a 1-down/2-up step size along a $\log_2$ function until the participant experienced 5 failures. For each failure, a perceptual threshold was computed as the average of the morphed stimulus from the failed trial and that from the most recent successful trial. For example, if a participant failed at a trial in which the 32% morph was presented, the perceptual threshold would be computed as (45% + 32%)/2 = 38.5%.

The final perceptual threshold was computed as the average of the five thresholds. This stopping criterion (5 failures) was determined as an appropriate stopping rule for the staircase procedure based on previous work (Motta-Mena & Scherf, 2016). This criterion appropriately balances the subject variability, but also interdependence of responses, like anchoring effects and adaptation-level phenomena, perseveration, and anticipation (Cornsweet, 1962). Participants were encouraged to answer as quickly and as accurately as possible. Each face attribute task was comprised of 6 blocks, one for each identity (3 male, 3 female), that were presented in a randomized order.

3.4.2 Face Identity Recognition Task

After the trait judgment task, participants completed an old/new recognition paradigm with male and female adult faces that we have employed in previous work from our lab (Picci & Scherf, 2016; Picci, Motta-Mena, & Scherf, in prep). This task included an encoding, delay, and test period, in which stimuli were presented in a randomized order. Specifically, after studying 10 neutral target faces, participants identified whether each face in a set of 20 smiling faces (10 targets, 10 distractors) was new or old. Participants first completed a practice phase, which consisted of an abbreviated version of the task. During the practice, the experimenter sat with the participant and guided the participant through the task (i.e., encoding, delay, recognition). At the end of practice, participants were instructed to "try to remember the person, and not the picture" to encourage participants to create an invariant representation of the face identity.

During the encoding phase, participants viewed 10 neutral target faces and were told that they needed to remember the faces because they would be tested on them later. Participants had 2000 ms to encode each face. In the delay period, participants watched a movie trailer (approximately 1.5 minutes). During the recognition phase, participants were presented with the 10 target faces together with 10 distractor faces, all of whom were smiling. The faces were each presented for 3000 ms and participants responded to the prompt "Have you seen this face?" with a "yes" or "no" response by button press.

3.4.3 Hand grip strength

Following previous work (Al-Asadi, 2018; Umar, Danborno, Olorunshola, & Adamu, 2016) left and right hand grip strength was measured in kilogram-force (kgf) with a digital hand grip dynamometer (Model EH101, Camry Digital Hand Dynamometer, China) as a proxy for physical dominance. Studies have reported equivalent results for comparison of dominant and non-dominant hand strengths (Armstrong & Oldham, 1999). As such, the arithmetical mean of right- and left-hand measures (rather than right-left differences) was calculated for statistical analyses. Participants were asked to perform a maximum force trial for each hand for approximately 2 sec. If an error was noted, the test was repeated after a 30-sec rest.

3.4.4 Biceps circumference (flexed and relaxed)

To measure biceps circumference, male participants were first asked to remove excessive clothing (e.g. sweaters, coats). If they declined, measures were taken over the sleeves. Male participants were then asked to extend their arm in front of them with their palm facing up, beginning with the right arm. The researcher then wrapped the measuring tape around the widest part of the male participant's biceps muscle (the midpoint between the participant's elbow and shoulder), and asked the participant to flex, while bringing their wrist back toward their shoulder. The researcher then noted the measurement in cm without adjusting the measuring tape. Upon successfully measuring the flexed biceps, the researcher then asked the male participant to relax his arm straight by his side, and the relaxed measurement was then recorded. This procedure was repeated for both arms until three observations were recorded each for flexed right and left bicep, and relaxed right and left bicep. For the current study, the arithmetic mean of the left and right flexed biceps measures was used in the analyses.

3.4.5 Waist/hip ratio

To measure waist/hip ratio, both waist circumference and hip circumference were measured with tailor's tape. Female participants were asked to extend their arms out in a "T" fashion while the experimenter wrapped the measuring tape around their waistline, or the lowest part of their ribcage. Participants were encouraged to breathe normally. The researcher measured the waistline in cm in three unique observations. Between each measure, the participant was asked to hold the measuring tape in place. For hip circumference, participants were instructed by the researcher that the hips would be measured at the widest point, or where the hip bones stick out the most. The researcher wrapped the measuring tape around the hips, and measured the hips circumference in three unique observations. Between each measure, the participant was asked to hold the tape in place.

To calculate WHR based on the waist and hip circumference, each of the three unique observations for hip circumference and waist circumference were averaged to create the variables “hip_average” and “waist_average”, respectively. WHR was calculated by dividing the average hip circumference by the average waist circumference for all female participants. WHR thus ranges from a minimum of 0 to a maximum of 1.

3.4.6 Height and weight

The protocol for measuring height and weight was adapted from the Anthropometric Standardization Reference Manual (Lohman, Roche, & Martorell, 1988), and the scale used was a Health-O-Meter Physician Balance Beam Scale (Model # 402LB).

To measure height, participants were first instructed to remove their shoes, coats, heavy sweaters, keys, and heavy pocket contents, and stand on the scale platform with their backs to the height beam. Participants were instructed to stand on the scale with their heels together, arms at their sides, legs straight, and shoulders relaxed. Participant’s heels, buttocks, and head were ascertained to be in contact with the vertical height beam. For participant who could not place all three body parts against the beam, at least the buttocks and heels or buttocks and head were ascertained to be touching the beam. The researcher then lowered the height beam to the highest point of the head, and made sure the hair was compressed. The participant was asked to step off the scale, and the height was noted to the nearest .5 cm. The height beam was then reset, and this process was repeated two more times, until three unique height observations were recorded.

To measure weight, participants were then asked to stand in the middle of the scale's platform with the body weight equally distributed on both feet. Weight was recorded to the nearest 0.5 lb (pound). The participant then stepped off the scale while the researcher reset the weight to zero. The participant was then asked to step back on the scale. This procedure was repeated two more times, until three unique weight observations were recorded.

3.4.7 Self- and Partner-Ratings

Participants were asked to rate themselves on a scale from 1 (not at all) to 7 (extremely) on attractiveness ("Relative to other individuals of your same sex at Penn State, how physically attractive would strangers rate you?"), physical dominance ("If you got into a physical fight with the average Penn State undergraduate of your same sex, how likely would you be to win?"), and prestige ("Relative to other individuals of your same sex at Penn State, how prestigious (i.e. respected, admired, talented, and successful) are you?"). In addition, participants also rated their partners on each dimension (e.g. "Relative to other individuals of your partner's sex at Penn State, how physically attractive would strangers rate your partner?").

3.5 Data Analysis

Prior to analyses, the biometric data and the data from each of the tasks were evaluated for 1) violations of normality, 2) appropriate skew and kurtosis, and 3) outliers separately for each task, sex, stimulus category (i.e. male and female faces), and condition (i.e. Attractiveness first, Dominance first, Likeability first), given that each condition was expected to drive unique effects (i.e. the d' data from the Attractiveness condition was expected to be different from the Dominance condition; therefore, differences in normality, skew, or kurtosis could theoretically be present and different across conditions).

Any individual data point beyond ± 2 SD of the mean for the respective group in response to the particular stimulus category, or for the biometrics within a particular group were replaced with the mean ± 2 SD for that group (e.g. BMI for women in the attractiveness condition, or threshold scores for males in response to male faces in the dominance condition). This procedure is typically used for minimizing effects of extreme scores while maintaining the size of the sample and minimally affecting the mean of the distribution (Dixon & Tukey, 1968; as in Motta-Mena & Scherf, 2016). Planned comparisons were conducted with appropriate Bonferroni-corrected t-tests.

3.5.1 Trait Judgment Tasks

For each trait, the perceptual thresholds for the three male identities and the three female identities were averaged within stimulus sex to create a “Male Face” and “Female Face” threshold for each trait (e.g. threshold for attractiveness in male faces vs. female faces). This permitted the evaluation of potential performance differences between men and women on each of the trait judgment tasks for male and female faces. Ideally, men and women should perform comparably in their ability to detect Attractiveness, Dominance, or Likeability. If men and women exhibited different perceptual thresholds in any of the trait judgment tasks, there would be potential considerations in the subsequent argument about how men and women perceive these traits, particularly with respect to the experimental manipulation. For example, sex differences in perceptual thresholds for Attractiveness would beg the question about whether the subsequent OGB in recognition is due to the experimental design, or due to individual differences in men and women's sensitivity to Attractiveness. As such, the perceptual thresholds from the trait evaluation tasks were evaluated for main effects of observer sex as well as observer sex X stimulus sex interactions.

To do so, perceptual thresholds from each trait judgment task (i.e. Attractiveness, Dominance, or Likeability) were submitted to separate repeated-measures ANOVAs with participant sex (2) as the between-subjects factor and stimulus sex (2) as the within-subjects factor within each condition (i.e. Attractiveness first, Dominance first, or Likeability first). Higher perceptual thresholds indicate that individuals require more information to detect the trait. Conversely, lower perceptual thresholds indicate that individuals need less information to detect the trait.

3.5.2 Recognition Task

Before calculating d' from this task, a loglinear transformation was applied to correct for hit and false alarm rates of 1 and 0. This is necessary because the corresponding z-scores would otherwise have resulted in infinite scores (Hautus, 1995; Snodgrass & Corwin, 1988; Stanislaw & Todorov, 1999). As recommended in the literature, the loglinear transformation was applied to all the data, and not only to hits and false alarms of 1 and 0 (Hautus, 1995; Schooler & Shiffrin, 2005; Snodgrass & Corwin, 1988). Specifically, 0.5 was added to the number of hits and the number of false alarms (for each participant). This value was then subsequently divided by N + 1, where N corresponds to the number of signal or noise trials. This procedure is advocated in signal detection studies, and successfully accounts for extreme scores in the recognition data (e.g. Cañal-Bruland, Balch, & Niesert, 2015; Ziaei, Salami, & Persson, 2017).

The hit and false alarm rates were submitted to SPSS statistical software, and d' scores were calculated using the SPSS function: COMPUTE DPRIME = PROBIT(H) – PROBIT(F) (where PROBIT z-scores each value; Stanislaw & Todorov, 1999). D' was thus computed as follows:

$$d' = z(\text{hit rate}) - z(\text{false alarm rate})$$

$$\text{Hit Rate } (H) = \frac{\#\, Hits + .5}{\#\, Total\ Hits + 1}$$

$$\text{False Alarm } (FA) = \frac{(\#\, FA + .5)}{\# Total\ FA + 1}$$

Separate d' scores were computed for female face recognition and male face recognition for each individual. Scores on the face recognition task were converted to d' rather than accuracy because it accounts for response biases in addition to hit rate and false alarm rates (Green & Swets, 1966). D' scores from the face recognition task were calculated to evaluate whether participants exhibited an OGB in face recognition behavior. In addition, inverse efficiency scores were also calculated for male and female faces in order to evaluate speed-accuracy trade-offs in men and women's performance for same- and opposite-sex faces. Inverse efficiency (IE) is calculated by dividing reaction time (RT) by the proportion of correct responses (Townsend & Ashby, 1985), thus accounting for any potential speed/accuracy tradeoff effects in the data. Thus, a higher IE score indicates worse performance; inversely, lower IE scores indicate more efficient performance (Bruyer & Brysbaert, 2011; Collignon et al., 2008).

Participants with below-chance performance (accuracy at <0.5 for either male or female faces) across all trials, were excluded from the recognition analysis (N=8). Three participants were also excluded because they were administered the “child” version of the recognition task that includes longer encoding and recall durations. The final sample in the recognition data analysis included 349 individuals.

In addition, to account for those trials where participants accidentally pressed a key and scored correctly, the 5 fastest correct trials across all participants were averaged to create a minimum response threshold criterion (2230 ms). Using this minimum response criterion, two trials were excluded from the entire dataset from two different participants.

Finally, from the d’ data, an OGB score was computed for men and women to evaluate superior performance on the sex-specific face for each group. Specifically, the female OGB was computed by subtracting d’ scores for male faces from d’ scores for female faces (i.e. d’ female – d’ male). Similarly, the male OGB was computed by subtracting d’ scores for female faces from d’ scores for male faces (i.e. d’ male – d’ female). This difference score is a measure of recognition performance for own-sex faces relative to recognition performance for opposite-sex faces (i.e. a proportion), and was employed as the outcome measure in the individual differences analysis with the relationship questionnaires and the physical measures (detailed below).

3.5.3 Relationship Questionnaires (Status, PRQC, Jealousy Scale)

The modified version of the PRQC included four preliminary questions asking about relationship status (Appendix C). Previous work has demonstrated that 81% of undergraduates have reported engaging in some form of “hookup behavior”, a term which focuses on the uncommitted nature of a sexual encounter (Garcia, Reiber, Massey, & Merriwether, 2013). Thus, to capture the transient and often informal nature of relationships during this age range, the PRQC was modified to include two questions asking participants who self-reported as “Single” whether they had any “friends with benefits” or “hookups” (based on terms reviewed in Garcia et al., 2013). If not, they were instructed to think of their last serious relationship throughout the questionnaire. Participants who reported never being in a relationship were excluded from the relationship analyses (n=2).

Prior to analysis, the responses to the PRQC-self and PRQC-partner were reviewed for errors. For example, following question #1 regarding relationship status (i.e. “What is your current relationship status? 1. Single, 2. In a relationship, or 3. Married”), participants must then specify the length of their relationship IF APPLICABLE (*“If you are currently in a relationship or are married, how long have you been in this relationship? 1. 0-12 months, 2. 12-24 months, 3. 24-36 months, 4. Greater than 36 months, 5. N/A”*). As such, individuals reporting as “Single” for question #1 should always respond with “N/A” to question #2 regarding length of their relationship. However, several individuals did not follow the instruction to respond with N/A if applicable for the follow-up question, and instead responded with “0-12 months”. For these participant errors, the researcher manually corrected the response to the follow-up question to be the appropriate response (i.e. N/A), (n = 11).

Similarly, if a participant reported “N/A” to the question “If you are single, is there someone in your life right now that you would get jealous over if they hooked up with someone else?” (key #3), the response to the next question (“If yes, how many times have you hooked up with this person in the last month? If not applicable, please select N/A.") is required to be key press #4 for N/A. However, several individuals reported that they did not follow the instruction to respond with the key press for N/A if applicable (due to accidental button press), and instead responded with key press #3 rather than key press #4 for N/A for the follow-up question regarding number of hook-ups. For these participant errors, the researcher manually corrected the response to the follow-up question to be the appropriate response (i.e. "N/A"), ($n = 14$).

As in previous work (Fletcher et al., 2000; Watkins et al., 2017), the reliability of the six items in the PRQC was high ($\alpha = 0.929$). As a result, responses were summed across all six items and averaged out of six, and range from a possible 1-7, with higher scores indicating greater relationship satisfaction. Similarly, as in previous work (Buunk, 1997), the reliability of the items in the Jealousy scale within the three types of jealousy was high ($\alpha = 0.846$). As a result, responses were summed across all three subscales, averaged out of 15, and range from a possible 15 to 75, with higher scores indicating higher rates of jealousy.

To evaluate the degree to which relationship satisfaction relates to the magnitude of the OGB, each of the sex-specific OGB difference scores (i.e. male OGB, female OGB) were submitted to simple linear regressions with the PRQC scores and the jealousy questionnaire as predictor variables for those participants in the Attractiveness or Dominance conditions (where an OGB was predicted to emerge). Specifically, participants with *lower* relationship satisfaction were expected to evince a greater OGB than those with greater relationship satisfaction. Similarly, given previous work suggesting that higher rates of jealousy are related to greater intrasexual vigilance in both men and women (Maner et al., 2007), participants with higher reports of jealousy were expected to evince a greater OGB than those with lower reports of jealousy.

3.5.4 Self- and partner-ratings

Participants' self-ratings and partner ratings of attractiveness, dominance, and prestige were submitted to separate linear regression analyses with the individual measures of the male and female OGB (i.e. sex-specific recognition performance for own-sex faces) to evaluate the extent to which self-reported attractiveness, dominance, and prestige were related to the magnitude of the OGB in face recognition.

3.5.5 Physical measures

Prior to computing any regressions between the physical measures, perceptual threshold scores, or measure of individual differences in face recognition (i.e. the sex-specific OGB), the data were visually inspected by creating scatterplots in SPSS with the appropriate outcome variable (y) and the physical measures as the independent variable (x) to check for linearity. In each regression analyses, the distributions of the residuals were checked for normality and constant variance. For multiple regressions, collinearity diagnostics were also examined to ascertain no autocorrelation. Finally, casewise diagnostics were obtained to ascertain that no outliers exceeded ±2 standard deviations in any regression analysis. To evaluate individual differences in recognition behavior as a function of participants' bicep circumference, height, and grip strength (own dominance), or WHR and BMI (own attractiveness), the sex-specific OGB difference scores were submitted to multiple regressions with each of the appropriate physical measures as the predictors.

To evaluate individual differences in men's sensitivity to detect dominance as a function of men's own dominance, men's sensitivity to dominance in male faces (i.e. perceptual threshold scores) were evaluated using multiple regressions with measures of men's own physical dominance (i.e. grip strength, bicep circumference, and height) as predictors. The goal of this analysis was to a) identify the strongest predictor of men's sensitivity to dominance in male faces, and b) evaluate whether more dominant men were also less sensitive to dominance in other men (e.g. as in Watkins, Fraccaro, et al., 2010). The same analysis was also conducted with female dominance to ascertain that this relationship was specific to *male* facial dominance. An additional comparison analysis was conducted in the control condition (where men evaluated *likeability* in men's faces) to evaluate the specificity of the relationship between *physical* measures of dominance and *sensitivity* to facial dominance.

To evaluate individual differences in women's sensitivity to detect attractiveness as a function of women's own attractiveness, women's sensitivity to attractiveness in female faces (i.e. perceptual threshold scores) were evaluated using multiple regressions with measures of women's own physical attractiveness (i.e. BMI, WHR) as predictors. The goal of this analysis was to a) identify the strongest predictor of women's sensitivity to attractiveness in female faces, and b) evaluate whether more attractive women were also more sensitive to attractiveness in other women (given the hypotheses regarding assortative mating). The same analysis was also conducted with male attractiveness to ascertain that this relationship was specific to *female* facial attractiveness. An additional comparison analysis was conducted in the control condition (where women evaluated *likeability* in women's faces) to evaluate the specificity of the relationship between *physical* measures of attractiveness and *sensitivity* to facial attractiveness.

3.5.6 Linear mixed model (LMM) approach

In order to further evaluate the relationship between the male and female OGB and the sex-specific physical measures despite the main effect of stimulus sex, I used a linear mixed model with pre-determined weighted contrasts for each condition of interest (as in other work evaluating perceptual decision-making; Heekeren, Marrett, Bandettini, & Ungerleider, 2004; Gardner & Steinberg, 2005). Unlike the general linear model, which assumes that all observations are independent of each other, the LMM procedure allows for correlated variability among observations (e.g. as in the female vs male OGB scores, each of which include information about d' scores for male and female faces).

The LMM procedure does not permit the simultaneous analysis of multiple dependent variables, and as a result, separate LMM analyses were performed for each of the outcome measures in the specified contrast of interest. Using this approach, the condition of interest (i.e. where an OGB was expected to emerge) was weighted differentially relative to the other two conditions (where an OGB was not expected to emerge) in each analysis. More specifically, the female OGB was evaluated in women as a function of z-scored WHR and BMI in the Attractiveness condition, where a female OGB was expected to emerge. The male OGB was evaluated in men as a function of the z-scored biceps circumference and hand grip strength in the Dominance condition, where a male OGB was expected to emerge. Notably, given their correlation, the measures of men's physical dominance were combined to create a physical dominance composite score. Finally, the male and female OGB were each evaluated separately in men and women, respectively, with the appropriate sex-specific physical measures of attractiveness and dominance, in the Likeability condition, where no OGB was expected to emerge.

Prior to entering the independent and dependent variables for each analysis, the structure of each contrast was specified. The condition of interest in the contrast was specified as +1, while the other two conditions were specified as -.5 (e.g. for the male OGB in the Dominance condition, the contrast was specified as follows: Dominance (+1), Attractiveness (-.5), and Likeability (-.5). Then, for each analysis, subject was included as a random factor, the sex-specific OGB (i.e. female OGB for women, male OGB for men) was included as the outcome variable, the specified contrast was included as a fixed factor, and the sex-specific physical measures were included as covariates in the model. In short, I evaluated the interactions between condition and physical measures on the sex-specific OGB and included the intercept in the model as well.

4 Results

4.1 Are there baseline sex differences in perceptual sensitivity to Attractiveness, Dominance, or Likeability?

Perceptual threshold scores from each of the perceptual trait judgment task were analyzed to determine whether men and women exhibit differential sensitivity to any of the traits. The full set of means and standard deviations for male and female participants' perceptual threshold scores for each trait task are reported in Table 2. The results from each 2 (stim sex) x 2 (participant sex) repeated-measures ANOVA on perceptual threshold scores within each condition are reported in Table 3 with sphericity assumed.

Only the significant findings will be discussed here. There were no interactions between participant sex and stimulus sex in any condition. There was a main effect of stimulus sex within each condition (Attractiveness: $F(1,118) = 13.46$, $p < .001$, $\eta^2 = .102$; Dominance: $F(1,118) = 7.59$, $p < .001$, $\eta^2 = .060$; Likeability: $F(1,118) = 5.56$, $p < .05$, $\eta^2 = .045$). For each trait rating task, participants exhibited lower thresholds for detecting the traits in the male compared to the female faces (see Table 2). Critically, therefore, male and female participants were equally sensitive to detect attractiveness, dominance, and likeability in the faces in the trait judgment tasks, and it was easier to do so in the male faces. Given that there were no sex differences in perceptual thresholds for any of the trait judgment tasks, any differences in face recognition behavior should be attributable to the experimental design and manipulation, and not due to differences in men and women's perceptual sensitivity.

To fully ascertain that men and women performed comparably on male and female faces on each trait judgment tasks, threshold scores for male and female faces were also submitted to independent samples t-tests within each task. These planned comparisons yielded no performance differences between men and women for male and female faces in any of the conditions (all $p > .05$; Table 4). Given that there were no sex differences in sensitivity to detect each of the traits, there is increased confidence that any effects in the recognition data are from the experimental manipulation.

4.2 Does Attractiveness or Dominance induce an OGB in face recognition behavior?

To evaluate whether there were significant differences in recognition behavior as a function of viewing Attractiveness, Dominance, or Likeability first, the loglinear corrected d' sensitivity scores were submitted to a 3-way repeated measures ANOVA, with condition (Attractiveness, Dominance, Likeability) as the between-subjects factor, and participant sex (male, female) and stimulus sex (male, female) as the within-subjects factors. All effects from this omnibus ANOVA are reported in table 5a.

The three-way interaction (condition X participant sex X stimulus sex) was not significant, $F(2, 343) = 0.349$, $p = .706$, $\eta^2 = .002$, and there was no main effect of participant sex, $F(1, 343) = 2.836$, $p = .093$, $\eta^2 = .008$ or of condition, $F(1, 343) = 0.142$, $p = .868$, $\eta^2 = .001$ (Figure 5a-b). There was, however, a main effect of stimulus sex, $F(1, 343) = 54.426$, $p < .001$, $\eta^2 = .137$. Bonferroni-corrected pairwise comparisons revealed that all participants exhibited higher recognition performance for female faces ($M = 1.807$, *S.D.* = 0.72) than male faces, ($M = 1.454$, *S.D.* = 0.73) regardless of participant sex or condition. However, this main effect was then qualified by a stimulus sex X participant sex interaction, $F(1, 343) = 15.864$, $p < .001$, $\eta^2 = .044$, with no interactions with condition. In other words, the condition manipulation did not induce the predicted between-condition differences in men and women's d' scores for male faces (figure 6a) or female faces (figure 6b).

To decompose the stimulus sex X participant sex interaction, d' sensitivity scores for male and female faces were submitted to a Bonferroni-corrected independent samples t-test with 95% confidence intervals with sex as the between-subjects factor. This analysis revealed that, regardless of condition, men and women performed comparably on male faces, $t(1,349) = 1.118$, $p = .264$, but were significantly different in their recognition of *female* faces, $t(1,349) = -3.639$, $p <.001$ (table 5b). Specifically, women outperformed men in recognition of female faces across conditions (means, standard deviations, and confidence intervals included in table 5c; women: *M* = 1.953, *SD* = 0.705; men: *M* = 1.660, *SD* = 0.704). Men and women both remembered more female faces than male faces, *and* women remembered female faces to a greater degree than men did (figure 7a).

As in previous work evaluating the interaction between participant sex and stimulus sex in tests of face recognition (e.g. Lovén, Herlitz, & Rehnman, 2011; Scherf et al., 2017), planned comparisons contrasting group performance on the recognition task were investigated using separate Bonferroni-corrected independent sample t-tests with 95% confidence intervals *within each condition*. The specificity of the predicted pattern of results within each condition further lend support for the planned comparisons (e.g. women in the Attractiveness condition were expected to remember more female faces than male faces, *and* to a greater degree than men in the same condition; men in the Dominance condition were expected to remember more male faces than female faces, *and* to a greater degree than women in the same condition).

Thus far, results have demonstrated that a) men and women remember more female faces than male faces, and b) women outperform men on memory for female faces. Directly comparing men and women's performance on male and female faces allowed for evaluation of whether men outperform women in recognition of male faces in any of the conditions (e.g. as predicted for the Dominance condition). These planned comparisons provided a more fine-grained analysis of the stimulus sex X participant sex interaction within each condition, and helped test whether men and women statistically differed in their recognition of own- and opposite-sex faces. However, given that there was no statistically significant 3-way interaction, some caution is warranted in interpreting these results.

4.2.1 Attractiveness: D' sensitivity scores for male and female faces were each submitted to separate independent-samples t-tests with participant sex as the between-subjects factor. Male and female participants were significantly different in their ability to recognize male faces $t(114) = 2.239$, $p = .027$; but not female faces, $t(114) = -1.605$, $p = 0.111$. For male faces, men exhibited higher d' sensitivity ($M = 1.59$, $S.D. = 0.635$) than women ($M = 1.33$, $S.D. = 0.31$), suggesting that men outperformed women on recognition for male faces specifically in this condition (table 6a-b; figure 8a).

4.2.2 Dominance: D' sensitivity scores for male and female faces were each submitted to separate independent-samples t-tests with participant sex as the between-subjects factor. Male and female participants performed comparably in their ability to recognize male faces, $t(114) = .419$, $p = 0.676$, but were significantly different in their accuracy to recognize female faces, $t(114) = -2.409$, $p = .018$. For female faces, women exhibited higher d' sensitivity ($M = 1.98$, $S.D. = 0.695$) than men ($M = 1.66$, $S.D. = 0.727$). Thus, for the Dominance prime, the only modulation in face recognition behavior was in female participants for female faces, such that females exhibited an OGB, but males did not (table 6c-d; figure 8b).

4.2.3 Likeability: D' sensitivity scores for male and female faces were each submitted to separate independent-samples t-tests with participant sex as the between-subjects factor. Male and female participants performed comparably in their ability to recognize male faces, $t(115) = -0.416$, $p = 0.678$, but were significantly different in their accuracy to recognize female faces, $t(115) = -2.695$, $p = .008$. For female faces, women exhibited higher d' sensitivity ($M = 1.94$, $S.D. = 0.719$) than men ($M = 1.59$, $S.D. = 0.653$).

Thus, for the Likeability prime, the only modulation in face recognition behavior was in female participants for female faces, as in the Dominance prime (table 6e-f; figure 8c).

4.3 Does inverse efficiency differ as a function of participant sex, stimulus sex, or condition?

Inverse efficiency was first calculated by dividing RT by accuracy for all participants. To evaluate whether there were significant differences in IE (effort to arrive at a response) as a function of viewing Attractiveness, Dominance, or Likeability first, IE scores were submitted to a 3-way repeated measures ANOVA, with condition (Attractiveness, Dominance, Likeability) as the between-subjects factor, and participant sex (male, female) and stimulus sex (male, female) as the within-subjects factors. Recall that 11 participants were excluded from this analysis; as such, the final sample for the IE scores analyses included 349 participants (Attractiveness: 57 males, 59 females; Dominance: 57 males, 59 females; Likeability: 58 males, 59 females).

To evaluate whether there were significant differences in IE as a function of viewing Attractiveness, Dominance, or Likeability first, the IE scores were submitted to a 3-way repeated measures ANOVA, with condition (Attractiveness, Dominance, Likeability) as the between-subjects factor, and participant sex (male, female) and stimulus sex (male, female) as the within-subjects factors. The 3 X 2 X 2 repeated-measures ANOVA revealed that IE scores were equivalent across conditions, $F(2, 343) = .025$, $p = .975$, $\eta^2 = .000$ for both female faces (figure 9a) and male faces (figure 9b). In addition, there was a main effect of stimulus sex $F(1,343) = 31.787$, $p < .001$, $\eta^2 = 0.085$ (table 7a), as in the analysis of the d' sensitivity scores. IE scores for female faces were lower than IE scores for male faces, regardless of participant sex (table 7b). Thus, performance for all participants was more efficient for female faces regardless of participant sex or condition, which explains, at least in part, the general superior performance for female faces exhibited in the d' recognition scores. There were no other main effects or interactions in this analysis (Table 7a; Figure 7b). The IE scores are plotted by condition in Figure 10a-c for comparison.

4.4 Results: Physical measures

4.4.1 Are measures of physical dominance in men related to one another?

Previous work has shown that men's grip strength, height, and bicep circumference are highly correlated (and predictive of perceptions of physical dominance in men, e.g. Han et al., 2017). Thus, as a quality check, the first analysis was an attempt to replicate these findings. Correlational analyses between men's weight, height, mean grip strength, bicep circumference, and BMI revealed that all measures were highly intercorrelated (all $p < .001$) (table 8a-b).

4.4.2 Are measures of men's own physical dominance related to their sensitivity to male facial dominance?

As in previous work (Watkins et al., 2017), regression analyses were used to evaluate the relationship between measures of men's physical dominance (grip strength, bicep circumference, and height) and their sensitivity to detect dominance in male faces (i.e. perceptual thresholds in the dominance trait judgment task). Note that this analysis was specifically conducted in those males in the dominance condition, as these were the males who made explicit judgments about facial dominance (figure 3).

The results of the multiple regression indicated that two of the three predictors significantly explained 12.7% of the variance, $R_2 = .127$, $F(3,56) = 2.711$, $p = .054$ (Tables

9a-c). Biceps circumference significantly predicted men’s sensitivity to detect dominance in male faces (β = -.344, *p* = .019; Figure 11a), as did grip strength (β = .329, *p* = .028; Figure 11b). When combined in the model, this positive relationship suggests that as physical dominance increases, perceptual thresholds increase as well (i.e. decreased sensitivity)(Figure 11c). However, height did not significantly predict men’s sensitivity to male facial dominance (*β* = -.078, *p* = .572; Table 9c). Critically, this relationship was not present when these same men evaluated dominance in *female* faces, $F(3,56) = 1.109$, $p = .353$. In addition, this relationship was not present in the separate sample of men that evaluated likeability in men’s faces, $F(3,56) = 1.438$, $p = .241$ (Table 10a-c). Specifically, when making judgments about how *likeable* a face is, men’s own grip strength (*β* = -.132, *p* = .401) and bicep circumference (*β* = .002, *p* = .988) were not related to sensitivity to likeability (Table 10c).

Men’s sensitivity to male dominance (from the threshold data) was also submitted to a simple linear regression with the male OGB (d’ male faces – d’ female faces) as the outcome variable. Critically, this analysis was conducted specifically in the Dominance condition, where a male OGB was initially predicted to emerge. There was no relationship between men’s sensitivity to dominance in male faces and the magnitude of the male OGB, $F(1,58) = .144$, $p = .706$ (Figure 12).

Finally, men’s self-rated dominance was submitted to bivariate correlational analysis with perceptual thresholds for detecting male facial dominance. The negative correlation was not significant, $r = -.077$, $p = 0.571$. Similarly, self-rated dominance was not related to the sex-specific OGB, $r = -.025$, $p = 0.851$.

4.4.3 Are measures of men's own physical dominance related to individual differences in the male OGB?

As a measure of individual differences in participant's recognition performance for faces of their own sex (i.e. sex-specific OGB), a difference score was computed between d' for male and female faces. This sex-specific difference score was submitted to a multiple regression with grip strength, bicep circumference, and height as the predictors, and the male OGB score as the outcome variable. Note that these analyses were conducted specifically in the Dominance condition, where a male OGB was initially predicted to emerge, to evaluate the prediction that males lower in physical dominance would experience an OGB to a greater extent than males who higher in physical dominance.

The results of the multiple regression were not significant $F(3, 53) = 1.434$, $p = .243$ (Table 11b). However, there was one significantly contributing predictor: biceps circumference significantly predicted the measure of the male OGB ($\beta = -.312$, $p = .045$; Table 11c), whereas grip strength and height did not ($p > .05$; Table 11c). A simple linear regression revealed that biceps circumference is negatively and significantly related to men's OGB, $F(1,58) = 4.66$, $p = .035$ (Figure 13). As a comparison, these same analyses were conducted in the males in the Likeability condition. None of the relationships were significant (all $p > .05$; table 12a-c).

4.4.4 Are measures of attractiveness in women related to one another?

The average WHR in our sample of 180 women was .802 (*S.D.* = 0.062), and the average BMI was 23.837 (*SD* = 5.171), both of which reflect national norms for women ages 18-35 (Flegal et al. 2008; descriptive statistics included in Table 13a). Weight was significantly correlated with height, BMI, and grip strength (all $p < .001$), but not WHR (Table 13b).

4.4.5 Are measures of women's physical attractiveness related to sensitivity to female attractiveness?

Multiple regression analyses were used to evaluate the relationship between measures of women's physical attractiveness (WHR and BMI) and their sensitivity to attractiveness in female faces (i.e. perceptual thresholds in the attractiveness trait judgment task). The multiple regression analysis revealed that WHR and BMI did not predict women's sensitivity to female attractiveness, $F(2, 57) = .082$, $p = .921$ (tables 14a-c), or female likeability (the control condition), $F(2, 57) = 1.21$, $p = .306$ (tables 15a-c).

4.4.6 Are measures of women's physical attractiveness related to individual differences in the female OGB?

Multiple regression analyses were used to evaluate the relationship between measures of women's physical attractiveness (WHR and BMI) and their sex-specific OGB score. Note, this analysis was conducted specifically in those women in the Attractiveness condition, given the prediction that Attractiveness should induce an OGB in women specifically. The multiple regression analysis revealed that WHR and BMI did not predict the measure of women's OGB, $F(2, 53) = .173$, $p = .842$ (tables 16a-c).

As a comparison, this same analysis was conducted in the women in the Likeability condition. There was a statistical trend for this model's significance, $F(2, 56) = 2.810$, $p = .058$. WHR significantly predicted the measure of women's OGB in the Likeability condition, $\beta = .298$, $p = .023$ (Table 17a-c; Figure 14).

4.5 Results: Linear mixed effects model

4.5.1 Attractiveness: The intercept emerged as a significant predictor, $F(1, 167) = 53.733$, $p < .001$. None of the other main effects or interactions were significant (all $p > .05$). The full model is illustrated in Table 18.

4.5.2 Dominance: The intercept was not a significant predictor, $F(1, 171) = 2.084$, $p = .151$, and none of the other main effects or interactions were significant (all $p > .05$). The full model is illustrated in Table 19.

4.5.3 Likeability: When evaluating the male OGB in male participants with the composite measure of physical dominance as a covariate, the intercept did not emerge as a significant predictor, $F(1, 171) = 2.711$, $p = .151$. None of the other main effects or interactions were significant (all $p > .05$). The full model is illustrated in Table 20.

When evaluating the female OGB in female participants with WHR and BMI as covariates in the model, the intercept did not emerge as a significant predictor, $F(1, 166) = .906$, $p = 1.00$. zWHR, however, did emerge as a significant predictor, $F(1,166) = 3.989$, $p = .047$. None of the other main effects or interactions were significant ($p > .05$). The full model is illustrated in Table 21.

4.6 Relationship satisfaction and jealousy

Jealousy tends to increase intrasexual vigilance, while high rates of relationship satisfaction tend to reduce intrasexual vigilance (Roney et al., 2003). Here, I evaluated the extent to which a) higher rates of jealousy and b) lower relationship satisfaction might predict women's recognition of female faces specifically in the Attractiveness condition (given the prediction that the female OGB should emerge in this condition), and men's recognition of male faces specifically in the Dominance condition (given the prediction that the male OGB should emerge in this condition).

Scores on the PRQC-Self, PRQC-Partner, Jealousy-Self, and Jealousy-Partner scales were submitted to bivariate correlational analyses with the sex-specific OGB scores (i.e. female OGB). For women in the attractiveness condition, scores on all four questionnaires were highly positively and significantly intercorrelated (table 22a). In addition, self-reported relationship satisfaction was significantly negatively correlated with women's OGB (r = -.272, p = .044, N = 55), whereas reported partner satisfaction was only trending significance (r = -.59, p = .056, N = 55). Interestingly, and contrary to the prediction, self-reported jealousy and reported partner jealousy were not correlated with the female OGB (all p > .05; table 22a). As a comparison, the same bivariate correlation was conducted in the women in the Likeability condition (table 22b). None of the relationship or jealousy measures were related to the female OGB in this condition, where women evaluated faces for likeability instead of attractiveness (table 22b).

Similarly, there was no significant relationship between men's OGB and self-reported relationship satisfaction (r = -.125, p = .353 4, N = 57) or jealousy (r = -.074, p = 0.584, N = 57) or any measure of partner relationship satisfaction or jealousy and the male OGB (table 22c) in men in the Dominance condition (where a male OGB was predicted to emerge), or in the Likeability condition (control condition; table 22d).

4.7 Self-ratings

Female OGB scores were not related to self-reported attractiveness ratings in women in the attractiveness condition (where a female OGB was predicted to emerge), F(1,54) = 1.210, p = .276. Female OGB scores were also unrelated to self-reported attractiveness ratings in women in the likeability condition (the control condition), $F(1,57) = .101$, $p = .752$. Male OGB scores were significantly related to self-reported attractiveness ratings in men in the dominance condition (where a male OGB was predicted to emerge), $F(1,55) = 5.436$, $p = .023$, but not self-reported dominance, $F(1,55) = .036$, $p = .851$. In other words, men in the dominance condition that rated themselves as more attractive (but not necessarily as more dominant) experienced an OGB to a greater degree than men who rated themselves as lower in attractiveness. This relationship between the male OGB and self-rated attractiveness was not present in the males in the likeability condition, $F(1,56) = 2.557$, $p = .115$. Similarly, there was no relationship between self-rated dominance and the male OGB in the men in the likeability condition, $F(1,56) = .034$, $p = .855$.

5 Discussion

There is long-standing scholarly interest in understanding whether and to what extent men and women differ in the way they process faces and how stable these supposed differences are (Armony & Sergerie, 2007; Cross, Cross, & Daly, 1971; Catharina Lewin & Herlitz, 2002; Lovén et al., 2011; McKelvie, 1987). To address the mixed findings in the literature, I proposed and tested an alternative way of thinking about the influence of biological sex on face recognition. Specifically, I argued that the influence of an observer's biological sex on face recognition behavior (e.g., the own gender bias [OGB]) is context-dependent.

I employed a unique experimental design to test whether an OGB in face recognition can be elicited by activating intrasexual competition mechanisms via evaluations of attractiveness and dominance in females and males, respectively. Given the developmental tasks of adult hood, heterosexual men must keep track of their relative position within a social hierarchy (Watkins, Fraccaro, et al., 2010) in order to ward off potential competitors (i.e., other males) for mates. Thus, I aimed to trigger this drive to keep track of other males in the social environment in order to evaluate whether this would create an impetus to remember male faces better. More specifically, I hypothesized that by having men evaluate facial dominance, they would be motivated to encode male, and not female, faces. Similarly, women tend to compete with other women for mates by advertising qualities that indicate youth and fecundity (Durante, Li, & Haselton, 2008; Haselton & Gangestad, 2006), and by derogating rivals (e.g. through gossip and devaluing other women; for review, see Campbell, 2004; Fisher, 2004) rather than via direct displays of dominance, as in men. As a result, I predicted that intrasexual vigilance may be triggered in females by priming them with judgments of attractiveness, which was then predicted to induce an OGB in women's face recognition behavior.

5.1 Sensitivity to detect Attractiveness, Dominance, and Likeability

The first goal was to investigate whether there were sex differences in sensitivity to detect Attractiveness, Dominance, and Likeability in male and female faces. To this end, I employed a staircase procedure within a perceptual sensitivity paradigm. The present findings yielded no sex differences in sensitivity to detect any of the traits in the trait judgment tasks (Attractiveness, Dominance, or Likeability). Instead, the results suggest that *all* participants exhibited greater sensitivity to male faces than female faces in all of the trait judgment tasks, regardless of participant sex.

This replicates previous work from our lab (Motta-Mena, Picci, & Scherf, 2016; Picci, Motta-Mena, & Scherf, in prep), whereby all participants exhibited lower perceptual thresholds to detect dominance in *male* faces, but not female faces. Indeed, in two previous studies from our lab, one evaluating the OGB in face recognition (Picci, Motta-Mena, & Scherf, in prep) and one evaluating the OGB in expression recognition (Motta-Mena, Picci, & Scherf, in prep), we employed the same Dominance and Likeability trait judgment tasks used here, with 60 male and 60 female participants. The statistical means in sensitivity to detect each trait from each of these studies is similar to that of the current study. Critically, the current study has twice as many participants per condition (120; 60 females, 60 males) than the original study (60; 30 females, 30 males) and still reflects the same main effect of stimulus sex in the perceptual threshold data.

Thus, given that the means in the current study converge with previous studies employing the same tasks, and given that there were no interactions with participant sex or condition in the current study, it is likely that the main effect of stimulus sex (whereby all participants exhibited lower perceptual thresholds for male faces than female faces) is due to task-related factors. One interpretation of these findings is that each of these traits were inadvertently easier to distinguish in male faces compared to the female faces. Follow-up analyses will need to be conducted in order to evaluate this hypothesis more carefully. Critically, men and women's perceptual thresholds were similarly impacted by the task-related differences; participant's sex did not interact with the task parameters.

To fully ascertain that there were no sex differences in sensitivity to detect each of the traits, planned comparisons were performed to specifically evaluate whether male and female participants differed in their sensitivity to detect each trait male faces or female faces. These planned comparisons revealed that men and women were comparable at detecting each of the traits in male and female faces.

To date, no theoretical framework has been proposed for understanding the contexts under which one might expect sex differences in perceiving and/or discriminating face-based social inferences, which led to the prediction in the current study that there should be no sex differences in the trait judgment tasks. In addition, the empirical work examining sex differences in perceptual processing of trait inferences is scant. With the exception of attractiveness, to date, no published studies have specifically investigated whether there are sex differences in the ability to perceive, discriminate, or detect face attributes such as dominance and likeability. As a result, this is the first study (to the author’s knowledge), that has empirically evaluated sex differences in sensitivity to detect dominance or likeability.

5.2 The influence of sex on biases in face recognition behavior

A second goal was to test whether an OGB in face recognition might be induced in men as a function of judging Dominance, or in women as a function of judging Attractiveness. Specifically, I evaluated whether male participants exhibited superior recognition for male compared to female faces in the Dominance condition, and whether female participants exhibited superior recognition for female compared to male faces in the Attractiveness condition. The Likeability condition was not predicted to induce any biases in recognition behavior.

The current findings do not support these hypotheses. The repeated-measures analyses with the loglinear-corrected d’ recognition scores revealed that all participants exhibited better memory for female faces than male faces, regardless of participant sex or condition. This finding, whereby female faces are easier to recognize than male faces, replicates a main effect of stimulus sex that we have found in three previous studies from our lab (Picci, Motta-Mena, & Scherf, in prep; Motta-Mena, Elbich, Duchaine, & Scherf, 2017; Scherf, Elbich, & Motta-Mena, 2017) using similar methods. Briefly, in Picci et al., 120 participants made trait judgments about dominance and likeability prior to completing the same face recognition task employed here (Picci et al., in prep). In Motta-Mena et al. (2017), 149 young adults completed the widely-used Cambridge Face Memory Task (CFMT, which only uses male faces; Duchaine & Nakayama, 2006; Russell, Duchaine, & Nakayama, 2009), as well as a female version of the CFMT that we created (F-CFMT; Motta-Mena et al., 2017). Finally, in Scherf et al. 2017, a sex-matched subsample of the participants from Motta-Mena et al. 2017 (n=116) completed the male and female CFMT tasks, and men and women both performed better on the female version (Scherf et al., 2017). Thus, in each of the above studies, participants consistently performed better on female faces than male faces. Critically, in the present study, given that the inverse efficiency analysis revealed that women were not necessarily more efficient than men, it is likely that this effect is due to task differences rather than important differences about face recognition for male and female faces.

In Scherf et al. (2017), the authors interpreted the main effect of stimulus sex as a main effect of *task,* given that *both* men and women exhibited superior performance on the F-CFMT compared to the M-CFMT, and there were no interactions with participant sex. Once the authors z-scored performance on both CFMT tasks in order to compare them in the same distribution, the main effect of the stimulus sex was no longer present, and results from the planned comparisons indicated that men and women did not experience superior recognition for faces of their own sex (i.e. no OGB).

Critically, however, the analyses in the current study revealed that the main effect of stimulus sex was qualified by an interaction between stimulus sex and participant sex. Regardless of condition, women had greater recognition performance for female faces than male faces (just as the men did), but *also* performed significantly better than men in recognizing female faces. Thus, while all participants were more accurate in remembering women's faces than men's faces, women specifically outperformed men in recognizing female faces, thereby reflecting the OGB that has been reported previously in the literature (Herlitz & Lovén, 2013; Lewin & Herlitz, 2002; Lovén et al., 2011; Loven, Svard, Ebner, Herlitz, & Fischer, 2014; Witryol & Kaess, 1957). However, given the main effect of stimulus sex, interpretation of these results merits caution, as men also exhibited greater performance on female faces.

Given the specificity of the hypotheses, planned comparisons within each condition were also conducted to better understand the nature of the stimulus sex by participant sex interaction (e.g. as in Loven et al., 2014; Scherf et al., 2017). These planned comparisons revealed that in the Attractiveness condition, men exhibited greater recognition for male faces than women did (an effect that was initially predicted for the Dominance condition). However, men and women were not significantly different in their performance on female faces in the Attractiveness condition, which is also directly contrary to the prediction that Attractiveness would induce a female OGB. In contrast, in both the Dominance condition and Likeability condition, men and women had equivalent memory for male faces, but not for female faces (women exhibited higher d' scores than men for female faces).

There is evidence to suggest that men and women both attend more to attractive women than to attractive men (Maner et al., 2007). In addition, even when women do attend to attractive men, women's memory for attractive women tends to be higher than for attractive men (Maner et al., 2003, 2005). In examining the stimuli for the recognition task, the images of female faces (Figure 15a) may be considered as more attractive than average (although there is no current evidence to support this hypothesis), and more attractive than the male faces (Figure 15b).

However, the literature on memory for attractive faces is mixed. In a recent study that matched attractive and unattractive faces on distinctiveness, the authors reported poorer memory for attractive faces (Wiese, Altmann, & Schweinbetger, 2014). However, in another study that did *not* match attractive faces and unattractive faces on distinctiveness, attractive faces were remembered better than other faces (Tsukiura & Cabeza, 2011) suggesting that perhaps attractiveness and distinctiveness may differentially influence memory for faces. Future work will need to evaluate whether the images in the recognition task employed here are matched in attractiveness and distinctiveness in order to successfully test this hypothesis.

Importantly, the task effect whereby both male and female participants exhibited better recognition for female compared to male faces has been reported in other studies using similar measures (e.g., Lovén et al., 2011; Motta-Mena et al. 2017; Scherf et al. 2017). In some studies, the authors do not find a stimulus sex by participant sex interaction (e.g. Lovén et al. 2011), yet still interpret their findings to reflect a selective OGB in the females, but not males, instead of a main effect of task. In this project, however, the data revealed *both* a main effect of stimulus sex as well as an interaction between stimulus sex and participant sex, suggesting that this effect is not simply due to the images employed in the task.

5.3 The influence of sex on biases in inverse efficiency

In order to evaluate whether there were significant differences in the amount of *effort* participants engaged into arrive at an answer, sex differences in inverse efficiency (IE) were also evaluated. Specifically, some work suggests that sex differences may be attenuated with simple task modifications (e.g. longer exposure time; Heisz et al. 2013). As such, IE sores were evaluated in order to test for sex differences while controlling for speed/accuracy tradeoffs. This analysis revealed that all participants were more efficient in recognizing female faces, which was also reflected in higher d' sensitivity scores for female faces as well. Importantly, the analysis with IE scores did not reveal a stimulus sex by participant sex interaction, suggesting that *both* males and females are exerting more effort to recognize male faces than to recognize female faces.

Some work suggests that women's faces are more "distinct", and sex differences may be induced in face recognition if the stimuli are not matched in attractiveness and distinctiveness (Steffens, Landmann, & Mecklenbräuker, 2013). To the extent that women's faces are indeed more distinctive, this would be reflected in a general effect of the stimulus, and not an interaction between the participant sex and stimulus sex (as in the analysis of d' scores). As a result, it may be the case that all participants (regardless of sex) are indeed exerting more effort to encode male faces, but women in particular may be employing a unique strategy that enables them to successfully remember more female faces specifically. This hypothesis will need to be tested in future work.

5.4 Measures of physical dominance are related to sensitivity to male facial dominance

To investigate the effect of men's physical dominance (as measured by height, bicep circumference, and grip strength) on men's perceptual thresholds for dominance in male faces, scores on the dominance trait judgment task were submitted to a multiple regression analysis with each physical measure (height, bicep circumference, and grip strength) as the predictors. Bicep circumference and grip strength were both significantly related to men's sensitivity to detect facial dominance, but not facial likeability. Results from the multiple regression revealed that as men's own physical dominance increased, perceptual thresholds for detecting male (and not female) facial dominance also increased (i.e. lower sensitivity). In other words, more physically dominant men tended to be less sensitive to male facial dominance. This finding supports the prediction in this study that more dominant men would be less sensitive to dominance in other males.

These findings are consistent with previous work demonstrating that more dominant men are less sensitive to masculine facial and vocal cues of dominance than less dominant men (Watkins et al., 2010). However, inconsistent with the Watkins study, height was not a significant predictor of men's sensitivity to male facial dominance in this experiment. Some work suggests that men's *own* dominance does not impact their perception of dominance in *other* men (notably, however, this was the case for *vocal* dominance; Wolff & Puts, 2010). The current findings suggest that men's own dominance (as assessed by bicep circumference and hand grip strength) is significantly related to their sensitivity to detect facial dominance in other men.

The experimental paradigm and results in Watkins et al. (2010) study are most relevant for the current study. In this experiment, the authors evaluated the influence of physical dominance (i.e. height) on perceptions of vocal and *facial* dominance by asking participants to indicate which face (or voice) was more dominant, and to what degree (much more dominant, more dominant, somewhat more dominant, etc.). As a result, the method by which sensitivity to dominance was calculated is fundamentally different.

In the current study, I employed a perceptual staircase procedure in order to measure the minimum amount of perceptual information necessary to detect facial cues related to dominance. In addition, Watkins et al. (2010) employed real faces that included hair, facial marks, etc. but that were matched on other dimensions (i.e. identity, skin color, and texture). The stimuli employed in the current study were not matched for skin color or lighting, but they were similarly manipulated on a femininity-masculinity dimension.

The pattern of results in this study highlight the specificity of the effect: bicep circumference and grip strength significantly predicted sensitivity to *male* facial dominance, and not male facial likeability. To date, no study has evaluated whether men's own hand grip strength or bicep circumference is related to men's sensitivity to male facial dominance.

5.5 Measures of physical dominance are related to men's memory for male faces

Men's OGB (i.e. d' for male faces – d' for female faces) was also related to the physical measures of men's dominance. While the model resulting from the multiple regression was not significant, the negative relationship between bicep circumference and the male OGB was significant. When bicep circumference was submitted to a simple linear regression with the male OGB as the outcome variable, the two were revealed to be highly positively related. Specifically, as bicep size increased, memory for male faces decreased. This directly supports the hypothesis that more dominant men would experience an OGB to a lesser degree than less dominant men (i.e. men with lower bicep size). As a comparison, these same analyses were conducted in the males in the Likeability condition, and none of the relationships were significant. Finally, men's sensitivity to dominance in other men was also unrelated to the magnitude of their OGB in face recognition.

In summary, of the men who were primed to think of other men as competitors (i.e. those who judged dominant male faces at the beginning of the experiment), those who were *more* dominant experienced an OGB to a lesser degree than men who were lower in dominance. This finding was not present in the men who evaluated likeability first. As such, the fact that this relationship emerged specifically in those men that were primed to view other male faces as competitors (i.e. evaluated dominance first) supports the initial hypothesis. Given that men's mate value relies heavily on perceptions of social status and physical dominance, it is unsurprising that men evaluate other men on dimensions of dominance, masculinity, and social status in order to assess another male's potential as a competitor for access to mates (Dijkstra & Buunk, 2002). However, more dominant men remembered less male faces (relative to female faces) specifically when they were primed to think of other males as competitors, which suggests that tapping into cognitive mechanisms related to intrasexual competition may indeed directly influence face recognition behavior in a flexible, dynamic way. The evidence provided in the current study suggests that, while men may tend to monitor potential competitors in their environment (Watkins, Fraccaro, et al., 2010; Watkins, Jones, & DeBruine, 2010), men higher in dominance monitor competitors to a lesser degree. These findings underscore the notion that men's perceptual system is, at least in part, adaptively tuned and related to one's own dominance in the service of navigating social hierarchies.

5.6 Women's physical attractiveness is not related to sensitivity to women's facial attractiveness or recognition memory for female face

To investigate the effect of women's physical attractiveness (as measured by WHR and BMI) on women's perceptual thresholds for attractiveness in female faces, scores on the attractiveness trait judgment task were submitted to multiple regression analysis with each physical measure (WHR and BMI) as predictors. These analyses revealed that women's perceptual threshold for attractiveness, as well as their recognition memory for female faces, were not significantly related with any measures of women's attractiveness, or any other variables (i.e. weight, height, or grip strength) specifically for those women in the attractiveness condition.

Contrary to the initial prediction, WHR significantly predicted the female OGB in the women in the *likeability* condition. Specifically, as WHR increased, so did women's bias to remember more female faces over male faces. Thus, not only was this effect present in the control condition where no biases were expected to emerge, it was also in a direction that is not necessarily intuitive. In other words, as women's own attractiveness decreased, their memory for female faces increased. One possibility is that by asking women to evaluate women's faces on how "Likeable" they are, I inadvertently tapped into intrasexual competition mechanisms. In so doing, as women's own attractiveness decreased (i.e. higher WHR), their hyperawareness of other women increased (reflected in greater memory for female faces relative to male faces).

Critically, the faces employed in the trait judgment tasks were not specifically evaluated for their “threat potential” for the participants. Thus, it is very likely that the attractive and dominant faces did not, in fact, represent intrasexual competitors for the participants. As a result, it cannot be ascertained that participants were primed in the way they were specifically predicted to be. Future work will benefit from having participants rate the computer-generated faces in the trait judgment tasks to evaluate their threat potential for participants.

While it is clear that women monitor attractiveness in other women in order to evaluate them as competitors (Dijkstra & Buunk, 2002; Haselton & Gangestad, 2006)it is unclear whether women’s *own* attractiveness reliably influences perceptions of attractiveness in other women. Some work suggests that attractive women are more sensitive to attractiveness in *men* than less-attractive women (Watkins et al., 2017), which is the opposite of the hypothesis regarding attractiveness as a priming mechanism by which an OGB may be induced. However, in Watkins et al. (2017), a priming technique induced valence differences related to relationship satisfaction and quality. As such, further work could test for contexts in which valence alters person memory, perhaps using more explicit priming techniques, such as directing participants to think of a time in which they needed to engage in mate-guarding behaviors by establishing dominance (in males) or deterring attractive competitors (in females).

5.7 Women's memory for same-sex faces is related to relationship satisfaction and jealousy

Only relationship satisfaction was significantly correlated with women's recognition bias for female faces. The negative relationship indicated that as relationship satisfaction decreased, the tendency for women to experience an OGB increased. Note that this relationship specifically emerged in the women that evaluated female faces on attractiveness first, and not the women that evaluated female faces for likeability, or in any of the male participants. This pattern of results directly supports the initial prediction that only those women in the attractiveness condition would exhibit an OGB that correlated with lower relationship satisfaction. On the other hand, the female OGB was not related to a) any measures of jealousy in any group, b) to women's sensitivity to facial attractiveness, c) men's memory for male or female faces, or d) men's sensitivity to dominance in other men.

Interestingly, all measures related to relationship satisfaction (PRQC-Self, PRQC-Partner) and mate guarding (Jealousy-Self, Jealousy-Partner) were highly positively intercorrelated in women, suggesting that as their own ratings of relationship satisfaction and jealousy increased, so did their perceived partner ratings (i.e., the more satisfied women reported themselves and their partners in their relationship, the more jealous they reported being as well). For men, the PRQC-Self was not related to the Jealousy-Self or Jealousy-Partner scales.

While there is evidence supporting the notion that men and women in relationships attend to and/or devalue attractive potential alternative partners (Lydon, Fitzsimons, & Naidoo, 2003), work evaluating the extent to which jealousy and relationship satisfaction influences face recognition sparse. Of the existing work, some evidence suggests that relationship satisfaction may be related to the length of time it takes participants to produce false recognitions (Silva, Macedo, Albuquerque, & Arantes, 2016), such that participants that were unsatisfied in their relationships took longer to produce false recognitions than participants that were satisfied in their relationships (but not necessarily more or less false recognitions). However, the authors provide no theoretical discussion regarding why this relationship might have emerged.

Several lines of research suggest that women in committed and satisfied relationships reportedly have poorer memory for attractive men's faces than women in low-commitment relationships (Wang, Hahn, DeBruine, & Jones, 2016b; Watkins et al., 2017), presumably in the service of maintaining their current relationship by devaluing potential alternatives. Notably, however, partnered women were not significantly different from unpartnered women in memory for attractive male faces in the Wang et al. (2016b) study. In a related study evaluating recognition memory for more and less attractive versions of male and female identities, Watkins et al. 2017 found that women in better quality relationships had greater false memories for attractive men. These findings suggest that women's memory for facial cues may vary systematically according to the factors that influence female mating competition and relationship maintenance (i.e. relationship status and male attractiveness). In the current study, women in committed relationships were not compared against single women in recognition performance. However, the findings from the current study support the conclusion that relationship satisfaction influences the OGB in female face recognition specifically in those women primed to view other women as potential competitors.

6 Conclusions

This work fundamentally informs the current theoretical models about sex differences in face recognition by highlighting that the female OGB persists despite several manipulations intended to bias participants in a uniquely different way. Our findings did not demonstrate that women who evaluated facial attractiveness first also had enhanced recognition for female faces, or that men who evaluated facial dominance first also had enhanced recognition for male faces (i.e. an OGB). Instead, all participants were more successful at remembering female faces than male faces, and women in particular outperformed men in remembering female faces (a female OGB regardless of condition). The evidence provided in this experiment does not support the theory that the OGB is flexible and reliably elicited, but rather that the OGB may be a stable trait of female face recognition, as has been previously suggested in the literature (e.g. Loven et al. 2013).

However, intrasexual competition may still motivate individuals to devote attentional resources toward same-sex competitors in face recognition. Given that the recognition task employed here only included 10 male and 10 female targets, the task itself may be underpowered to detect robust differences as a function of the experimental manipulation. Further, in selecting the stimuli for the task, the male and female targets and distractors were not matched for attractiveness or distinctiveness, which may have further influenced the task effects observed in the current study.

This work builds on prior work from our lab where we initially found an OGB in male face recognition as a function of first judging dominance in male faces (Picci, Motta-Mena, & Scherf, in prep). However, in re-analyzing the data from this initial study, we discovered an error in the code. In correcting this error and re-analyzing the data in the exact same way, the initial male OGB effect was eradicated. Instead, men and women both were more accurate to remember female faces than male faces, regardless of condition. The current study replicates this main effect of stimulus sex, highlight a task effect that will need to be revised for future work.

Future work evaluating the conditions under which an OGB in face recognition can and cannot be induced will benefit from employing explicit priming (e.g. vignettes or confederates), prior to evaluating more subtle, nuanced primes. The OGB may still be a reflection of the demands of one's social environment, which are subject to shift on a moment-by-moment basis.

Though this is not the first study to suggest that biases in face recognition are malleable within experimental paradigms (Anzures et al., 2013; Lebrecht, Pierce, Tarr, & Tanaka, 2009; Tanaka & Pierce, 2009; Xiao et al., 2015), this is the first study to evaluate whether a bias may be induced specifically as a function of making evaluations of dominance or attractiveness (traits that are expected to be highly relevant for contexts related to mate competition), and whether such a bias is related to physical measures of an individual's own attractiveness or dominance.

More research will be needed to test the ways in which intrasexual competition may impact the OGB, and other face processing behaviors. For example, how might more explicit priming techniques engage intrasexual competition mechanisms? These findings encourage future research questions regarding the myriad of ways that socially and adaptively relevant contexts can reliably elicit an OGB in males and females, and how those context-dependent behaviors potentially differ by biological sex.

APPENDIX A

TABLES

Table 1. Participant Demographics by Condition.

	Attractiveness First		**Dominance First**		**Likeability First**	
	Males	Females	Males	Females	Males	Females
Mean age	19.25	19.45	19.95	19.93	19.58	20.48
S.D.	1.71	2.46	3.08	3.00	2.29	3.07

Table 2. Perceptual Thresholds for Detecting Face Traits. Descriptives (means, standard deviations) for performance on each trait judgment task for male and female participants as a function of stimulus sex (female, male). Note that “Condition” is a between-subjects factor (i.e. the participants in the Attractiveness First condition are completely independent of those in the Dominance First or Likeability First condition).

		Male Faces			**Female Faces**		
		Attractiveness	Dominance	Likeability	Attractiveness	Dominance	Likeability
Male participants (N=180)	**Mean**	51.32	62.86	64.90	58.83	65.86	67.47
	S.D.	22.80	7.46	7.22	14.53	6.63	7.50
Female participants (N=180)	**Mean**	47.58	62.13	63.51	57.32	64.27	65.45
	S.D.	19.38	8.51	8.54	16.29	8.077	7.25

Table 3. Effects for Threshold Data. A full list of threshold effects from each two-way repeated measures ANOVA within each condition. Variables included participant sex (male, female), and stimulus sex (male, female). Significant effects are in italics. Effect sizes are reported as Partial Eta^2 (η^2).

Condition		dF	*F*	*p*	η^2
Attractiveness	**Main Effects**				
	Participant Sex	1, 118	1.17	.282	.010
	Stim Sex	***1, 118***	***13.46***	***.000***	***.102***
	Interactions				
	Participant Sex X Stim Sex	1, 118	74.67	.636	.002
Dominance	**Main Effects**				
	Participant Sex	1, 118	1.21	.273	.010
	Stim Sex	***1, 118***	***7.59***	***.007***	***.060***
	Interactions				
	Participant Sex X Stim Sex	1, 118	0.22	.640	.002
Likeability	**Main Effects**				
	Participant Sex	1, 118	2.79	.098	.023
	Stim Sex	***1, 118***	***5.56***	***.020***	***.045***
	Interactions				
	Participant Sex X Stim Sex	1, 118	0.109	.742	.001

Table 4. Independent Samples t-tests for Threshold Data between Men and Women within Condition. A full list of effects from the independent samples t-tests between men and women for performance on each trait judgment task. Independent variables included participant sex (male, female), and stimulus sex (male, female), with perceptual threshold as the outcome variable of interest. All comparisons yielded no significant effects.

	Male Faces			**Female Faces**		
Trait	**dF**	***t***	***p***	**dF**	***t***	***p***
Attractiveness	1, 118	0.969	.335	1, 118	0.537	.593
Dominance	1, 118	0.494	.622	1, 118	1.183	.239
Likeability	1, 118	0.959	.340	1, 118	1.496	.137

Table 5. Results from The Three-Way Repeated Measures ANOVA on d' Sensitivity Scores. (a) Results generated from the three-way repeated measures ANOVA with d' sensitivity scores as the outcome variable. Within-subjects variables included stimulus sex (male, female), and between-subjects variables included participant sex (male, female), and condition (Attractiveness, Dominance, or Likeability). Significant effects are in highlighted in bold. (b) Bonferroni-corrected pairwise comparisons revealed that, across conditions, women outperformed men specifically on female faces, but not male faces. (c) Descriptives (means, standard deviations, confidence intervals) for performance on each face sex for male and female participants (collapsed across condition, given no interactions with condition or main effects of condition).

a.

	dF	*F*	*p*	η^2
Stimulus sex	***1***	***54.426***	***.000***	***.137***
Stimulus sex X Participant Sex	***1***	***15.864***	***.000***	***.044***
Stimulus sex X Condition	2	.183	.833	.001
Stimulus Sex X Participant Sex X Condition	2	.349	.706	.002
Participant Sex	1	2.836	.093	.008
Condition	2	0.142	.868	.001
Participant Sex X Condition	2	1.201	.302	.007
Error (Stimulus Sex)	343	-	-	-
Error (Between-Subjects)	343	-	-	-

b.

	t	dF	*p*	Mean Difference	Std. Error Difference	95% Confidence Int	
						Lower	Upper
D' male faces	1.118	349	.264	.08787	.07857	-.06666	.24241
D' female faces	***-3.639***	***349***	***.000***	***-.27954***	***.07682***	***-.43063***	***-.12845***

c.

Participant Sex	Stimulus Sex	Mean	Std. Deviation	Std. Error	95% Confidence Int	
					Lower Bound	Upper Bound
Men	Male	1.498	.738	.055	1.390	1.607
	Female	1.660	.704	.053	1.555	1.766
Women	Male	1.410	.721	.055	1.301	1.519
	Females	**1.953**	.705	.054	1.847	2.058

Table 6a-c. Planned comparisons within each condition to evaluate the interaction between stimulus sex by participant sex. Planned comparisons contrasting group performance on the recognition task were investigated using separate Bonferroni-corrected independent sample t-tests with 95% confidence intervals within each condition. The descriptives and results from each t-test are included for the Attractiveness condition (a-b), Dominance condition (c-d), and Likeability condition (e-f).

a)

Attractiveness Condition - Descriptives					
	Participant Sex	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
D' male faces	Male	60	1.5901	.63534	.08202
	Female	56	1.3267	.63127	.08436
D' female faces	Male	60	1.7298	.73353	.09470
	Female	56	1.9454	.71168	.09510

b)

Attractiveness Condition - Independent Samples t-test							
	t	**df**	***p***	**Mean Difference**	**Std. Error Difference**	**95% Confidence Int**	
						Lower	**Upper**
D' male faces	***2.239***	***114***	***.027***	***.263***	***.11769***	***.030***	***.496***
D' female faces	-1.605	114	.111	-.215	.13435	-.482	.050

c)

Dominance Condition - Descriptives					
	Participant Sex	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
D' male faces	Male	57	1.481	.807	.106
	Female	59	1.420	.764	.099
D' female faces	Male	57	1.657	.726	.096
	Female	59	1.975	.695	.090

d)

Dominance Condition - Independent Samples t-test							
	t	**df**	***p***	**Mean Difference**	**Std. Error Difference**	**95% Confidence Int**	
						Lower	**Upper**
D' male faces	.419	114	.676	.061	.145	-.227	.350
D' female faces	***-2.409***	***114***	***.018***	***-.318***	***.132***	***-.579***	***-.056***

e)

Likeability Condition - Descriptives					
	Participant Sex	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
D' male faces	Male	58	1.423	.768	.100
	Female	59	1.482	.759	.098
D' female faces	Male	58	1.594	.653	.085
	Female	59	1.936	.719	.093

f)

Likeability Condition - Independent Samples t-test							
	t	**df**	***p***	**Mean Difference**	**Std. Error Difference**	**95% Confidence Int**	
						Lower	**Upper**
D' male faces	-.416	115	.678	-.058	.141	-.338	.221
D' female faces	***-2.695***	***115***	***.008***	***-.342***	***.127***	***-.594***	***-.090***

Table 7a-b. Results from The Three-Way Repeated Measures ANOVA on inverse efficiency scores. A) Results were generated from the three-way repeated measures ANOVA in with IE scores as the primary variable of interest. Variables included stimulus sex (male, female), participant sex (male, female), and condition (Attractiveness, Dominance, or Likeability). Significant effects are in bold. B) A list of descriptives from the ANOVA.

a.

	df	F	*p*	η^2
Stimulus sex	***1***	***31.787***	***.000***	***.085***
Stimulus sex X Participant Sex	2	.237	.789	.001
Stimulus sex X Condition	1	1.496	.222	.004
Stimulus Sex X Participant Sex X Condition	2	1.794	.168	.010
Condition	2	.025	.975	.000
Participant Sex	1	.688	.408	.002
Condition X Participant Sex	2	.416	.660	.002
Error(Stimulus Sex)	343	-	-	-
Error(Between-Subjects)	343	-	-	-

b.

Stimulus sex	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	1.623	.044	1.536	1.710
Female	1.344	.031	1.284	1.405

Table 8a-b. Means and correlations between physical measures for males. A) A full list of the means, standard deviations, and sample size values for the sample of 180 men's physical measures, including weight, height, grip strength, bicep circumference, and BMI. B) Bivariate correlations using Pearson's *r* indicate that all measures are highly correlated with one another.

a.

	Mean	**Std. Deviation**	**N**
Weight (kg)	79.994	15.275	180
Height (m)	1.780	.072	180
Hand Grip Strength (kgf)	38.549	9.100	180
Bicep Circumference	34.892	3.841	180
BMI	25.141	4.025	180

b.

Correlations						
		Weight (kg)	Height (m)	Grip Strength (kgf)	Bicep Circumference	BMI
Weight (Kg)	Pearson Correlation	1	.569**	.330**	.757**	.902**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	180	180	180	180	180
Height (M)	Pearson Correlation	.569**	1	.335**	.382**	.167*
	Sig. (2-tailed)	.000		.000	.000	.025
	N	180	180	180	180	180
Grip Strength (Kgf)	Pearson Correlation	.330**	.335**	1	.492**	.237**
	Sig. (2-tailed)	.000	.000		.000	.001
	N	180	180	180	180	180
Bicep Circumference	Pearson Correlation	.757**	.382**	.492**	1	.718**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	180	180	180	180	180
BMI	Pearson Correlation	.902**	.167*	.237**	.718**	1
	Sig. (2-tailed)	.000	.025	.001	.000	
	N	180	180	180	180	180

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9a-c. Grip strength and bicep circumference significantly men's predict sensitivity to male dominance. A) The model summary with height, bicep size, and grip strength as the predictors, and perceptual thresholds for male dominance as the outcome measure. B) When the predictors are combined in the model, the positive relationship suggests that as physical dominance increases, perceptual thresholds increase as well (i.e. decreased sensitivity). C) When evaluating the predictors individually, two of the three physical measures of men's physical dominance are found to be significantly related to men's sensitivity to detect dominance in male faces.

a.

Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate
.356[a]	.127	.080	7.16203

a. Predictors: (Constant), Height, Bicep Circumference, Grip Strength
b. Dependent Variable: Threshold for Male Dominance
c. Predictors: (Constant), Height, Grip strength, Bicep circumference

b.

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Regression	**417.168**	**3**	**139.056**	**2.711**	**.054[b]**
Residual	2872.500	56	51.295		
Total	3289.668	59			

a. Dependent Variable: Threshold for Male Dominance
b. Predictors: (Constant), Height, Bicep Circumference, Grip Strength
c. Predictors: (Constant), Height, Grip strength, Bicep circumference

c.

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	89.952	23.528		3.823	.000	42.819	137.084
Grip Strength	**.236**	**.105**	**.329**	**2.249**	**.028**	**.026**	**.445**
Bicep Circumference	**-.626**	**.259**	**-.344**	**-2.420**	**.019**	**-1.144**	**-.108**
Height	-7.856	13.821	-.078	-.568	.572	-35.543	19.830

a. Dependent Variable: Threshold for Male Dominance

Table 10a-c. Grip strength and bicep circumference do not significantly predict men's sensitivity to male likeability. A) The model summary with height, bicep size, and grip strength as the predictors, and perceptual thresholds for male dominance as the outcome measure. B) When the predictors are combined in the model, the relationship is not significant. C) When evaluating the predictors individually, none of the three measures of men's physical dominance significantly explained men's sensitivity to detect dominance in male faces.

a.

Model Summary[b]

	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.267[a]	.072	.022	7.14269

a. Predictors: (Constant), Height, Bicep Circumference, Grip Strength

b. Dependent Variable: Threshold for Male Dominance

c. Predictors: (Constant), Height, Grip strength, Bicep circumference

b.

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Regression	220.111	3	73.370	1.438	.241[b]
Residual	2857.011	56	51.018		
Total	3077.122	59			

a. Dependent Variable: Threshold for Male Dominance

b. Predictors: (Constant), Height, Grip Strength, Bicep Circumference

c. Predictors: (Constant), Height, Bicep circumference, Grip strength

c.

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	103.117	25.764		4.002	.000	51.505	154.729
Grip Strength	-.112	.132	-.132	-.846	.401	-.377	.153
Bicep Circumference	.005	.309	.002	.015	.988	-.615	.624
Height	-19.317	16.766	-.180	-1.152	.254	-52.902	14.269

a. Dependent Variable: Threshold for Male Dominance

Table 11a-c. Bicep circumference significantly predicts the male OGB in men who judge dominance in male faces first. A) The model summary with height, bicep size, and grip strength as the predictors, and the male OGB as the outcome measure. B) When the predictors are combined, the model is not significant. C) When evaluating the predictors individually, bicep circumference is the only predictor found to be significantly related to men's OGB.

a.

R	R Square	Adjusted R Square	Std. Error of the Estimate
.274[a]	.075	.023	.91201

a. Predictors: (Constant), Height, Bicep circumference, Hand grip strength
b. Dependent Variable: Male OGB (d' male faces – d' female faces)
c. Predictors: (Constant), Height, Hand grip strength, Bicep circumference

b.

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Regression	3.579	3	1.193	1.434	.243[b]
Residual	44.083	53	.832		
Total	47.662	56			

a. Dependent Variable: Male OGB (d' male faces – d' female faces)
b. Predictors: (Constant), Height, Bicep circumference, Hand grip strength
c. Predictors: (Constant), Height, Hand grip strength, Bicep circumference

c.

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.147	3.027		.379	.706	-4.923	7.218
Grip strength	.013	.013	.152	.987	.328	-.014	.040
Bicep circumference	***-.070***	***.034***	***-.312***	***-2.054***	***.045***	***-.139***	***-.002***
Height	.369	1.804	.030	.205	.839	-3.249	3.987

a. Dependent Variable: Male OGB (d' male faces – d' female faces)

Table 12a-c. Bicep circumference, grip strength, and height do not significantly predict the male OGB in men who judged likeability in male faces first. A) The model summary with height, bicep size, and grip strength as the predictors, and the male OGB as the outcome measure. B) When the predictors are combined, the model is not significant. C) When evaluating the predictors individually, none of the three measures of men's physical dominance significantly explained men's OGB.

a.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.124[a]	.015	-.039	.83900

a. Predictors: (Constant), Height, Bicep circumference, Hand grip strength

b. Dependent Variable: Male OGB (d' male faces – d' female faces)

c. Predictors: (Constant), Height, Hand grip strength, Bicep circumference

Dependent Variable: Male OGB (d' male faces – d' female faces)

b.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.591	3	.197	.280	.840[b]
	Residual	38.012	54	.704		
	Total	38.602	57			

a. Dependent Variable: Male OGB (d' male faces – d' female faces)

b. Predictors: (Constant), Height, Bicep circumference, Hand grip strength

c. Predictors: (Constant), Height, Hand grip strength, Bicep circumference

c.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.490	3.067		.160	.874	-5.659	6.639
	Grip strength	.012	.016	.126	.766	.447	-.019	.043
	Bicep circumference	-.027	.037	-.122	-.724	.472	-.100	.047
	Height	-.117	2.012	-.010	-.058	.954	-4.150	3.917

a. Dependent Variable: Male OGB (d' male faces – d' female faces)

Table 13a-b. Correlations between physical measures for females. A) A full list of the means, standard deviations, and sample size values for the sample of 180 women's physical measures, including weight, height, grip strength, WHR, and BMI. B) Bivariate correlations using Pearson's *r* indicate that weight is correlated with height and BMI; significant correlations are highlighted in gray.

a)

Descriptive Statistics			
	Mean	Std. Deviation	N
WHR	.802	.062	180
Weight (kg)	64.692	15.090	180
Height (m)	1.646	.064	180
BMI	23.837	5.171	180
Grip strength (kgf)	23.77	4.548	180

b)

Correlations						
		WHR	Weight (kg)	Height (m)	BMI	Grip strength (kgf)
WHR	Pearson Correlation	1	.109	-.040	.137	-.002
	Sig. (2-tailed)		.146	.595	.068	.983
	N	180	180	180	180	180
Weight (kg)	Pearson Correlation	.109	1	.310**	.935**	.331**
	Sig. (2-tailed)	.146		**.000**	**.000**	**.000**
	N	180	180	180	180	180
Height (m)	Pearson Correlation	-.040	.310**	1	-.037	.254**
	Sig. (2-tailed)	.595	**.000**		.621	.001
	N	180	180	180	180	180
BMI	Pearson Correlation	.137	.935**	-.037	1	.254**
	Sig. (2-tailed)	.068	**.000**	.621		**.001**
	N	180	180	180	180	180
Grip strength (kgf)	Pearson Correlation	-.002	.331**	.254**	.254**	1
	Sig. (2-tailed)	.983	**.000**	**.001**	**.001**	
	N	180	180	180	180	180

**. Correlation is significant at the 0.01 level (2-tailed).

Table 14a-c. BMI and WHR do not significantly predict women's sensitivity to attractiveness in other women. A) The model summary with BMI and WHR as the predictors, and the perceptual thresholds for female attractiveness as the outcome measure. B) When the predictors are combined, the model is not significant. C) When evaluating the predictors individually, none of the measures of women's physical attractiveness significantly explained women's sensitivity to attractiveness in other women.

a.

Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate
.054[a]	.003	-.032	16.55053

a. Predictors: (Constant), BMI, WHR

b. Dependent Variable: Perceptual threshold for female attractiveness

b.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44.868	2	22.434	.082	.921[b]
	Residual	15613.438	57	273.920		
	Total	15658.306	59			

a. Dependent Variable: Perceptual threshold for female attractiveness

b. Predictors: (Constant), BMI, WHR

c.

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	42.113	38.037		1.107	.273	-34.056	118.281
WHR	16.758	46.776	.048	.358	.721	-76.910	110.426
BMI	.074	.548	.018	.135	.893	-1.024	1.172

a. Dependent Variable: Perceptual threshold for female attractiveness

Table 15a-c. BMI and WHR do not significantly predict women's sensitivity to likeability in other women. A) The model summary with BMI and WHR as the predictors, and the perceptual thresholds for female likeability as the outcome measure. B) When the predictors are combined, the model is not significant. C) When evaluating the predictors individually, none of the measures of women's physical attractiveness significantly explained women's sensitivity to likeability in other women.

a.

Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate
.202[a]	.041	.007	7.22528

a. Predictors: (Constant), BMI, WHR
b. Dependent Variable: Perceptual threshold for female likeability

b.

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Regression	126.365	2	63.183	1.210	.306[b]
Residual	2975.663	57	52.205		
Total	3102.028	59			

a. Dependent Variable: Perceptual threshold for female likeability
b. Predictors: (Constant), BMI, WHR

c.

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	49.007	13.036		3.760	.000	22.904	75.110
WHR	21.946	14.303	.199	1.534	.130	-6.695	50.587
BMI	-.050	.240	-.027	-.207	.837	-.531	.432

a. Dependent Variable: Perceptual threshold for female likeability

Table 16a-c. For women in the attractiveness condition, BMI and WHR did not significantly predict women's OGB. A) The model summary with BMI and WHR as the predictors, and the female OGB as the outcome measure. B) When the predictors are combined, the model is not significant. C) When evaluating the predictors individually, none of the measures of women's physical attractiveness were significantly related to the female OGB.

a.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.080[a]	.006	-.031	.87209

a. Predictors: (Constant), BMI, WHR

b. Dependent Variable: Female OGB (d' female faces – d' male faces)

b.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.263	2	.131	.173	.842[b]
	Residual	40.309	53	.761		
	Total	40.572	55			

a. Dependent Variable: Female OGB (d' female faces – d' male faces)

b. Predictors: (Constant), BMI, WHR

c.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.528	2.082		-.254	.801	-4.703	3.648
	WHR	1.180	2.583	.063	.457	.650	-4.001	6.361
	BMI	.009	.029	.041	.295	.769	-.050	.067

a. Dependent Variable: Female OGB (d' female faces – d' male faces)

Table 17a-c. For women in the likeability condition, WHR did significantly predict the female OGB. A) The model summary with BMI and WHR as the predictors, and the female OGB as the outcome measure. B) When the predictors are combined, the model is trending significance. C) When evaluating the predictors individually, WHR is significantly related to the female OGB.

a.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.311[a]	.097	.064	.91085

a. Predictors: (Constant), BMI, WHR

b.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.967	2	2.484	2.994	.058[b]
	Residual	46.460	56	.830		
	Total	51.428	58			

a. Dependent Variable: Female OGB (d’ female faces – d’ male faces)
b. Predictors: (Constant), BMI, WHR

c.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-3.504	1.644		-2.131	.037	-6.798	-.210
	WHR	***4.243***	***1.811***	***.298***	***2.343***	***.023***	***.616***	***7.871***
	BMI	.023	.031	.096	.753	.455	-.038	.084

a. Dependent Variable: Female OGB (d’ female faces – d’ male faces)

Table 18. Linear mixed effects model 1: Evaluating the female OGB in women in the Attractiveness condition. The model summary the mixed model regression evaluating the female OGB. zBMI and zWHR were included in the model as covariates, and the Attractiveness contrast specified is weighted as (Attractiveness: +1, Dominance: -.5, and Likeability: -.5). Only the intercept emerged as a significant predictor.

Predictor	df	F	*p*
Intercept	1, 167	53.733	<.001
Attractiveness contrast X zBMI	1, 167	1.463	.228
Attractiveness contrast X zWHR	1, 167	.163	.687
zBMI X zWHR	1, 167	.444	.506
Attractiveness contrast	1, 167	.991	.321
zBMI	1, 167	.269	.605
zWHR	1, 167	1.230	.269

Table 19. Linear mixed effects model 2: Evaluating the male OGB in men in the Dominance condition. The model summary the mixed model regression evaluating the male OGB. The physical dominance composite measure was included in the model as a covariate, and the Dominance contrast specified is weighted as (Attractiveness: -.5, Dominance: +1, and Likeability: -.5). None of the predictors emerged as significant.

Predictor	df	F	*p*
Intercept	1, 171	2.084	.151
Dominance contrast	1, 171	.001	.974
Physical dominance composite measure	1, 171	2.613	.108
Dominance contrast X Physical dominance composite measure	1, 171	.001	.970

Table 20. Linear mixed effects model 3: Evaluating the male OGB in men in the Likeability condition. The model summary the mixed model regression evaluating the male OGB. The physical dominance composite measure was included in the model as a covariate, and the Likeability contrast specified is weighted as (Attractiveness: -.5, Dominance:-.5, and Likeability: +1). None of the predictors emerged as significant.

Predictor	df	F	*p*
Intercept	1, 171	2.711	.101
Likeability contrast	1, 171	.333	.565
Physical dominance composite measure	1, 171	1.331	.250
Likeability contrast X Physical dominance composite measure	1, 171	1.110	.294

Table 21. Linear mixed effects model 4: Evaluating the female OGB in women in the Likeability condition. The model summary the mixed model regression evaluating the female OGB. zBMI and zWHR were included in the model as covariates, and the Likeability contrast specified is weighted as (Attractiveness: -.5, Dominance: -.5, and Likeability: +1). Only zWHR emerged as a significant predictor.

Predictor	df	F	*p*
Intercept	1, 166	.906	1.000
Likeability contrast * zBMI	1, 166	2.470	.118
Likeability contrast * zWHR	1, 166	1.508	.221
Likeability contrast * zBMI * zWHR	1, 166	.038	.847
Likeability contrast	1, 166	.377	.540
zBMI	1, 166	.075	.785
zWHR	1, 166	3.989	.047
zBMI * zWHR	1, 166	.204	.652

Table 22a-d. Evaluating the relationship between women's relationship satisfaction, rates of jealousy, and female OGB. A) Correlational analyses in the women in the Attractiveness condition reveals that jealousy and relationship satisfaction are related to the female OGB. B) This effect was not present in the Likeability condition, or in men who were in the C) Dominance condition, or D) Likeability condition.

a)

Correlation: Women in Attractiveness condition						
		PRQC - Self	**PRQC - Partner**	**Jealousy - Self**	**Jealousy - Partner**	**Female OGB**
PRQC Self	Pearson Correlation	1	.947**	.355**	.400**	-.272*
	Sig. (2-tailed)		**.000**	**.008**	**.002**	**.044**
	N	55	55	55	55	55
PRQC Partner.	Pearson Correlation	.947**	1	.297*	.430**	-.259
	Sig. (2-tailed)	**.000**		**.028**	**.001**	**.056**
	N	55	55	55	55	55
Jealousy self	Pearson Correlation	.355**	.297*	1	.594**	-.241
	Sig. (2-tailed)	**.008**	**.028**		**.000**	.073
	N	55	55	56	56	56
Jealousy Partner	Pearson Correlation	.400**	.430**	.594**	1	-.109
	Sig. (2-tailed)	**.002**	**.001**	**.000**		.424
	N	55	55	56	56	56
Female OGB	Pearson Correlation	-.272*	-.259	-.241	-.109	1
	Sig. (2-tailed)	**.044**	**.056**	.073	.424	
	N	55	55	56	56	56
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						

b.)

Correlation: Women in Likeability condition						
		PRQC - Self	**PRQC - Partner**	**Jealousy - Self**	**Jealousy - Partner**	**Female OGB**
PRQC Self	Pearson Correlation	1	.915**	.100	.311*	.069
	Sig. (2-tailed)		**.000**	.460	**.018**	.612
	N	57	57	57	57	57
PRQC Partner.	Pearson Correlation	.915**	1	.079	.332*	.076
	Sig. (2-tailed)	**.000**		.560	**.012**	.574
	N	57	57	57	57	57
Jealousy self	Pearson Correlation	.100	.079	1	.484**	-.115
	Sig. (2-tailed)	.460	.560		**.000**	.390
	N	57	57	58	58	58
Jealousy Partner	Pearson Correlation	.311*	.332*	.484**	1	.090
	Sig. (2-tailed)	**.018**	**.012**	**.000**		.502
	N	57	57	58	58	58
Female OGB	Pearson Correlation	.069	.076	-.115	.090	1
	Sig. (2-tailed)	.612	.574	.390	.502	
	N	57	57	58	58	58

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c.)

Correlation: Men in Dominance condition						
		PRQC - Self	**PRQC - Partner**	**Jealousy - Self**	**Jealousy - Partner**	**Male OGB**
PRQC Self	Pearson Correlation	1	.867**	-.020	.217	-.125
	Sig. (2-tailed)		**.000**	.882	.105	.353
	N	57	56	57	57	57
PRQC Partner.	Pearson Correlation	.867**	1	.124	.503**	-.067
	Sig. (2-tailed)	**.000**		.361	**.000**	.624
	N	56	56	56	56	56
Jealousy self	Pearson Correlation	-.020	.124	1	.634**	.074
	Sig. (2-tailed)	.882	.361		**.000**	.584
	N	57	56	57	57	57
Jealousy Partner	Pearson Correlation	.217	.503**	.634**	1	.038
	Sig. (2-tailed)	.105	**.000**	**.000**		.777
	N	57	56	57	57	57
Male OGB	Pearson Correlation	-.125	-.067	.074	.038	1
	Sig. (2-tailed)	.353	.624	.584	.777	
	N	57	56	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

d.)

Correlation: Men in Likeability condition							
		PRQC - Self	PRQC - Partner	Jealousy - Self	Jealousy - Partner	Male OGB
PRQC Self	Pearson Correlation	1	.908**	.198	.176	-.081
	Sig. (2-tailed)		**.000**	.140	.191	.547
	N	57	57	57	57	57
PRQC Partner.	Pearson Correlation	.908**	1	.146	.226	-.050
	Sig. (2-tailed)	**.000**		.274	.089	.710
	N	57	58	58	58	58
Jealousy self	Pearson Correlation	.198	.146	1	.548**	.193
	Sig. (2-tailed)	.140	.274		**.000**	.147
	N	57	58	58	58	58
Jealousy Partner	Pearson Correlation	.176	.226	.548**	1	.130
	Sig. (2-tailed)	.191	.089	**.000**		.333
	N	57	58	58	58	58
Male OGB	Pearson Correlation	-.081	-.050	.193	.130	1
	Sig. (2-tailed)	.547	.710	.147	.333	
	N	57	58	58	58	58

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX B

FIGURES

Figure 1. Experimental design. The experimental design involved randomizing 180 females and 180 males into one of three conditions. In each condition, participants completed a series of tasks, including a trait judgment task, face recognition task, and relationship questionnaire. At the conclusion of the computer measures, participants then completed the biometric measures. Each condition was expected to induce uniquely different patterns of recognition behavior. Participants are assigned to only one of the three conditions.

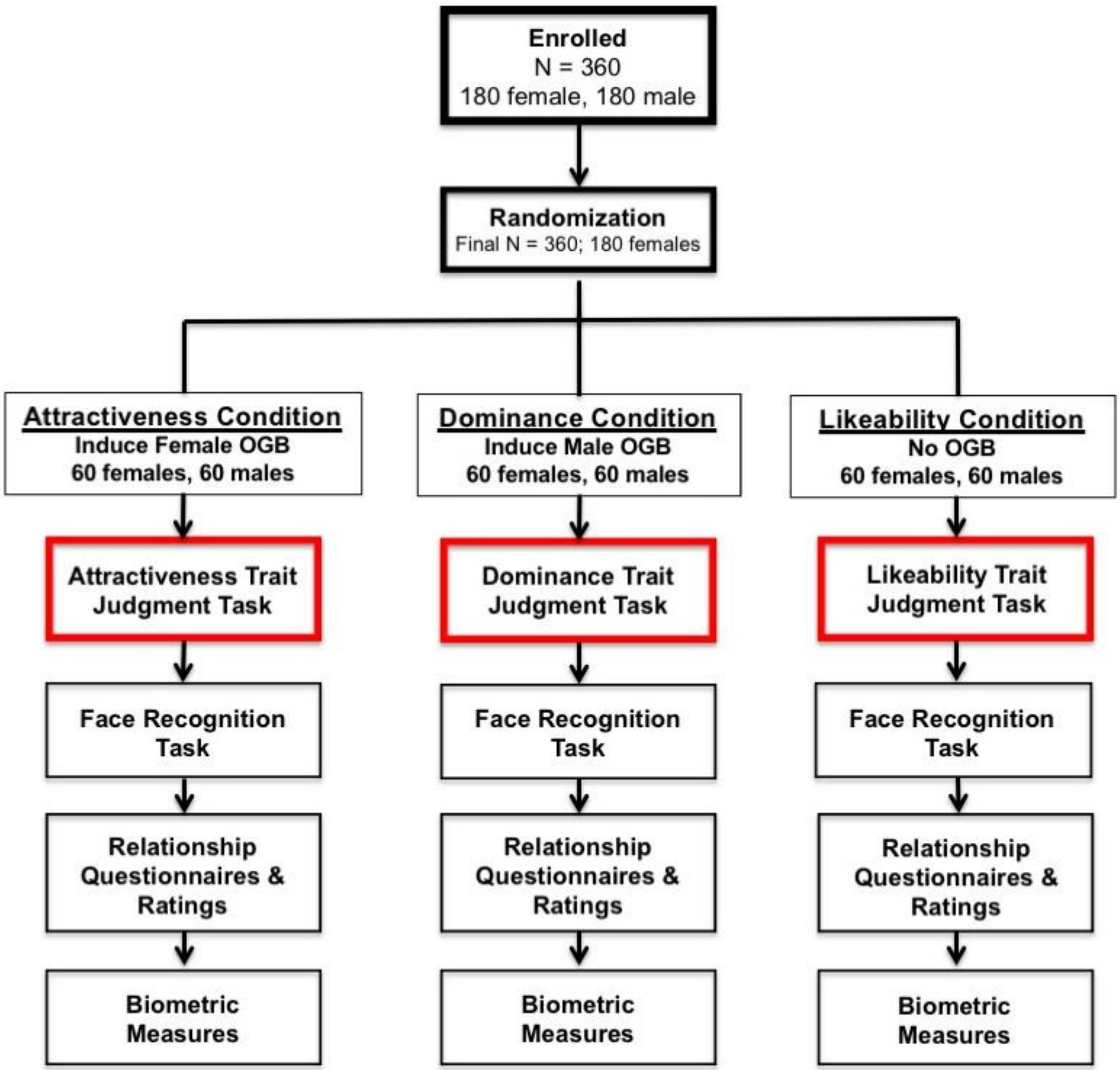


Figure 2. Stimuli used in the Attractiveness judgment trait task.

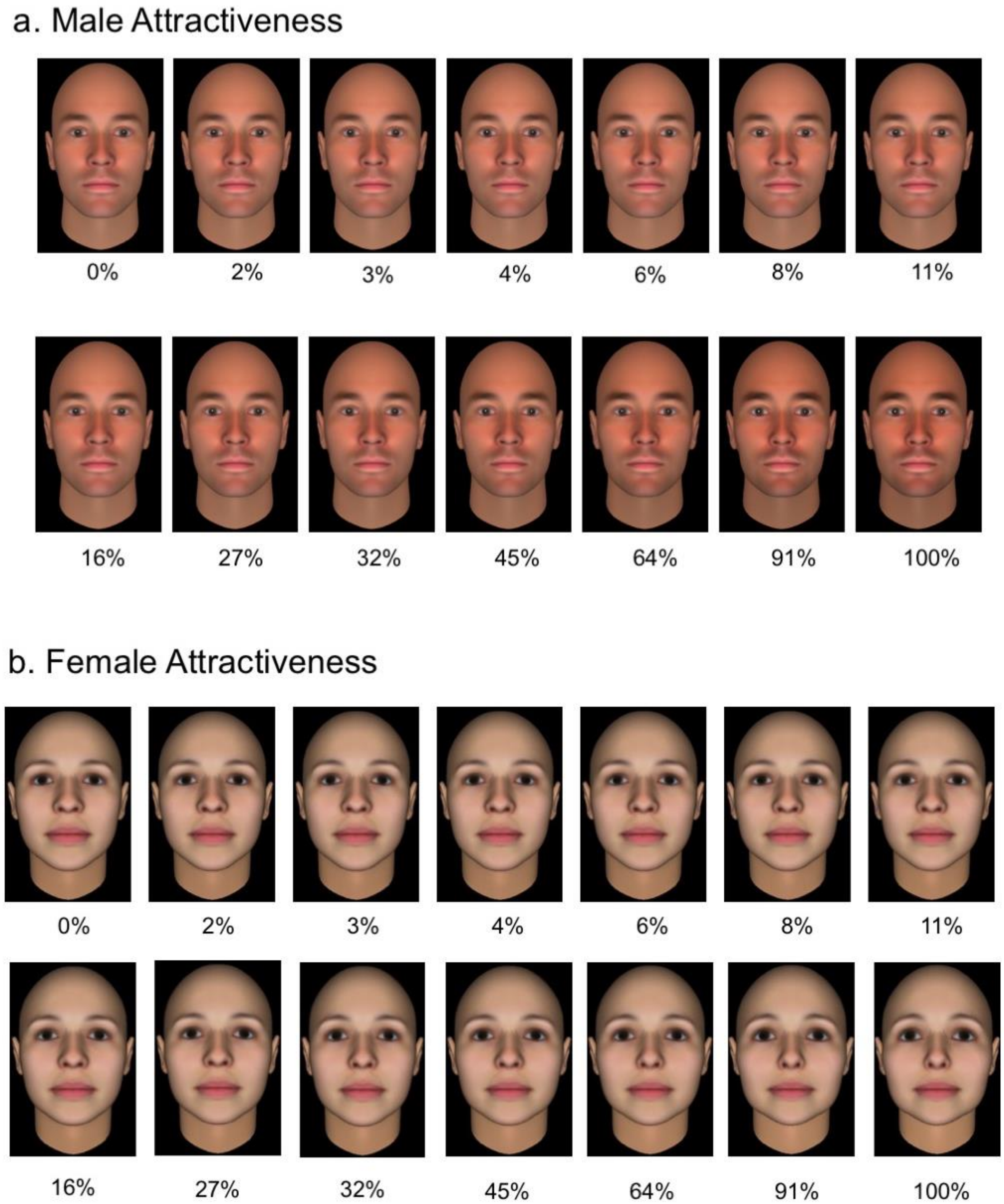


Figure 3. Stimuli used in the Dominance judgment trait task.

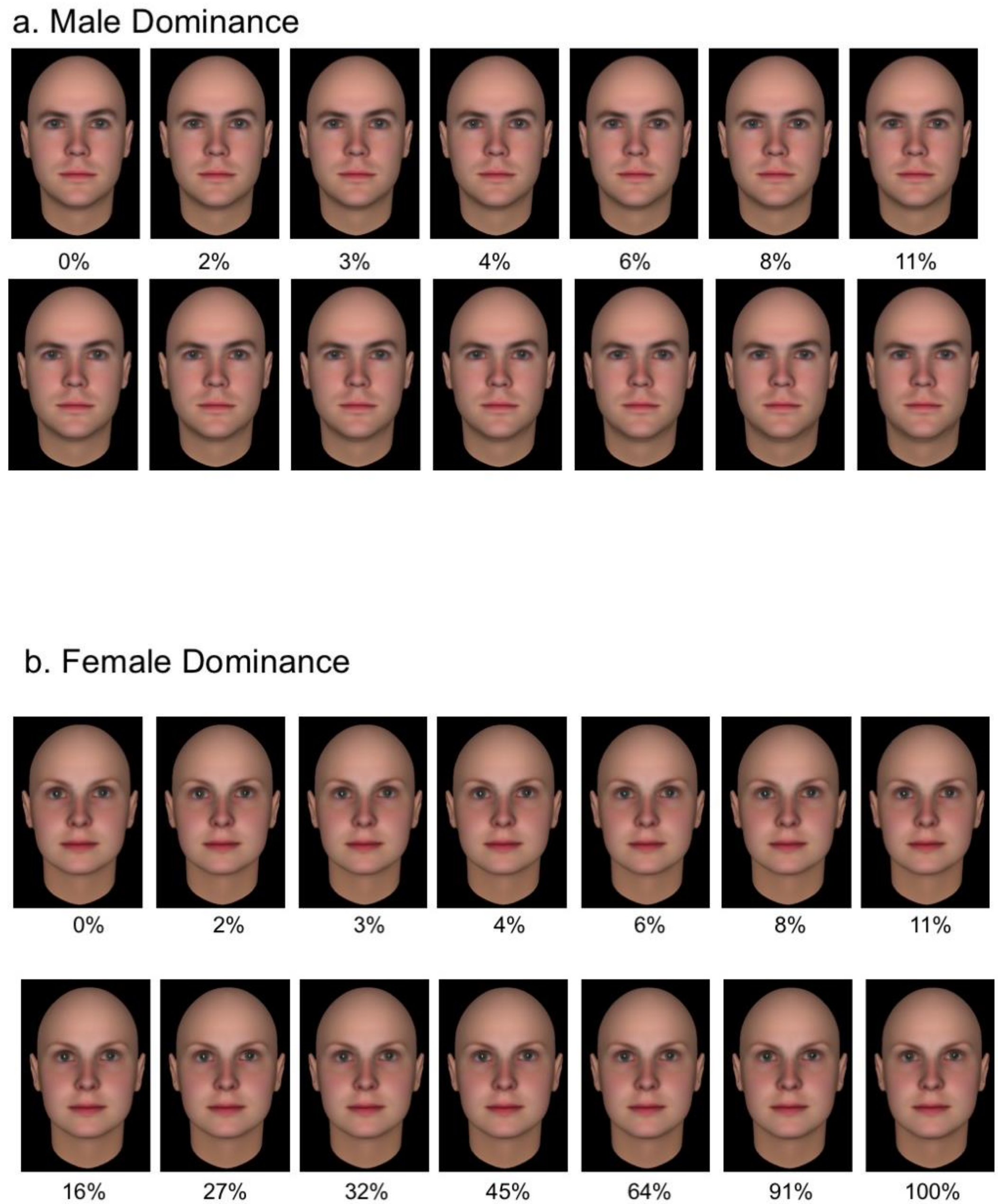


Figure 4. Stimuli used in the Likeability judgment trait task.

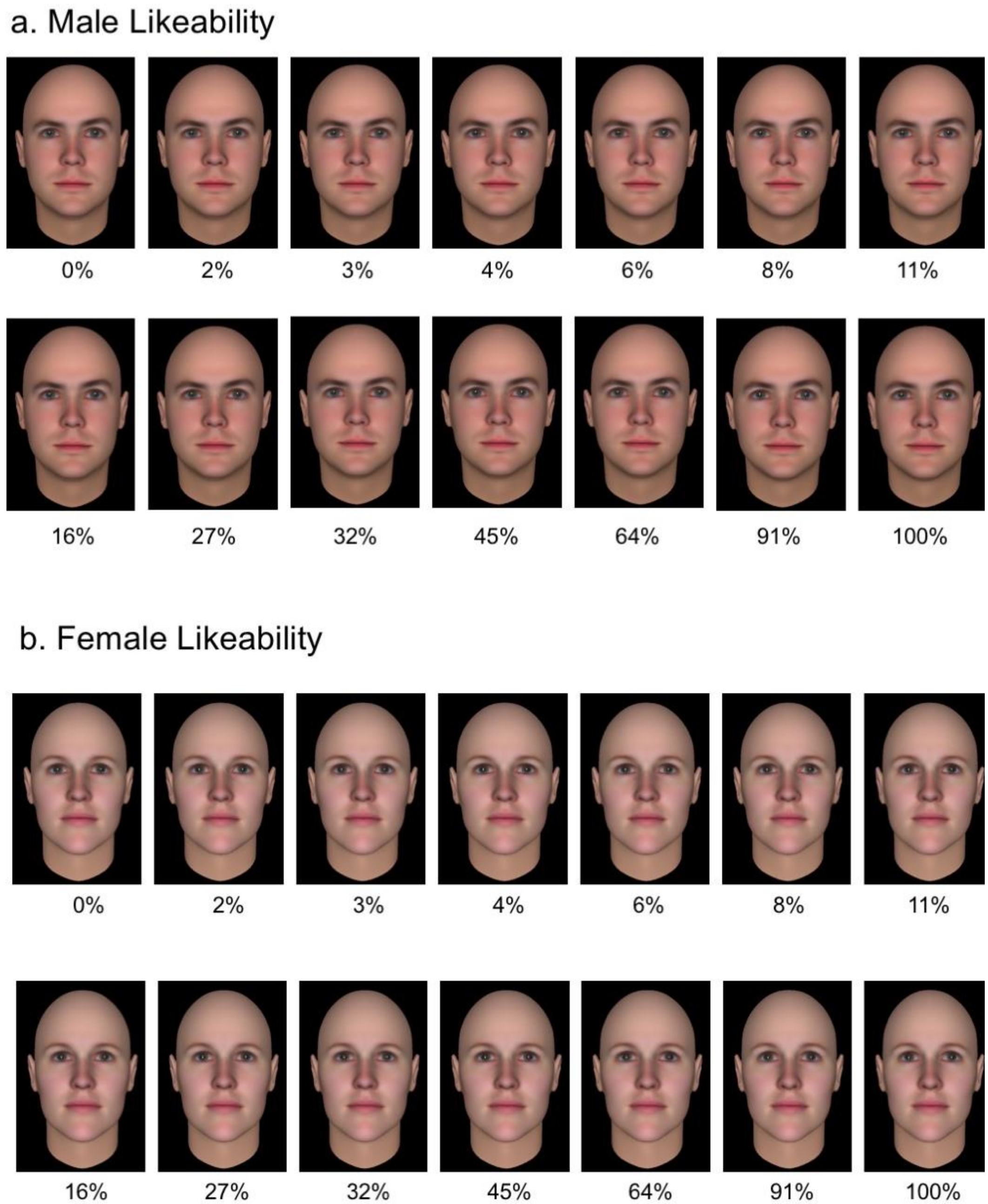


Figure 5. Schematic of stimuli from each of the computer tasks. A) Examples of the dominance and likeability instruction screens that participants viewed for two of the three trait judgments tasks. B) A schematic of the face recognition paradigm employed. C) An example slide from the relationship questionnaire.

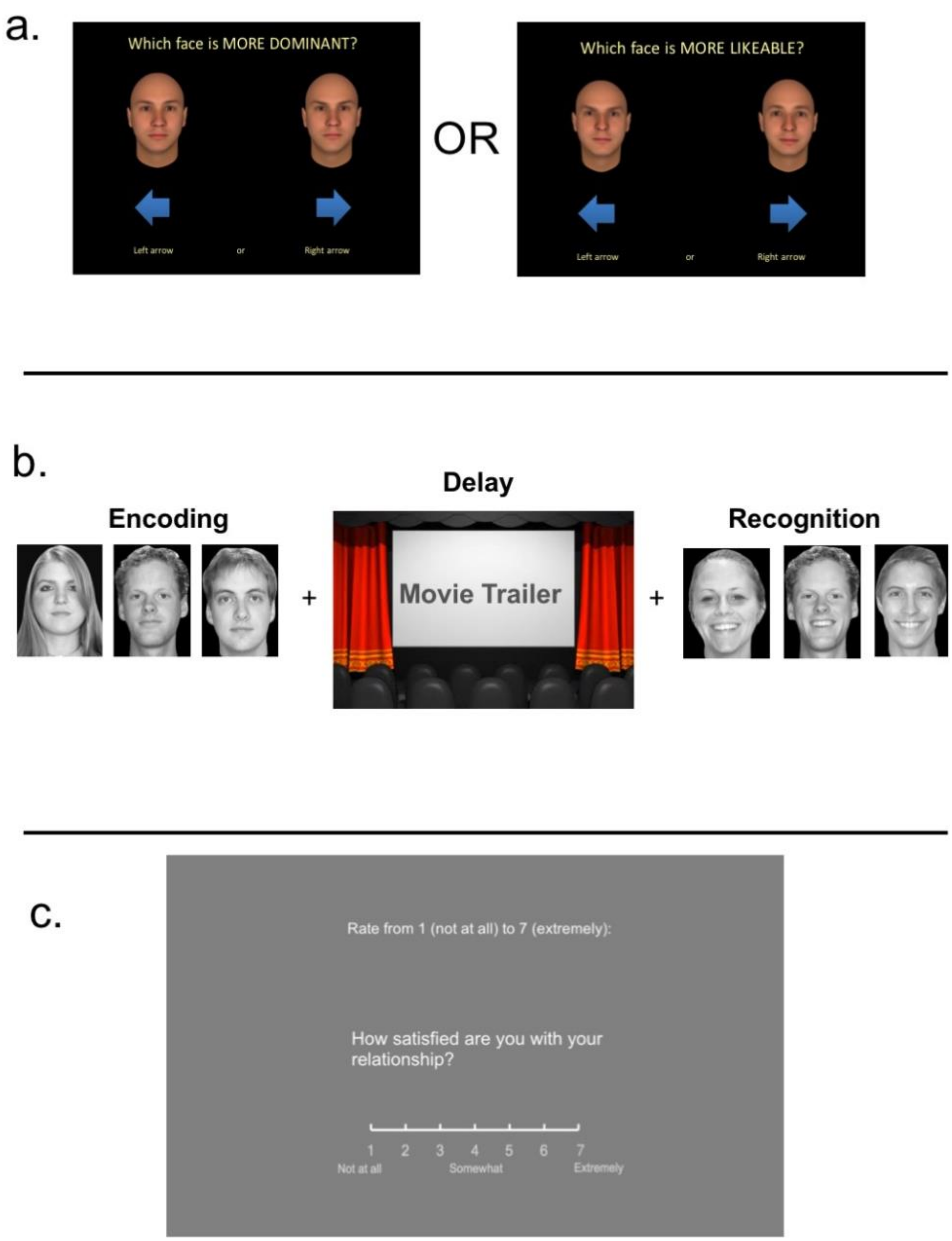


Figure 6a-b. Repeated-measures analysis of variance on d' sensitivity scores between condition, stimulus sex, and participant sex reveals no effect of condition manipulation. Men and women's recognition memory for male faces (A), and female faces (B), was consistent across condition.

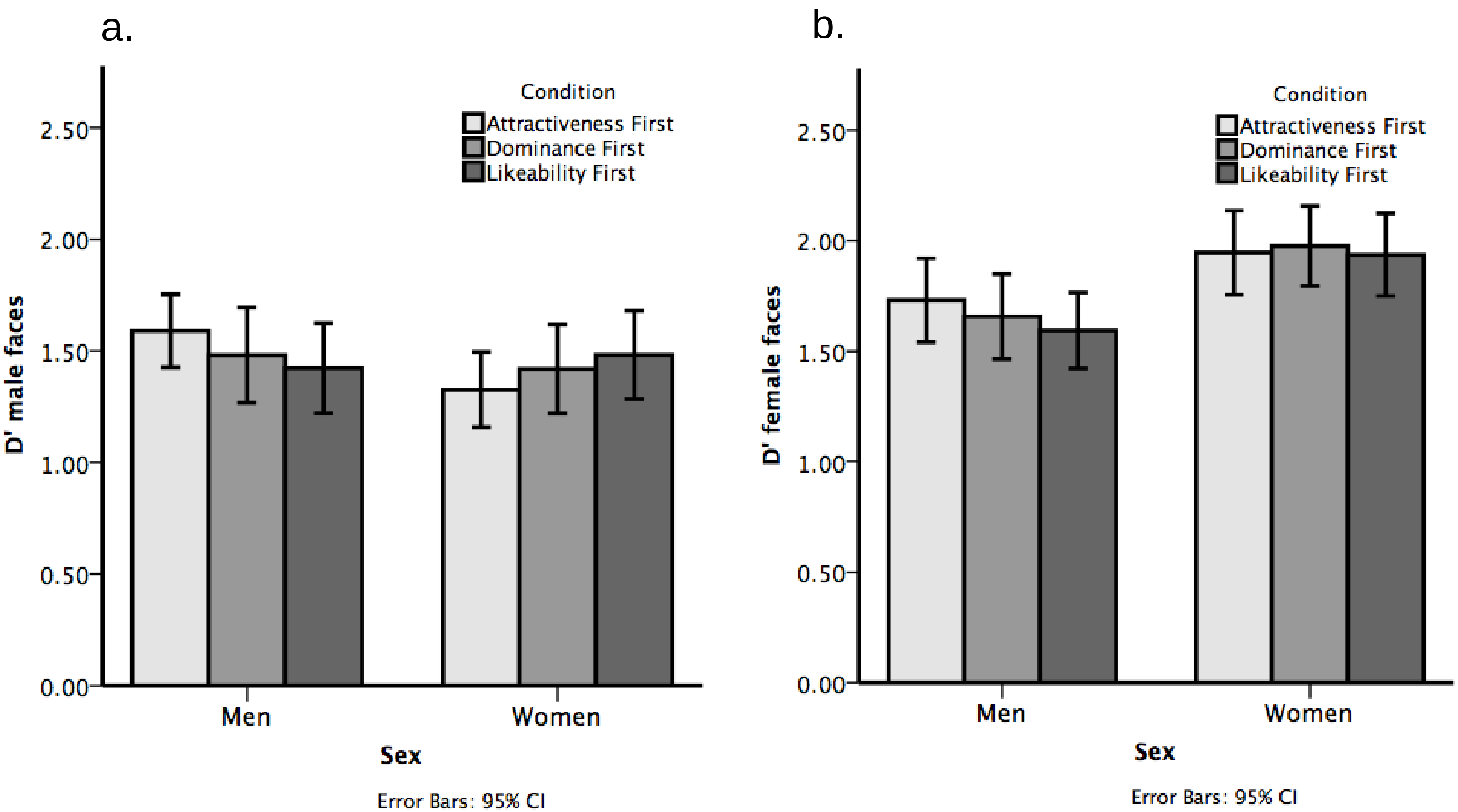


Figure 7. The stimulus sex X participant sex interaction only present in d' data, and not in the inverse efficiency data.

A) Men and women exhibited significantly higher d' scores for female faces compared to male faces, and women further outperformed men in recognition of female faces, regardless of condition. B) This interaction was not present in the same analysis with IE as the outcome variable.

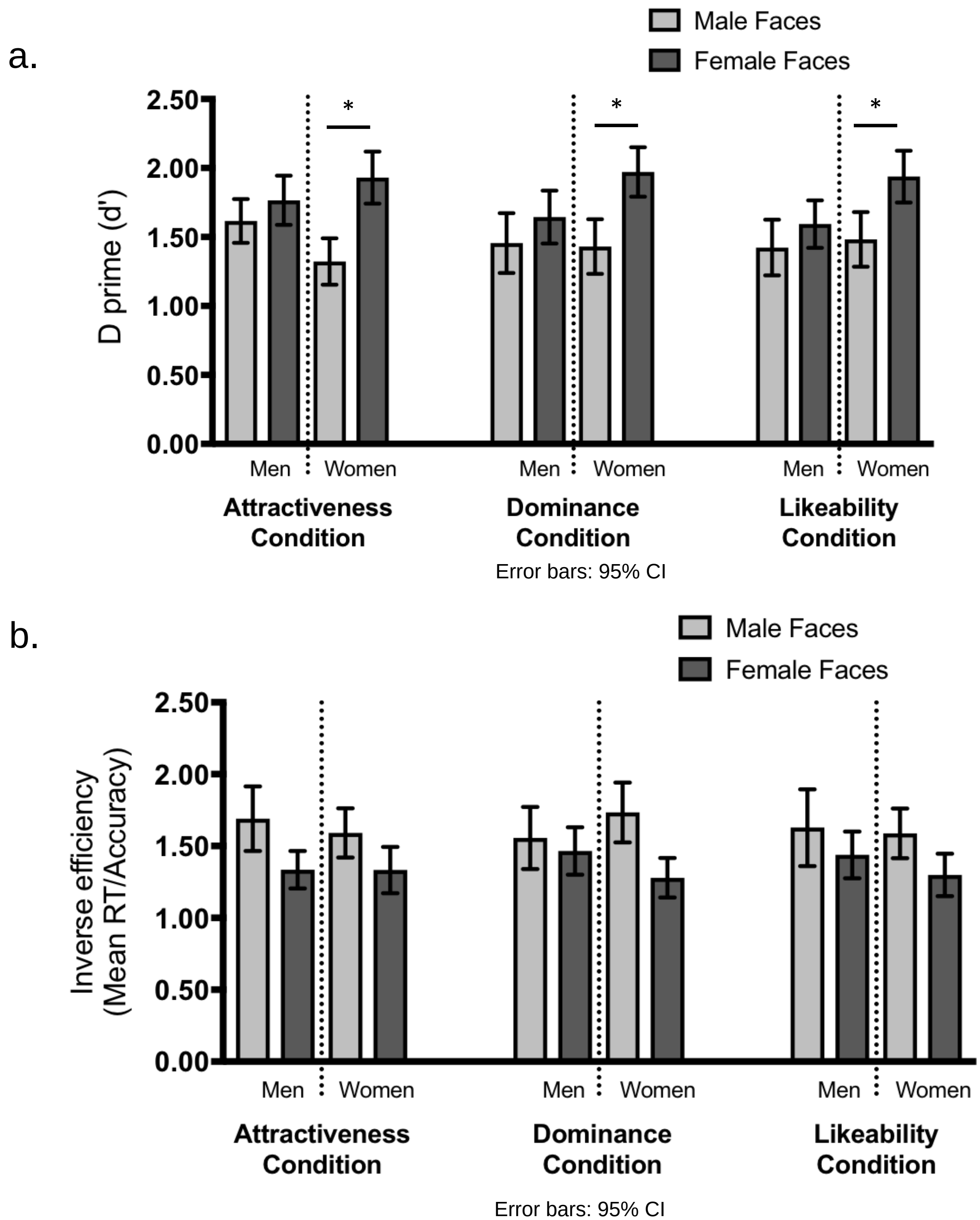


Figure 8. D’ scores by condition, stimulus sex, and participant sex. Planned comparisons provided a more fine-grained analysis of the stimulus sex X participant sex interaction within the Attractiveness condition (A), Dominance condition (B), and Likeability condition (C). In every condition except for the Attractiveness condition, women outperformed men on recognition for female faces.

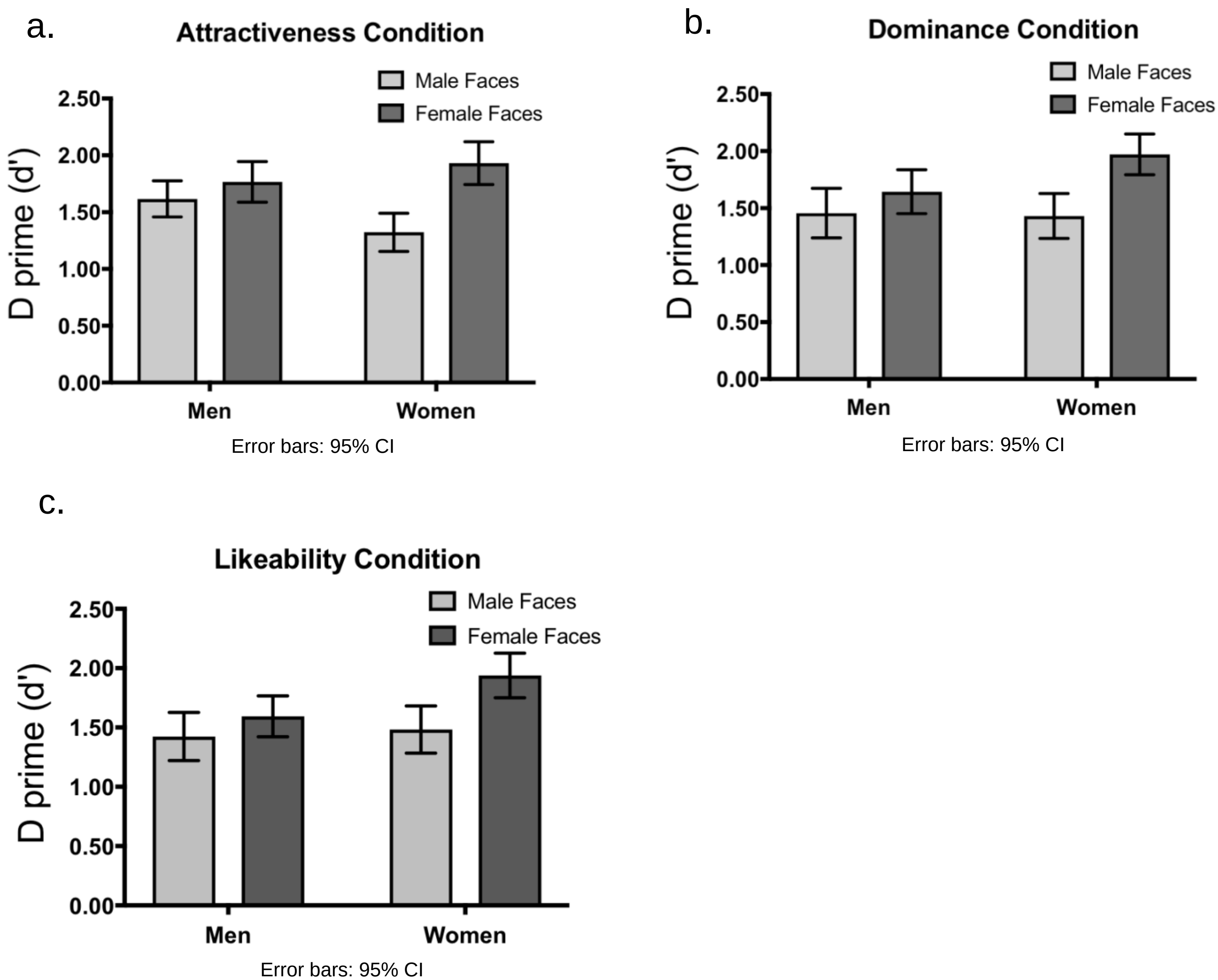


Figure 9a-b. Repeated-measures analysis of variance on inverse efficiency (IE) scores between condition, stimulus sex, and participant sex reveals no effect of condition manipulation. Men and women's IE scores for male faces (A), and female faces (B), was consistent across condition.

a. b.

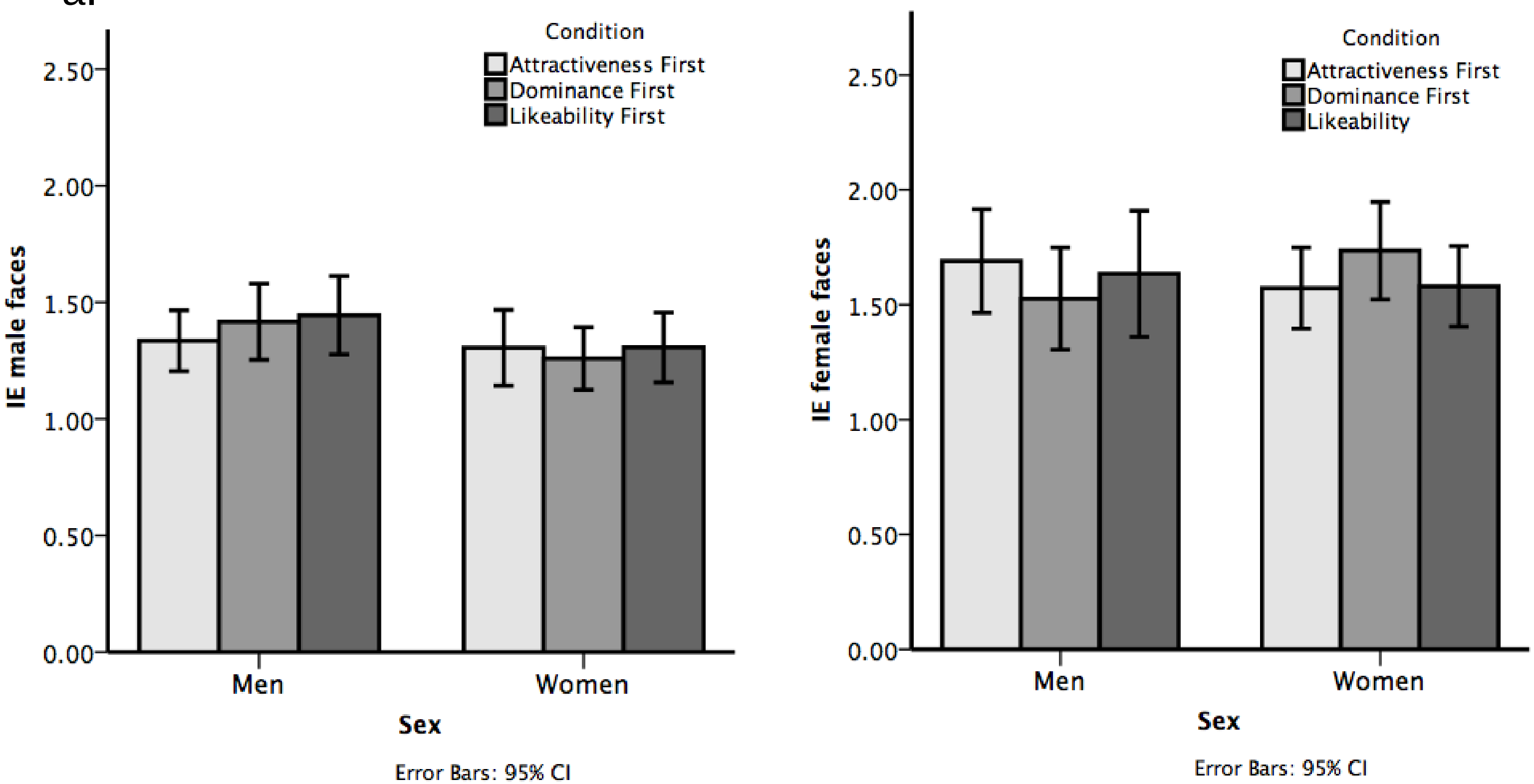


Figure 10a-c. IE scores by condition, stimulus sex, and participant sex. Planned comparisons revealed that the stimulus sex X participant sex interaction in the d' data was not present in the IE analysis. A main effect of stimulus sex suggests that men and women exhibited greater efficiency in recognizing female faces in the Attractiveness condition (A), Dominance condition (B), and Likeability condition (C).

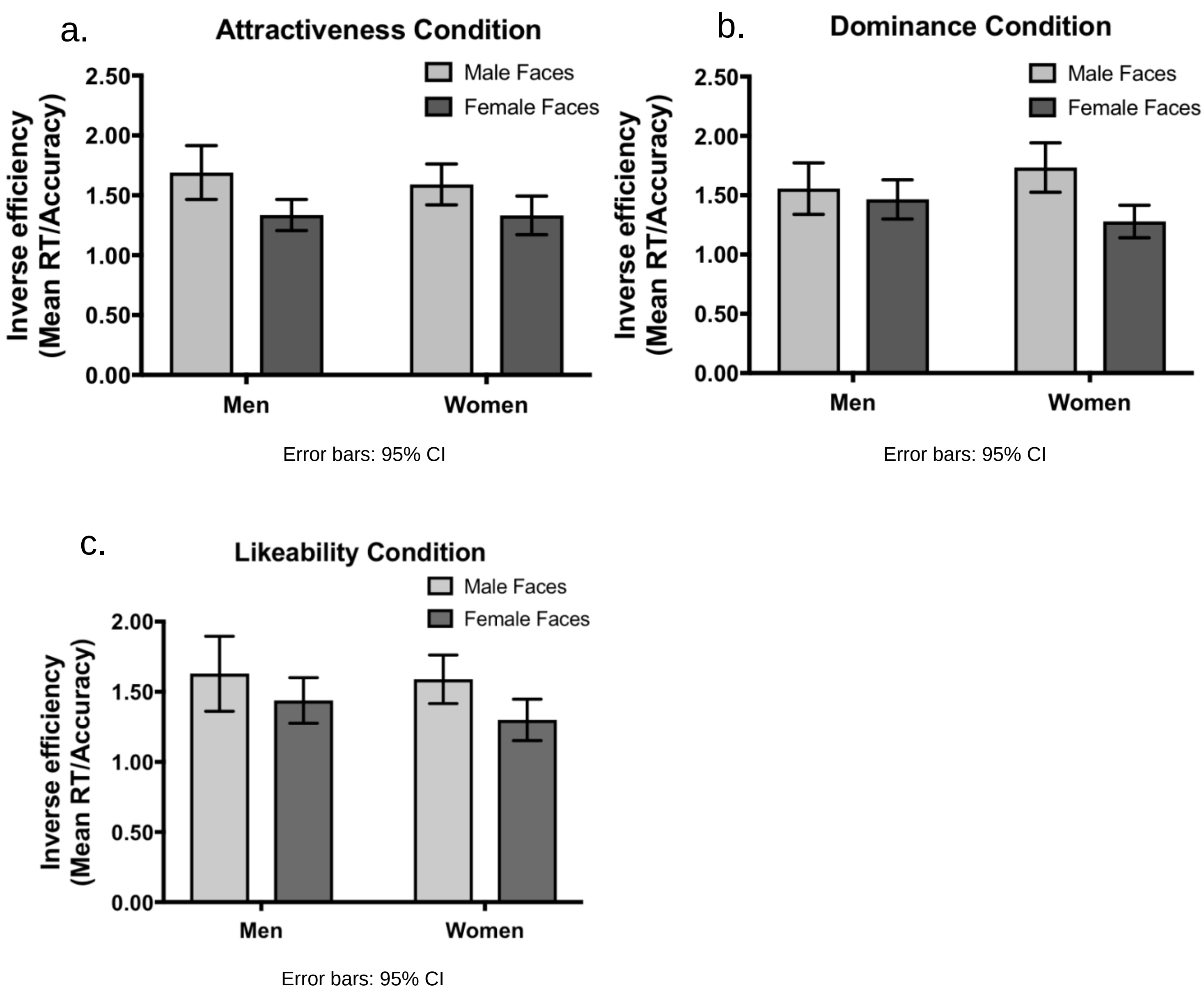
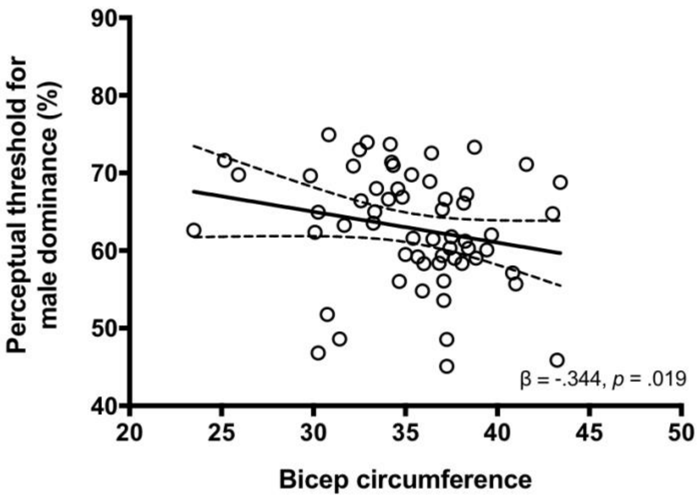
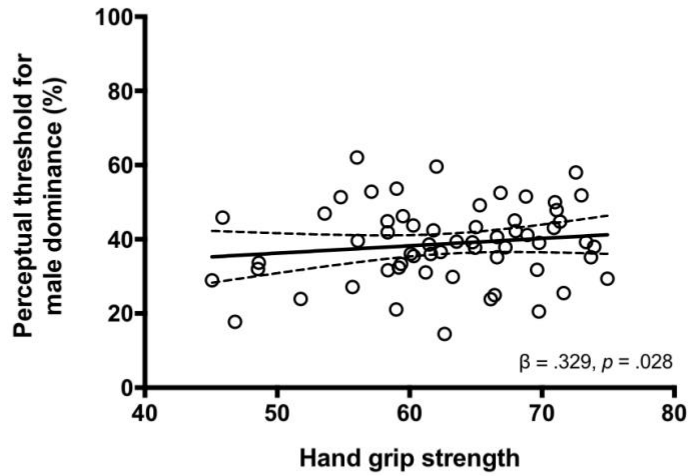


Figure 11a-c. Bicep circumference and hand grip strength predicted perceptual thresholds for detecting male dominance. A multiple regression analysis revealed that perceptual sensitivity to detect dominance in male faces is related to men's bicep size (A) and hand grip strength (B). When combined in the model, the positive relationship suggests that as men's physical dominance increases, perceptual thresholds increase as well (i.e. lower sensitivity to dominance.

a.



b.



c.

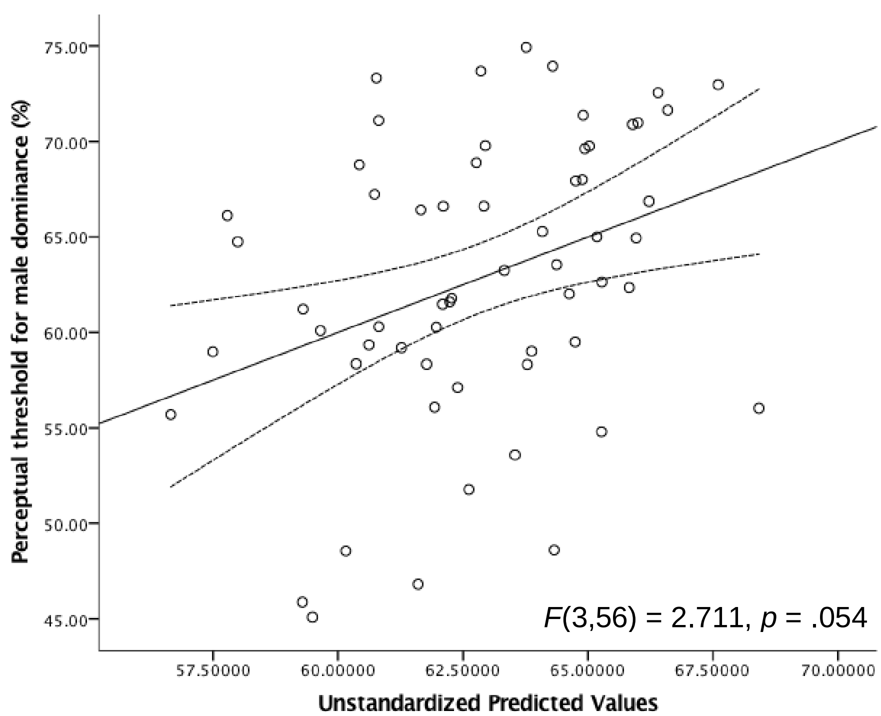


Figure 12. Men's sensitivity to dominance was not related to their male OGB (d' scores for male faces – d' scores for female faces).

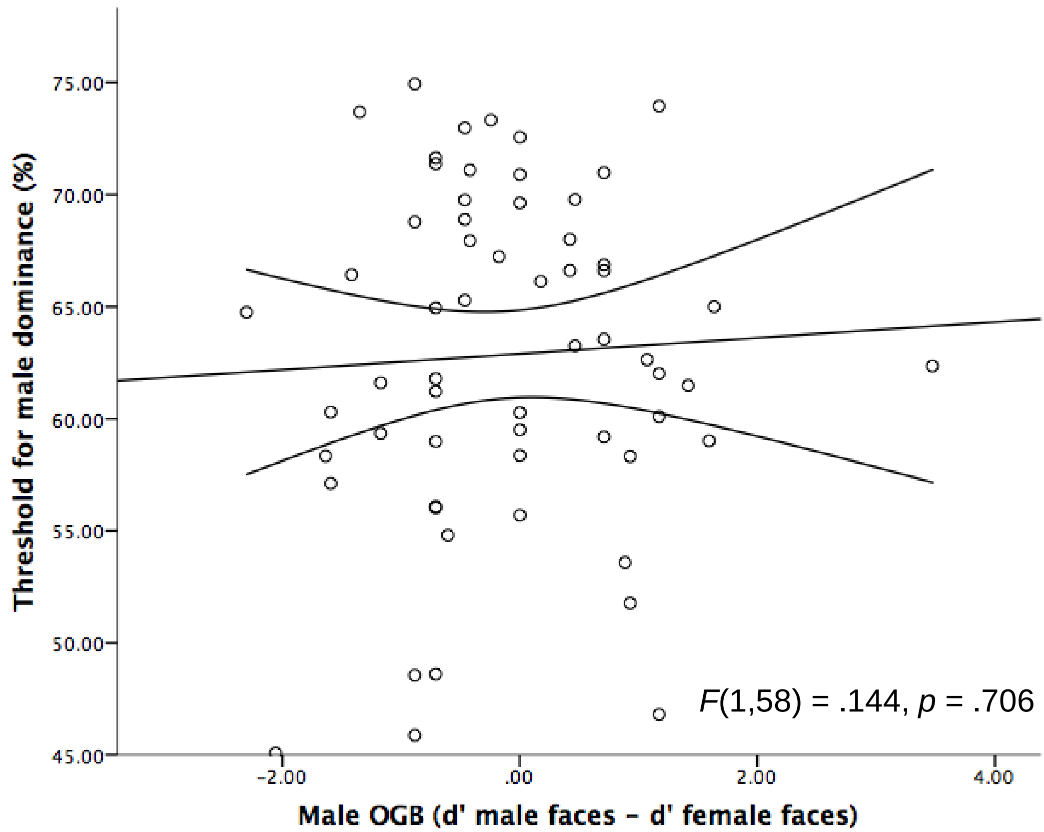


Figure 13. Bicep circumference is negatively and significantly related to the male OGB in men in the dominance condition. For the men in the dominance condition, as bicep size decreases (i.e. dominance decreases), men's OGB (i.e. memory for male faces over female faces) increases.

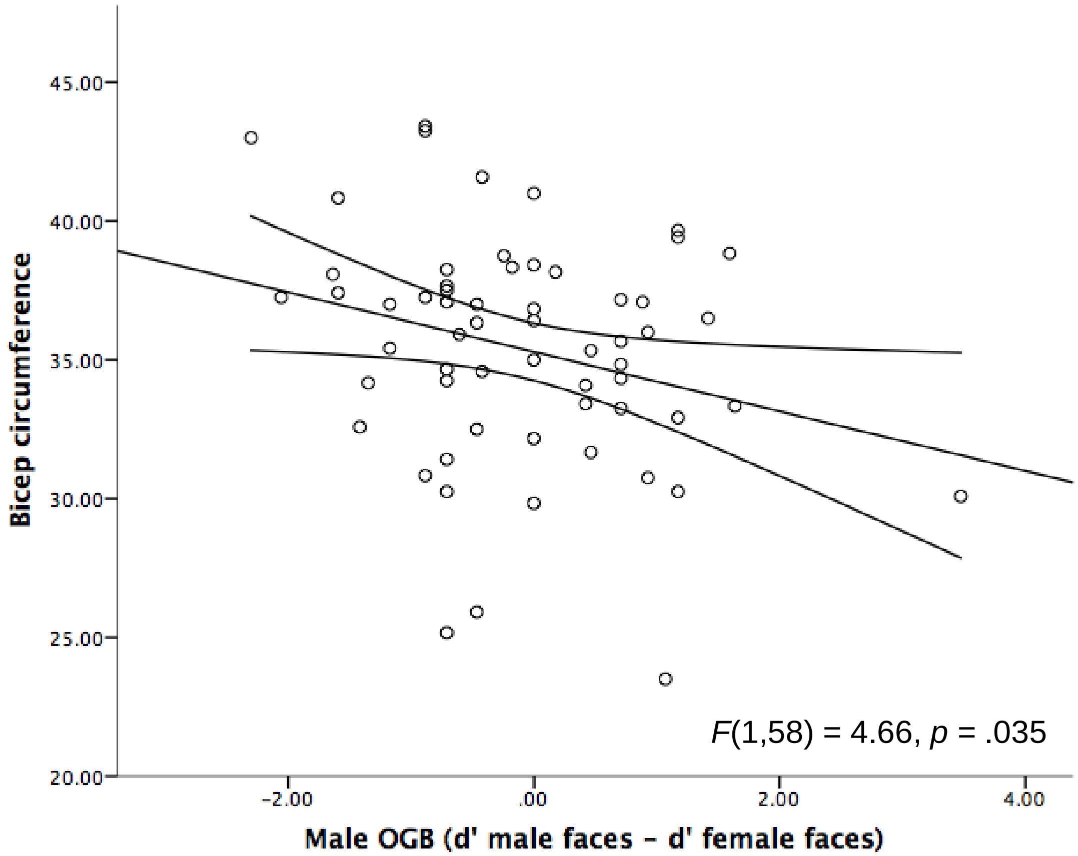


Figure 14. Women's physical attractiveness was related to their female OGB (d' scores for female faces – d' scores for male faces) only in the likeability condition. The only significant predictor of women's face recognition for females (female OGB) was their WHR, specifically in the likeability condition.

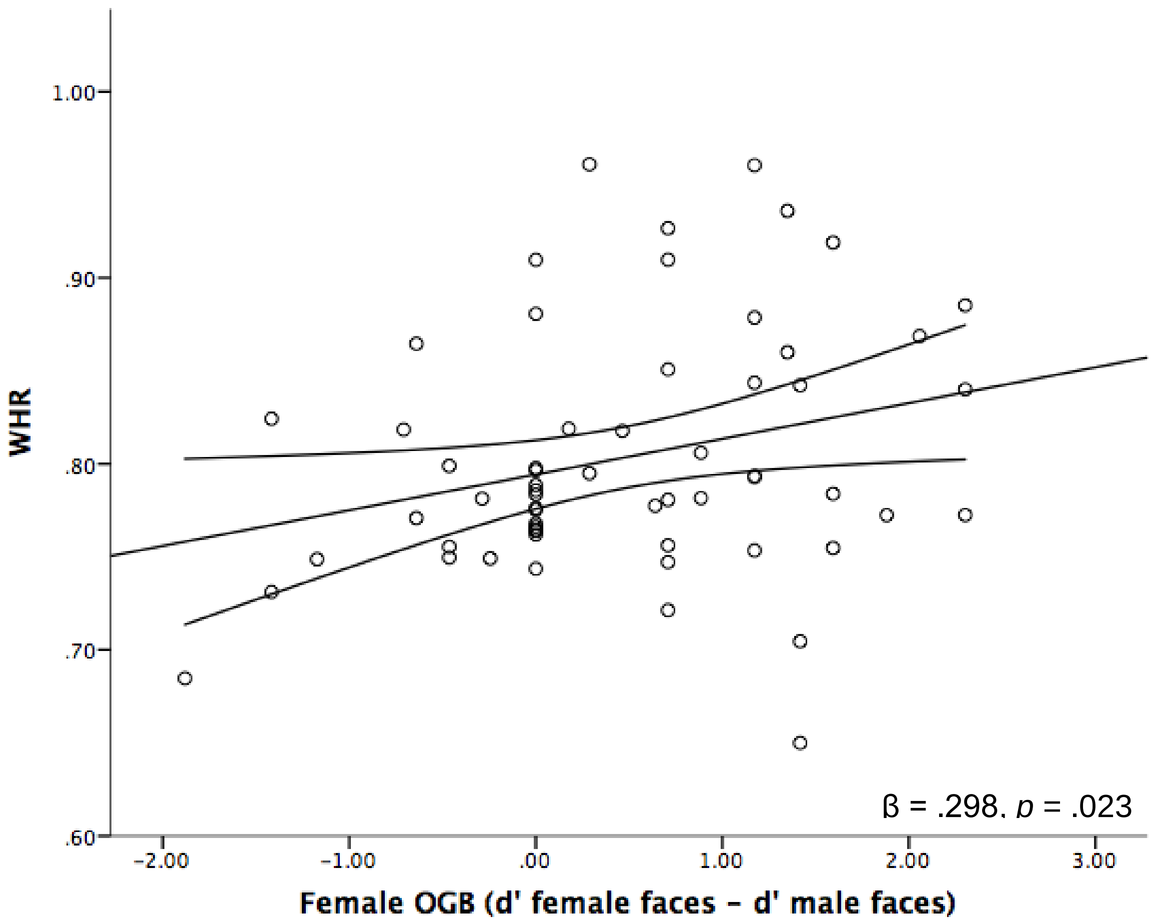
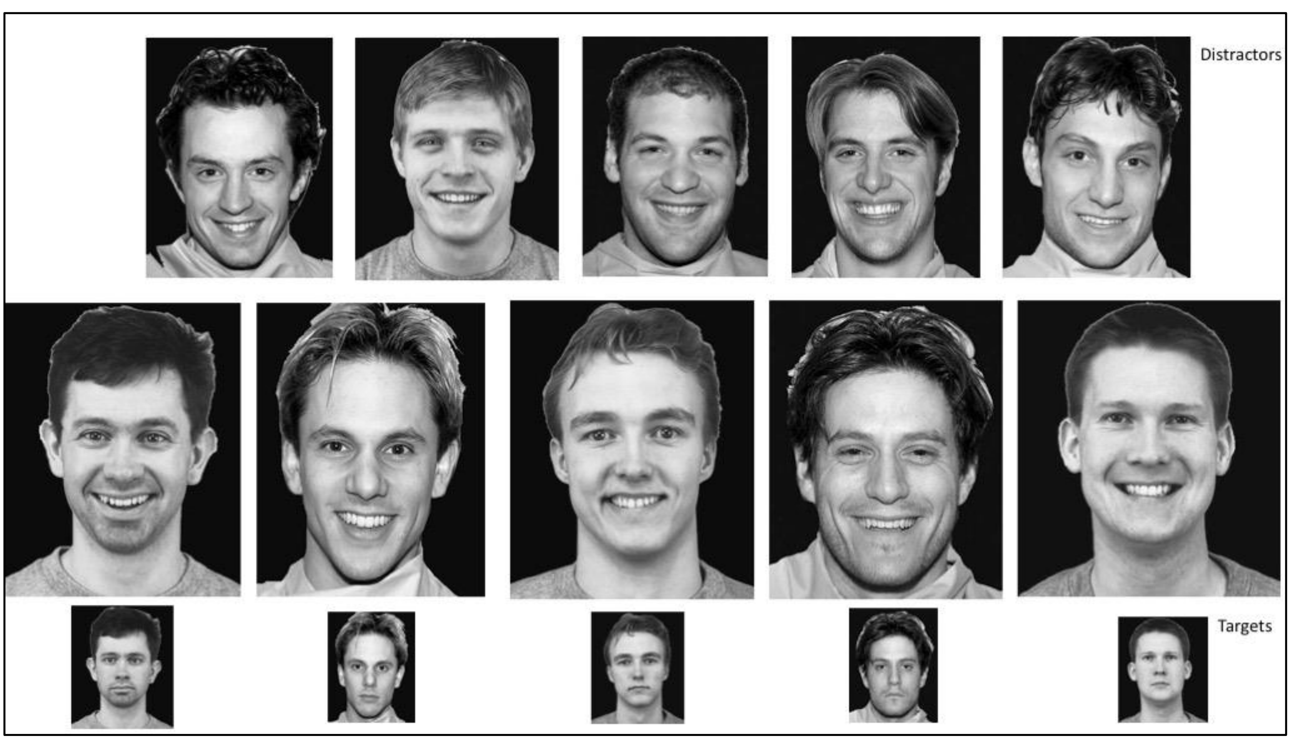


Figure 15. A visual representation of the stimuli employed in the face recognition task. The female faces (A) appear to have more variation (e.g. in hairstyles) than the male faces (B). Differences in the images of the male and female targets and distractors could have contributed to the main effect of stimulus sex observed in the experiment.

a.

b.



Appendix C

Perceived Relationship Quality Components Inventory (PRQC)

Instructions: Please indicate what your current partner/relationship is like, answering each question that follows. Use this scale when answering each question:

1	2	3	4	5	6	7
not at all						extremely

Relationship Satisfaction

1. How satisfied are you with your relationship?
2. How content are you with your relationship?
3. How happy are you with your relationship?

Commitment

4. How committed are you to your relationship?
5. How dedicated are you to your relationship?
6. How devoted are you to your relationship?

Intimacy

7. How intimate is your relationship?
8. How close is your relationship?
9. How connected are you to your partner?

Trust

10. How much do you trust your partner?
11. How much can you count on your partner?
12. How dependable is your partner?

Passion

13. How passionate is your relationship?
14. How lustful is your relationship?
15. How sexually intense is your relationship?

Love

16. How much do you love your partner?
17. How much do you adore your partner?

18. How much do you cherish your partner?

<u>Note to Users</u>: The 6 subscales of the Perceived Relationship Quality Components (PRQC) Inventory are labelled, but the labels should be *omitted* when the scale is administered.

<u>Reference</u>: Fletcher, G. J. O., Simpson, J. A., & Thomas, G. (2000). The measurement of perceived relationship quality components: A confirmatory factor analytic approach. *Personality and Social Psychology Bulletin, 26*, 340-354.
doi: 10.1177/0146167200265007

Appendix D
SCALE FOR THREE TYPES OF JEALOUSY

English version

Primary reference:

Barelds, D.P.H. & Dijkstra, P. (2007) Relations between different types of jealousy and self and partner perceptions of relationship quality. *Clinical Psychology & Psychotherapy, 14,* 176-188

Buunk, B.P. (1997). Personality, birth order and attachment styles as related to various types of jealousy. *Personality & Individual Differences, 23*, 997-1006

Response scale for questions 1 - 5

1	2	3	4	5
Not at all upsetting				Extremely Upsetting

Please think of the relationship with your current partner. Mark the number that best reflects your opinion.

How would you feel when your partner would do the following things?

1 ...flirting with someone else.

2. ...discussing personal things with someone of the opposite sex.

3. ...having sex with someone else.

4. ...dancing intimately with someone of the opposite sex.

5. ...kissing someone of the opposite sex on the mouth when greeting or saying goodbye.

Response scale for questions 6 - 10

1	2	3	4	5
Never				All the time

Please check to what degree the following applies to you.

6. I am concerned that my partner finds someone else more attractive than me.

7. I am worried that my partner has a sexual relationship with someone else.

8. I am afraid that my partner is sexually interested in someone else.

9. I am worried about all the things that could happen when my partner comes into contact with persons of the opposite sex.

10. I am worried that my partner will leave me for someone else.

Response scale for questions 11 - 15

1	2	3	4	5
Does not apply to me				Applies to me very much

To what degree do the following statements apply to you?

Applies very much to me

11. I don't want my partner to have too much contact with persons of the opposite sex.

12. It is unacceptable to me that my partner has friends of the opposite sex.

13. I expect my partner not to look at other men/women.

14. I am rather possessive with regard to my partner.

15. It is difficult for me to give my partner enough space.

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PUBLICATIONS

7. Jünger, J., **Motta-Mena, N. V**., Cardenas, R., Bailey, D., Rosenfield, K.A., Schild, C., Penke, C., Puts, D.A. (Under review). Do women's preferences for masculine voices shift across the ovulatory cycle?

6. Puts, D.A., & **Motta-Mena, N. V**. (2018). Is human brain masculinization estrogen receptor-mediated? Reply to Luoto and Rantala. *Hormones and behavior*, *97*, 3-4.

5. **Motta-Mena, N. V.**, & Puts, D. A. (2017). Endocrinology of human female sexuality, mating, and reproductive behavior. *Hormones and behavior*, *91*, 19-35.

4. **Motta-Mena, N. V.,** & Scherf, K. S. (2017). Pubertal development shapes perception of complex facial expressions. *Developmental Science*, 20(4).

3. Scherf, K. S., Elbich, D. B., & **Motta-Mena, N. V.** (2017). Investigating the Influence of Biological Sex on the Behavioral and Neural Basis of Face Recognition. *eNeuro*, *4*(2), ENEURO-0104.

2. Whyte E.M., Behrmann M., Minshew N., **Garcia N.V.**, & Scherf K.S. (2016). Animal, but not human, faces engage the distributed face network in adolescents with autism. *Developmental Science*, *19*(2), 306-317. DOI: 10.1111/desc.12305

1. **Garcia N.V.**, & Scherf, K.S. (2015). Emerging sensitivity to socially complex expressions: A unique role for adolescence? *Child Development Perspectives*. 10.1111/cdep.12114

AWARDS & GRANTS

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