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Cross-sex and intrasexual theory of mind: Perceptions of sex-typical sexual desires☆

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ABSTRACT

Theory of mind refers to the ability to infer the thoughts, motivations, and desires of others. Although traditionally studied as domain-general, an evolutionary psychology perspective leads to the hypothesis that theory of mind mechanisms may be sexually dimorphic in domains where male and female minds differ, such as sexual desires. Using an error management perspective, we conducted a preregistered study with 710 adults (452 men; *M* age = 34.54, *SD* = 12.26). We hypothesized that adaptive inferential biases such as men's sexual overperception bias, would also be reflected in inferences about the typical sexual desires of the opposite sex. Drawing on three questions derived from Sexual Strategies Theory, we tested the predictions that men would (1) overestimate the number of sexual partners women desire, (2) underestimate the time women require before wanting sex, and (3) overestimate women's comfort with sex without love. In contrast, we predicted women would infer men's sexual desires more accurately. The results provided partial support for these predictions. Men overestimated women's desire for sexual variety and underestimated the time women required before engaging in sexual activity. Unexpectedly, women showed similar biases when estimating the desires of men. We also explored same-sex mindreading and found that both men and women overestimated the sexual desired of their same sex peers. We discuss possible explanations of this observed pattern. One invokes intrasexual competition, whereby individuals inflate perceptions of their peers' sexual desires to simultaneously derogate rivals, enhance their own mate value, and remain vigilant against mate poaching and infidelity threats. Unrestricted sociosexuality and Dark Triad traits, particularly psychopathy in both sexes, were associated with exaggerated perceptions of others' sexual desires. These findings contribute novel insights to the theory of mind literature and potential sources of conflict between the sexes.

1. Introduction

> *"The great question that has never been answered, and which I have not yet been able to answer, despite my thirty years of research into the feminine soul, is 'What does a woman want?'".*
> - Sigmund Freud (1933).

Theory of mind is the capacity to infer others' beliefs, desires, and intentions to predict and interpret behavior (Baron-Cohen, 1999; Wellman, 2017). In its prototypical form of *belief–desire psychology* it involves representing how others believe the world is, how they want it to be, and how they might act to achieve their goals (Wellman, 2014). Theory of mind abilities help humans solve adaptive problems such as anticipating aggression, recruiting allies, reconciling parental conflicts, enhancing the credibility of threats, and maintaining coalitions (Buss, 2024). It also underlies key human activities including communication, teaching, persuasion, and deception (Baron-Cohen, 1999). For all these reasons, theory of mind does not simply "click in" early in development but continues to become more sophisticated across the lifespan (Wellman,

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2017).

Theory of mind has traditionally been studied as a domain-general cognitive ability (Rakoczy, 2022). Research investigating inferences about the minds of others are traditionally domain-general in at least two senses: (1) they are not tethered to specific content domains, and (2) they are assumed to be similar in males and females, regardless of the domain in question (Buss, 1996).

Some small but consistent sex differences in empathy and emotion recognition have been documented, likely stemming, in part, from women's ancestral childcare obligations (Baron-Cohen, 2005; Eisenberg and Lennon, 1983; Hall, Gunnery, and Schlegel, 2025; McCauley, McAuliffe, and McCullough, 2024). This work, however, has generally focused on broad socio-emotional domains rather than theory of mind in specific contexts where the sexes face unique adaptive challenges, such as mating (Buss, 1995).

1.1. The case for a domain-specific theory of mind in mating

Some have hypothesized that theory of mind mechanisms may be far more content saturated and sex-differentiated than has yet been discovered (e.g., Buss, 1996). From an evolutionary perspective, such differences are most likely to emerge in domains where men and women faced distinct adaptive challenges (Buss, 1995). Women, for example, might have a "theory of men's minds" that differs from their "theory of women's minds" because the adaptive problems confronting women differ depending on whether they are strategically interacting with a man or a woman (e.g., making inferences about others' sexual desires; Haselton and Buss, 2000; Perilloux, Easton, and Buss, 2012).

Theory of mind specialization becomes even more pertinent when considering the post-pubertal divergences in human male and female psychology (DeBolle et al., 2015; Shirazi et al., 2020), particularly in sexual desires (Schmitt et al., 2003). Many of these psychological differences between men and women arise from asymmetries in reproductive biology, with ancestral men having experienced lower levels of obligatory parental investment, leading to less choosiness about sexual behavior on their part (Trivers, 1972). On average men tend to report more than women that they desire a greater number of sexual partners (Schmitt et al., 2003), desire faster sexual initiation (Buss and Schmitt, 1993), are more accepting of "sex without love" (Schmitt, 2005), and have a sexual over perception bias whereby they overperceive women's sexual interest (Haselton and Buss, 2000).

The sex differences in desire for sexual variety are culturally pervasive and among the largest in psychological sciences, often reaching Cohen's *d*s of 0.7 and above (see Buss and Schmitt, 2011). Despite these large sex differences in sexual desires, how each sex perceives the typical sexual desires of the other is not yet fully understood. We fill this gap with the current study. We hypothesize that the fundamental reproductive differences between men and women likely shaped distinct inferential pathways when mind-reading across sexes.

1.2. The role of error management in cross-sex mindreading

Cross-sex mindreading refers to the ability to infer the thoughts, desires, and intentions of the opposite sex (Geher, 2009). Accurate perceptions of the opposite sex's desires are often crucial in mating strategies, helping individuals pursue courtship effectively while avoiding physical risk, emotional trauma, or wasted effort. Yet systematic errors in cross-sex mindreading can also be adaptive, if they minimize more costly mating mistakes (Geher, Kaufman, Garcia, Kaufman, and Dawson, 2016).

Error management theory (Haselton and Buss, 2000) proposes that sex-specific inferential biases evolved to minimize more costly errors. For men, a critical bias is sexual over perception (i.e., the tendency to interpret ambiguous cues as indicative of sexual interest). This bias would have increased ancestral men's fitness by reducing the likelihood of missing genuine mating opportunities, which carried high reproductive costs. By contrast, the cost of a false alarm (perceiving interest when none existed) was relatively smaller, typically resulting in wasted time or mild social costs rather than a lost mating opportunity. Thus, natural selection would have favored a bias toward sexual over perception in men (Haselton, 2003).

Several empirical studies confirm this bias across cultures, including the United States (Haselton and Buss, 2000), Norway (Bendixen, 2014; Stavang et al., 2025), and Japan (Hiraishi, Murasaki, Okuda, and Yamate, 2016), as well as in meta-analyses (e.g., La France, Henningsen, Oates, and Shaw, 2009). Men also overperceive sexual interest in opposite-sex friendships (Koenig, Kirkpatrick, and Ketelaar, 2007). Some work, however, suggests that observed over perception effects may partly reflect women's underreporting of their own interest (Perilloux, Muñoz-Reyes, Turiegano, Kurzban, and Pita, 2015) and that cultural norms can attenuate effects (Perilloux et al., 2015).

Women, in contrast, tend to exhibit a commitment skepticism bias, being more cautious about men's intentions and especially about men's willingness to invest in a long-term relationship (Haselton and Buss, 2000). This bias would have protected women from the large costs of being deceived by men feigning commitment in order to obtain short-term sex (Buss, 2017).

1.2.1. Alternative accounts of male sexual over perception

Although error management theory has been the predominant evolutionary account of men's tendency to infer sexual interest under uncertainty, several alternative perspectives warrant consideration. One line of work distinguishes sensitivity (the ability to discriminate between cues of interest vs. disinterest) from response bias (a general tendency to favor one type of judgment), suggesting that men's judgments may reflect genuine cue sensitivity rather than a general over perception bias (e.g., Brandner, Pohlman, and Brase, 2021).

Some researchers argue that men's belief-generating systems may be relatively accurate, but that action thresholds are shifted by asymmetric reproductive costs (McKay & Dennett, 2009; McKay & Efferson, 2010; Perilloux, 2014). From this perspective, a man might correctly believe that a woman is unlikely to be interested, yet still choose to pursue her because the potential payoff of a rare "hit" outweighs the relatively small cost of a false alarm. His behavior thus appears biased even if his cognition is not. Another possible source of men's biases is projection. Individuals often anchor on their own desires when estimating others' (Tversky and Kahneman, 1974). Thus, when asked to infer women's sexual desires, men may use their own higher desire levels as the anchor, leading to overestimation (Lee, Sidari, Murphy, Sherlock, and Zietsch, 2020; Page, Hammermeister, and Scanlan, 2000; Samara, Roth, and Kret, 2021).

Taken together, these perspectives leave open key questions about the origins of cross-sex mindreading errors. Are they underpinned by baseline cognitive misbeliefs, or do they arise primarily from signal detection processes, strategic action thresholds, or projection from one's own desires? The present study helps address this issue by focusing on *belief-level* inferences about typical opposite-sex targets rather than on behavior. This approach allows us to test, for example, whether men's characteristic overperceptions extend beyond their interpretations of ambiguous social interactions to broader assumptions about sex-typical sexual psychology.

1.3. The current study

Although prior research has explored men's sexual over perception bias in specific contexts, such as interpreting ambiguous cues of interest (e.g., Haselton and Buss, 2000), we are aware of no study that has examined how men and women infer the broader, typical sexual desires of the opposite sex. Our research addresses this gap by testing whether cross-sex mindreading biases extend beyond momentary cues to underlying misperceptions about sex-typical desires.

Our design allows us to contribute evidence toward competing

explanations for over perception. For instance, men's projection may serve as a proximate mechanism of error management biases, but it could also represent an alternative explanation if both sexes simply project their own psychology onto others. If projection is the primary driver, men should overestimate women's desires whereas women, with typically more restricted desires (Schmitt, 2005), should underestimate men's. If, however, both sexes exhibit baseline overperceptions (or if women are more accurate about men's desires) this would support a broader error management account of cross-sex mindreading biases.

Specifically, we test the pre-registered predictions that, on average, men will (1) overestimate the number of sexual partners women desire, (2) underestimate the length of time women require to pass before wanting to have sex, and (3) overestimate the ease with which women report they can have sex without love. In contrast, we predict that women will be more accurate in their perception of men's desires. On an exploratory basis we also investigate men and women's intrasexual mindreading of the desires of the typical member of their own sex.

In addition to sex differences, individual differences in personality, such as those captured by the Dark Triad traits (narcissism, psychopathy, and Machiavellianism; Paulhus and Williams, 2002), may play a role in shaping biases in theory of mind in the mating domain. Dark Triad traits, associated with exploitative and manipulative social strategies, are particularly relevant to understanding how people may infer the sexual desires of others, because such inferences may serve adaptive or self-serving mating strategies (e.g., Schmitt et al., 2017). Some studies have found, for example, that Dark Triad traits are more strongly linked to unrestricted sociosexuality and short-term mate seeking in men than women (Jonason, Li, Webster, and Schmitt, 2009), but others have not (Valentova, Junior, Štěrbová, Varella, and Fisher, 2020). By exploring these individual differences alongside the hypothesized sex differences, we aim to contribute to a deeper understanding of the evolutionary origins and functional significance of the mechanistic adaptive biases in cross-sex and intrasexual mindreading in humans.

Before reviewing the logic for the specific predictions stemming from our overarching hypotheses about cross-sex mindreading, we note that we do not have concrete insight into people's actual desires, beliefs, and intentions. That is, we cannot truly *know* what others' desires, beliefs, and intentions are. We therefore compare participants' self-reported estimates of the hypothesized target (e.g., the typical woman) with the average self-reported desires of the target group (e.g., human female participants). This participant-level average is assumed to represent our samples' "baseline" desire upon which we evaluate accuracy of inferences. Throughout this paper, we use "accuracy" as shorthand for this correspondence between inferences and group self-reports, rather than as a claim about objective accuracy in an absolute sense.

1.4. Specific predictions

1.4.1. Men's cross-sex mind reading of women's sexual desires

Building on the well-documented male sexual over perception bias (Haselton and Buss, 2000), we hypothesize that this bias extends beyond men's interpretation of ambiguous cues to broader inferences about women's typical sexual desires. A baseline overestimation of female sexual desires may have been adaptive by motivating mating effort even in the absence of explicit cues to overperceive.

Extending the male sexual over perception bias to broader inferences about women's sexual psychology generates specific predictions for how men will perceive women's desires. Overestimating the number of sexual partners women want would increase men's motivation to pursue short-term mating opportunities, while underestimating the time women require before sex would reduce hesitation in initiating early advances. Similarly, overestimating women's willingness to have sex without love would encourage men to pursue sexual opportunities without the costly investment of providing (or feigning) commitment first. In each case, the adaptive logic is that a bias toward overestimation increases the likelihood of pursuing potential mating opportunities, whereas underestimation would risk missed reproductive chances. Based on this adaptive logic, we propose the following specific predictions for men's perceptions of women's sexual desires.

Prediction 1: Men will overestimate the number of sexual partners women desire to have.

Prediction 2: Men will underestimate the length of time women require before wanting sex to occur.

Prediction 3: Men will overestimate the ease with which women will report being able to have sex without love.

1.4.2. Women's cross-sex mind reading of men's sexual desires

A plausible reason for women's predicted greater accuracy is that it would be more costly for women to be unaware of men's greater desires in the domain of sexual behavior. According to sexual conflict theory, conflicting sexual strategies co-evolved in an evolutionary arms race (Buss, 2017). For instance, men have evolved behavioral strategies to gain sexual access even at women's expense, such as feigning love or long-term commitment to obtain sex without intending to invest (Haselton, Buss, Oubaid, and Angleitner, 2005). If, as evidence suggests, men evolved strategies of sexual deception, it is likely that women evolved defenses against them, including a more acute awareness of men's willingness to have sex without love. Such awareness would help women avoid exploitation by accurately perceive men's underlying sexual psychology.

Because ancestral women incurred enormous obligatory parental investment from sexual activity, selection favored greater choosiness in women (Trivers, 1972). Although both sexes benefited from carefully vetting mates, the costs of failing to do so were especially high for women. Women who failed to properly evaluate a mate risked bearing offspring in poor health or with reduced survival prospects (Buss, 2017). This helps explain why women typically require more time and information before consenting to sex, whereas men often pursue earlier sexual access, especially in short-term contexts (Buss and Schmitt, 1993). Accurate awareness of men's desire for less delay before sex would thus help women avoid compromising situations where premature sexual involvement could impose large costs.

Finally, men's stronger desire for sexual novelty, variety, and multiple sexual partners (Buss and Schmitt, 2011) creates a direct risk for women. Their partners may redirect sexual attention and investment toward additional mates. Women's accurate awareness of this male-typical desire could help trigger vigilance and mate-guarding tactics designed to reduce the likelihood of partner defection or diminished paternal investment in her and her offspring (Buss, 2002).

Taken together, these considerations suggest that women may be accurate in perceiving three core features of men's sexual psychology, (1) their willingness to have sex without love, (2) their preference for less delay before initiating sex, and (3) their stronger desire for multiple sexual partners.

Prediction 4: Relative to men, women will accurately assess the number of sexual partners that men desire.

Prediction 5: Relative to men, women will accurately assess the amount of time that men require to pass before wanting sex to occur.

Prediction 6: Relative to men, women will accurately assess the ease with which men report they can have sex without love.

1.5. Individual differences: Sociosexuality, mate value, dark triad

Although we make firm predictions about general sex differences in desires and mindreading abilities, the nuances of individual differences will be examined on an exploratory basis. Below, we outline the evolutionary logic and rationale for the potential effects of sociosexuality (Penke and Asendorpf, 2008), mate value (Edlund and Sagarin, 2014), and the Dark Triad traits (Paulhus and Williams, 2002), which are then summarized for clarity in Table 1.

Table 1
Exploratory expectations for individual difference effects in cross sex and intrasexual mindreading of sexual desires.

Individual difference	Potential effect(s)	Rationale/Supporting evidence
Sociosexuality	More unrestricted individuals, especially men, expected to overestimate opposite-sex sexual interest and sociosexuality.	Greater openness to casual sex leads to projection of one's own desires onto others (e.g., Lee et al., 2020). Facilitates favored short-term mating strategies by minimizing missed opportunities.
Male Mate Value	High mate value men expected to overperceive women's interest, anchored in their own sexual success.	Men with higher self-perceived mate value report more frequent sexual opportunities, which may bias beliefs about women's typical desires (e.g., Haselton, 2003; Kohl and Robertson, 2014; Perilloux et al., 2012).
Female mate value	High mate value women may overestimate men's interest due to frequent sexual attention. Low mate value women may assume other women are also less selective or encounter pushier men.	Mate value shapes the sexual attention individuals receive and the strategies they can demand (e.g., Buss and Shackelford, 2008).
Dark Triad Traits (Machiavellianism, Psychopathy, Narcissism)	Higher levels expected to predict greater overestimation of sexual interest. Potential sex differences: Machiavellianism linked to strategic short-term mating in men; psychopathy linked to impulsive sociosexual behavior in women.	Dark Triad traits associated with exploitative mating strategies and unrestricted sociosexuality (Freyth and Jonason, 2023; Jonason et al., 2009; Valentova et al., 2020).

1.5.1. Sociosexuality

Men with more unrestricted sociosexual orientations (i.e., greater openness to casual sex; Simpson & Gangestad, 1991) may have more inaccurate theories of mind regarding women's levels of sexual interest. That is, men with more unrestricted sociosexual orientations may be more likely to believe that more women are interested in sex than they are in reality. Prior research supports this pattern, showing that individuals with more unrestricted sociosexual orientations tend to perceive faces as more flirtatious (Howell, Etchells, and Penton-Voak, 2012). Similarly, Perilloux et al. (2012) found that men with higher sociosexuality scores were more likely to overperceive sexual interest. Such men are particularly prone to interpreting ambiguous cues as sexual interest, a bias that would facilitate the success of their favored short-term mating strategy by minimizing missed sexual opportunities (Haselton and Buss, 2000; Kohl and Robertson, 2014).

Men who are especially attracted to a woman are also more vulnerable to the sexual over perception bias, seemingly projecting their own desires (Lee et al., 2020; Samara et al., 2021). Men with more unrestricted sociosexualities may experience heightened attraction toward a wider range of women, and therefore perceive women in general as having a higher level of sexual desire than they do. As a result, men with unrestricted sociosexualities may be more prone to believing that their attraction is reciprocated, reinforcing the cognitive bias to perceive women as more sexually desirous than they actually are.

1.5.2. Mate value

Men who are higher in mate value and have enjoyed an elevated level of success in their sexual encounters with women, may have a skewed impression of what women's typical desires are, that is anchored in their own experience (Haselton, 2003; Schmitt and Jonason, 2019; Tversky and Kahneman, 1974). Consistent with this perspective, men's self-perceived mate value is positively associated with over perceptions of women's sexual interest (Henningsen and Henningsen, 2010; Kohl and Robertson, 2014; Lee et al., 2020; Lemay Jr and Wolf, 2016; Perilloux et al., 2012; Shotland and Craig, 1988).

Women sometimes use short term mating opportunities as a strategy to facilitate long term relationships, particularly with higher mate value men (Buss, 2017). This strategy is likely more pronounced for lower mate value women, who cannot afford to be as discriminate about sex as higher mate value women (Buss and Shackelford, 2008). Therefore, lower mate value women may assume other women are similarly unrestricted. This strategy may also be more pronounced for women high in Machiavellianism, who have no issue in using sex to manipulate people, and may assume others do the same. It is also likely that men higher in mate value have more frequently encountered this strategy in women and therefore may believe that a short-term mating strategy is more typical for women than it really is. The reverse may be true for men lower in mate value, who have rarely encountered women using a short-term mating strategy toward them at all.

Furthermore, women who are higher in mate value likely experience men trying to initiate sexual encounters with them at higher rates (Goetz et al., 2012). Such women may overestimate men's typical desires due to their own experience. The reverse may be true for women lower in mate value, who may encounter fewer sexual propositions. Alternatively, higher mate value women may have experienced men willing to be more patient in waiting for sex, whereas low mate value women may have encountered men who are pushier and expect them to provision sexual access earlier. High mate value women are also in a position to demand more signs of commitment from men before having sex and so may expect this to be the norm for men (Buss and Shackelford, 2008).

1.5.3. Dark triad

In addition to sociosexuality and mate value, the Dark Triad personality traits (Paulhus and Williams, 2002) may play a role in shaping biases in sexual mindreading. These traits are associated with manipulative and exploitative social strategies, making them particularly relevant to how individuals may infer and project sexual desires onto others (Schmitt et al., 2017). Prior research suggests that Dark Triad traits are linked to unrestricted sociosexuality and short-term mating strategies, for example, a recent meta-analysis confirmed a robust positive association between trait psychopathy and unrestricted sociosexual orientation ($r = 0.31$; White et al., 2025).

Some research suggests that the link between dark triad and short-term mating strategies is particularly pronounced in men (Jonason et al., 2009), though some studies have found more nuanced sex differences (Freyth and Jonason, 2023; Valentova et al., 2020). For example, Freyth and Jonason (2023) found that psychopathy positively predicts impulsive sociosexual behaviors more strongly in women, while Machiavellianism is linked to strategic short-term mating behaviors in men.

By exploring Dark Triad traits alongside sociosexuality and mate value, we aim to investigate whether these traits contribute to systematic biases in sexual perception. If Dark Triad traits facilitate exploitative mating strategies, individuals high in these traits may be more likely to overperceive the typical sexual desires of the opposite sex to serve their self-interest. For example, men high in "dark" personality traits are positively associated with the likelihood of perpetrating sexual assault (Zeigler-Hill, Besser, Morag, and Campbell, 2016) and such men are less likely to accurately perceive the degree to which sexual aggression upsets women (Klümper and Schwarz, 2020). Understanding these individual differences will contribute toward a more comprehensive picture of the mechanisms underlying adaptive errors in cross-sex and intrasexual mindreading.

2. Method

2.1. Power analysis

We ran an a priori power analysis using G*Power (Version 3.1; Faul, Erdfelder, Buchner, and Lang, 2007). Our anticipated model — a 2 (Mind-Reading Target: opposite-sex; same-sex) × 2 (Participant Sex: male; female) × 1 (Desired number of sex partners) ANCOVA with four covariates — required a sample size of 400 to achieve 80% power to detect a medium effect size with an alpha of 0.05. To accommodate data cleaning and potential data loss, we aimed to recruit a sample of at least 600 participants, evenly distributed by sex. This power analysis provided us with a conservative estimate of the minimum sample required as running power analysis for generalized mixed models was difficult in the absence of an estimate of the variability of the random components.

2.2. Participants

A total of 710 participants (male $n = 452$) were recruited for the study through poster advertising, social media advertising, and snowball sampling. Participants were on average 34.54 years old ($SD = 12.26$). Participants were predominantly from the United States (47.7%), Europe (19.4%), or the United Kingdom (16.9%). Most were White (83.9%) and heterosexual (80.3%) and almost half were single (48.2%). The median duration of the study was 17 min. Participation was voluntary and not compensated.

2.3. Procedure

Data were collected during a six-month period through flyers posted across the University of Texas at Austin campus, local coffee shops, and across social media. Most of our sample was collected through X. Participants scanned a QR code or directly accessed a link that brought them to the survey.

Our survey consisted of several demographic questions followed by three questions for three separate sections. The first section captured self-ratings using the following questions:

1. In an ideal world, how many sexual partners would you like to have through the next…?
2. If the conditions were right, how likely would you be to have sex with someone you viewed as desirable if you had known that person for…?
3. How easy do you think it is for you to have sex without love?

These were then adapted for the remaining two sections where participants guessed how an "average the average heterosexual member of the opposite [/same] sex" would respond. Although we were primarily looking for perceptions of the opposite sex, the two other sections asked the exact same three questions but replaced "opposite sex" with "same sex" or with "yourself." We wanted to gather perceptions of the same sex as both a control and for future research and wanted to gather information about the "actual" (self-reported) desire of each participant so that we could compare perceptions of the opposite sex with real self-reported preferences.

Following Buss and Schmitt (1993) seminal sexual strategies theory questions, for the first question (time needed before having sex), we had a range of times from one hour to one year. Through a 7-point Likert scale (1- Extremely Unlikely to 7- Extremely Likely) participants were asked to rate how likely they think an average member of the opposite sex, the same sex, and themselves would be to have sex with a person they found desirable at each given time point.

The second question, asking about how many sexual partners would be ideal [self, opposite sex, & same sex], people were made to answer from 0 to 100 for different points in time ranging from one month to the entire lifetime.

Finally, the third question asked how easy it would be to have sex without love, without you loving the other person, and without the other person loving you for [self, opposite sex, & same sex].

2.4. Individual difference measures

2.4.1. Dark Triad scale

Participants were required to respond to a 27-item Dark Triad scale developed by Jones and Paulhus (2014) called the short dark triad (SD3). The scale asked participants how much they agreed or disagreed with questions that measured Machiavellianism, Psychopathy, and Narcissism through a 5-point Likert scale (1- *Disagree Strongly* to 5- *Agree Strongly*). These measures were taken to control for individual differences effects as previous literature suggests that the dark triad may predict sexually exploitative strategies in men (e.g., Lewis, Easton, Goetz, and Buss, 2012).

2.4.2. Sociosexual orientation

Participants completed the revised sociosexual orientation inventory (Penke and Asendorpf, 2008), which is composed of nine items designed to assess an individual's openness to participating in casual sexual relationships. This inventory assesses three distinct dimensions evaluating sexual behaviors, sexual attitudes, and sexual desires. A more unrestricted sociosexuality in women may serve to predict better cross-sex mindreading.

2.4.3. Mate value

Participants also completed a self-perceived mate value scale (Edlund and Sagarin, 2014). The scale asked participants a series of questions regarding how they perceive their own desirability. This scale has been shown to be a reliable measure of actual mate value (Edlund and Sagarin, 2014).

2.5. Data and materials availability

The study was preregistered at https://aspredicted.org/qm4j-7mp6.pdf). All data and analysis code will be made publicly available at https://osf.io/325rm/overview on the Open Science Framework upon publication.

3. Results

3.1. Accuracy ratings

We started by computing average responses for men and women in our samples for each of the dependent variables. Because participants were asked to guess how heterosexual men and women would respond to the questions, we formed our average responses using the heterosexual participants only. For ideal number of sexual partners over time, a negative binomial generalized linear mixed-effects model was computed, as responses had a positively skewed distribution. The model contained a random intercept for each participant to account for the lack of independence in repeated measures. We examined the predicted number of desired partners as a function of fixed effects of time and sex. Because age and relationship status (in a relationship = 0, single = 1) could affect the number of desired partners, we included these as controls. From the resulting model, we extracted the estimated marginal means for each time point for men and women separately. Next, we repeated the process for willingness to have sex with someone after certain lengths of time using the same predictors and controls. This variable was not as positively skewed, so we used a linear mixed-effects model. After establishing that the three "sex without love" items had high reliability when combined ($\alpha = 0.94$), we used a linear model to predict the total score for the men and women in our sample. We chose a standard linear model as there was no repeated measures component to this particular dependent variable.

3.1.1. Magnitude of perceptual error ratings

At the end of this process, we had average scores for men and women at every level of dependent variable in the study. These were then subtracted from participant's individuals estimates of how the average man and woman would respond to each question. Thus, positive numbers represent an overestimation of number of desired sexual partners, willingness to have sex with someone, and comfort in having sex without love.

3.1.2. Number of sexual partners

Using a generalized linear mixed-effects model, we predicted how accurate our participants were at estimating how many sexual partners the average man and woman said they desired across different time intervals. The top panel of Fig. 1 shows that both men and women tended to overestimate the self-reported number of partners men desired, with men's estimates being higher than women. Overestimation increased and sex differences become larger further into the future. The model confirmed that prediction accuracy differed between the sexes ($\chi^2[1] = 19.05$, $p < .001$), changed over time ($\chi^2[10] = 8730.26$, $p < .001$), and that an interaction between the two was present ($\chi^2[10] = 77.92$, $p < .001$). Using Bonferroni corrected p-values, men overestimated more than women at every time point greater than 6 months (all $ps_{adj} < 0.042$). At their largest (20 years), the sex difference was small to medium in size (Cohen's $d = 0.36$). The prediction (Prediction 4) that women would accurately assess the number of sexual partners desired by men was not confirmed. Women overestimated this number; however, they were more accurate in their estimations than men were.

Next, we looked at the predictions of the average woman's responses. As before, both sexes tended overestimate the self-reported number of partners women desired, and this overestimation grew with time (Fig. 1, bottom panel). However, we did not document any sex differences in misperception. The model revealed a significant effect of time ($\chi^2[10] = 3418.76$, $p < .001$), though there was neither a main effect of sex ($\chi^2[1] = 0.39$, $p = .532$) nor an interaction between sex and time ($\chi^2[10] = 7.17$, $p = .701$). The prediction (Prediction 1) that men will overestimate the number of sexual partners women desire was confirmed. This was also the case for women.

3.1.3. Desire for sex across time points

Using a linear mixed-effects model, we predicted how accurate our participants were at predicting how willing an average heterosexual man or woman would be to have sex with someone after knowing them for different durations. As can be seen in Fig. 2 (top), both men and women tended to overestimate how willing men would be to have sex at every duration, but accuracy was worse for short durations. At shorter durations men tended to overestimate willingness slightly more than women, but these differences appeared small.

When predicting the average man's response, we found that prediction accuracy differed only marginally between the sexes ($\chi^2[1] = 3.14$, $p = .076$), and changed over duration ($\chi^2[9] = 2162.78$, $p < .001$), but that there was an interaction between the two ($\chi^2[9] = 24.41$, $p = .004$). Using Bonferroni corrected p-values, men overestimated more than women at durations of 1 h ($p = .004$) and 1 day ($p = .048$). All other sex differences were not significant (all $ps > 0.326$). At their largest (1 h) the sex difference was small to medium in size ($d = 0.39$). The prediction (Prediction 5) that women will accurately assess the amount of time that men require to pass before wanting sex to occur was not supported, though women were slightly more accurate than men at very low time durations.

Next, we looked at the predictions of the average woman's response. Both men and women tended to equally overestimate women's willingness, and that overestimation was more pronounced for medium-to-long durations compared to short durations. The model revealed that prediction accuracy changed depending on duration ($\chi^2[9] = 345.88$, $p < .001$), but that there was neither a main effect of sex ($\chi^2[1] = 0.03$, $p = .856$) nor an interaction between sex and duration ($\chi^2[9] = 3.23$, $p =$

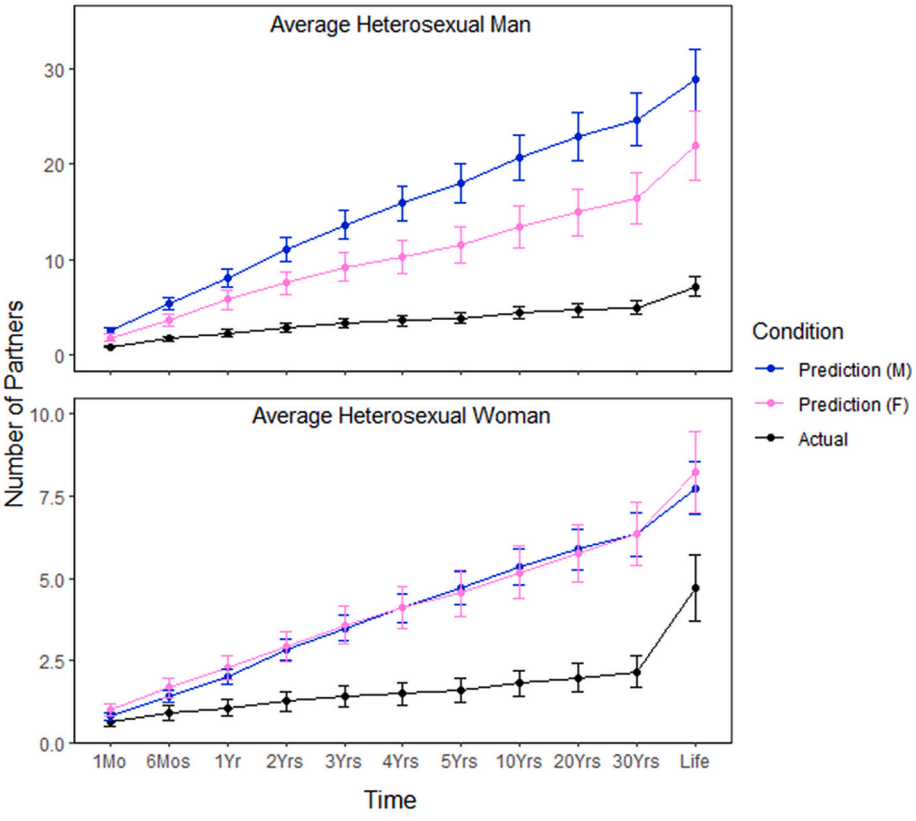

Fig. 1. Accuracy when predicting the average heterosexual man's (top) and woman's (bottom) self-reported ideal number of sexual partners across time (error bars = 95% CI).

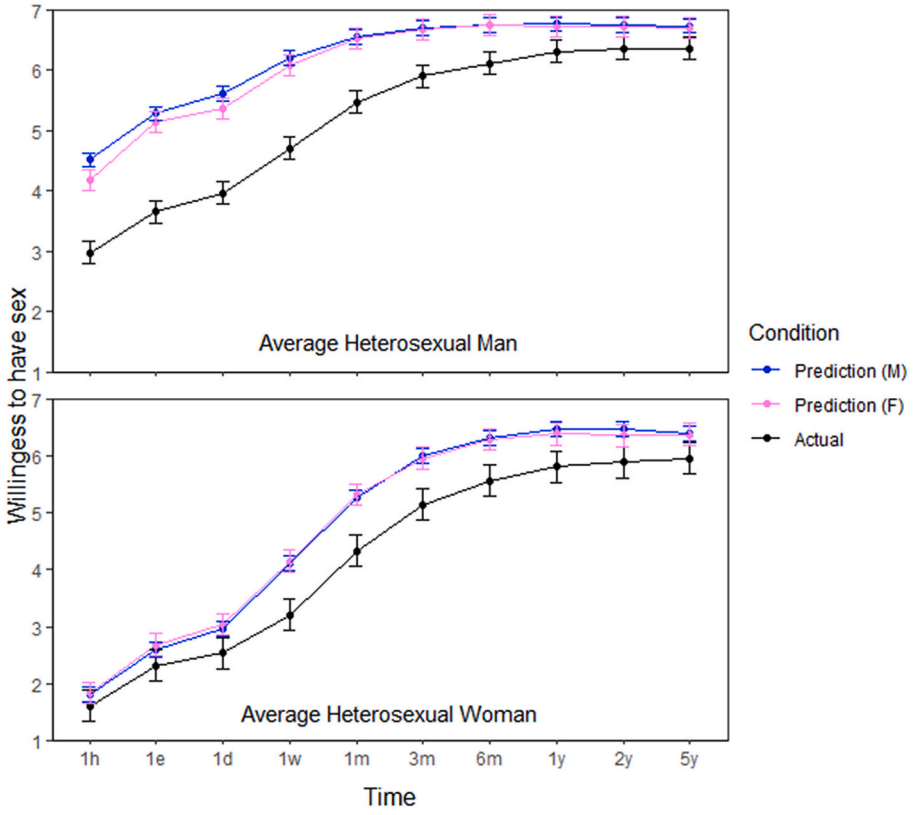

Fig. 2. Accuracy when predicting the average heterosexual man's (top) and woman's (bottom) self-reported willingness to have sex after knowing someone for different durations (error bars = 95% CI).

.954). Overall, accuracy was at its highest at low durations (up to one week), became worse for medium term durations (one week to six months) before becoming progressively more accurate as the durations became very long. At no time point were the predictions of men different to those of women (all Bonferroni corrected *p*s = 1.00). The prediction (Prediction 2) that men will underestimate the length of time women require before wanting sex to occur was only partially supported.

3.1.4. *Ease of sex without love*

We used a linear model to predict how accurate participants were when predicting the average man and woman's willingness to have sex without love (see Fig. 3). When predicting the average man, both sexes overestimated willingness, but there was no sex difference (F[1706] = 1.4953, p = .22).

When predicting the average woman, women were accurate while men overestimated willingness slightly. The sex difference in prediction was marginally significant (F[1707] = 3.785, p = .052) and constituted a small effect (d = 0.15). Thus, the prediction that women would accurately assess the ease with which men report they can have sex without love (Prediction 6) was not supported while the prediction that men would overestimate the ease with which women will report being able to have sex without love (Prediction 3) was supported.

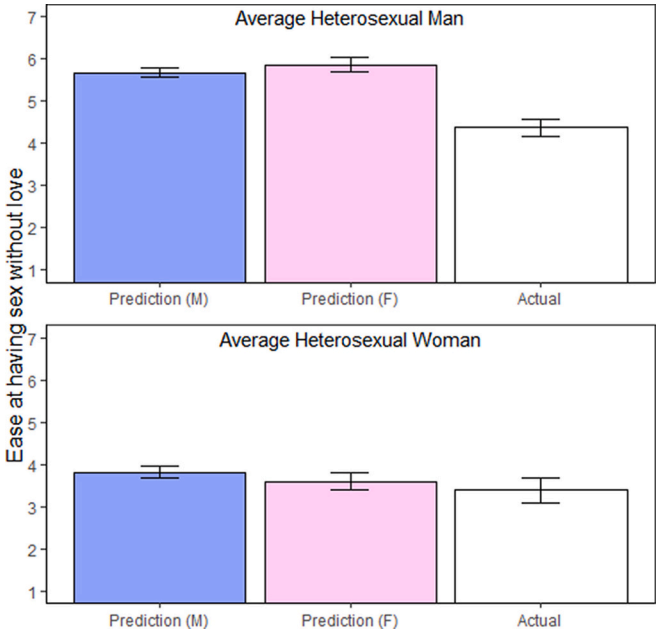

Fig. 3. Accuracy when predicting the average heterosexual man's (top) and woman's (bottom) self-reported ease at having sex without love (error bars = 95% CI).

3.2. *Individual differences*

To explore individual differences, we added the fixed effects of the dark triad traits, sociosexuality, and mate value, as well as their two-way interactions with sex to the models. Then, we performed post hoc tests by generating estimated marginal means for those high (+1 *SD*) and low (−1 *SD*) for each trait. For brevity, we consider the fixed effects, averaged across time (number of sexual partners) or duration (desire for sex after different durations of time) conditions only.

3.2.1. *Number of sexual partners*

When predicting men's ideal number of sexual partners (Fig. 4, top), we found a significant main effect of sociosexuality and a small effect of Machiavellianism (Mach) that approached significance (p = .058). No other main effects were significant and there was no interaction between

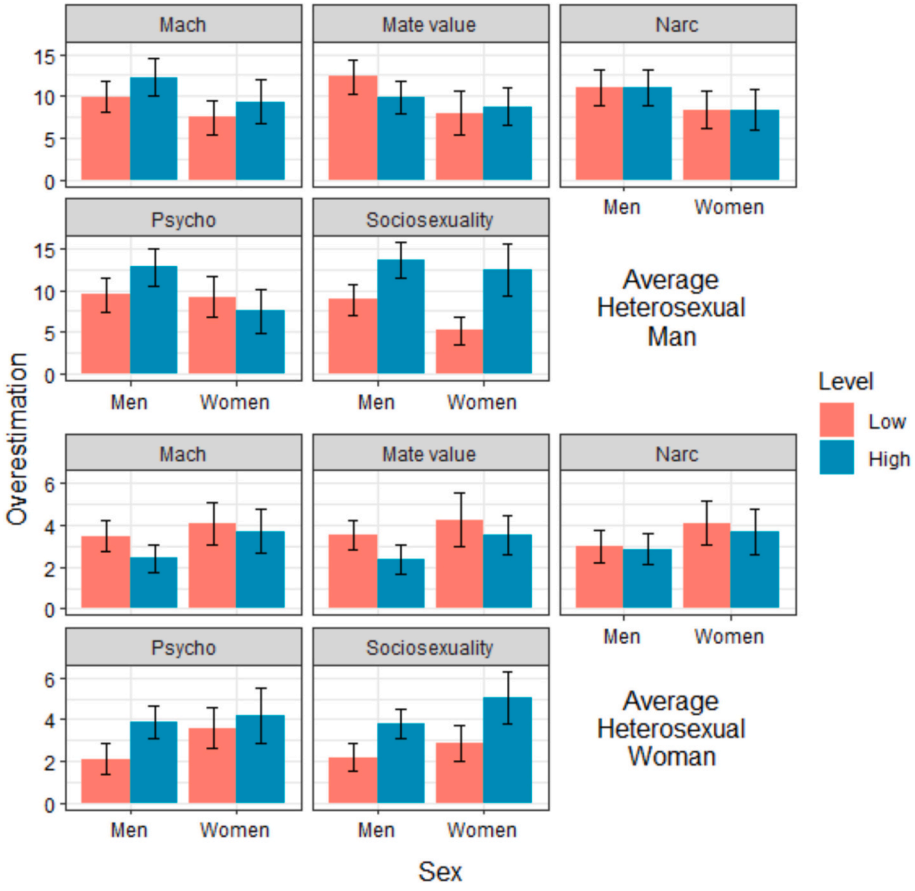

Fig. 4. Accuracy when predicting the average heterosexual man's and woman's self-reported ideal number of sexual partners collapsed across time. Estimates are broken down by low (−1 *SD*) and high (+1 *SD*) groups for dark triad, sociosexuality, and mate value and are further delineated by sex (error bars = 95% CI).

sociosexuality and sex. Examining high to low differences revealed that unrestricted sociosexuality led to greater overestimation ($p < .001$, $d = 0.38$). The difference between high and low groups for Mach were non-significant.

Predicting women's ideal number of partners revealed more individual differences (Fig. 4, bottom). There were main effects of sociosexuality, psychopathy, mate value and a small effect of Mach that approached significance ($p = .058$). Again, none of these traits interacted with sex. Examining high to low differences revealed that both unrestricted sociosexuality ($p < .001$, $d = 0.20$) and higher psychopathy ($p = .026$, $d = 0.13$) led to greater overestimation. The difference between high and low groups for mate value and Mach were non-significant.

3.2.2. Desire for sex after time known

When predicting how willing the average man would be to have sex after knowing someone for different durations (Fig. 5, top), we found a significant main effect of sociosexuality. No other main effects were significant and there was no interaction between sociosexuality and sex. Examining high to low differences revealed that unrestricted sociosexuality led to greater overestimation ($p < .001$, $d = 0.56$). Similarly, when predicting women's willingness (Fig. 5, bottom) only a main effect of sociosexuality was found with unrestricted sociosexuality causing greater overestimation ($p < .001$, $d = 0.35$).

3.2.3. Ease of sex without love

When predicting how at ease men would be having sex without love (Fig. 6, top), we found a significant main effect of sociosexuality and a significant interaction between narcissism and sex. No other main effects or interactions were significant. Examining high to low differences revealed that unrestricted sociosexuality led to greater overestimation ($p < .001$, $d = 0.62$). Higher narcissism was also associated with overestimation but only for women ($p = .004$, $d = 0.44$) and not men ($p = .214$, $d = 0.16$). More individual difference was accounted for when predicting women's willingness (Fig. 6, bottom). Here, there were main effects of psychopathy, mate value and sociosexuality. Higher levels of both psychopathy ($p = .028$, $d = 0.24$) and sociosexuality ($p < .001$, $d = 0.53$) led to overestimation. However, in the case of mate value, it was *lower* levels that were associated with overestimation ($p = .017$, $d = 0.24$).

3.3. Changes based on heterosexual participants only

It could be argued that estimation of heterosexual men and women's desires might be influenced by one's own sexual orientation which could impact one's mating experiences. To test this idea, we re-ran out analyses on heterosexual participants only ($n = 570$). This resulted in the a few changes in the results.

When estimating the average heterosexual man's preferred number of sexual partners over time, men estimated that this would be higher than women at every time point longer than 1 year (all $ps < 0.006$) rather than 6 month and the influence of Mach became significant ($p = .041$). We also found a new interaction between psychopathy and sex ($p = .028$). Follow-up tests revealed that participants high in Mach ($p = .009$, $d = 0.23$) and men high in psychopathy ($p = .003$, $d = 0.44$) overestimated more than their low counterparts. When predicting women's desired sexual partners over time, neither mate value nor Mach were significant, or marginally significant, predictors. The effect of psychopathy, while still significant overall, did not result in a significant difference between low and high groups ($p = .130$).

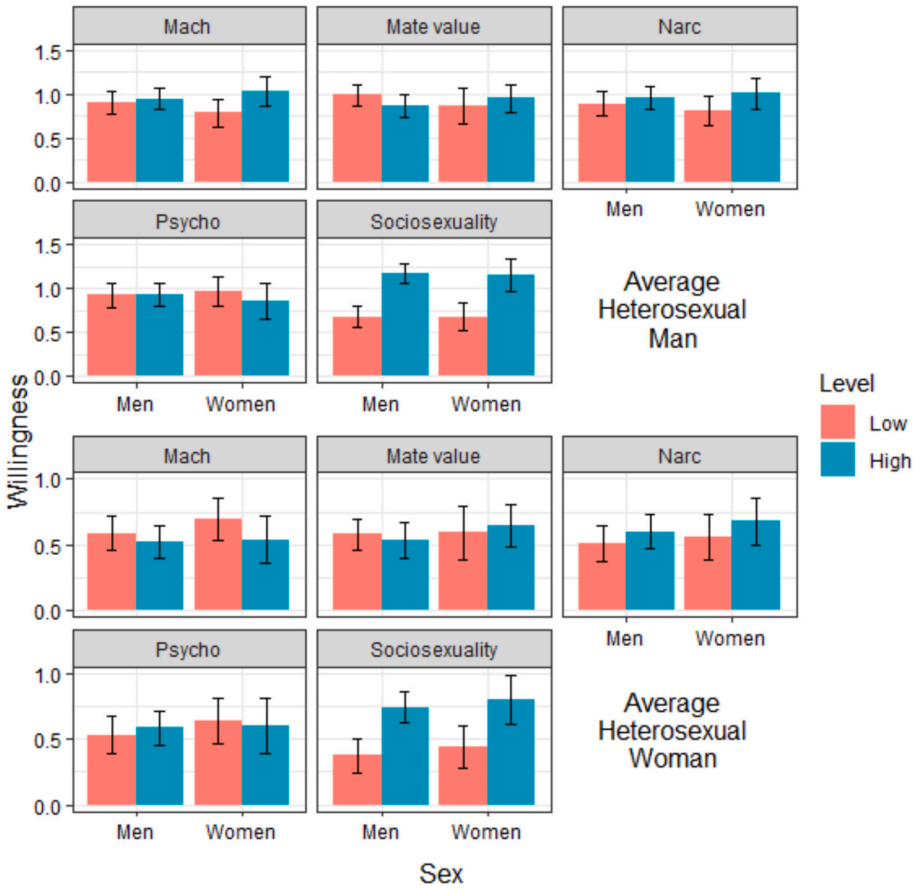

Fig. 5. Accuracy when predicting the average heterosexual man's and woman's self-reported ease in having sex collapsed across different durations. Estimates are broken down by low (−1 *SD*) and high (+1 *SD*) groups for dark triad, sociosexuality, and mate value and are further delineated by sex (error bars = 95% CI).

When predicting men's willingness to have sex after different durations, men continued to overestimate more than women at a duration of 1 h ($p = .017$), but no other durations showed a sex difference.

Finally, when predicting the average man's ease of sex without love there was no longer a sex by narcissism interaction effect ($p = .08$) and the significant effect of psychopathy, could not be detected by comparing low and high groups ($p = .065$). When predicting if the average woman's ease of having sex without love, the small marginal sex difference was no longer significant ($F(1,568) = 2.917$, $p = .09$).

Overall, restricting the participants to heterosexual participants led to slightly smaller sex differences and the influence of individual differences on accuracy was reduced in some cases and strengthened in others, particularly in the cases of Machiavellianism and psychopathy. The sociosexuality effects were robust. Some of these changes may be the result of reduced statistical power.

4. Discussion

Our findings indicate that both men and women systematically overestimated the opposite sex's sexual desires. These results suggest that the classic male sexual over perception effect extends beyond ambiguous, momentary interactions to broader assumptions about the opposite sex's typical sexual desires, and may also apply to women's inferences about men.

As per the original error management logic (Haselton and Buss, 2000), which did not predict systematic overestimation among women, we expected women to be more accurate and only men to overestimate. However, we found that both sexes showed similar inferential biases, with only small and inconsistent sex differences. Sociosexual orientation emerged as a stronger and more consistent predictor of perceptual bias than sex itself, suggesting that dispositional mating psychology may shape cross-sex mindreading more than sex per se.

An alternative interpretation of the results is that although our original predictions expected greater accuracy from women, a broader application of error management theory logic than originally formulated by Haselton and Buss (2000) suggests that both sexes have incentives to err on the side of overestimating the typical sexual desires of the opposite sex. Men's overestimation aligns with the well-documented sexual over perception bias, and reflects their tendency to perceive women as more sexually receptive than they are (Haselton, 2003). For women, it may be very costly to underestimate the sexual desires of men, so their overestimations also fit within an error management framework. Women's overestimations may reflect vigilance against potential sexual deception or unwanted advances. If this interpretation is correct, it suggests that women's overestimations may have very different adaptive functions than men's. This testable hypothesis (Costello et al., 2026) awaits future empirical studies.

That both men and women overestimated the opposite sex's sexual desires suggests that these biases are not solely driven by an anchoring effect, where individuals project their own desires onto others (Tversky and Kahneman, 1974). If anchoring/projection were the primary mechanism, we would expect men, who typically report more unrestricted sociosexuality than women (e.g., Schmitt, 2005), to overestimate women's sexual desires, while women who are typically more restricted, would underestimate men's. Instead, both sexes exhibited baseline overperceptions, implying a broader tendency to overestimate the desires of the opposite sex in the mating domain.

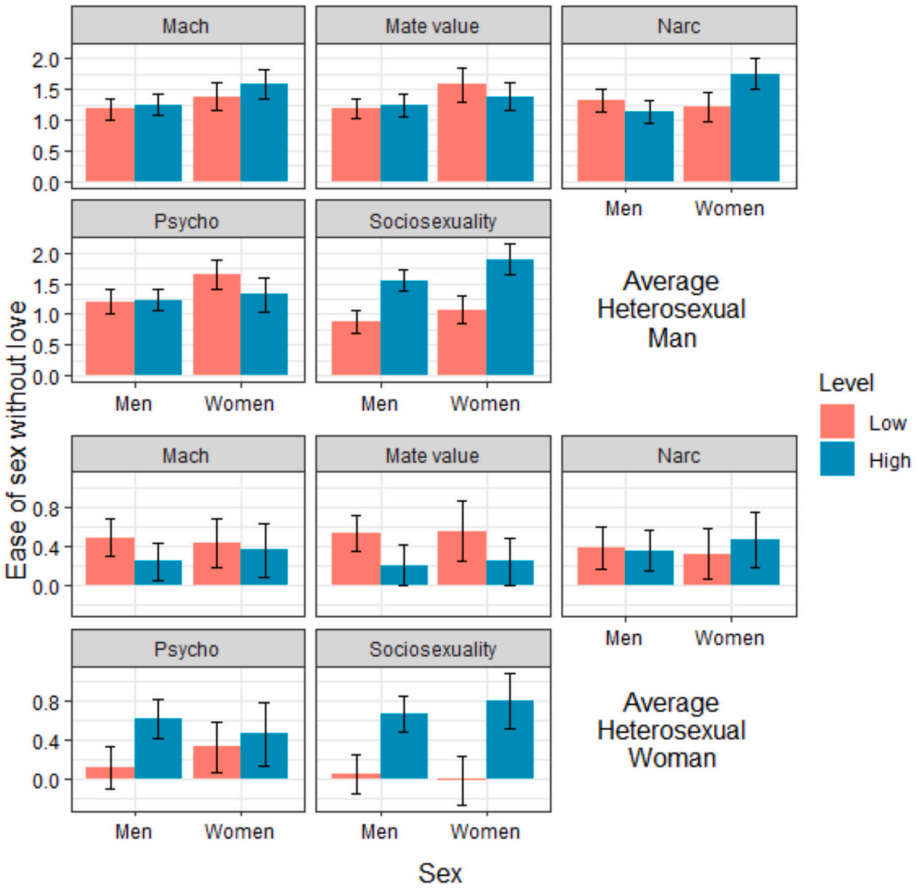

Fig. 6. Accuracy when predicting the average heterosexual man's and woman's self-reported ease in having sex without love. Estimates are broken down by low (−1 *SD*) and high (+1 *SD*) groups for dark triad, sociosexuality, and mate value and are further delineated by sex (error bars = 95% CI).

4.1. Men and women's intrasexual mindreading

Both sexes overestimated the sexual desires of the average member of their own sex. One possible explanation for some of the observed biases in intrasexual mindreading is that they may be shaped, in part, by intrasexual competition. Overestimating the sexual desires of typical members of one's own sex could serve both as rival derogation and self-enhancement (e.g., Schmitt and Buss, 1996), strategically positioning oneself as distinct from rivals by implying "I'm not like other girls/guys." This form of social signaling could be particularly relevant in competitive mating environments, where derogating rivals may enhance one's own mating prospects.

Women possess mechanisms for detecting mating rivals, which involve tracking both other women's willingness (e.g., flirtatiousness) and capacity (e.g., physical attractiveness) to compete for mates (Merrie, Krems, and Byrd-Craven, 2025). Our findings that women overestimate other women's sexual desires, suggests a bias that could functionally complement these rival-detection systems. Such overestimation may reflect promiscuity derogation, a well-documented strategy whereby women portray rivals as sexually unrestricted to diminish their mate value (Schmitt and Buss, 1996). Because men generally prefer cues of sexual fidelity in long-term partners (Buss and Schmitt, 1993; Thomas et al., 2020, 2025), exaggerating the sexual desires of rivals could be an effective intrasexual competition tactic.

Men in our study also tended to overestimate their same sex peers' sexual desires, possibly reflecting an awareness of the fact that neither sex desires a partner with an extensive sexual past (Stewart-Williams, Butler, and Thomas, 2016; Thomas et al., 2025). Overestimating the sexual desires of typical members of your own sex may also promote vigilance against potential mate poaching attempts from rivals (Schmitt and Buss, 2001). These overestimations all fit with an error management perspective (i.e., "don't underestimate the desires of your competition").

An alternative explanation for the observed overestimations in intrasexual mindreading is the role of perceived social norms rather than error management biases. Research shows that college students often overestimate their peers' sexual activity (Lambert, Kahn, and Apple, 2003). Future research should seek to disentangle whether the overestimation of sexual desires observed in this study stems from adaptive error management strategies or perceived social norms.

4.2. Individual difference effects

Most individual difference effects beyond sociosexuality were weak, so interpretations should be made cautiously. Men and women with more unrestricted sociosexual orientations consistently overestimated both cross-sex and intrasexual sexual desires, suggesting that individuals more open to casual sex project their own tendencies onto others, to some extent (e.g., Lee et al., 2020).

Psychopathy modestly predicted greater overestimation among women, narcissism was linked to women's overestimation of men's willingness to have sex without love, and lower mate value corresponded with overestimation on one item.

Overall, dispositional mating orientation appears to play a more reliable role than dark personality traits or self-perceived mate value in shaping people's inferential biases about sexual desire.

4.3. Implications

Beyond their theoretical significance, these findings have some important implications for understanding sexual conflict and the

persistent mindreading divides between the sexes.

Women's overestimation of other women's sexual desires, for example, may undermine their intrasexual cooperation. Research shows that women often avoid friendships with sexually promiscuous peers and downplay their own sexual desires in same-sex interactions (Bleske and Shackelford, 2001). Such misperceptions could therefore erode trust and impede the formation of supportive female alliances.

Perceptual biases may also shape women's own sexual behavior. According to sexual economics theory (Baumeister and Vohs, 2004), if women perceive their rivals as more sexually unrestricted than they truly are, they may feel pressured to lower their own sexual selectivity to remain competitive in the mating market, even if doing so conflicts with their personal preferences and may have a negative impact on their mental health (Lambert et al., 2003; McKeen, Anderson, and Mitchell, 2022).

For men, overestimating women's desire for casual sex may increase the likelihood of using sexual deception to obtain short-term mating opportunities, perhaps without full awareness of the potential psychological harm to women. Just as men tend to underestimate women's distress over sexual violence (e.g., Buss, 1989b; Hahnel-Peeters et al., 2026), they may similarly underestimate the emotional consequences of deceptive sexual encounters, perpetuating mismatches in sexual expectations and conflict between the sexes.

Systematic overestimations of sexual desire across sexes may also fuel unhelpful cultural narratives, for example, that "all men are only after sex," or that "everyone else is having sex except me." Both misconceptions can reinforce dissatisfaction, anxiety, and resentment, as seen within online subcultures such as incel (involuntary celibate) communities (Costello, Whittaker, and Thomas, 2025). Understanding these biases may therefore help contextualize, and ultimately correct, such distorted beliefs about contemporary mating life.

4.4. Limitations

One limitation of our study is that it is based on a mostly WEIRD (Western Educated Industrialized Rich and Democratic, Henrich, Heine, and Norenzayan, 2010) sample. Though mating psychology tends to show high degrees of cross-cultural consistency (e.g., Lippa, 2009; Thomas et al., 2020), it is important to replicate these findings cross-culturally to determine whether these biases in cross-sex mindreading are universal or culturally specific.

Several methodological limitations should be noted. First, some outcome measures showed potential floor and ceiling effects. When reporting the number of desired partners over short time intervals, many participants selected "0," while a small proportion (about 6%) chose the upper limit of 100. We used negative binomial models to account for this positive skew, which performed adequately in diagnostic checks. Nonetheless, future studies could permit open-ended responses to reduce ceiling constraints and better distinguish plausible from implausible entries.

Second, two items asked about sexual desires "in an ideal world" or "if the conditions were right" (following Buss and Schmitt, 1993). Such qualifiers may have encouraged more aspirational responses. Future work should test whether more neutral phrasing yields different patterns.

Third, all participants reported on their own desires before rating the opposite and same sex. This fixed order may have influenced subsequent responses. Engeler & Raghubir (2018) found that asking about others first can reduce "purer-than-thou" underreporting. Counterbalancing item order in future studies would help mitigate this risk.

Finally, it is important to reiterate that our measure of "accuracy" reflects correspondence between perceived and self-reported desires, not objective accuracy in an absolute sense. Longitudinal designs linking perceptions, stated intentions, and actual mating outcomes would provide stronger tests of accuracy in real-world contexts.

4.5. Future directions

The domain of cross-sex and intrasexual theory of mind in the mating domain is now wide open for scholars to investigate further. We suggest that some of the more interesting avenues for exploration may be to start with areas where the sexes differ meaningfully, (e.g., mate preferences; Buss and Schmitt, 2019). Some early research suggests that men overestimate the importance of physical attractiveness and financial resources to women and underestimate the importance of traits like intelligence, kindness, and humor (Costello, Rolon, Thomas, and Schmitt, 2023). Other domains with large sex differences include sexual jealousy (Buss, 2018), sexual disgust (Crosby, Durkee, Meston, and Buss, 2020), sexual regret (Galperin et al., 2013), and fear and upset about sexual violence (Buss, 1989a).

Regarding the intrasexual competition hypothesis interpretation of our results, future research should also incorporate an intrasexual competition scale (e.g., Buunk and Fisher, 2009) to examine whether individuals who score higher on intrasexual competition are more likely to overestimate the typical sexual desires of their own sex. It would also be valuable to test whether these biases are more pronounced in ecologies characterized by heightened competition, such as contexts with high income inequality or skewed sex ratios (e.g., Blake, Bastian, Denson, Grosjean, and Brooks, 2018).

An important question is whether these observed biases fluctuate with mating context. Overestimation may be strategic, intensifying during periods of short-term mating motivation and diminishing when long-term mating or parenting becomes a priority. Future research could examine whether these perceptions vary with recent mating experiences or physiological states.

Some evidence indicates that perceptual biases are influenced by hormonal and contextual factors. In a placebo-controlled study, Goetz et al. (2024) found that testosterone-treated men were more likely to interpret affiliative female behavior as sexual interest, but only if they already perceived themselves as attractive, suggesting that testosterone amplifies existing tendencies rather than creating new biases. Similarly, Samara et al. (2021) found that men's accuracy in detecting attraction in speed-dating scenarios declined when they were sexually interested in a given woman.

Men's mating strategies can also shift rapidly in response to cues such as parental care, resource abundance, or environmental danger, indicating that mating biases, perhaps including cross-sex mindreading, are flexible rather than fixed (Thomas and Stewart-Williams, 2018). Heightened sexual arousal likewise increases short-term mating motivation independent of personality, relationship status, or sociosexuality (Wisman and Thomas, 2023). Although these studies (Goetz et al., 2024; Thomas and Stewart-Williams, 2018; Wisman and Thomas, 2023) focused on men, they raise the broader question of whether momentary physiological states modulate overestimation biases in both sexes. Examining such effects could further clarify the mechanisms underlying errors in sexual mindreading.

Finally, it may be that people's strongest perceptual anchors come from their own real-world social experiences. The typical sociosexuality of past partners, opposite-sex friends, and siblings may shape expectations of the opposite sex's general mating psychology (e.g., Lambert et al., 2003), which in turn could amplify or constrain overestimation biases. Investigating how personal experiences influence cross-sex mindreading would provide valuable insights into the development and flexibility of these biases.

4.6. Conclusion

Using three questions derived from sexual strategies theory, we investigated how men and women infer the sex typical sexual desires of the opposite sex, focusing on (1) number of desired sexual partners, (2) willingness to engage in sex after different time intervals, and (3) ease of having sex without love. Consistent with error management theory, men

overestimated women's desire for sexual variety and underestimated the time women require before engaging in sexual activity. Women also generally overestimated the sexual desires of men too. These findings support the notion that biases in cross-sex mindreading are shaped by evolved sexual strategies, with men's overestimation minimizing missed reproductive opportunities and women's overestimation reflecting a defense against potential sexual deception.

In addition to cross-sex biases, we found evidence of intrasexual mindreading biases. Both men and women overestimated the sexual desires of members of their own sex, with women displaying stronger biases. These intrasexual biases may serve adaptive functions, such as rival derogation and vigilance against mate-poaching threats. Finally, we found that some individual differences played a role in shaping mindreading biases. Specifically, unrestricted sociosexuality and Dark Triad traits, particularly psychopathy and narcissism, were associated with exaggerated perceptions of sexual desires.

These findings extend the literature on theory of mind and error management theory by demonstrating that systematic biases in cross sex mindreading apply not only to momentary cues but also to broader inferences about the general sexual desires of the opposite sex. Future research should investigate these biases across diverse cultural contexts and further investigate whether intrasexual mindreading biases reflect intrasexual competition, as well as investigating cross-sex mindreading in domains of other large sex differences, such as sexual jealousy, disgust, regret, and mate preferences.

CRediT authorship contribution statement

Paola A. Baca: Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **William Costello:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rebecka K. Hahnel-Peeters:** Writing – review & editing, Investigation, Conceptualization. **Andrew G. Thomas:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Data curation. **David P. Schmitt:** Writing – review & editing, Supervision, Conceptualization. **David M. Buss:** Writing – review & editing, Supervision, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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