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Adaptive mating memory: Attractiveness and contextual effect on the remembering and misremembering of potential mates' faces

Peter Kay Chai TAY
Singapore Management University, kaychai.tay.2012@phdps.smu.edu.sg

Adaptive Mating Memory:
Attractiveness and Contextual Effect on the Remembering and Misremembering of Potential Mates' Faces

by

Peter KC Tay

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Dissertation Committee:

Norman Li (Supervisor/Chair)
Associate Professor of Psychology
Singapore Management University

Peter K Jonason (Co-supervisor)
Senior Lecturer in Personality or Individual Differences
Western Sydney University

Yang Hwajin
Associate Professor of Psychology
Singapore Management University

Park Guihyun Grace
Assistant Professor of Psychology
Singapore Management University

Singapore Management University
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Abstract

Research on *adaptive memory* demonstrates that words and objects are remembered better if they are evaluated in relation to their survival or reproductive fitness value. Using the error management theory as a framework to elucidate memory biases emerging from adaptive costs and benefits, the present research examined if memory is enhanced for faces of potential mates (i.e., opposite sex individuals) in an ancestral context when the facial attractiveness and the observer's short-term mating motive were also considered (i.e., *Adaptive mating memory*). In two studies, participant read scenarios depicting survival threats, mating, or modern environment, and were told to rate a set of faces based on these scenarios. After the rating task, they were given a surprise memory test. In both studies, participants were generally more accurate for unattractive faces than attractive faces, and they tended to falsely recognized attractive opposite sex faces more frequently compared to unattractive opposite sex faces. In addition, women falsely recognized attractive female faces more frequently than other types of faces, consistent with the female intrasexual competition hypothesis. Across both studies, women demonstrated more accurate memory for faces compared to men, and context did not influence memory for faces, regardless of attractiveness, target sex, and participant sex. Findings from the present research suggest that adaptive memory for potential mates' faces emerges at the interface of costs and benefits associated with facial cues (i.e., face sex, and attractiveness), and is invariant of the context the faces are situated in.

Keywords: adaptive memory; facial memory; false memory; recall; sexual cognition; mate selection

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Chapter 1: Introduction

The notion of an adaptive memory suggests that committing certain types of information to memory promotes survival or reproductive fitness in the future (Klein, Robertson, & Delton, 2010; Nairne, Thompson, & Pandeirada, 2007). For instance, mechanisms that direct memory towards important stimuli such as source memory for cheaters (Bell & Buchner, 2010; Buchner, Bell, Mehl, & Musch, 2009) or potential mates (Allan, Jones, DeBruine, & Smith, 2012; Nairne, 2010) have been selected for because they led to strategic, fitness-enhancing approach or avoidance of certain individuals. In the context of mate selection, cognitive mechanisms may have been functionally selected because they promoted behaviors that led to mating with individuals who possess high-quality genes.

The present research was undertaken to explore this notion in the context of memory for potential mates. On the basis that the human memory system is tuned to solving adaptive problems in the ancestral environment in domain-specific ways (Nairne & Pandeirada, 2008b), memory for the faces of potential mates may be dependent on facial characteristics and specific contextual features (i.e., adaptive mating memory). In particular, such memory may be enhanced when the face signals superior genetic quality, and the context contains ancestral survival threat (i.e., survival processing) and the observer is motivated to procure a mate in the near future (see Figure 1). In other words, an ancestral environment that contains survival threats (e.g., being stranded in a foreign grassland without food and water) increases the urgency of reproduction, and hence, increases the memory for stimuli that are particularly relevant to mating (i.e., attractive members of the opposite sex). In the following sections, the role of facial attractiveness for mating is examined. Next, I review the literature on survival processing and elucidate its relevance to our memory for the faces of potential mates. At the end of the section, I explain how memory biases towards faces with different attractiveness in different contexts can be revealed through the error management theory.

Effects of mating motive and facial attractiveness

Cognitive resources are limited, and stimuli innumerable. Thus, motivational states of an individual can direct cognitive resources such as attention and memory toward evolutionary advantageous stimuli (Kenrick, Neuberg, Griskevicius, Becker, & Schaller, 2010; Maner, Gailliot, Rouby, & Miller, 2007). In particular, having a mating motive can lead to biased processing of attractive individuals of the opposite sex (Li & Kenrick, 2006). Furthermore, because adaptive memory is in service of some future purposes (Klein et al., 2010; Klein, Robertson, & Delton, 2011), faces are more likely to be remembered if they are important for actions in the future. For example, someone intending to find a mate is more likely to remember an attractive face compared to someone who has no intentions of finding a mate, suggesting that attractive faces are prioritized in cognitive processing because they are particularly relevant to mating strategies including mate selection and mate guarding (Maner et al., 2007; Maner et al., 2003).

Physical attractiveness plays a pertinent role in human mate choice. Particularly in short-term mating context, both men and women prioritize physical attractiveness (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Karremans, Dotsch, & Corneille, 2011; Li, Bailey, Kenrick, & Linsenmeier, 2002; Li & Kenrick, 2006; Penton-Voak & Perrett, 2000). Research demonstrated that human cognitive systems are tuned to identify and remember physically attractive individuals in mating contexts (Allan et al., 2012; Little, Jones, & DeBruine, 2011). For instance, human perceptual mechanisms appear to be tuned to rapidly appraise facial attractiveness (Olson & Marshuetz, 2005), and attractive faces can be processed unconsciously (Hung, Nieh, & Hsieh, 2016).

It is noteworthy that mate preference in relation to physical attractiveness is not the same between men and women. Particularly, long-term mate preference for men is geared towards women’s physical attractiveness while women emphasize on men’s resourcefulness

(Buss, 1989; Buss & Schmitt, 1993; Li et al., 2002). This is based on the notion that ancestral men and women faced distinct adaptive problems: "For men, one major reproductive constraint has been the number of reproductively valuable or fertile women they can successfully inseminate. For women, one major reproductive constraint has been obtaining as mates men who showed an ability and willingness to invest resources in themselves and their offspring" (Buss & Schmitt, 1993, p. 225; see also, Jonason, Valentine, & Li, 2012). Perceptions of facial attractiveness are also sexually dimorphic. For instance, while women remember moderately attractive male faces better than attractive male faces, both women and men remember attractive female faces better than average female faces (Study 5, Maner et al., 2003). Despite the sex differences, both men and women generally prefer and remember better physically attractive mates over unattractive ones because physical attractiveness is linked to underlying health and fecundity such as better sperm quality (Boothroyd, Scott, Gray, Coombes, & Pound, 2013; Lee et al., 2012; Soler et al., 2003) and higher intelligence (Kanazawa & Kovar, 2004; Zebrowitz, Hall, Murphy, & Rhodes, 2002). In the same vein, because mate quality is harder to assess in male faces compared to female faces, greater cognitive resources are allocated to facial attributes among men more so than among women (Kenrick et al., 2010). Thus, men's attention and memory for attractive opposite sex individuals is better compared to women (Becker, Kenrick, Guerin, & Maner, 2005), particularly when they are sexually motivated (Duncan et al., 2007).

More specifically, facial attractiveness on its own is particularly important in assessing long-term mate value for both men and women, although men tend to focus more on body attractiveness compared to women for short-term mates (Confer, Perilloux, & Buss, 2010; Jonason, Raulston, & Rotolo, 2012; Lu & Chang, 2012). In particular, women prefer men with symmetrical faces and faces with moderate masculinity (Gangestad, Thornhill, & Yeo, 1994; Scheib, Gangestad, & Thornhill, 1999). Similarly, symmetry in women's faces

are also preferred because it signals fecundity and physical health (Thornhill & Grammer, 1999). This suggests that the perception of facial attractiveness is an evolved mechanism that enables individuals to perceive genetic quality important in the reproductive fitness for offspring. Because of people's preference for attractive faces, physically attractive faces are remembered better compared to unattractive faces (Maner et al., 2003; Tsukiura & Cabeza, 2011).

Although men and women have preexisting biases, memory for the attractiveness of faces belonging to the opposite-sex can also be biased by contexts such as the romantic relationship status of the observer (Karremans et al., 2011; Maner, Gailliot, & Miller, 2009; Maner, Rouby, & Gonzaga, 2008), and current survival and mating motive (Kenrick et al., 2010). For instance, a married man may not be as attentive towards an attractive woman as a man who is single and out with his mates at the club. As such, memory for attractive faces is enhanced only in relevant contexts. While memory for attractive faces have been shown to be dependent on reproductive context, it remains unclear if the same would be observed in a survival context.

Contextual effect and the survival processing advantage

Fundamental motives such as survival and mating affect attention and memory in adaptive ways (Kenrick et al., 2010). Such motives are selectively activated in terms of the context because cognitive biases towards a stimuli may be adaptive in one context but maladaptive or irrelevant in another context (Schaller, Kenrick, Neel, & Neuberg, 2017). The same object can be remembered better in a specific context if it is thought that survival is at stake. In particular, the *survival processing advantage* (SPA) refers to the observed phenomenon that memory for objects is enhanced when the objects are considered essential for survival. For instance, memory for objects that are ostensibly needed for survival in a foreign grassland has been found to be better than memory for the same objects in the context

of a foreign city or for objects that are rated for their pleasantness (Kang, McDermott, & Cohen, 2008; Kostic & Cleary, 2012; Nairne & Pandeirada, 2008a; Nairne et al., 2007; Otgaar et al., 2011; Smeets, Otgaar, Raymaekers, Peters, & Merckelbach, 2012). Similar pattern has been observed for pictures (Nairne, VanArsdall, Pandeirada, & Blunt, 2012; Otgaar, Smeets, & Van Bergen, 2010). Nevertheless, studies that have examined the SPA have yielded equivocal results (e.g., Howe & Derbish, 2010; Klein, 2012; Otgaar & Smeets, 2010; Seamon et al., 2012). In particular, a SPA was not observed when other measures of recall rates were used or when the survival processing condition was compared to other conditions that enable other types of mnemonic mechanisms to come into play. For instance, in one study when the recall rate included both the true recall and false memory rates, the SPA was reduced to non-significance (Otgaar & Smeets, 2010). Thus, a complete picture of memory requires analyses that include both accuracy, and false memory.

Adaptive memory for faces

The importance of attractiveness is influenced by the presence of environmental threats and mating motives (Gangestad & Simpson, 2000; Lee & Zietsch, 2011; Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Puts, Jones, & DeBruine, 2012). For instance, women's interest in men is geared towards attractiveness when there is prevalent pathogens while women prefer men with high status and parental investment when there is a lack of resources (Lee & Zietsch, 2011). However, it is not clear if memory for faces is also enhanced under survival threat, especially when the faces are rated for their relevance in a mating context.

So far, only one study examined memory for faces using a survival processing procedure and had obtained null findings (Savine, Skullin, & Roediger, 2011). This suggests that either survival context is insufficient in enhancing memory for faces, the survival threat may have little relevance to faces to induce memory advantage, or individual differences in terms of susceptibility to survival threat may have moderated the memory effect. However,

there are several issues in this set of studies that are relevant to the current research. First, they reported that the aggregated score for the dimensions including facial attractiveness, trustworthiness, expressions of anger and fear collectively showed significant main effects but did not further examine how these factors may have confounded the results (Savine et al., 2011, experiment 3). While they reported no interaction between the dimensions as an aggregate and the survival and moving conditions, it is unknown if one or more of the dimensions independently interacted with the conditions. For instance, while the authors observed that the memory for the faces did not differ between the survival and control conditions, they did not examine if facial attractiveness moderated the memory.

Second, while the researchers examined facial recognition in contexts including fitness relevant scenarios (e.g., hunting for the purposes of feeding the tribe), survival threat scenario (e.g., presence of hostile individuals) and scenarios with social information (e.g., He smells bad), they did not examine survival processing for faces in a mating context. Last, the study used male faces only, as such, it remains unclear if there are sex differences with respect to the sex of the face.

Thus, it leaves unclear whether faces viewed in a survival mating processing scenario (i.e., finding a mate in a foreign grassland) would be recognized more accurately than the non-survival mating processing scenario (i.e., finding a mate in a foreign city). In addition, previous studies demonstrated that facial attractiveness is particularly linked to memory of faces in contexts related to mating (Allan et al., 2012; Karremans et al., 2011), suggesting that facial attractiveness may moderate the effect between the mating survival processing scenarios and facial memory. Furthermore, this attractiveness effect is likely to differ between male and female faces, and depending on whether the observer is a man or woman.

Effects of facial attractiveness and sex

Inherent properties of the face such as sex, facial expression, and attractiveness convey information such as the degree of threat, solidarity, and mate quality (Fink & Penton-Voak, 2002; Gangestad et al., 1994; Oosterhof & Todorov, 2009; Scheib et al., 1999; Tay, 2015). Scholars recently proposed that such stimulus properties are concurrently processed together rather than extracted and processed independently in a non-interacting way (Adams, Hess, & Kleck, 2015), suggesting that the whole (i.e., memory) is greater than the sum of its parts (i.e., individual stimulus property). Thus, the memory for a face in a survival processing context may also be driven by properties such as sex and attractiveness when it is first encountered. Because the survival processing paradigm assumes that memory advantages are invariant of properties inherent in the perceived stimuli, experiments that examined the SPA typically did not consider the stimulus properties. The current research reconsiders the absence of SPA for faces by examining the inherent property of faces (i.e., attractiveness) as a potential moderator for the survival processing effect on the memory for potential mate faces. Specifically, SPA for faces should be observed for attractive faces but not unattractive faces, given that attractive faces signals survival and/or reproductive benefits. This is elucidated in the following sections.

Effect of survival threats

Researchers posit that survival processing encompasses memory systems that have evolved in the ancestral environment and are activated when survival is at stake (Nairne & Pandeirada, 2008a). For instance, anticipating the possibility of being stranded in foreign grassland leads to a heightened memory for items encoded in that context. This condition is typically compared to a moving condition which induces similar processing but in a different context (i.e., modern environment). Hence, a significant difference between the survival processing condition and the moving condition suggests that memory is enhanced specifically

when the items are encoded in the context of an ancestral environment when survival is at stake (i.e., ancestral priorities).

Instead of ancestral priorities leading to the enhancement of memory for potential mates' faces, the presence of survival threat is more likely to activate terminal investment (Bonneaud, Mazuc, Chastel, Westerdahl, & Sorci, 2004; Clutton-Brock, 1984). That is, when an individual's survival prospects are perceived to be low, s/he may be driven to increase current reproductive success over growth investment (Clutton-Brock, 1984). One strategy to promote current reproductive success is to actively seek out potential mates who display cues signaling good genotypic quality and intensify mating frequency with these individuals when survival threat is detected. Threats to survival can be detected through intrinsic factors such as advancing reproductive age, and also extrinsic factors such as the presence of predators and the scarcity of food (Bonneaud et al., 2004). Thus, engaging in short-term mating (i.e., terminal investment behavior) is a more effective strategy in terms of reproductive success in a precarious environment compared to a secure environment. Theory and evidence are consistent with this notion in that individuals who grow up in stressful environments are observed to engage in riskier sexual activities at an earlier age (Belsky, Steinberg, & Draper, 1991; Belsky, Steinberg, Houts, & Halpern-Felsher, 2010; Ellis & Garber, 2000).

In the current research, participants who imagine themselves in an ancestral environment containing survival threat including the presence of predators, and a lack of food and water are hence hypothesized to be more likely to remember faces of potential mates compared to participants who imagine themselves to be in a modern environment where encounters with survival threats are less perceptible. In addition, as the payoff for men adopting the terminal investment strategy is greater than women (Bateman, 1948; Sadd et al., 2006), men exposed to the survival threat context are hence more likely than women to remember the faces of their potential mates. In particular, remembering attractive potential

mates can promote approach (versus avoidant) behaviors when the men subsequently encounter the attractive women again (Kenrick et al., 2010). On the other hand, relatively less reproductive fitness advantages may be gained if women intensify their mating efforts given the lengthy gestation period that follows conception. Specifically, I predict that increased short-term mating frequency does not lead to a corresponding increase in reproductive fitness for women.

In sum, the level of priority given to the cognitive processing of potential mates can be influenced by the context and relies on the inherent properties of the face, the sex of the observer, and whether a mating motive is present (Duncan et al., 2007; Maner et al., 2007; Maner, Miller, Moss, Leo, & Plant, 2012). Thus, memory for attractive opposite sex individuals is better in an ancestral context containing survival threats coupled with an increase in mating motivation (see Figure 1). In the following section, I conceptualize adaptive mating memory within the error management theory (EMT) framework to elucidate the emergence of memory biases for potential mate faces.

Error management in adaptive memory

Recurring cognitive biases and errors can be understood in terms of the adaptive values in terms of survival or reproductive benefits for attending to or remembering certain objects or faces. In particular, the error management theory (EMT) predicts that "a bias will evolve when it minimizes the net fitness cost of errors in judgment and decision making – even if that bias produces more errors overall than alternative psychological designs (Haselton & Galperin, 2013, p. 2)." Critically, the tendency to commit one form of error over another, in terms of false recognition and misses, would evolve to the extent that the cost or benefit associated with one form of error is greater than the other (Haselton & Buss, 2000; Haselton & Nettle, 2006). For instance, the cost of mistaking a rope for a snake (i.e., false recognition) is much lower than the cost for failing to seeing a snake (i.e., miss). Thus, we

rarely mistake a snake for a rope even though we might occasionally mistake a rope for a snake. This is adaptive because the failure to detect a snake is more detrimental than the failure to detect a rope (or any object resembling a snake). On top of accurate memory, the current research examines adaptive mating memory in terms cognitive biases and errors of these sorts.

Error management in adaptive mating

It is difficult to judge a potential mate's sexual and romantic interest. Correspondingly, it is difficult to ascertain which potential mates should be committed to memory. In the context of mating, cognitive biases refer to adaptive errors related to differential reproductive costs and benefits associated with mating strategies that exist between men and women. In particular, while it benefits men to falsely perceive sexual interest from women (i.e., male sexual overperception bias), it is evolutionarily costly for women to adopt this strategy (Henningsen & Henningsen, 2010). Conversely, while it benefits women to miss out on unattractive men (i.e., female sexual underperception bias), it is evolutionarily less costly for men to attend to less attractive women (Henningsen & Henningsen, 2010).

These two forms of cognitive biases could have been partially driven by female concealed ovulation, and have evolved to facilitate clandestine extrapair copulation. For men, there is no overt ovulation cues that they can rely on to determine whether a woman is currently fertile. Furthermore, the benefits of not missing out women who have interests outweigh the costs of mistaking a woman's non-existent romantic interest, leading to the emergence of the male sexual overperception bias. This is consistent with a study which found a misinterpretation of female friendliness as seduction (Abbey, 1982). However, it is noteworthy that female sexual interest may confound with mere friendliness, and women may be uncertain of their interest at the outset because they are unable to establish male long-term

romantic interest (Haselton & Galperin, 2013). Indeed, female gestures such as smiling and hair touching on first contact have limited correlation with future romantic interest (Grammer, Kruck, Juette, & Fink, 2000). Relatedly, individuals observing speed dating interactions are less accurate in terms of romantic interest in women than in men (Place, Todd, Penke, & Asendorpf, 2009). As such, given the difficulty in predicting women's intent in a mating context, it is more adaptive for men to err on the side of female sexual interest.

While men tend to be oversensitive towards female romantic interest, it serves evolutionary advantage for women to underperceive male romantic interest (Haselton, 2003). For instance, a speed dating study demonstrated that women tend to underreport male sexual interest (Perilloux, Easton, & Buss, 2012). In view of the sexually differentiated mating strategy (Buss & Schmitt, 1993), this female tendency may have evolved in response to the men's tendency to conceal their sexual interest. In addition, given the evolutionary cost involved when women mistaken men's sexual interest for long-term commitment (Hurtado & Hill, 1992), women who are less assuming in male romantic interest are more likely to retain security in terms of their children and their own survival.

This extends to long-term romantic relationships where both men and women strategically engaged in extra-pair copulation to optimize their reproductive fitness. On one hand, men adopt reproductive strategy by mating with a greater variety of women, including less attractive women (Clutton-Brock & Parker, 1992; Clutton-Brock & Vincent, 1991; Li & Kenrick, 2006; Schmitt, 2003). On the other hand, women engage in extrapair copulation in order to secure long term investment from their primary partners while procuring greater genetic fitness from extrapair partners (Pillsworth & Haselton, 2006).

Taken together, given the uncertainty in determining female romantic interest and the evolutionary advantage to overestimate female romantic interest among men, it is adaptive for men to overperceive female romantic interest. On the other hand, given the adaptive costs

associated with mistaking men's short-term sexual interest for long-term commitment, women are likely to underperceive male romantic interest.

Error management in adaptive mating memory

Research based on the EMT largely investigates the perception of sexual intent of potential mates. The current research extends on this set of literature by examining memory for potential mates' faces. The memory system is likely to mirror the cognitive biases outlined above given that the initial attention systematically differs between men and women. While perception may serve to facilitate immediate decision making, memory biases are necessary for long-term decision making. As aforementioned, because human mate interest is concealed and overtly uncertain, strategic memory processes may have evolved for the purposes of keeping a cognitive inventory of potential mates surreptitiously. Indeed, accessing memory for potential mate faces is critical to decision making processes (Nairne & Pandeirada, 2008b; Weber, 2006). As such, memory for potential mates is adaptive to the extent that it is biased towards faces that are attractive viewed in a context where the survival and mating motives are activated.

Table 1 displays the memory tendencies (i.e., hits, false alarms, correct rejections, and misses) in terms of recalling whether one has previously seen a potential mate's face. In particular, the male sexual overperception bias drives the tendency among men to commit false alarms (i.e., recalling a face as seen before when it was not). The female sexual underperception bias drives the tendency among women to commit misses (i.e., thinking a face as not seen before when it was). Accuracy rate refers to the probability of getting the hits and correct rejections out of all the items in the test phase. Thus, memory biases can be calculated based on the person's performance on memory tests using the following formulas (refer to table 1 for the matrix displaying the memory parameters and cognitive biases).

Sexual overperception bias, the tendency to falsely recognize faces not seen before: Rate of false alarms = False alarms/(False alarms + correct rejection).

Sexual underperception bias, the tendency to not recognize faces seen before: Rate of misses = Misses/(Misses + Hits).

Accuracy rate = (Hits + Correct rejections)/(Hits + Correct rejections + False alarms + Misses).

Context specific adaptive mating memory

Cognitive biases are likely to be context specific given that costs and benefits vary across different situations, and the characteristics of the target and observer (Haselton & Galperin, 2013). For instance, men's overperception of female sexual interest increases for attractive women (Haselton, 2003; Maner et al., 2005; Perilloux et al., 2012), whereas women's underperception of male long-term commitment is attenuated when women are ovulating or when the male target is attractive (Cyrus, Schwarz, & Hassebrauck, 2011; Durante, Griskevicius, Simpson, & Li, 2010).

To date, the environment context *per se* such as grassland environment containing survival threats such as predators, and lack of food and water has yet been investigated in adaptive mating. Given that the motivation to mate intensifies in a survival condition (Bonneaud et al., 2004; Clutton-Brock, 1984), I expect a corresponding increase in memory errors indicated by an intensified male sexual overperception bias, and a decrease in memory errors emerging from a weaker female sexual underperception bias, particularly for attractive faces. That is, men will have greater false alarms for attractive female faces while women will have fewer misses for attractive male faces. In addition, because of greater intrasexual competition among women in terms of physical attractiveness (Buss, 1988; Fisher, 2013), I expect greater false alarms for attractive female faces among women.

Chapter 2: Study 1

Study 1 aims to investigate the notion that an environment that contains a survival threat will enhance the memory for attractive faces of the opposite sex (i.e., adaptive mating memory). In other words, memory for potential mates relies on the interaction among the context and the inherent properties of the face. As outlined above, previous research suggests that memory for faces is influenced by the inherent properties of the face such as sex and attractiveness, and the motivational states of the observer. In addition, the SPA theory (Nairne & Pandeirada, 2011; Palmore, Garcia, Bacon, Johnson, & Kelemen, 2012) suggests that congruity between these factors and the context can affect memory. While studies on the SPA effect demonstrated that survival context can have a significant effect on *verbal memory*, it remains unclear if the same effect can be observed for *facial memory* particularly in the case when the context potentially drives reproductive motives. I examine this idea by including facial attractiveness and mating motive in the survival processing paradigm. I predict that participant would recognize attractive faces of the opposite sex more accurately, especially when they are romantically motivated in a context containing survival threats.

Drawing on the literature on mate preference and the EMT, I predict that on one hand, men would tend toward false alarms recognition for attractive female faces. On the other, women would commit fewer misses for attractive male faces. In addition, I explore contextual effect associated with survival processing. In particular, the presence of survival threats in an environment along with a motive to mate would intensify these effects compared to contexts which do not include these elements.

Taken together, I hypothesize that (a) recognition memory for potential mate faces among men is more accurate in a survival context involving short-term mating motivation relative to other contexts (i.e., survival ally, moving sex, moving ally), particularly for attractive faces. Based on the notion of mate preferences, (b) recognition memory for

potential mate faces is more accurate for attractive compared to unattractive faces, especially for female faces. Based on the EMT, (c) men tend to falsely recognize attractive potential mate faces in a survival context involving short-term mating motivation relative to other contexts, (d) attractive potential mate faces will be falsely recognized more frequently compared to unattractive potential mate faces, especially for female faces, (e) women tend to miss out fewer attractive potential mate faces in a survival context involving short-term mating motivation (i.e., survival mating condition) relative to other contexts, and (f) unattractive potential mate faces will be missed out more frequently compared to attractive potential mate faces, especially for female faces.

Method

Participants

Three-hundred and sixty-six undergraduates from the subject pool in the Singapore Management University participated in the study. The participants participate in the study for course credits. Seventeen homosexuals and bisexuals were removed, leaving 106 men and 243 women aged between 18 and 41 years with a mean (SD) age of 23 (2.50) years and 21 (1.85) years respectively. Two-hundred and seventy-four (78.5%) participants were Chinese, 26 (7.4%) were Malays, 31 (8.9%) were Indians, and the remaining 18 (5.2%) students either reported ‘others’ as their ethnicity or did not report their ethnicity.

Design

The context (i.e., survival sex, survival ally, moving sex, moving ally) and the sex of the participants were the between-participant factors, and the target’s sex and the level of facial attractiveness were within-participant factors. The data was collected using the Qualtrics® system. Information including sex, sexual orientation, relationship status, and age were requested.

Materials

A stimuli pool consisting of 180 facial stimuli were selected from across four datasets (see Appendix A). The faces were cropped to remove clothing details, hair style and background information. An independent group of fifty-one undergraduates (38 women) rated the faces for attractiveness, emotionality, distinctiveness and masculinity-femininity characteristics based on a standard Likert scale ranging from 1 (e.g., *very masculine*) to 7 (*very feminine*). From the set of 180 faces, 72 faces were selected: 36 faces from below the median of the distribution of attractiveness ratings (M = 2.72, SD = 0.26, range = 2.12 – 3.12) and 36 faces from above the median (M = 3.55, SD = 0.33, range = 3.13 – 4.37). In addition, care was taken to ensure the male and female faces equated on their mean different attractiveness levels. This enabled the comparison of the relative contribution of attractiveness to memory between the male and female faces. The 72 faces were split into two sets with an equal number of faces for each level of attractiveness. These two sets of faces were used to counterbalance between the to-be-remembered faces in the study phase and the distractor faces in the recognition phase. The faces from these two sets were counterbalanced across participants and balanced for attractiveness, emotionality, distinctiveness, and masculinity-femininity.

Procedure

Following Nairne et al (2007), and Savine and colleagues (2011), participants were randomly assigned to one of the following four scenarios with the corresponding instructions below. Each scenario induced the participants to perceive that they were under survival threat (or not) and having a short-term mating motive (or coalition forming motive, i.e., finding an ally). The instructions were different from the original study in terms of the inclusion of the mating context.

Survival ally. In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water, and protect yourself from predators. We would like for you to imagine that there is another individual in the grasslands with you. We are going to show you a set of faces of whom the person may be. We would like you to rate how helpful this person would be in aiding your survival in this situation. Some of the people may be helpful and others may not – it's up to you to decide.

Survival mating. In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water, and protect yourself from predators. We would like for you to imagine that there is another individual in the grasslands with you. We are going to show you a set of faces of whom the person may be. We would like you to rate how likely you will engage in a short-term sexual relationship with this person. Some of the people may be likely and others may not – it's up to you to decide.

Moving ally. In this task, we would like you to imagine that you are planning to move to a new home in a foreign land. Over the next few months, you'll need to locate and purchase a new home and transport your belongings. We would like for you to imagine that there is another individual moving with you. We are going to show you a set of faces of whom the person may be. We would like you to rate how helpful this person would be in aiding you in your move. Some of the people may be helpful and others may not – it's up to you to decide.

Moving mating. In this task, we would like you to imagine that you are planning to move to a new home in a foreign land. Over the next few months, you'll need to locate and purchase a new home and transport your belongings. We would like for you to imagine that there is another individual moving with you. We are going to show you a set of faces of

whom the person may be. We would like you to rate how likely you will engage in a short-term sexual relationship with this person. Some of the people may be likely and others may not – it's up to you to decide.

As the participants, being city dwellers, were unlikely to encounter or know how savannah grassland looks like, there was a picture depicting a grassland scene beneath the instructions for the ancestral mating condition. In addition, a picture depicting a city scene appeared beneath the instructions for the moving condition. The faces were presented individually for 5s each. Participants rated each face on a 7-point scale, with 1 indicating extremely unlikely and 7 indicating extremely likely (i.e., relevance rating). For participants who read the scenarios involving an ally, they were asked "How helpful was the person in aiding you?" while participants who read the scenarios involving a short-term sexual mate were asked "How likely would you engage in a short-term sexual relationship with the person?" There was no mention of the memory test later.

After the last face was presented, instruction for the filler task was displayed. This included having the participants write numbers in decreasing order of 3s from number 721 for 1 minute. This was followed by the surprise recognition task to test the participants' memory for the faces they saw. Participants were told to respond as fast and as accurately as they can. In this phase, 72 faces were randomly presented, made up of 36 old faces they saw in the study phase and the additional 36 new faces as distractor faces. The participants responded to each face by pressing either the Old or New keys. The study ended with questions on participant demographic including age, sexual orientation, nationality, ethnicity and relationship status. As a manipulation check, the participants rated the level of physical and psychological threat posed by the context they are assigned to on a scale of 0-8.

Results

Manipulation checks

A manipulation check indicated that participants who read the survival scenarios perceived that the environment was less safe, contained more psychologically disturbing elements and were less likely to enjoy living in this environment compared to participants who read the moving scenarios (see Table 2).

Accuracy

Participants had a 75.2% accuracy rate[1] overall (*M* errors = 17.88 out of 72 identifications, *SD* = 6.25). To analyze the ability to recognize faces accurately, I computed and analyzed accuracy rate ([true positives + true negatives]/[true positives + true negatives + false positives + false negatives]) for each face type (i.e., male attractive, male unattractive, female attractive, and female unattractive) (higher values = more accurate). The true positives refer to the number of target faces (i.e., 'old' faces) correctly recognized, whereas the true negatives refer to the number of foil faces (i.e., 'new' faces) correctly rejected. The false positives refer to the number of foil faces incorrectly recognized as target faces, whereas the false negatives refer to the number of target faces incorrectly rejected as foil faces.

Accuracy rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and target sex and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect of attractiveness, $F(1, 341) = 76.49$, $p < .001$, $\eta^2_p = .18$. Participants were more accurate for unattractive faces ($M = 0.77$, $SD = 0.10$) compared to attractive faces ($M = 0.72$, $SD = 0.10$). A main effect of target sex was observed, $F(1, 341) = 57.50$, $p < .001$, $\eta^2_p = .14$, in which participants were more accurate for female faces ($M = 0.77$, $SD = 0.09$) compared to male

[1] The overall accuracy rate is the total hits and correct rejections (18, 897) divided by the highest possible score possible by all participants (72 faces x 349 participants = 25, 128). The error rate is the total misses and false alarms.

faces (M = 0.73, SD = 0.11). In addition, a main effect of participant sex was observed, F(1, 341) = 4.44, p = .04, η^2_p = .01, in which women (M = 0.76, SD = 0.08) are more accurate compared to men (M = 0.74, SD = 0.09). There was no significant main effect for context, F(3, 341) = 0.53, p = .66. Thus, participants who rated the faces in the survival sex context were not more accurate compared to those in the other three contexts.

There was a significant interaction effect between attractiveness and context, F(1, 341) = 3.05, p = .03, η^2_p = .03. To examine the simple effects, a Multivariate Analysis of Variance (MANOVA) was conducted for attractiveness and context. *Post hoc* tests revealed that participants showed that participants were more accurate for unattractive compared to attractive faces across all contexts (p < .01) (Figure 2). In addition, unattractive faces in the survival ally condition were recognized more accurately compared to the moving ally condition (p = .03). Other than moving sex context (p = .08), participants were more accurate for unattractive faces compared to attractive faces in the survival sex, survival ally, and moving ally contexts (p < .001) (Figure 2).

To examine memory biases, I computed and analyzed overperception bias rate (false positives/[false positives + true negatives]), and the underperception bias rate (false negatives/[false negatives + true positives]) for each face type (i.e., male attractive, male unattractive, female attractive, and female unattractive) (higher values = more accurate). The overperception bias rate is a measure of the tendency to recognize a face as seen before when it was not previously displayed, and is an indicator of the number of foil faces incorrectly recognized as target faces, out of all the foil faces (i.e., male sexual overperception bias, Table 1). The underperception bias rate is a measure of the tendency to reject a face as not seen before when it was previously displayed, and is an indicator of the number of target faces missed, out of all the target faces (i.e., female sexual underperception bias, Table 1).

Overperception bias

The overperception bias (OB) rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and target sex and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect of attractiveness, $F(1, 341) = 17.93$, $p < .001$, $\eta^2_p = .05$. Participants had higher OB rate for attractive faces ($M = 0.21$, $SD = 0.17$) compared to unattractive faces ($M = 0.18$, $SD = 0.16$). A main effect of participant sex was observed, $F(1, 341) = 9.54$, $p < .01$, $\eta^2_p = .03$, in which men ($M = 0.23$, $SD = 0.16$) had higher OB rate compared to women ($M = 0.18$, $SD = 0.14$). There was no significant main effect for target sex, $F(1, 341) = 0.07$, $p = .79$, and no significant main effect for context, $F(3, 341) = 0.42$, $p = .74$. Thus, participants who rated the faces in the survival sex context did not have higher OB rates compared to those in the other three contexts.

There was a significant interaction effect among attractiveness, participant sex and target sex, $F(1, 341) = 9.99$, $p < .01$, $\eta^2_p = .03$. To examine the simple effects, a MANOVA was conducted for attractiveness, participant sex, and target sex. *Post hoc* tests revealed that among men, attractive female faces were subjected to higher OB rate compared to the unattractive female faces, $F(1, 347) = 20.83$, $p < .001$, $\eta^2_p = .06$ (Figure 3). Among women, attractive male faces were subjected to higher OB rate compared to unattractive male faces, $F(1, 347) = 6.94$, $p < .01$, $\eta^2_p = .02$, and attractive female faces were subjected to higher OB rate compared to unattractive female faces, $F(1, 347) = 6.19$, $p = .01$, $\eta^2_p = .02$ (Figure 4). Notably, the attractiveness effect size is greater among men compared to among women.

Consistent with adaptive mating memory, the overperception bias data demonstrated a tendency to falsely recognized attractive opposite sex individuals compared to unattractive ones. Additionally in the case of women, there was an overperception bias towards attractive same-sex faces, which is consistent with intrasexual competition. However, these effects are

invariant across contexts suggesting that survival threats in the environment did not affect false positive recognition of potential mate faces.

Underperception bias

The underperception bias (UB) rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and target sex and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect of attractiveness, $F(1, 341) = 54.32$, $p < .001$, $\eta^2_p = .14$. Participants had higher UB rate for attractive faces ($M = 0.34$, $SD = 0.16$) compared to unattractive faces ($M = 0.27$, $SD = 0.16$). A main effect of target sex was observed, $F(1, 341) = 109.48$, $p < .01$, $\eta^2_p = .24$, in which male faces ($M = 0.35$, $SD = 0.18$) were subjected to higher UB rate compared to female faces ($M = 0.25$, $SD = 0.14$). There was no significant main effect for participant sex, $F(1, 341) = 0.41$, $p = .52$, and there was no significant main effect for context, $F(3, 341) = 0.40$, $p = .76$. Thus, participants who rated the faces in the survival sex context did not have higher UB rate compared to those in the other three contexts.

There was a significant interaction effect among context, participant sex and target sex, $F(3, 341) = 2.72$, $p = .05$, $\eta^2_p = .02$. To examine the simple effects, a MANOVA was conducted for context, participant sex, and target sex. Across all conditions, and among men and women, there was a main effect for target sex, $F(1, 344) = 109.72$, $p < .001$, $\eta^2_p = .24$, where male faces were subjected to higher UB rate compared to female faces. There was a significant interaction between context and target sex, $F(3, 344) = 3.33$, $p = .02$, $\eta^2_p = .03$. *Post hoc* tests revealed that among female faces, there was higher UB rate in the survival sex condition compared to the survival ally condition, $F(3, 344) = 3.00$, $p = .03$, $\eta^2_p = .03$ (Figure 5).

There was a significant interaction effect among attractiveness, participant sex, and context, $F(1, 341) = 2.948$, $p = .03$, $\eta^2_p = .03$. To examine the simple effects, a MANOVA

was conducted for attractiveness, participant sex, and context. There was a significant interaction between attractiveness and context, $F(3, 344) = 2.793$, $p = .04$, $\eta^2_p = .02$. *Post hoc* tests revealed that other than moving sex context ($p = .08$), participants had higher UB rate for attractive faces compared to unattractive faces in the survival sex, survival ally, and moving ally contexts ($p < .001$) (Figure 6).

There was a significant interaction effect between attractiveness and target sex, $F(1, 341) = 10.32$, $p < .01$, $\eta^2_p = .03$. To examine the simple effects, a MANOVA was conducted for attractiveness and target sex. Participants had higher UB rate for attractive faces compared to unattractive faces within male faces, $F(1, 348) = 64.75$, $p < .001$, $\eta^2_p = .16$, and female faces, $F(1, 348) = 14.37$, $p < .001$, $\eta^2_p = .04$ (Figure 7).

Contrary to the current hypothesis, the underperception bias rate data suggests that participants across conditions tend to miss out attractive faces more often than unattractive faces.

Discussion

Study 1 examined the effect of facial attractiveness on our recognition memory for faces when short-term mating motive was induced in a survival context. I hypothesized that the recognition memory for potential mate faces among men is better in a survival context involving short-term mating motivation relative to other contexts which do not contain survival threat and/or mating motivation, particularly for attractive faces; recognition memory for potential mate faces is better for attractive compared to unattractive faces, especially for female faces. The OB (i.e., false recognition) and UB (i.e., incorrect rejection) rates were hypothesized to correspond to findings on the accuracy rate.

The hypotheses were partially supported in that facial attractiveness and the sex of the observer and target influenced recognition memory for faces, but contexts which include survival threat and mating motivation did not. In addition, participants recognized female

faces more accurately compared to male faces, independent of attractiveness. The false recognition data demonstrated that attractive faces of the opposite sex were falsely recognized more frequently compared to the unattractive faces. Furthermore, women tend to falsely recognize attractive female faces more frequently compared to unattractive female faces, which is related to intrasexual competition among women. On the other hand, participants failed to recognize male faces more frequently compared to female faces, and failed to recognize male and female attractive faces more frequently compared to unattractive faces across all contexts except the moving sex context.

Explanations for adaptive memory for attractive and unattractive faces

The present findings concurrently examined two sets of theories in the facial memory domain. On one hand, prospect theory (Kahneman & Tversky, 1979) and error management theory (Haselton & Buss, 2000) suggest that adaptive memory involves remembering and misremembering in terms of costs and benefits associated with the faces. Study 1's findings indicate that putting more weight on negative traits is more adaptive compared to emphasizing on positive traits. In mating context particularly, people weigh negative cues (i.e., dealbreakers) such as poor health and bad personality traits more heavily compared to positive cues (i.e., dealmakers) (Jonason, Garcia, Webster, Li, & Fisher, 2015). This is adaptive because avoiding unhealthy potential mates can be beneficial in terms of reproductive fitness, and this is especially important for women (Trivers, 1972). Furthermore, negative trait cues may be more salient than positive trait cues because it is costlier to take on a poor quality mate (Jonason et al., 2015). Previous studies demonstrated that people recognize unattractive faces better than attractive faces (Light, Hollander, & Kayra-Stuart, 1981; Sarno & Alley, 1997; Wiese, Altmann, & Schweinberger, 2014), but it is unclear if this subserves mating strategy to avoid costs associated with low quality mates. Study 1 showed that recognition memory for unattractive individuals was more accurate than attractive

individuals. This seems to be consistent with the notion that it is more adaptive to place emphasis on negative traits more than positive traits.

On the other hand, sexual selection theories and mate choice literature (Allan et al., 2012; Rhodes, 2006) suggest that people falsely recognize attractive faces, which may facilitate attention towards genetically superior potential mates. Relatedly, intra-sexual competition among women suggest that attractive women (i.e., mate competitors) are pertinent to other women in terms of mate guarding (Maner et al., 2007). However, intra-sexual competition among men in terms of facial attractiveness is not as relevant because women tend to focus on male resourcefulness (Anderson et al., 2010; Buss, 1989; Buss & Schmitt, 1993; Jonason, Li, & Madson, 2012). Indeed, the current study demonstrated that women tend to falsely recognize attractive same-sex faces but there is no corresponding pattern among men, although greater false recognition for attractive compared to unattractive faces opposite-sex faces was observed for both sexes. As such, memory in this sense is adaptive because falsely recognizing an attractive opposite-sex person may facilitate attention and approach towards the person, and falsely recognizing an attractive same-sex person (particularly for women) may enhance attention towards potential mate competitors for mate-guarding purposes.

Certainly, remembering attractive faces is adaptive in some situations and has been empirically observed (Marzi & Viggiano, 2010; Tsukiura & Cabeza, 2011). While theorists proposed that there is attentional bias towards attractive faces (Maner et al., 2003; Rhodes, 2006), the relationship between memory and facial attractiveness is less clear. In particular, perception and attention do not always correspond to memory (Anderson et al., 2010; Silva, Macedo, Albuquerque, & Arantes, 2016). For instance, despite allocating greater attention to attractive faces than unattractive faces, people tend to falsely recognize attractive faces as having seen before more frequently than unattractive faces (Silva et al., 2016). One reason

may be that memory, which involve multiple factors such as remembering and forgetting, encoding, storing and retrieving, and short-term and long-term storages, is complex. Thus, allocating the same level of attentional resources to each face may not result in identical recognition rate. Notwithstanding this discordance, using a functional evolutionary analysis can provide explanations for differential memory for faces. For instance, remembering faces of opposite-sex is adaptive when the observer is evaluating the face as a potential mate. It is noteworthy that previous studies generally only use single sex faces, precluding comparison between genders (e.g., Silva et al., 2016; Zhang, Wei, Zhao, Zheng, & Zhang, 2016). This is problematic particularly when inferences based on sexual selection is made. The present research attempts to close this gap by investigating interactions between observer sex and target sex in terms of facial attractiveness compared between mating (i.e., short-term sexual partner) and non-mating (i.e., ally) motives.

Explanations for memory for female faces

It is also noteworthy that generally, female faces were observed to be particularly relevant in evaluation across different contexts for both men and women in the current study. Other than mate quality, people's tendency to remember female faces is adaptive because female faces contain adaptive cues indicating willingness to mate, cooperate and befriend (Taylor et al., 2000). In contrast, remember male faces as allies may not be as adaptive because of their lower tendency to cooperate, befriend, and offer care (Taylor et al., 2000). Furthermore, adaptive cues are more variable among male faces in mating contexts. In particular, male faces are preferred based on their masculinity or femininity according to whether female mate choice tends towards genetic quality or long-term mating respectively (Penton-Voak & Perrett, 2000; D. S. Smith, Jones, & Allan, 2013). Thus, because of this evaluative ease for female faces, it may result in these faces being remembered more easily compared to male faces.

Chapter 3: Study 2

The finding that unattractive faces were remembered better compared to attractive faces contradicts my initial hypothesis, presenting a possibility that this could be an artifact. However, the faces were counterbalanced between old and new faces. Furthermore, evolutionary theories suggest that cognitive resources tend toward negative cues because of the greater survival and reproductive costs involved (Jonason et al., 2015). Study 2 drew participants from a different population (i.e., MTurk workers) to examine if unattractive faces are indeed committed to memory more than attractive faces.

Study 2 was conducted to address several methodological gaps in study 1. First, study 1 combined both contextual (either grassland or city) and motivational (either short-term sex or ally) primes within the same scenario, and did not find that context and motivation influenced memory for potential mates' faces. This leaves open the possibility that the priming effects may have been attenuated or reversed. To ascertain whether contextual effect comes into play for adaptive mating memory, study 2 used simpler scenarios in place of those in study 1. Study 2 used scenarios consisting of a single priming context (i.e., survival grassland, mating, and attractiveness rating as control condition).

Second, because the participants' current mating motives were not measured, it is not clear if the findings were confounded by individual differences in preexisting mating motive. study 2 elicited current mating motive at the beginning. Three, study 1 did not include a control scenario that did have contextual and motivation primes. Thus, study 2 included a control condition which instructed participants to rate the attractiveness of the faces. Four, it is not clear if cognitive biases lead to behavioral biases. Particularly, cognitive biases are adaptive to the extent that behaviors are altered in the direction benefitting survival and/or reproductive fitness. Study 2 examined this question by including an additional task

following the recognition task, requesting participants to rate their tendency to approach each individual.

Study 1 focused on short-term mating. In study 2, participants in the mating context are primed with scenario that involved rating faces as long-term mates. Particularly, while both men and women prefer physically attractive opposite sex partners in a short-term mating context (Li & Kenrick, 2006), greater emphasis is placed on female attractiveness than male attractiveness in a long-term mating context (Buss, 1989; Gangestad & Simpson, 2000; Li et al., 2002). This may explain why there was a lack of findings in terms of mating and survival context. Thus, the mating context condition in study 2 instructed participants to rate each face as a long-term mate.

Method

Participants

Participants were a United States national sample of Asians recruited online through Amazon's Mechanical Turk (MTurk, see Buhrmester, Kwang, & Gosling, 2011). Three-hundred and nineteen participants completed the study for US$1 compensation. Forty-four homosexuals and bisexuals were removed, leaving 148 men and 127 women aged between 18 and 45 years with a mean (SD) age of 30.55 (6.32) years and 30.80 (7.70) years respectively. Seventy-seven (28%) were Chinese, 44 (16%) were Koreans, 38 (13.8%) were Filipino, 36 (13.1%) were Indians, 32 (11.6%) were Japanese, 17 (6.2%) were Vietnamese, and the remaining 31 (11.3%) either reported 'others' as their ethnicity or did not report their ethnicity. One-hundred and fifteen (41.9%) participants were single, 156 (56.6%) were attached, and the remaining 4 (1.5%) reported 'others' as their marital status[2].

[2] Separate analysis for participants who were unattached (i.e., single, divorced, widowed) and those who were attached (i.e., dating, married) largely did not alter the results for the combined dataset in terms of accuracy, overperception bias, and underperception bias. However, both groups of participants did not show any significant results for facial recognition as predictors for approach tendency. Combined dataset demonstrated a

Design

The context (i.e., survival, long-term mating, attractiveness) and the sex of the participants were the between-participant factors, and the level of facial attractiveness were within-participant factors. The participants viewed only opposite sex faces. The data was collected using the Qualtrics® system, and the same demographic information were collected as per study 1.

Materials

The same set of facial stimuli as study 1 were used. However, instead of displaying both male and female faces to all participants, only opposite-sex faces were used in the present study. Thus, each participant rated eighteen faces during the study phase, and viewed 36 faces during the recognition phase. As per study 1, the faces were counterbalanced for target and foil faces.

Procedure

The participant's sex was elicited at the beginning followed by questions on their current long-term mating motivation. Following Baker and Maner's (2008) procedure, the participants responded to the questions: "To what extent would you describe yourself as currently motivated toward pursuing romantic/sexual interests?" based on a seven-point scale. The question was embedded among a set of distractor questions (e.g., "To what extent would you describe yourself as currently motivated toward academic achievement?"). The rest of the study remained the same, except for the instructions for the scenarios below.

Survival. In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water, and protect yourself from predators. We would like for you to imagine that there is another individual in the grasslands with you.

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significant association with approach tendencies for false positives among attractive faces and true positives among unattractive faces.

We are going to show you a set of faces of whom the person may be. We would like you to rate how helpful this person would be in aiding your survival in this situation. Some of the people may be helpful and others may not – it's up to you to decide.

Mating. In this task, we would like you to imagine that you would like to start a meaningful long-term romantic relationship with someone desirable. Over the next few months, you plan to go out on dates with this special person to get very closely acquainted with him/her. We would like for you to imagine that you are about to meet someone who could be this romantic partner. We are going to show you a set of faces of whom the person may be. We would like for you to rate how likely this person would be a long-term partner for you. Some of the people may be likely long-term material and others may not – it's up to you to decide.

Attractiveness. In this task, we are going to show you a set of faces. We would like you to rate how attractive each face is to you.

In addition, to examine whether the behavioral tendency correspond to the memory biases for faces, the participants were instructed to rate the faces on a five-point scale based on the scenario they were assigned to. For the survival scenario, the participants were told to indicate how likely they will approach the person to aid him/her in a survival situation. For the mating scenario, they were told to indicate how likely he/she will be in a long-term relationship with the person. For the attractiveness condition, they were told to indicate how likely they will approach the person by rating on a five-point scale ranging from "extremely unlikely" to "extremely likely". Items for manipulation check were included at the end of the study.

Results

Manipulation checks

To examine the current mating motivation for participants across the three contexts, a one-way between participants Analysis of Variance (ANOVA) was conducted for the item "To what extent would you describe yourself as currently motivated toward pursuing romantic/sexual interests?". There was a significant difference of context on mating motivation, $F(2, 272) = 4.46$, $p = .01$. In particular, *post hoc* comparisons indicated that participants in the survival context ($M = 3.97$, $SD = 1.75$) have lower mating motivation compared to those in the mating context ($M = 4.62$, $SD = 1.79$) and control condition (i.e., attractiveness rating, ($M = 4.65$, $SD = 1.63$). However, entering current romantic motivation as the covariate in the following analyses did not alter the results for accuracy, overperception bias, and underperception bias (see Appendix C).

To determine if the manipulation on the context was successful, the participants were tested on their memory at the end of the study for the elements present in the scenarios they read. As shown in table 3, participants who read the survival scenario generally recalled that there were grasslands, predators, and a lack of food and water; participants who read the mating scenarios generally recalled that the scenario involved a potential romantic partner, and dating someone desirable; participants in the attractiveness control condition generally recalled that they were told to rate the faces for attractiveness, compared to their counterparts who read the other scenarios.

In addition, I elicited responses from the participants for their perception of the scenarios they read. A one-way ANOVA was conducted for the item "The scenario contains elements that suggest the environment is not safe". There was a significant difference, $F(2, 272) = 35.83$, $p < .001$, and *post hoc* comparisons indicated that participants in the survival context ($M = 3.33$, $SD = 1.34$) had higher ratings compared to those in the mating context (M

= 1.97, *SD* = 1.09) and control condition (i.e., attractiveness rating, *M* = 2.25, *SD* = 1.00). Another one-way ANOVA was conducted for the item "The scenario contains elements that are romantic". There was a significant difference, $F(2, 272) = 15.56$, $p < .001$, and post-hoc comparisons indicated that participants in the mating context (*M* = 3.21, *SD* = 1.25) and control condition (*M* = 3.02, *SD* = 1.00) had higher ratings compared to those in the survival context (*M* = 2.31, *SD* = 1.15).

To examine participants' recognition memory for opposite sex faces, I conducted a series of ANOVA tests for accuracy, false alarm rates as indicators of overperception bias, and misses as indicators of underperception bias below.

Accuracy

Participants had a 72.2% accuracy rate[3] overall (*M* errors = 9.99 out of 36 identifications, *SD* = 5.40). To analyze the ability to recognize faces accurately, I computed and analyzed accuracy rate ([hits + correct rejections]/[hits + correct rejections + false alarms + misses]) for each face type (i.e., attractive, and unattractive) (higher values = more accurate). Hits refer to the number of target faces (i.e., 'old' faces) correctly recognized, whereas the correct rejections refer to the number of foil faces (i.e., 'new' faces) correctly rejected. The false alarms refer to the number of foil faces incorrectly recognized as target faces, whereas the misses refer to the number of target faces incorrectly rejected as foil faces.

Accuracy rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect of attractiveness, $F(1, 268) = 10.99$, $p = .001$, $\eta^2_p = .04$. Participants were more accurate for unattractive faces (*M* = 0.74, *SD* = 0.17) compared to attractive faces (*M* = 0.71, *SD* = 0.17). A main effect of participant

[3] The overall accuracy rate is the total hits and correct rejections (7, 152) divided by the highest possible score possible by all participants (36 faces x 275 participants = 9, 900). The error rate is the total misses and false alarms.

sex was observed, $F(1, 268) = 29.45$, $p < .001$, $\eta^2_p = .10$, in which women ($M = 0.77$, $SD = 0.14$) were more accurate compared to men ($M = 0.68$, $SD = 0.15$). There was no significant main effect for context, $F(2, 268) = 1.13$, $p = .32$. Thus, participants who rated the faces in the survival context were not more accurate compared to those in the mating and control contexts.

There was a significant interaction effect between attractiveness and participant sex, $F(1, 268) = 5.16$, $p = .02$, $\eta^2_p = .02$. To examine the simple effects, a Multivariate Analysis of Variance (MANOVA) was conducted for attractiveness and participant sex. *Post hoc* tests revealed that women were more accurate compared to men regardless of the attractiveness of the faces ($p < .001$). Accuracy for unattractive faces is greater compared to attractive faces among men ($p < .01$), but accuracy did not differ between unattractive and attractive faces among women ($p = .45$) (Figure 8).

Overperception bias

The overperception bias (OB) rate was submitted to a repeated-measures ANOVA with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect of attractiveness, $F(1, 269) = 14.18$, $p < .001$, $\eta^2_p = .05$. Participants had higher OB rate for attractive faces ($M = 0.26$, $SD = 0.23$) compared to unattractive faces ($M = 0.21$, $SD = 0.21$). A main effect of participant sex was observed, $F(1, 269) = 12.55$, $p < .01$, $\eta^2_p = .05$, in which men ($M = 0.27$, $SD = 0.20$) had higher OB rate compared to women ($M = 0.19$, $SD = 0.17$). There was no significant main effect for context, $F(2, 269) = 0.60$, $p = .55$. Thus, participants who rated the faces in the survival sex context did not have higher OB rates compared to those in the other two contexts.

There was a significant interaction effect between attractiveness and participant sex, $F(1, 269) = 5.01$, $p = .03$, $\eta^2_p = .02$. To examine the simple effects, a Multivariate Analysis of

Variance (MANOVA) was conducted for attractiveness and participant sex. *Post hoc* tests revealed that men had higher OB rate compared to women for both unattractive ($p = .03$) and attractive faces ($p < .001$), and OB rates did not differ between unattractive and attractive faces among women ($p = .29$) (Figure 9).

Underperception bias

The underperception bias (UB) rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. There was a main effect for participant sex, $F(1, 268) = 20.66$, $p < .001$, $\eta^2_p = .07$, in which men ($M = 0.37$, $SD = 0.21$) had greater UB rates compared to women ($M = 0.27$, $SD = 0.18$). There was no significant main effect for attractiveness, $F(1, 268) = 0.63$, $p = .43$, and context, $F(2, 268) = 2.00$, $p = .14$.

Memory effects on behavioral tendencies

To examine if memory effect was related to behavioral tendencies, I conducted a multivariate multiple regression analysis for true positives and false positives for attractive, and unattractive faces, while controlling for participant sex and context. That is, I examined if the tendency to indicate a person as seen before would led to a greater tendency to approach the person.

For attractive faces, the results indicated that hits did not predict behavioral tendency for these faces. However, higher false alarms marginally predicted higher approach tendencies ($\beta = .46$, $p = .09$), $R^2 = .20$, $F(9, 264) = 7.35$, $p < .001$. For unattractive faces, higher hits led to lower tendency to approach these faces ($\beta = .58$, $p = .04$), $R^2 = .26$, $F(9, 264) = 10.46$, $p < .001$. However, false alarms did not predict behavioral tendency for these faces.

Generally, findings for memory effects on behavioral tendency was consistent with the adaptive mating memory hypothesis. In particular, false recognition for attractive faces led to an increased tendency to approach the faces, and correct recognition for unattractive faces led to a decreased tendency to approach the faces. However, correct recognition for attractive faces and false recognition for unattractive faces were unrelated to behavioral tendency.

General discussion

The present research aimed to investigate if inherent properties of the face (i.e., attractiveness, face sex), and context (i.e., survival, mating) contribute to people's memory for faces. Memory was assessed based on the EMT which examined the accuracy, and memory biases in terms of false alarms and misses. Higher false alarm rate (i.e., incorrect recognition) indicates the presence of overperception bias which suggest that people have a preference for these faces while higher misses (i.e., incorrect rejection) indicates the presence of underperception bias suggesting that people have lower preference.

In two studies, participants were induced to consider the faces as allies who may aid their survival in a grassland, and as potential short-term or long-term romantic partners. Following which, they studied and rated the target faces. The participants' memory for the faces was tested in a surprise recognition memory task. Across both studies, participants did not show enhanced memory following contextual induction in terms of accuracy (i.e., correct recognition and correct rejection), overperception bias (i.e., incorrect recognition), and underperception bias (i.e., incorrect rejection). However, their memory was generally enhanced for unattractive faces, and women demonstrated better memory for faces compared to men. In addition, the facial attractiveness effect seems to occur mainly among men (study 1 and 2), although women incorrectly recognized attractive male and female faces more frequently than unattractive ones (study 1). Some evidence suggests that recognition memory and memory bias are related to later approach tendency. Taken together, while the current findings are consistent with adaptive mating memory in terms of face sex and facial attractiveness, contexts that presumably induce SPA and mating motivation do not appear to be involved. These findings have implications in term of contextual influence on memory, and the involvement of cognitive processing for mating behaviors.

Contextual effect

The current research examined contextual effect for memory for faces in terms of the presence of survival threats, and short-term and long-term mating motivation. Activating fundamental motives such as survival and mating can lead to cognitive, and behavioral consequences. For instance, men (but not women) engage in non-conformist behaviors when mating motive is activated (Kenrick et al., 2010). Similarly, men whose mating motivation is activated are more willing to spend on luxury items but pinch on inconspicuous items such as tile cleaner (Griskevicius et al., 2007). While it has been argued that goal-driven cognition provide better explanations for human behaviors compared to domain-general approach-avoidance explanations (Kenrick et al., 2010), it has yet been addressed directly whether fundamental motives underlie memory leading to approach, and avoidant tendencies.

In both studies, context did not affect memory for faces, whether it included a combination of survival threats and mating motivation (study 1) or in isolation (study 2). A wealth of literature has established that context is implicated in memory (Godden & Baddeley, 1975; Murnane, Phelps, & Malmberg, 1999; S. M. Smith & Vela, 2001). Notably, studies that observed context-dependent memory largely use verbal stimuli while the present research investigated memory for faces. Given that neurological and cognitive studies suggest that facial recognition is distinct from other types of stimuli (Farah, 1992, 1996), the present findings cannot be considered as contradicting existing theories on context-dependent memory.

Presumably, fundamental motives were induced by the contextual scenarios the participants read. However, context did not lead to different outcome for memory of potential mates. Because different fundamental motives are associated with qualitatively different cognitive tendencies (Kenrick, Li, & Butner, 2003; Kenrick et al., 2010), scenarios as in study 1 that combines survival prime and mating prime may produce effects canceling out

each other. Particularly, while mating motive may direct cognitive resources for faces of potential mates, survival motive may not, or may instead, direct cognitive resources away from remembering faces. Nonetheless, when survival and mating contexts were separately compared with a facial attractiveness rating control condition (study 2), memory for faces remained unaffected by context.

The present findings replicated Savine and colleagues' (2011) study, which found that survival processing (i.e., savannah grassland) did not benefit recognition memory for faces relative to non-survival processing (i.e., moving to a new city). Taken together, the current findings indicate that faces contain cues relevant to reproductive fitness but not survival fitness. Instead, facial expressions may be more relevant facial cues to assess for allies in a survival context because happy facial expression is associated with trustworthiness (Oosterhof & Todorov, 2009; Todorov, 2008). This remains untested and represent an area of research for the future. Furthermore, previous research demonstrated that attractive faces in themselves are sufficient mating primes (Baker & Maner, 2008). Findings from the current research support this notion with respect to recognition memory for opposite sex faces. However, the current research demonstrated this only for false recognition of attractive faces, which may correspond to subsequent approach tendency.

Recognition memory for attractive and unattractive faces

In accordance to the relationship dealbreaker hypothesis (Jonason et al., 2015), the current research observed that participants' accuracy memory was better for unattractive compared to attractive faces. This is consistent to the notion that people place greater weights on negative than positive traits because avoiding genetically inferior potential mate is more adaptive than gaining a genetically superior potential mate (Haselton & Buss, 2000; Kahneman & Tversky, 1979). In contrast with previous research however (Jonason et al., 2015), the current research found that the effect was largely observed among men, rather than

women. However, this is consistent with the evolutionary explanation for sex difference in facial attractiveness where facial attractiveness is a more important criterion for men, particularly in a long-term mating context (Bech-Sørensen & Pollet, 2016; Buss & Schmitt, 1993). Jonason and colleagues (2015) examined behavioral dealbreakers (e.g., has anger issues or is abusive, is currently dating multiple partners), which are evolutionarily more critical for women than men. As such, it is not surprising that the dealbreaker effect was stronger among women in their study while the unattractiveness effect was stronger among men in the present research.

Despite the emphasis on accurate memory for unattractive faces, cognitive biases for attractive faces is not entirely absent. The current research suggests that an initial poorer memory for attractive faces is addressed downstream through memory biases. In particular, both studies demonstrated that participants tend to incorrectly recognize attractive faces as seen before. Specifically, participants' overperception for opposite sex faces (study 1 and 2), and women's overperception for attractive female faces (study 1) support the adaptive mating memory view. Taken together, this dual memory strategy may ensure that subsequently, unattractive individuals are avoided while attractive individual would be approached.

Downstream behavioral tendencies

The present research extends on the literature on adaptive memory and mating strategies. Importantly, scholars argue that memory is a necessary precursor to decision making and behavioral actions (e.g., Horgan, Broadbent, McKibbin, & Duehring, 2016). The present research suggests that false memory can come in play as well. In particular, even if someone does not remember a face, the tendency to approach an attractive potential mate is nevertheless facilitated by false recognition. Because human memory is often subjected to rapid decay, it may be adaptive to develop such an error management system in place to promote reproductive fitness. Indeed, greater false positives for attractive faces in study 2

were associated with an increase in approach tendency, and greater true positives for unattractive faces was related to a decrease in approach tendency. On the other hand, approach tendency was not predicted by true positives for attractive faces, and false positives for unattractive faces. This suggests that cognitive biases are not always concordant with behavioral biases.

Evolved biases do not serve to always lead to behavioral outcomes (Haselton & Galperin, 2013; Haselton & Nettle, 2006; McKay & Efferson, 2010). For instance, a behavioral bias such as a man's tendency to approach a lonesome woman at the bar may be partly driven by cognitive bias that the woman is in a mood for sex, other factors such as the potential for embarrassing outcomes and how it would affect his reputation, say if he is alone versus when he is with friends. In the current research, it serves good reasoning that men approach attractive women even though they may not have a cognitive bias (i.e., greater false positives) for her. Such behavioral biases do not require corresponding cognitive biases (McKay & Efferson, 2010). Instead, these cognitive biases may have evolved to support action readiness (or action tendencies), so that given the right combination of external factors, it would lead to adaptive behaviors. As such, memory biases may be reflective of the frame of minds that emerge given a combination of situational factors, or are life history sensitive. These memory biases may be indicative of the general state of mind that serve adaptive purpose at certain periods in life such as bachelorhood.

Many cognitive biases are unconscious. For instance, even though men indicate that it is socially more costly to overestimate female sexual interest because of the ensuing conflict and embarrassment, their actual bias tend towards the costly (but adaptive) one (Haselton & Galperin, 2013). Correspondingly, social distancing can take place implicitly without any explicit indications. Remembering people who are unattractive may not necessarily lead to an active avoidance even though it may serve as an inventory of 'dealbroken' potential mates in

the person's mind. Thus, I do not expect a complete concordance between memory and behavioral tendencies. Nonetheless, the present findings demonstrated that memory biases can lead to behavioral tendencies for specific instances; contingent on facial attractiveness in the present research.

Recognition memory differences between men and women

Across both studies, women demonstrated better recognition compared to men, in terms of poorer accuracy, committing more false positives, and more false negatives, a finding that has been reported in previous research (Lewin & Herlitz, 2002; Rehnman & Herlitz, 2006, 2007). The current research extents on this finding by the observation that women were not only more accurate in recognizing faces compared to men, they also committed less false positive (study 1 and 2), and less false negative recognition (study 2). Interest may underlie this tendency, which can lead to a sense of familiarity (McKelvie, Standing, Jean, & Law, 1993; Monin, 2003). In particular, this interest pertains to the social domain where women and girls are more interested in and knowledgeable about the social aspects of the world, including decoding faces and cues associated with faces such as facial expressions (Connellan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2000; McClure, 2000; Taylor et al., 2000). This notion lends support to adaptive memory in that it benefits women to remember faces across different social domains (i.e., mating context, forming friendship, caring for children) compared to men because of their sexually differentiated roles in the ancestral hunter-gatherer milieu (Gavashelishvili & Tarkhnishvili, 2016; Silverman, Choi, & Peters, 2007).

While women's superiority in memory for faces could be explained in terms of general worse memory for faces among men, interaction effects observed in both studies suggest that there is more than a general cognitive advantage among women. Particularly, while men were poorer on all counts of memory for faces compared to women, men were

more accurate for unattractive faces on one hand, while committing greater false alarms for attractive female faces on another. Women however, did not show such a discrimination in both studies, except for false alarm bias in study 1. These observations are consistent with theories related to mate selection. For instance, false positives for attractive female faces among men can be accounted for by familiarity effects following feelings of interest (Monin, 2003). In particular, romantic interest activated by attractive female faces may have resulted in a sense of familiarity. Thus, causing the men to think that they have seen the attractive female faces more frequently compared to unattractive ones.

Alternative accounts for memory for faces

Taken together, the present data suggests that adaptive memory for faces may be sensitive to potential costs and benefits. Although attractive faces appear to augment memorability, the current research suggests this memory bias is dependent on target sex, observer sex, but not the context. Alternative accounts can potentially explain the attractiveness effect on memory for faces. In particular, it was proposed that attractive faces occupy the central portion of the prototypicality spectrum of faces which are more similar to one another compared to unattractive faces (Light et al., 1981; Potter & Corneille, 2008; Potter, Corneille, Ruys, & Rhodes, 2007). In addition, non-typicality, which is more characteristic of unattractive faces, account for the memorability of faces better than attractiveness (Sarno & Alley, 1997). Correspondingly, average looking faces are perceived to be more attractive than non-typical ones (Rhodes & Tremewan, 1996), and greater emotional arousal from viewing attractive faces compared to unattractive faces may interrupt encoding processes resulting in poorer memory for attractive faces (Wiese et al., 2014). Overperception bias toward attractive faces might result from a tendency to perceive attractive faces as familiar (Monin, 2003), and vice versa (DeBruine, 2004). While these processes could be proximate mechanisms that underlie the current evolutionary explanations

for memory of faces, proximate explanations cannot account for the sex dependent attractiveness effect observed in the current and previous studies. For instance, it remains unclear if men are more emotionally aroused (proximate mechanism of aversion) towards unattractive faces compared to women. This gap between evolutionary and proximate explanations is also evident in the current observation that accuracy for unattractive faces, and false positive for attractive faces were greater compared to the counterparts.

Practical implications

The modern dating scene is largely made up of dating apps (e.g., OKCupid, Tinder, Grindr), speed dating, and club partying, where rapid encounters with potential mates is similar to the present experimental set up. In particular, these dating contexts consist of ten to twenty individuals with interaction lasting from seconds to minutes. Potential mates are selected within a very tight time frame. As such, evolution theories applied to a modern context can provide insights between the interaction of a stone age brain and the modern milieu. The present research found that the facial attractiveness effect is present more prominently among men than women, and this may have implications in terms of later approach and avoidant tendencies. Given that women have better memory for faces, and men tend to discriminate based on facial attractiveness, there may be dissociation between women and men's interaction styles. For instance, women may spend equal level of effort in knowing potential mates while men may be more selective in allocating their effort across different potential mates.

The current mode of analysis using the EMT built on evolutionary theories provides explanations for sexually differentiated behaviors that are hard to explain using domain-general memory models. For instance, men seem to find attractive women more familiar than unattractive ones. Although men may knowingly pretend to find attractive women familiar and approach them, underlying memory biases can provide the impetus for such behaviors.

However, women do not have such a memory or behavioral bias. The current findings suggest that these behaviors may be facilitated by false memory biases, especially among men.

Limitations and Future Directions

The present research has a number of limitations that I address in this section. Notwithstanding these limitations, the current findings will inform new directions in memory research which can potentially fill in gaps identified herein.

I examined the effect of short-term and long-term mating in two separate studies. Future studies can include both forms of mating strategies within the same study to compare the relative effects between short-term and long-term mating induction, and investigate within-individual changes for memory of potential mate faces when different mating strategies are activated. Considering that theorists previously proposed that cognitive biases are dependent on the type of fundamental motives activated (Griskevicius et al., 2007; Kenrick et al., 2010; Maner et al., 2005; Schaller et al., 2017), insights on memory biases for faces can be furnished by studies that involve various contextual manipulation. For instance, it is not certain whether memory for attractive opposite sex individuals would attenuate correspondingly when someone becomes a parent.

A related limitation is that the scenarios used in the current studies to induce mating motivation were shorter than scenarios used in past research (Griskevicius, Cialdini, & Kenrick, 2006; Griskevicius et al., 2007). This could explain why there was no contextual effect on memory for faces when contextual manipulation in past research influenced subsequent behaviors such as greater conspicuous spending among men who were exposed to mating induction (Griskevicius et al., 2007). Nonetheless, manipulation checks in the current studies indicate that participants did understood and remember the scenario. This suggests that participants did not sufficiently feel that they were in a mating motivated state, or mating

motive influence related behaviors more than memory for faces. These potential explanations remain to be investigated in future research, particularly research that include longer and deeper mating induction, or recruit participants who are personally invested in finding mates.

In relation to contextual effect, the present research focused on survival threats in the environment. Past studies showed that the effect of environmental threats on attractiveness may be different depending on the type of threats posed (Pettijohn Ii & Tesser, 1999; Webster, 2008). For instance, the presence of socioeconomic threats (versus survival threats) leads to a preference for actresses with neonatal features instead of mature features (i.e., small eyes, thin cheeks, and large chins) (Pettijohn Ii & Tesser, 1999). Considering that socioeconomic threats are more salient in the modern environment, the facial attractiveness effect may be stronger for contextual manipulations that include socioeconomic threats rather than environmental threats.

The present research only examined Asian participants' memory for Asian faces. While the present findings are similar to those studies based on Western populations using Caucasian faces (Maner et al., 2007; Savine et al., 2011; Silva et al., 2016), it is uncertain if cross-cultural similarities would be observed. At least one study demonstrated that women outperformed men in terms of their memory for faces, regardless of the ethnicity of the face (Rehnman & Herlitz, 2007). It remains unclear if facial attractiveness across different ethnicities would produce similar memory patterns.

The present research focused on memory for faces with respect to facial attractiveness, and found that facial attractiveness effect is particularly prominent in men but not among women. Although women assess male mate value based on facial attractiveness under certain contexts such as their ovulation phase (Anderson et al., 2010; Durante et al., 2010; Pillsworth & Haselton, 2006), women generally place greater emphasis on potential mates' resources (Li et al., 2002; Li & Kenrick, 2006). Thus, future research can enlighten

the sexual selection literature by examining the effect of mate resources on women's memory for male faces with different levels of attractiveness.

Chapter 4: Conclusion

The dating scene has change tremendously in the last century, and with greater freedom in the mating scene, research at the intersection of adaptation and the modern mate selection arena represent a pursuit that can provide insight into how modern men and women form romantic bonds. It is worth mentioning that research using speed dating or mobile dating apps have higher ecological validity because these are tools that modern young adults use.

The present research further informs the mate selection literature by considering remembering and misremembering of potential mates' faces. In addition, by including both male and female participants, and viewing both same- and opposite-sex faces of varying attractiveness, the current research augmented our understanding facial attractiveness plays in our memory for faces. The current findings demonstrate that context did not affect any aspect of memory for faces. This is consistent with past research which found that survival processing advantage does not generalize to facial stimuli (Savine et al., 2011). On the other hand, observer's sex, and the inherent characteristics of the face (i.e., attractiveness, sex) contribute or impede memory in adaptive ways, suggesting that human memory evolved to solve adaptive problems that recur in the ancestral milieu. This notion fits with a growing body of evidence that support the functionalist perspective on memory, including mating contexts (D. S. Smith et al., 2013). In particular, the present research suggests that remembering (and misremembering) faces based on the attractiveness and sex is domain specific, relevant to enhancing reproductive fitness.

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Tables

Table 1. Memory biases related to the male sexual overperception bias and the female underperception bias.

	Study phase	
Test phase	Faces presented	Faces not presented
Old	Hits (i.e., true positives)	*Male sexual overperception bias*: False alarms (i.e., false positives)
New	*Female sexual underperception bias*: Misses (i.e., false negatives)	Correct rejections (i.e., true negatives)

In the study phase, "faces presented" refers to faces shown while "faces not presented" refers to faces not shown when the participants were rating the faces. Under test phase, "old" refers to participants indicating that a face was present during the study phase, while "new" refers to participants indicating that a face was not present during the study phase.

Table 2. Manipulation check based on the survival (*n* = 176) and moving (*n* = 173) scenarios the participants read.

Question	Survival (grassland)	Moving (city)	*F*	*d*
1. The scenario contains elements that suggest the environment is not safe	3.44 (1.07)	2.53 (1.16)	57.9*	0.82
2. The scenario contains elements that are psychologically disturbing.	2.64 (1.06)	2.17 (1.00)	18.5*	0.46
3. I would enjoy living in the type of environment described in the scenario.	2.33 (1.08)	3.01 (1.00)	36.8*	0.67
4. I would enjoy living with the people I rated in the type of environment described in the scenario.	2.07 (0.94)	2.23 (1.00)	2.2	0.17

Table 3. Manipulation check based on participants' memory for elements present in survival scenario (n = 87), mating scenario (n = 100), and attractiveness condition (n = 88).

Question	Survival (grassland)	Mating	Attractiveness (control)	χ^2
1. The scenario involved grasslands.	83.9%	11.0%	11.4%	139.87*
2. The scenario involved predators, and a lack of food and water.	74.7%	10.0%	8.0%	122.66*
3. The scenario involved a potential romantic partner.	25.3%	90.0%	56.8%	80.72*
4. The scenario involved dating someone desirable.	16.1%	83.0%	50.0%	83.45*
5. The scenario involved rating faces for attractiveness.	20.7%	82.0%	89.8%	111.66*

Percentages in the cells refer to the percentage of participants who responded 'true'. Pearson chi-square tests χ^2, were based on $p < .001$.

Figures

Figure 1. Memory of potential mates is influenced by the facial characteristics (i.e., sex, attractiveness) and context (i.e., presences of survival threats, mating motivation).

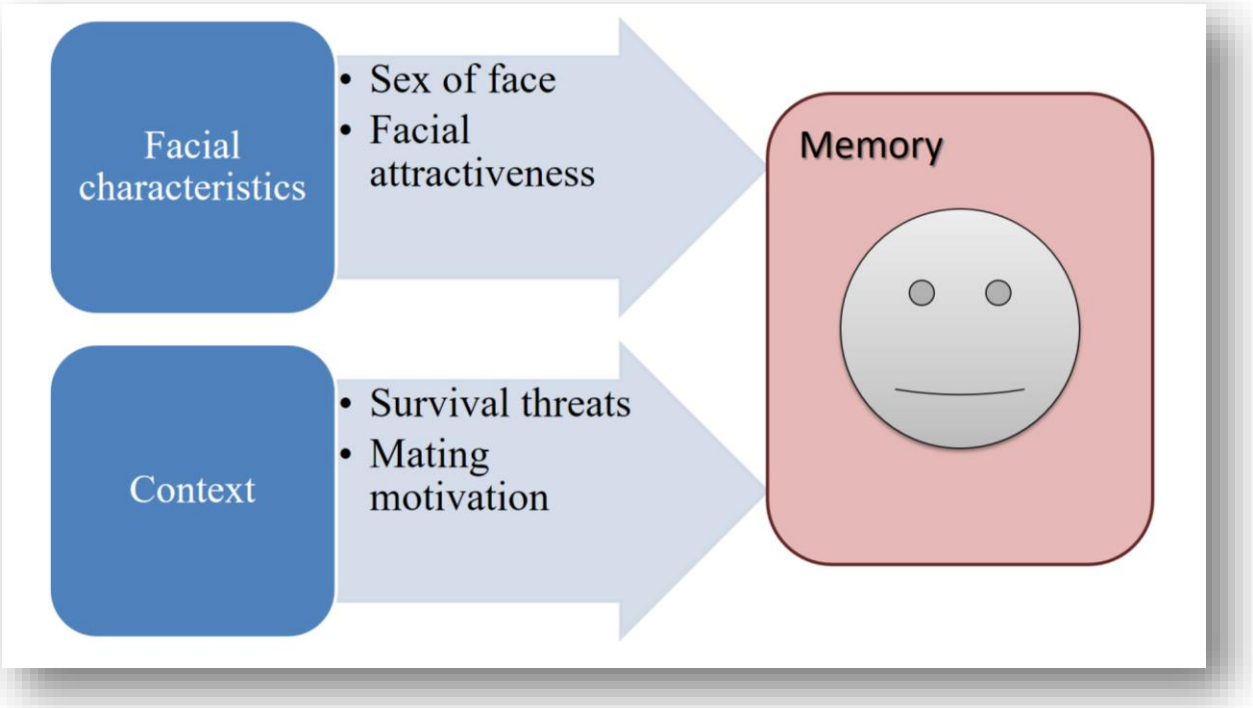


Figure 2. Accuracy rate for faces as a function of encoding context and facial attractiveness.

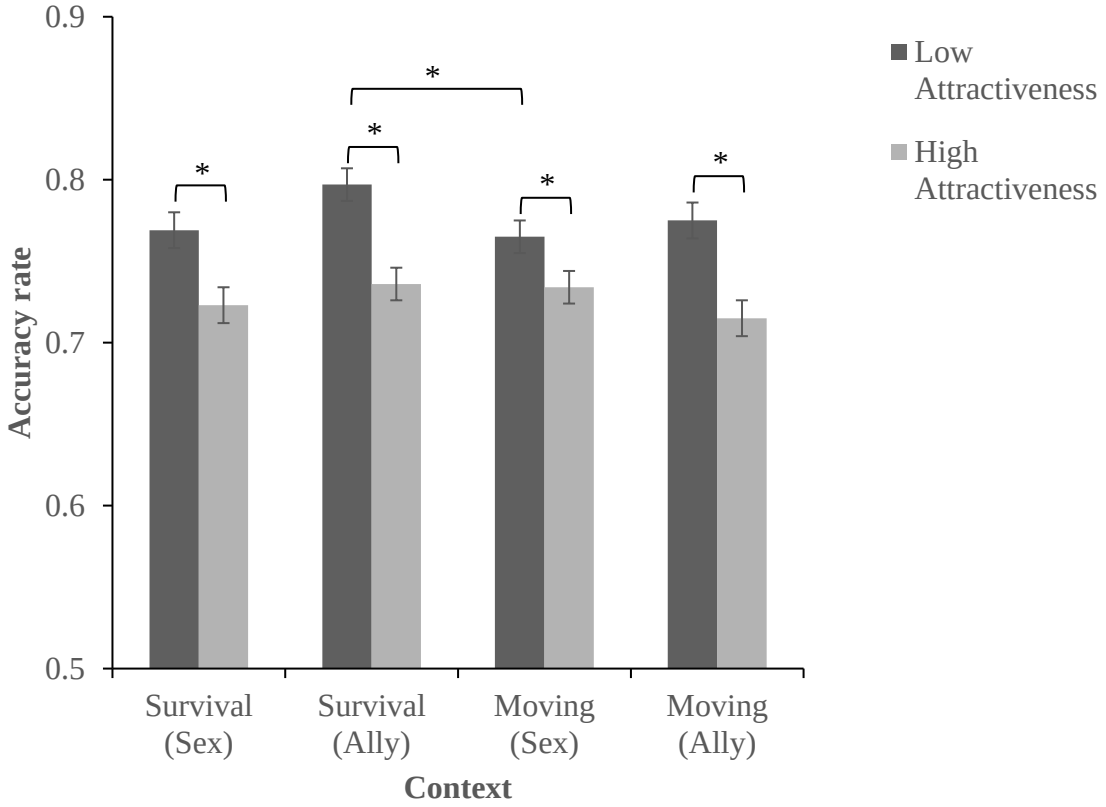


Figure 3. Overperception bias rate for faces as a function of target sex and facial attractiveness among men.

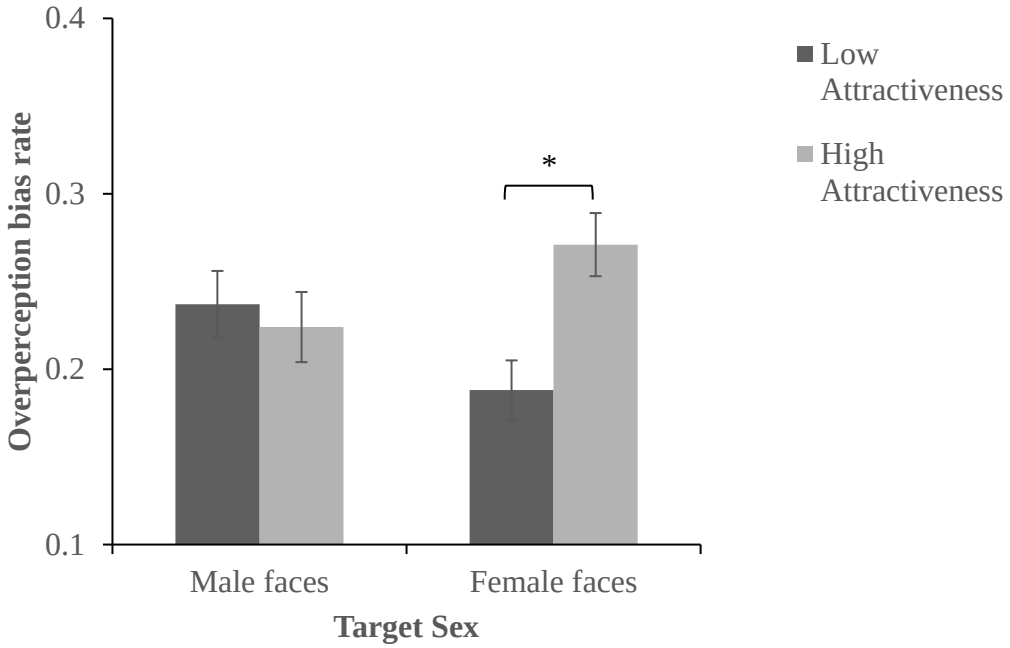


Figure 4. Overperception bias rate for faces as a function of target sex and facial attractiveness among women.

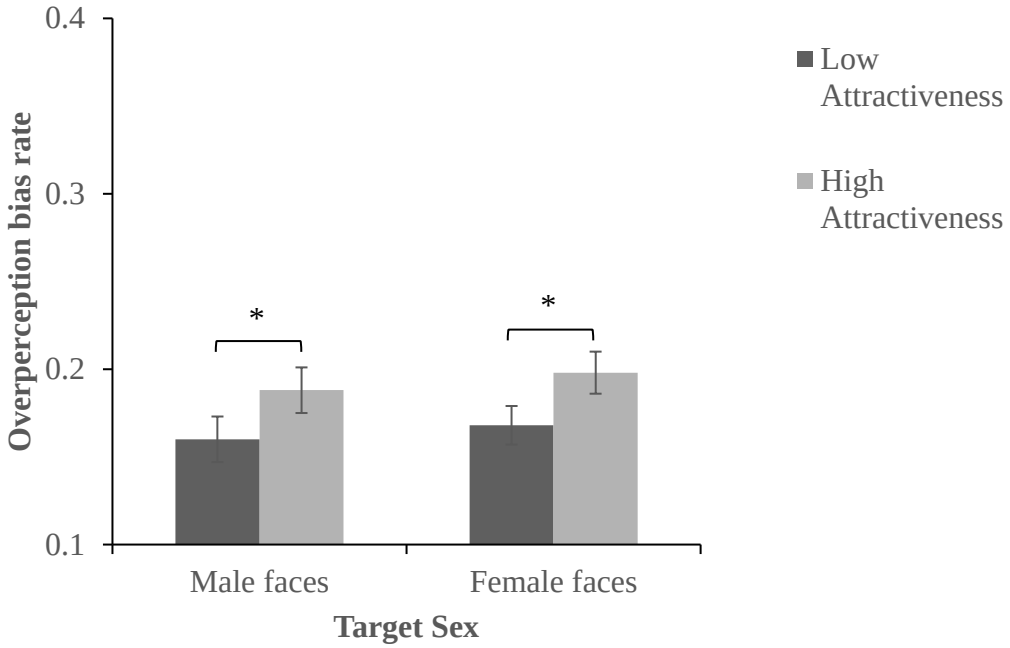


Figure 5. Underperception bias rate for faces as a function of context and target sex.

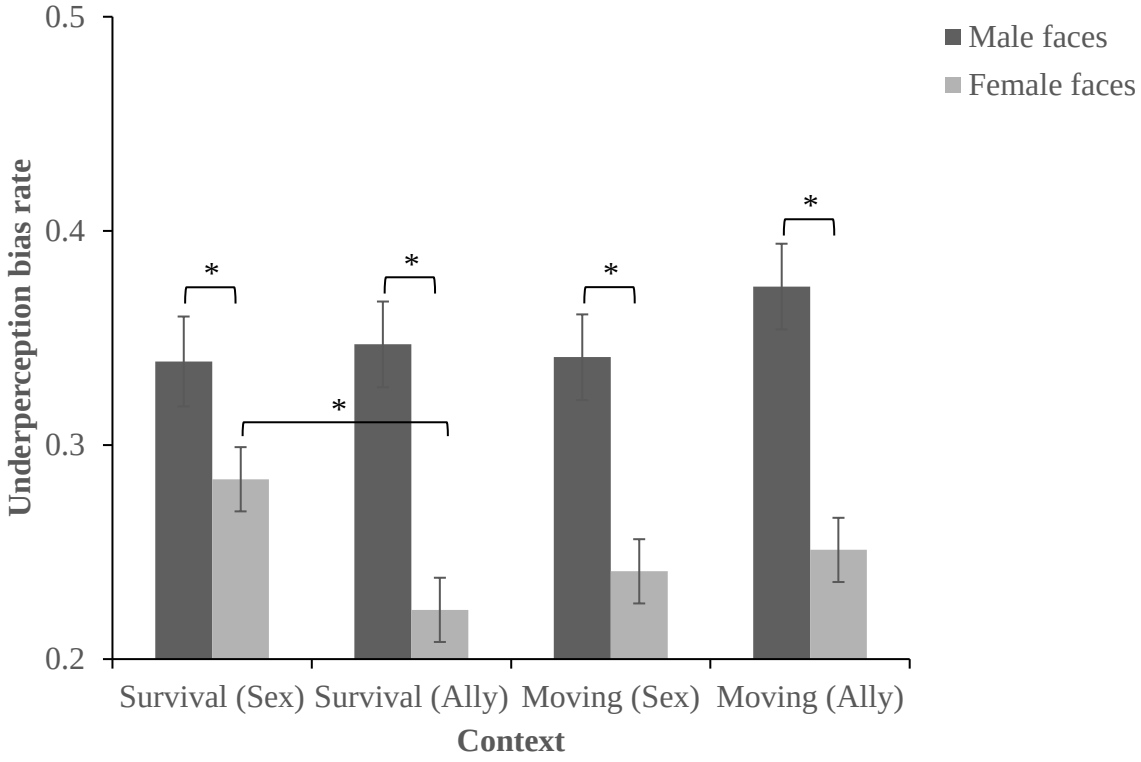


Figure 6. Underperception bias rate for faces as a function of attractiveness and context.

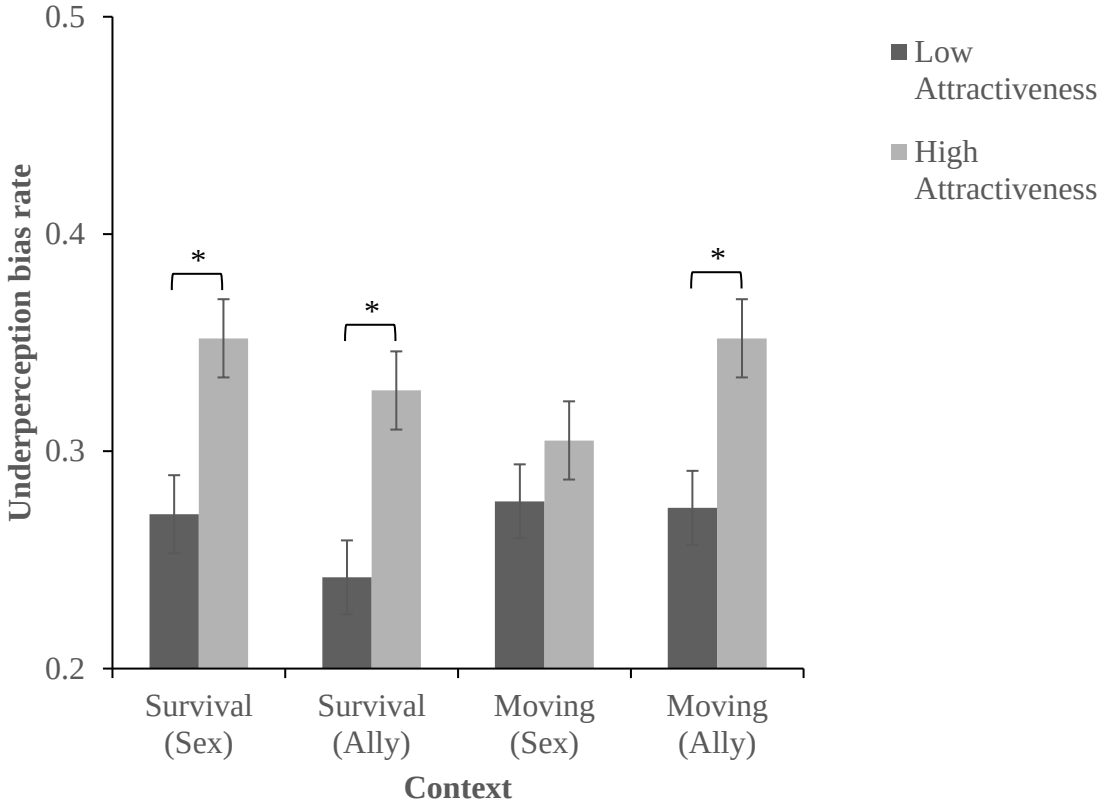


Figure 7. Underperception bias rate for faces as a function of attractiveness and target sex.

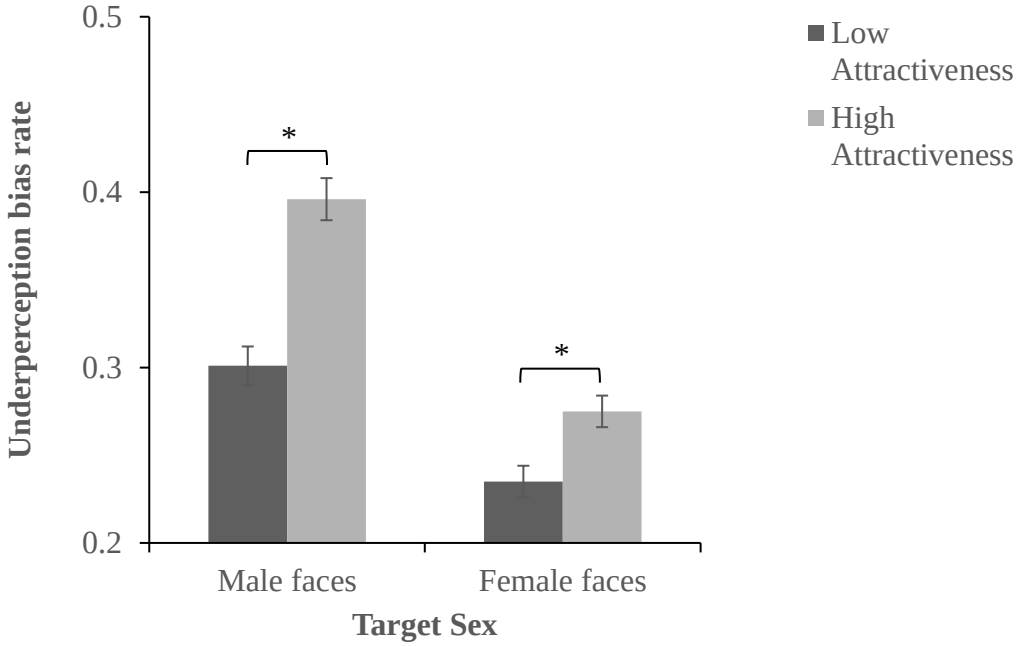


Figure 8. Accuracy rate for faces as a function of facial attractiveness and participant sex.

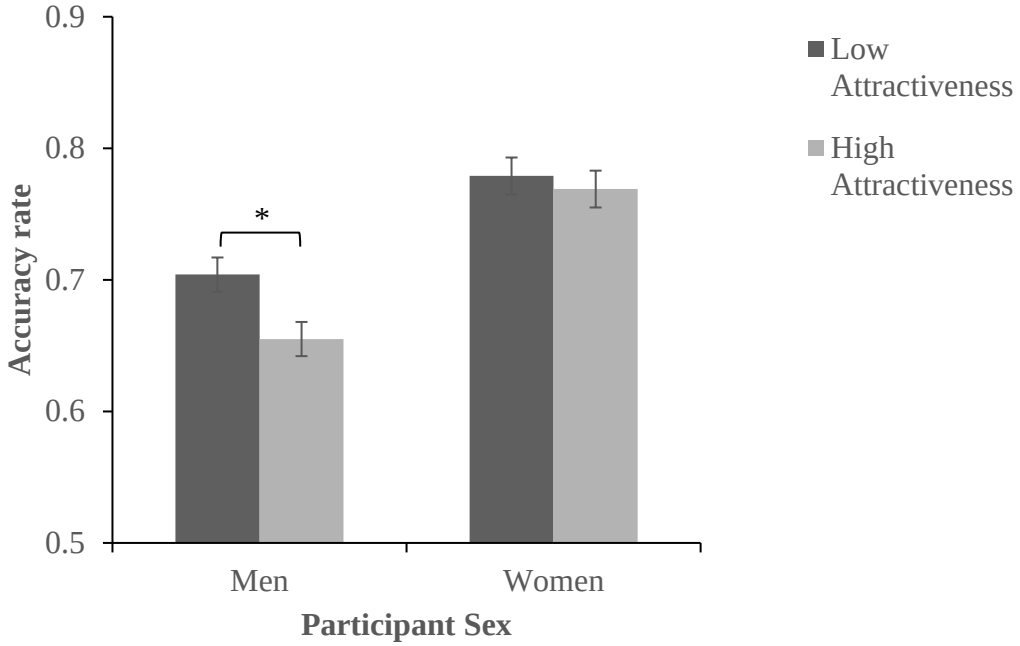
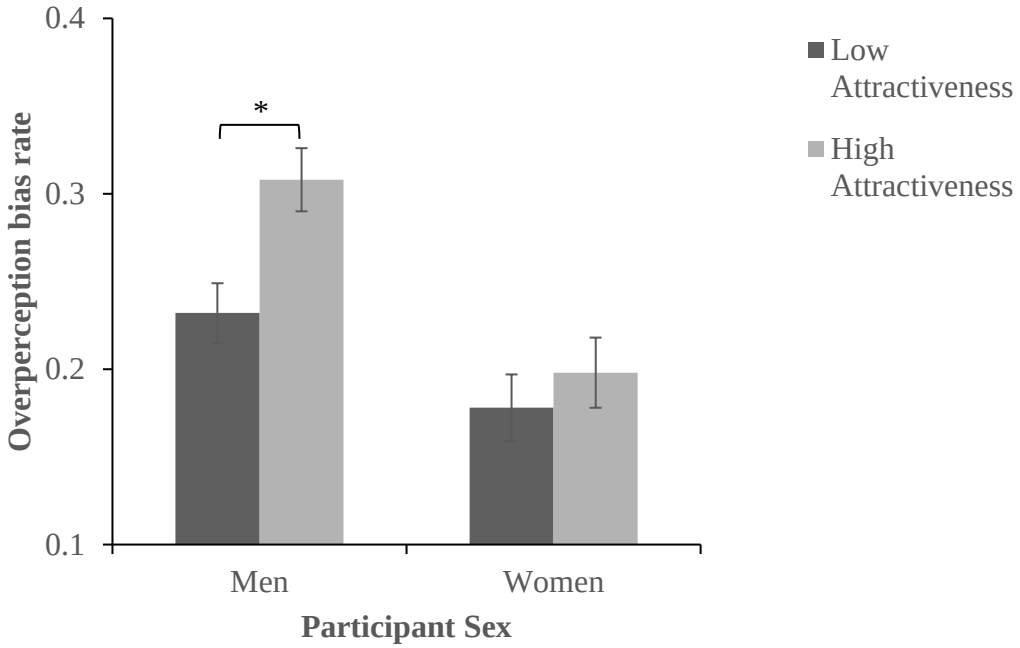


Figure 9. Overperception bias rate for faces as a function of facial attractiveness and participant sex.



Appendix A

Pretest study

To obtain facial attractiveness ratings for the purpose of selecting attractive and unattractive faces for the main research, I conducted a pretest study on a separate group of participants from the same cohort. In order to control for potential confounding variables, the ratings for emotional valence, distinctiveness (i.e., whether the face is a common or unique face) and masculinity-femininity were concurrently obtained.

Method

Thirteen male participants (ages 20-24, M = 21.92, SD = 1.12) and 38 female participants (ages 18-26, M = 20.39, SD = 1.64) rated 90 male and 90 female anonymous faces. These faces were obtained from the Asian Emotion Database (Wong & Cho, 2009; Wong & Cho, 2007), the Matsumoto and Ekman's Japanese faces (Matsumoto & Ekman, 1988), and the CAS-PEAL-R1 face database collected under the sponsor of the Chinese National Hi-Tech Program and ISVISION Tech. Co. Ltd. (Gao et al., 2008). The faces were cropped to remove clothing, accessories or hairstyle information. Each facial image measures 450 × 500 pixels. The ratings were based on a 7-point Likert-type scale on the following dimensions: attractiveness (very unattractive – very attractive), emotionality (very negative – very positive), distinctiveness (very common – very unique), and masculinity-femininity (very masculine – very feminine).

Procedure

The participants were tested in groups of between three to ten individuals. They were asked to rate the 180 faces that were individually presented in random order based on the four rating scales.

Results

I conducted a three-way multivariate analysis of variance (MANOVA) on the ratings for each dimension (i.e., attractiveness, emotionality, distinctiveness, and masculinity-femininity) across two sets of faces (i.e., Set A, Set B), sex and attractiveness level (i.e., Low, High). Each set consists of 36 faces with equal number of male and female faces, giving a total of 72 faces selected from the initial 180 faces. The purpose of having these two sets of faces is to ensure that the dimensions are controlled for between the faces displayed during the study phase and those added during the recognition phase in the main research. Significant main effects were observed for the attractiveness level and masculinity-femininity dimensions. Faces selected for low attractiveness (M = 2.72, SD = 0.26) is significantly less attractive than those selected for high attractiveness (M = 3.55, SD = 0.33), $F(1, 64) = 129.89$, $p < .001$, $MSE = .095$, $\eta^2_p = .67$. These differences did not differ across the sets and sexes. Female faces (M = 4.29, SD = 0.06) are significantly more feminine than male faces (M = 2.97, SD = 0.06), $F(1, 64) = 227.42$, $p < .001$, $MSE = .138$, $\eta^2_p = .78$. This difference did not differ between the two sets. No other main effects or interaction effects were observed. The table shows the properties between the two sets of male and female faces.

Table. Properties of the faces based on an independent norming study.

	Male		Female	
	Set A	Set B	Set A	Set B
Attractiveness	3.14 (0.51)	3.14 (0.54)	3.14 (0.52)	3.14 (0.52)
Emotionality	3.76 (0.61)	3.63 (0.39)	3.86 (0.65)	3.93 (0.65)
Distinctiveness	3.52 (0.31)	3.58 (0.31)	3.70 (0.40)	3.59 (0.31)
Masculinity-Femininity*	2.93 (0.31)	3.00 (0.35)	4.32 (0.63)	4.25 (0.63)

*Significant difference between the male and female faces at $p <. 001$.

Appendix B: Secondary analysis for study 1

Relevance ratings

The relevance ratings as the dependent variables were analyzed and reported separately below. The relevance rate was submitted to a repeated-measures analysis of variance (ANOVA) with context (i.e., survival, moving), motive (i.e., ally, sex) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factors.

There was a main effect of attractiveness, $F(1, 341) = 339.48$, $p < .001$, $\eta^2_p = .50$, in which participants rated attractive faces ($M = 3.20$, $SD = 1.31$) as more relevant than unattractive faces ($M = 2.66$, $SD = 1.28$); a main effect of motive, $F(1, 341) = 769.51$, $p < .001$, $\eta^2_p = .70$, in which participants rated allies ($M = 4.01$, $SD = 0.58$) as more relevant than sexual mates ($M = 1.85$, $SD = 0.75$); and a main effect of participant's sex, $F(1, 341) = 4.83$, $p = .03$, $\eta^2_p = .01$, in which women ($M = 2.92$, $SD = 1.29$) rated the faces as more relevant than men ($M = 2.96$, $SD = 1.23$). There was no main effect of context, $F(1, 341) = 0.05$, $p = .82$ and no main effect of target's sex, $F(1, 341) = 0.20$, $p = .66$.

The means and standard deviations of the relevance rating as a function of participant sex, context (survival, moving), target's sex, and face attractiveness (low, high) are presented in Table B1.1. The effect of attractiveness was qualified by a three-way interaction with face sex and context, $F(1, 341) = 12.61$, $p < .001$, $\eta^2_p = .04$. In particular, follow-up tests revealed that male faces were consistently rated as more relevant compared to female faces except for attractive faces in the moving context, $t(172) = 0.06$, $p = .95$. In the survival context, attractive male faces were rated as more relevant compared to attractive female faces, $t(175) = 4.32$, $p < .001$, and unattractive male faces were rated as more relevant compared to unattractive female faces, $t(175) = 4.23$, $p < .001$. In the moving context, unattractive male

faces were rated as more relevant compared to unattractive female faces, $t(172) = 2.91$, $p < .01$.

Table B1.1. Mean (standard deviation) relevance rating for men and women between different context (survival, moving) for the four types of facial stimuli.

	Men		Women	
	Survival (n = 46)	Moving (n = 60)	Survival (n = 130)	Moving (n = 113)
Unattractive male	2.64 (1.49)	2.71 (1.58)	2.92 (1.35)	2.66 (1.37)
Attractive male	3.02 (1.66)	2.89 (1.70)	3.61 (1.40)	3.27 (1.40)
Unattractive female	2.67 (1.00)	2.71 (1.26)	2.54 (1.27)	2.44 (1.32)
Attractive female	3.34 (1.09)	3.64 (1.17)	2.93 (1.48)	2.88 (1.51)

The means and standard deviations of the relevance rating as a function of participant sex, motive (ally, sex), target's sex, and face attractiveness (low, high) are presented in Table B1.2. The effect of attractiveness was qualified by a three-way interaction with target's sex and motive, $F(1, 341) = 13.14$, $p < .001$, $\eta^2_p = .04$. In particular, follow-up tests revealed that male faces were consistently rated as more relevant compared to female faces except for attractive faces for the sex motive, $t(174) = 1.01$, $p = .31$. For the ally motive, attractive male faces were rated as more relevant compared to attractive female faces, $t(173) = 3.84$, $p < .001$, and unattractive male faces were rated as more relevant compared to unattractive female faces, $t(173) = 4.86$, $p < .001$. For the sex motive, unattractive male faces were rated as more relevant compared to unattractive female faces, $t(174) = 2.35$, $p = .02$.

Table B1.2. Mean (standard deviation) relevance rating for men and women between different motive (ally, sex) for the four types of facial stimuli.

	Men		Women	
	Ally (n = 60)	Sex (n = 46)	Ally (n = 114)	Sex (n = 129)
Unattractive male	3.89 (0.82)	1.10 (0.24)	3.92 (0.87)	1.82 (0.86)
Attractive male	4.26 (0.86)	1.23 (0.52)	4.48 (0.73)	2.54 (1.22)
Unattractive female	3.52 (0.65)	1.63 (0.66)	3.68 (0.68)	1.45 (0.64)
Attractive female	4.01 (0.75)	2.85 (1.22)	4.15 (0.81)	1.81 (1.02)

In line with an opposite-sex preference (given that the participants in the analysis are heterosexuals), we found a three-way interaction among participant sex, motive, and target's sex, $F(1, 341) = 76.46$, $p < .001$, $\eta^2_p = .18$. In particular, follow-up tests revealed that for sex motive, male faces were rated as more relevant for women compared to men, $t(172.98) = 9.81$, $p < .001$, while female faces were rated as more relevant for men compared to women, $t(173) = 4.35$, $p < .001$.

Similarly, a three-way interaction was observed for participant sex, attractiveness, and target's sex, $F(1, 341) = 76.44$, $p < .001$, $\eta^2_p = .18$. Among men, attractive female faces received higher relevance ratings compared to attractive male faces, $t(104) = 3.79$, $p < .001$. However, no difference was observed between unattractive female and male faces, $t(105) = 0.20$, $p = .85$. Among women, attractive male faces received higher relevance ratings compared to attractive female ratings, $t(242) = 8.19$, $p < .001$, and unattractive male faces had higher relevance ratings compared to unattractive female ratings, $t(242) = 6.70$, $p < .001$.

An interaction between context and motive was observed, $F(1, 341) = 5.08$, $p = .025$, $\eta^2_p = .015$. In particular, the relevance ratings were higher when the participants rated faces as

allies compared to sexual partner for both the survival, $t(157.98) = 18.47$, $p < .001$, and moving contexts, $t(166.09) = 25.10$, $p < .001$.

Sexual strategy and facial memory

Pearson product-moment correlation coefficients were computed to assess the relationship between Sociosexuality Orientation Index (SOI) and memory for faces. There were positive correlation between men's SOI (M = 26.23, SD = 13.62) and hits for attractive male faces (M = 0.59, SD = 0.24), r = .25, p = .01, n = 106, and a positive correlation between men's SOI and false alarms for unattractive female faces (M = 0.19, SD = 0.18), r = .27, p < .01, n = 106.

The SOI score was entered as covariate in a mixed-model ANCOVA to examine the relationships among context (i.e., survival, moving), motive (i.e., ally, sex) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factors, with hit rate as the dependent variable.

After controlling for participants' SOI score, there was a main effect of attractiveness, F(1, 340) = 16.87, p < .001, η^2_p = .05. Participants recognized unattractive faces (M = 0.73, SD = 0.16) more frequently than attractive faces (M = 0.66, SD = 0.16). In addition, a main effect of target's sex was observed, F(1, 340) = 39.61, p < .001, η^2_p = .10, in which female faces (M = 0.75, SD = 0.14) were recognized more frequently than male faces (M = 0.65, SD = 0.14). There was no main effect of participant sex, F(1, 340) = 0.11, p = .74, no main effect for context, F(1, 340) = 0.33, p = .57, and no main effect for motive, F(1, 340) = 0.00, p = .99.

After controlling for participants' SOI score, the effect of attractiveness was qualified by a three-way interaction with participant sex and motive, F(1, 340) = 7.66, p < .01, η^2_p = .02. Specifically, follow-up tests revealed that among women, unattractive female faces were recognized more frequently for the ally motive compared to the sex motive, t(241) = 2.8, p < .01, while unattractive male faces were recognized more frequently for the sex motive

compared to the ally motive, $t(241) = 2.18$, $p = .03$. The findings suggest that generally, unattractive faces were more memorable relative to attractive faces.

A three-way interaction among target's sex, participant sex, and motive was also observed, $F(1, 340) = 5.16$, $p = .02$, $\eta^2_p = .02$. In particular, follow-up tests revealed that among women, female faces were recognized more frequently for the ally motive compared to the sex motive, $t(241) = 2.20$, $p = .03$. In addition, there was a significant two-way interaction between target's sex and participant sex, $F(1, 340) = 6.28$, $p = .01$, $\eta^2_p = .02$. In particular, female faces were recognized more frequently compared to male faces among both men, $t(105) = 7.48$, $p < .001$, and women, $t(242) = 7.68$, $p < .001$, suggesting that women compared to men, may function more pertinently as adaptive partners across different social contexts.

The SOI score was also entered as covariate in a mixed-model ANCOVA to examine the relationships among context (i.e., survival, moving), motive (i.e., ally, sex) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factors, with false alarm rate as the dependent variable.

There was a marginal significant main effect of attractiveness, $F(1, 340) = 3.37$, $p = .07$, $\eta^2_p = .01$. Consistent with the literature, participants falsely recognized attractive faces ($M = 0.21$, $SD = 0.17$) more frequently than unattractive faces ($M = 0.18$, $SD = 0.16$). In addition, a main effect of participant's sex was observed, $F(1, 340) = 6.47$, $p = .01$, $\eta^2_p = .02$, in which men ($M = 0.23$, $SD = 0.16$) made more false recognition than women ($M = 0.18$, $SD = 0.14$). There was no main effect of target sex, $F(1, 340) = 0.31$, $p = .58$, no main effect for context, $F(1, 340) = 0.003$, $p = .85$, and no main effect for motive, $F(1, 340) = 1.13$, $p = .29$.

The effect of attractiveness was qualified by a three-way interaction with participant sex and target sex, $F(1, 340) = 10.57$, $p < .01$, $\eta^2_p = .03$. Specifically, follow-up tests revealed

that among men, attractive female faces were falsely recognized more frequently compared to the unattractive female faces, $t(105) = 4.35$, $p < .001$. Among women, attractive male faces were also falsely recognized more frequently compared to unattractive male faces, $t(242) = 2.65$, $p < .01$, and attractive female faces were falsely recognized more frequently compared to unattractive female faces, $t(242) = 2.54$, $p = .01$.

Taken together, including SOI scores as a covariate did not alter the findings for hit rates reported above. Similarly, SOI score as covariate did not alter the findings for false alarm rates.

Signal Detection Theory

Using the signal detection theory procedure (MacMillan & Creelman, 1991, 2005), I computed and analyzed sensitivity (*d'*) measure, which can be interpreted as a participant's ability to discriminate old (i.e., rated) faces from new faces (i.e., foils). I adjusted the raw hits and false alarms to eliminate values of 0 or 1. Then, a z-transformation[4] was performed to convert the hit and false alarm rates into z-scores. The sensitivity measure (*d'*) was calculated using the formula, *d'* = z(Hits) – z(False alarms).

The participants' *d'* scores were submitted to a repeated-measures mixed-factor ANOVA with context (i.e., survival, moving), motive (i.e., ally, sex) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factor. I found a significant main effect of participant sex, $F(1, 341) = 3.96$, $p = .05$, $\eta^2_p = .01$, which indicated that women were more sensitive to the faces compared to men. I also found an interaction between motive and facial attractiveness, $F(1, 341) = 8.12$, $p < .01$, $\eta^2_p = .02$. Follow-up analysis showed marginal significance in the ally motive condition where participants were more sensitive to unattractive faces compared to attractive faces, $t(173) = 1.71$, $p = .09$, while participants in the sex motive condition were more sensitive to the attractive faces compared to the unattractive faces, $t(174) = 1.83$, $p = .07$.

[4] A range of values is cast as a normal distribution, with standard deviations around the mean. The mean value is set to 0, and the range of most values is about 3 standard deviations above and below the mean. So each value is some number of SD units above or below the mean. This transform is valuable in allowing comparison of measures with different ranges of absolute values, and in taking into account the inherent variability of different measures (http://www.linguistics.ucla.edu/faciliti/facilities/statistics/dprime.htm).

False recognition across simple contextual factors

The following data examines whether false recognition rate differs across contexts in terms of survival threats per se, and mating motivation per se.

Recognition rate

The effects of participant sex, target sex and attractiveness are further examined in terms of survival processing and observer motive. In particular, the hit rate was submitted to a repeated-measures ANOVA with context (i.e., survival, moving), motive (i.e., ally, sex) and the participant sex as between-group factors, and the target sex and facial attractiveness (i.e., low, high) as within-participant factors.

There was a main effect of attractiveness, $F(1, 341) = 54.32$, $p < .001$, $\eta^2_p = .14$. Contrary to my hypothesis, participants recognized unattractive faces ($M = 0.73$, $SD = 0.16$) more frequently than attractive faces ($M = 0.66$, $SD = 0.16$). In addition, a main effect of target sex was observed, $F(1, 341) = 109.48$, $p < .001$, $\eta^2_p = .24$, in which female faces ($M = 0.75$, $SD = 0.14$) were recognized more frequently than male faces ($M = 0.65$, $SD = 0.14$). There was no main effect of participant sex, $F(1, 341) = 0.41$, $p = .52$, no main effect for context, $F(1, 341) = 0.28$, $p = .60$, and no main effect for motive, $F(1, 341) = 0.00$, $p = .99$.

The means and standard deviations of the hit rates as a function of participant sex, context (survival, moving), target sex, and face attractiveness (low, high) are presented in Table 4a. The effect of attractiveness was qualified by a two-way interaction with target sex, $F(1, 341) = 10.32$, $p < .01$, $\eta^2_p = .03$. In particular, follow-up test revealed that female faces were recognized more frequently compared to male faces for both unattractive faces, $t(348) = 5.99$, $p < .001$, and attractive faces, $t(348) = 9.65$, $p < .001$, suggesting that attractiveness matters more in recognition for female target compared to male target. However, attractiveness, participant sex and target sex did not interact with context.

Table 4a. Mean (standard deviation) hit rates for men and women between different contexts (survival, moving) for the four types of facial stimuli.

	Men		Women	
	Survival (n =46)	Moving (n = 60)	Survival (n = 130)	Moving (n = 113)
Unattractive male	0.73 (0.25)	0.67 (0.20)	0.71 (0.19)	0.69 (0.21)
Attractive male	0.61 (0.25)	0.58 (0.23)	0.60 (0.23)	0.62 (0.21)
Unattractive female	0.78 (0.18)	0.79 (0.15)	0.77 (0.16)	0.75 (0.18)
Attractive female	0.73 (0.17)	0.76 (0.14)	0.71 (0.18)	0.73 (0.18)

The means and standard deviations of the hit rate as a function of participant sex, motive (ally, sex), target sex, and face attractiveness (low, high) are presented in Table 4b. The effect of attractiveness was qualified by a three-way interaction with participant sex and motive, $F(1, 341) = 7.8$, $p < .01$, $\eta^2_p = .02$. Specifically, follow-up tests revealed that among women, unattractive female faces were recognized more frequently for the ally motive compared to the sex motive, $t(241) = 2.8$, $p < .01$, while unattractive male faces were recognized more frequently for the sex motive compared to the ally motive, $t(241) = 2.18$, $p = .03$. The findings suggest that generally, unattractive faces were more memorable relative to attractive faces.

Table 4b. Mean (standard deviation) hit rates for men and women between different motives (ally, sex) for the four types of facial stimuli.

	Men		Women	
	Ally (*n* = 60)	Sex (*n* = 46)	Ally (*n* = 114)	Sex (*n* = 129)
Unattractive male	0.72 (0.21)	0.65 (0.25)	0.67 (0.21)	0.73 (0.18)
Attractive male	0.57 (0.22)	0.63 (0.25)	0.60 (0.22)	0.61 (0.22)
Unattractive female	0.79 (0.16)	0.77 (0.17)	0.79 (0.16)	0.73 (0.17)
Attractive female	0.73 (0.16)	0.77 (0.15)	0.73 (0.18)	0.71 (0.18)

A three-way interaction among target sex, participant sex, and motive was also observed, $F(1, 341) = 4.87$, $p = .03$, $\eta^2_p = .01$. In particular, follow-up tests revealed that among women, female faces were recognized more frequently for the ally motive compared to the sex motive, $t(241) = 2.20$, $p = .03$. In addition, there was a marginal significant two-way interaction between target sex and participant sex, $F(1, 341) = 3.37$, $p = .07$, $\eta^2_p = .01$. In particular, female faces were recognized more frequently compared to male faces among both men, $t(105) = 7.48$, $p < .001$, and women, $t(242) = 7.68$, $p < .001$, suggesting that women compared to men, may function more pertinently as adaptive partners across different social contexts.

Taken together, recognition rate data shows that context did not influence memory for potential mate faces, whether in isolation as main effect or in terms of the attractiveness of the faces or the motive of the participant. Nonetheless, recognition for potential mate faces is influenced by facial attractiveness, observer motive, participant sex, and target sex.

False recognition

The participants' memory for faces was also examined based on erroneous recognition of faces (i.e., indicating they had seen a face when it did not previously appear).

False recognition of faces suggests that these faces, although not committed to memory, is adaptive in a survival and/or mating context. Thus, people tend to think they saw these faces even though they have never encounter them before. The false recognition rate was submitted to a repeated-measures analysis of variance (ANOVA) with context (i.e., survival, moving), motive (i.e., ally, sex) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factors.

There was a main effect of attractiveness, $F(1, 341) = 17.93$, $p < .001$, $\eta^2_p = .05$. Consistent with the literature, participants falsely recognized attractive faces ($M = 0.21$, $SD = 0.17$) more frequently than unattractive faces ($M = 0.18$, $SD = 0.16$). In addition, a main effect of participant's sex was observed, $F(1, 341) = 9.54$, $p < .01$, $\eta^2_p = .03$, in which men ($M = 0.23$, $SD = 0.16$) made more false recognition than women ($M = 0.18$, $SD = 0.14$). There was no main effect of target sex, $F(1, 341) = 0.07$, $p = .79$, no main effect for context, $F(1, 341) = 0.06$, $p = .80$, and no main effect for motive, $F(1, 341) = 1.13$, $p = .29$.

The effect of attractiveness was qualified by a three-way interaction with participant sex and target sex, $F(1, 341) = 9.99$, $p < .01$, $\eta^2_p = .03$. Specifically, follow-up tests revealed that among men, attractive female faces were falsely recognized more frequently compared to the unattractive female faces, $t(105) = 4.35$, $p < .001$. Among women, attractive male faces were also falsely recognized more frequently compared to unattractive male faces, $t(242) = 2.65$, $p < .01$, and attractive female faces were falsely recognized more frequently compared to unattractive female faces, $t(242) = 2.54$, $p = .01$.

Taken together, false recognition data also shows that context did not influence memory for potential mate faces, whether in isolation or moderated by attractiveness and motive of the participant. Nonetheless, false recognition data shows support for both intersexual attraction and intrasexual competition in terms of attractiveness, participant sex, and target sex.

False recognition across complex context

The following data analysis examines whether false recognition rate differs across contexts when considered in terms of dual priming (i.e., environmental threats, and mating motivation prime).

False recognition rate

The participants' memory for faces was also examined based on erroneous recognition of faces (i.e., indicating they had seen a face when it did not previously appear). False recognition of faces suggests that these faces, although not committed to memory, is adaptive in a survival mating context. Thus, people tend to think they saw these faces even though they have never encounter them before. The false recognition rate was submitted to a repeated-measures analysis of variance (ANOVA) with context (i.e., survival sex, survival ally, moving sex, moving ally) and the sex of the participant as the between-group factors, and the target's sex and facial attractiveness (i.e., low, high) as the within-participant factors.

There was a main effect of attractiveness, $F(1, 341) = 17.93$, $p < .001$, $\eta^2_p = .05$. Consistent with the literature, participants falsely recognized attractive faces ($M = 0.21$, $SD = 0.17$) more frequently than unattractive faces ($M = 0.18$, $SD = 0.16$). In addition, a main effect of participant's sex was observed, $F(1, 341) = 9.54$, $p < .01$, $\eta^2_p = .03$, in which men ($M = 0.23$, $SD = 0.16$) made more false recognition than women ($M = 0.18$, $SD = 0.14$). There was no main effect of target sex, $F(1, 341) = 0.07$, $p = .79$, and no main effect for context, $F(3, 341) = 0.42$ $p = .74$.

There was a significant interaction effect among attractiveness, participant sex and target sex, $F(1, 341) = 9.99$, $p < .01$, $\eta^2_p = .03$. To examine the simple effects, a MANOVA was conducted for attractiveness, participant sex, and target sex. *Post hoc* tests revealed that among men, attractive female faces were falsely recognized more frequently compared to the unattractive female faces, $F(1, 347) = 20.83$, $p < .001$, $\eta^2_p = .06$ (Figure 6a). Among women,

attractive male faces were also falsely recognized more frequently compared to unattractive male faces, $F(1, 347) = 6.94$, $p < .01$, $\eta^2_p = .02$, and attractive female faces were falsely recognized more frequently compared to unattractive female faces, $F(1, 347) = 6.19$, $p = .01$, $\eta^2_p = .02$ (Figure 6b).

Figure 6a. Mean proportions of faces falsely recognized as a function of target sex and attractiveness among men.

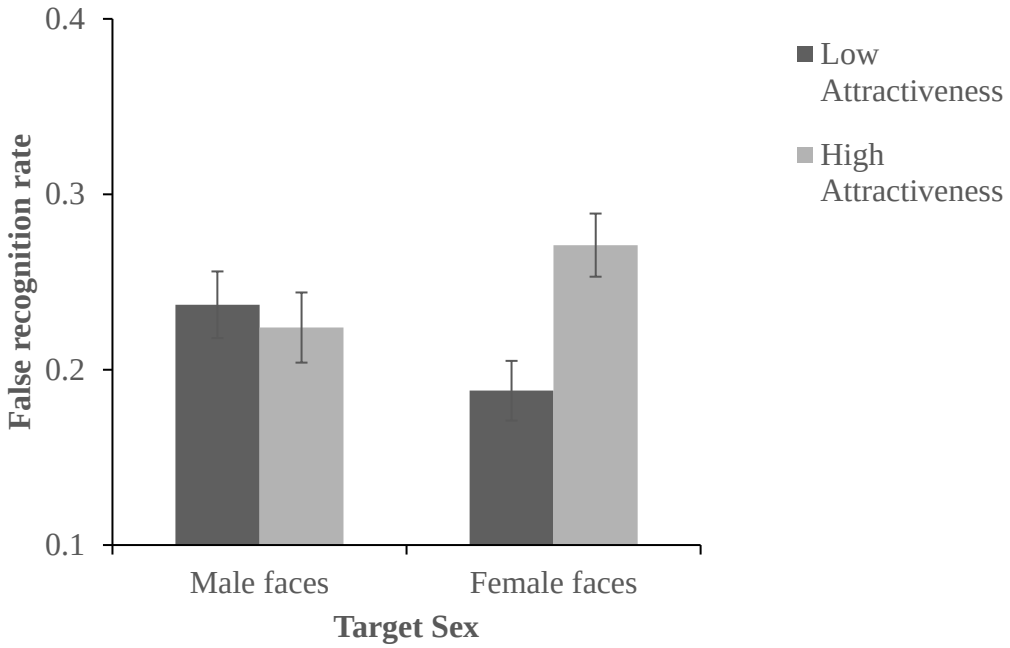
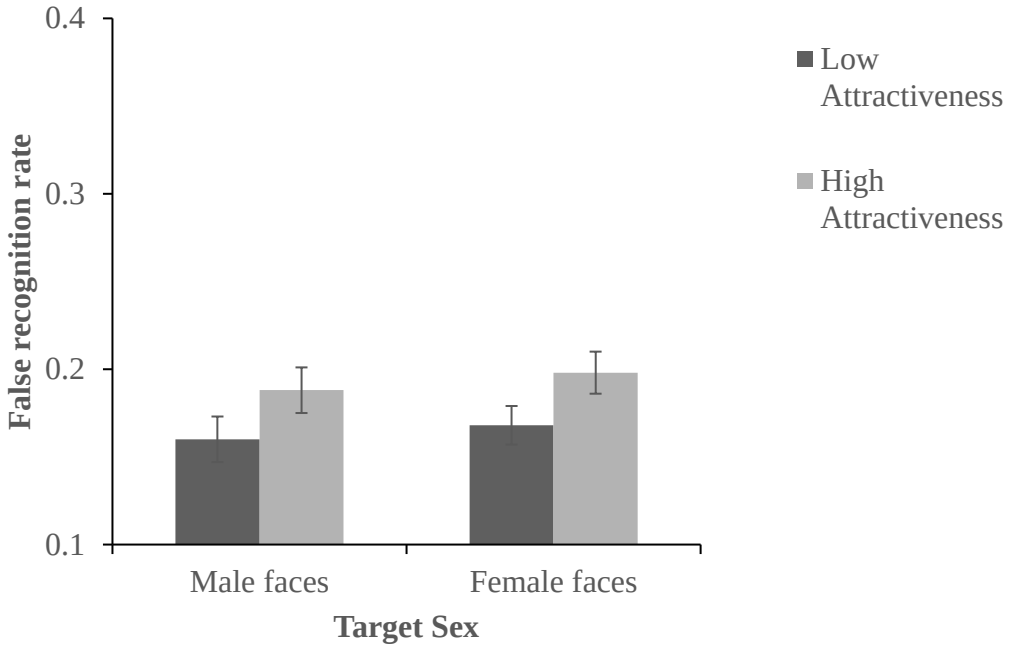


Figure 6b. Mean proportions of faces falsely recognized as a function of target sex and attractiveness among women.



Taken together, false recognition data also shows that context did not influence memory for potential mate faces, whether independently or in terms of attractiveness and sex of the participant and target. Nonetheless, false recognition data shows support for both intersexual attraction and intrasexual competition in relation to attractiveness, participant sex, and target sex.

Appendix C: Secondary analysis for study 2

Current long-term motivation effect on facial memory

Accuracy

Accuracy rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, facial attractiveness (i.e., low, high) as within-participant factors, and mating motivation as the covariate. There was a main effect of attractiveness, $F(1, 267) = 5.28$, $p = .02$, $\eta^2_p = .02$. Participants were more accurate for unattractive faces ($M = 0.74$, $SD = 0.17$) compared to attractive faces ($M = 0.71$, $SD = 0.17$). A main effect of participant sex was observed, $F(1, 267) = 29.39$, $p < .001$, $\eta^2_p = .10$, in which women ($M = 0.77$, $SD = 0.14$) were more accurate compared to men ($M = 0.68$, $SD = 0.15$). There was no significant main effect for context, $F(2, 267) = 1.00$, $p = .37$. Thus, participants who rated the faces in the survival context were not more accurate compared to those in the mating and control contexts.

There was a significant interaction effect between attractiveness and participant sex, $F(1, 267) = 5.85$, $p = .02$, $\eta^2_p = .02$.

Overperception bias

The overperception bias (OB) rate was submitted to a repeated-measures ANOVA with context and the participant sex as between-group factors, facial attractiveness (i.e., low, high) as within-participant factors, and mating motivation as the covariate. There was a marginal main effect of attractiveness, $F(1, 268) = 3.81$, $p = .05$, $\eta^2_p = .01$. Participants had higher OB rate for attractive faces ($M = 0.25$, $SD = 0.23$) compared to unattractive faces ($M = 0.21$, $SD = 0.21$). A main effect of participant sex was observed, $F(1, 268) = 11.27$, $p < .01$, $\eta^2_p = .04$, in which men ($M = 0.27$, $SD = 0.20$) had higher OB rate compared to women ($M = 0.19$, $SD = 0.17$). There was no significant main effect for context, $F(2, 268) = 0.11$, $p = .90$.

Thus, participants who rated the faces in the survival sex context did not have higher OB rates compared to those in the other two contexts.

There was a significant interaction effect between attractiveness and participant sex, $F(1, 268) = 5.30$, $p = .02$, $\eta^2_p = .02$.

Underperception bias

The underperception bias (UB) rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, facial attractiveness (i.e., low, high) as within-participant factors, and mating motivation as the covariate. There was a main effect for participant sex, $F(1, 267) = 22.54$, $p < .001$, $\eta^2_p = .08$, in which men ($M = 0.38$, $SD = 0.21$) had greater UB rates compared to women ($M = 0.26$, $SD = 0.18$). There was no significant main effect for attractiveness, $F(1, 267) = 1.28$, $p = .26$, and context, $F(2, 267) = 1.45$, $p = .24$.

Behavioral tendencies

To examine if memory effect was related to behavioral tendencies, I conducted a multivariate multiple regression analysis for true positives and false positives for attractive, and unattractive faces, while controlling for participant sex, context, and mating motivation. That is, I examine if the tendency to indicate a person as seen before would led to a greater tendency to approach the person.

For attractive faces, the results indicated that true positives did not predict behavioral tendency for these faces. However, higher false positives marginally predict higher approach tendencies ($\beta = .46$, $p = .09$), $R^2 = .20$, $F(10, 273) = 6.62$, $p < .001$.

For unattractive faces, higher true positives led to lower tendency to approach these faces ($\beta = .58$, $p = .04$), $R^2 = .28$, $F(10, 273) = 9.98$, $p < .001$. However, false positives did not predict behavioral tendency for these faces.

Marital status and facial memory

Accuracy

Accuracy rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. The results are split between those who were unattached (i.e., single, divorced, widowed), and those who were attached (i.e., dating, married). The findings are presented in table C1 below.

Table C1. Accuracy results for participants who were unattached and those who were attached.

Effect	Variable	Unattached	Attached
Main effects	Attractiveness	Unattractive > Attractive*	Unattractive > Attractive*
	Participant sex	Women > Men*	Women > Men*
	Context	n.s.	n.s.
Interaction effects	Attractiveness x Participant sex	*	**n.s.**

* refers to statistical tests that are significant at $p < .05$. Variables in bold means that the results differ from those which combine participants who were unattached and attached.

Overperception bias (OB)

OB rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. The results are split between those who were unattached, and those who were attached. The findings are presented in table C2 below.

Table C2. Overperception bias results for participants who were unattached and those who were attached.

Effect	Variable	Unattached	Attached
Main effects	Attractiveness	Attractive > Unattractive*	Attractive > Unattractive^
	Participant sex	Men > Women*	Men > Women^
	Context	n.s.	n.s.
Interaction effects	Attractiveness x Participant sex	**n.s.**	**n.s.**

*statistical tests that are significant at $p < .05$. ^statistical tests that are significant at $p < .10$.

Variables in bold means that the results differ from those which combine participants who were unattached and attached.

Underperception bias (UB)

UB rate was submitted to a repeated-measures analysis of variance (ANOVA) with context and the participant sex as between-group factors, and facial attractiveness (i.e., low, high) as within-participant factors. The results are split between those who were unattached, and those who were attached. The findings are presented in table C3 below.

Table C3. Underperception bias results for participants who were unattached and those who were attached.

Effect	Variable	Unattached	Attached
Main effects	Attractiveness	n.s.	n.s.
	Participant sex	**n.s.**	Men > Women*
	Context	n.s.	n.s.
Interaction effects	Attractiveness x Participant sex	n.s.	n.s.

*statistical tests that are significant at $p < .05$. Variables in bold means that the results differ from those which combine participants who were unattached and attached.

Memory effects on behavioral tendencies

To examine if memory effect was related to behavioral tendencies, I conducted a multivariate multiple regression analysis for true positives and false positives for attractive, and unattractive faces, while controlling for participant sex and context, between participants who were unattached and those who were attached. That is, I examine if the tendency to indicate a person as seen before would led to a greater tendency to approach the person. The findings are presented in table C4 below.

Table C4. Behavioral tendencies for participants who were unattached and those who were attached.

Attractiveness level	Memory parameter	Unattached	Attached
Low	Hits	**n.s.**	**n.s.**
	False alarms	n.s.	n.s.
High	Hits	n.s.	n.s.
	False alarms	**n.s.**	**n.s.**

*statistical tests that are significant at $p < .05$. Variables in bold means that the results differ from those which combine participants who were unattached and attached.