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AN EVOLUTIONARY APPROACH TO UNDERSTANDING SOCIAL FACILITATION: ENERGY EXERTION AND EXERCISE MOTIVATION

by

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DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
Psychology

The University of New Mexico
Albuquerque, New Mexico

July 2013

DEDICATION

For my dearest loves, Pablo and Josephine.

In the words of A.A. Milne,

“This would be my present to you my sweet,

if it weren’t your gift to me”

ACKNOWLEDGEMENTS

This dissertation would not exist without the help of so many wonderful people. Paul Hooper’s partnership, encouragement, guidance, inspiration, love and example have changed my trajectory, and that of all my work. I am deeply thankful that our paths collided. Angela Bryan has provided unwavering support and an incredible model that has shaped and allowed me to blossom as an academic. Steve Gangestad, I am so grateful to have your fingertips leave a mark on my education in evolutionary theory and psychology. This dissertation, and my education more generally have been crucially enriched by the input of my committee members, and faculty at UNM and elsewhere: Martin Muller, Josh Tybur, Jane Lancaster, Hilly Kaplan, Melissa Emery Thompson, Geoffrey Miller, Renee Magnan, and James Selig.

The data collection for the studies included in this dissertation was aided by an amazing research crew: Jessica Warren, Caitie McGuire, Tina Ouarie, Andrea Kuenzli, Tiffany Callahan, Kezica Yanez, Kate Cauthen, Daniel Castillo, Trent Irwin, and Travis Cheney. Many thanks to the folks at the Exercise Physiology Lab, Christine Mermier, Micah Zuhl, Jeremy McCormick, Jason Beam, Hun Sheng Hsu, Roy Salgado, Ailish White, Jen Roper, Tao Huynh, Mike Deyhle, and Joan Iverson for allowing me to recruit their participants. I thank the participants for volunteering.

Mom, Libby, Phil, Paul and Joanna Hooper, Amelia Roache, and Shannon Hancock, thank you all for keeping my little Josephine (and me) thriving and happy during my long hours of work. And to my dear friends, Karen Hancock and Whitney

Davis, thank you for your support and encouragement that helped keep me going.

And finally Dad, wherever you are, I love you and I hope I’ve made you proud (X).

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ABSTRACT

The current research draws on evolutionary and life history theory to understand social facilitation of human energy expenditure, and test predictions focused on when and for whom increases in energetic effort are more likely to occur. Two studies tested the premise that cues of mates and/or competitors for mates can modify perceptions of the socio-ecological context of energy expenditure, and thereby change short-term energetic effort and exercise motivation and self-efficacy. Tests of psychological and physiological mediators and moderators were performed. Results provide preliminary support for the utilization of evolutionary theory to understand social facilitation by demonstrating significant effects of primes on immediate performance in tests of muscular strength, and exercise motivation and self-efficacy, particularly among men. These findings may have implications for efforts to increase energy expenditure and exercise behavior.

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CHAPTER 1: Motivation and Theory

In the late 19th century Norman Triplett conducted what is largely considered to be the first social psychology experiment, examining the now widely researched phenomenon of social facilitation (Triplett, 1898). In reviewing international cycling records, Triplett noted that cyclists consistently perform better when they are paced by another cycler, and perform even better during paced races against other competitors. He then performed an experiment with children performing a novel task—using a fishing reel to move a piece of silk a given distance—as quickly as possible. Triplett observed that children had enhanced performance when competing against another as compared to when performing the task alone, concluding that, "…the bodily presence of another contestant participating simultaneously in the race serves to liberate latent energy not ordinarily available" (p.533). In the past century, research on social facilitation has proliferated, with researchers aiming to understand the effect that the presence or awareness of others has on task performance across various social settings (e.g., having an audience vs. competing or co-acting, peers vs. experts, etc.); different types of tasks (simple vs. complex, novel vs. practiced, cognitive vs. motor, etc.); and different individual characteristics of the performer (attention to task, evaluation apprehension, level of self-presentation, etc.) in hundreds of studies (reviewed in Bond & Titus, 1983; Strauss, 2002; Uziel, 2007). Much of this work has proceeded atheoretically, with empirical findings driving the development of explanatory theories to delineate the circumstances and underlying physiological and psychological mechanisms that increase or inhibit social facilitation of task performance (with notable exceptions, e.g., Zajonc, 1965).

The current research brings a new body of biological and evolutionary theory to bear on Tripplett's original observations to more clearly understand how and why the presence or awareness of others may stimulate the liberation of "latent energy" that is otherwise not available. It focuses on the type of task most consistently associated with positive social facilitation in past studies: simple gross motor tasks that are well learned or easily mastered, and for which increased energetic effort leads to better performance (Bond & Titus, 1983; Strauss, 2002). The current approach draws on biological theory and human evolutionary history, first, to understand why humans typically reserve energy that can be devoted to physical tasks; and second, to formulate hypotheses regarding when and for whom the awareness of others may lead to increased energetic effort toward simple physical tasks.

The current research tests the premise that cues of the presence of others who are particularly important for reaching the salient evolutionary goals of a given life stage can change the perceived socio-ecological context of energy expenditure, in terms of the perceived costs and benefits of effort. Shifts in the costs and benefits of expenditure are hypothesized to modify short-term energetic effort, as well as cognitions related to exercise motivation and activity.

Two studies were designed to test whether perceptions of socio-ecological context, in terms of the availability or presence of potential mates or competitors for those mates, could be experimentally manipulated among young, unpaired, heterosexual individuals; and to test the effect of the manipulations on physical effort and social cognitive factors known to predict exercise behavior (i.e., motivation and self-efficacy/ perceived ability). The experimental manipulation required participants to view photographs of socially relevant males and/or females (close in age and locale) and attend to the sex ratio or attractiveness of the individuals in the photographs.

In Study 1, the effect of the manipulations was tested on implicit and explicit cognitions about mating and competition, social cognitive predictors of exercise, and changes in grip and chest strength, testosterone (T) and cortisol (C). Cognitions related to mating and competition, and changes in T and C were tested as potential psychological and physiological mediators of these effects.

In Study 2, performance was measured on two physical tests completed as part of a standardized exercise protocol after viewing the most effective manipulations for influencing energetic effort and mating, competition, and exercise cognitions from Study 1. These manipulations were also enhanced to include a peer evaluation component to examine if being explicitly aware that others would evaluate one's own performance would have a facilitative effect on performance above and beyond the initial manipulation. Finally, factors that are predicted to influence life-stage goals such energetic condition, relationship and parental status, age, and baseline T were tested as moderators of the effect of the manipulation on energy expenditure, motivation, and self-efficacy.

The following three sections of this chapter outline the evolutionary framework for understanding why humans selectively exert energy, and which underlies hypotheses for the circumstances that make social facilitation of physical tasks more or less likely to occur. The first section addresses the question of why human physiology and psychology would tend to conservative with respect to energy expenditure. The following section then presents a framework for understanding the circumstances predicted to motivate exceptional energy expenditure, and their interaction with sex and variation in developmental trajectory. The final section then addresses the mechanistic role of the endocrine system in mediating relationships between life stage, condition, socio-ecology and selective energetic output.

Why do humans conserve energy that could be available for physical tasks?

Life history theory, reproductive ecology and energetic effort

Life history theory (LHT) is a branch of evolutionary theory aimed at explaining differences in the age-schedules of growth, reproduction, and mortality (Charnov, 1993; Stearns, 1992). According to LHT, humans, like other animals, face trade-offs in how to optimally allocate limited time and energy between growth, reproduction and maintenance (i.e., survival) which depend on individual and ecological parameters (Hill & Kaplan, 1999). LHT suggests that long-term evolutionary pressures tend optimize energetic allocations toward behaviors that maximize expected reproductive success across the lifespan. Among the major physiological and psychological systems that regulate energetic effort across the lifespan, hormones play a key role in mediating energy allocation (Finch & Rose, 1995; Worthman & Barrett-Connor, 2002).

Physical activity is especially well suited to be examined from a life history perspective because physical activity both influences and is influenced by life history parameters, and is central to both energy expenditure and (at least traditionally) energy acquisition. According to LHT, a trait, characteristic, or behavior is favored over evolutionary time when its adaptive benefits outweigh the costs of time, risk, and energy invested. The key to applying LHT to understanding why humans would have evolved to selectively exert energy in physical activity, and the factors that increase willingness to exert energy (or liberate "latent energy") lies in understanding the costs and benefits of physical energy expenditure.

Physical activity clearly entails energetic costs. In addition to the direct metabolic costs of performing physical activity, costs are also incurred to develop and maintain cardiovascular and muscular fitness. Muscle tissue is more energetically costly than adipose tissue, and the high costs of cardiovascular and muscular fitness can be inferred from the significant decreases in fitness in response to detraining (Booth & Lees, 2007; Coyle et al., 1984). On the other hand, physical activity also has many benefits[1]. Over the course of human evolutionary history, a willingness to selectively exert oneself physically would have generated survival and reproductive benefits through the ability to run down prey, forage, protect oneself and family from danger, migrate over long distances, survive childbirth, care for children, and display one's physical health and condition to gain mates and social partners.

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[1] For the purposes of this section, the focus is on the benefits that are hypothesized to have existed during the majority of human evolution, rather than those associated with exercise in contemporary, Western environments.

Technological advances and globalization have led to an especially rapid and dramatic increase in the efficiency of resource extraction, processing, distribution, and consumption, such that little physical energetic expenditure is required to fulfill the basic biological goals of survival and reproduction in our current environment. The in-born conservatism of our evolved energy allocation system, moreover, appears to discourage us from maintaining energy expenditures similar to our Pleistocene ancestors in the absence of tangible evolutionary benefits. Across traditional populations, a large variation in energy expenditure exists, indicating that it is likely that physical activity behavior has evolved to flexibly respond to the costs and benefits of a given environment. Traditional populations for whom physical activity levels are known indicate that humans, like other animals, engage in a level of physical activity that corresponds to the demands of resource production and mate acquisition in a given ecology, while reserving energy when the benefits do not outweigh the costs (Dufour, 2008; W. R. Leonard, 2004; W.R. Leonard, 2008; W.R. Leonard & Robertson, 1997; Malina & Little, 2008; C. Panter-Brick, 2003; C. Panter-Brick & Pollard, 1999). The following paragraphs serve to flesh out the life history research in anthropology that helps us to understand variation in these costs and benefits.

Paleontological research suggests that our human ancestors were substantially more muscular than humans living in modern, sedentary contexts (Booth, Chakravarthy, & Spangenburg, 2002). However applying a comparative, phylogenetic approach, researchers have shown that humans actually have much less muscle tissue and more adipose tissue than other primates, which some researchers have suggested has allowed humans to balance the increased metabolic costs of a large brain (W.R. Leonard & Robertson, 1997; W.R. Leonard, Snodgrass, & Robertson, 2007).

In addition, some unique characteristics of human life history patterns are worth noting because of the influence they exert on both the availability of energy for physical activity as well as the costs and benefits of energy expenditure throughout the lifespan (Kaplan, Hill, Lancaster, & Hurtado, 2000; Lancaster & Kaplan, 2009). In humans, a shift to nutrient-dense, difficult-to-acquire resources is theorized to have strongly influenced the coevolution of increased relative brain size and long life-span, an extraordinarily long dependent juvenile period allowing for complex development and learning, and complementarity between the sexes in cooperatively provisioning multiple dependent offspring (Kaplan, et al., 2000). During ontogeny, energy is focused on growth and maintenance, with zero effort allocated toward current reproduction. Throughout development children learn about their environment and develop the skills they need to live in a given ecology. During and following puberty, energy must be balanced between the costs of maintenance, the development of secondary sex characteristics, and reproduction. Parental investment in offspring growth is much greater for humans compared to other primates, given their high investment in neurological development, altriciality at birth, and caloric dependency into the second decade of life (Aiello & Key, 2002; Kaplan, et al., 2000). Such high energy requirements for reproducing women, and the returns to sex- and age-specific division of labor, combine to favor returns to increased investment from fathers and other close kin, allowing pregnant and lactating women to actually *decrease* energy devoted to production of resources (Hooper, 2011; Hurtado, Hill, Kaplan, & Hurtado, 1992). Thus, age or life history stage, and sex are central factors in determining the costs and benefits of directing energy toward increased physical effort. The current research program focuses on the costs and benefits of increased physical effort among reproductive age men and women, both before and after forming monogamous pair bonds and reproducing.

During the reproductive period, some fraction of energetic effort toward physical activity, fitness and strength may represent effort to gain increased access to mates; physical activity may also pay off in terms of economic production and provisioning of offspring and kin, especially in pre-modern circumstances (Hooper, 2011). The mating effort hypothesis has motivated evolutionary psychologists to examine links between physical activity and mating attractiveness in four studies to date. The first two studies, by Honekopp and colleagues, were based on the postulate that during human evolution, visual indicators of physical fitness indicate increased mate value because they reflect tangible survival and reproductive benefits to potential mates such as: higher resource production, greater ability to protect one's self and kin from rivals, and—for females—greater ability to meet the physical demands of pregnancy, lactation, and childbirth, and capacity to ward off sexual predators (Honekopp, Bartholome, & Jansen, 2004; Honekopp, Rudolph, Beier, Liebert, & Muller, 2007). Physical fitness was therefore hypothesized to be a signal of both genetic and parenting quality. These researchers found that physical fitness, measured by a fitness test of speed, flexibility, dexterity, and strength was related to the opposite sex's ratings of women's facial attractiveness and men's body attractiveness as well as self-reported number of sexual partners. In a related line of research, Mealey (1997) and Jonason (2007) independently found that in contemporary societies, men and women each perform exercises that enhance muscles that will highlight sex-specific mate value. The linkage between physical fitness and reproductive effort can be further elaborated by considering both the biology and ecology of human reproduction.

Who may be more willing to increase physical energy expenditure?

Sex differences in the costs of increased energy expenditure

Physiological costs. Compared to men, women not only face higher reproductive fitness costs with higher levels of energy expenditure, but also have increased metabolic costs resulting from physical activity. Women are at a disadvantage for transporting oxygen to working muscles during exercise because they have a smaller heart, lower filling volume, maximal stroke volume, cardiac output and lower blood hemoglobin concentration. Men also have more lean body mass, and a higher proportion of slow-twitch muscle fibers, which contribute to greater overall muscular strength. Notably, however, when expressed relative to lean body mass, women and men have no sex differences in strength or increased muscle hypertrophy in response to training (Robergs & Roberts, 1997).

Women also have higher returns to stored adipose tissue, which is utilized during pregnancy and lactation (reviewed in Lancaster & Kaplan, 2009). Despite this, evidence suggests that women catabolize more fat during physical activity than men. Furthermore, in a study of previously sedentary men and women, exercise changed metabolism-regulating hormones[2] in a direction associated with increased appetite (i.e., increased ghrelin and decreased insulin), but only among women (Hagobian et al., 2009). Physical activity may therefore increase desired and/or required food intake, and utilize fats that are particularly costly resources among women. In an environment of limited food resources, as was experienced by humans over the majority of evolutionary history, this would have been a substantial cost to all physical activity, but particularly any *inessential* physical activity.

Costs to reproduction.

There are sex-specific costs to reproduction associated with increased physical activity during this the reproductive period. Peter Ellison and colleagues, in particular, have focused on the influence of energetics on reproductive function in men and women (Ellison, 1990, 2001, 2003, 2008; Jasienska, 2001, 2003).

Women: For women, both negative energy balance alone, and high levels of energy expenditure coupled with neutral or negative energy balance, can influence reproductive function in multiple ways. First, ovarian function is a key component of female fecundity, or biological capacity to reproduce. While ovarian function was once considered an on/off phenomenon measured by the presence or absence of menses, it is now well accepted that the presence of menses does not indicate that ovulation has occurred, and ovarian function varies along a continuum of fecundity

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[2] The thyrotrophic axis and endocrine pathways associated with metabolic regulation and energy intake specifically are also likely to be essential for a complete characterization of the hormonal mediation of energy allocation decisions related to physical activity. They were not included in this proposal because much less research has focused on these hormones relative to life history parameters, and they are primarily examined in terms of maladaptive responses to current energy conditions.

that can be indirectly measured by levels of ovarian steroids. In particular, low levels of estrogen during the follicular phase and low progesterone during the luteal phase have been shown to reflect decreased fecundity (Lipson & Ellison, 1996). There is strong evidence that female fecundity is sensitive to changes in transient shifts in energy available for reproduction in both Western and non-Western populations. Ovarian steroid levels, for example, have been demonstrated to be lower in Western women who are losing weight, are restraining their intake below appetite, have low levels of stored fat and lipid profiles, and have high energy expenditure through exercise or workloads with neutral or negative energy balance (reviewed in Ellison, 2008; Vitzthum, 2009). The combination of high energy expenditure and low energy intake has an even more pronounced negative impact on fecundity (Ellison, 2001). It is interesting to note that increased workload or physical activity has been shown to decrease steroid profiles even when food availability is not limited (e.g., Jasienska & Ellison, 2004; Jasienska, Ziomkiewicz, Thune, Lipson, & Ellison, 2006). Less research has examined the influence of energy expenditure on fecundity given a consistently positive energy balance, though it is unlikely this combination of circumstances that occurred frequently during the majority of human history. In one study among the Tamang in Nepal, a subsample of women actually gained weight during the heavy work season, and did not show decreases in steroid profiles (C. Panter-Brick, Lotstein, & Ellison, 1993). Vitzthum (2009) has hypothesized that acclimation and high consumption levels allow some Tamang women to buffer against ovarian suppression in the face of high energetic output. Women also appear to have some buffer against ovarian suppression in light of chronic under-nutrition, lowering basal metabolic rate in order to increase energy available for reproduction (Jasienska, 2003).

Energy balance also influences female reproduction in terms of offspring birth weight and length of gestation, with smaller birth weight and shorter length of gestation among women facing under-nutrition (Ellison, 2003; Kline, 1989). Energetics also influence female reproduction by modulating the duration of lactational amenorrhea. Lactation is extremely energetically costly for women, and is estimated to increase metabolic load by 700 kcal/day (Ellison, 2003), which typically leads to ovarian suppression. . The duration of lactational amenorrhea varies greatly between and within populations, and is thought to be directly affected by energetic resources. The role of physical activity in determining the duration of lactational ovarian suppression is not well understood, and is difficult to tease apart from other factors that influence lactation, such as frequency and duration of breastfeeding. Women who have heavy workloads often breastfeed less frequently and begin to supplement children's diet with alternative food sources earlier, decreasing maternal levels of prolactin and reducing the drive for milk production (C. Panter-Brick & Pollard, 1999). Given the high metabolic costs of gestation and lactation for human females, researchers have hypothesized that this heightened responsiveness to energetic condition and energetic stress would be adaptive in order to decrease the likelihood of conception when it is questionable whether the energetic demands of pregnancy and/or lactation can be met (e.g., Ellison, 2001; Jasienska, 2003; Vitzthum, 2009).

Men: Men's reproductive physiology, on the other hand, is generally less energetically costly and more robust in the face of reductions in energy availability or increases in energy expenditure. The quantity and quality of sperm production appear to be insensitive to short term changes in energy availability (Bribiescas, 2006). Testosterone—which modulates muscle mass, as well as allocations to reproductive and parenting effort (Burnham et al., 2003; Ellison & Gray, 2009; Gray, Ellison, & Campbell, 2007; Gray, Kahlenberg, Barrett, Lipson, & Ellison, 2002; Ketterson & Nolan, 1992; C.W. Kuzawa, Gettler, Muller, McDade, & Feranil, 2009)—appears to be unresponsive to short term changes in energy availability, but sensitive to longer-term energetic deficit (Ellison, 2003). Some researchers have argued that investment in muscle mass can be thought of primarily as somatic effort aimed at reproduction by increasing mating opportunities (Bribiescas, 2001, 2006). More recently, others have speculated that non-negligible somatic investment in musculature is also required for paternal investment through provisioning and protecting partner and offspring from external threats (Lancaster & Kaplan, 2009).

A considerable and growing body of research thus demonstrates the relationship between overall energy balance over the short and long term and energy allocated to reproduction in both men and women. Given the high fitness costs of decreased fecundity, it is reasonable to hypothesize that human physiology and psychology has been selected to conservatively economize energy expenditure to prevent negative energy balance, when possible, especially in women of reproductive age.

Prenatal availability of resources and energy allocation

A related line of research has examined the effects of energetic constraints during development on later health and life history trajectories (that is, the timing and levels of energy allocated to growth, reproduction, maintenance and survival). Early epidemiological evidence has shown that early life under-nutrition, indexed by size at birth, can have profound influences on biology and long-term health, as it elevates the risks of chronic conditions such as cardiovascular disease, diabetes, and stroke (Barker, 1989, 1994). Since then, researchers have proposed that organisms, through developmental plasticity, adaptively anticipate the energetic constraints of future environments based on fetal and early developmental conditions in order to maximize fitness, which has been deemed a "predictive adaptive response" (PAR; Ellison, 1990; Ellison & Jasienska, 2007; Gluckman & Hanson, 2004; C.W. Kuzawa, 2005, 2007; Lipson, 2001).

Recent human and non-human animal studies support a relationship between energetic condition in utero and energy expenditure later in life. Jasienska and colleagues (2006) demonstrated in a sample of Polish women that size at birth, measured by ponderal index (PI; kg/m^3), moderated the relationship between physical activity and ovarian suppression (measured by mid-follicular salivary estradiol) such that those who had high PI at birth were buffered from ovarian suppression at moderate levels of physical activity. On the other hand, women who experienced a constrained fetal environment, reflected by low or moderate PI at birth, showed a heightened sensitivity of fecundity in response to increased energetic demands. The authors explain that among women who "anticipate" nutritional challenges, increased workload would be more likely to result in negative energy balance; therefore they benefit from temporarily delaying reproduction by suppressing ovulation.

Another pathway through which intrauterine environment can increase the risks of chronic disorders is by influencing physical activity levels more directly. A meta-analysis of 13 Scandanavian birth cohorts demonstrated that lower than normal birth weight was related to lower leisure time physical activity later in life (Andersen et al., 2009). Birth weight has also been demonstrated to influence the energy cost of running, with low birth weight individuals experiencing a higher energy cost of running (Baraldi et al., 1991) and lower mechanical efficiency (Workman, 2012). An experimental study of Wistar rats comparing the exercise behavior of those born to undernourished versus ad libitum fed mothers (Vickers, Breier, McCarthy, & Gluckman, 2003) also supports this hypothesis. At weaning, rats were assigned to a control diet or a hypercaloric diet (30% fat). Voluntary activity was measured before and after pubertal maturation. Offspring from undernourished mothers were significantly smaller at birth, and were significantly less active at all time points compared those born to ad libitum fed mothers. This difference was heightened in those who were fed a hypercaloric diet post weaning. The same pattern was observed for food intake, which was significantly greater in the rats born to undernourished mothers, and even higher among those fed a hypercaloric diet. Rats born to undernourished mothers and subsequently fed a hypercaloric diet ate the most and were the least active. Interestingly, a hypercaloric diet was related to relatively lower energy expenditure in each condition of maternal nutrition.

In addition, physical activity is also linked to reproductive effort in the form of somatic investment for intrasexual competition and increased provisioning of offspring, particularly among men. Among men, the association between increased physical activity and investment in reproductive effort is more clear-cut, as it does not need to be balanced with high energetic costs of gestation and lactation. Among women, on the other hand, a *decrease* in physical activity may be associated with higher mating effort to make more energy available for pregnancy and lactation. Empirical support for the prediction among men was demonstrated in a recent study among Filipino males. Kuzawa and colleagues (2010) found that an early developmental cue of resource availability (rapid weight gain within 6 months after birth) predicted metabolically costly adult somatic characteristics such as elevated reproductive hormones, size, and strength. Those with rapid growth reached puberty earlier, had higher T levels, were taller and more muscular, had greater grip strength, had sex at earlier ages, and had more lifetime sexual partners than those who did not grow rapidly during infancy.

These lines of research suggest that birth weight, as an index for energy availability during development, may moderate the influence of the awareness of others on energy expenditure. Low birth weight individuals may be less responsive to stimuli to increase energy expenditure, even in the presence of others, because they have a relatively stronger drive to conserve energy and decreased drive to build costly embodied capital in the form of muscles and physical fitness. Birth weight was therefore aimed to be tested as a potential moderator of the experimental manipulation on energy expenditure in the current studies.

The endocrine system: a biological mechanism for increases in energy expenditure

The endocrine system is considered to play a particularly central role in shaping life histories by mediating energy allocation across competing domains of investment (Bribiescas, 2001; Ellison, 2003; Finch & Rose, 1995; Worthman & Barrett-Connor, 2002). Hormones are increasingly being included in research that aims to apply a life history perspective to understanding behavior (Finch & Rose, 1995; Stearns, 1989; Worthman & Barrett-Connor, 2002; Zera & Harshman, 2001). As Worthman & Barrett-Connor (2002) eloquently state:

> *Hormones establish the short-and long-term balance of resource allocation between growth, reproduction, and maintenance. Hormones juggle net energy availability by modulating metabolism and setting internal regulatory parameters, they regulate the rate of growth and the timing of developmental transitions such as puberty, and they dynamically manage the interface between the individual and environment by orchestrating responses to everything from stress to workload. (p. 198)*

The current research focused on testosterone (T) and cortisol (C) as potential physiological mediators of the social facilitation of physical energy expenditure for two primary reasons. First, they both influence and are influenced by physical energy expenditure. Second, theoretical and empirical support for the regulation of male traits and behavior by T and C levels in the evolution of not just human, but all vertebrate life histories (Hau, 2007), particularly in circumstances related to mating and competition (Archer, 2006; Sapolsky, Romero, & Munck, 2000; Worthman & Barrett-Connor, 2002). They are by no means the only hormones or endocrine pathways involved in this multi-faceted system, but rather candidate hormones for which substantial interest has led to research and theory in physical activity and life history.

Life history regulation, testosterone and competition

The hypothalamo-pituitary-gonadal (HPG) axis controls the onset of reproductive maturation, maintains and regulates reproductive function in adults, and regulates the termination of reproductive function in women (Worthman & Barrett-Connor, 2002). These functions are carried out through the hypothylamic pulsatile secretion of gonadotropin-releasin hormone (GnRH), which stimulates the anterior pituitary to release follicle stimulating hormone (FSH) and leutenizing hormone (LH). FSH and LH then stimulate gonadal steroid production, principally estradiol and progesterone in women, and T in men; however T is also produced in the ovaries of women. T levels in men are roughly 10 times that of women, and less research has focused on the role of T in the regulation of life history energy allocation in women; however T may play a similar and important role in women as well as men, particularly in the energy allocation to competitive and physically demanding tasks.

One leading hypothesis for understanding the influence of T on behavior within a life history framework is the 'challenge hypothesis', originally introduced to understand aggression and T in birds with monogamous mating systems (Wingfield, Hegner, Dufty, & Ball, 1990). It has since been applied more broadly in humans and other mammals. The challenge hypothesis predicts that there are two primary types of testosterone-behavior relationships; those that facilitate courtship and mating, and those that facilitate competitive behavior in circumstances relevant to reproduction (Archer, 2006). When applied to humans, the challenge hypothesis (and a LHT framework more generally) must also include predictions regarding the role of T in variation in reproductive opportunities (i.e., cultural variation in monogamy and polygyny) and parental care across populations. The following paragraphs highlight relevant previous research testing specific and related aspects of the challenge hypothesis in men and women separately.

Men. Several studies to date have examined men's T response to interactions with female confederates in an effort to test the role of T and facilitating mating opportunities (e.g., Roney, Lukaszewski, & Simmons, 2007; Roney, Maher, & Maestripieri, 2003; Roney, Simmons, & Lukaszewski, 2010; van der Meij, Almela, Buunk, Fawcett, & Salvador, 2012; van der Meij, Buunk, van de Sande, & Salvador, 2008). These studies demonstrated that men who associated with a female had greater increases in T than men who did not interact with anyone or who interacted with another man, suggesting the hypothesis that men's T will increase in response to an experimental manipulation that focuses attention on mating opportunities, particularly among young, unpaired individuals. Ronay & von Hippel (2010) further found that men who interacted with a female confederate increased risk taking in performing skateboarding tricks, resulting in more successes, but also more crash landings.

Empirical studies on T and competition have not primarily been designed from an evolutionary or challenge-hypothesis framework (with one recent exception), and therefore have not specifically tested if men's pre-competition rise in T is associated with gaining access to mates. However, they have shown that men have a T responses to competition in general; with increases occurring before, during, and after competition for winners (with losers typically having a post-competition decrease; Archer, 2006). It should be noted that the anticipatory increase in T is particularly demonstrated in real-life sports competitions compared to artificial laboratory competitions (but see Kivlighan, Granger, & Booth, 2005 for failure to replicate). A recent study found that the composition of an ultimate Frisbee audience influenced male and female competitors T responses such that if there were more opposite sex audience members, the competitors had greater increases in T (Miller, Maner, & McNulty, 2012). While the authors interpret this finding as supporting the challenge hypothesis, the challenge hypothesis, might more intuitively predict that a same sex biased audience composition would lead to greater increases in T (as there are more competitors and fewer potential mates present). The results do however support the hypothesis that T responses are influenced by cues of potential and immediate mating opportunities. Study 1 will thus test whether men and women have a T response to experimental manipulations designed to increase cognitions related to mating and/or competition for mates, and if this increase is associated with increased energy expenditure in tasks of physical strength, or social cognitive predictors of exercise behavior.

The literature regarding the relationship between men's T, reproductive opportunities, and paternal care has recently matured. On average, men with children and those in monogamous relationships have lower T than single and childless men (e.g., Alvergne, Faurie, & Raymond, 2009; Burnham, et al., 2003; Gray, et al., 2007; Gray, et al., 2002). Though most studies have been cross-sectional, longitudinal research (e.g., on divorced men or new fathers) generally suggests that T levels change with relationship status or paternal circumstances (Berg & Wynne-Edwards, 2001; L. T. Gettler, McDade, Feranil, & Kuzawa, 2011; Mazur & Michalek, 1998; Storey, Walsh, Quinton, & Wynne-Edwards, 2000). These findings are consistent with data from several other species with high paternal care and/or extensive pair-bonding (e.g., Clar & Galef, 1999; Nunes, Fite, Patera, & French, 2001). Exceptions to the general pattern have been documented, but even they fit a conceptually meaningful pattern. For instance, Muller et al. (2009) compared T levels of fathers and non-fathers in two neighboring groups in Tanzania, Hadza foragers and Datoga pastoralists. They found a similar pattern of lower levels of T in fathers compared to non-fathers in the Hadza, but not the Datoga. Datoga fathers are minimally involved in direct child-care and, hence, paternal status is less meaningful in that group. Kuzawa et al. (2009) also reported lower T among pairbonded fathers among a large representative sample of Filipino men in Cebu City, but did not find lower T in men who were pairbonded but not fathers. The authors speculate that this may reflect a cultural pattern of maintaining extrapair mating effort until children are born.

Sociosexual orientation has been shown to moderate the relationship between men's T and relationship status in Western samples. Specifically, partnered men who are relatively open to and interested in mating opportunities outside their current relationship (those scoring as having unrestricted sociosexual orientation; Simpson & Gangestad, 1991) have higher T levels than partnered men with more restricted sociosexual orientation scores (Edelstein, Chopik, & Kean, 2011; McIntyre et al., 2006). In fact, men with high sociosexual orientation showed no evidence of reductions in T as a function of relationship status; only men specifically committed to remaining faithful to their partners experienced lower T levels. Further, T levels have been shown to be inversely related to relationship commitment, even among paired men (Caldwell Hooper, Gangestad, Emery Thompson, & Bryan, 2011).

Gray (2003) found that while Swahili men had slightly lower T levels when they had young offspring, married men did not have lower T than unmarried men. This is likely due to the high degree of polygyny in this culture, such that marriage does not necessarily reduce men's mating effort, which is consistent with greater T levels in polygynously married men. Alvergne et al. (2009) also found higher T in polygynously mated versus monogamously paired men, with T levels relating to relative investment in parental care versus mating effort. Gray et al. (2007) did not find this result among Ariaal pastoralists in Northern Kenya. They noted, however, that in this population, men with multiple wives were older, and thus likely to have lower T levels, as they had to accumulate enough wealth to acquire multiple wives. Differences across individuals and populations in commitment to monogamous pair-bonds thus may, as with paternal investment, modulate the association between relationship status and T levels in a meaningful way. It is worth noting that some have suggested that non-negligible levels of T may be necessary for men devoted entirely to parental investment for the development of physical strength in subsistence activities, handling dangerous domesticated animals, and protecting women and children from outside threat (Lancaster & Kaplan, 2009), though this has yet to be empirically confirmed. In the current research (Study 2), the extent to which baseline T, relationship status, commitment, sociosexual orientation, and paternity moderate participants' responsiveness to the primes was examined.

Women. One study to date has tested whether women have a similar increase in T to ostensibly facilitate mating opportunities, which measured T before and after exposing women to a video of an attractive male courting a female (Lopez, Hay, & Conklin, 2009). This study found that women indeed showed an increase in T in response to the video in a similar fashion to men's T increase in response to a short encounter with an attractive female within 30 minutes of the stimuli.

In terms of T response and competition in women, two studies with conflicting results have been reported in the literature. The first found that women, like men, had an increase in T both in anticipation of a rugby match, and during the match (Bateup, Booth, Shirtcliff, & Granger, 2002). The second study did not find an anticipatory increase in T in men or women, nor an increase from pre-competition to 20 minutes post competition among women in a cycle ergometer competition (Kivlighan, et al., 2005). Future study of competition among women is required to reconcile these conflicting findings. The extant literature on women's T has focused on, and found an overall positive association between, T levels and trait-level aggression and dominance (e.g., Grant & France, 2001).

Far fewer studies have examined the association between T and mating effort and maternal care among women. One study did not find evidence that T was higher among unpaired compared to paired heterosexual women, but did find elevated T in unpaired compared to paired non-heterosexual women (van Anders & Watson, 2006). A second study found a relationship between T and relationship status with a sample comprised of women of mixed sexual orientation (van Anders, Hamilton, & Watson, 2007). In a more recent study among an exclusively heterosexual sample, no association was found between T and relationship commitment (Caldwell Hooper, et al., 2011). Another study found that women in mating contexts deemed more competitive (i.e., polyamorous) had higher T than single or paired women in primarily monogamous mating markets (van Anders, et al., 2007).

Pair-bonding and maternal status and T have also been examined in one non-Western samples among a sample of Filipino women. Kuzawa and colleagues (2010) found that compared to non-mothers, T levels were lower among breastfeeding mothers and those with children < 2 years. T levels in morning saliva samples were significantly lower among women in pair-bonded relationships, but afternoon T levels were not different according to relationship status. Additionally, high T levels during pregnancy have been related to impaired breastfeeding (Carlsen, Jacobsen, & Vanky, 2010). These studies suggest that, as in men, lower androgens are perhaps related to parental investment and care in women.

Given the available research, the relationships between reproductive opportunities, competition, and T in women clearly warrant further investigation and clarification. Women's T regulatory system may or may not be similar to men's in trading off between increased mating and parenting effort. The current research aims to examine these questions further, by testing men and women's T response to primes designed to increase perceptions of mating and intrasexual competition; and by testing whether this increase leads to increased effort on measures of physical strength. Baseline T, relationship status, sociosexual orientation, and maternity were also hypothesized to moderate the effect of the primes on energetic effort in Study 2.

Physical activity and testosterone

Testosterone is known to increase acutely in response to physical activity, but T levels are lower in response to longer bouts of endurance exercise and in highly active men (Robergs & Roberts, 1997). T aids in protein synthesis in muscle tissue and therefore leads to increased musculature, strength and lean body mass. In addition, T has been shown to increase the uptake of glucocorticoids in muscle cells, which may lead to immediate increases in strength, with more energy directed toward exercising muscles (Sapolsky, et al., 2000; Tsai & Sapolsky, 1996). Note again that while men are stronger than women due to having a higher proportion of lean body mass, there are no sex differences in strength and power when expressed as relative to lean body mass (Robergs & Roberts, 1997). T is often thought of as somatic investment related to increasing mating effort, mediating life history allocation to future reproduction (Bribiescas, 2001; Ellison, 2003). A recent study found evidence partially supporting this hypothesis among a sample of Filipino men. T levels predicted lean body mass and strength, but only among men who were active, suggesting that T levels mediate investment in costly somatic traits, such as muscles, but specifically in conjunction with environmental interaction demanding regular muscular use (L.T. Gettler, Agustin, & Kuzawa, 2010). The current research aims examine the extent to which an experimental manipulation can influence T levels by increasing the awareness of potential mates and competitors for those mates, and to examine if these short-term increases mediate the social facilitation of physical tasks in men and/or women.

Life history regulation, cortisol and competition

Faced with physiological and psychological challenges, adrenal hormones adaptively mobilize resources to respond both physiologically and behaviorally. The fast acting, sympatheto-adrenal-medullary axis organizes the immediate endocrine response, releasing adrenal neurotransmitters or catecholamines (epinephrine and norepinephrine) within milliseconds, which lead to a rapid increase in heart rate and heightened arousal, facilitating vigilant behavioral reactions (Worthman & Barrett-Connor, 2002). This response is costly, and continued or prolonged activation can result in hypertension and functional impairment. Many studies examining social facilitation have examined these autonomic responses as evidence that increased arousal has occurred in response to the presence of other individuals or competitors (e.g., Henchy & Glass, 1968; Martens, 1969). A slower hormonal cascade begins with corticotropin releasing hormone (CRH) produced in the hypothalamus. CRH production stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH), which in turn results in adrenal production of C. Cortisol is often thought of specifically as a stress hormone; however, when applying a life history approach it is more useful to appreciate the broader function of C as mediating physiological energy allocation from long-term (growth, reproduction) to short-term (vigorous activity, alertness) functions (Sapolsky, et al., 2000; Worthman & Barrett-Connor, 2002; Worthman & Kuzara, 2005). Cortisol is a glucocorticoid that promotes immediate survival needs at the expense of long-term processes: it prioritizes increases in blood glucose at the expense of protein and fat stores and increased focus, with reduced food intake, HPG activity, gut motility, growth, and memory formation, and altering immune activity (increasing leukocytes in the short term and decreasing immune function if elevated over a prolonged period (Robergs & Roberts, 1997; Sergstrom, 2010; Sherwood, 2001)). Small increases in C can thus indicate a preparation for action. Cortisol has been shown to increase in anticipation of competition, particularly in the context of sports competitions (e.g., Passelergue & Lac, 1999; Salvador, Suay, Gonzalez-Bono, & Serrano, 2003; Suay et al., 1999); and has also been shown to be related to pre-competition anxiety (Filaire, Maso, Sagnol, Ferrand, & Lac, 2001). Two studies have also demonstrated rapid increases in C in response to interacting with an attractive or flirtatious female (Roney, et al., 2007; van der Meij, Buunk, & Salvador, 2010), and this response is thought to increase preparedness and facilitate mating behaviors.

Sex differences: Relative to the HPG axis, the HPA axis is largely similar in men and women. Sex differences in adrenal response to ACTH emerge at puberty, however, with more C produced in women in response to the same level of ACTH. The mechanism driving this difference remains unclear; it may occur through different ACTH delivery to the adrenal gland or a heightened sensitivity or responsiveness by the adrenal gland to ACTH stimulation (Worthman & Barrett-Connor, 2002).

Physical activity and cortisol

The HPA axis also responds acutely to physical activity, with the catecholamines and C increasing as intensity increases (Worthman & Barrett-Connor, 2002; Robergs & Roberts, 1997). These increases stimulate the mobilization of free fatty acids that can be used by the liver for gluconeogensis. Given that liver gluconeogenesis is not needed during short-term exercise, it is thought that acute increases in C are particularly helpful for recovering during short-term exercise. In addition, circulating amino acids are increased by reducing the uptake of amino acids by peripheral tissues. Social facilitation of energy expenditure may thus be related to ecological cues that induce increases in C (and thereby gluconeogenesis and energy available for short-term increases in effort or recovery), such as behaviors that influence mating opportunities or intrasexual competition. The current studies are the first to test C as a potential mediator of social facilitation of physical task performance.

Summary and conclusion

The current research is designed under the basic thesis that natural selection has shaped human physiology and psychology to flexibly respond to energetic demands and resource availability in an attempt to optimize survival and reproduction within a given ecology. This system was, for the vast majority of human evolution, consistently constrained by resource scarcity, and in response, organisms are evidenced to decrease energy expenditure adaptively in response to decreased intake or early fetal cues of nutritional constraints (Shetty, 1999; Vickers, et al., 2003). Furthermore, ecology plays a particularly important role in producing variation in the benefits and costs of physical activity. Among horticulturalists with seasonal resource availability, for example, energy expenditure is drastically reduced when not required for harvesting resources, particularly among women. Human females also demonstrate acutely responsive reproductive function in response to increased energetic demands (Ellison & Jasienska, 2007); and among foragers show greater variation than males in physical production effort according to the intensity of child care demands (Hooper, 2011; Hurtado, et al., 1992; Lancaster & Kaplan, 2009). Moreover, humans have greatly reduced muscle mass compared to our primate relatives, which is thought to balance the energetic demands of our greatly increased relative brain size (W.R. Leonard, et al., 2007). We can infer from the fact of near zero population growth over the majority of human evolutionary history that selection would have favored physiological and psychological mechanisms that reduce energy expenditure when not needed for survival or reproduction. Thus, it can be expected that evolution has led to a flexible system that responds to varying costs and benefits of physical activity, both general and sex-specific, in 'deciding' when to conserve and when to expend energy. From this theoretical perspective, hypotheses are derived and tested regarding the social facilitation of energy expenditure among reproductive age men and women.

CHAPTER 2: Study 1

Introduction

Regular exercise can reduce the risk of developing 20 of the most deadly chronic disorders, including cardiovascular disease, obesity, hypertension, and type 2 diabetes (Booth, Chakravarthy, Gordon, & Spangenburg, 2002; Roberts & Barnard, 2005; WHO, 2008), which cost the United States an estimated $75 billion in medical costs each year (CDC). Moreover, evidence suggests that regular exercise is related to better cognitive functioning (Hillman, Erickson, & Kramer, 2008), and perceived physical and mental well-being (Penedo & Dahn, 2005). Despite these benefits, individuals in the US are remarkably inactive, with estimates as low as only 5% of the population attaining the recommended levels of physical activity (including purposeful exercise and other non-sedentary behaviors) (Troiano et al., 2008). The current study aims to apply an evolutionary framework to a widely researched social psychology phenomenon, social facilitation, to make predictions about how ecological, physiological, and psychological factors influence immediate energy expenditure, and more long-term, psychological predictors of exercise behavior.

The extant social facilitation research examining performance on physical tasks in which increased effort is directly related to increased performance has consistently demonstrated a positive effect of the presence or awareness of others on performance (Anderson-Hanley, Snyder, Nimon, & Arciero, 2011; Rhea, Landers, Alvar, & Arent, 2003; Strauss, 2002). Anderson-Hanley et al. (2011) recently demonstrated, that the introduction of a virtual competitor on a cycle ergometer enhanced cycling performance among elderly individuals overall, but that individual competitiveness moderated this effect such that those with higher competitiveness responded more positively than individuals low in competitiveness. Hence, there are many individual and environmental factors that are likely to influence the strength of social facilitation on energy expenditure that have yet to be explored. The current investigation generates predictions regarding circumstances that make increases in energy expenditure in the presence of others more or less likely to occur (detailed in the previous chapter), and explores potential psychological and physiological factors that mediate and moderate social facilitation.

The current studies used an experimental manipulation that showed photograph arrays causing participants to attend to socially relevant men and women who could potentially influence individuals' reproductive fitness (i.e., as mates or competitors for mates) in order to test if pre-task awareness of socially relevant others could have a facilitative effect on energy expenditure or social cognitive predictors of exercise. A large meta-analysis of 241 studies examining social facilitation determined that the audience need not be directly visible to the performer in order to influence task performance (Bond & Titus, 1983). Moreover, this type of experimental paradigm has been used effectively to manipulate social-ecological perceptions in contexts with consequences for mating and intrasexual competition. For instance, Roney (2003) demonstrated that men who viewed photographs of young, highly attractive females place a significantly greater value on material wealth and had greater feelings of ambition and aggression than men who viewed photographs of older, less attractive females. The author suggested that visual stimuli can produce psychological changes in men that are theoretically in line with female mate preferences (i.e., wealth, ambition, social status), and purportedly underlie courtship tactics. Griskevicius et al. (2012) used photographic arrays to manipulate perceptions of the operational sex ratio to examine the effect of these perceptions on temporal discounting on economic decisions. Biased operational sex ratio has been demonstrated to influence mating effort and behavior and intrasexual competitiveness among humans and non-human animals (e.g., Barber, 2001; James, 1987; Kruger, 2009; Pollet & Nettle, 2008; Schmitt, 2005). In Griskevicius et al. (2012), male-biased sex ratio was hypothesized to increase men's intrasexual competition, which would be reflected in higher temporal discounting. The authors indeed found that men who viewed male-biased sex ratio photograph arrays were more likely to choose a smaller amount of money now over waiting for a larger amount. Higher intrasexual competitiveness was observed in the male-biased sex ratio condition relative to the female-biased condition, but no differences were observed in mating drive between conditions.

More recently, experimental manipulations have been used to change cognitions related to other health related behaviors. Tybur et al. (2011), for example, increased intentions to use condoms using an olfactory pathogen disgust manipulation. Participants primed with a pathogen cue (a fecal odor novelty spray) reported significantly higher intentions to use condoms, suggesting that social cognitive predictors of health behaviors can be manipulated by relevant environmental cues. Li et al. (2010) showed, showed that women who were primed with photographs and character descriptions of highly competitive women had significantly more restrictive and aversive eating attitudes, greater desire for thinness, and lower body image compared to women exposed to photographs matched for attractiveness but described as low in competitiveness. The authors suggest this as evidence in support for the theory that factors that can lead to pathological eating disorders function as an intrasexual competition strategy among women (Abed, 1998). The current studies aimed to determine if a similar type of experimental manipulation can have a facilitative effect on energetic effort and/or cognitive factors that predict exercise behavior.

The Current Study

The primary aim of Study 1 was to compare the effectiveness of photographic primes designed to experimentally manipulate perceptions of socio-ecological context in causing participants to focus more on mating and intrasexual competition. The premise of the study was that among young, unpaired, heterosexual adults, for whom mating is an immediately salient evolutionary goal, exposure to males and females similar in age and proximity would prime thoughts about mating and competing for mates; and that these potential mates or competitors for mates and would make an effective 'audience' for facilitating increases in energy expenditure by shifting individuals' focus toward mating and competition. The effect of the experimental manipulation on cognitions related to mating and/or competition, exercise motivation and self-efficacy, and changes in measures of strength, T and C were examined. Meditational tests were performed to evaluate whether changes in T or C mediate the effect of the primes on exercise motivation and self-efficacy, and on changes in strength. In the absence of significant manipulation or mediation effects, exploratory analyses of the psychological and physiological measures were conducted to better understand the relationships between intrasexual competition, cognitions about mating and exercise, strength, and hormones.

Methods

Participants

Participants were recruited from the introductory psychology research pool, and received one research credit in return for their participation. Participants were excluded if they were currently in a relationship and living with their partner, in order to recruit a primarily non-committed sample. Initially, 211 undergraduates (110 women; 101 men) at the University of New Mexico completed the study. 16 participants were subsequently excluded because they were over the age of 30; 11 were excluded because they reported being more attracted to members of the same sex than members of the opposite sex; and one participant became ill after beginning participation and was also excluded. Thus, the final sample included 184 undergraduates (95 women; 89 men). The mean age was typical for this type of sample (*M* = 19.81, *SD* = 2.26). Participants were randomly assigned to one of five conditions and run individually.

Materials

Experimental condition photo arrays. Two types of experimental manipulations were employed, each with two levels. The first type of manipulation, hereafter referred to as the sex ratio prime (SR prime), involved two conditions designed to simultaneously manipulate perceptions of mating opportunities and intrasexual competition for those mates through differing sex ratios. The first condition included photo arrays with a male-biased sex ratio, which aimed to manipulate perceptions of the socio-ecological context so that male participants perceive a shortage of potential mates and high competition for those mates; while females perceive a shortage of competitors, and an abundance of potential mates. The second condition contained photo arrays with a female-biased sex ratio, which aimed to manipulate perceptions such that men perceive an abundance of mates, and a lack of competitors; while females perceive a lack of mates and an abundance of competitors. The second manipulation type, hereafter referred to as the attractiveness prime (A prime) was designed to manipulate cognitions about mating and competition by exposing participants to photo arrays of all males or all females and having them attend to the attractiveness of the individuals by rating the top five most attractive photographs in each array (see Appendices A. and B. for array examples). Participants in the control condition viewed arrays of photographs of cats and dogs.

The SR prime photo arrays have been used previously (Griskevicius, et al., 2012). Each photo array consists of 18 headshot photographs of college aged men and women. The female-biased array included 12, 13, or 14 photographs of females and 6, 5, or 4 or 4 photos of females. Publicly available profile photographs from an online dating site, www.okcupid.com, were added to the existing arrays in order to complete the three opposite sex and three same sex arrays necessary for the A conditions. Pilot testing indicated that the photos in each array were of comparable attractiveness between men and women.

Participants were told that the purpose of the study was to test perception and memory, and the effect of cognitive and physical tasks on perception and memory. Post-study debriefing interviews did not reveal suspicion or knowledge of the hypotheses being tested.

Implicit mating and competitive cognition. Mating cognitions were measured implicitly by having participants complete 10 word fragments that could be completed to make at least one sexual word, and at least one non-sexual word (e.g., s _ x) following the procedure of Miller & Maner (2010). These word fragments were intermixed with 10 word fragments generated for this study that could be completed to make one competitive word, and at least one non-competitive word (e.g., c _ m p _ t e). Scores were computed for each participant for number of sexual words generated and competitive words generated (each ranging from 0-10, with higher scores indicating more sexual or competitive words generated).

Explicit mating cognition. Explicit mating cognitions were measured by simply asking participants to rate their current level of arousal among 16 other mood items on a scale from 1 'definitely do not feel' to 7 'definitely feel'.

General competitiveness. General competitiveness was measured following Li et al. (2010) by computing the average of two items asking participants to rate the degree to which they agree with the following statements: "I feel the need to compete with others" and "Competition is a part of life" on a 7-point Likert scale from 1 'disagree' to 7 'agree' (α = .77).

Intrasexual competitiveness. was measured using an intrasexual competition scale (Buunk & Fisher, 2009) which assesses competitiveness with other members of the same sex specifically with twelve 7-point Likert items with responses ranging from 1 = not at all applicable to 7 = completely applicable (α = .89).

Social cognitive predictors of exercise. The social cognitive predictors of exercise (motivation and self-efficacy) were measured by constructs from the Theory of Planned Behavior (Ajzen, 1991) via self-report questionnaires. The TPB is widely used to predict intentions to perform health behaviors and behavior itself, including exercise (Armitage & Conner, 2001). Consistent with Information-Motivation-Behavior skills model (Fisher & Fisher, 1992), *motivation* was comprised of attitudes, social norms and intentions. *Attitudes* were measured with seven 7-point Likert items assessing affective (e.g, pleasant-unpleasant) and instrumental (e.g., beneficial-harmful) attitudes about exercising in the coming week. *Norms* were measured with two 7-point Likert items assessing the extent to which participants feel important others 'do some form of exercise' and 'think I should do exercise' (1 'disagree strongly' to 7 'agree strongly'). *Intentions* to exercise in the coming week were measured using a scale with seven 7-point Likert items (1 'disagree strongly/very unlikely' to 7 'agree strongly/very likely'). Reliability for the combined scale of motivation was high (α = .92). *Self-efficacy* was measured with six 7-point Likert items assessing how confident participants are in exercising in the coming week under various circumstances with responses ranging from 1 'not at all true' to 7 'very true' (α = .90).

Strength. Baseline and post-prime grip and chest strength were measured using a hydraulic dynamometer (Baseline, TN). Three consecutive measures of grip and chest strength were taken before and after participants viewed the photographs following the procedures detailed in Mathiowetz et al. (1985). The three measures taken for grip and chest strength were averaged into a composite strength measure for each time-point.

Testosterone and cortisol. Saliva samples were collected using Oral Swabs (Salimetrics, State College, PA). Experimenters gave the swabs to participants to place under their tongue and set a 2-minute timer, once before participants viewed the primes, and then again exactly 15 minutes after the participants began viewing the primes. Samples were frozen immediately after collection at -20°C until assay. The samples were assayed for testosterone using enzyme linked immunoassay (ELISA; Salimetrics,PA), and for cortisol using a non-commercial ELISA developed at the University of California Davis, at the Hominoid Reproductive Ecology Lab at the Department of Anthropology, University of New Mexico. The samples were run in duplicate and the inter-assay CVs were 8.1% (low sample) and 3.1% (high) for T and 10.5% (low) and 10.4% (high) for cortisol. Intra-assay CVs averaged 3.6% for testosterone and 3.8% for cortisol. Samples from women who were using hormonal contraceptives were not assayed, and some samples did not contain enough saliva for assay; therefore the sample size for analyses with T included 86 men and 65 women, while analyses with C included 80 men and 64 women. To minimize the influence of diurnal variation in T and C, all experimental sessions were run in the afternoon. . In addition, time of day did not significantly predict T levels, nor did it change the outcome of the results for T or C when included as a covariate.

Mood. To evaluate the potential effect of the manipulations on affective valence and arousal, the Brief Mood Introspection Scale was utilized (BMIS; Mayer &

Gaschke, 1988). This 16-item scale assesses affective valence with 16 items (e.g., pleasant-unpleasant), and arousal with 12 items (e.g., aroused-calm). It is well validated, and has been used to measure affective valence and arousal to compare conditions in studies with similar experimental manipulations (Maner, Gailliot, Rouby, & Miller, 2007).

Procedure

Participants were told that the purpose of the study was to measure perception and memory. Following informed consent, participants provided a baseline saliva sample for T and cortisol assay. Next, grip and chest strength were measured. Participants were then shown three arrays of photographs according to experimental condition. In the four experimental conditions, participants were told that the first array was comprised of 18 to 30 people on a local dating site, that the second was comprised of recent UNM graduates who live in the area, and that the third was comprised of current UNM students. Each array initially flashed on the screen for one second. Participants were then asked to answer questions about the array. In the SR conditions, participants were asked to guess how many men and how many women were in each array. In the A conditions, participants were asked to indicate how many men or women were attractive, then were given a chance to view the arrays again and were asked to rate the top five most attractive individuals. In the SR conditions, participants were given twenty seconds to view the arrays again and carefully count the number of men/women, and were then asked to report how many men and women were in each array. The same procedure was followed for those in the control condition, with participants reporting how many dogs and cats were in each array. Next, participants answered a battery of questionnaires with the expectation that their memory of the photograph arrays would be tested afterward.

After viewing the arrays, participants completed the 20 word fragments for implicit mating and competitive cognitions. Next, participants completed the BMIS mood measure, including the explicit mating question and explicit general competitiveness. (Personality was measured but not used in these analyses.) Participants then completed measures of established social cognitive predictors of exercise behavior (i.e., motivation and self-efficacy) and the desire to exercise. Finally, participants again answered the previous questions regarding how many men/women, attractive men/women, and dogs/cats were in each array as if their memory is being measured.

Participants were then told the study was testing how perception and memory are influenced by physical tasks. Participants were shown the photo arrays again, while providing a second saliva sample (15 minutes after they viewed the arrays for the first time). After viewing the arrays and answering array questions for a second time, grip and chest strength were measured in triplicate. (Measures taken but not included in analyses: anthropometric measures, height, weight, waist, hip, shoulder circumferences, self-perceived mate value, SOI, demographics.)

The type of prime that was the most effective in priming mating and/or competition was then used in Study 2 (Chapter 3) to more thoroughly examine the influence of the photo array primes on increased physical effort during a standardized exercise testing task.

Hypotheses

The experimental conditions in the SR prime are hypothesized to differentially influence competitive cognitions but may similarly influence mating cognitions since both conditions will expose single participants to photographs of attractive members of the opposite sex. The all male attractiveness condition was predicted to increase women's cognitions about mating, while increasing men's cognitions related to general and intrasexual competitiveness. Similarly, the all female attractiveness condition was predicted to increase men's cognitions about mating, while increasing women's cognitions about general and intrasexual competitiveness. The sex ratio conditions were predicted to differentially influence competitive cognitions, such that same-sex biased conditions would increase competitive and intrasexual competitive more than the opposite sex biased sex ratio conditions. Given the different constraints on life history and physical exertion between the sexes, men and women were examined separately in both studies; men were predicted to respond more acutely and robustly to the manipulation.

Planned analyses

Mating, competition, and exercise cognitions

To determine the relative influence of the photograph manipulation on implicit and/or explicit cognitions about mating, competition, and exercise, a series of statistical tests was performed using SPSS (version 18). For each outcome, a 2 (sex: male or female) X 2 (target sex: mostly/all female or mostly/all male) X 2 (manipulation type: sex ratio or attractiveness) 3-way between-subjects ANOVA was performed. Significant effects and interactions were followed up with 2 (target sex: mostly/all female or mostly/all male) X 2 (manipulation type: sex ratio or attractiveness) ANOVAs and simple effects tests *within sex.* To determine the pattern of results and examine the effects of the experimental conditions with the control condition, a priori contrasts were performed. Differences between the two conditions in each manipulation type were tested. Where significant differences were observed between conditions within a manipulation type, contrasts between each of the experimental conditions and the control condition were performed. Due to the exploratory nature of this research, a critical alpha level of $p \leq .05$ was used for all tests.

Strength, T and C.

For each outcome, a 2 (sex: male or female) X 2 (target sex: mostly/all female or mostly/all male) X 2 (manipulation type: sex ratio or attractiveness) repeated measures ANOVA was performed. This was followed up with 2 (target sex: mostly/all female or mostly/all male) X 2 (manipulation type: sex ratio or attractiveness) repeated measures ANOVA within sex to examine differences between men and women.

Moderation, mediation and exploratory analyses.

Baseline T was hypothesized to moderate the effect of the manipulation on the outcomes. To test for this, all models within sex were run including baseline T, the two-way manipulation type X T and target sex X T interactions, and the 3-way manipulation type X target sex X T interaction within sex.

Tests of mediation were performed where there was a significant effect of the manipulation on a psychological or physiological mediator (e.g., mating cognitions, competitiveness, T and/or C) and the strength and exercise cognition outcomes. These tests were performed using a bootstrap method to estimate the significance of the indirect effect with 1000 resamples. In instances where there was no significant effect of the manipulation on a mediator or outcome, exploratory analyses were conducted to understand the relationships between the mediators and the outcomes controlling for the effect of the experimental manipulation.

Results

Summary statistics and bivariate relationships among variables

Descriptive statistics for the variables of interest by condition within sex are provided in Tables 1 and 2. Bivariate relationships between the outcome variables are included in Table 3.

Table 1. *Means and (Standard Deviations) for the hypothesized mediators and manipulation check variables by sex and condition.*

	n	**Implicit mating**	**Explicit mating**	**Implicit competitiveness**	**General competitiveness**	**Intrasexual competitiveness**	**Affective arousal**
Men	**89**	4.57 (1.85)	3.53 (1.52)°°	5.19 (1.67)	7.87 (2.51)°°	3.24 (1.12)	28.37 (7.59)
Male biased	19	5.37 (1.71)	3.21 (1.23)	4.84 (1.50)†	7.92 (2.70)	3.46 (1.11)	29.36 (6.18)
Female biased	18	4.67 (1.46)	3.12 (1.47)	5.78 (2.02) †	7.8 (2.18)	3.17 (1.09)	27.44 (7.30)
All female	18	5.00 (2.22)**	4.28 (1.64)	5.17 (1.50)	8.75 (2.02)**	3.66 (1.04)**	28.27 (7.54)
All male	18	**3.20 (1.71)****	3.56 (1.79)	4.67 (1.61)†	6.92 (3.07)**	2.70 (1.14)**	28.00 (7.52)
Control	16	**4.50 (1.46)**	3.53 (1.31)	5.56 (1.59)†	7.97 (2.33)	3.2 (1.10)	28.75 (10.00)
Women	**95**	4.51 (1.76)	2.74 (1.34)°°	5.53 (1.30)	6.84 (2.31)°°	2.99 (1.13)	27.25 (6.68)
Male biased	20	4.85 (1.95)	2.90 (1.48)	5.90 (1.17)	7.50 (1.97)†	3.27 (1.27)	25.85 (7.26)
Female biased	18	4.61 (1.33)	2.55 (1.34)	5.72 (1.27)	6.22 (2.30)†	2.81 (1.29)	26.94 (5.12)
All female	20	4.00 (1.56)	**2.00 (1.03)****	5.50 (1.24)	6.00 (2.49)†	2.63 (0.84)	25.60 (7.76)**
All male	20	4.70 (2.15)	3.10 (1.37)**	5.05 (1.54)	7.38 (2.59)†	3.05 (0.89)	29.80 (7.17)**
Control	17	4.35 (1.69)	**2.74 (1.19)**	5.47 (1.18)	7.06 (1.87)	3.18 (1.30)	28.17 (4.87)

**Denotes a significant difference between the all male and all female attractiveness conditions

°°Denotes a signifincat difference between men and women

Bold text denotes a significant difference between a condition and the control condition
†Denotes a marginally significant difference between conditions within manipulation type

Table 2. *Means and (Standard Deviations) for the social cognitive predictors of exercise, strength, log T and log C by sex and condition.*

	n	Exercise motivation	Exercise self-efficacy	Baseline strength	Strength change	n	Baseline log T	Post log T	n	Baseline log C	Post log C
Men	**89**	16.88 (2.71)	5.14 (1.46)	83.06 (21.78)	85.48 (24.78)	86	4.84 (0.36)	4.88 (0.35)	80	8.69 (0.53)	8.65 (0.49)
Male biased	19	16.97 (2.39)	5.50 (1.00)	84.96 (23.88)	90.99 (28.44)	19	4.87 (0.28)	4.90 (0.32)	18	8.74 (0.36)	8.68 (0.43)
Female biased	18	16.47 (3.75)	4.99 (1.79)	75.51 (19.51)	78.67 (21.38)	17	4.78 (0.50)	4.86 (0.46)	16	8.61 (0.47)	8.58 (0.41)
All female	18	17.79 (1.77)**	5.25 (1.27)†	90.28 (22.25)	88.66 (26.48	17	4.80 (0.34)	4.82 (0.33)	17	8.62 (0.62)	8.56 (0.55)
All male	18	**15.32 (2.66)****	**4.34 (1.67)**†	**81.36 (20.17)**	**83.28 (22.04)**	18	**4.90 (0.33)**	**4.94 (0.32)**	18	**8.77 (0.66)**	**8.78 (0.54)**
Control	16	**17.96 (1.87)**	**5.68 (1.18)**	**93.43 (21.92)**	**100.58 (21.16)**	15	**4.89 (0.21)**	**4.93 (0.18)**	11	**8.50 (0.46)**	**8.47 (0.43)**
Women	**95**	16.59 (2.65)	4.99 (1.42)	46.57 (10.97)	49.07 (11.26)	65	4.22 (0.31)	4.23 (0.29)	64	8.55 (0.47)	8.45 (0.42)
Male biased	20	16.57 (2.80)	5.08 (1.58)	48.30 (13.82)	50.63 (12.69)	13	4.18 (0.29)	4.21 (0.27)	13	8.59 (0.40)	8.46 (0.42)
Female biased	18	16.57 (3.04)	5.24 (1.32)	45.34 (9.56)	48.00 (13.28)	13	4.23 (0.27)	4.20 (0.28)	13	8.68 (0.53)	8.50 (0.48)
All female	20	16.60 (2.41)	4.63 (1.67)	45.41 (10.57)	46.11 (8.95)	13	4.14 (0.37)	4.17 (0.36)	13	8.56 (0.49)	8.46 (0.52)
All male	20	16.46 (2.59)	5.02 (1.23)	47.10 (9.84)	51.44 (9.83)	14	4.33 (0.31)	4.31 (0.26)	14	8.39 (0.47)	8.37 (0.28)
Control	17	16.79 (2.64)	5.00 (1.28)	46.90 (9.17)	48.97 (8.64)	12	4.00 (0.28)	4.01 (0.33)	11	8.24 (0.35)	8.19 (0.33)

* *Denotes a significant difference between the all male and all female attractiveness conditions

Bold text denotes a significant difference between a condition and the control condition

†Denotes a marginally significant difference between conditions

Table 3. *Correlations between the Study 1outcome variables among men (lower diagonal) and women (upper diagonal).*

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Sexual words	---	**0.28****	**-0.23***	0.02	**0.24***	**-0.20***	**-0.26***	0.00	-0.04	0.01	-0.07	**-0.24***	**-0.25***
2. Arousal	-0.01	---	-0.15	0.13	**0.28****	0.06	0.00	-0.03	-0.08	**-.316***	-0.17	-0.08	-0.08
3. C words	**0.21***	-0.11	---	**-0.03**	-0.14	0.14	0.03	-0.00	-0.09	0.07	-0.05	0.14	0.12
4. G C	**0.22***	0.03	**0.31****	---	**0.37****	0.20	0.17	-0.05	-0.05	-0.18	-0.21	0.18	**0.23***
5. IS C	**0.33****	0.12	**0.23***	**0.36****	---	-0.06	0.00	0.15	0.14	-0.02	-0.05	0.04	0.06
6. Motivation	**0.32****	0.11	**0.23***	**0.27***	0.18	---	**0.68****	0.05	0.11	-0.10	0.06	**0.21***	0.16
7. SE	**0.38****	-0.08	**0.21***	**0.21***	0.07	**0.70****	---	-0.01	0.07	0.02	0.14	0.14	0.13
8. BL log T	-0.10	-0.02	-0.13	-0.11	-0.14	-0.20	**-0.30****	---	**0.87****	**0.47****	**0.46****	-0.14	-0.07
9. Post log T	-0.08	0.11	-0.14	-0.14	-0.16	-0.20	**-0.26***	**0.85****	---	**0.36****	**0.52****	-0.07	-0.01
10. BL log C	0.07	0.02	-0.01	0.01	-0.01	-0.16	-0.10	**0.56****	**0.42****	---	**0.73****	-0.03	-0.09
11. Post log C	0.05	0.02	0.01	-0.09	-0.04	-0.09	0.00	**0.52****	**0.51****	**0.85****	---	-0.11	-0.14
12. BL strength	0.21	0.02	-0.11	0.16	0.10	0.15	0.11	**-0.24***	**-0.21***	-0.12	-0.16	---	**0.89****
13. Post strength	0.18	0.04	-0.06	0.14	0.17	0.20	0.17	**-0.26***	**-0.26***	-0.17	-0.18	**0.92****	---

C words = competitive words, G C = General competitiveness, IS C = Intrasexual competitiveness, SE = Self-efficacy, BL = Baseline

*$p < .05$

**$p < .01$

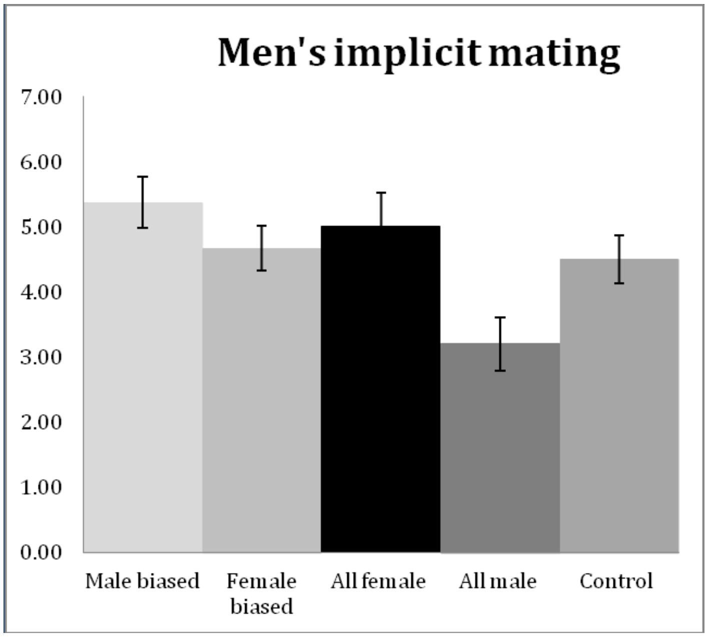
Mating cognitions

Implicit: Sexual word stem completion

There was a significant main effect of manipulation type on the number of sexual words generated $F(1, 143) = 4.65$, $p = .03$, $\eta_p^2 = .03$; and a significant 3-way interaction between participant sex, target sex, and manipulation type, $F(1, 143) = 6.10$, $p = .02$, $\eta_p^2 = .04$. Overall, the sex ratio conditions led to greater sexual words generated ($M = 4.88$, $SD = 1.66$) compared to the attractiveness manipulations ($M = 4.25$, $SD = 2.00$). To interpret the 3-way interaction, 2 (target sex) X 2 (manipulation type) ANOVAs were performed within sex.

Among men, there was a significant main effect of manipulation type, $F(1, 69) = 4.38$, $p = .04$, $\eta_p^2 = .06$, qualified by a target sex X manipulation type interaction, $F(1, 69) = 8.33$, $p < .01$, $\eta_p^2 = .11$. Overall, men in the sex ratio conditions generated more sexual words ($M = 5.03$, $SD = 1.62$) compared to men in the attractiveness conditions ($M = 4.14$, $SD = 2.14$), but this effect depended on the sex of the targets. Men who attended to the attractiveness of males generated significantly fewer sexual words compared to men who attended to the attractiveness of females, $F(1,84) = 8.83$, $p < .01$, $\eta_p^2 = .10$, and men in the control condition, $F(1, 84) = 4.18$, $p = .04$, $\eta_p^2 = .05$. The male and female-biased sex ratio conditions did not differentially affect the number of sexual words generated ($p = .22$; See Table 2 and Figure 1).

Figure 1. *Number of sexual words generated in the word-stem completion task by condition among men. Men in the all male condition were significantly lower than the all female and control conditions.*

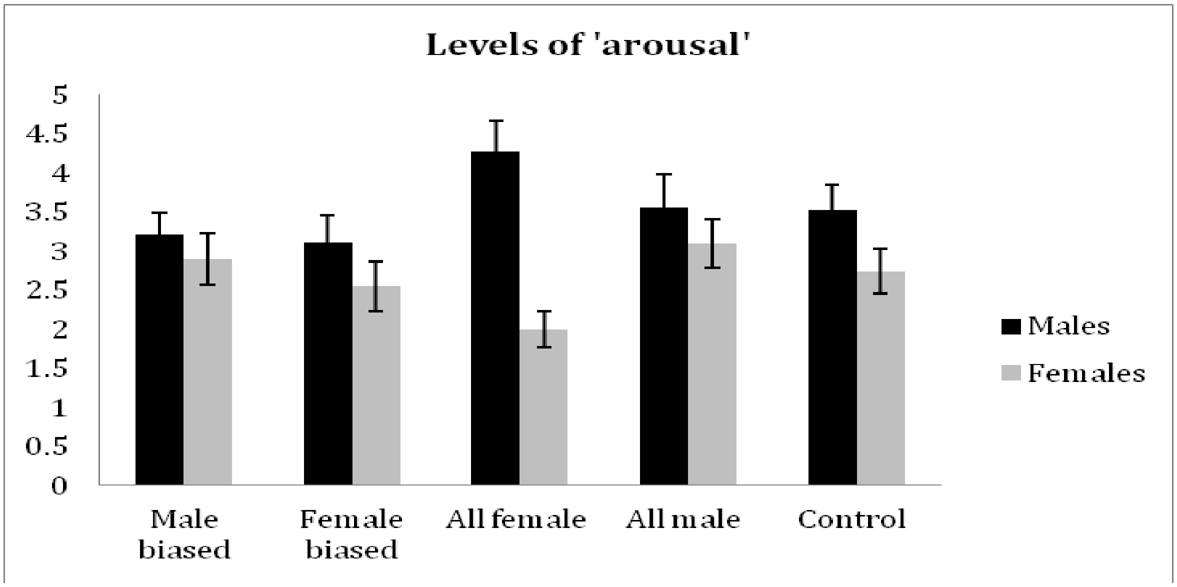


Among women, there were no significant main effects of target sex or manipulation type, nor was there a significant interaction on number of sexual words generated (p's > .25). No difference was observed between the male and female-biased conditions. Women who rated female photographs for attractiveness generated fewer sexual words than those who rated male photos and those in the control condition, but these differences were not statistically significant (p's > .22).

Explicit: Self-reported arousal

A significant main effect of sex was observed for self-reported arousal, $F(1, 143) = 15.41$ $p < .001$, $\eta_p^2 = .10$. There was also a significant sex X target sex interaction, $F(1, 143) = 5.20$ $p = .02$, $\eta_p^2 = .04$, and a sex X manipulation type interaction, $F(1, 143) = 3.79$ $p = .05$, $\eta_p^2 = .03$ As can be seen in Figure 2, men reported higher arousal overall, and the pattern of results across condition differed by sex.

Figure 2. *Self-reported arousal by condition among men and women. Men reported significantly higher arousal overall, with femaes in the all male/male biased significantly higher than the control condition.*



Among men, there was a significant main effect of manipulation type on level of arousal, $F(1, 69) = 4.08$ $p < .05$, $\eta_p^2 = .06$, with men in the attractiveness conditions ($M = 3.92$, $SD = 1.73$) reporting higher arousal then men in the sex ratio conditions ($M = 3.19$, $SD = 1.36$). Simple effects tests revealed no differences between conditions within the manipulation types, or differences with the control condition.

Among women, there was a significant main effect of target sex on arousal, $F(1, 74) = 5.87$ $p = .02$, $\eta_p^2 = .07$. Women in conditions with a male-biased sex ratio or all males reported significantly higher arousal ($M = 3.00$, $SD = 1.41$) than women in conditions with a female-biased sex ratio or all females ($M = 2.26$, $SD = 1.20$). Simple effects tests revealed that women who attended to the attractiveness of females reported significantly lower levels of arousal compared to those who attended to the attractiveness of males, $F(1,90) = 7.24$, $p < .01$, $\eta_p^2 = .07$, and those in the control condition, $F(1, 90) = 7.61$, $p < .01$, $\eta_p^2 = .08$. Women in the all male condition reported slightly, but not significantly higher arousal than women in the control condition. There were not significant differences between the male and female-biased sex ratio conditions.

Men therefore demonstrated significantly lower implicit mating cognitions when viewing and attending to the attractiveness of other males, driving a manipulation type X target sex interaction; and reported higher arousal in the attractiveness conditions relative to the sex-ratio conditions. Women reported significantly higher arousal when viewing male-biased or all male arrays; and significantly lower arousal when attending to the attractiveness of other females compared to the all male and control conditions.

Competitive cognitions

Implicit: Competitive word stem completion

The main effects of sex, $F(1, 143) = 3.11$, $p = .08$, $\eta_p^2 = .02$ and target sex, $F(1, 143) = 3.07$, $p = .08$, $\eta_p^2 = .02$ on the number of competitive words generated fell just short of statistical significance. Women tended to generate more competitive words ($M = 5.54$, $SD = 1.33$) than men ($M = 5.10$, $SD = 1.69$), while participants in the sex ratio conditions tended to generate more competitive words ($M = 5.56$, $SD = 1.54$) than those in the attractiveness conditions ($M = 5.11$, $SD = 1.47$).

Similarly, the main effect of target sex on competitive words generated fell just short of significance among men, $F(1, 69) = 3.36$, $p = .07$, $\eta_p^2 = .05$. Contrary to predictions, a trend was observed that men generated more competitive words in conditions that were female-biased or all female ($M = 5.47$, $SD = 1.78$) compared to men in conditions with male-biased or all male photos ($M = 4.76$, $SD = 1.53$). No significant differences were observed between conditions within manipulation type, or when contrasted with the control condition.

Among women, the main effect of manipulation type on competitive words generated fell just short of significance, $F(1, 74) = 3.25$, $p = .08$, $\eta_p^2 = .04$, with women in the sex ratio conditions generating slightly, but not significantly more competitive words ($M = 5.82$, $SD = 1.20$) than those in the attractiveness conditions ($M = 5.28$, $SD = 1.40$). No differences were observed in the simple effects tests between conditions within manipulation type, or when contrasted with the control condition.

Explicit: General competitiveness

There was a significant main effect of sex, $F(1, 143) = 7.29$, $p <.01$, $\eta_p^2 = .05$, and a significant sex X target sex interaction $F(1, 143) = 7.55$, $p < .01$, $\eta_p^2 = .05$. Men reported higher general competitiveness ($M = 7.84$, $SD = 2.56$) than women ($M = 6.79$, $SD = 2.40$); however the effect of target sex on competitiveness depended on the sex of the participant.

Among men, there were no significant main effects of target sex or manipulation type, or a target sex X manipulation type interaction (p's > .11). Simple effects tests revealed that men attending to the attractiveness of females reported significantly higher competitiveness than those attending to the attractiveness of males, $F(1, 84) = 4.85$, $p = .03$, $\eta_p^2 = .06$, but neither the all female nor all male condition was significantly different from the control condition (p's > .22).

Among women, there was a significant main effect of target sex on general competitiveness, $F(1, 74) = 6.18$, $p = .02$, $\eta_p^2 = .08$. Women in conditions with male-biased sex ratio or all males reported significantly higher competitiveness ($M = 7.44$, $SD = 2.28$) than women in conditions with female-biased sex ratio or all females ($M = 6.11$, $SD = 2.37$). Simple effects tests further revealed that women in the all male condition reported higher competitiveness compared to those in the all female, though this difference fell just short of significance, $F(1, 90) = 3.65$, $p = .06$, $\eta_p^2 = .04$, and women in the male-biased sex ratio condition reported slightly, but not significantly higher competitiveness compared to those in the female-biased sex ratio condition, $F(1, 90) = 2.99$, p = .09, $\eta_p^2 = .03$. No differences in competitiveness were observed between the control and experimental conditions (p's > .16).

Thus, both men and women reported greater general competitiveness when viewing and attending to the attractiveness of individuals of the opposite sex compared to same sex.

Explicit: Intrasexual competitiveness

The main effect of sex on intrasexual competitiveness was not significant, $F(1, 143) = 2.96$, $p = .09$, $\eta_p^2 = .02$; however there was a significant sex X target sex interaction, $F(1, 143) = 4.68$, $p = .03$, $\eta_p^2 = .03$. The target sex X manipulation type interaction, $F(1, 143) = 3.35$, $p = .07$, $\eta_p^2 = .02$, and the 3-way sex X target sex X manipulation type interaction, $F(1, 143) = 2.91$, $p = .09$, $\eta_p^2 = .02$ did not reach statistical significance.

Among men, there were no main effects of target sex or manipulation type on intrasexual competitiveness, but there was a significant target sex X manipulation type interaction, $F(1, 69) = 6.01$, $p = .02$, $\eta_p^2 = .08$. In the attractiveness manipulation, men who attended to the attractiveness of females reported significantly higher intrasexual competitiveness than those who attended to the attractiveness of males, $F(1, 84) = 6.88$, $p = .01$, $\eta_p^2 = .08$. In the sex ratio manipulation, men in the male-biased condition reported slightly higher intrasexual competitiveness than men in the female-biased condition, but this difference was not significant ($p = .41$).

Among women, the main effect of target sex on intrasexual competitiveness fell just short of significance, $F(1, 74) = 3.17$, $p = .08$, $\eta_p^2 = .04$. As was the case for implicit competitiveness, women who were in conditions with male-biased sex ratio or all males tended to report higher intrasexual competitiveness ($M = 3.16$, $SD = 1.08$) than women in conditions with female-biased sex-ratio or all females ($M = 2.71$, $SD = 1.07$). Among women, there were no significant differences in intrasexual competition between the experimental conditions, nor differences between the experimental and control conditions (p's $> .21$).

Men therefore demonstrated significantly greater explicit general and intrasexual competitiveness when viewing and attending to the attractiveness of females as opposed to males. Women demonstrated significantly greater explicit general competitiveness, and there was a trend toward greater implicit and intrasexual competitiveness when viewing photograph arrays comprised primarily or completely of males.

Social cognitive predictors of exercise

Motivation

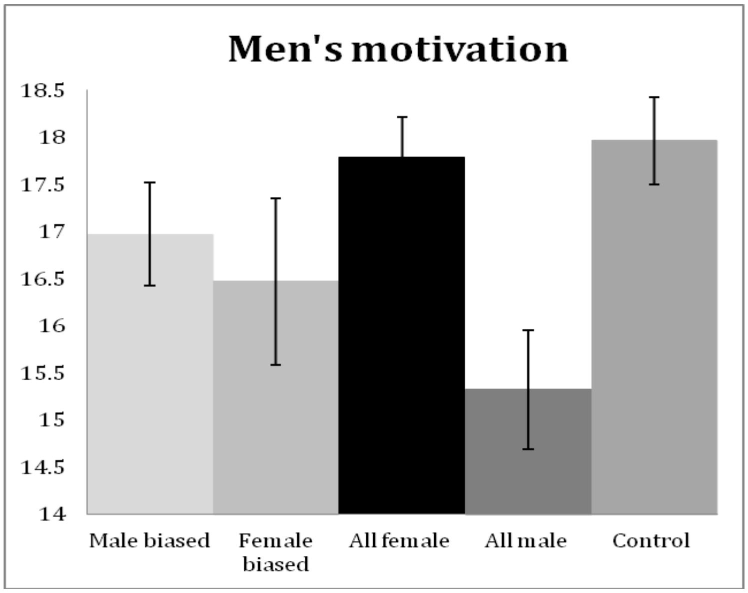
There were no significant main effects of sex, target sex, or manipulation type on exercise motivation. The target sex X manipulation type interaction fell just short of significance, $F(1, 143) = 3.06$, $p = .08$, $\eta_p^2 = .02$.

Among men, the main effects of target sex and manipulation type were non-significant, but there was a significant target sex X manipulation type interaction, $F(1, 143) = 5.38$, $p = .02$, $\eta_p^2 = .07$. Simple effects tests revealed that men in the all male attractiveness condition reported significantly lower motivation to exercise compared to those in the all female attractiveness condition, $F(1, 84) = 8.16$, $p < .01$, $\eta_p^2 = .09$, and those in the control condition, $F(1, 84) = 8.73$, $p < .01$, $\eta_p^2 = .09$ (Figure 3a). Men in the male-biased sex ratio condition reported slightly higher motivation than those in the female-biased sex ratio condition, but these differences were non-significant.

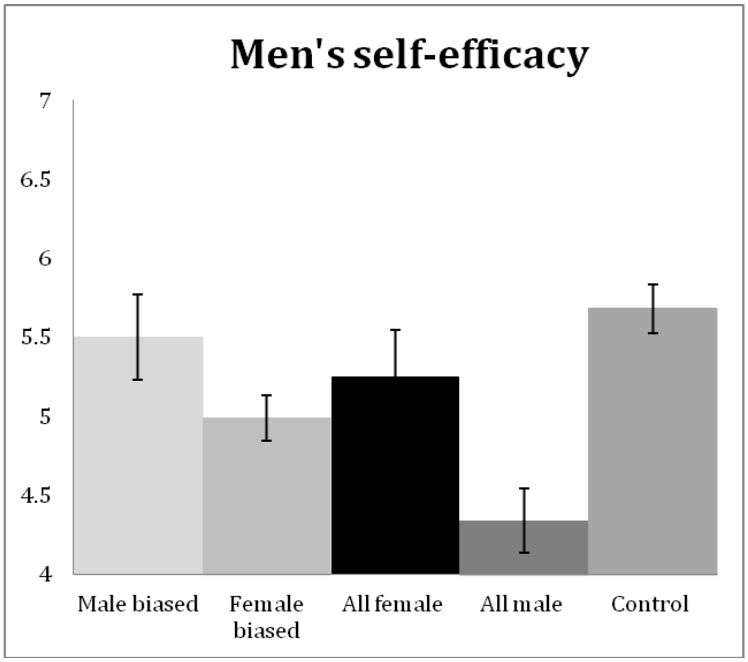
Among women, there were no significant main effects of target sex, manipulation, nor a significant target sex X manipulation type interaction on exercise motivation. Simple effects tests revealed no significant differences in motivation between the conditions in either prime type (p's $> .88$).

Figure 3. *Social cognitive predictors of exercise by condition among men. Men in the all male condition reported significantly lower exercise motivation (a) and self-efficacy (b) relative to the all female and control conditions.*

a.



b.



Self-efficacy

There were no significant main effects of sex, target sex, or manipulation type on exercise self-efficacy (p's > .36). There was a significant 3-way sex X target sex X manipulation type, $F(1, 143) = 4.21$, $p = .04$, $\eta_p^2 = .03$.

Among men, there were no main effects of target sex or manipulation type on exercise self-efficacy. The target sex X manipulation type interaction was significant, $F(1, 69) = 4.28$, $p = .04$, $\eta_p^2 = .06$. Simple effects test revealed that men in the all male attractiveness condition reported lower exercise self-efficacy compared to those in the control condition, $F(1, 84) = 1.53$, $p < .01$, $\eta_p^2 = .08$, and those in the all female attractiveness condition, though this difference fell short of statistical significance $F(1, 84) = 3.70$, $p = .06$, $\eta_p^2 = .04$,. Men in the male-biased sex ratio condition reported slightly, but not significantly, higher exercise self-efficacy (see Figure 3b).

Among women, there were no significant main effects of target sex or manipulation type, nor a target sex X manipulation type interaction. Simple effects tests further revealed no differences between the conditions within either manipulation type (p's > .40).

Thus, men who attended to the attractiveness of other males reported significantly lower exercise motivation and moderately lower exercise self-efficacy; however, the experimental manipulation did not influence women's exercise motivation or self-efficacy.

Changes in strength

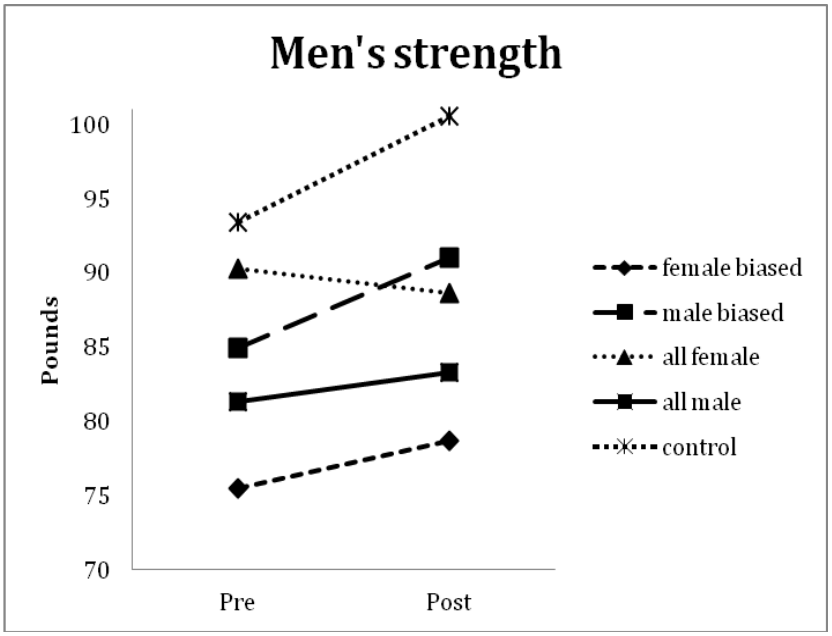
There was a significant main effect of time on strength, $F(1, 143) = 16.03$, $p < .001$, $\eta_p^2 = .10$, indicating that strength increased from baseline to post-manipulation overall. This main effect was qualified by a significant time X target sex interaction, $F(1, 143) = 3.97$, $p < .05$, $\eta_p^2 = .03$, while the time X manipulation type interaction fell just short of significance, $F(1, 143) = 3.28$, $p = .07$, $\eta_p^2 = .02$.

Among men, there was a significant main effect of time, $F(1, 69) = 4.72$, $p = .03$, $\eta_p^2 = .06$, which was qualified by a significant time X manipulation type interaction, $F(1, 69) = 4.13$, $p < .05$, $\eta_p^2 = .06$. As can be seen in Figure 4a, paired samples t-tests within condition revealed that men in the male-biased and control conditions had significant increases in strength (p's $< .02$). This trend was seen in the female-biased condition, though difference fell short of significance ($p = .09$). The differences in strength in the all male and all female attractiveness conditions were not significant, but went in opposite directions: men who viewed all females had slight decreases in strength, while men who viewed all males had slight increases in strength.

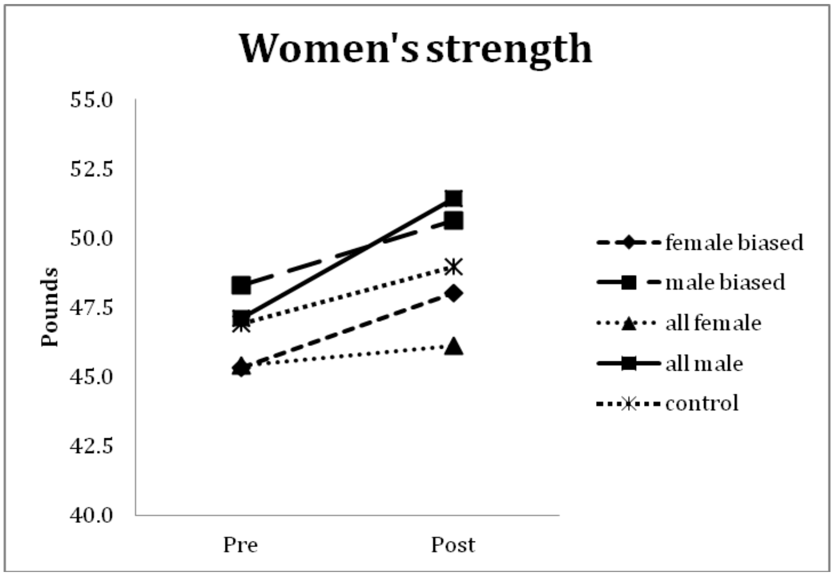
Among women, there was a significant main effect of time, $F(1, 74) = 18.08$, $p < .001$, $\eta_p^2 = .20$. As shown in Figure 4b, women in all conditions had increases in strength from baseline to post-manipulation, and neither the manipulation type nor the target sex of the individuals in the photographs moderated the effect of the prime on strength. Paired samples t-tests revealed that these differences were significant in the male-biased, all male, and control conditions (p's $< .05$); fell just short of significance in the all female-biased condition (p = .07); and was non-significant in the all female condition (p = .44).

Figure 4. *Strength measures from pre- to post-manipulation by condition among men (a) and women (b).*

a.



b.



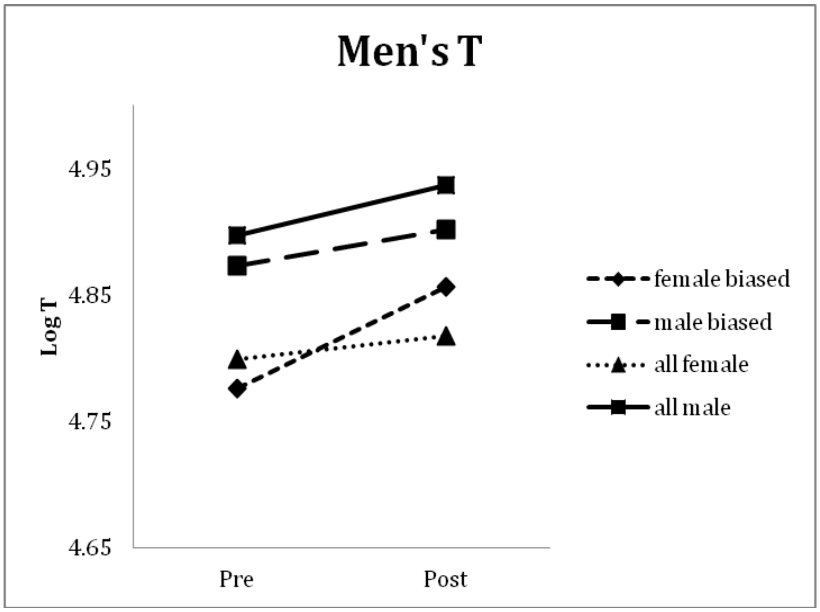
Changes in testosterone

Two outliers had increases in T that were more than 4 standard deviations above the mean and were excluded from analyses. There were no main effects of time, nor any interactions between time and sex, manipulation type, and target sex.

As can be seen in Figure 5, men in the experimental condition show a trend toward increased T from pre to post-manipulation, $F(1, 67) = 3.77$, $p = .06$, $\eta_p^2 = .05$. However this effect became weaker and non-significant when controlling for sex of the experimenter, $F(1, 66) = 1.54$, $p = .22$, $\eta_p^2 = .02$. There were no significant differences in these increases according to the target sex or manipulation type.

Among women, there was no main effect of time on T, nor any time X target sex or manipulation type interactions.

Figure 5. *Log Testosterone pre- and post-manipulation by condition among men*



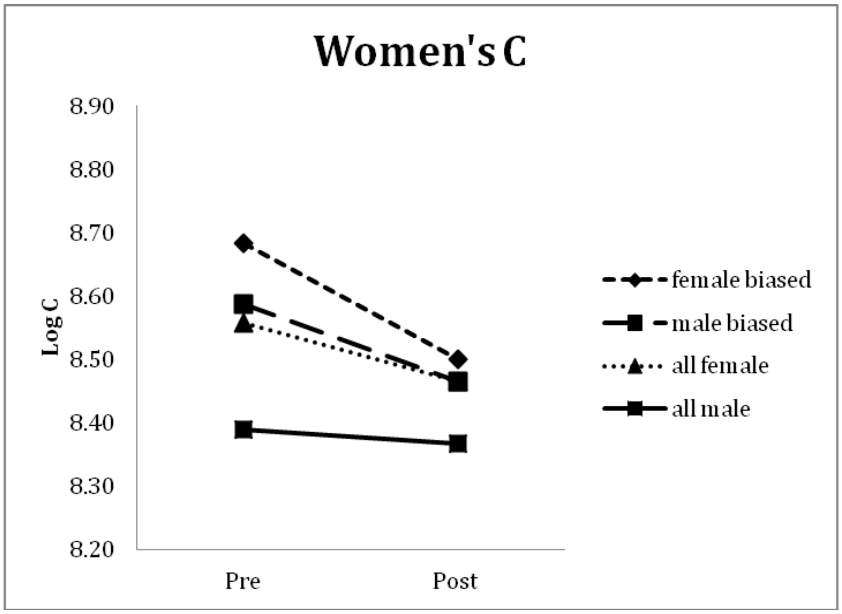
Changes in cortisol

Three outliers had increases in C that were more than 4 standard deviations above the mean and were excluded from analyses. There was a significant overall main effect of time on C, *F*(1, 113) = 5.76, $p = .02$, $\eta_p^2 = .06$. None of the time X sex, target sex, or manipulation type interactions were significant (*p*'s >.24).

Among men, there was no main effect of time, nor any time X target sex or manipulation type interactions.

As can be seen in Figure 6, women in all experimental conditions had significant decreases in C from pre to post-manipulation, *F*(1, 48) = 4.73, $p = .04$, $\eta_p^2 = .09$. This effect became stronger when controlling for the sex of the experimenter, *F*(1, 47) = 5.54, $p = .02$, $\eta_p^2 = .11$. There were no significant differences in these increases according to the target sex or manipulation type.

Figure 6. *Cortisol pre- and post-manipulation by condition among women.*



Moderation of effects by baseline T

No significant interactions were detected between T and the manipulation on any of the outcomes; thus the effect of the manipulation did not depend on baseline T levels in men or women. It though it should be noted that power to detect such moderation was reduced given the smaller sample size for which T was successfully measured (67 females and 87 males).

Mediation analyses

Among men, the manipulation led to significant differences in exercise motivation and self-efficacy in the all male versus control condition, and differences in motivation between men in the all male versus all female conditions. There were also differences in general and intrasexual competitiveness and the number of sexual words generated between the all male and all female conditions; and differences in the number of sexual words generated in the all male versus control conditions. Therefore implicit mating cognitions were tested as a mediator of the effect of condition on motivation and self-efficacy among men in the all male and control conditions (N = 34); and the effect of condition on motivation among men in the all male versus all female conditions (N = 38). Intrasexual and general competitiveness were also tested as mediators of the effect of condition on motivation among those in the all male versus all female condition. All mediation tests were run using bootstrapping procedures with the lavaan package in R with 1,000 resamples. None of the indirect effects were significant; however the indirect effect of implicit mating cognitions on self-efficacy among men in the all male and control conditions fell just short of significance (indirect effect = 0.50, *SE* = 0.30, p = .09; all other p's > 0.14).

Exploratory analyses

Follow-up analyses were conducted to better understand the relationships between the hypothesized psychological mediators (mating and competitive cognitions) and changes in strength and T and C above and beyond the effect of the experimental paradigm. Specifically, it was of interest to determine whether mating or competitive cognitions, or both, predicted changes in strength, T and C. Repeated measures ANOVA models were therefore run predicting changes in strength, T and C that included the mating outcomes (explicit and implicit) and competitive cognitions (general and intrasexual) separately within sex. Among men, the time X intrasexual competitiveness interaction significantly predicted changes in strength, $F(1, 68) = 4.07$, $p < .05$, $\eta_p^2 = .06$, suggesting that controlling for the effect of the manipulation, intrasexual competitiveness positively predicted changes in strength. Also among men, there was a significant time X explicit mating interaction on T, $F(1, 66) = 4.10$, $p < .05$, $\eta_p^2 = .06$, suggesting that men's self-reported arousal positively predicted changes in T. No other significant effects were detected in men or women (p 's > .18). Thus, it appears that, though the experimental manipulation had an inconsistent effect on the hypothesized psychological mediators and changes in strength, T and C, among men there is a predictive relationship between intrasexual competitiveness and measures of strength, and between arousal and changes in T.

Ancillary analyses

Mood: Affective valence and arousal

Additional analyses were performed to evaluate the potential effects of the manipulation on affective valence and arousal. There were no significant main effects of sex, target sex or manipulation type, or interactions between them on affective valence in the entire sample, or within sex (*p*'s > .25). In addition, there were no significant differences within sex between conditions in each prime type, or differences compared to the control condition (*p*'s > .21). Similarly, there were no significant main effects of sex, target sex, or manipulation type, or 2- or 3-way interactions between them on affective arousal in the entire sample or within sex (*p*'s > .10). No differences between conditions within prime type were observed in men (*p*'s >.61); however women in the all female attractiveness condition reported significantly lower arousal (M = 25.60, SD = 7.76) than those in the all male attractiveness condition (M = 29.80, SD = 7.17), $F(1, 90) = 1.02$, $p = .05$, $\eta_p^2 = .04$.

Experimenter sex

Participants were randomly assigned to condition, but interacted with either a male or female experimenter. To test for the effect of the experimenter sex on the outcomes, the models were run including experimenter sex as a covariate. Overall, including experimenter sex did not alter the significance of the primary hypotheses tests. There were some main effects of experimenter sex (reported below), but interpretation of any causal effects is limited due to a lack of random assignment.

There was a main effect of experimenter sex on men's motivation to exercise, $F(1, 67) = 4.51$, $p = .04$, $\eta_p^2 = .06$. Men who had a female experimenter reported lower motivation to exercise (M = 16.32, SD = 3.00) than those who had a male experimenter (M = 17.25, SD = 2.42).

There was no main effect of experimenter sex on changes in strength, but there was a main effect of experimenter sex on baseline strength in the whole sample, $F(1, 141) = 4.46$, $p = .04$, $\eta_p^2 = .03$. Those who had a female experimenter had lower baseline strength (M = 63.23, SD = 24.81) compared to those who had a male experimenter (M = 65.54, SD = 25.53). The effect of manipulation type, and a sex X manipulation type interaction that were not detected in the initial analyses were observed when controlling for experimenter sex (p's < .04). Analyses within sex did not reveal significant main effects of experimenter sex on changes in strength or baseline strength.

There was also a significant effect of experimenter sex on changes in T, $F(1, 141) = 4.73$, $p = .03$, $\eta_p^2 = .04$ overall. Repeated measures t- tests within sex and experimenter sex revealed that men who had a female experimenter had significant increases in T from baseline to post-test, $t(56) = 2.54$, $p = 0.01$, while men who had a male experimenter, and women who had a male or female experimenter did not have significant changes in T (p's > 0.92).

The main effect of target sex on women's affective arousal also became non-significant when controlling for experimenter sex, though there were no main effects nor interactions of experimenter sex on affective arousal.

Discussion

The first aim of Study 1 was to determine if having individuals attend to the sex ratio or the attractiveness of individuals in photographs could influence perceptions of their socio-ecological context measured by implicit and explicit cognitions related to mating and competitiveness. Results were mixed, but provided preliminary evidence in support of this hypothesis for the attractiveness manipulation with differences in mating and competitive cognitions observed between the all male and all female conditions, particularly among men. In men, the manipulations also differentially influenced changes in strength, exercise motivation and self-efficacy. No differences were observed between conditions in changes in strength, exercise motivation or self-efficacy in women.

Target sex of the individuals in the photographs affected men differently depending on manipulation type for implicit mating cognitions, intrasexual competitiveness, and exercise motivation and self-efficacy. In each case the pattern of results was the same, with men attending to the attractiveness of other males reporting lower mating cognitions, intrasexual competitiveness, exercise motivation and self-efficacy. In each case, with the exception of intrasexual competitiveness, these differences were also lower than the control condition. On the other hand, no significant differences were found between the male- and female-biased sex ratio conditions; however in each case the men in the male-biased condition reported slightly higher cognitions related to mating, competitiveness, and exercise.

Somewhat unexpectedly, men who attended to the attractiveness of females had slight, though non-significant, decreases in strength measures from pre to post manipulation, while significant increases in energetic effort were observed in the male-biased and control conditions.

A trend was observed for increases in T in the experimental conditions, with no differences across conditions. However, there was a significant difference in T response according to the sex of the experimenter, such that men's T increased significantly in the presence of a female experimenter and did not change in the presence of a male experimenter. The overall main effect of time was reduced to non-significant when controlling for sex of the experimenter. No changes in C were observed in men. This was the first study I am aware of to test whether a visual stimuli manipulation can influence T or C, and results do not support a significant effect of this type experimental paradigm for predictably changing T or C. Future research should consider what appeared to be a stronger manipulation of T for men, the sex of the experimenter, when attempting to manipulate hormonal responses.

Among women, the largest effects were observed when examining the effect of target sex in the photograph arrays, regardless of the nature of the task (i.e., attending to the sex ratio or attractiveness of the individuals in the photographs). Women in the male-biased sex ratio or all male conditions reported significantly higher arousal and general competitiveness compared to women in the female-biased or all female conditions. Arousal was also significantly higher when women attended to the attractiveness of male compared to female photographs and compared to control. The difference in arousal between the all female and all male attractiveness condition was only marginally significant. No significant differences were observed in arousal between the male- and female-biased sex ratio conditions.

Although there was some evidence that the manipulations influenced women's mating and competitive cognitions, there were no differences in exercise motivation, self-efficacy, changes in strength, T or C. Cortisol did decrease significantly in women, but did not differ across conditions. It was likely more reflective of diurnal decreases in C. Women were predicted to respond less to the experimental manipulation because of the greater inherent biological opportunity and energetic costs faced by women. The null findings in women in exercise cognitions and performance on the strength task contrasted with the findings in men giving preliminary support for this hypothesis, though further investigation is necessary.

Results therefore supported hypotheses with regard to mating cognitions, in that men and women both demonstrated relatively higher cognitions about mating when looking at or attending to the attractiveness of opposite sex individuals. No differences were predicted or observed in mating cognitions between the sex ratio conditions.

Initial predictions regarding competitiveness were not supported. Competitiveness was predicted to increase in response to attending to the attractiveness of same sex individuals and in same sex biased sex ratio conditions. In contrast, competitiveness was relatively higher when attending to the attractiveness of opposite sex photographs in both men and women. No differences were observed between the sex ratio conditions in competitiveness. Instead, the pattern of results from the ANOVA analyses and the zero-order correlations suggest that increases in cognitions about mating were accompanied by increases in cognitions about competitiveness, which were higher in the opposite sex condition relative to the same sex condition, though neither opposite or same sex conditions were different from control. In women, the relationships between mating cognitions and general competitiveness were non-significant, and ANOVA results with competitiveness outcomes were inconclusive.

The mediation analyses did not support the hypothesis that the effects of the manipulation on strength and exercise-related cognitions were mediated by cognitions related to mating or competitiveness. These analyses were limited in power to detect such effects however, and additional research with larger samples is necessary to rule out this possibility. Consistent with theoretical predictions, men's social cognitive predictors for exercise (motivation and self-efficacy) in the coming week were correlated with cognitions about mating and competitiveness. Moreover, exploratory analyses revealed that, controlling for experimental condition, arousal predicted changes in strength from pre to post manipulation, while intrasexual competitiveness predicted changes in T among men. Thus, the results do support further examination of the hypothesized relationships between mating and competitiveness to influence T, C, and strength or effort toward measures of strength, particularly among men. However, an experimental paradigm that more consistently leads to changes in mating and/ or intrasexual competitiveness and T or C may be necessary to test for mediation, or to more clearly determine the effect of mating and competitive cognitions on strength.

In addition, there were main effects of experimenter sex on baseline strength, and on exercise motivation in men and changes in T among men who had a female experimenter. Controlling for the effect of experimenter sex did not alter the significance of the findings regarding cognitions related to mating, competitiveness, or exercise, but may have confounded the results for T and strength. These results are intriguing in their own right, and warrant follow-up in future research where participants can be randomly assigned to have a male or female experimenter. It is possible that interpersonal interactions are a more effective manipulation technique, particularly for testing whether changes in T (and potentially C) facilitate the effects of others on physical performance. Previous research has demonstrated an effect of interactions with a female experimenter on men's T (Ronay & von Hippel, 2010; Roney, et al., 2007; Roney, et al., 2003; Roney, et al., 2010) and C (Roney, et al., 2007; van der Meij, et al., 2010), and a greater propensity toward risk (Miller & Maner, 2010; Ronay & von Hippel, 2010). Due to these differences, only female experimenters were used in Study 2.

CHAPTER 3: Study 2

Introduction

In Study 2, the best performing experimental manipulations from Study 1 (the all male and all female attractiveness primes) were used to test whether attending to the attractiveness of males or females influenced performance on a standardized fitness test or self-reported social cognitive predictors of exercise (i.e., motivation and self-efficacy). The investigation was expanded in two ways. A broader sample of participants was included in order to test the moderating effect of factors that influence the timing of life history events or reflect different energy allocation strategies: birth weight (as a proxy for pre-natal energetic condition), relationship and parental status, age, sociosexual orientation, and baseline T. In addition, two additional experimental conditions that included a peer evaluation element were added to test whether explicitly believing that future male or female participants would be aware of how well individuals performed on the fitness test would increase energetic effort on the fitness test above and beyond merely attending to the attractiveness of the photographs.

In applying drive theory to understand social facilitation, Zajonc (1965) asserted that the mere presence of others, whether in competition, coacting, or as an audience, would increase arousal or drive, and increase the likelihood of dominant responses. Cotrell et al. (1968) argued that it was not simply the presence of others, but the fear of evaluation that increased drive, and thus increases in dominant response patterns. Overall, social facilitation research does not support Cottrell's hypothesis (Bond & Titus, 1983); however there are major differences in how studies examining differences between the mere presence of others, versus the evaluation by others, are designed and conducted. First, some studies contrast an evaluative versus non-evaluative audience by manipulating whether or not the audience can see the performer, assuming that if an audience can see the performance, they automatically evaluate it, whereas others manipulate the expertise of the audience, contrasting between peers and experts or judges. When contrasting peers and experts, peers actually have a larger effect on performance speed (though not accuracy), suggesting a larger social facilitative effect on increases in energy toward completing the tasks when theoretically more socially relevant individuals are present (Bond & Titus, 1983). The question of evaluation versus the mere presence or awareness of others has been tested in one study with a conditioning task as the outcome. Worringham and Messick (1983) compared running speed with one person present who either had their backs turned, or were watching the runner. Not surprisingly, they found that runners perform faster when there is someone actually watching, compared to when there is someone present who cannot see them. The authors interpret their findings as support for an enhanced facilitative effect if performance is being evaluated. The current study aimed to test the influence of audience evaluation above and beyond the mere increased awareness of socially relevant others by including an enhanced version of both of the attractiveness manipulations that explicitly leads participants to believe that future participants will see a picture of them and find out how well they did on the fitness test. The effect of this enhancement was compared to the attractiveness manipulations used in Study 1 and against a no treatment control condition.

Methods

Participants

Participants for Study 2 were recruited from a pool of individuals performing a standardized fitness test through the Division of Exercise Science, Exercise Physiology lab in the Department of Health, Exercise & Sports Sciences at the University of New Mexico. Participation in the study was completely voluntary. The fitness tests are provided to individuals currently enrolled in exercise classes (e.g., weight lifting, aerobics, swimming, jogging, etc.). Participants reported exercising regularly (*M* = 3.28 days/week, *SD* = 1.58). The cover story was the same as in Study 1 (i.e., that the study was examining how perceptions and memory are influenced by physical activity and performance). Those willing to participate in this study were randomly assigned to one of the five conditions. The sample for Study 2 was slightly older than that in Study 1 (*M* = 21.20, *SD* = 3.93).

Materials

Experimental condition photo arrays. The all male and all female attractiveness photo arrays from Study 1 were used in Study 2. In addition, an all male enhanced and an all female enhanced condition were added. The enhanced versions of the manipulations included a peer evaluation component, which informed participants that future male or female (depending on condition) participants would know how well they did on the fitness test. In these conditions, after viewing the photo arrays and rating the 5 most attractive individuals in each array, a photo of one individual, ostensibly chosen at random but actually one rated most attractive in pilot studies, was shown on the screen. Participants were asked to guess how many sit-ups and push-ups that participant completed during the fitness test they were about to complete. They were then told how many sit-ups and push-ups that person 'actually' completed. They were then asked to bring in a similar photo of themselves to have future male or female (depending on condition) participants guess and know how well they did on the fitness test. In this study a no treatment control group was used. These participants did not view any photographs, but simply answered the battery of questionnaires before completing their fitness test.

Testosterone. Baseline testosterone was measured from saliva samples collected using oral swabs (Salimetrics, PA), placed under the tongue for two minutes. Samples were frozen immediately after collection at -20°C until assay. The samples were assayed for testosterone using enzyme immunoassay (ELISA; Salimetrics,PA), at the Hominoid Reproductive Ecology Lab at the Department of Anthropology, University of New Mexico. The samples were run in duplicate and the inter-assay CVs were 3.7% (low sample) and 12% (high). Intra-assay CVs averaged 3.5%. Women who were using hormonal contraceptives did not provide saliva samples, and some samples did not contain enough saliva for assay, therefore the sample size for analyses with T included 141 people (81 men and 60 women). To minimize the influence of diurnal variation in T, all experimental sessions were run in the afternoon. In addition, the effect of time of day was examined and did not significantly predict T levels, and did not change the outcome of the results.

Grip strength. Baseline grip strength was measured using a hydraulic dynamometer (Baseline, TN) similarly to Study 1 with one exception. Three consecutive measures of grip strength were taken before participants viewed the photographs following the procedures detailed in Mathiowetz et al. (1985), with one minute rest between measures for participants to recover. The average of the three measures taken for grip strength was used as a covariate in analyses with push-ups as the dependent variable to control for individual variation in upper body strength.

Muscular fitness and predicted VO_2 max. Muscular fitness was measured with tests of upper body and core strength tasks. Upper body strength was measured by having participants complete as many push-up repetitions as possible in 60 seconds. Men were required to place their toes or forefeet on the floor, with legs hips and back straight, while women placed knees on the floor mat with hips and back straight. The YMCA Half Sit-up test protocol was used to measure core strength. Participants lie supine on a floor mat with their fingertips touching the two of four Velcro markers perpendicular to the body that are placed 3.5" apart. Participants are instructed to flex spine so that fingertips reach the second Velcro marker and return shoulders to the mat and repeat as many times as possible in 60 seconds (YMCA). Predicted VO_2max was measured using a validated single-stage submaximal treadmill walk test protocol (Ebbeling, Ward, Puleo, Widrick, & Rippe, 1991). Participants first walk at a 0% grade for two minutes, with heart rate monitored at two minutes to make sure it is within the desired range (> 100 bpm). At 2-minutes the grade is increased to 5% for 4 minutes. VO_2max is then estimated with an equation using the participant's heart rate, speed, gender and age. Two males and one female were missing push-up data due to physical problems, and one male and one female were unable to complete the sit-ups. These individuals were excluded from analyses with push-ups and/or sit-ups.

Intrasexual competitiveness. Intrasexual competitiveness was measured using an Intrasexual competition scale (Buunk & Fisher, 2009) which assesses competitiveness with other members of the same sex specifically with twelve 7-point Likert items with responses ranging from 1 'not at all applicable' to 7 'completely applicable' (α = .87).

Social cognitive predictors of exercise. The social cognitive predictors of exercise (motivation and self-efficacy) were measured by constructs from the Theory of Planned Behavior (Ajzen, 1991) via self-report questionnaires. The TPB is widely used to predict intentions to perform health behaviors and behavior itself, including exercise (Armitage & Conner, 2001). Consistent with Information-Motivation-Behavior skills model (Fisher & Fisher, 1992), *motivation* was comprised of attitudes, social norms and intentions. *Attitudes* were measured with seven 7-point Likert items assessing affective (e.g, pleasant-unpleasant) and instrumental (e.g., beneficial-harmful) attitudes about exercising in the coming week. 7-point Likert items assessing the extent to which participants feel important others 'do some form of exercise' and 'think I should do exercise' (1 'disagree strongly' to 7 'agree strongly'). *Intentions* to exercise in the coming week were measuring using a scale with seven 7-point Likert items (1 'disagree strongly/very unlikely to 7 'agree strongly/very likely'). Reliability for the combined scale of motivation was high (α = .88). Self-efficacy was measured with six 7-point Likert items assessing how confident participants are in exercising in the coming week under various circumstances with responses ranging from 1 ‘not at all true’ to 7 ‘very true’ (α = .89).

Energetic condition. Self-reported birth weight was recorded as a measure of prenatal energetic condition.

Sociosexual orientation. A revised version (Penke & Asendorpf, 2008) of the sociosexual orientation inventory (Simpson & Gangestad, 1991) was used to measure participants’ openness to mating opportunities outside of a committed relationship. This 9-item scale is widely used reliable measure that assesses sociosexual orientation across three domains: attitudes (α = .83), behavior (α = .86), and desire (α = .93) and total (α = .90).

(Measures taken but not included in analyses: intrasexual competitiveness, self-perceived mate value, Kinsey sexuality, demographics.)

Procedure

Following informed consent participants provided a saliva sample for T assay with Oral Swabs (Salimetrics, State College, PA) placed under their tongue for two minutes. Then grip strength was measured similarly to Study 1, with three consecutive measures but with one minute of rest between each measure. Participants were then shown a set of photo arrays according to condition and answered the questions from Study 1 regarding the arrays, psychological predictors of exercise, and current exercise frequency. Next, participants performed the standardized protocol of physical exercises. Participants completed a graded submaximal treadmill test to predict VO_2max, then had one minute to complete as many push-ups as possible, and one minute to complete as many sit-ups as possible. Once the exercises were completed, they were tested on their memory of the photo arrays, and were then asked to complete a battery of questionnaires with individual difference measures before being funnel debriefed as to the actual purpose of the experimental manipulation. Post-study debriefing interviews did not reveal suspicion or knowledge of the hypotheses being tested.

Hypotheses

The all male and all female conditions were predicted to increase performance on the fitness test tasks (number of push-ups and sit-ups in one minute) compared to the no treatment control condition in men; these differences were expected to be observed among women, but be of smaller magnitude. Given the mixed results in the social facilitation literature with regards to the evaluative potential of the audience, no strong directional hypotheses were made with regard to the enhanced versions of the manipulations that included an explicit evaluation component. It was, however, predicted that they may have an additional facilitative effect above merely increasing individuals awareness of socially relevant others.

The effect of the primes on the outcomes was hypothesized to be moderated by energetic condition, relationship status, baseline T, sociosexual orientation, and parental status. The effect was hypothesized to be stronger among those who were not low birth weight, are not in a committed relationship, have higher baseline T, have less restricted sociosexual orientation, and are not parents.

Planned analyses

Energy exertion, exercise motivation and self-efficacy

To determine the relative influence of the photograph manipulation on energy exertion and exercise cognitions, a series of statistical tests was performed using SPSS (version 18). For each outcome, a 2 (sex of participant: male or female) X 2 (target sex: male or female) X 2 (evaluation enhancement: no or yes) between-subjects ANCOVA was performed. Significant effects and interactions were followed up with 2 (target sex: all female vs all male) X 2 (evaluation enhanced: no or yes) ANCOVAs and simple effects tests *within sex.* To determine the pattern of results and compare the effects of the experimental conditions with the no treatment control condition, a priori contrasts were performed. When no effect of the enhancement was found, a complex contrast between the all male and all male enhanced versus control, and/or the all female and all female enhanced versus control were performed. If an effect of the enhanced manipulation was found, a contrast between the enhanced condition versus control was performed. Due to the exploratory nature of this research, a critical alpha level of $p \leq .05$ was used for all tests.

Results

Summary statistics and bivariate relationships among variables

Descriptive statistics by sex and condition are provided in Table 4, and bivariate relationships between the outcome variables are included in Table 5. It was initially hypothesized that birth weight, baseline T, relationship status, parenting status, and sociosexual orientation may moderate the effect of the

Table 4. *Means and (Standard Deviations) for the Study 2 outcome variables by sex and condition.*

Outcome	n	Push-ups	n	Sit-ups	n	Motivation	Self-efficacy
Men	**88**	36.25 (17.45)°°	**89**	67.34 (15.77)°°	**89**	17.63 (1.95)	5.83 (1.00)
All female	18	22.78 (11.87)**	18	64.39 (13.84)	18	**17.80 (1.03)**†	**5.71 (1.14)**
All female enhanced	16	36.00 (20.95)**	17	66.67 (14.28)	18	**18.25 (1.03)**†	**6.34 (0.61)**
All male	18	**46.25 (15.83)****	18	73.82 (12.16)†	17	17.50 (2.56)†	**5.95 (1.21)**
All male enhanced	19	**43.00 (12.80)****	19	69.36 (21.44)†	18	17.69 (2.45)†	**5.92 (0.85)**
Control	17	**33.82 (16.00)**	17	62.41 (14.05)†	18	**16.86 (2.06)**	**5.23 (0.81)**
Women	**114**	27.17 (12.56)°°	**114**	60.71 (15.98)°°	**115**	17.55 (2.00)	5.35 (1.27)
All female	23	28.00 (9.33)	23	**65.13 (14.19)**§§	23	17.94 (1.54)	5.62 (1.18)
All female enhanced	21	25.88 (11.77)	21	56.20 (15.79)§§	25	17.22 (2.42)	5.19 (1.19)
All male	24	27.86 (15.23)	25	**62.29 (14.61)**	21	17.50 (2.07)	**5.89 (1.11)**
All male enhanced	23	30.61 (12.61)	22	**67.32 (16.63)**	23	17.24 (2.20)	**5.33 (1.19)**
Control	23	23.61 (13.37)	23	**53.43 (15.36)**	23	17.89 (2.28)	**4.78 (1.47)**

* *Denotes a significant difference between the male + all male enhanced versus the female + female enhanced conditions

°°Denotes a significant difference between men and women

Bold text denotes a significant difference between a condition/pair of conditions and the control condition

§§Denotes a significant difference between the A condition and the A enhanced condition

†Denotes a marginally significant difference between conditions/pair of conditions

Table 5. *Correlations between the Study 2 outcome variables among men (lower diagonal) and women (upper diagonal)*

	1	2	3	4	5	6	7	8
1. Push-ups	---	**.51****	**0.17**	**.19***	0.11	**0.19***	**-0.15**	**0.33****
2. Sit-ups	**.35****	---	0.13	**.20***	0.04	0.14	-0.03	**0.23***
3. Motivation	0.07	**.21***	---	**.48****	-0.08	0.11	**-0.24***	**0.33****
4. Self-efficacy	**0.30****	**.36****	**.58****	---	0.18	0.01	**-0.18**	**0.50****
5. Log T	0.06	-0.05	0.08	-0.04	---	0.03	**-0.19**	0.02
6. Relationship status	**-0.18**	-0.16	-0.15	-0.04	**-0.35****	---	-0.14	-0.1
7. Sociosexual orientation	0.16	0.01	**0.19**	0.07	0.09	-0.13	---	-0.01
8. Exercise frequency	**0.40****	**0.28****	**0.41****	**0.46****	0.14	**-0.17**	**0.32****	---

p < .10

*p < .05

**p < .05

manipulation on the outcomes. However, it was not possible to recruit people based on these characteristics, and the analyses were thus limited by the naturally occurring frequencies in the sample randomly assigned to one of five conditions. Only 13 individuals (11.2% of the sample) were considered low birth weight according to the World Health Organization definintions (5lbs 8 oz), and only 8 had children (5 men and 3 women). These variables were therefore not examined as moderators. Just over half of the sample was not in a committed relationship (52 women and 53 men), while the other half reported seriously dating someone or higher levels of commitment (63 women and 37 men), so relationship status was examined.

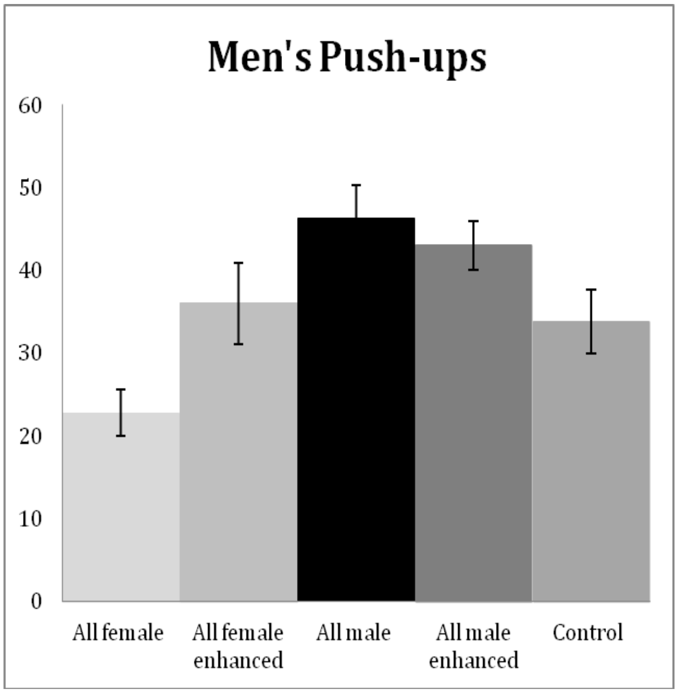
Energy exertion: Push-ups and sit-ups

Push-ups

There was a significant main effect of target sex on the number of push-ups completed $F(1, 151) = 16.26$, $p < .001$, $\eta_p^2 = .10$, while the effect of participant was not significant, $F(1, 151) = 2.95$, $p = .09$, $\eta_p^2 = .02$. There was a significant participant sex X target sex interaction $F(1, 151) = 7.42$, $p < .01$, $\eta_p^2 = .05$, indicating that the sex of the targets influenced men and women differently. In addition, there was a significant 3-way interaction between participant sex, target sex, and enhancement, $F(1, 151) = 4.30$, $p = .04$, $\eta_p^2 = .03$. The main effect of evaluation enhancement, and the 2-way interactions with enhancement and participant and target sex were non-significant (p's > .30).

Among men, there was a significant main effect of target sex on number of push-ups completed, $F(1, 64) = 14.76$, $p < .001$, $\eta_p^2 = .19$. There was not a significant main effect of evaluation enhancement, nor an enhancement X target sex interaction (p's > .11). Thus, the evaluation enhancement did not lead to increases in energetic effort above and beyond the influence of the target sex of the photographs in the manipulation. The all male and all male enhanced conditions and the all female and all female enhanced conditions were therefore combined for simple effects tests, which revealed that men who attended to the attractiveness of other males performed significantly more push-ups ($M = 44.49$, $SD = 14.14$) than men who attended to the attractiveness of female photographs ($M = 29.39$, $SD = 18.07$), $F(1, 80) = 13.39$, $p < .001$, $\eta_p^2 = .14$, and than men in the no treatment control condition ($M = 33.82$, $SD = 16.00$), $F(1,80) = 3.94$, $p = .05$, $\eta_p^2 = .05$ (see Figure 7).

Figure 7. *Push-ups by condition among men. Significant differences were observed between the all male/all male enhanced compared to men in the all female/all female enhanced conditions and the control condition.*



Among women, the main effects of target sex and enhancement, and the target sex X enhancement interaction were all non-significant (p's > .28). No differences in the number of push-ups completed were observed between the experimental conditions in women (p's > .30).

Sit-ups

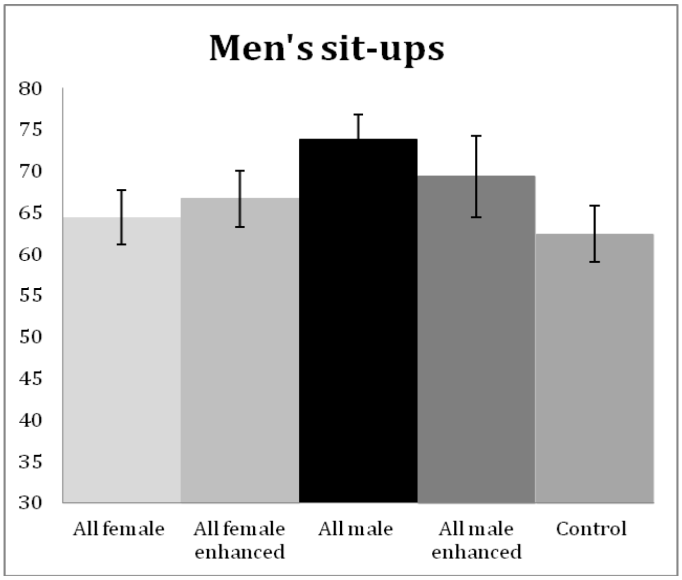
The main effect of target sex on the number of sit-ups completed fell just short of statistical significance, $F(1, 153) = 3.05$, $p = .08$, $\eta_p^2 = .02$. The main effects of enhancement and sex, the two-way interactions between them, and the three-way interaction of participant sex, target sex and evaluation enhancement were not significant (p's > .13).

Among men, there were no main effects of target sex or evaluation enhancement, nor a target sex X enhancement interaction (p's > .36). Simple effects tests suggested that men who attended to the attractiveness of other males tended to perform more sit-ups ($M = 71.47$, $SD = 17.58$) than men in the control condition ($M = 62.41$, $SD = 14.05$), but this trend fell short of statistical significance, $F(1,80) = 2.73$, $p = .10$, $\eta_p^2 = .03$ (see Figure 8a).

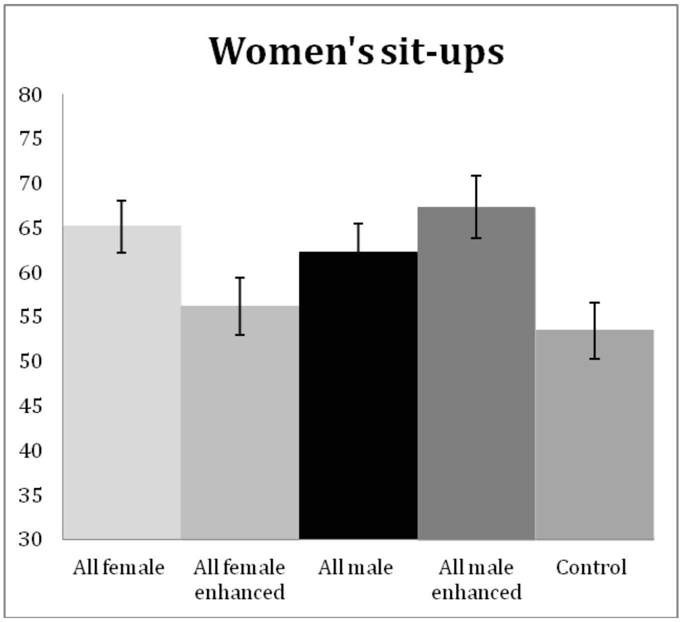
Among women, the main effects for target sex and enhancement were non-significant (p's > .19), but there was a significant target sex X enhancement interaction, $F(1,85) = 4.80$, $p = .03$, $\eta_p^2 = .05$. Simple effects tests revealed that women in the enhanced evaluation condition who believed other female participants would know how well they did on the fitness test performed fewer sit-ups ($M = 56.20$, $SD = 15.79$) than women who merely attended to the attractiveness of female photos ($M = 65.13$, $SD = 14.19$), $F(1,107) = 3.90$, $p = .05$, $\eta_p^2 = .04$. Women

Figure 8. *Sit-ups by condition among men (a) and women (b). Nearly significant differences were observed between the all male/all male enhanced compared to men in the control condition. Significant differeneces were observed between the all female and all female enhanced conditions; and between the control conditions and the all female condition and the all male/all male enhanced condition.*

a.



b.



who merely attended to the attractiveness of female photos performed significantly more sit-ups than those in the control condition (M = 53.43, SD = 15.36), $F(1,107)$ = 4.66, p = .01, η_p^2 = .05. There was not a significant effect of the manipulation enhancement in the male conditions, therefore the all male and all male enhanced conditions were combined to test the complex contrast between the all male and all male enhanced conditions compared to the control. Women who attended to the attractiveness of male photographs performed significantly more sit-ups (M = 64.86, SD = 15.70) than those in the control condition, $F(1,107)$ = 6.25, p = .01, η_p^2 = .05 (see Figure 8b).

Social cognitive predictors of exercise

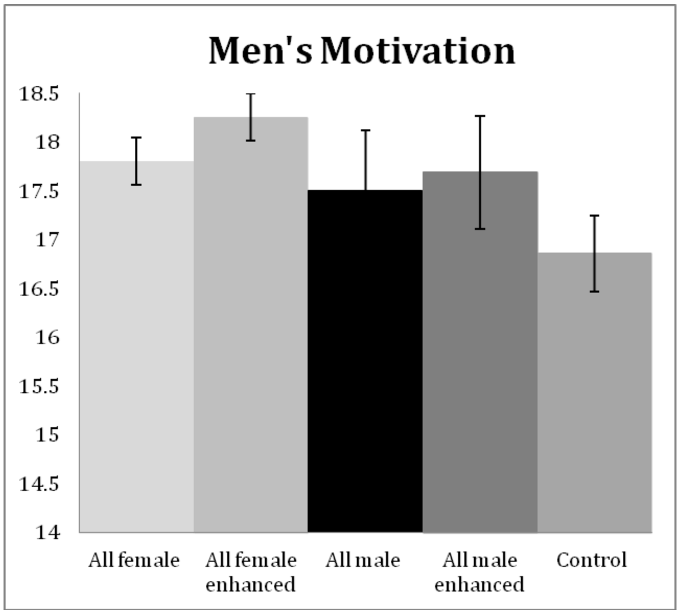
Motivation

There were no significant main effects of target sex, participant sex, or evaluation enhancement on exercise motivation, (p's > .12). The two- and three-way interactions were also non-significant (p's > .29). Given the non-significant evaluation enhancement effect, the enhanced conditions were combined with the all female or all male conditions in both men and women for the simple effects tests.

Among men, the effect of target sex on exercise motivation was not significant, $F(1,65)$ = 2.88, p = .09, η_p^2 = .04, and there were no main effects of evaluation enhancement or a target sex X enhancement interaction detected (p's > . 33). As can be seen in Figure 9, complex contrasts indicated that men who attended to the attractiveness of females reported significantly higher exercise motivation than those in the control condition $F(1,82)$ = 5.54, p = .02, η_p^2 = .06, and a trend toward higher motivation compared to men attending to the attractiveness of males, $F(1,82) = 3.31$, $p = .07$, $\eta_p^2 = .04$.

Among women, there were no significant main effects of target sex, enhancement or a target sex X enhancement interaction (p's > .33). Simple effects tests revealed there were no significant differences between conditions in exercise motivation among women.

Figure 9. *Exercise motivation by condition among men. Significant differences were observed between the all female/all female enhanced and the control condition.*



Self-efficacy

There were no significant main effects of participant sex, target sex, or evaluation enhancement on exercise self efficacy (p's > .16); however a significant sex X enhancement interaction was observed, $F(1, 153) = 4.49$, $p = .04$, $\eta_p^2 = .03$; and the target sex X sex interaction fell just short of statistical significance, $F(1, 153) = 3.47$, $p = .06$, $\eta_p^2 = .02$.

Among men, there were no significant main effects of target sex or evaluation enhancement on exercise self-efficacy, or a target sex X enhanced condition interaction (p's > .18). As shown in Figure 10a, men who attended to the attractiveness of females reported significantly greater exercise self-efficacy than those in the control condition $F(1,82) = 11.17$, $p = .001$, $\eta_p^2 = .12$, as did men who attended to the attractiveness of males, $F(1,82) = 4.19$, $p = .04$, $\eta_p^2 = .05$. There was not a significant difference in self-efficacy between men who viewed females and men who viewed males ($p = .14$).

Among women, the main effect of the evaluation enhancement on self-efficacy fell just short of statistical significance, $F(1,86) = 4.19$, $p = .06$, $\eta_p^2 = .04$. The simple effects tests did not reveal significant differences between the plain and enhanced versions of the manipulation in the all female or male conditions; however in both cases the pattern of results suggested the evaluation enhancement had a negative effect on women's exercise self-efficacy. Simple effects tests revealed that women who attended to the attractiveness of males reported significantly greater exercise self-efficacy than those in the control condition, $F(1,108) = 4.75$, $p = .03$, $\eta_p^2 = .04$ (see Figure 10b).

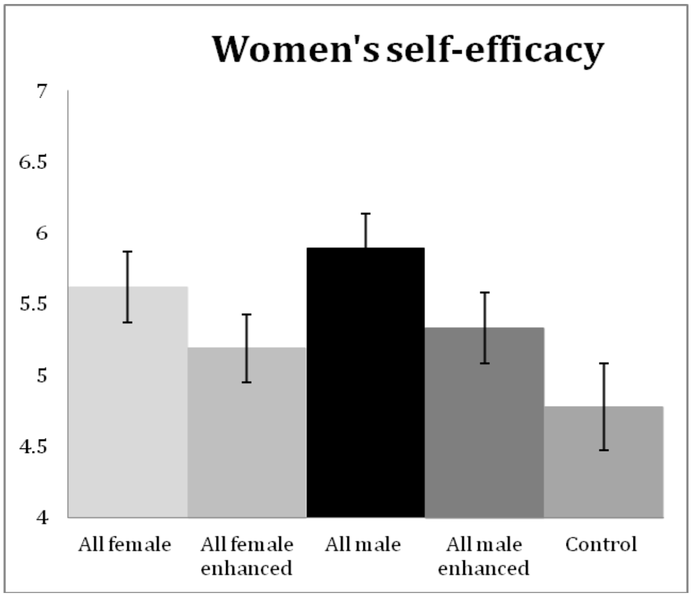
Moderation

To test for moderation, the variables of interest (i.e., relationship status, baseline T, and sociosexual orientation) were added to the models within sex, as were the following two-way interactions: target sex X T, target sex X relationship

Figure 10. *Self-efficacy by condition among men (a) and women (b). Among men both the all female/all female enhanced and the all male/all male enhanced were significantly higher than the control condition. Among women, those in the all male/all male enhanced conditions reported significantly greater exercise self-efficacy.*

a.

b.



status, target sex X sociosexual orientation, relationship status X T, and relationship status X sociosexual orientation, and the following three-way interactions: target sex X relationship status X T, target sex X relationship status X sociosexual orientation.

Push-ups

Among men, the main effect of relationship status on push-ups was not significant, $F(1,47) = 3.09$, $p = .09$, $\eta_p^2 = .06$. Neither of the main effects of T or sociosexual orientation, nor any of the two- or three way interactions were significant.

Among women, there were no significant main or interaction effects on the number of push-ups completed one minute.

Sit-ups

In men and women, there were no significant main or interaction effects of the moderators on the number of sit-ups completed.

Motivation

Among men, there were no significant main effects of relationship status, T, or sociosexual orientation on exercise motivation. There was a significant target sex X relationship status X T interaction, $F(1,48) = 4.28$, $p = .04$, $\eta_p^2 = .08$. In order to probe this interaction, regression models predicting motivation with T, controlling for self-reported exercise and vo2max were run separately within target sex and relationship status. Among single men who viewed photographs of other men, there was a nearly significant negative relationship between T and motivation, $\beta = -.94$, $p = .06$. The relationship between T and motivation was not significant among paired men who viewed photographs of other men, nor among single or paired men who viewed photographs of females.

Among women, the main effect of sociosexual orientation on exercise motivation was significant, $F(1,36) = 4.17$, $p < .05$, $\eta_p^2 = .10$; as was the main effect of relationship status, $F(1,36) = 11.25$, $p < .01$, $\eta_p^2 = .24$. Simple effects tests revealed that single women had slightly lower motivation ($M = 17.31$, $SD = 2.23$) than paired women ($M = 17.75$, $SD = 2.01$). There was also a negative correlation between sociosexual orientation and exercise motivation, $r(115) = -.24$, $p = .01$, suggesting that women who had a more open orientation reported less motivation to exercise.

Self-efficacy

Among men, there were no significant main effects of relationship status, T, or sociosexual orientation on exercise self-efficacy. The target sex X T interaction was significant, $F(1,48) = 4.16$, $p < .05$, $\eta_p^2 = .08$ as was the target sex X relationship status X T interaction, $F(1,48) = 7.75$, $p < .01$, $\eta_p^2 = .14$. To probe this interaction, regression models predicting self-efficacy with baseline T were run for each target sex and relationship status, controlling for exercise frequency and predicted VO_2max. There was a significant and negative relationship between T and self-efficacy among paired men looking at females, $\beta = -.87$, $p = .01$. The relationship between T and self-efficacy was non-significant among single men looking at female photographs, and both single and paired men looking at male photographs.

Among women, there were no significant main effects of relationship status, T, or sociosexual orientation, or two-or three way interactions on exercise self-efficacy.

Ancillary analyses

Participants were randomly assigned to condition, and all interacted with a female experimenter, but also interacted with either a male or female fitness tester. To test for the effect of the fitness tester sex on the outcomes, the models for push-ups and sit-ups were run including fitness tester sex as a covariate. Overall, including fitness tester sex did not alter the significance of the primary hypotheses tests. There was a significant main effect of fitness tester sex on number of sit-ups, $F(1,150) = 5.34$, $p = .02$, $\eta_p^2 = .03$. Those who had a female fitness tester performed more sit-ups ($M = 68.70$, $SD = 15.66$) than those who had a male fitness tester ($M = 63.08$, $SD = 16.08$). In addition, the effect of target sex on number of sit-ups became significant. Within sex, the effect of fitness tester sex on number of sit-ups was significant among women, $(1,82) = 4.09$, $p < .05$, $\eta_p^2 = .05$, but not men. Women who had a female fitness tester performed more sit-ups ($M = 67.38$, $SD = 14.21$) than those who had a male fitness tester ($M = 59.90$, $SD = 16.08$). However, it should be noted that these analyses are limited due to a lack of random assignment.

Discussion

The primary purpose of Study 2 was to examine the effect of viewing males and females on energetic effort in a standardized fitness protocol and on social cognitive predictors of exercise. Results showed that the experimental manipulation influenced effort on physical tasks in both men and women, and exercise cognitions in men.

Men who attended to the attractiveness of other males performed more push-ups and trended toward performing more sit-ups than men in the control condition and, contrary to predictions, men in the all female conditions. Men who viewed and attended to the attractiveness of women did not complete a significantly different number of push-ups than men who did not view any photographs. Women attending to the attractiveness of males and women attending to the attractiveness of other females (in the absence of the evaluation enhancement) all performed more sit-ups than women in the no treatment control. Women did not demonstrate differences in the number of push-ups performed across conditions.

Women similarly performed more sit-ups when attending to the attractiveness of males, but did not demonstrate differences in the number of push-ups performed across conditions.

Consistent with the results from Study 1, men who attended to the attractiveness of females reported significantly greater exercise motivation and self-efficacy. In Study 2, men who attended to the attractiveness of other men also reported greater self-efficacy than men in the control condition. Among women, those who attended to the attractiveness of males reported higher self-efficacy to exercise, but there were no differences across condition in motivation.

A secondary aim of Study 2 was to examine the effect of an explicit evaluation component of the experimental manipulation, to test whether having participants believe that other participants would know how well they did on the fitness test increased the social facilitation of energy expenditure on the fitness tests or social cognitive predictors of exercise. The evaluation enhancement had no effect on performance in men, nor on the social cognitive predictors of exercise in either sex. While the evaluation enhancement did not affect women's performance when the target sex of the photographs was male, when the target sex was female, the enhanced component actually had a negative effect on the number of sit-ups completed. That is, women who believed future female participants would know how well they did on the fitness test performed fewer sit-ups than women who did not believe other women would know how well they did, but still attended to the attractiveness of other females. This result—decreased female performance in the female evaluation condition—might be interpreted as a form of self-handicapping under the pressure of peer evaluation. However, it is worth noting that women who had a female conducting their fitness test performed more sit-ups than women who had a male performing their fitness test (keeping in mind that experimenter sex was not randomized). One potential explanation for the discrepancy is that participants in the evaluation enhancement condition were told that the female they observed completed only 41 sit-ups. While this number was above average for the established sex and age specific norms (Canadian Society for Exercise Physiology, 2003), it was lower than the mean number of sit-ups completed by women in the current sample (wholly 11 sit-ups fewer than the mean among women in the enhanced condition). This target number may therefore have set a low bar, and may therefore have caused women to reduce effort once they had surpassed the stated number. Note that this effect may be specific to women with female targets, as there was no effect of the evaluation enhancement on the number of sit-ups completed in the male condition, even though the men had a similarly low bar (40 sit-ups). Future research aimed specifically at the understanding the effect of the sex of the fitness tester can potentially tease apart these effects.

The final objective of Study 2 was to test for potential moderators of the effect of the manipulation on energetic effort and social cognitive predictors of exercise. Based on previous research in humans and other animals, it was hypothesized that factors that modulate mating effort and intrasexual competition, specifically T, relationship status, and sociosexual orientation would potentially moderate the effect of the manipulation on exercise cognitions and performance on the fitness test. The results suggested that individual difference factors that are theoretically predicted to influence mating effort and intrasexual competitiveness affect performance on the fitness test and exercise cognitions directly, and by moderating the effect of the manipulation in complex and interesting ways that should be examined in future research. The results showed that single men tended to do more push-ups than paired men, though this effect fell short of significance and did not depend on the experimental manipulation. A negative relationship was observed between T and exercise motivation among single men, while no relationship was found between T and motivation in paired men. For single men, high T may actually predict lower exercise motivation, which may translate into less exercise. Finally, a negative relationship between T and self-efficacy was observed among paired men who viewed female photographs and rated them for attractiveness. Paired and single men with high T are theoretically those more interested in investing in more mating effort behavior, however in both populations higher T was related to lower exercise motivation and self-efficacy. Similarly, single women, and those with higher sociosexual orientation, those theoretically likely to invest more in mating effort had lower exercise motivation. Taken together with the results of lower male physical performance when viewing females, these results potentially indicate that men and women more invested in mating effort are actually less likely to express high exercise motivation and, among men, report high self-efficacy or exhibit increased performance on physical tasks in the absence of environmental cues of intrasexual competition for those mating opportunities. This interpretation is not consistent, however, with the observed trend that single men did more push-ups overall than paired men. While one may speculate that this was due to an age difference in single versus paired men, there was not a difference in age in single and paired men in the current study. These findings are preliminary, and additional research is required to clarify the complex ways that these variables may interact, and to assess the generality of the relationships observed in the current studies.

CHAPTER 4: General discussion and conclusions

The purpose of the current research was to test the premise that increased awareness of individuals who are socially relevant, as potential mates or competitors for mates, would lead to increased energetic effort and performance on physical tasks, exercise motivation, and self-efficacy. Experimental manipulations were used to test whether viewing photographs of socially relevant individuals and attending to their attractiveness would illicit increases in cognitions related to mating and/or intrasexual competition, which would in turn lead to increased performance on physical tasks, and potentially influence social cognitive constructs used to predict and increase exercise behavior. Evolutionary and life history theory, and previous research in humans and other animals were employed to understand why humans may have evolved to selectively exert energy on physical tasks, and when and for whom increases in energetic effort are more or less likely to occur. An increased awareness of similarly aged men and women was predicted to have a facilitative effect on energetic effort, particularly among young, unpaired, heterosexual adults. Men were hypothesized to respond more easily to the experimental paradigm because of the higher metabolic and reproductive opportunity costs of physical activity faced by women. Results from the current two studies provide preliminary evidence to support this premise in an experimental paradigm. For both the positive and negative results discussed here, the evolutionary theoretical framing of the studies allow for novel empirical insight into the conditions leading individuals to selectively conserve or exert physical energy, and social facilitation of task performance.

Energetic effort

Men exhibited greater energetic effort toward measures of strength and muscular fitness after viewing photographs of other (ostensibly local) males and attending to their attractiveness, relative to individuals who viewed and attended to the attractiveness of females, and a control condition (Study 2). The increases relative to the control condition were predicted based on previous research in social facilitation that has demonstrated a consistently positive effect of the presence or awareness of others on physical tasks where increased effort results in better performance (reviewed in Strauss, 2002) and the hypothesis that increased awareness of competitors for mates would lead to increased intrasexual competitiveness and physical effort. The result that men in conditions with all female photographs either did not differ from control, or actually had slight decreases in grip and chest strength performance was unexpected from a traditional social facilitation perspective as well as the evolutionary theoretical prediction that men viewing women would demonstrate increases in mating effort in the form of immediate energy expenditure. It may be that this surprising finding is related to the specific way cognitions about mating and competition were primed in the current studies, or individual differences that influence the response to the manipulation.

The aim of the all female photograph manipulation was to prime men's awareness of potential mates by having them view the arrays of 'local' women and pick the top 5 most attractive women in each array. It was initially hypothesized that viewing and attending to the attractiveness of women would facilitate performance on physical tasks through an increased motivation or preparedness to perform behaviors that would attract potential mates. Several studies to date have used experimental paradigms or naturalistic observations to measure differences in various indicators of increased mating effort (i.e., changes in hormones, aggression, risky behavior, temporal discounting, etc.) in response to interactions with females or visual stimuli, as in the current studies (Griskevicius, et al., 2012; Ronay & von Hippel, 2010; Roney, et al., 2007; Roney, et al., 2003). Results from both studies presented here instead indicated that men who viewed and attended to the attractiveness of females had poorer performance on physical tasks. It may be that men who interact with or perceive they are surrounded by females employ different, more affiliative behaviors to attract mates as opposed to more aggressive and physically competitive behaviors that are likely to increase performance in intrasexual competition. Recently, van der Meij et al., (2012) found that men whose T was elevated in response to a competitive experimental manipulation exhibited greater friendly and flirtatious (i.e., smiling, making eye contact and self-presenting) behaviors when they interacted with a female confederate after the competition. The strength results from Study 2, and the preliminary finding that participants had lower baseline strength when interacting with a female experimenter in Study 1 support this interpretation. This is consistent with theoretical predictions from intrasexual competition and sexual selection that suggests that reproductive advantage can come through success in intrasexual competition for access to mates, as well as through being preferentially chosen, and behaviors consistent with each strategy (while not always mutually exclusive) are predicted to be used under circumstances where they would probabilistically have led to greater reproductive success (Buss & Schmitt, 1993; Trivers, 1972). A man facing an increased awareness of mating opportunities in the absence of competitors may immediately allocate energy differently than a man faced with increased mating opportunities in the presence of other males to compete with for access to those mates, which would lead to differential performance on the fitness tests. This is also consistent with the exploratory finding in Study 1 that changes in strength among men were predicted by intrasexual competitiveness, but not implicit or explicit mating cognitions. These findings are preliminary, however, and future studies are needed to replicate these exploratory findings in support of this interpretation. Importantly, a study comparing the facilitation of physical strength (as might be preferentially recruited for intrasexual competition) versus affiliative behaviors (as might be preferentially recruited to demonstrate desirability as a mate) is warranted to test these predictions.

Furthermore, this design may have inadvertently influenced the evolved psychology of perceptions of biased sex ratios on mating strategies or mating effort. Griskivicius et al. (2012) found differences in temporal discounting in men who had been primed to perceive a male-biased sex ratio with the sex ratio manipulation used in Study 1. There were no differences in any of the outcomes between male- and female-biased sex ratio conditions in Study 1 (and it was therefore dropped for Study 2); but the theoretical foundation for understanding the influence that perceptions of operational sex ratio have on mating effort strategies may inform the interpretations of current findings. In the current study, the all female condition had the presence of many potential mates and an absence of competitors for those mates, which may have a very different effect on men's mating strategy, and hence, immediate prioritization of energy expenditure. Population level research on operational sex ratio has demonstrated that ecologies with female-biased sex ratios are associated with lower marriage rates and paternal investment, indicating low effort by males to appeal to female preferences (South & Trent, 1988). The attractiveness manipulation utilized in the current studies, picking the top 5 most attractive of an abundance of mates in the absence of competitors, may have had a similar effect on men's psychology, making them feel like they had the 'pick of the litter', and therefore increases in immediate mating effort, in the particular form of increased energy expenditure, was unnecessary.

There are also likely to be other individual difference factors that were not measured in the current studies that might change the effect of the manipulation on hormones and performance that could have influenced the current findings. It was hypothesized that the manipulation would lead to increases in T and/or C, which would mediate the effect of the manipulation on strength measures and exercise cognitions; and that and that baseline T—as indicative of greater mating effort—would moderate the effect of the manipulation on physical performance. Results did not clearly support these hypotheses. While the manipulations did not lead to greater increases in T compared to the control condition (Study 1), T did increase in response to the manipulations overall, suggesting that there was something about the experimental setting that influenced men's T production. These changes were not related to strength, exercise cognitions, or intrasexual competitiveness, but were predicted by self-reported arousal. A more clear understanding of the manipulation and the experimental setting (e.g., sex of the experimenter) and how these factors are perceived will help lead to a more complete understanding of how these factors interrelate and if they are predictive of changes in strength and social cognitive predictors of exercise.

There may also be genetic factors associated with T response. Roney, Simmons and Lukaszewski (2010) recently demonstrated that differences in the number of CAG repeats (a polymorphism) at the androgen receptor (AR) gene, and baseline C predicted the effect of interacting with potential mates on changes in T among men. Further, one researcher has suggested that individual's perceptions of a competitive stimulus, specifically how important, controllable, and a challenging it is influences the HPA and HPG response (Salvador, 2005). Perceptions of the current manipulations and fitness test were not included in the current research, but may help to explain some of the unexpected findings and are important to consider in future research on the endocrine response and physical performance.

Finally, there are obvious differences between interactions with actual males or females versus visual stimuli, which likely had an effect on the findings in the current research. It is unclear whether men who actually had attractive women watching them do push-ups would perform better (or worse) than a man performing push-ups in a room alone.

As predicted, women were generally less responsive to the manipulations than men, and did not show a particularly clear pattern of results. Women did perform more sit-ups after viewing and attending to the attractiveness of ostensibly local males and females. There was also a significant effect of the evaluation enhancement on women in the number of sit-ups completed, with women who believed that other women would know how well they did on the test performing *fewer* sit-ups than women who merely viewed and attended to the attractiveness of other women. There were no differences in women between conditions in the number of push-ups performed (Study 2), or measures of grip and chest strength (Study 1).

Motivation and self-efficacy

The findings for exercise motivation and self-efficacy in the two samples were somewhat distinct. In Study 2, men attending to the attractiveness of females reported more motivation and self-efficacy to exercise in the coming week compared to men in the all male conditions and men in the control condition, while men in the all male conditions had higher self-efficacy (but not motivation) than men in the control condition. In Study 1, men attending to the attractiveness of other males reported lower motivation and self-efficacy compared to individuals in the control condition, with no significant differences between the all female and control condition. Women in Study 2 had higher self-efficacy in the all male condition compared to control. There were no differences in motivation or self-efficacy across condition among women in Study 1, however. The differences between the two studies may have to do with differences in recruitment that resulted in very different samples. Study 1 drew from introductory psychology students, while Study 2 drew from students currently enrolled in an exercise class, who were likely more interested in and committed to exercising a certain amount each week. Thus the effect of an increased awareness of others on exercise motivation and self-efficacy may depend on the interest and commitment of the individuals in the intervention.

It was initially hypothesized that the same circumstances that would lead to immediate increases in energy expenditure would also lead to higher exercise motivation and self-efficacy. This was the case for women in Study 2 who performed more sit-ups and had greater exercise self-efficacy when viewing and attending to the attractiveness of males. In men, however, physical performance was higher in the all male conditions, while motivation and self-efficacy were higher in the all female conditions (Study 2), and lower in the all male condition (Study 1). These results may indicate a disconnect between men's immediate physical response and their higher level cognitive response to an increased awareness of competitors and/or mates. It may also be related to an effect of sex ratio on mating strategies. As stated earlier, Griskivicius et al. (2012) found that a male-biased sex ratio leads men to discount the future, and prioritize current mating effort. The current results may suggest that men who viewed an abundance of mates in the absence of competitors do not discount the future, and are therefore more willing to be motivated and confident to exercise in the coming week, but less willing to increase immediate energetic effort.

Social facilitation

Overall, the results of the current studies can inform some longstanding debates within the social facilitation literature with regards to 1) Zajonc's (1965) drive/arousal theory of social facilitation and 2) Cottrell's (1968) contention that rather than the 'mere presence' of others, it is the potential evaluation by others that increases drive/arousal and therefore improved performance in dominant responses (i.e., simple, conditioning motor tasks). Among men, there were no differences in self-reported affective arousal between conditions, yet there were differences in performance in measures of strength (Study 1). On the other hand, women had higher arousal in conditions that were primarily or all male, but there were no corresponding differences in strength measures (though women in Study 2 demonstrated greater performance after viewing all males). Arousal reported at the conscious level was also not correlated with performance on strength measures or exercise motivation and self-efficacy in men or women (Study 1). Thus, in the current studies, consciously experienced arousal did not appear to be related to increased performance on the strength measures. It is possible, however, that there was a restriction of range in arousal as a result of the experimental paradigm used in the current studies.

In men, there was no effect of the evaluation enhancement on performance above and beyond the original experimental manipulations. In women, there was an effect of the manipulation on the number of sit-ups completed that was contrary to predictions: women who believed that future participants would know how well they did on the fitness test did fewer sit-ups than those who rated other females for attractiveness. Our results are therefore in line with the majority of studies that do not support the prediction that an increased awareness of being evaluated increases arousal and performance.

Future directions

The findings in the current study are intriguing and show promising preliminary support for applying an evolutionary framework to understand social facilitation in physical tasks and social cognitive predictors of exercise behavior. However, the analysis of the factors that mediate the effect of the mate/competitor primes on changes in strength, T or C in Study 1 did not lend to a concise interpretation. While men in the all female attractiveness conditions reported slightly higher competitiveness compared to men in the all male attractiveness conditions (Study 1), the manipulation did not otherwise robustly increase or decrease competitiveness. However, intrasexual competitiveness did predict changes in strength overall. An experimental design that more consistently up-regulated intrasexual competitiveness would be beneficial for understanding the effect of environmental conditions that lead to increased energetic effort toward intrasexual competition. Similarly, while arousal was found to predict changes in T among men, the current manipulation did not lead to differences in arousal, and changes in arousal were not related to changes in strength.. A manipulation that consistently affected men's arousal would thus also be useful to understand the conditions that lead to increases in T, and whether or not changes in T may mediate the effect of experimental conditions on energetic effort.

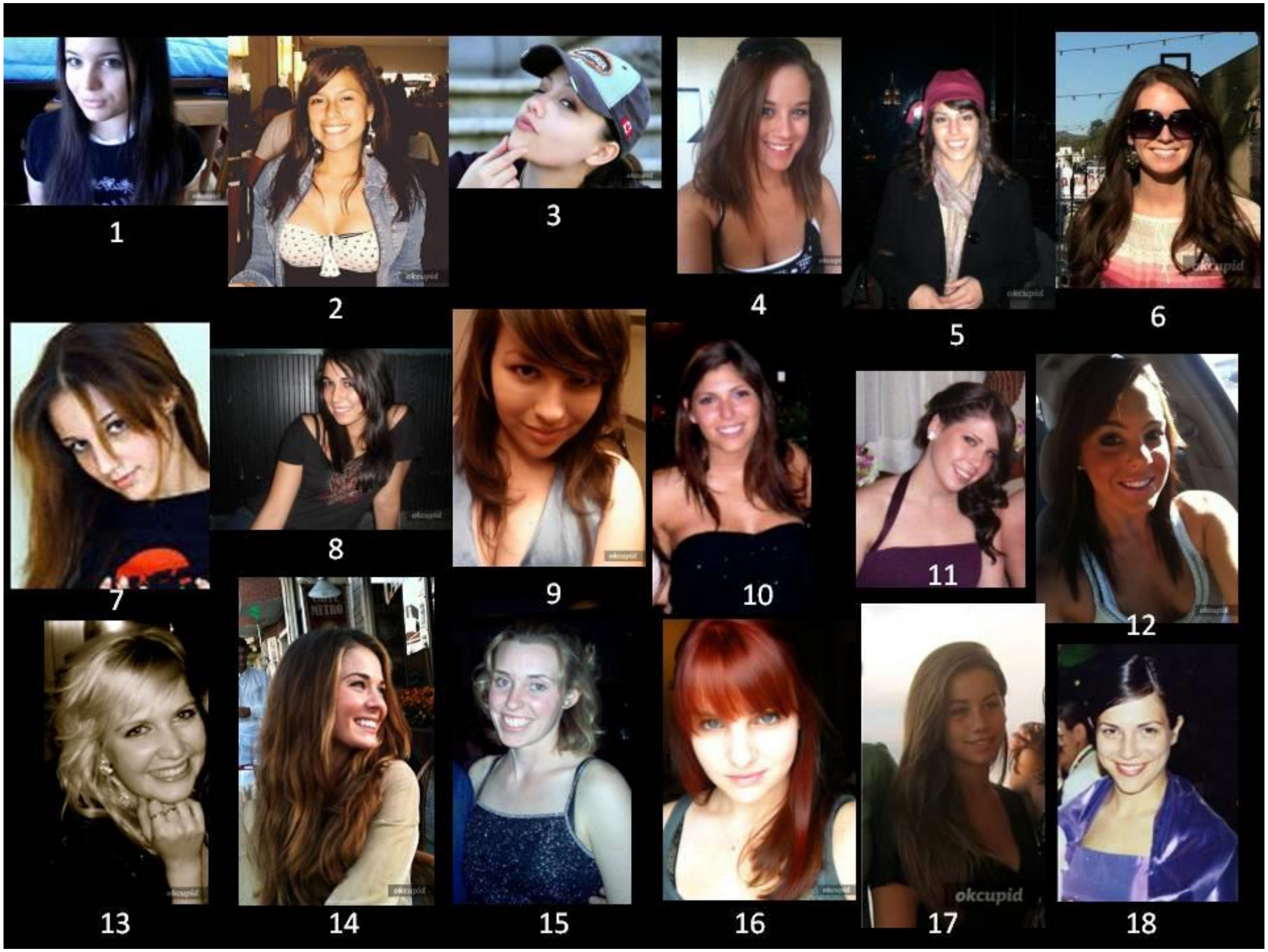
Alternative explanations must be considered and evaluated in future research. For example, one can speculate that young men are more commonly associated with muscular strength, which might lead both men and women who are primed with male stimuli to increase energetic effort in physical tasks regardess of life stage. An evolutionary hypothesis related to mating effort and intra-sexual competition, on the other hand, would predict that viewing photographs of young men would not have the same effect on energetic effort among individuals outside the mating market, such as post-reproductive adults or children. In addition, relevant life-history parameters (prenatal energetic condition, age, relationship status, T, parental status) should be investigated further as potential moderators of social facilitative effects in larger samples in order to better test predictions derived from an evolutionary framework. In addition, non-negligible effects of the sex of the experimenter were detected in Study 1, and should be examined explicitly in future research.

Conclusions

The current research provides preliminary support for the utilization of evolutionary theory to understand social facilitation of physical conditioning tasks. Results suggest that an experimental manipulation involving photographs of socially relevant others can significantly alter immediate performance on physical tasks, as well as exercise motivation and self-efficacy, particularly among men. These findings may have implications for efforts to increase energy expenditure and exercise behavior.

APPENDIX A. An example of the all male array

APPENDIX B. An example of the all female array



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