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The Presence of an Attractive Woman Elevates Testosterone and Physical Risk Taking in Young Men

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Abstract

The authors report a field experiment with skateboarders that demonstrates that physical risk taking by young men increases in the presence of an attractive female. This increased risk taking leads to more successes but also more crash landings in front of a female observer. Mediational analyses suggest that this increase in risk taking is caused in part by elevated testosterone levels of men who performed in front of the attractive female. In addition, skateboarders' risk taking was predicted by their performance on a reversal-learning task, reversal-learning performance was disrupted by the presence of the attractive female, and the female's presence moderated the observed relationship between risk taking and reversal learning. These results suggest that men use physical risk taking as a sexual display strategy, and they provide suggestive evidence regarding possible hormonal and neural mechanisms.

Keywords

risk taking, evolutionary psychology, decision making, social neuroscience, neuroscience

The archetype of the femme fatale appears in the religious texts, art, and literature of a range of cultures. She appears as a woman whose overwhelming allure has the capacity to part men from their reason, in essence embodying the relationship between female sexuality and loss of self-control among men. Although such a relationship might be nothing more than a dubious defense, concocted by men to mitigate their own behavior, recent research supports the possibility of such an association: Attractive women have the power to shift men's time perspective away from the long-term consequences of their choices and focus their attention on the here and now (Wilson & Daly, 2004).

A theoretical account of why attractive women inspire such a myopic time perspective in the male mind can be found in Trivers's (1972) theory of parental investment. Because of unequal gamete size, females invest more than males in reproduction in most species, with the result that males typically compete with each other for access to females (Trivers, 1972). Sexual selection consequently favors males who engage in competitive behavior and costly displays to attract females (Andersson, 1994). Although such displays can enhance reproductive success, they can also be detrimental in terms of survival (Brooks, 2000; Kokko, Brooks, McNamara, & Houston, 2002). Such effects of sexual selection have been documented in a variety of nonhuman animals, but they should also be apparent in humans, as differential parental investment is exacerbated in humans by lengthy gestation and lactation and by the extended period of development of dependent young. Consistent with this logic, human evolution shows signs of recurrent male–male competition for access to females, such as sexual size dimorphism (Alexander, Hoogland, Howard, Noonan, & Sherman, 1979) and the size and shape of male genitalia (Gallup et al., 2003). Presumably as a consequence of these evolutionary pressures, men are more predisposed than women toward risk taking, same-sex competition, and aggression (Byrnes, Miller, & Schaeffer, 1999; Eagly & Steffen, 1986; Wilson, Daly, & Pound, 2002).

Although physical risk taking can bestow important reproductive and reputational benefits on young men (Chagnon, 1988), there are obvious costs as well, particularly in a contemporary context. For example, men are 2.5 times more likely than women to be killed in road accidents (World Health Organization, 2002), and this sex difference exceeds a factor of 3 among 15- to 29-year-olds (Roads and Traffic Authority of New South Wales, 2001). Same-sex homicides are also predominantly committed by young single men (Daly & Wilson, 1990), with disputes over respect and saving face being the typical

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catalyst (Daly & Wilson, 1988). As a result of this greater tendency toward risk taking, young men occupy the highest demographic risk category for early mortality in industrialized nations (Kruger, 2004).

If men take risks in pursuit of mating opportunities, then such risk taking should be attuned to cues that signal the potential for successful mating (Baker & Maner, 2008; Wilson & Daly, 2004). As female attractiveness conveys statistically reliable and observable cues to fertility (Rhodes, 2006; Singh, 1993), we hypothesized that young men would engage in greater physical risk taking when in the presence of an attractive woman. To test this possibility, we recruited young adult male skateboarders and recorded whether the presence of an attractive female experimenter affected their risk taking.

Performing tricks on a skateboard gives young men the opportunity to display mastery, physical prowess, and bravado, but skateboarding tricks also involve the potential for physical harm and embarrassment. When skateboarders attempt their tricks, there is a decisive moment at which they must choose to abort the trick or try to land it. If there is any doubt of success, the safest option is to abort the trick and land on one's feet. This decision cannot be made in advance but rather must be made in midair, based on a split-second evaluation of the likelihood of success and on the physical costs that failure might bring. It was this split-second decision making in the face of risk that we sought to examine, in part because it resembles the type of risky decisions that young men make when behind the steering wheel of a car or when in physical confrontations with each other.

To examine a possible proximal mechanism for the hypothesized increase in this sort of risk taking in the presence of an attractive female, we focused on the role of testosterone. Testosterone fuels competition; high-testosterone males strive for positions of dominance, and short-term increases in testosterone help high-testosterone males achieve dominance by reducing fear while increasing assertiveness, violence, and competitiveness (Dabbs & Dabbs, 2000). Increases in testosterone have been shown to focus attention on rewards and reduce sensitivity to losses (van Honk et al., 2004), a volatile combination likely to enhance risky decision making. Testosterone also fuels sexual interest, arousal, and activity (Tuiten et al., 2006). High-testosterone males pay more attention to sexual stimuli (Rupp & Wallen, 2007), have more sexual partners (van Anders, Hamilton, & Watson, 2007), and are more likely to seek nonmonogamous sexual relationships (McIntyre et al., 2006) than low-testosterone males. Importantly, testosterone levels also increase in response to brief interactions with attractive women (Roney, 2003; Roney, Lukaszewski, & Simmons, 2007). Because male testosterone levels rise in the presence of attractive women, and because testosterone is associated with increased competition and risk taking (Coates & Herbert, 2008; Dabbs & Dabbs, 2000), we hypothesized that increased risk taking in the presence of an attractive woman might be induced by elevated testosterone.

Finally, we sought to test the possibility that this increase in risk taking might also be associated with decreased executive control, as facilitated by the prefrontal cortex (Barkley, 2001). Specifically, we wished to target the ventral medial prefrontal cortex (VMPFC) because of its role in the processing of rewards and punishments that are essential to decision making under risk (Bechara, Damasio, Damasio, & Anderson, 1994; Hare, Camerer, & Rangel, 2009; Xue et al., 2009). The VMPFC has been shown to play a role in the provision of somatosensory feedback, and these visceral cues appear to be critical in learning to avoid punishment (Bechara, 2004). In addition, the VMPFC is activated in response to a range of reward cues including food (Hare et al., 2009), attractive members of the opposite sex (O'Doherty et al., 2003), and money (O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001). Taken together, these findings suggest that the VMPFC is integral to the appraisal of a range of potential rewards and punishments that underlie effective decision making.

One possible consequence of the VMPFC's generalized response to rewards is misattribution. Note that we do not refer here to a misattribution of physiological arousal, as in Dutton and Aron's (1974) classic study but rather to a misattribution of the source of neural activity. Specifically, it is possible that during decision making, the presence of reward cues unrelated to the decision under consideration might contribute to activation of the VMPFC and thereby exert an influence on the decision at hand. This potential for misattribution may be greater during decisions providing less time for deliberation and reflection, such as those made in midair by our skateboarding participants. We therefore suspected that the presence of an attractive female experimenter might lead to increased activation of our skateboarders' VMPFCs and thereby interfere with the manner in which the region guides the rapid decisions required for successful skateboarding.

Although functional magnetic resonance imaging (fMRI) would enable the most direct test of such a hypothesis, our field experiment ruled against this possibility, and so we sought a proxy measure of VMPFC function. One task that has been shown in fMRI studies to target the VMPFC is a "reversal-learning" procedure (Fellows & Farah, 2005). Reversal learning requires participants to choose between two options that differ in terms of the rewards and punishments provided by their selection. One option results in larger rewards, smaller punishments, and more of the former than the latter, whereas the other results in an even distribution of smaller rewards and larger punishments. Given these contingencies, most participants quickly learn to choose the more profitable option. However, once they begin to repeatedly choose the profitable option, the contingencies are switched without notice, and participants' ability to adjust their choices in accordance with this shift is the measure of interest.

Such reversal-learning tasks measure participants' capacity to process dynamically changing reward–punishment contingencies and use this information to guide decision making. Thus, although the surface features of reversal-learning tasks are quite different from those involved in performing tricks on a skateboard, there may be overlap in the neural regions involved in both tasks, with the result that poorer reversal-learning performance should predict riskier skateboarding. Furthermore, because the female experimenter's presence should lead to increased activation of the VMPFC (O'Doherty et al., 2003), we expected that her presence would interfere with both the reversal-learning task and the skateboarding task. That is, because her presence should cause task-irrelevant activation of the VMPFC, this region should no longer be able to guide reversal learning or skateboarding as effectively as if she were not there, leading to poorer performance in the reversal-learning task and greater risk taking on the skateboard. If the degree of disruption caused by the female experimenter in reversal learning is commensurate with the degree of disruption on the skateboarding task, the relationship between the two should remain intact. Alternatively, if the degree of disruption on the two tasks is incommensurate, we would expect attenuation of the relationship between reversal learning and skateboarding. Thus, we also examined the possibility that the female experimenter's presence might moderate the predicted relationship between risky skateboarding and reversal-learning performance.

Method

Participants

A total of 96 young adult male skateboarders (age $M = 21.58$, $SD = 3.99$, range = 18–35) completed the experiment in skateboarding parks in Brisbane, Australia. Participants were recruited at skateboard parks and offered Aus$20 (∼US$16) as compensation for their time. Of the participants, 43 were assigned to the male-experimenter condition (age $M = 21.26$, $SD = 3.37$) and 53 were assigned to the female-experimenter condition (age $M = 21.85$, $SD = 4.44$). Testing was conducted between 2:00 p.m. and 6:00 p.m. to control for diurnal variation in testosterone concentrations.

Procedure

Skateboarders were asked to choose one easy trick (i.e., one they could successfully complete on most attempts) and one difficult trick (i.e., one they were currently learning and that they could successfully complete approximately 50% of the time), each of which they then attempted 10 times while being video recorded by a male experimenter (Block 1). Following a short break, they were asked to make 10 attempts of both of these same tricks again (Block 2), either for the same male experimenter or for an attractive 18-year-old female experimenter who was blind to hypotheses. Attractiveness of the female experimenter was established by having 20 independent male raters (age $M = 21.05$, $SD = 3.58$) view a photograph of the female experimenter and rate how attractive they found her on a scale from 1 (*very unattractive*) to 7 (*very attractive*). The mean attractiveness rating was 5.58 ($SD = 0.84$), which was significantly higher than the scale midpoint of 4, $t(19) = 8.31$, $p < .01$, $d = 3.81$ (these attractiveness ratings were corroborated by many informal comments and phone number requests from the skateboarders).

Skateboarders' attempts were subsequently coded by two raters ($\kappa = .81$) for one of three possible outcomes: success, crash landing, or an aborted attempt, with the latter an inverse indicator of risk taking.

Testosterone Assays

Saliva samples were collected by passive drool at the conclusion of the experiment—thereby providing enough time for testosterone changes induced by the second experimenter to appear in participants' saliva (Schultheiss et al., 2005). Samples were frozen and stored until the experiment was completed, at which point they were sent to the lab for analysis. As a consequence, samples were stored from 1 to 5 months at –20°C until assay with RadioImmunoAssay by Pathlab Integrative Medicine in Burwood, Australia.[1] As noted by Granger, Shirtcliff, Booth, Kivlighan, and Schwartz (2004), storage at –20°C for this duration does not lead to significant degradation of testosterone.

Reversal Learning

A modified version of the reversal-learning task was developed for this study, as the standard version was found to be insufficiently interesting to maintain the attention of the skateboarders. In this modified version, inspired by the Balloon Analogue Risk Task of Lejuez et al. (2002), participants pumped up a series of 40 cyber-balloons on a laptop, earning money for each pump but losing the money earned for each balloon if it popped before participants decided to move on to the next balloon. In the first half of the trials, pink balloons popped at a smaller size ($M = 14$ pumps, $SD = 2.56$) than did blue balloons ($M = 45$ pumps, $SD = 11.20$). In the second half of the trials these contingencies were reversed. Successful learning of this reversal is indicated by fewer pumps on the blue balloon and more on the pink balloon after the reversal. The learning component involved in the reversal-learning task precluded administering it more than once, and thus its placement in the experimental order was counterbalanced; 49 of the participants completed the task before the first block of skateboarding trials and 47 of the participants completed it before the second block of trials.

Heart Rate

To test the possibility that arousal might be responsible for changes in skateboarding performance in front of the female experimenter, participants' pulses were recorded with a Nordic sports watch that measured heart rate at the tip of the index finger through an electronic sensor.[2] Measurements were taken immediately prior to the first block of skateboarding and then again immediately prior to the second block of skateboarding.

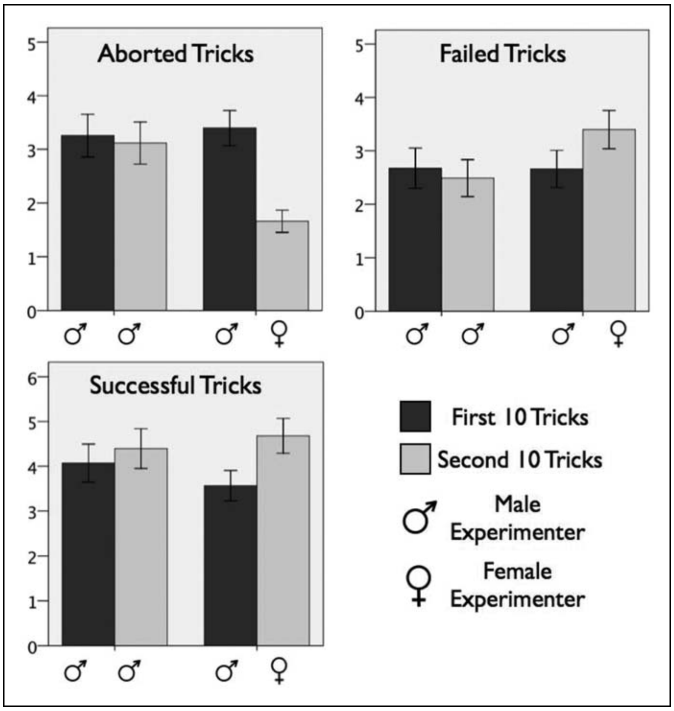

Figure 1. Performance on difficult tricks in Block 1 and Block 2 by experimenter gender. For examples of aborted tricks, failed tricks, and successful tricks see supplementary files at http://spp.sagepub.com/supplemental.
Note: Error bars represent 1 standard error.

Results

Skateboarding

Consistent with predictions, participants took greater risks on the difficult tricks in the presence of the female experimenter, as indicated by fewer aborted tricks (see Figure 1). This reduction in aborted tricks led to an increase in both crash landings and successful tricks (see Figure 1). Significant interactions emerged between gender of the second experimenter and trial block on all three measures of skateboarding performance on the difficult tricks: aborted tricks, $F(1, 94) = 13.18$, $p < .001$, $d = 0.75$, successful tricks, $F(1, 94) = 4.14$, $p < .05$, $d = 0.42$, and crash landings, $F(1, 94) = 5.91$, $p < .02$, $d = 0.50$. In all three of these interactions, no differences in performance emerged in front of the male experimenter across the two blocks of trials (all $ps > .20$), but the presence of the female experimenter led to fewer aborted tricks, $t(52) = -5.39$, $p < .001$, $d = 1.49$, more crash landings, $t(52) = 3.01$, $p < .01$, $d = 0.84$, and more successes, $t(52) = 4.23$, $p < .001$, $d = 1.17$. Controlling for age had no effect on any of these results.

Testosterone

As predicted, testosterone levels were significantly higher among men who skateboarded in front of the female experimenter ($M = 295.95$ pmol/L, $SD = 143.69$) than among men who skateboarded only in front of the male experimenter ($M = 212.88$ pmol/L, $SD = 101.62$), $F(1, 69) = 5.99$, $p < .02$, $d = 0.67$. Importantly, this increase in testosterone partially accounted for the decreased likelihood of aborting tricks in front of the female experimenter (see Figure 2). A bootstrapping procedure (Preacher & Hayes, 2004) with 10,000 resamples indicated that testosterone significantly mediated the relationship between experimenter gender and the number of aborted tricks (indirect effect $= -.14$, $SE = .07$, 95% confidence interval $= -.33, -.03$). These analyses suggest that increased risk taking in front of the female experimenter was partially mediated by increased testosterone. All analyses were then rerun while controlling for age, and all effects remained significant.

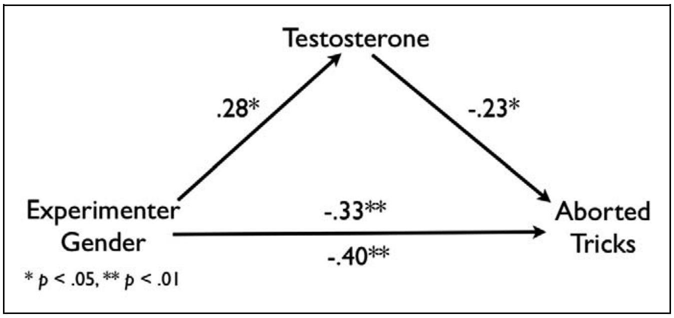

Figure 2. Mediation of the effect of experimenter gender on number of aborted tricks via testosterone
Note: Path coefficients represent standardized regression weights. The coefficient below the path from experimenter gender to aborted tricks represents the direct effect with no mediator in the model; the coefficient above the path represents the effect when testosterone is included as a mediator.

Reversal Learning

Reversal-learning data were log transformed prior to analysis to overcome positive skew, although for ease of interpretation raw means are reported below (all results remain significant when the raw data were analyzed without log transformation). Because of counterbalancing of the reversal-learning task, order of administration was controlled in all reported analyses. Consistent with expectations, reversal learning was better when the task was performed in front of the male experimenter ($M = 2.41$, $SD = 0.44$, $n = 70$) than when it was performed in front of the female experimenter ($M = 2.21$, $SD = 0.28$, $n = 26$), $t(94) = 2.23$, $p < .05$, $d = 0.44$. Reversal-learning performance did not differ significantly across the three conditions in which the task was performed in front of the male experimenter ($ts \leq 1.5$, $ps \geq .14$). Better reversal learning was also associated with increased frequency of aborting the tricks in front of the male experimenter, $\beta = .31$, $t(40) = 2.07$, $p < .05$, but not in front of the female experimenter, $\beta = -.11$, $t(50) = -0.73$, $p = .47$, and this difference between conditions was itself significant, $\beta = -.23$, $t(91) = -2.38$, $p = .02$.

Alternative Explanations

An alternative proximal mechanism for the current results is that the attractive experimenter increased men's arousal and

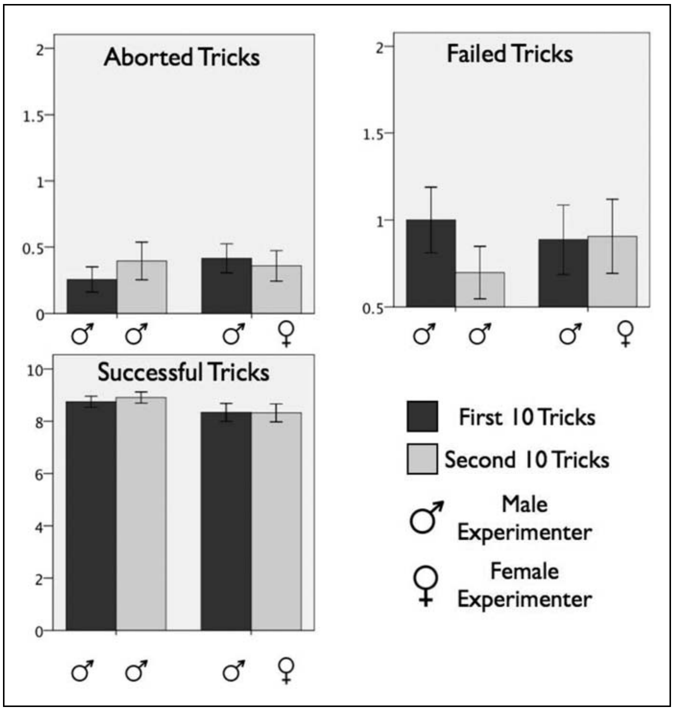

Figure 3. Performance on easy tricks in Block 1 and Block 2 by experimenter gender
Note: Error bars represent 1 standard error.

that this increased arousal led to greater risk taking. However, if arousal were the proximal mechanism, then participants would have performed better on the easy tricks and worse on the difficult tricks in the presence of the attractive female (Zajonc, 1965). In contrast to this possibility, participants showed a mix of greater failure *and* greater success on the difficult tricks in the presence of the attractive female. Furthermore, experimenter gender had no main or interactive effects on performance outcomes for the easy tricks, aborted tricks, interaction $F(1, 94) = 0.46$, $p = .50$, successful tricks, interaction $F(1, 94) = 1.34$, $p = .25$, and crash landings, interaction $F(1, 94) = 1.95$, $p = .17$ (see Figure 3), although ceiling and floor effects with the easy tricks make this absence of an effect somewhat ambiguous. In addition, an increase in arousal should be marked by an elevated heart rate in the presence of the female experimenter. Tentative evidence emerged for an increase in heart rate from Block 1 ($M = 80.04$, $SD = 18.14$) to Block 2 ($M = 84.63$, $SD = 21.04$) of the experiment, $F(1, 88) = 3.55$, $p < .07$, but no evidence emerged for this change in heart rate being affected by the gender of the experimenter, $F(1, 88) = 1.32$, $p > .05$. Correlations between heart rate measurements at Block 1 and Block 2 were $r = .59$, $p < .01$ and $r = .34$, $p < .05$ for the control and experimental conditions, respectively. A comparison of the two correlations following Fisher's r to z transformations (Preacher, 2002) revealed no significant difference between the two conditions ($z = 1.47$, $p = .14$). Finally, none of the skateboarding variables were correlated with the change in heart rate from Block 1 to Block 2, nor with either of the independent measures of heart rate (all rs < .06, all ps > .57).

Another alternative to the mediational model proposed in Figure 2 is that attractive women might lead men to take greater risks, and this enhanced risk taking might itself lead to elevated testosterone. Because testosterone increases with success compared to failure (Archer, 2006), this alternative model suggests that increased testosterone in the presence of the female experimenter should be mediated by the increased number of successful landings, change in the ratio of successful to crash landings, or the decreased number of aborted landings. None of these alternative models showed evidence for mediation.

Discussion

The results of this field experiment provide evidence that young men take greater physical risks when in the presence of an attractive woman and that increases in circulating testosterone partially explain this effect. Such displays of physical risk taking might best be understood as hormonally fueled advertisements of health and vigor aimed at potential mates and signals of strength, fitness, and daring intended to intimidate potential rivals. The finding that increased risk taking led to both more successes and more crashes suggests that although sexual displays in human males might be adaptive in terms of reproductive success, they might also be costly in terms of survival, as has been found in other species (Hunt et al., 2004). Other instances of physical risk taking that contribute to men's early mortality, such as dangerous driving and physical aggression, might also be influenced by increases in testosterone brought about by the presence of attractive women. The possibility that male risk taking emerges in part because of an adaptive legacy that wages survival against reproductive success offers a Darwinian perspective on the causes of such costly expressions of risk taking.

Our finding that reversal-learning performance predicted risk taking among the skateboarders in this study provides evidence that reversal learning is linked to a real-world instance of risk taking. It is notable that the split-second decisions underlying our measure of risk taking afforded participants little opportunity for choosing a course of action in advance. The dynamic evaluation of potential rewards and losses required by the skateboarding task is likely to be at least partially facilitated by the functioning of the VMPFC (Bechara et al., 1994; Glimcher & Rustichini, 2004; Hare et al., 2009; Xue et al., 2009), and, as noted, reversal-learning tasks such as the one completed by the skateboarders in this study have also been linked to activation of the VMPFC (Fellows & Farah, 2005). It is therefore possible that the VMPFC provides a source of the relationship observed between the two tasks in the current study. Nevertheless, replication and extension are clearly necessary to confirm this interpretation of these findings.

The results of the current study also suggest possible underlying mechanisms for Wilson and Daly's (2004) finding that attractive women increase delay discounting (also see Baker & Maner, 2008; McAlvanah, 2008). First, these data suggest that increases in young men's testosterone levels in response to an attractive woman provide a partial explanation for shifts toward greater risk taking. Future research might seek to establish whether similar hormonal changes following exposure to attractive women mediate shifts in delay discounting. Second, if delay discounting and increased risk taking in the presence of attractive females have an evolutionary origin (Baker & Maner, 2008; Wilson & Daly, 2004), then it is possible that the sort of misattribution that might take place in the VMPFC may have evolved in part to facilitate young men's risky decisions that can be necessary to get into the mating game. That is, the VMPFC might have evolved to facilitate risk taking during those circumstances when it was most adaptive to risk one's own survival in the pursuit of reproduction.

Caveats and Limitations

There are important limitations to this study that should be noted. First, because of the collection of only a single posttest sample of testosterone, it is possible that the presence of the male experimenter caused participants' testosterone levels to decrease rather than the female experimenter causing them to increase. Such a possibility seems unlikely, given that no evidence supports such a possibility, whereas there is evidence that women elevate male testosterone levels (Roney, 2003; Roney et al., 2007); nevertheless, future research should replicate these results using changes in pretest to posttest measures of testosterone. Second, and related, the experimental group experienced a change in experimenter (from male to female) but the control group did not, and thus it is possible that the higher levels of testosterone and risk taking found among the experimental group were because of the novelty of having a new experimenter present for the second half of the study. Although we have no theoretical reason to expect novelty alone to have such an impact, it remains a possibility that would be best addressed in future research by the assessment of pretest and posttest testosterone levels.

Third, as only one female experimenter was used throughout the study, we do not know whether the presence of any female would have led to the same results and thus whether her attractiveness was a relevant detail (Wells & Windschitl, 1999). We suspect that her attractiveness is important, given Baker and Maner's (2008) research demonstrating that male risk taking increases only after exposure to attractive females. Nonetheless, although we anticipate that the current effects are likely to be stronger in the presence of attractive women, it is possible that most women of reproductive age could serve as a sufficient mating cue to lead to the increase in risk taking seen in the current study.

Fourth, we have no evidence of whether all of our participants were indeed heterosexual and not in committed relationships, and thus we do not know if all of them were potentially interested in the attractive female experimenter. We chose not to ask our participants about these issues, in part because of the questionable veracity of their responses in this context. Nevertheless, the unintended inclusion of homosexual participants or participants in committed relationships should only weaken our pattern of results.

Finally, it is important to keep in mind that the reversal-learning task used in this study is a distal measure of VMPFC function. Although previous fMRI studies suggest that reversal learning involves activation of the VMPFC (Fellows & Farah, 2005), no task is process pure, and thus it is quite possible that other aspects of the task beyond its relationship with VMPFC functioning underlie its correlation with risk taking. Future research with other measures and procedures will be necessary to corroborate the effects reported here.

Conclusion

The current experiment provides evidence for an effect that has existed in art, mythology, and literature for thousands of years: Beautiful women lead men to throw caution to the wind. Our data extend this ancient literature in two directions, by suggesting that increased male risk taking in the presence of an attractive woman is mediated by increases in circulating testosterone and by suggesting that the VMPFC might play an intermediary role in these processes. These findings suggest that, for men, the adaptive benefits gained by enticing mates and intimidating rivals may have resulted in evolved hormonal and neurological mechanisms that facilitated greater risk taking in the presence of attractive women.

Notes

1. Consistent with the challenges of field experiments, not all participants were willing to provide saliva samples, and not all collected samples were free of contaminants, as some participants appeared not to rinse thoroughly and some chose not to wait the requested 5 minutes after rinsing their mouth with water prior to providing a saliva sample. Thus, of the 89 assayed samples, 13 were below and 5 were above the normal range of 100 to 720 pmol/L for young adult males established by Pathlab with its assaying procedures. Because of concerns about the causes of these outliers, they were excluded from subsequent analyses. When the missing values (outliers, those who refused to provide a sample, or both) were replaced with the sample mean for testosterone (270.21), all reported analyses replicated significantly. When the outliers were retained in the analyses, the effect of experimenter gender on testosterone remained significant, but the mediation analysis did not.
2. The watch was validated against heart rate measured 10 times directly at the radial artery with a stopwatch ($r = .72, p = .02$). Sensitivity of the device was established by comparing 10 measurements taken at rest ($M = 83.4$, $SD = 2.50$) to 10 measurements taken after climbing six flights of stairs ($M = 89.5$, $SD = 6.85$), $t(9) = 3.05, p = .01$.

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