The presence of a woman increases testosterone in aggressive dominant men

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ABSTRACT

In line with the challenge hypothesis, this study investigated the effects of the presence of a woman on the testosterone (T) levels of young men. An informal contact with a woman of approximately 5 min resulted in an increase in salivary T among men. These effects occurred particularly in men with an aggressive dominant personality. In addition, higher salivary T levels were related to a more aggressively dominant personality, being sexual inactive for a month or more, and not being involved in a committed, romantic relationship. The most important findings of this study are that the short presence of a woman induces specific hormonal reactions in men, and that these effects are stronger for aggressively dominant men.

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Introduction

The challenge hypothesis (Wingfield et al., 1990) has had a big impact on behavioral endocrinology since it was first formulated (Moore, 2007). This hypothesis intends to explain the relationship between testosterone (T) and behavior in monogamous birds, and states that T levels rise during challenges in contexts that are relevant for reproduction, such as inter-male competition over receptive females. On the contrary, when males are required to care for offspring T levels tend to be low. More recently, the challenge hypothesis has been extended to research on humans, now also incorporating challenges facing human males such as social status disputes and reactions towards sexual stimuli (Archer, 2006).

In humans, indirect findings supporting this hypothesis range from men showing T increases after engaging in sexual intercourse (Dabbs and Mohammed, 1992), after any sexual activity resulting in an orgasm (Knussman et al., 1986) and even after watching erotic videos (Hellhammer et al., 1985; Stoléru et al., 1993). On the other hand, it has been found that T levels are lower in contexts that require parenting effort rather than mating effort. For example, men with lower T levels feel more sympathy in response to infant cries (Fleming et al., 2002), and men who express more need to comfort a crying baby actually decrease their T levels (Storey et al., 2000). Furthermore, men who are in committed relationships have lower T levels than uncommitted men (Burnham et al., 2003; Gray et al., 2004) and married men have lower T levels than unmarried men (Gray et al., 2002). In fact, T seems to decline when men marry (Mazur and Michalek, 1998) and when

they become fathers (Storey et al., 2000; Berg and Wynne-Edwards, 2002).

Much more direct evidence comes from a study that examined if contact with a potential mate induces in men a mating response, consisting of a reactive increase in sex hormone levels accompanied by courtship behaviors (Roney et al., 2003). Although in this study the authors did find a significant increase in T levels after contact with a woman, and not after contact with a man, the difference in change between both conditions was not significant. Furthermore, Roney et al. (2003) examined if sexual experience acted as a potential moderator of the T change in men when in contact with a woman. This was in line with the animal literature, since in animals sexual experience seems to moderate the release of T after the presence of a female and after sexual contact (Kamel et al., 1975; Bonilla-Jaime et al., 2006). Roney et al. (2003) did find some limited evidence, in the sense that changes in T levels were close to zero among men with little sexual experience. In a follow up study, using a larger sample of men Roney et al. (2007), found more unequivocal evidence for an increase of T when in contact with a young woman. The number of previous sex partners did not influence this T increase, although this could only be tested in a sub sample consisting of men who were in a relationship.

Individual differences in T responses to potential mates have not been studied in much detail. Here we propose that differences in dominance may lead to different hormonal responses to interactions with women. This is because individuals high in dominance are expected to display relatively more dominant behavior when in challenging situations. Contact with a potential mate introduces challenge and might especially increase T levels in individuals high in dominance. This anticipating effect may occur because T plays a key roll in processes concerning the attainment or struggle for dominance. T is related to achieving status (Booth et al., 1989; Mazur et al., 1992),

to a dominant or vigilant response towards angry faces (van Honk et al., 2000), to competition (Suay et al., 1999; Salvador et al., 2003; Salvador, 2005), and to dominance (for a review see Archer, 2006). Competing, being vigilant, achieving status or being dominant can be viewed as being evolutionary adaptive in terms of gathering critical resources such as food, shelter and potential mates (Mazur and Booth, 1998). Although there are many possible ways of defining dominance (Mazur and Booth, 1998), according to Kalma et al. (1993) two different dominance personality types can be distinguished: sociable dominance and aggressive dominance. Kalma et al. (1993) showed that both observational and self report data indicate that the two types of dominance are associated with the use of power strategies to influence others. However, aggressive dominant men tend to use a mix between "stating what one wants" and Machiavellian tactics, whereas sociably dominant men tend to use more reasoning strategies to influence people.

Bearing all this in mind, the aim of this study was to investigate the T responses of men when they come into contact with a potential mate. Building directly on the study of Roney et al. (2003), an informal contact was staged in which male participants had to wait in a waiting room situation with either a female confederate (experimental condition) or a male confederate (control condition). Salivary T levels were measured before and after the contact period. In addition to examining the main effect of being exposed to a woman we also examined the role of several potential moderators. First, we included sexual experience by using the following variables: number of sex partners, last time of sexual contact, and involvement in a committed romantic relationship. We expected that more sexual experience is associated with higher initial T levels and with stronger increases in the T response. Second, we included a questionnaire measuring sociable and aggressive dominance. We predicted that individuals high in either type of dominance would show a more pronounced hormonal change when meeting a potential mate and have higher T levels. In this study, we only considered dominance related to power relations and not phenomena like eminence or prestige, which refer to social status that is earned through accomplishments and that is bestowed freely (Kemper, 1990; Johnson et al., 2007).

Method

Participants and stimulus persons

Sixty-three male students were recruited from different cafeterias of the University of Groningen and Hanze College in Groningen. A male and female recruiter approached men and asked them if they would like to participate in a study at the faculty of psychology. Participants were paid 5 euros for their participation. Ages of the participants ranged from 18 to 27 years (*M* = 21.8, SD = 2.1). The data of four participants were removed because they indicated to have a gay or bisexual orientation.

Participants came into contact with a confederate who was either a man (control condition) or a woman (experimental condition). In order to achieve this, three men and three women played the role of stimulus person. At face value, female stimulus persons were chosen on the basis of being moderately attractive for the student population (in the experiment this was later validated, see 3.1). Ages of the female stimulus persons were 20, 23, and 23 years and for the men the ages were 21, 23, and 25 years.

Procedure

Upon arrival at the faculty the participants were told by the experimenter that they were about to participate in a study on the link between personality and physiological reactions. Next, to habituate the participants to the experimental setting, they filled in a general background questionnaire, signed an informed consent, and answered several questions that were not related to this study. After this, half of the participants were randomly assigned to have contact with a man (control condition) and the other half to have contact with a woman (experimental condition). The contact procedure was partly taken from Roney et al. (2003).

Next, the participants provided their first saliva sample to measure T. As a bogus task, the participants were then brought to another room to solve a puzzle (the type of puzzle was a sudoku). In this room another participant appeared to solve a similar puzzle, but this participant was actually a confederate of the experimenter and functioned as a stimulus person. The experimenter then made the excuse that he did not have the correct puzzle for the participant. The participant and stimulus person were then asked to wait, so the experimenter could get the correct puzzle. The experimenter left and the participant and the stimulus person were left alone to wait together for 5 min. All stimulus persons received the instructions to engage in friendly conversation in a natural manner, were instructed to act as if they were participants in the same study, and were tolled to allow long pauses if the subjects elected not to talk. These instructions were given to avoid a competitive interaction among participants and stimulus persons.

After 5 min, the experimenter returned with the correct puzzle. The participant received the instruction to solve the puzzle in a relaxed manner. Then the stimulus person left the room with the experimenter. After trying to solve the puzzle for 15 min, the experimenter returned to collect the puzzle from the participant. He then asked the participant to provide a second saliva sample, for the purpose of determining a change in their T level. After this, the participant filled in several questionnaires and rated the attractiveness of the female stimulus person.

Finally, the participants were debriefed, received five euros, and a letter with a detailed description of the true purpose of the study. The session took about 60 min to complete and participants were tested from nine o'clock in the morning to four o'clock in the afternoon.

Questionnaires and scales

At the end of the study the participants filled in two questionnaires measuring sociable and aggressive dominance, consisting of eight items for the sociable dominance scale and seven items for the aggressive dominance scale (Kalma et al., 1993). A Cronbach Alpha of 0.79 has been reported for the sociable dominance scale and an Alpha of 0.68 for the aggressive dominance scale (Kalma et al., 1993). The original Dutch versions of the questionnaires were used (Kalma et al., 1993). Examples of the items for sociable dominance are: *No doubt I'll make a good leader*, *I like taking responsibility*, and *People turn to me for decisions*. Examples of the aggressive dominance scale are: *I make smart, sarcastic remarks to people when they deserve it*, *I think it is important that my opinion prevails*, and *while telling a lie, I can look anyone in the eye.* For every item in the two questionnaires, the participants rated to what extent they agreed with the statements on a scale from 1 (strongly disagree) to 6 (strongly agree).

After being presented with the dominance scales, the participants were asked how many sexual partners they have had (open end), if they were involved in a committed romantic relationship (yes or no), when the last time was when they engaged in sexual activity ranging from 1 = a few days ago to 6 = more than a year (or 7 = I never had sexual contact), and their sexual orientation (heterosexual, homosexual, or bisexual). Participants also could choose not to answer all these questions by filling in 'private'. Next, they rated how attractive they thought the female stimulus person was from 1 = very unattractive to 7 = very attractive.

Finally, participants were asked what they thought was the true purpose of the study. None of the participants included in their answer that the stimulus persons were part of the experiment.

Hormonal assays

Participants provided two saliva samples by depositing 5 ml of saliva into plastic vials. The samples were frozen at −20 °C and shipped to the endocrinology laboratory at the University Medical Center Utrecht. We chose 20 min as the interval between the two saliva samples because psychological stimulation needs some time to affect T levels (Hellhammer et al., 1985).

The saliva samples were tested using a radio-immunoassay. T in saliva was measured after diethyl-ether extraction, using an in house competitive radio-immunoassay employing a polyclonal anti-T-antibody. The lower limit of detection was 10 pmol/L. Inter-assay coefficient of variation ranged from 8–13% (range 40–500 pmol/L) and the intra-assay coefficient of variation ranged from 5–7%.

For calculating a T change, the data of one participant were removed because the second saliva sample did not contain enough saliva to measure T.

Statistical analysis

We first performed several independent *t*-tests to assess if the random distribution of the participants among conditions created any differences between the experimental and the control group. A Spearman correlation was used to look at the possible influence of time of saliva sample with baseline T.

To examine if there was an increase of the salivary T level in response to contact with a woman, we executed an ANCOVA with Repeated Measures with moment of collecting the saliva sample as within-subject variable and sex of the stimulus person as between-subject variable. As a covariate we included being in a relationship (see 3.1). Post hoc, paired *t*-tests were used to assess differences with baseline T.

Regression analyses were used to investigate the moderating effects of attractiveness of the stimulus person, sexual experience and dominance on the T change in the female condition. Independent *t*-tests were performed to investigate differences in baseline T for sexual experience and dominance. For this purpose we divided our sample in being sexual active or inactive in the last month and we compared participants low (below the mean) and high (above the mean) for both sociable and aggressive dominance.

No violation of the normality assumption was found in the T values, therefore there was no need to transform them. A value of $p<0.05$ (two-tailed) was considered statistically significant. Statistical tests were performed with SPSS version 13.0 and effect sizes were calculated with G*Power 3 (Faul et al., 2007). Cohen's d, f^2, and d_z are reported for the effect sizes and when not otherwise specified values are Mean±SEM.

Results

Preliminary analysis

The data from 59 participants were used for the statistical analysis, of whom 29 participants had contact with a man (28 when analyzing the T change, see 2.4) and 30 participants had contact with a woman. There were no differences between conditions for the following variables: age, housing condition, educational level, last time of sex, number of sex partners, sociable dominance, and aggressive dominance ($p \geq 0.149$). However, we did find that by chance we had more participants with a committed romantic relationship in the control condition ($n=23$) than in the experimental condition ($n=12$), $t(57)=-2.9$, $p=0.005$. We therefore controlled for this variable by including it as a covariate in our analysis to examine a possible T change.

The participants rated the female stimulus persons on average a 4.2±0.2, meaning they thought the female stimulus persons were moderately attractive. Finally, in our sample there did not appear to be a significant relation between time of collecting the saliva sample and baseline T, $r=-0.14$, ns.

Main effect of the testosterone change

There was a significant interaction between the sex of the stimulus persons and moment of collecting the saliva sample, $F(1,55)=4.02$, $p=0.050$. An inspection of Fig. 1 reveals that men showed an increase in their salivary T level when they had been in contact with a woman. The participants who had contact with a woman had an average increase in their salivary T level of +7.8%, paired-$t(29)=2.69$, $p=0.012$, $d_z=0.49$. Participants who had contact with a man had on average a decrease in their salivary T level of −0.5%, paired-$t(27)=0.63$, $p=$ns, $d_z=0.12$. Finally, there were no baseline differences in T level between the male and female condition, $t(57)=-1.09$, $p=$ns, $d=0.28$. We also examined if the increase in T depended on the perceived attractiveness of the female stimulus person. No significant effect was found, $\beta=0.04$, $p=$ns. Thus, the T increase was not influenced by the perceived attractiveness of the female stimulus person.

Sexual experience

There was no relation between T change in the female condition and number of sex partners, $\beta=-0.092$, $p=$ns, nor with last time of having sex, $\beta=-0.093$, $p=$ns. The T increase during contact with a woman did not differ between men with a relationship (27.7±14.8, $n=7$,) and men without a relationship (21.8±10.4, $n=23$), $t(28)=0.29$, $p=$ns, $d=0.13$. Furthermore, the T increase did not differ between

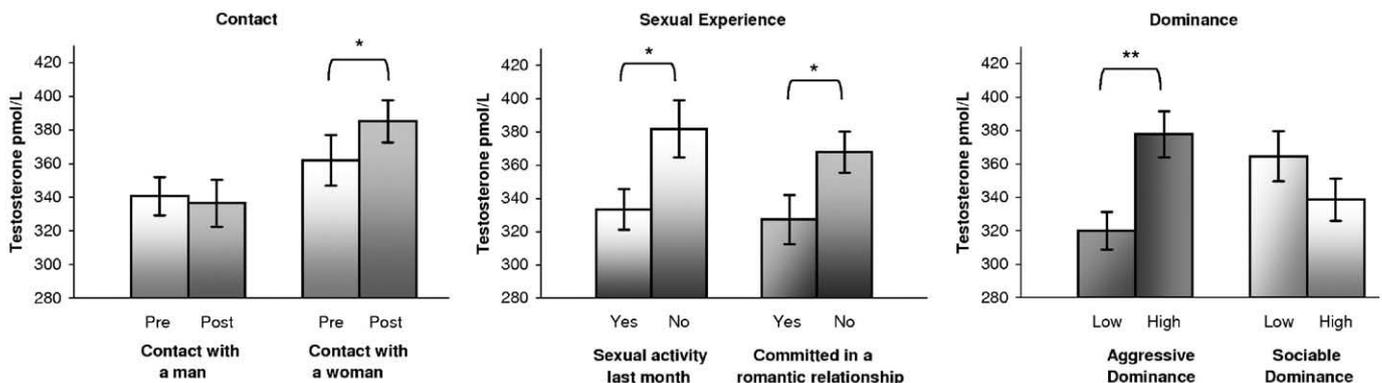**Fig. 1.** Salivary testosterone concentrations depicted by contact with a man ($n=28$) or contact with a woman ($n=30$). Baseline testosterone levels are reported for men with a relationship ($n=24$) or without one ($n=35$), and for men who were sexually active in the last month ($n=31$) or inactive ($n=22$). Also depicted are men low ($n=27$) or high ($n=32$) in aggressive dominance, and for men low ($n=29$) or high ($n=30$) in sociable dominance. Values are Mean±SEM. *$p<0.05$, **$p<0.01$.

those who had been sexually active (36.8±15.9, n=13) or sexually inactive (18.0±9.0, n=14) in the last month, $t(25)$=1.0, p=0.306, d=0.40. Only one participant in the condition of contact with a female was a virgin, and was therefore excluded from this last analysis; however, including him did not change p to significance.

The results did show that participants who were not sexually active in the last month had higher baseline T levels compared to men who were sexually active in the last month, $t(51)$=−2.36, p=0.022, d=0.65 (see Fig. 1). There were four virgins in our total sample and they were excluded from this last analysis, although including them did not change the p level to significance. Additionally, men who were involved in a committed, romantic relationship had lower salivary T levels, $t(57)$=−2.10, p=0.041, d=0.68 (see Fig. 1). However, sexual activity in the last month (virgins included) and being in a relationship were heavily correlated, Spearman's rho=0.75, p≤0.001. When added together in the same multiple regression using the enter method we found a significant model, $F(2,54)$=3.3, p=0.044, adjusted R square=0.08, f^2=0.12. Although not significant, participants who did not have sexual contact in the last month had somewhat higher T baseline levels, β=0.27, p=0.170. Being in a relationship was not related to baseline T, β=0.07, p=0.711. These data suggest that most important was sexual activity in the last month, whereas being in a relationship was of no importance.

Dominance

Sociable dominance did not predict a T change in the female condition, β=0.21, p=ns. However, aggressive dominance marginally predicted a T change, β=0.35, p=0.058. The more the participants had an aggressive dominant personality, the greater their T change was during contact with the female stimulus person. Since baseline T was related to aggressive dominance (see below) we included baseline T as a predictor together with aggressive dominance. When added together in the same multiple regression using the enter method we found a significant model, $F(2,27)$=6.1, p=0.006, adjusted R square= 0.26, f^2=0.45. As participants scored higher on the aggressive dominance scale, their T levels increased more, β=0.50, p=0.006. As participants had a higher baseline T level, the increase in T was lower, β=−0.46, p=0.011.

Finally, the results showed that participants scoring above the mean of the aggressive dominance scale had higher baseline T levels than persons scoring below the mean, $t(57)$=−3.2, p=0.003, d=0.84, whereas for sociable dominance no effects were found, $t(57)$=1.3, p=ns, d=0.35 (see Fig. 1).

Discussion

Originally the challenge hypothesis was formulated to explain the relationship between T and behavior in monogamous birds (Wingfield et al., 1990). However, the main results of the present research were in line with predictions from the challenge hypothesis when applied to humans (Archer, 2006). Participants showed an increase in their salivary T level after exposure to a woman and not after exposure to a man. Thus, we did not find evidence for a competitive inter-male interaction in our control condition since for this condition no T changes were found. However, the use of other control groups can be of interest, for example contact with a considerably older woman. Our results are similar to that obtained in an earlier study (Roney et al., 2007), with the difference that we already found a T increase after only 5 min of exposure to a woman, while Roney et al. (2007) found effects after 15 min of exposure.

One of the ultimate functions of T may be to attract mates, since it has been speculated that T could have the proximate function of promoting dominant behavior intended to achieve or maintain high status (Mazur and Booth, 1998) which might increase one's desirability as a sexual partner. This hypothesis is supported by evidence

that dominance behaviors of men increases their sexual attractiveness and desirability as a date (Sadalla et al., 1987), and by research showing that men who exhibit more dominant-like behavior make more frequent successful contact with women in bars (Renninger et al., 2004).

The female stimulus persons probably represented the type of women with whom the participants normally form sexual relationships, since the female stimulus persons were rated as moderately attractive, and both participants and stimulus persons were students of approximately the same age. If this reasoning is correct and the hormonal changes are part of a response to a potential partner, it is possible that this response depends on the attractiveness of the woman in question. However, the present results did not show evidence for this. It is possible that the stimulus persons did not differ enough in attractiveness to moderate the T increase or that the increase in T described here is an automatic process which is not influenced by conscious judgments of attractiveness.

While we expected on the basis of the animal literature (Kamel et al., 1975; Bonilla-Jaime et al., 2006) that sexual experience would moderate the hormonal reactions of men to the presence of a woman, we did not find clear evidence for this. However, tentative evidence was found for a higher increase in T during contact with a woman when being sexually active in the last month or more. This promising result did not reach significant levels most likely due to a type II error, since the group sizes were small (Cohen, 1992). Possibly, moderation by sexual experience is more difficult to detect in humans than in animals, since in humans their complex personal experiences may obscure any effect. Perhaps research with more participants and more detailed information regarding the sexual experience will find more unequivocal evidence for moderation of sexual experience on a T response to women.

There were various relationships between baseline salivary T and sexual experience. We found that men who had not been sexually active in the past month or longer had higher T levels. It is possible that a lack of sexual contact in the long term induces a rise of baseline T in the male body, thereby causing a stronger motivation and preparation to engage in mate attraction. Following this reasoning, one of the evolutionary functions of high T may be promoting sexual contact. As previous research did (Burnham et al., 2003; Gray et al., 2004), we also found that men who were involved in a committed, romantic relationship had lower T. This result supports the view that men involved in committed, romantic relationships may be less engaged in seeking mating opportunities. However, when including sexual experience it appeared that lower T levels among committed men were actually driven by recent sexual activity. All the men in our study with a committed romantic relationship had had sexual contact in the last month, and it was therefore probably the lack of sexual contact that induced higher T levels among non-committed men.

The present study is the first study to show that personality differences in dominance influence an increase in T when meeting a woman. We found that only aggressive dominance and not sociable dominance moderated this increase in T. The more the participants had an aggressively dominant personality the more their salivary T increased during contact with a woman. Our study cannot give a definite answer to the important question of whether high T causes dominance or dominance causes high T. But we would like to suggest that aggressively dominant men may have more extreme hormonal reactions when they come into contact with potential partners, i.e. they possibly seek more short term mating opportunities. This reasoning is in line with studies investigating the positive relation between antisocial behavior and short term mating (Ellis, 1988; Charles and Egan, 2005), and with findings that men with higher T are less likely to marry and have a greater likelihood to divorce (Booth and Dabbs, 1993). In addition, high baseline T levels were associated with a lesser T increase. Perhaps those men with high baseline T levels are close to their optimal T level for successful mate attraction. Another

physiological possibility is that those men had a lesser increase because negative feedback from their hypothalamic–pituitary–gonadal axis was more sensitive in signaling a decrease of T, due to already high T levels.

We also showed that men with high baseline T were more aggressively dominant. These results are supported by other studies finding that dominance and T are linked. A review by Archer (2006) showed a solid relation between dominance and T with a mean weighted r value of 0.27 ($n=11$, excluding two studies as outliers). A recent study found that T levels are actually negatively related to prestige (Johnson et al., 2007). Examination of the scales we used revealed that only one item could be related to prestige (for the items see Kalma et al., 1993), and we therefore view our dominance scales as assessing different characteristics than obtained prestige. Our study did not detect a link between T and sociable dominance, while some previous studies did show such a relationship. T and social dominance (i.e. sociable dominance) have been found to be related among boys (Schaal et al., 1996; Tremblay et al., 1998) and among prisoners (Ehrenkranz et al., 1974). The discrepancy between these findings and those of the present research may be due to differences in measuring social dominance. To determine social dominance, this study used a self reporting questionnaire, while the other studies used ratings of toughness and leadership by unfamiliar peers after 3 h interaction (Schaal et al., 1996; Tremblay et al., 1998), and recognition as socially dominant by inmates and prison staff (Ehrenkranz et al., 1974). There is some evidence that self report can yield lower effect sizes in T studies when comparing it to behavioral measures (for a review see Archer et al., 2005) and therefore it is possible that our study did not provide enough power to detect an effect.

Most findings from this study lend support for evolutionary theorizing. Independently building upon previous findings, we showed that T levels increased in men after contact with women. This increase is probably an important mechanism through which men acquire partners. At the same time, this T response seemed to be moderated by individual differences in aggressive dominant personality. Results from this study fit into theorizing viewing an increase in T as an evolved human response, activating receptors in organs and the nervous system to prepare the human body for mate attraction. Potentially interesting for further research are measuring other types of dominance like prestige or eminence as well as measuring the influence of status disputes on T.

Acknowledgments

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