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Testosterone reactivity to facial display of emotions in men and women

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ABSTRACT

Previous studies have examined testosterone's role in regulating the processing of facial displays of emotions (FDEs). However, the reciprocal process – the influence of FDEs, an evolutionarily ancient and potent class of social signals, on the secretion of testosterone – has not yet been studied. To address this gap, we examined the effects of emotional content and sex of facial stimuli in modulating endogenous testosterone fluctuations, as well as sex differences in the endocrine responses to faces. One hundred and sixty-four young healthy men and women were exposed, in a between-subjects design, to happy or angry same-sex or opposite-sex facial expressions. Results showed that in both men (n = 85) and women (n = 79), extended exposure to faces of the opposite sex, regardless of their apparent emotional content, was accompanied by an accumulation in salivary testosterone when compared to exposure to faces of the same sex. Furthermore, testosterone change in women exposed to angry expressions was greater than testosterone change in women exposed to happy expressions. These results add emotional facial stimuli to the collection of social signals that modulate endocrine status, and are discussed with regard to the evolutionary roles of testosterone.

Introduction

In social mammals, most social behaviors can be viewed as belonging to two broad categories that control social organization: dominance behaviors, which often involve conflict between individuals, and affiliative behaviors, which bring individuals together in a prosocial manner (Wilson, 1975). The steroid hormone testosterone plays an important role in regulating both types of behaviors, through its modulatory actions on both cortical and subcortical brain mechanisms (for examples, see Stanton et al., 2009; Mehta and Beer, 2010).

One way in which the relationship between hormones and social behaviors has been investigated in humans is through presentation of facial stimuli, such as angry and happy faces, serving as proxies for social interactions (e.g., van Honk et al., 2000). Facial displays of emotion (FDEs) are perceived as being closely tied to the emotional experiences of the displaying individual, and thus are decoded as a paralinguistic communication channel reflecting the individual's emotional state (Ekman and Friesen, 1971). Cross-cultural similarities have been reported in the recognition and production of facial expressions in both adults and children, generally supporting theories about their universality (Izard, 1994). Hence, from an evolutionary point of view, FDEs represent potent, species-specific social signals that help individuals coordinate their responses, so as to improve their inclusive fitness and shape group hierarchies. For example, happy faces are indicative of affiliative intentions from conspecifics (Knutson, 1996). On the other hand, angry faces are thought to convey threat and signal imminent dominance challenges (Dimberg and Öhman, 1996). Approach or avoidance behaviors in response to these ritualized displays seem to depend on individual and contextual differences in motivational stance. For instance, the threat conveyed by an angry face may be perceived as more intimidating by a submissive person, who in response may avert his or her gaze away from the potential competitor. In dominant individuals the same FDE might be perceived as a provocation or dominance challenge, giving rise to a face-to-face competition for status. In this context, testosterone seems to help regulate the processing of FDEs, by affecting these motivational dimensions (van Honk et al., 2000).

In contrast to the work exploring the impact of hormonal status on processing of affective facial displays, less attention has been paid to the reverse relationship: the impact of processing social affective cues on hormonal responses, and the functional significance of such responses (van Anders and Watson, 2006b). In other words, how does the perception of FDEs affect testosterone levels? To our knowledge only one previous study, more than a decade ago, has indirectly addressed this issue (van Honk et al., 2000). In a between subject design, van Honk and colleagues compared endocrine responses of young men to two different versions of an emotional Stroop task, used to assess selective attention to male angry faces. The researchers found that the individual stance towards angry faces (vigilance vs. avoidance) was associated with testosterone reactivity in the subliminal presentation (i.e. backward-masked); specifically, participants engaging in vigilance behavior showed an increase in testosterone when subliminally exposed to angry faces. Supraliminal, consciously-perceived

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angry stimuli lacked an equivalent effect on testosterone. Clearly, more systematic data on endocrine reactivity to FDEs is needed, and in both sexes.

Sex differences in emotion processing

A number of striking sex differences in electrophysiological responses (Mazurski et al., 1996; Bradley et al., 2001) and fMRI activation (e.g., Killgore and Yurgelun-Todd, 2001; Fine et al., 2009; Whittle et al., 2011) to emotional stimuli have emerged. In general, women exhibit stronger overall activation in response to negative cues – that is, unpleasant, traumatic and *some* threatening stimuli (e.g. fearful faces) – whereas men tend to show stronger activation in response to positive affective stimuli and different threatening stimuli (e.g. cues of dominance). These sex differences appear to be especially evident with regard to emotional reactivity (the subject's threshold, extent and intensity of affective arousal) (Williams et al., 2005; Wrase et al., 2003) and emotion regulation (the subject's effort to manage, inhibit and enhance emotions) (Mak et al., 2009). For example, when fMRI and skin conductance were recorded during processing of fearful faces, men showed an attenuation of activation in brain regions associated with emotional processing (i.e. amygdala) and in the sympathetic nervous system, from early to late phases of the experiment. In contrast, women generally showed increased amygdalar activity, persisting for the entire course of the experiment, possibly indicative of a higher resistance to extinction of emotional arousal (Williams et al., 2005).

Increased female (vs. male) activation in subcortical (i.e. amygdala) and prefrontal (i.e. orbitofrontal cortex) regions has been also observed in response to static angry faces (McClure et al., 2004). This result, however, was restricted to a small sample of healthy adults and was not extended to adolescents tested in the same study (McClure et al., 2004). Recently, a larger study using brief video clips of neutral faces evolving into angry expressions seemed to counter this conclusion by showing that amygdalar responses to angry faces were more accentuated in male than female adolescents (Schneider et al., 2011). Although it is plausible that these discrepancies derive from methodological differences, they may simply reflect a developmental switch (adolescent vs. adults) in men's sensitivity to cues of dominance, such as angry faces of other males. More research is needed to answer this question. The hypothesis that men are generally more sensitive to status-threatening stimuli is supported by other studies, wherein greater neural (Schienle et al., 2005) and psychophysiological (Mazurski et al., 1996) activation was recorded in males exposed to pictures of attacks by humans or non-human animals (Schienle et al., 2005), or specifically angry faces of other males (but not females) (Mazurski et al., 1996).

There is better agreement among studies investigating responses to positive emotional stimuli. For example, Wrase and colleagues (2003) found that depictions of positive affect caused a stronger amygdalar response in men than women. Similarly, Killgore and Yurgelun-Todd (2001) reported a sex difference in lateralized amygdalar activation during viewing of happy facial expressions, with men showing relatively greater right amygdala activity compared to women. Pro-sexual imagery generates complementary results, such as enhanced amygdala and hypothalamus activations in men viewing heterosexual sexual activity (Hamann et al., 2004), and greater sympathetic arousal (i.e. skin conductance) in men compared to women when viewing erotic pictures (Bradley et al., 2001). Whether such effects extend to the endocrine system, with FDEs bringing about complementary modulations of circulating hormones, has not been empirically explored.

Given the importance of testosterone for sexually-selected traits, and its important role in regulating social emotional behavior (van Anders and Watson, 2006b), the current study was designed to explore possible sex differences in testosterone responses to same-sex and opposite-sex FDEs signaling either threat (i.e. angry faces) or affiliation (i.e. happy faces). The Challenge Hypothesis (Archer, 2006; Wingfield et al., 1990) – which is mainly concerned with males, but might extend to females in less sexually-dimorphic species (Ketterson et al., 2005) – builds on the observation that testosterone secretion prepares the body to face imminent adaptive challenges relating to dominance. For example, testosterone is implicated in defense of resources (e.g. food, territory, offspring, status) that determine mate value and reproductive success. Accumulation of testosterone is thus observed both in response to dominance challenges such as intra-sexual competition (see for example, Bateup et al., 2002; Zilioli and Watson, 2012), or conspecific signs of threat (van Honk et al., 2000), as well as in situations involving exposure to sexual stimuli, such as interactions with potential mates (Lòpez et al., 2009; Roney et al., 2007).

Taken together, the extant data and theoretical frameworks provide for certain sex-specific hypotheses regarding testosterone reactivity to orthogonal FDEs. Specifically, for men we expect that happy faces of women would induce a rise in testosterone compared to happy male faces or neutral male faces. This would be in line with both the Challenge Hypothesis and the fact that males show a greater emotional activation in response to positive stimuli. A similar activation could be also observed in the case of men watching faces of potential status-challengers and/or physical aggressors (i.e. angry males) (Sell et al., 2009). However, the null finding reported by the only previous experiment on steroid reactivity in response to FDEs (van Honk et al., 2000), wherein men that consciously and unconsciously perceived angry faces did not show increased secretion of testosterone, argues against this hypothesis.

In women, we expect that angry male faces, as evolutionarily salient signals of potential physical aggression (McDonald et al., 2012), and angry female faces, as potential status-challengers, might be associated with endocrine activity when compared to happy female faces or neutral female faces. As an alternative hypothesis women increase in testosterone might be restricted to faces of potential status challengers (i.e. angry females). An increase in testosterone concentration in response to angry males – potentially associated with a disposition toward anger/aggression – might in fact be maladaptive, given sex differences in body size and physical strength.

Lastly, contrary to expectations with men, women are predicted to not experience a significant increase in testosterone when exposed to happy faces of the opposite sex. Indirect evidence suggests that women's testosterone responses to potential mates might be more selective than in men (van der Meij et al., 2008; Lòpez et al., 2009). This would be in keeping with the conclusion reached earlier of a blunted response to positive/arousing emotional cues in women.

In summary, because angry faces might signal imminent challenges, it is possible that an increase in testosterone would be observed in both sexes when exposed to threatening stimuli (i.e. angry male faces for men and angry female and male faces for women). Further, given preliminary clues in the literature that relate to sex differences in steroidal and neural reactivity to positive emotional expressions of the opposite sex, it is plausible that only men would be affected by positive affective cues of females (i.e. smiling faces). In order to test these possibilities, we evaluated testosterone reactivity in response to photographs of emotional faces in a large sample of young people.

Methods

Participants

Two hundred undergraduate participants (92 men, M = 20.04 years, SD = 2.7 years; and, 108 women, M = 19.87 years, SD = 2.22 years) were recruited from the Department of Psychology undergraduate participant pool at Simon Fraser University, and received course credit for participation. Screening at the beginning of the testing session disqualified 2 participants due to consumption of food immediately prior (1 female and 1 male). Three participants (one male) were excluded due to current use of medications. Furthermore, because hormonal contraceptives blunt hormone responses to emotionally-relevant stimuli (Lòpez et al., 2009), data