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Testosterone administration modulates moral judgments depending on second-to-fourth digit ratio

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Summary Moral judgment involves the interplay of emotions and social cognitions. The male sex-hormone testosterone might play a role in moral reasoning as males are more utilitarian than females in their moral decisions, and high salivary testosterone levels also are associated with utilitarian moral decisions. However, there is no direct evidence for a role of testosterone in moral reasoning. Recent testosterone administration studies show effects on cognitive empathy and social cooperation, which depend on right-hand's second-to-fourth (2D:4D) digit ratio, a proxy for prenatal sex-hormone (testosterone-versus-estradiol) priming. Here, in a placebo-controlled within-subjects design using 20 young females we show that 2D:4D predicts 44% of the variance in the effects of testosterone administration on moral judgment. Subjects who show an increase in utilitarian judgments following testosterone administration have significantly higher than average 2D:4D (relatively high prenatal estradiol priming), while subjects showing more deontological judgments following testosterone administration have near-significantly lower 2D:4D (relatively high prenatal testosterone priming). We argue that prenatally-organized differences in aromatase, i.e. conversion from testosterone to estradiol in the brain, might underlie these effects. Our findings suggest that early neurodevelopmental effects of sex steroids play a crucial role in the activational effects of hormones on moral reasoning later in life.

1. Introduction

Moral judgment involves the complex interplay of emotions such as harm aversion and cognitions about what other people feel (Moll et al., 2002; Greene et al., 2004; Moll and de Oliveira-Souza, 2007). There is evidence suggesting that the neuroendocrine system, by way of the male

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sex-hormone testosterone plays a role in moral judgments. Males are more utilitarian than females in their moral decisions (Fumagalli et al., 2010; Youssef et al., 2012), and individuals with high salivary testosterone levels also make more utilitarian decisions (Carney and Mason, 2010). Crucially, utilitarian decisions are aimed at maximizing overall welfare (''the ends justify the means''), and are viewed as rational, whereas deontological decisions are the opposite; they are driven by emotion (''the means are more important than the ends'') (Greene et al., 2001; Moll and de Oliveira-Souza, 2007). Testosterone therefore may facilitate instrumental over emotion-driven moral decision making.

Testosterone has indeed shown to be an important hormone in a range of human social cognitions and behaviors (Bos et al., 2012). Firstly, administration of testosterone reduces stress and fear in humans (Hermans et al., 2007; McCall and Singer, 2012; Bos et al., 2012), which is thought to underlie utilitarian moral decisions (Carney and Mason, 2010). Testosterone furthermore influences automatic affiliative behaviors, as administration of the hormone reduces facial mimicry, which is considered a measure of affective empathy (Hermans et al., 2006b). Moreover, on the social-cognitive level, testosterone influences social judgment; it decreases trustworthiness ratings of others (Bos et al., 2010) and importantly in the present respect, it decreases the ability to correctly identify complex emotions and feelings of others (i.e. cognitive empathy) (van Honk et al., 2011a). Importantly, this reduction of cognitive empathy by testosterone was strongly mediated by second-to-fourth finger length ratio (2D:4D); a proxy of prenatal sex-hormone (testosterone-versus-estradiol) priming (Lutchmaya et al., 2004; Zheng and Cohn, 2011). Only subjects with low 2D:4D, who are prenatally more strongly primed by testosterone, were substantially impaired in cognitive empathy after testosterone administration. Recently, we also showed increases in social cooperation after testosterone administration, but only in subjects with high 2D:4D, who are prenatally more strongly primed by estradiol (Zheng and Cohn, 2011; van Honk et al., 2012). Thus prenatal sex-hormone priming appears to modulate the effects of testosterone administration on social cognitions and behaviors later in life. In sum, empathic feelings, stressfulness and fearfulness are thought to play a role in moral reasoning and guide moral judgment (Young et al., 2007; Blair, 2007; Youssef et al., 2012; Starcke et al., 2011; Reniers et al., 2012), and testosterone administration influences all of these processes (Hermans et al., 2006b, 2007; van Honk et al., 2011a), partly depending on prenatal hormone priming (van Honk et al., 2011a).

In moral judgment tasks, subjects are confronted with scenarios of moral conflict, and they have to judge the moral permissibility of a harmful act. Prepotent negative affect such as harm aversion, but also higher-order cognitive ability such as the capacity to infer other people's feelings and the social consequences of moral dilemmas are important in this task (Haidt, 2007; Greene, 2007; Greene et al., 2009; Reniers et al., 2012). Testosterone might thus, by affecting prepotent negative responses and on a higher-order level by affecting cognitive empathy, influence the moral judgment process, but these effects might depend on prenatal exposure to the sex steroids. Therefore, in the present study we investigate the effects of testosterone administration on moral judgment. We hypothesize, on the basis of the sex differences and correlational data with testosterone levels (Carney and Mason, 2010; Fumagalli et al., 2010) that testosterone administration increases utilitarian judgments, but that 2D:4D, the proxy of prenatal sex-hormone priming might mediate in these effects (van Honk et al., 2011a, 2012).

2. Methods

2.1. Subjects

Twenty healthy females (age range, 18—30) participated in this experiment that is approved by the local medical ethical committee (University Medical Center Utrecht). All participants were students at Utrecht University and were recruited through a participant database. Exclusion criteria were smoking, use of medication other than single-phase oral contraceptives, and history of medical, psychiatric or endocrine illness. All women used standard estrogen/progestagen oral contraceptives (containing ethinylestradiol and levonorgestrel).

2.2. Study design

Participants were tested in a randomized, double-blind, placebo-controlled, within-subjects design. Subjects were tested in groups of four and tables were separated by screens to guarantee privacy. The testosterone samples consisted of 0.5 mg of testosterone, 5 mg of the carrier cyclodextrine, 5 mg of ethanol, and 5 ml of water. The placebo samples were identical except for the omission of 0.5 mg of testosterone. Sublingual administration was used. Prior investigations into the pharmacokinetics of this exact testosterone administration in women showed that this method leads to a 10-fold increase in testosterone plasma levels which returns to baseline within 15 min and that behavioral effects peak at 4 h after intake (Tuiten et al., 2000). Multiple studies using this time interval and administration method have found behavioral, neural, and physiological effects of testosterone (van Honk et al., 2001, 2004, 2005; Hermans et al., 2006a, b). Therefore, in the current study the same interval of 4 h was applied. Furthermore, to minimize the influence of fluctuations due to diurnal hormonal and menstrual cycles, drug administration always took place in the morning and testing was restricted to the period wherein the participants took contraceptives.

2.3. Moral judgment task

The moral judgment task is based on previous work (Greene et al., 2001, 2004) and consists of impersonal and personal moral dilemmas. An example of a personal dilemma is the famous Trolley scenario: ''*A runaway trolley is heading down the tracks toward five workmen who will be killed if the trolley proceeds on its present course. You are on a footbridge over the tracks, in between the approaching trolley and the five workmen. Next to you on this footbridge is a stranger who happens to be very large. The only way to save the lives of the five workmen is to push this stranger off the bridge and onto the tracks below where his large body will stop the trolley. The stranger will die if you do this, but the five workmen will be saved.*'' Twenty-four moral dilemmas were selected in order to make two versions of the moral