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Sexy thoughts: Effects of sexual cognitions on testosterone, cortisol, and arousal in women

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ABSTRACT

Previous research suggests that sexual stimuli increase testosterone (T) in women and shows inconsistent effects of sexual arousal on cortisol (C), but effects of cognitive aspects of arousal, rather than behaviors or sensory stimuli, are unclear. The present study examined whether sexual thoughts affect T or C and whether hormonal contraceptive (HC) use moderated this effect, given mixed findings of HC use confounding hormone responses. Participants (79 women) provided a baseline saliva sample for radioimmunoassay. We created the Imagined Social Situation Exercise (ISSE) to test effects of imagining social interactions on hormones, and participants were assigned to the experimental (sexual) or one of three control (positive, neutral, stressful) conditions. Participants provided a second saliva sample 15 min post-activity. Results indicated that for women not using HCs, the sexual condition increased T compared to the stressful or positive conditions. In contrast, HC using women in the sexual condition had decreased T relative to the stressful condition and similar T to the positive condition. The effect was specific to T, as sexual thoughts did not change C. For participants in the sexual condition, higher baseline T predicted larger increases in sexual arousal but smaller increases in T, likely due to ceiling effects on T. Our results suggest that sexual thoughts change T but not C, baseline T levels and HC use may contribute to variation in the T response to sexual thoughts, and cognitive aspects of sexual arousal affect physiology.

A variety of evidence links testosterone (T) and sexuality-related contexts, including sexual desire, arousal, stimuli, and behavior (for reviews, see Bancroft, 2005; Regan, 1999; van Anders and Watson, 2006c). For example, partnered sexual activity increases T in women (van Anders et al., 2007) and men (Dabbs and Mohammed, 1992). However, physical partner presence may not always be necessary for a sexually-stimulated T response, as exposure to visual sexual stimuli elevates T in men (Hellhammer et al., 1985; Redoute et al., 2000; Rowland et al., 1987; Stoleru et al., 1999). Findings on T responses to sexual stimuli other than partnered activity in women are mixed. One study reported small increases in T after women viewed an erotic film and masturbated to orgasm (Exton et al., 1999). However, van Anders et al. (2009) found no statistical change in T in response to an erotic film when masturbation was not involved, which might imply that orgasm or sexual activity is required for the T response to occur in women. Interestingly though, another study found that women's T increased after watching a film depicting an attractive man initiating a romantic relationship with a woman and imagining themselves as the woman in the film (Lopez et al., 2009). Thus, neither sexual behavior nor partner presence may be required to induce a T response, but sexual arousal or interest might be.

If sexual behavior increases T, is it the behavior, or other sexual elements, that affect physiology? Human sexual behavior and arousal include several cognitive elements acknowledged as important to the sexual response, including perceptions of genital and autonomic arousal (Toledano and Pfaus, 2006), a psychological readiness to respond to sexual stimuli (Toledano and Pfaus, 2006), and recognition of a situation "as sexual" (Rosen and Beck, 1988; Stoleru et al., 1999). Here, we focus on cognitive arousal as a "state" encompassing the factors described above (perceptions of genital and autonomic arousal, etc.) which occurs in response to a stimulus, and this stimulus could be sensory or imagined. In addition to their role in sexual arousal, sexual cognitions may induce T responses, given that van Anders et al. (2007) found that women's T was higher before intercourse than before control activities (cuddling or exercise), suggesting that anticipation of sexual activity may increase T. In women in long-distance relationships, T increases the day before women first see their partners after a separation, which may also reflect anticipation of sexual activity (Hamilton and Meston, 2010). One previous study found preliminary evidence that discussing topics of a sexual nature during an interview resulted in increased concentrations of luteinizing hormone (which cues T release) in men (LaFerla et al., 1978). And, Anonymous (1970) reported that a

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biomarker of T (beard growth) appeared to increase in anticipation of sexual activity. Despite these suggestive findings, no studies have explored whether simply thinking about sex, without the presence of partners, sexual behavior, or external sensory stimuli, can change T.

Though there is no clear consensus at present with T, the role of cortisol (C) in sexuality is even less clear. C levels appear to decrease in women after viewing an erotic video (Hamilton et al., 2008; van Anders et al., 2009), though two studies found no difference in C responses between women in erotic video and control video conditions (Exton et al., 2000; Heiman et al., 1991). Masturbation to orgasm does not appear to affect C in women (Exton et al., 1999). Finally, in women experiencing passionate love, C increased in response to thinking and writing about a romantic partner compared to thinking and writing about a friend (Loving et al., 2009). Although this finding suggests that activities involving mental imagery and cognitions about relational intimacy can elicit C responses, previous research has not examined whether thinking and writing about sexuality could produce a similar response.

Hormonal responses to sexual stimuli may vary as a result of baseline hormone levels, which is why most studies have used within-participant designs. However, large numbers of young women are using hormonal contraceptives (HCs), so HC use may lead to a large source of between-participant variability. HC use decreases baseline levels of free T (Bancroft et al., 1991; Coenen et al., 1996; Edwards and O'Neal, 2009; Greco et al., 2007; Swinkels et al., 1988; Thorneycroft et al., 1999; van Anders and Watson, 2006a) and increases concentrations of sex-hormone binding globulin (SHBG), a protein that binds T, resulting in the lower free T (Murphy et al., 1990; Swinkels et al., 1988; Thorneycroft et al., 1999). However, whether HC use affects T changes in response to social stimuli is less clear. Although some studies have not found effects of HC status on T responses to social stimuli (Edwards and O'Neal, 2009; van Anders et al., 2007), previous authors have emphasized the need to clarify how HC use is associated with between-participant variability in T responses (Edwards and O'Neal, 2009; Josephs, 2009). Furthermore, recent evidence suggests that HC use attenuates women's T responses to stimuli involving an attractive man (Lopez et al., 2009).

HC use affects baseline T levels, so there is reason to suspect effects on responses. There is also evidence that HC use affects C responses to stress, but perhaps not to sexuality. Although women using HCs show similar C responses to stress compared with women in the follicular phase, they show blunted C responses to stress compared with women in the luteal phase (Kirschbaum et al., 1999). However, Hamilton et al. (2008) found no effect of HC use on baseline C or C responses to sexual stimuli; likewise, HC use did not affect C responses to thinking about a romantic partner (Loving et al., 2009) or to cues involving an attractive man (Lopez et al., 2009). As such, effects of HC use on C responses, like T responses, to sexual stimuli are still unclear.

In addition to baseline levels of hormones, sexual experience may moderate physiological responses to sexual stimuli. For example, sexually experienced male rats show higher T responses to mating than naïve males (Kamel et al., 1975). Sexual experience is required for male rats to show a T response when exposed to a receptive female, and experience increases the C response to mating (Bonilla-Jaime et al., 2006). For male rats, past mating experiences may prompt the formation of learned associations between cues relevant to mating and mating itself, resulting in T responses to cues (e.g., visual, olfactory) associated with mating (Alexander et al., 1994; Graham and Desjardins, 1980). In humans, Roney et al. (2003) (c.f. Roney et al., 2007; van der Meij et al., 2008) found that men with recent sexual experience showed an increase in T after a social interaction with a woman, whereas men with no recent experience did not. Past research has not addressed the role of previous experience on women's hormonal responses to sexual stimuli.

In the current study, we investigated whether sexually arousing thoughts in the absence of sensory stimuli result in a T or C response in women. Because no established experimental paradigm exists to assess the effects of sexual cognitions on physiology, we developed a novel design, the Imagined Social Situation Exercise (ISSE), to determine whether sexual cognitions affect T and C. We compared hormone responses to imagining and describing a sexually arousing situation to three control scenarios: a) a neutral condition to control for passage of time and imagining a social interaction; b) a stressful condition to control for autonomic arousal and the potentially stressful response to imagining a sexual encounter; and c) a positive condition to control for feelings of pleasure, reward, and affiliation that might accompany imagining a sexual encounter. In each condition, participants read about and imagined themselves in a social situation and responded to open-ended questions about the situation. Considering that imagining oneself as a participant in a situation (Janssen et al., 2003) and focusing on responses as well as stimuli (Dekker and Everaerd, 1988) facilitate sexual arousal, our paradigm was designed to elicit meaningful sexual arousal as the open-ended questions targeted both participants' actions and feelings in their imagined scenario.

Based on evidence that sexual arousal increases T in women (Dabbs and Mohammed, 1992; Exton et al., 1999; van Anders et al., 2007), we hypothesized that participants in the sexual condition would show an increase in T compared to participants in the control conditions. We examined the effect of sexual thoughts on C, but given previous conflicting findings on C responses to sexual stimuli (Exton et al., 1999, 2000; Hamilton et al., 2008; van Anders et al., 2009), we did not make a specific prediction for changes in C in response to sexual thoughts. Finally, we explored whether baseline levels of hormones, HC use, or sexual experience influenced T or C responses to sexual thoughts. Effects of sexual thoughts on hormones have potentially broad implications for understanding the link between hormones and sexuality, and, even more broadly, the effects of cognitions on physiology.

Method

Participants

Participants were 79 women (mean age = 20.58 years, SD = 4.18 years, range = 18–39 yrs) recruited from the undergraduate psychology pool and the community through online advertisements and posters. Participants were compensated with course credit or $15. The majority of participants ($n = 73$) were students, but some ($n = 21$) were employed in a variety of occupations. All participants had graduated high school and had some college, and several ($n = 8$) had graduated from college. Participants self-identified their race/ethnicity, and we categorized their responses such that we had 6 African American, 15 Asian, 7 Bi/multiracial, 2 Hispanic, and 49 White/Caucasian participants. Most participants had spent the majority of their lives in the USA, although eight participants had lived in the USA for 10 years or less. Participants self-identified their sexual orientation; the majority identified as heterosexual ($n = 69$), three participants identified as bisexual, one as heterosexual/bicurious, and one as queer, with five nonresponders. Participants were varied by relationship status: 21 were single, 22 were casually partnered, and 35 were in committed partnerships, with one nonresponder. With the exception of hormonal contraceptive users, participants ($n = 13$) who were using medications that affect hormones (e.g., medications containing corticosteroids), using medications with sexual side effects (e.g., antidepressants), and/or had a medical condition that may affect hormones (e.g., ovarian cysts) were excluded from subsequent analyses.

Materials and methods

Health and background questionnaire

This questionnaire contained demographic items to describe the sample, height and weight to calculate BMI (body mass index, a measure of weight adjusted for height), and items regarding possible confounds with hormone measures.