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Menstrual cycle phase predicts women's hormonal responses to sexual stimuli

Talia N. Shirazi[a], Jennifer A. Bossio[b], David A. Puts[a], Meredith L. Chivers[b,*]

[a] Department of Anthropology, Pennsylvania State University, PA, USA
[b] Department of Psychology, Queen's University, Kingston, Ontario, Canada

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ABSTRACT

A robust body of research has demonstrated shifts in women's sexual desire and arousal across the menstrual cycle, with heightened desire and arousal coincident with heightened probability of conception (POC), and it is likely that ovarian hormones modulate these shifts. However, studies in which women are exposed to audiovisual sexual stimuli (AVSS) at high POC (mid-follicular) and low POC (luteal) phases have failed to detect significant differences in genital or subjective arousal patterns based on menstrual cycle phase. Here, we tested whether hormonal responsivity to AVSS differs as a function of cycle phase at testing, and whether phase during which participants were first exposed to AVSS influences hormonal responsivity in subsequent test sessions. Twenty-two naturally cycling heterosexual women were exposed to AVSS during the follicular and luteal phases, with phase at first test session counterbalanced across participants. Salivary samples were collected before and after AVSS exposure. Estradiol increased significantly during both follicular and luteal phase sessions, and increases were higher during the follicular phase. Testosterone (T) increased significantly only during the follicular phase session, while progesterone (P) did not change significantly during either cycle phase. Session order and current cycle phase interacted to predict P and T responses, such that P and T increased during the follicular phase in women who were first tested during the luteal phase. These data suggest that menstrual cycle phase influences hormonal responsivity to AVSS, and contribute to a growing body of clinical and empirical literature on the neuroendocrine modulators of women's sexuality.

1. Introduction

Menstrual cycle shifts in sexual behavior have been reported for nearly 40 years. Autosexual or solitary (Brown et al., 2011; Burleson et al., 2002; Van Goozen et al., 1997) and female-initiated (Adams et al., 1978; Bancroft et al., 1983; Harvey, 1987; Matteo and Rissman, 1984; Sanders et al., 1983) sexual behaviors increase near ovulation, though some studies have failed to detect changes in sexual behavior across the cycle (Brewis and Meyer, 2016; Elaut et al., 2016; Roney and Simmons, 2013). Trends in partnered sexual behavior may be more heavily dependent upon external factors; for example, several studies have found the strongest predictors of partnered sexual activity to be the day of the week ('the weekend effect,' Caruso et al., 2014; Palmer et al., 1982; Roney and Simmons, 2013; Wilcox et al., 2004). Further, as partnered sexual behavior typically requires the sexual interest of both members of a copulatory pair, its occurrence is not solely a reflection of women's desires. Putative menstrual cycle shifts in sexuality should therefore be more apparent in constructs and behaviors that are more dependent on internal motivation, as opposed to the availability and interest of sexual partners. Unlike other mammals in which sexual activity is strictly modulated by hormonal condition and confined to high fertility periods (Wallen, 1990), humans are able to mate independently of hormonal condition, allowing for the unique decoupling of sexual interest and sexual behavior.

Indeed, women's sexual desire and arousal show relatively more robust cyclic patterns such that desire and arousal are heightened when probability of conception (POC) is highest, during the late follicular and ovulatory phases, and decrease when POC decreases, during the early follicular and luteal phases (Wilcox et al., 1995). Peaks in self-reported sexual desire (Brown et al., 2011; Diamond and Wallen, 2011; Englander-Golden et al., 1980; Graham et al., 2000; Pillsworth et al., 2004; Röder et al., 2009; Roney and Simmons, 2016, 2013), frequency of sexual fantasies (Dawson et al., 2012; Matteo and Rissman, 1984; Slob et al., 1996), and degree to which fantasies are rated as arousing (Dawson et al., 2012) have been reported in women prior to ovulation. Shifts across the menstrual cycle in sexual desire and arousal may have therefore evolved to promote sexual behavior and the saliency of sexual stimuli when POC is heightened, during the mid-follicular and

* Corresponding author at: Department of Psychology, Queen's University, 62 Arch Street, Kingston, Ontario K7L3N6, Canada.
E-mail address: Meredith.Chivers@queensu.ca (M.L. Chivers).

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ovulatory phases (Roney, 2015; Roney and Simmons, 2013). In contrast, men do not exhibit cyclic changes in steroid hormone concentrations, conception status, or sexual desire and arousal.

Due to their fluctuating patterns across the menstrual cycle, the ovarian steroid hormones estradiol (E_2), progesterone (P), and testosterone (T) have been evaluated as moderators of menstrual cycle shifts in women's sexual desire and arousal. The single study measuring both sexual desire and salivary hormones for complete menstrual cycles found that within women, sexual desire was positively associated with E_2, negatively associated with P, and unassociated with T levels (Roney and Simmons, 2013), mirroring patterns observed in rhesus macaques (Wallen et al., 1984; for review of the roles of estrogens and androgens in modulating women's sexual desire, see Cappelletti and Wallen, 2016; Motta-Mena and Puts, 2017).

E_2, P, and T may further be implicated in women's sexuality, as these hormones may be acutely responsive to external sexual stimuli and concomitantly increase sexual desire, arousal, and behavior. T increases as a result of orgasm (Exton et al., 1999) and partnered sexual behavior (van Anders et al., 2007), as may E_2 (van Anders et al., 2009). Studies in which women were exposed to videotaped courtship interactions (Lopez et al., 2009), pictures of opposite-sex faces (Zilioli et al., 2014), and studies in which women were instructed to imagine a sexual social interaction (Goldey and van Anders, 2011) have reported significant increases in T. Interestingly, several studies in which participants were exposed to visual sexual stimuli (VSS) or audiovisual sexual stimuli (AVSS) have reported no increases in T (Goldey and van Anders, 2016; Hamilton et al., 2008; Heiman et al., 1991; van Anders et al., 2009), while others have shown that the magnitude and direction of T and E_2 changes may differ substantially among women (Garcia et al., 2015). Research on the factors modulating hormonal responses to mating-related and sexual stimuli is sparse, and no studies have systematically examined the effects of menstrual cycle phase on such responses. As menstrual cycle shifts in psychology and behavior generally involve phenotypes related to mating and sexuality, and given that E_2, P, and T modulate these phenotypes, it follows that hormonal responsivity to sexual stimuli may differ as a function of menstrual cycle phase.

Though hormonal responsivity to mating-related and sexual stimuli across cycle phases has not yet been examined, eye gaze patterns, subjective ratings, and genital arousal patterns have, with results differing as a function of experimental design. Eye tracking studies employing a within-subjects design, wherein menstrual cycle phase at first testing session is counterbalanced across women, have failed to detect significant effects of current menstrual cycle phase on eye gaze patterns and subjective reports of arousal to VSS (Rupp and Wallen, 2007; Wallen and Rupp, 2010); when only data from the first testing session are considered, however, significant differences based on current menstrual cycle phase emerge. Similarly, when genital responses to and subjective ratings of AVSS are measured repeatedly across the cycle in women, differences as a function of menstrual cycle phase are not detected (Bossio et al., 2014; Meuwissen and Over, 1992; Slob et al., 1991, 1996; Suschinsky et al., 2014), but differences are detected when analyzing data from the first session in isolation (Slob et al., 1991, 1996; but see Meuwissen and Over, 1992). How could significant effects of menstrual cycle phase be detected in cross-sectional, but not within-subjects designs? Accounting for this phenomenon in part is the 'carry-over effect,' or significant effect of menstrual cycle phase at initial stimuli exposure, first reported by Slob et al. (1991). Women who were first tested in the follicular phase exhibited heightened genital and subjective responses to AVSS as compared to women tested first in the luteal phase, and continued to exhibit such heightened responses during subsequent test sessions. These results suggest that cycle phase may modulate genital and visual responses to AVSS, though intra-individual menstrual cycle shifts may be masked by the magnitude of such carry-over effects. Though significant order effects of testing have been reported for genital measures (Slob et al., 1996) as well as for eye gaze patterns (Wallen and Rupp, 2010) in within-subjects studies, some studies have not found significant effects of session order on genital arousal patterns (Bossio et al., 2014; Suschinsky et al., 2014) and subjective reports (Slob et al., 1996). Whether hormonal responses to AVSS would exhibit current cycle phase and session order effects has not been systematically examined.

Given increases in cognition and behavior related to mating and sexual desire when conception is more probable, it is likely that hormonal responses to AVSS would be modulated by cycle phase. Here, we present the first empirical evaluation of this hypothesis. Naturally cycling women were recruited for sexual psychophysiology test sessions during the mid-follicular (when POC > 0) and luteal phases (when POC = 0), with session order counterbalanced across participants to detect any order effects. During sessions, participants were exposed to AVSS, and pre- to post-stimuli levels of E_2, P, and T were measured. We hypothesized that greater hormone responsivity to AVSS would be observed in sessions during the follicular phase as compared to those during the luteal phase. Further, consistent with work suggesting carry-over effects (Slob et al., 1991, 1996; Wallen and Rupp, 2010), we hypothesized that the magnitude of hormone responsivity would be modulated by cycle phase at initial test session, with women tested first during the follicular phase exhibiting greater hormone responsivity to AVSS across test sessions.

2. Method

2.1. Participants

Women were recruited via flyers posted on a university campus, and were screened via telephone to determine study eligibility. All participants were required to be between the ages of 18 and 40, naturally cycling (i.e., not be on a hormonal contraceptive regimen or pregnant), and to have regular menstrual cycles between 27 and 33 days long. No participants had a history of sexually transmitted infections or sexual dysfunction, and were required to have past experience with vaginal penetration. Experience with vaginal penetration was required, as genital arousal data were collected via a gauge inserted into the vagina, analyzed in other studies (Bossio et al., 2014; Suschinsky et al., 2014). Only women who reported being exclusively or predominantly androphilic, or attracted to men (rating of 0 or 1 on the Kinsey Sexual Fantasy Scale; Kinsey et al., 1953), were included. All study procedures were IRB approved, and all participants provided informed consent.

Of the 37 women initially recruited for the study, 22 were included in the present analyses (M age = 21.9, SD = 4.8). Participants were excluded if: a) they did not attend a second testing session (n = 6); b) cycle phase could not be confirmed by hormonal analyses (n = 7); c) issues arose with freezing hormone samples (n = 1); or d) equipment malfunctions were experienced during the session (n = 1).

2.2. Experimental stimuli

Audiovisual stimuli used in the present study were neutral and erotic videos, which have previously been shown to elicit subjective and genital arousal among androphilic women (Chivers et al., 2007). The eight AVSS categories, with two exemplars of each category presented, were as follows: female nude exercise, female masturbation, female-female intercourse, male nude exercise, male masturbation, male-male intercourse, female-male intercourse, and landscapes. Presentation order was randomized for all participants, and films were separated by intertrial intervals to allow for physiological sexual response return to baseline levels.

2.3. Procedure

Procedures in the present study are identical to those of Bossio et al. (2014) and Suschinsky et al. (2014), though the hormone data in the