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Influences of menstrual cycle position and sex hormone levels on spontaneous intrusive recollections following emotional stimuli

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ABSTRACT

Spontaneous intrusive recollections (SIRs) are known to follow emotional events in clinical and non-clinical populations. Previous work in our lab has found that women report more SIRs than men after exposure to emotional films, and that this effect is driven entirely by women in the luteal phase of the menstrual cycle. To replicate and extend this finding, participants viewed emotional films, provided saliva samples for sex hormone concentration analysis, and estimated SIR frequency following film viewing. Women in the luteal phase reported significantly more SIRs than did women in the follicular phase, and SIR frequency significantly correlated with salivary progesterone levels. The results are consistent with an emerging pattern in the literature suggesting that menstrual cycle position of female participants can potently influence findings in numerous cognitive domains. The potential implications of these results for disorders characterized by intrusions, such as post-traumatic stress disorder, are also discussed.

1. Introduction

Emotional events tend to be remembered better than are relatively neutral events (Christianson, 1992). This is true in the real world as well as in laboratory settings when the stimuli used are words, pictures, slideshows, or films (Bradley, Greenwald, Petry, & Lang, 1992; Cahill & McGaugh, 1995; Cahill et al., 1996; Heuer & Reisberg, 1990; Kensinger & Corkin, 2003; Rubin & Friendly, 1986). Additionally, intrusive memories are known to occur in the aftermath of emotional events. Although intrusive memories are particularly common in patients with post-traumatic stress disorder and depression, non-clinical populations often report intrusions after traumatic or emotional events as well (Brewin, Christodoulides, & Hutchinson, 1996; Brown & Kulik, 1977; Hall & Berntsen, 2008; Nolen-Hoeksema & Morrow, 1991; Reynolds & Brewin, 1998, 1999; Wilkinson, 1983). A previous investigation in our lab (Ferree & Cahill, 2009) sought to determine whether the enhancement of memory for emotional stimuli is due in part to an increased tendency for people to experience post-event spontaneous intrusive recollections (SIRs) following exposure to emotional events or stimuli. SIRs would constitute unintentional covert rehearsal, which would in turn strengthen memory for those stimuli. In our previous study we found that emotional stimuli were associated with more SIRs than were neutral stimuli, and that there was a quantitative positive relationship between SIR frequency and subsequent memory strength for emotional stimuli (Ferree & Cahill, 2009). Our results were consistent with those of Hall and Berntsen (2008), who found that emotional arousal during the encoding of aversive pictures was associated with higher levels of both voluntary and involuntary (intrusions) recall.

Disorders characterized by intrusive thoughts and memories, such as depression and post-traumatic stress disorder (PTSD), are significantly more prevalent in women than men (Breslau, Davis, Andreski, Peterson, & Schultz, 1997; Kendler,

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Thornton, & Prescott, 2001). As such, we were not surprised to observe a sex difference in SIR frequency, such that women reported significantly more intrusions than did men (Ferree & Cahill, 2009). One key difference between the sexes is fluctuating levels of ovarian hormones throughout the menstrual cycle in female participants, and we examined the possibility that a woman's reported frequency of SIRs might be affected by her circulating levels of estradiol and progesterone.

A good deal of evidence suggests that menstrual cycle position can influence many aspects of cognition including spatial and verbal performance (Halpern & Tan, 2001; Rosenberg & Park, 2002), as well as brain activity patterns during cognitive task performance (Maki & Resnick, 2001) and the neural circuitry underlying the response to stress and arousal (Goldstein et al., 2005). Menstrual cycle position is also thought to influence the stress hormone response, with higher levels of salivary cortisol in response to psychosocial stress during the luteal phase compared to the follicular phase (Kirschbaum, Kudeilka, Gaab, Schommer, & Hellhammer, 1999). Some evidence suggests that whether a positive or negative correlation is observed between stress hormone levels and memory depends critically upon menstrual cycle position (Andreano, Arjomandi, & Cahill, 2008).

Phase-dependent differences in stress hormone response may have clinical significance as well, as PTSD has long been associated with abnormalities in various aspects of the stress hormone response (Yehuda, 2002). Given the evidence relating stress hormones and PTSD, some authors have proposed that menstrual cycle influences on stress hormone reactivity may have an impact on PTSD symptoms (Rasmusson & Friedman, 2002; Saxe & Wolfe, 1999). As we regard the SIRs that we observe in the laboratory as a form of perseverative cognition that may be analogous to the intrusive symptoms that are a key symptom of PTSD, we hypothesized that we might observe menstrual phase-dependent differences in SIR frequency. In fact, in our previous study we found that women in the luteal phase of the cycle reported significantly more SIRs than did men or women in the follicular phase of the cycle (the latter two groups did not differ), suggesting that the sex difference we observed was driven entirely by the high level of SIR frequency reported by women in the luteal phase (Ferree & Cahill, 2009). However, the classification of female participants into follicular and luteal phases in the previous study was based on women's self-reported position within the menstrual cycle, which may not be completely accurate (Maki & Resnick, 2001; Phillips & Sherwin, 1992b). Because we did not analyze levels of estradiol and progesterone in these participants, we could not verify the accuracy of their menstrual reports, nor could we begin to explore whether differences in estradiol, progesterone, or both, were responsible for the heightened SIR frequency in the luteal phase.

The current study was designed to further explore the menstrual cycle effect found in our previous study (Ferree & Cahill, 2009) and to extend these findings by incorporating analyses of salivary estradiol and progesterone levels. Salivary analysis offers the ability to verify a woman's self-report of menstrual cycle position as well as to directly examine the potentially distinct contributions of estradiol and progesterone to the enhanced intrusion frequency in the luteal phase. We anticipated that, as in our previous study, women in the luteal phase would report more intrusions than would women in the follicular phase.

In the early follicular phase (days 1–5 from the start of menstruation), levels of estradiol and progesterone are very low. In the late follicular phase (days 6–13), estradiol levels rise until they peak the day before ovulation (which occurs on day 14) while progesterone levels remain low. Levels of progesterone are high throughout most of the luteal phase (peaking around day 22 and beginning to drop between days 24 and 28), while estradiol levels reach a second gradual peak that is significantly lower than the preovulatory peak but significantly higher than early follicular levels (Weis & Hausmann, 2009). Because we collapsed across the low estradiol early follicular and the high estradiol late follicular sub-phases into one follicular group, we expected that estradiol levels would not differ significantly between the follicular and luteal phases and that any observed menstrual phase effects would be due to the large expected differences in progesterone levels between the two groups. Consistent with the hypothesis that our observed effects are mediated primarily by progesterone, luteal levels of progesterone have been associated with increased amygdala activity, which is known to be involved in emotional tasks such as the one used in this study (Andreano & Cahill, 2010; van Wingen et al., 2007a).

2. Materials and methods

2.1. Participants

Fifty-two undergraduates at the University of California, Irvine between the ages of 18 and 23 participated in this study, which was approved by the university's Institutional Review Board. All women were naturally cycling (not using hormonal birth control). Women reporting consistently irregular cycles less than 24 or more than 32 days in length were not included. Menstrual cycle position was determined by self-report and salivary estradiol and progesterone levels were used to verify a woman's position within the reported phase. Three participants (two luteal, one follicular) were excluded based on estradiol or progesterone levels outside the range expected for their self-reported menstrual cycle position. Six participants were excluded due to SIR measures more than two standard deviations from the mean (three follicular, three luteal). Additionally, three participants chose to withdraw from the experiment before its completion. The final analyses involved data from 40 women, with 19 in the follicular (days 1–13 since the start of menstruation) and 21 in the luteal phase (days 15–28) of the cycle.

2.2. Procedures

Each participant was shown a series of six emotional film clips depicting violence against humans or animals previously shown to reliably elicit emotional reactions (Ferree & Cahill, 2009). After each film clip, participants were asked to