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Women with an avoidant attachment style show attenuated estradiol responses to emotionally intimate stimuli

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ABSTRACT

The current study examined neuroendocrine processes associated with emotional intimacy in humans. Despite the importance of this aspect of close relationships, emotional intimacy has received much less attention in neuroendocrine research compared to other aspects of close relationships. In this study, participants viewed movie clips depicting an emotionally intimate parent–child interaction or other, non-intimate themes, and we assessed whether depictions of emotional intimacy increased levels of estradiol, a steroid hormone associated with attachment and caregiving processes. We also examined whether estradiol responses were moderated by individual differences in attachment avoidance, or people's discomfort with closeness and intimacy. Our findings revealed that, among single participants, estradiol levels increased in response to the emotionally intimate clip, but this effect was not observed among currently partnered participants. Moreover, the effects of emotional intimacy were moderated by gender and attachment avoidance, such that highly avoidant women showed smaller increases in estradiol after watching the emotionally intimate clip. Women's avoidance was unrelated to estradiol responses in the non-intimate control conditions, however, suggesting that the effects of avoidance were specific to intimate contexts. Taken together, the current findings contribute to our understanding of the biological bases of attachment and caregiving processes. They also highlight the potential role of estradiol in avoidant individuals' regulation of closeness and intimacy.

Introduction

Close relationships are an important source of pleasure and support throughout the lifespan. Individuals who are more socially connected and engaged in higher quality relationships also reap benefits in other important life domains; for instance, they have better mental and physical health outcomes and lower rates of mortality (e.g., Cacioppo et al., 2002; House et al., 1988). Although many aspects of social relationships are likely to underlie these beneficial effects, research has emphasized the importance of the quality, rather than simply the quantity, of an individual's social connections (e.g., Amieva et al., 2010; McAdams, 1989). For instance, adult romantic relationships characterized by *emotional intimacy* (e.g., self-disclosure, mutual responsiveness; Reis and Shaver, 1988) tend to be more satisfying and rewarding than those lacking such intimate qualities (Cordova et al., 2005; Laurenceau et al., 1998). Increases in emotional intimacy also predict increases in couples' marital and sexual satisfaction over time (Greeff and Malherbe, 2001; Rubin and Campbell, in press).

The goal of the current study was to assess neuroendocrine processes associated with emotional intimacy in humans. Despite the importance of this aspect of close relationships, it has received relatively little attention in neuroendocrine research. In the current study, participants viewed movie clips depicting an emotionally intimate parent–child interaction or other, non-intimate themes and we assessed whether depictions of emotional intimacy increased levels of estradiol, a steroid hormone associated with attachment and caregiving processes (Mileva-Seitz and Fleming, 2011). We also examined whether estradiol responses were moderated by individual differences in adult attachment, or people's characteristic approaches to close relationships (Shaver and Mikulincer, 2006).

Research with humans and other animals highlights the central role of estradiol in caregiving behavior (Mileva-Seitz and Fleming, 2011). In females, estradiol levels rise during pregnancy, peak around parturition, and then decline following birth (e.g., Storey et al., 2000); the rise of estradiol prior to delivery is thought to be especially critical for the onset of maternal behavior (Wynne-Edwards and Reburn, 2000). During this period, for instance, pregnant female macaques demonstrate heightened caregiving behavior toward other females'

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infants, and such behavior is correlated with rising estradiol levels (Maestripieri and Zehr, 1998). In humans, mothers who maintain high levels of estradiol before and after childbirth report feeling more attached to their infants after birth compared to postpartum women with lower levels of estradiol (Fleming et al., 1997). Although research with males is more limited, estradiol has also been linked with paternal caregiving behavior (Wynne-Edwards, 2001). For instance, in humans and nonhuman primates, estradiol levels are higher among expectant fathers compared to non-fathers (Berg and Wynne-Edwards, 2001), particularly those with prior parental experience (Ziegler et al., 2004).

These findings suggest that state levels of estradiol fluctuate in response to both biological processes (e.g., pregnancy) and social contexts (e.g., parental experience) that are relevant to caregiving and bonding. To date, however, there have been very few experimental investigations of contextual influences on human estradiol responses. In one relevant exception, van Anders et al. (2009) showed women an erotic film clip (portraying a heterosexual encounter) and measured pre- to post-manipulation changes in estradiol. Women's estradiol levels increased after watching the erotic movie, suggesting that estradiol may be sensitive to sexual content, at least in women. However, this study did not include a control condition to assess the effects of relational content per se (apart from sexuality), so it is unclear whether women's responses were a function of the sexual content of the film specifically or its intimate nature more generally. Women's estradiol responses were also uncorrelated with their self-reported sexual arousal and with genital arousal (measured with vaginal pulse amplitude), which could suggest that estradiol responses were not uniquely tied to sexual aspects of the film. Finally, it is unclear whether and how male participants would respond to the same erotic stimuli.

Nonetheless, van Anders et al.'s (2009) findings suggest that women's estradiol levels are sensitive to at least one aspect of intimacy—sexuality—in adult relationships. Their findings are also consistent with other studies demonstrating that thematic video stimuli can effectively elicit hormone responses in the laboratory (e.g., López et al., 2009; Schultheiss et al., 2004). In the current study, we expected that participants who viewed depictions of emotional intimacy would show pre- to post-movie increases in estradiol. We also included two control conditions that portrayed non-intimate themes: 1) an emotionally positive movie clip depicting platonic social interactions, to control for the effects of positive emotion and social interaction in general, and 2) an emotionally neutral movie clip depicting non-affiliative themes, to control for the effects of simply watching the videos.

In contrast to prior work (e.g., van Anders et al., 2009), we were specifically interested in the extent to which *emotional*, rather than sexual, aspects of intimacy would elicit hormone responses. Few studies have examined emotional aspects of intimacy or closeness in relation to hormones (but see Brown et al., 2009; Schultheiss et al., 2004) and, to our knowledge, none have examined estradiol responses specifically. Further, sexual stimuli are known to elicit hormone responses (Hamilton and Meston, 2011; Hellhammer et al., 1985), including increases in estradiol as just described (van Anders et al., 2009). To ensure that any hormonal responses we observed were due to the emotionally intimate nature of the stimuli rather than any sort of sexual content, we chose a portrayal of a parent–child relationship (described in more detail below), rather than that of a romantic relationship.

We additionally examined whether estradiol responses were moderated by individual differences in adult attachment, which are generally conceptualized as differences in attachment *avoidance* and *anxiety* (Shaver and Mikulincer, 2006). Attachment avoidance reflects people's comfort with closeness and intimacy (Edelstein and Shaver, 2004). Individuals with an avoidant attachment style dislike both physical and emotional aspects of intimacy in close relationships (Brennan et al., 1998).[1] Attachment avoidance is also associated with negative feelings about physical touch in both romantic and parent–child relationships (Edelstein et al., in preparation). Moreover, there is evidence that avoidant adults have lower endogenous estradiol levels, particularly if they also have a low desire for emotional intimacy (Edelstein et al., 2010). We therefore expected that, in the current study, more avoidant participants would show attenuated estradiol responses to depictions of emotional intimacy.

Attachment anxiety, in contrast, reflects people's concern about abandonment in close relationships. Highly anxious individuals tend to be hypervigilant to relationships and relationship partners (Mikulincer et al., 2002), and they typically desire more closeness from their relationship partners than those partners are willing to give (Mashek and Sherman, 2004). At the same time, anxious individuals' concern about rejection can interfere with their ability to achieve the closeness they so desire (Shaver et al., 2005). Perhaps because of these competing motivations, attachment anxiety generally does not show clear associations with caregiving behavior (e.g., Edelstein et al., 2004; Simpson et al., 1992), and anxiety was unrelated to endogenous estradiol levels in our prior research (Edelstein et al., 2010). We therefore did not expect attachment anxiety to be associated with estradiol responses to emotional intimacy. However, for exploratory purposes, and because anxiety and avoidance tend to be positively correlated (Del Giudice, 2011), we included attachment anxiety in our analyses as well.

In addition, we included relationship status as a covariate and tested whether relationship status moderated the effects of attachment avoidance on estradiol responses to emotionally intimate stimuli. Relationship status shows important associations with endogenous hormones, with partnered individuals typically having lower testosterone and higher cortisol levels compared to single individuals (e.g., Gettler et al., 2011; van Anders and Siciliano, 2010). Although there is less direct evidence for associations between relationship status and baseline estradiol levels or estradiol responses (e.g., Berg and Wynne-Edwards, 2001; van Anders et al., 2009), several studies have documented stronger associations between estradiol and measures of personality among single versus partnered women (e.g., Schultheiss et al., 2003; Stanton and Edelstein, 2009).

There are also reasons to expect that responses to emotional intimacy would differ according to participants' relationship status. Greenwood and Long (2011), for instance, found that single participants imagined more intimacy with opposite-sex media characters compared to partnered participants, which could be a way of compensating for perceived deficits in closeness (Greenwood and Long, 2009). Finally, it is important to note that avoidant adults are much less likely than their less avoidant counterparts to be in a romantic relationship at any given time (e.g., Noftle and Shaver, 2006), and there is evidence that associations between avoidance and behavioral outcomes differ for single versus partnered individuals (e.g., Birnbaum, 2007; Edelstein and Gillath, 2008). Taken together, these findings suggest that relationship status may be an important factor to consider in the context of avoidant individuals' neuroendocrine responses to emotionally intimate stimuli.

Methods

Participants and procedure

Participants were 229 undergraduate students (51% female), ranging in age from 18 to 37 ($M = 19.50$ years, $SD = 2.47$), who received

[1] For the sake of simplicity, we refer to individuals with high scores on measures of attachment avoidance or anxiety as "avoidant" or "anxious", respectively. However, as recommended by attachment researchers (e.g., Fraley and Waller, 1998), we assess these constructs on a continuum, and all analyses are conducted using continuous variables (i.e., we do not create attachment "categories").

course credit or monetary compensation for their participation.[2] Participants were tested between the months of September and June. The ethnic composition of the sample was 63% Caucasian, 17% Asian-American, 8% African-American, and 12% of mixed or other ethnicities. Thirty-five percent of participants reported that they were currently involved in a romantic relationship. Female participants were tested during all phases of their menstrual cycles and women reported being, on average, 16.13 days ($SD = 11.09$) past the onset of their last menstruation.[3] Eighteen women reported being on oral contraceptives. Seven additional participants were tested but were missing data on either the attachment measure (due to computer malfunctions, $n = 3$) or estradiol (due to insufficient saliva, $n = 4$) and are therefore not included in the present analyses. In addition, because estradiol levels decline sharply in the years surrounding menopause (Burger et al., 2002), one 68-year-old female participant was excluded from the present analyses.

All procedures were approved by the University of Michigan Institutional Review Board. Participants were asked to refrain from eating, drinking, smoking, or brushing their teeth for 1 h prior to the beginning of the experimental session. Participants were tested between the hours of 10:00 and 19:00 h, but most participants (91%) were tested between 12:00 and 18:00 h to control for circadian changes in estradiol. (We also included time of day as a covariate in our analyses.) During individual testing sessions, informed consent was first obtained, after which participants provided a saliva sample that was used to assess baseline (pre-movie) estradiol levels. Participants then completed a series of questionnaires, including a measure of adult attachment. Next, participants were randomly assigned to view one of three 25-minute video clips (described in more detail below) depicting an emotionally intimate, positive, or neutral theme. Immediately after watching the video (i.e., approximately 25 min after video onset), participants provided a second saliva sample to assess changes in estradiol as a function of the experimental manipulation. Although the time course of estradiol responses has not been well characterized, Schultheiss et al. (in press) recommend that the post-manipulation hormone assessment be placed approximately 20 to 30 min after what is thought to be the most impactful component of the manipulation. Moreover, the timeframe used in the current study is similar to that used successfully in prior research with other steroid hormones (e.g., López et al., 2009; Schultheiss et al., 2004), including estradiol (van Anders et al., 2009).

Materials

Adult attachment

The Experiences in Close Relationships (ECR) Inventory (Brennan et al., 1998) was used to assess individual differences in adult attachment. The ECR *avoidance* subscale ($\alpha = .94$) reflects an individual's discomfort with closeness. The *anxiety* subscale ($\alpha = .90$) reflects an individual's concern about abandonment. Sample items for avoidance include "I don't feel comfortable opening up to romantic partners" and "I get uncomfortable when a romantic partner wants to be very close"; sample items for anxiety include "I often worry that my partner doesn't really love me" and "I worry a fair amount about losing my partner". Participants rate the extent to which they agree with each statement, using a 7-point Likert-type scale, ranging from 1 (*disagree strongly*) to 7 (*agree strongly*).

Video stimuli

All movie clips were approximately 25 min in length and were created by extracting scenes from a commercially available film (using iMovie). The extracted scenes were edited to create a continuous, coherent stimulus, which was presented to participants on a 23" computer screen. We intentionally selected movies that we thought would be unfamiliar to most undergraduate participants. The *emotionally intimate* clip was from *A Simple Twist of Fate* (1994), a dramatic film about the father–daughter relationship that develops between a middle-aged man and a young girl whose mother has died and whom he is seeking to adopt. The *emotionally positive* clip was from *Mad Hot Ballroom* (2005), a documentary film about a ballroom dance program in New York City. It chronicles the lives of elementary-school children who are engaged in the world of competitive dancing. The *emotionally neutral* clip was from an installment of *Planet Earth* (2006), an engaging television series produced by the BBC Natural History Unit and aired on the Discovery Channel. The selected segment focused on animal life in the deep ocean.

The video clips were pre-rated by an independent sample of undergraduate students ($N = 71$; 55% female; 34% in a relationship) to determine whether they depicted the intended themes. Participants were asked to rate the extent to which the clips elicited various emotions and depicted various themes, using 5-point Likert-type scales, ranging from 1 (*not at all*) to 5 (*extremely*). They were also asked whether they had seen the movie depicted in the clips. None of the participants reported having seen the emotionally intimate or neutral movies, but two participants reported having seen the positive movie; data for these two participants were excluded from further analyses because we were interested in their impressions of the clips per se rather than their pre-existing knowledge about the full-length movies.

Analyses of variance (ANOVAs) were conducted on participants' ratings (see Table 1) to confirm that the movie clips differed in the intended ways but did not differ on other important dimensions. These analyses revealed that the clips differed significantly in *emotional closeness*, a composite of "this clip portrayed emotional closeness", and "this clip portrayed an intimate relationship" ($\alpha = .87$), $F(2, 66) = 16.72$, $p < .01$, $\eta_p^2 = .34$. As shown in Table 1, the emotionally intimate clip was rated as depicting more emotional closeness compared to the positive clip and the neutral clip. The positive and neutral clips did not significantly differ on ratings of emotional closeness. Additionally, the clips differed on ratings of general *affiliation*, a composite of "this clip portrayed a happy relationship" and "this clip made me think about my friendships" ($\alpha = .63$), $F(2, 66) = 14.53$, $p < .01$, $\eta_p^2 = .31$. The neutral clip was rated as depicting less affiliation compared to the emotionally intimate clip and the emotionally positive clip. Importantly, however, the emotionally intimate and positive clips did not significantly differ on ratings of affiliation. The clips also differed significantly on ratings of *positive affect*, a composite of "this clip was emotionally positive" and "this clip made me feel happy" ($\alpha = .88$), $F(2, 66) = 8.00$, $p < .01$, $\eta_p^2 = .20$. The emotionally neutral clip was rated as less positive compared to the emotionally intimate clip and the emotionally positive

Table 1
Pre-ratings of video stimuli.

	Experimental condition					
	Intimacy		Positive		Neutral	
Rating	*M*	*SD*	*M*	*SD*	*M*	*SD*
Emotional closeness	3.56_a	1.40	2.25_b	.70	1.81_b	.97
Affiliation	3.18_a	1.16	2.55_a	1.08	1.75_b	.69
Positive affect	3.30_a	1.20	3.75_a	.97	2.50_b	.94
Interest level	$3.38_{a,b}$	1.35	3.61_a	.86	2.75_b	1.23

Note. Within each row, means with different subscripts are significantly different at $p < .05$. All post-hoc comparisons were conducted using the Tukey HSD correction.

[2] Baseline testosterone data from this sample were combined with those from a second sample and reported in Edelstein et al. (2011). Although these two reports include many of the same participants, the prior report focused on baseline associations between testosterone and sociosexuality, whereas the current report focuses on changes in estradiol as a function of an experimental manipulation and individual differences in attachment.

[3] Five women who reported being more than 45 days past onset of their last menstruation are not included in this average or in analyses involving menstrual cycle phase.

clip. Importantly, however the emotionally intimate and positive clips did not significantly differ on ratings of positive affect. Finally, participants' ratings of how *interesting* the clips were, a composite of "this clip was interesting" and "this clip was enjoyable to watch" ($\alpha = .94$), did not significantly differ between the emotionally intimate and positive clips or between the emotionally intimate and neutral clips. However, the positive clip was rated as more interesting than the neutral clip, overall $F(2, 66) = 3.20$, $p < .05$, $\eta_p^2 = .09$.

We additionally examined whether participants' ratings were associated with their gender and/or relationship status. When these variables were included as factors in the ANOVAs just described, only one marginally significant effect emerged: Across conditions, videos were rated more positively by single participants, $M = 3.40$, $SD = 1.10$, than by partnered participants, $M = 3.19$, $SD = 1.15$, $F(1, 57) = 3.46$, $p = .07$, $\eta_p^2 = .06$. There were no other significant effects or interactions involving gender or relationship status, all p's $> .13$. In addition, the effects of condition (described above) were virtually identical with gender and relationship status included.

Salivary estradiol: collection and assessment

Participants used a stick of sugar-free chewing gum to collect up to 7.5 mL saliva in a sterile polypropylene vial and then discarded the chewing gum. The vials were placed in frozen storage immediately after the experimental session was complete. Samples were freed from mucopolysaccarides and other residuals by three freeze–thaw cycles followed by centrifugation. Salivary estradiol was assessed with a solid phase 125I radioimmunoassay (TKE21, Diagnostic Products Corporation, Los Angeles) at the University of Michigan Core Assay Facility. All samples were assayed in duplicate. Analytical sensitivity of the assay (B0 −2 SD) was .06 pg/mL. The mean inter- and intra-assay coefficients of variation were 11.2% and 9.8%, respectively.

Statistical analyses

The Statistical Package for the Social Sciences (SPSS, version 19) and SAS (version 9.2) were used to conduct all analyses. Mean differences were assessed using independent samples *t*-tests (two-tailed) and associations were assessed using correlations, general linear models, and multiple linear regressions.

Data for three participants (two males, one female) with estradiol levels greater than 3.5 standard deviations above the mean at one or both time points were excluded. To examine pre- to post-manipulation changes in estradiol, we computed percent change scores (i.e., ((post-video estradiol − pre-video estradiol)/pre-video estradiol) × 100), which provide a measure of change that accounts for baseline differences in hormone levels (e.g., Hamilton and Meston, 2011; van Anders et al., 2009).[4] To reduce positive skewness, percent change scores were log-transformed for use in subsequent analyses; however, for ease of interpretation, values in the text, tables, and figures are presented in the untransformed metric.

An additional fourteen participants reported having oral infections or lacerations, which can lead to blood contamination in saliva and subsequent elevations in steroid hormone levels (Schultheiss and Stanton, 2009). Although these participants did not differ significantly from the rest of the sample in Time 1 (pre-movie) or Time 2 (post-movie) estradiol levels, t's $< |1.47|$, p's $> .14$, they did show significantly larger percent changes in estradiol, $M = 43.87$, $SD = 46.07$, than participants who did not report such infections or lacerations, $M = 3.44$, $SD = 55.10$, $t(224) = 2.98$, $p < .01$. Thus, we excluded these participants from further analyses as well, leaving 212 participants (108 women) for all subsequent analyses. (Results including participants with oral infections or lacerations were very similar to those reported here, although some effects were slightly smaller in magnitude.)

Table 2
Descriptive statistics and correlations among primary study variables.

	1	2	3	4	5	6
Gender						
Relationship status	−.07					
Attachment avoidance	−.06	−.35**				
Attachment anxiety	−.14*	−.09	.06			
Time 1 (pre-movie) estradiol	−.25**	.04	.08	.04		
Time 2 (post-movie) estradiol	−.16*	−.01	.12	.07	.59**	
Mean	–	–	3.04	3.64	1.51	1.35
Standard deviation	–	–	1.11	.97	.92	.69

Note. $N = 212$; gender: 0 = female, 1 = male; relationship status: 0 = single; 1 = in a relationship. Estradiol levels are reported in pg/mL.
* $p < .05$.
** $p < .01$.

Results

Preliminary analyses

Descriptive statistics and correlations among the primary study variables are presented in Table 2. As shown in Table 2, estradiol levels were higher among women compared to men at both time points (see also Table 3). In addition, Time 1 and Time 2 estradiol levels were significantly positively correlated, demonstrating rank-order stability of estradiol levels over time. Attachment anxiety was higher among women, $M = 3.77$, $SD = .98$, compared to men, $M = 3.50$, $SD = .94$, $t(210) = 2.00$, $p < .05$, but attachment avoidance did not significantly differ by gender, $p = .37$. Single participants also reported higher levels of attachment avoidance, $M = 3.34$, $SD = 1.11$, compared to participants in a relationship, $M = 2.53$, $SD = .92$, $t(210) = 5.45$, $p < .01$, but attachment anxiety was not significantly associated with relationship status, $p = .19$. Finally, time of day was significantly negatively correlated with Time 1 estradiol levels, $r = -.16$, $p < .05$, reflecting an expected decline in estradiol over the course of the day; the association between time of day and Time 2 estradiol levels was in the same direction but was not statistically significant, $r = -.11$, $p = .11$.[5]

Pre- to post-movie changes in estradiol

Means and standard deviations for Time 1 and Time 2 estradiol levels and percent changes in estradiol are presented in Table 3 by condition and gender. The general linear model (PROC GLM) procedure in SAS was used to examine percent changes in estradiol as a function of the experimental condition, gender, attachment avoidance, attachment anxiety, and relationship status. An important advantage of the GLM procedure over traditional ANOVA models is that GLM allows for interactions between fixed factors (i.e., condition, gender, and relationship status) and continuous covariates (i.e., avoidance and anxiety). Time of day was also included in this model as a continuous covariate. Avoidance and anxiety were mean-centered, as is recommended for continuous covariates included in interaction terms (Aiken and West, 1991), and all two- and three-way interactions involving experimental condition, gender, attachment avoidance, and relationship status were included. To reduce the number of interaction terms in our analyses, and because we did not have predictions regarding estradiol responses as a function of attachment anxiety, we included the main effect of anxiety but not any

[4] All results were very similar when difference scores were used instead of percent change scores.

[5] Eight participants reported having previously seen the movies depicted in these clips (four in the neutral condition, three in the positive condition, and one in the emotional intimacy condition). All findings were virtually identical with these participants excluded.

Table 3
Pre- and post-movie estradiol levels by gender and condition.

	Women ($N=108$)								Men ($N=104$)							
	Intimacy		Positive		Neutral		Total		Intimacy		Positive		Neutral		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pre-movie	1.80	1.12	1.72	.89	1.70	.91	1.74	.97	1.38	.93	1.24	.71	1.19	.78	1.27	.81
Post-movie	1.59	.69	1.44	.69	1.36	.75	1.46	.71	1.35	.69	1.24	.60	1.14	.66	1.24	.65
% Change	7.71	56.99	−8.25	37.00	−.70	73.35	−.64	57.57	3.79	35.17	6.58	35.46	12.16	73.72	7.68	52.35

Note. Estradiol levels are reported in pg/mL.

of its interactions with other independent variables. (None of these interactions were statistically significant when included in the model, all *p*'s > .15.)

Results from the GLM analysis yielded a significant two-way interaction between experimental condition and relationship status, $F(2, 188) = 3.58$, $p < .05$, $\eta_p^2 = .04$, and a significant three-way interaction among gender, experimental condition, and attachment avoidance, $F(2, 188) = 4.13$, $p < .05$, $\eta_p^2 = .04$. No other main effects or interactions were statistically significant, all *F*'s < 1.71, *p*'s > .19. As depicted in Fig. 1, post-hoc tests of the condition × relationship status interaction revealed that, among single participants, percent changes in estradiol were significantly larger in the emotional intimacy condition compared to the neutral condition. The difference between single participants' responses in the emotional intimacy condition and the positive condition was in the same direction but was not statistically significant, $p = .19$, and there was no significant difference between single participants' responses in the neutral and positive conditions, $p = .37$. In addition, in the emotional intimacy condition, single participants showed larger estradiol increases compared to partnered participants (also depicted in Fig. 1). The effect of relationship status was not significant in the positive, $p = .71$, or neutral conditions, $p = .14$. Finally, it is worth noting that estradiol changes approached a significant increase from zero only among single participants in the emotional intimacy condition, $t(40) = 1.92$, $p = .06$ (one-tailed).

Thus, our experimental manipulation of emotional intimacy had the hypothesized effect of eliciting estradiol responses only among single participants, a point to which we return in the discussion. Next, to decompose the significant gender × condition × avoidance interaction, we conducted separate GLM analyses for men and women, with experimental condition, avoidance, anxiety, and relationship status as independent variables, time of day as a covariate, and percent changes in estradiol as the dependent variable. All two-way interactions among condition, avoidance, and relationship status were included. Results from these analyses revealed that the interaction between avoidance and experimental condition was significant for women, $F(2, 96) = 4.97$, $p < .01$, $\eta_p^2 = .09$, but not for men, $F(2, 92) = .41$, $p = .66$.

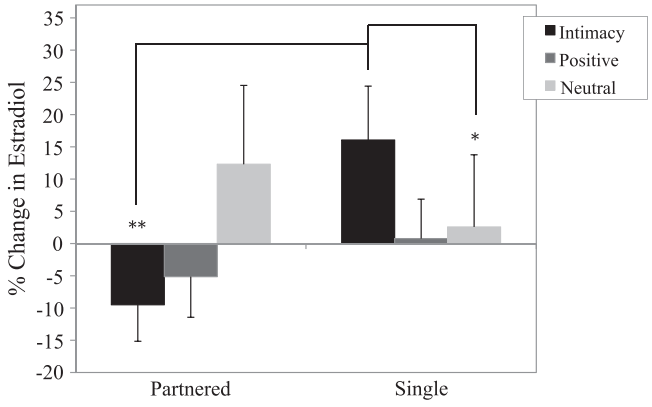

Fig. 1. Percent changes in estradiol as a function of experimental condition and participants' relationship status. *$p < .05$, **$p < .01$. Error bars represent standard errors of the mean. Note that statistical tests were conducted on log-transformed percent-change scores.

To decompose the condition × avoidance interaction for women, we conducted separate multiple linear regressions for each condition, predicting percent changes in women's estradiol from avoidance, anxiety, relationship status, and time of day. As expected, avoidance was negatively associated with changes in estradiol for women in the emotional intimacy condition, $ß = -.41$, $p < .05$. However, avoidance was, if anything, positively associated with estradiol responses in the positive, $ß = .18$, $p = .33$, and neutral conditions, $ß = .30$, $p = .10$, although these effects were not statistically significant. Associations between avoidance and percent changes in estradiol are depicted in Fig. 2.[6] In summary, highly avoidant women in the emotional intimacy condition showed a smaller estradiol response compared to less avoidant women; the effects of avoidance were not observed among men or among women in the emotionally neutral or positive conditions.

Effects of women's oral contraceptive use and menstrual cycle phase

Because women's estradiol levels can be influenced by the use of oral contraceptives and by menstrual cycle phase (e.g., Edelstein et al., 2010; Kirschbaum et al., 1999), we examined the extent to which these variables played a role in our findings. At both time points, estradiol levels were lower among women using oral contraceptives, $M_{Time1} = 1.08$ pg/mL, $SD_{Time1} = .93$; $M_{Time2} = 1.05$ pg/mL, $SD_{Time2} = .44$, compared to normally cycling women, $M_{Time1} = 1.84$ pg/mL, $SD_{Time1} = .94$; $M_{Time2} = 1.52$ pg/mL, $SD_{Time2} = .72$, *t*'s (106) > 2.46, *p*'s < .05. However, percent changes in estradiol did not differ according to women's use of oral contraceptives, $p = .19$. Moreover, excluding the 15 women on oral contraceptives from our analyses yielded a virtually identical pattern of results: in the GLM analysis predicting percent changes in estradiol among women, the interaction between experimental condition and avoidance was significant, $F(2, 81) = 5.29$, $p < .01$, $\eta_p^2 = .12$. In the regression analyses predicting percent changes in estradiol for each experimental condition, women's avoidance was negatively associated with estradiol changes in the emotional intimacy condition, $ß = -.40$, $p = .08$.

Next, we assessed the role of menstrual cycle phase among the 88 normally cycling women who provided usable day-of-cycle data. These women reported being, on average, 15.74 days ($SD = 10.94$) past the onset of their last menstrual period. Days since last menstruation was positively associated with women's estradiol levels at Time 1, $r = .31$, $p < .01$; this association was in the same direction at Time 2 but was not statistically significant, $r = .15$, $p = .17$. However, days past last menstruation was negatively associated with percent changes in estradiol, $r = -.23$, $p < .05$.[7] When we included days past

[6] The raw scores depicted in Fig. 2 include one seemingly large estradiol response for a woman in the neutral condition; however, this participant's response fell within the normal range ($Z = 3.16$) once percent change scores were log-transformed (and all analyses were conducted using log-transformed scores). Further, all findings reported here were virtually identical with this participant excluded.

[7] We also examined whether there was a quadratic association between days past last menstruation and estradiol levels or estradiol responses; none of the quadratic terms were significant, all *p*'s > .62.

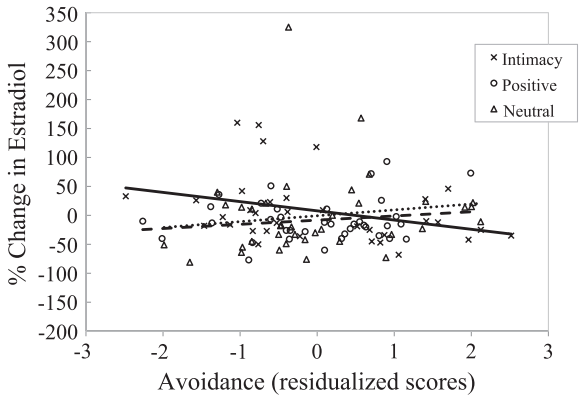

Fig. 2. Percent changes in estradiol among women. Regression lines are plotted separately for each condition as a function of women's attachment avoidance scores, which have been residualized for the effects of attachment anxiety, relationship status, and time of day. Higher scores reflect higher levels of avoidance. The solid line corresponds to the regression line for women in the emotional intimacy condition; the dashed line corresponds to the regression line for women in the positive condition; and the dotted line corresponds to the regression line for women in the neutral condition. Note that statistical tests were conducted on log-transformed percent-change scores.

last menstruation as a covariate in our analyses, results were virtually identical to those presented earlier: in the GLM analysis predicting percent changes in estradiol among women, the interaction between experimental condition and avoidance was significant, $F\ (2, 75) = 3.46$, $p < .05$, $\eta_p^2 = .09$. In the regression analyses predicting percent changes in estradiol for each condition, women's avoidance was negatively associated with estradiol changes in the emotional intimacy condition, $ß = -.50$, $p = .07$.

Finally, to examine whether attachment-related differences in women's estradiol responses varied according to menstrual cycle phase, we included the three-way interaction among avoidance, experimental condition, and days since last menstruation (as well as all constituent two-way interactions) in the original GLM analysis predicting percent changes in estradiol. This interaction was not statistically significant, $F\ (2, 70) = .75$, $p = .48$, indicating that the interaction between women's avoidance and experimental condition was not moderated by menstrual cycle phase. Thus, our findings regarding attachment-related differences in estradiol responses do not appear to be driven by changes in estradiol as a function of women's oral contraceptive use or by changes that occur over the course of the menstrual cycle.

Discussion

Findings from the current study provide novel experimental evidence that emotional intimacy can elicit estradiol responses in humans. We found that single participants showed increases in estradiol after watching a movie depicting an emotionally intimate parent–child relationship; such changes were not observed after participants watched movies depicting non-intimate themes. Further, changes in estradiol were moderated by participants' gender and level of attachment avoidance, such that more avoidant women did not show the estradiol-enhancing effects of emotional intimacy. Taken together, these findings contribute to our understanding of the biological bases of attachment and caregiving processes, and they highlight the potential role of estradiol in avoidant individuals' regulation of closeness and intimacy.

Very few studies have experimentally assessed the effects of social context on human estradiol responses (but see, e.g., Stanton and Schultheiss, 2007), and the current findings are the first to show that emotional intimacy specifically elicits increases in estradiol. Importantly, the emotionally intimate clip we used differed from the emotionally positive clip only in the extent to which it portrayed emotional intimacy, and from the neutral clip in the extent to which it elicited positive emotion and depicted general affiliation. Thus, we can be more confident that the estradiol responses we observed were due not to the emotional nature of the intimate clip or its general focus on social interactions, but to its emotionally intimate nature specifically.

Moreover, because our study focused on a depiction of a parent–child relationship, our findings can be explicitly attributed to emotional rather than sexual aspects of intimacy. Prior research using erotic film clips indicates that estradiol may be responsive to sexual content (van Anders et al., 2009); however, because these sexual portrayals occurred in an interpersonal context, the extent to which estradiol responses were a function of the sexual nature of the stimuli specifically or their intimate nature more generally remains unclear. The current findings further our understanding of the interpersonal nature of estradiol responses by demonstrating that such responses are also sensitive to emotional aspects of intimacy.

Of course, we did not include a sexually intimate video condition in our study, in part because it would have differed from the emotionally intimate video in more than just its sexual nature (e.g., in the kind of relationship it depicted). Thus, our findings cannot speak to the effects of sexual *versus* emotional intimacy on estradiol responses. van Anders et al. (2011) argue that estradiol should be responsive to both sexual and emotional aspects of intimacy in adult romantic relationships. However, to our knowledge, researchers have not yet attempted to differentiate the effects of sexual versus emotional intimacy on estradiol responses. These two aspects of intimacy can be difficult to separate in adult romantic relationships (Diamond, 2003), and it may be especially difficult to identity stimuli that evoke sexual but not emotional intimacy. Nonetheless, it would be particularly interesting to assess whether such "purely" sexual stimuli also elicit estradiol responses.

It is also important to note that our manipulation of emotional intimacy elicited significant increases in estradiol only among participants who were not currently involved in a romantic relationship; among currently partnered individuals, estradiol responses did not differ across conditions. Why might single but not partnered participants show estradiol responses to emotionally intimate stimuli? One possibility is that single participants were more likely to identify with the parent–child interaction depicted in the emotionally intimate video clip, potentially enhancing the experience of emotional intimacy and, in turn, estradiol responses. Parents typically serve as an individual's primary attachment figure from infancy through adolescence, but peers and romantic partners become increasingly likely to serve attachment functions during young adulthood (Fraley and Davis, 1997). Given that the majority of our sample was between the ages of 18 and 22, and most were not currently partnered, it is possible that many currently single individuals had not yet experienced this shift in attachment functions from parents to romantic partners, and that, for single individuals, parents remained the primary attachment figure (Doherty and Feeney, 2004). It is also possible that the causal direction works in the opposite way, such that young adults who are overly attentive to or enmeshed in relationships with parents may have greater difficulty establishing independent romantic relationships (e.g., Seiffe-Krenke, 2006). Either possibility suggests that single participants may have found the parent–child interaction particularly relevant to their lives, which could have heightened estradiol responses. This line of reasoning further suggests that partnered individuals would find a depiction of an emotionally intimate *romantic* interaction particularly evocative, and would therefore experience larger estradiol responses to this kind of interaction. Of course, this is an empirical question, and it would be interesting to examine whether currently single and partnered individuals show differential estradiol responses to depictions of different kinds of intimate relationships.

Thus, our first hypothesis—that emotional intimacy would lead to increases in estradiol—was at least partially supported, in that such increases were observed among single participants. Our second hypothesis was that the effects of emotional intimacy would be moderated by individual differences in attachment avoidance. Specifically, we expected that avoidant individuals would be less likely to show the estradiol-enhancing effects of emotional intimacy. This hypothesis also received some support, in that avoidant women showed smaller increases in estradiol after viewing the emotionally intimate movie clip. Moreover, women's avoidance was not significantly related to their estradiol responses in the two non-intimate control conditions, suggesting that the effects of avoidance were specific to emotional intimacy rather than to positive emotion or interpersonal interactions more generally.

These findings contribute to a growing body of research on the strategies used by avoidant individuals to regulate closeness and intimacy (Edelstein and Shaver, 2004; Fraley et al., 1998) and the biological mechanisms that may underlie such strategies (Edelstein et al., 2010; Gillath et al., 2005). For example, avoidant individuals tend to restrict attention to information with emotional, intimate themes (both positive and negative), perhaps as a way of reducing attachment-related distress, but such biases are not apparent for other kinds of emotional information (Dewitte et al., 2007; Edelstein, 2006; Edelstein and Gillath, 2008). Avoidant adults also tend to dislike more affectionate aspects of sexual interactions (e.g., kissing, cuddling; Fraley et al., 1998), and report more negative and fewer positive emotions after sexual activities (Brennan et al., 1998). Perhaps some of these effects can be at least partially attributed to differences in avoidant individuals' neuroendocrine responses to intimacy, potentially making intimate behavior less rewarding and ultimately discouraging future intimate interactions.

Additionally, our previous research indicated that the association between avoidance and endogenous estradiol levels was moderated by people's desire for intimacy (Edelstein et al., 2010). That is, avoidance was associated with lower estradiol levels primarily in the context of high levels of intimacy, a finding that is conceptually similar to that obtained in the current study. Although there were no significant baseline (i.e., pre-movie) associations between avoidance and estradiol in the current study, avoidance was nevertheless negatively associated with estradiol levels in the context of high levels of intimacy.

Yet it should be noted that, in the current study, associations between avoidance and estradiol were observed only among women. Perhaps estradiol responses are more closely tied to caregiving processes among women compared to men (e.g., Wynne-Edwards and Timonin, 2007), making it more difficult to detect differences in estradiol among men. There is evidence that men's estradiol levels change as a function of parenting and caregiving (e.g., Wynne-Edwards, 2001), and we did not find gender differences in estradiol-avoidance associations in our previous research (Edelstein et al., 2010); however, in other studies, estradiol has been linked with outcomes among women but not men (e.g., power motivation; Schultheiss et al., 2003; sexual desire; van Anders and Dunn, 2009).

Another possibility is that our emotionally intimate movie clip, which depicted a father–daughter dyad, elicited stronger defensive responses among avoidant women compared to avoidant men. Interestingly, there is evidence linking women's (but not men's) avoidance with heightened stress reactivity during a conflict discussion with a romantic partner (Powers et al., 2006). Fraley and Shaver (1998) similarly found that women's (but not men's) avoidance predicted distancing behavior among separating couples. Thus, women's avoidance may be particularly relevant in situations involving caregiving or potential relationship threat. That we did not find any gender differences in our pre-test ratings of the video clips suggests that there were not obvious differences in the perceptions of these videos by men versus women. Nonetheless, it will be important to explore this finding in future research, perhaps by manipulating the gender of the protagonists or by assessing hormones other than estradiol.

Several limitations of our research should also be considered. First, although our laboratory manipulation of emotional intimacy allowed experimental control over many aspects of the stimuli used in this study, the ecological validity of our findings remains to be determined. There is evidence that "real life" physically intimate activities, such as sexual activity, cuddling, and massage, can elicit changes in hormones such as testosterone and oxytocin (e.g., Holt-Lunstad et al., 2008; van Anders et al., 2007). Thus, there are reasons to expect that emotional intimacy would similarly modulate estradiol responses in non-laboratory contexts, but, to our knowledge, such research has not yet been conducted. Second, participants in the current study were young adults, the majority of whom were not currently involved in a romantic relationship. Although we did not ask about parenting experience, it is likely that most of our participants did not yet have children of their own. The current findings demonstrate that relationship status is an important moderator of estradiol responses, and there is evidence that parenting experience may be similarly important (Mileva-Seitz and Fleming, 2011). Thus, we do not yet know whether our findings will extend to older samples of participants with more diverse relationship and parenting experiences.

Finally, the emotionally intimate and emotionally positive video clips both focused on positive social interactions, which differed in their level of emotional intimacy. However, emotional intimacy can also occur in the context of negative emotion, for instance in situations of separation and loss. Given that such situations are likely to elicit proximity-seeking and caregiving behavior (Bowlby, 1980), it is plausible that they would elicit estradiol responses as well. Moreover, research has shown that avoidant individuals are less responsive to relationship partners in stressful situations (Edelstein et al., 2004; Simpson et al., 1992) and less attentive to relationship-threatening information (Dewitte et al., 2007; Edelstein and Gillath, 2008). Future research should investigate whether the emotional valence of an intimate situation influences estradiol responses, and whether such responses are moderated by attachment avoidance.

Despite these limitations, findings from the current study demonstrate that emotional intimacy can increase estradiol levels, and that there are important moderators of the estradiol-enhancing effects of emotional intimacy. We found that single (but not partnered) participants showed increases in estradiol following an experimental manipulation of emotional intimacy. Estradiol responses were not observed following exposure to interpersonal, emotionally positive stimuli or to neutral control stimuli, however, suggesting that such responses are not simply a function of positive affect or the depiction of social relationships. Moreover, avoidant women showed smaller estradiol increases in the emotional intimacy condition, suggesting that they may not experience the estradiol-enhancing effects of emotional intimacy. Further research will be necessary to determine whether other kinds of emotionally intimate stimuli elicit estradiol responses in partnered individuals, why men's avoidance was not associated with estradiol responses to our stimuli, and whether our findings generalize from the laboratory to the real world. Nevertheless, the current findings advance our understanding of the neuroendocrine bases of emotional intimacy in humans. They also highlight a potential neuroendocrine correlate of avoidant individuals' defensive responses to closeness and intimacy, which could ultimately feed forward to impair future intimate experiences.

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References

Aiken, L., West, S., 1991. Multiple Regression: Testing and Interpreting Interactions. Sage Publications, Newbury Park, CA.
Amieva, H., Stoykova, R., Matharan, F., Helmer, C., Antonucci, T.C., Dartigues, J.F., 2010. What aspects of social network are protective for dementia? Not the quantity but the quality of social interactions is protective up to 15 years later. Psychosomatic Medicine 72, 905–911.
Berg, S.J., Wynne-Edwards, K.E., 2001. Changes in testosterone, cortisol, and estradiol levels in men becoming fathers. Mayo Clin. Proc. 76, 582–592.
Birnbaum, G.E., 2007. Beyond the borders of reality: attachment orientations and sexual fantasies. Pers. Relat. 14, 321–342.
Bowlby, J., 1980. Attachment and loss. Sadness and Depression, vol. III. Basic Books, New York, NY.
Brennan, K.A., Clark, C., Shaver, P.R., 1998. Self-report measurement of adult attachment: an integrative overview. In: Simpson, J., Rholes, W. (Eds.), Attachment Theory and Close Relationships. Guilford Press, New York, NY, pp. 46–76.
Brown, S.L., et al., 2009. Social closeness increases salivary progesterone in humans. Horm. Behav. 56, 108–111.
Burger, H.G., Dudley, E.C., Robertson, D.M., Dennerstein, L., 2002. Hormonal changes in the menopause transition. Recent Prog. Horm. Res. 57, 257–275.
Cacioppo, J.T., et al., 2002. Loneliness and health: potential mechanisms. Psychosom. Med. 64, 407–417.
Cordova, J.V., Gee, C.B., Warren, L.Z., 2005. Emotional skillfulness in marriage: intimacy as a mediator of the relationship between emotional skillfulness and marital satisfaction. J. Soc. Clin. Psychol. 24, 218–235.
Del Giudice, M., 2011. Sex differences in romantic attachment: a meta-analysis. Pers. Soc. Psychol. Bull. 37, 193–214.
Dewitte, M., Koster, E.H.W., De Houwer, J., Buysse, A., 2007. Attentive processing of threat and adult attachment: a dot-probe study. Behav. Res. Ther. 45, 1307–1317.
Diamond, L.M., 2003. What does sexual orientation orient? A biobehavioral model distinguishing romantic love and sexual desire. Psychol. Rev. 110, 173–192.
Doherty, N.A., Feeney, J.A., 2004. The composition of attachment networks throughout the adult years. Pers. Relat. 11, 469–488.
Edelstein, R.S., 2006. Attachment and emotional memory: investigating the source and extent of avoidant memory impairments. Emotion 6, 340–345.
Edelstein, R.S., Shaver, P.R., 2004. Avoidant attachment: exploration of an oxymoron. In: Mashek, D.J., Aron, A.P. (Eds.), Handbook of Closeness and Intimacy. Lawrence Erlbaum Associates, Mahwah, NJ, pp. 397–412.
Edelstein, R.S., Gillath, O., 2008. Avoiding interference: adult attachment and emotional processing biases. Pers. Soc. Psychol. Bull. 34, 171–181.
Edelstein, R.S., Chopik, W.J., Kean, E.L., 2011. Sociosexuality moderates the association between testosterone and relationship status in men and women. Horm. Behav. 60, 248–255.
Edelstein, R.S., Stanton, S.J., Henderson, M.M., Sanders, M.R., 2010. Endogenous estradiol levels are associated with attachment avoidance and implicit intimacy motivation. Horm. Behav. 57, 230–236.
Edelstein, R. S., van Anders, S. M., Samples-Steele, C. R., Kean, E. L., Chopik, W. J., Too close for comfort? Adult attachment and cuddling behavior in romantic and parent–child relationships. Manuscript in preparation.
Edelstein, R.S., et al., 2004. Adult attachment style and parental responsiveness during a stressful event. Attach. Hum. Dev. 6, 31–52.
Fleming, A.S., Ruble, D., Krieger, H., Wong, P.Y., 1997. Hormonal and experiential correlates of maternal responsiveness during pregnancy and the puerperium in human mothers. Horm. Behav. 31, 145–158.
Fraley, R.C., Davis, K.E., 1997. Attachment formation and transfer in young adults' close friendships and romantic relationships. Pers. Relat. 4, 131–144.
Fraley, R.C., Waller, N.G., 1998. Adult attachment patterns: a test of the typological model. In: Simpson, J., Rholes, W. (Eds.), Attachment Theory and Close Relationships. Guilford Press, New York, NY, pp. 77–114.
Fraley, R.C., Shaver, P.R., 1998. Airport separations: a naturalistic study of adult attachment dynamics in separating couples. J. Personal. Soc. Psychol. 75, 1198–1212.
Fraley, R.C., Davis, K.E., Shaver, P.R., 1998. Dismissing-avoidance and the defensive organization of emotion, cognition, and behavior. In: Simpson, J.A., Rholes, W.S. (Eds.), Attachment Theory and Close Relationships. Guilford Press, New York, NY, pp. 249–279.
Gettler, L.T., Mcdade, T.W., Kuzawa, C.W., 2011. Cortisol and testosterone in Filipino young adult men: evidence for co regulation of both hormones by fatherhood and relationship status. Am. J. Hum. Biol. 5, 609–620.
Gillath, O., Bunge, S.A., Shaver, P.R., Wendelken, C., Mikulincer, M., 2005. Attachment-style differences in the ability to suppress negative thoughts: exploring the neural correlates. NeuroImage 28, 835–847.
Greeff, A.P., Malherbe, H.L., 2001. Intimacy and marital satisfaction in spouses. J. Sex Marital Ther. 27, 247–257.
Greenwood, D.N., Long, C.R., 2009. Psychological predictors of media involvement. Commun. Res. 36, 637–654.
Greenwood, D.N., Long, C.R., 2011. Attachment, belongingness needs, and relationship status predict imagined intimacy with media figures. Communication Research 38, 278–297.
Hamilton, L.D., Meston, C.M., 2011. The role of salivary cortisol and DHEA-S in response to sexual, humorous, and anxiety-inducing stimuli. Horm. Behav. 59, 765–777.
Hellhammer, D.H., Hubert, W., Schürmeyer, T., 1985. Changes in saliva testosterone after psychological stimulation in men. Psychoneuroendocrinology 10, 77–81.
Holt-Lunstad, J., Birmingham, W.A., Light, K.C., 2008. Influence of a 'warm touch' support enhancement intervention among married couples on ambulatory blood pressure, oxytocin, alpha amylase, and cortisol. Psychosom. Med. 70, 976–985.
House, J., Landis, K., Umberson, D., 1988. Social relationships and health. Science 241, 540–545.
Kirschbaum, C., Kudielka, B.M., Gaab, J., Schommer, N.C., Hellhammer, D.H., 1999. Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamic–pituitary–adrenal axis. Psychosom. Med. 61, 154–162.
Laurenceau, J.-P., Barrett, L.F., Pietromonaco, P.R., 1998. Intimacy as an interpersonal process: the importance of self-disclosure, partner disclosure, and perceived partner responsiveness in interpersonal exchanges. J. Personal. Soc. Psychol. 74, 1238–1251.
López, H.H., Hay, A.C., Conklin, P.H., 2009. Attractive men induce testosterone and cortisol release in women. Horm. Behav. 56, 84–92.
Maestripieri, D., Zehr, J.L., 1998. Maternal responsiveness increases during pregnancy and after estrogen treatment in macaques. Horm. Behav. 34, 223–230.
Mashek, D.J., Sherman, M.D., 2004. Desiring less closeness with intimate others. In: Mashek, D.J., Aron, A.P. (Eds.), Handbook of Closeness and Intimacy. Lawrence Erlbaum Associates, Mahway, NJ, pp. 343–356.
McAdams, D.P., 1989. Intimacy: The Need to be Close. Doubleday & Co, New York, NY US.
Mikulincer, M., Giilath, O., Shaver, P.R., 2002. Activation of the attachment system in adulthood: threat-related primes increase the accessibility of mental representations of attachment figures. J. Personal. Soc. Psychol. 83, 881–895.
Mileva-Seitz, V., Fleming, A.S., 2011. How mothers are born: a psychobiological analysis of mothering. In: Booth, A., et al. (Ed.), Biosocial Foundations of Family Processes. Springer, New York, pp. 3–34.
Noftle, E.E., Shaver, P.R., 2006. Attachment dimensions and the big five personality traits: associations and comparative ability to predict relationship quality. J. Res. Personal. 40, 179–208.
Powers, S.I., Pietromonaco, P.R., Gunlicks, M., Sayer, A., 2006. Dating couples' attachment styles and patterns of cortisol reactivity and recovery in response to a relationship conflict. J. Personal. Soc. Psychol. 90, 613–628.
Reis, H.T., Shaver, P., 1988. Intimacy as an interpersonal process. In: Duck, S., et al. (Ed.), Handbook of Personal Relationships: Theory, Research and Interventions. John Wiley & Sons, Oxford England, pp. 367–389.
Rubin, H., Campbell, L., in press. Day-to-day changes in intimacy predict heightened relationship passion, sexual occurrence, and sexual satisfaction: a dyadic diary analysis. Social Psychological and Personality Science.
Schultheiss, O.C., Stanton, S.J., 2009. Assessment of salivary hormones. In: Harmon-Jones, E., Beer, J.S. (Eds.), Methods in Social Neuroscience. Guilford Press, New York, pp. 17–44.
Schultheiss, O.C., Dargel, A., Rohde, W., 2003. Implicit motives and gonadal steroid hormones: effects of menstrual cycle phase, oral contraceptive use, and relationship status. Horm. Behav. 43, 293–301.
Schultheiss, O.C., Wirth, M.M., Stanton, S.J., 2004. Effects of affiliation and power motivation arousal on salivary progesterone and testosterone. Horm. Behav. 46, 592–599.
Schultheiss, O. C., Schiepe, A., Rawolle, M., in press. Hormone Assays. In: H. Cooper (Ed.), Handbook of research methods in psychology. American Psychological Association, Washington, DC.
Seiffe-Krenke, I., 2006. Leaving home or still in the nest? Parent–child relationships and psychological health as predictors of different leaving home patterns. Dev. Psychol. 42, 864–876.
Shaver, P.R., Mikulincer, M., 2006. Attachment theory, individual psychodynamics, and relationship functioning. In: Vangelisti, A.L., Perlman, D. (Eds.), The Cambridge Handbook of Personal Relationships. Cambridge University Press, New York, NY, pp. 251–271.
Shaver, P.R., Schachner, D.A., Mikulincer, M., 2005. Attachment style, excessive reassurance seeking, relationship processes, and depression. Pers. Soc. Psychol. Bull. 31, 343–359.
Simpson, J.A., Rholes, W.S., Nelligan, J.S., 1992. Support seeking and support giving within couples in an anxiety-provoking situation: the role of attachment styles. J. Personal. Soc. Psychol. 62, 434–446.
Stanton, S.J., Schultheiss, O.C., 2007. Basal and dynamic relationships between implicit power motivation and estradiol in women. Horm. Behav. 52, 571–580.
Stanton, S.J., Edelstein, R.S., 2009. The physiology of women's power motive: implicit power motivation is positively associated with estradiol levels in women. J. Res. Personal. 43, 1109–1113.
Storey, A.E., Walsh, C.J., Quinton, R.L., Wynne-Edwards, K.E., 2000. Hormonal correlates of paternal responsiveness in new and expectant fathers. Evol. Hum. Behav. 21, 79–95.
van Anders, S.M., Dunn, E.J., 2009. Are gonadal steroids linked with orgasm perceptions and sexual assertiveness in women and men? Horm. Behav. 56, 206–213.
van Anders, S.M., Siciliano, K.L., 2010. Testosterone and partnering are linked via relationship status for women and "relationship orientation" for men. Horm. Behav. 58, 820–826.

van Anders, S.M., Goldey, K.L., Kuo, P.X., 2011. The steroid/peptide theory of social bonds: integrating testosterone and peptide responses for classifying social behavioral contexts. Psychoneuroendocrinology 36, 1265–1275.
van Anders, S.M., Hamilton, L.D., Schmidt, N., Watson, N.V., 2007. Associations between testosterone secretion and sexual activity in women. Horm. Behav. 51, 477–482.
van Anders, S.M., Brotto, L., Farrell, J., Yule, M., 2009. Associations among physiological and subjective sexual response, sexual desire, and salivary steroid hormones in healthy premenopausal women. J. Sex. Med. 6, 739–751.
Wynne-Edwards, K.E., 2001. Hormonal changes in mammalian fathers. Horm. Behav. 40, 139–145.
Wynne-Edwards, K.E., Reburn, C.J., 2000. Behavioral endocrinology of mammalian fatherhood. Trends Ecol. Evol. 15, 464–468.
Wynne-Edwards, K.E., Timonin, M.E., 2007. Paternal care in rodents: weakening support for hormonal regulation of the transition to behavioral fatherhood in rodent animal models of biparental care. Horm. Behav. 52, 114–121.
Ziegler, T.E., Washabaugh, K.F., Snowdon, C.T., 2004. Responsiveness of expectant male cotton-top tamarins, *Saguinus oedipus*, to mate's pregnancy. Horm. Behav. 45, 84–92.