Psychoneuroendocrinology 75 (2017) 91–99

Contents lists available at ScienceDirect

Psychoneuroendocrinology

journal homepage: www.elsevier.com/locate/psyneuen

High estradiol and low progesterone are associated with high assertiveness in women

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ARTICLE INFO

Article history:
Received 8 July 2016
Received in revised form 6 October 2016
Accepted 11 October 2016

Keywords:
Assertiveness
Estradiol
Progesterone
Fertility
Mate selection
Sexual motivation

ABSTRACT

Sexual selection theory posits that women are more selective than men are when choosing a mate. This evolutionary theory suggests that "choosiness" increases during the fertile window because the costs and benefits of mate selection are highest when women are likely to conceive. Little research has directly investigated reproductive correlates of choice assertion. To address this gap, in the present research we investigated whether fertility, estradiol, and progesterone influenced general assertiveness in women. We recruited 98 naturally cycling, ethnically diverse women. Using a within-subjects design and ovarian hormone concentrations at fertile and non-fertile menstrual cycle phases, we measured implicit assertiveness and self-reported assertive behavior. To see if fertility-induced high assertiveness was related to increased sexual motivation, we also measured women's implicit sexual availability and interest in buying sexy clothes. Results showed that high estradiol and low progesterone predicted higher assertiveness. Sexual availability increased during periods of high fertility. Low progesterone combined with high estradiol predicted greater interest in buying sexy clothes. Results held when controlling for individual differences in mate value and sociosexual orientation. Our findings support the role of fluctuating ovarian hormones in the expression and magnitude of women's assertiveness. High assertiveness during the fertile window may be a psychological adaptation that promotes mate selectivity and safeguards against indiscriminate mate choice when conception risk is highest.

1. Introduction

Darwinian approaches to understanding female sexual behavior emphasize that women are the more discerning and "choosy" sex in mate selection (Trivers, 1972). Little research, however, has investigated whether women's general ability to make and assert choices elevates when the costs and benefits of mate selection are greatest (i.e., when they are fertile). The current study aimed to address this gap. Using a within-subject design, hormonally-verified fertility, and repeated salivary estradiol and progesterone, we investigated whether fertility was associated with high assertiveness in women.

1.1. Sexual selection theory and women's mate preferences

A cornerstone of sexual selection theory is that the sex with the greatest minimum investment in producing offspring will be more selective in choosing a mate (Trivers, 1972). In most animal species and all mammals, this sex is female. In contrast to males, female mammals' minimum obligatory parental investment is greater. Furthermore, female reproductive success is physiologically limited by estrus rates and the duration and energetic costs of gestation and lactation. As a result, females usually bear greater reproductive costs from indiscriminate or low quality mating and greater benefits from strongly asserting their desired mate choice. Females demonstrate more mate selectivity in the vast majority of animal species studied (Andersson, 1994). Likewise, women assert more selectivity in mate choice than men across cultures (Buss and Schmitt, 1993).

The potential ramifications of low or high quality mate choice are greatest for women during periods of fertility when genes could be passed on to offspring. Although findings have been mixed, evidence suggests that under some conditions, fertile women are attracted to characteristics in men that may confer higher genetic quality and reproductive success (Gildersleeve et al., 2014; but c.f. Wood et al., 2014). The implication is that women are more selective at times when conception is likely (Gangestad and Thornhill, 1998). Fertile, ancestral women who found these characteristics more attractive and effectively asserted their mate choices should have had higher reproductive success due to their likelihood of mating with high quality men.

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http://dx.doi.org/10.1016/j.psyneuen.2016.10.008
0306-4530/

An elevated, fertility-induced ability to assert one's wishes generally and attain desired goals may have also conferred women higher reproductive success. We present *the fertility-assertiveness hypothesis*, which is that women assert their wishes and exert control in their environment to a greater extent when fertile than when non-fertile. We suggest that this phenomenon is an evolved tendency, which should have been (and may still be) particularly relevant to fertile women faced with reproductive pressures to acquire and discern the quality of a potential mate. Ancestral women who exhibited more of these characteristics when fertile should have had more success approaching potential mates, discerning their quality, and rejecting low quality mates. As a result, fertile compared to non-fertile women may exhibit elevated assertiveness. The primary aim of this research was to investigate this hypothesis.

1.2. Fertility, hormones, and assertiveness

Assertiveness refers to the quality of behaving confidently with respect to saying what one wants or believes ('Assertive', 2016). No known research to date has examined associations between ovarian hormones and assertiveness, although characteristics consistent with high assertiveness may be positively associated with fertility. Hromatko et al. (2008) found that women in the middle of their menstrual cycle reported higher scores on a masculine trait index; one of the traits in that index was 'assertiveness'. Women's preference for influencing or dominating others is positively associated with high estradiol (Schultheiss et al., 2003; Stanton and Schultheiss, 2007). Temperaments conducive to high assertiveness—such as high endurance and action-orientation—are associated with both high estradiol and progesterone profiles favorable to reproduction (Ziomkiewicz et al., 2012). When women are fertile, estradiol is high and progesterone is low (Porerfield and White, 2007,pp. 237–238). This convergent indirect evidence suggests that assertiveness may increase when women are fertile; however, direct evidence of the proposed relationship between fertility, ovarian hormones, and assertiveness is lacking.

1.3. Fertility, hormones, and sexual availability

The *fertility-assertiveness hypothesis* implies that high assertiveness during the fertile window supports women's mating goals. The secondary aim of this research was to determine if fertility-induced increases in assertiveness corresponded with women's sexual availability. We also aimed to provide further evidence regarding the hormones that may regulate women's sexual motivation.

Although evidence suggests that women are more sexually motivated and interested in attracting mates when fertile (e.g., Bancroft et al., 1983), the proximal mechanisms underlying the effect of fertility on sexual motivation are less well understood. Past studies sometimes implicate testosterone, endogenous or exogenous estrogens, neither hormone, or a combination of the two hormones in women's sexual functioning (Alexander et al., 2004; Sherwin, 1991). In an advancement of this field, Roney and Simmons (2013) showed that self-reported sexual desire in normally cycling women was associated with high endogenous estradiol and low progesterone but not with endogenous testosterone. In the present research, we aimed to conceptually replicate Roney and Simmons (2013) with novel measures of sexual motivation. We then investigated whether assertiveness and sexual availability measures were positively correlated.

1.4. The current study

Using a within-subject design, we estimated ovulation for 98 women using urinary luteinizing hormone (LH) tests. We then assessed measures of assertiveness and sexual availability at fertile and non-fertile time points. For a subgroup of the sample for which hormone measures were available ($n = 60$), we further examined whether estradiol and progesterone at each time point were associated with assertiveness and sexual availability. We also controlled for the effect of self-rated mate value and sociosexual orientation (to ensure that relationships between variables were not reducible to a positive mating-related self-concept during fertile periods). We predicted that assertiveness would be positively associated with hormonal profiles reflective of peak fertility (high estradiol and low progesterone) and with sexual availability. We further expected that high estradiol and low progesterone would positively correlate with sexual availability.

2. Method

2.1. Participants and design

2.1.1. Ethics statement and data availability

The study was carried out in accordance with the Declaration of Helsinki and the UNSW Ethics Committee approved the protocol. Participants were recruited in two waves and were informed that they were contributing to a study investigating reproductive biology and self-presentation (Wave 1) or hormone regularity and social judgments (Wave 2).

2.1.2. Participants

Ninety-eight women ($M_{age} = 22.19$ years, $SD = 4.43$; Wave 1 $n = 60$; Wave 2 $n = 38$) participated in both sessions of the study as part of their course requirements or in exchange for AUD$45–$70. Participants ranged from 18 to 36 years old; 75% were aged between 18 and 24 years. We removed data from two participants for completing the fertile session measures more than two days after a detected LH surge. A power analysis in GPower 3.1.7 showed that the remaining sample size ($n = 96$; $M_{age} = 22.24$ years, $SD = 4.46$) provided power at 0.99 to detect a medium effect for fertility ($d = 0.50$) and power at 0.83 to detect a small effect for fertility ($d = 0.30$; $\alpha = 0.05$, two-tailed).

Exclusion criteria from entrance in both waves of the study were use of hormonal birth control (current or within the past two months); irregular menstrual cycles; pregnancy/breastfeeding (current or recent); immune, cardiovascular, metabolic, or kidney disorders; anabolic steroid use; and cancer/tumors. Participants providing salivary hormone samples (Wave 1 only) additionally refrained from consuming caffeine or eating/drinking anything except water within one hour of their session; recreational drug use within the past 30 days; and smoking or alcohol use within the past 12 h. Additional exclusion criteria for entrance in Wave 2 were medically diagnosed fertility problems, polycystic ovarian syndrome, and endometriosis. Interested readers can consult the Open Science Framework (https://osf.io/sxnr6/) for further details regarding prescreening and entrance criteria.

2.2. Procedure and materials

The experiment was composed of two near-identical sessions, one when participants were non-fertile, and one when they were fertile (verified by LH tests, see 'Fertility calculation'). All participants attended both of these sessions and any difference between sessions is outlined below. Wave 1 participants were randomly allocated to attend their first session when fertile ($n = 29$) or non-fertile ($n = 31$). Wave 2 participants ($n = 38$) attended their first session when non-fertile and second session when fertile.

Wave 1 participants completed the hormone pre-screening questionnaire, rinsed out their mouth with water, completed the clothes buying task, and provided one saliva sample at each session via passive drool. Using Inquisit 4.0.4.0, they then completed a Single Category Implicit Association Task (SC-IAT) assessing associations between the self and assertiveness; an intentional binding paradigm measuring implicit perceptions of volitional control of one's own actions; a second SC-IAT assessing associations between the self and sexual availability; then questionnaires assessing mate value, self-report assertiveness, and sociosexual orientation.[1] All Wave 1 laboratory sessions were conducted between 1200 h and 1800 h in order to control for diurnal progesterone and estradiol variation. Wave 1 non-fertile sessions also included an LH test prior to the saliva sample (to confirm participants were not ovulating).

Wave 2 participants first completed the hormone pre-screening questionnaire. They then completed the clothes buying task, the mate value measure, and the SC-IAT assessing associations between the self and sexual availability. Because Wave 2 participants did not provide hormone samples and dependent measures did not need to be collected in the laboratory, Wave 2 participants completed their second session online.

2.2.1. Fertility calculation

To maximize the likelihood of detecting surges in LH, we followed the standardized LH testing procedure in Blake et al. (2016b). All participants used commercially available urinary LH tests (Blue Cross Bio-Medical Co. LTD, CE/FDA Registered) and tested until a positive surge was detected. Wave 1 participants tested until a positive result was reported (a maximum of 10 days) and Wave 2 tested for 11 continuous days, even if a surge was reported earlier. We instructed participants to test between 1000 h and 2000 h and report the result to the research team via SMS or email. The repeated design of the study required that all participants attended one fertile and one non-fertile laboratory session. Hence, all participants included here detected a LH surge and thus had ovulatory cycles. Participants who did not record a surge in LH were not eligible for inclusion in the study (see Blake et al., 2016b for full details of the sampling procedure).

Forty-seven percent of non-fertile sessions occurred in the early follicular phase (mean cycle day = 4.02, $SD = 2.54$) and the remainder occurred in the late luteal phase (mean cycle day = 26.06, $SD = 3.45$). Most participants completed both fertile and non-fertile sessions in the same menstrual cycle (63.5%), the remainder attended sessions occurring 1, 2, or 3 cycles apart. Once a positive LH surge was detected, 85.4% of participants attended their fertile session within one day, the remaining 14.6% attended this session within two days. Following a surge in LH, ovulation is expected to occur approximately 24–48 h later (Direito et al., 2013).[2]

[1] Wave 1 participants also posed for a full-length photograph and composed a written dating profile. We submitted the photograph and dating profile to coders (blind to fertility) to rate on perceived assertiveness ('To what extent does this woman strive to assert and expand herself?', 1 = not at all; 7 = very much). In both cases, reliability was unacceptable and no further analyses were conducted.

[2] To ensure effects were not confounded by fertile sessions +2 days after an LH surge, we re-ran all zero-order models excluding women whose fertile sessions were on Day +2 after their LH peak. All statistically significant results reported herein (which are for the entire sample) remained significant when +2 day fertile sessions were excluded, with one exception. Progesterone was a significant predictor in the final model for implicit perceived volitional control of one's actions (see Table 2), but when +2 day sessions were excluded, this statistic was $\beta = -0.06$, $SE = 0.04$, CI [-0.14, 0.01], $t(64.52) = -1.63$, $p = 0.108$.

2.2.2. Interest in buying sexy versus non-sexy clothing

Sixty-seven people in a pilot study (45 men, $M_{age} = 32.54$ years, $SD = 10.73$) read a description of the concept of sexual availability then rated 20 images of women's outfits on sexual availability on a 7-point scale (1 = very sexually unavailable, 7 = very sexually available; 'If you saw a woman wearing this outfit, how sexually available do you think she would be?'). The top seven sexually available outfits and bottom five non-sexually available outfits showed significant group differences on sexual availability, $t(66) = 12.48$, $p < 0.001$, $M_{LowSA} = 2.72$, $SD = 1.04$, $M_{HighSA} = 5.61$, $SD = 1.03$, $d = 3.23$. Five sexually available and five non-sexually available outfits were presented to participants in randomized order as a fashion catalogue. All outfits were generally attractive and consistent with what young, Western women might wear on a romantic date, but the sexualized outfits showed more skin, were tightly cut, and were shorter in length. Participants indicated how much they would pay for each outfit on 10-point scale (ranging from \$20 to \$200; Wave 1) or a 7-point scale (ranging from \$0 to \$175; Wave 2). Amounts were aggregated by clothing type (sexy versus non-sexy) then Z-transformed within waves to account for scale variability.

2.2.3. Implicit sexual availability

Sixty-seven people in a pilot study (45 men, $M_{age} = 32.54$ years, $SD = 10.73$) rated 32 traits on the concept sexual availability (e.g., lustful). The top and bottom group of eight traits had significantly different sexual availability ratings, $t(66) = 14.83$, $p < 0.001$, $M_{LowSA} = 2.23$, $SD = 1.21$, $M_{HighSA} = 6.10$, $SD = 1.07$, $d = 1.81$. The high sexual availability traits were: slutty, lustful, seductive, kinky, wild, provocative, sexy, and saucy; the low sexual availability traits were: frigid, restrained, chaste, conservative, proper, reserved, traditional, and prudent.

Participants categorized these traits with seven words characteristic of the self (me, my, mine, self, myself; and the participant's own first name and nickname [or, if they had no nickname, their name again]). Implicit associations were assessed by asking people to press the same response key for low sexual availability + self and to press the opposite response key for high sexual availability + self. These associations were then reversed and the order in which participants performed these trials was counterbalanced. The SC-IAT effect is the difference in response latency between low sexual availability + self and high sexual availability + self. We calculated D scores following Greenwald et al. (2003); data from five time points were excluded due to more than 10% of trials with latencies below 300 ms. Higher scores indicated stronger associations of the self with sexual availability.

2.2.4. Implicit assertiveness

The assertiveness SC-IAT mirrored the sexual availability SC-IAT, but with high and low assertiveness words. These words were taken from a pilot study on words that exemplify the concepts of high and low agency. Agency is a topic of investigation in a variety of psychological fields and approximates the term 'assertiveness' in meaning: Agency refers to the capacity to exercise control over the nature and quality of one's personal, political, or social life (Bandura, 2001). Twenty-six people read a description of the concept of agency then rated 61 traits on agency on a 7-point scale (1 = very non-agentic, 7 = very agentic). High agency was characterized as an ability to assert and expand one's self, affect one's environment, and perform actions. Low agency was characterized as unassertiveness. The top and bottom eight traits formed the high and low assertiveness words for the SC-IAT and showed significant group differences on assertiveness, $t(25) = 7.95$, $p < 0.001$, $M_{Lowassertiveness} = 2.29$, $SD = 1.18$, $M_{Highassertiveness} = 5.59$, $SD = 1.52$, $d = 1.48$. The high assertiveness words were: decisive, driven, go-getter, self-aware, persistent, independent, productive, and strong-minded. The low assertiveness words were: depen-

Table 1
Repeated-measures ANOVA results comparing assertiveness and sexual availability at fertile and non-fertile sessions.

Variable pair	Mean		F	df	η_p^2	F	df	η_p^2
	Non-fertile	Fertile	Fertility main effect			Fertility × T1 fertility		
Self-report assertiveness	3.90	4.07	5.05*	1, 94	0.05	4.29*	1, 94	.04*
Implicit sexual availability	−0.05	0.01	8.36**	1, 90	0.09	0.75	1, 90	< 0.01
Clothes buying intentions	−0.03	0.07	4.75*	1, 94	0.05	0.96	1, 94	0.01
Mate value	4.42	4.55	7.49**	1, 94	0.07	1.16	1, 94	0.01

Note. † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 2
Linear mixed model results testing hormonal predictors of assertiveness and sexual availability.

Model	Parameter estimate	CIs	*t*	*p*
Assertiveness				
Self-report assertiveness				
Intercept	3.98	[3.80, 4.16]	44.13	< 0.001***
Estradiol	**0.13**	**[0.001, 0.26]**	**2.01**	**0.048***
Progesterone	**−0.16**	**[−0.30, −0.03]**	**−2.35**	**0.021***
Estradiol × Progesterone	−0.02	[−0.16, 0.11]	−0.34	0.735
Mate value	**1.36**	**[1.16, 1.56]**	**13.81**	**< 0.001*****
Volitional control of one's actions				
Intercept	−1.69	[−1.95, −1.43]	−12.92	< 0.001***
Estradiol	**0.24**	**[0.03, 0.46]**	**2.26**	**0.027***
Progesterone	**−0.08**	**[−0.16, −0.00003]**	**−2.00**	**0.050***
Estradiol × Progesterone	0.04	[−0.03, 0.12]	1.12	0.266
Hours since waking	−0.05	[−0.08, −0.02]	−3.24	0.002**
Hours since waking × Estradiol	−0.03	[−0.06, 0.001]	−1.92	0.059†
Implicit assertiveness				
Intercept	0.08	[−0.16, 0.31]	0.65	0.518
Estradiol	**0.26**	**[0.01, 0.52]**	**2.09**	**0.039***
Progesterone	−0.002	[−0.03, 0.03]	−0.13	0.897
Estradiol × Progesterone	−0.01	[−0.04, 0.02]	−0.69	0.493
Time of day	−0.00005	[−0.0002, 0.0001]	−0.59	0.553
Time x Estradiol	−0.0002	[−0.0004, −0.00002]	−2.20	0.030*
Sexual availability				
Implicit sexual availability				
Intercept	−0.01	[−0.04, 0.02]	−0.61	0.543
Estradiol	0.01	[−0.02, 0.03]	0.56	0.580
Progesterone	0.002	[−0.03, 0.03]	0.14	0.891
Estradiol × Progesterone	0.02	[−0.01, 0.04]	1.09	0.280
Sociosexual orientation	**0.26**	**[0.11, 0.41]**	**3.53**	**0.001****
Sexy clothes buying intentions				
Intercept	0.07	[−0.12, 0.26]	0.73	0.471
Estradiol	0.02	[−0.12, 0.15]	0.24	0.813
Progesterone	**−0.12**	**[−0.24, −0.01]**	**−2.17**	**0.033***
Estradiol × Progesterone	**−0.16**	**[−0.30, −0.02]**	**−2.35**	**0.022***

Note. † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. CI = 95% confidence interval. Bold face font shows relevant significant predictors. Estradiol and progesterone were *Z*-score standardized. All continuous predictors were grand mean-centered.

dent, meek, hesitant, apathetic, idle, inactive, unconcerned, and scatterbrained.

Participants categorized these words with the same self-words from the sexual availability SC-IAT. Data from two time points were excluded due more than 10% of trials with latencies below 300 ms (Greenwald et al., 2003) and *D* scores were computed as in the sexual availability SC-IAT. Higher *D* scores indicate stronger associations of the self with assertiveness.

2.2.5. Implicit perceived control of one's own actions

Intentional binding tasks measure one's perceived ability to control their own actions and influence events in their external environment respective to one's goals (Moore and Obhi, 2012). Participants listened to a tone, and then pressed a button to stop the tone. The tone stopped after a delay of 100 ms, 400 ms, or 700 ms (randomized across trials) and participants estimated the perceived length of the delay on a 9-point scale (1 = 100 ms, 9 = 900 ms). After six practice rounds, participants completed 20 trials with a break at 10 trials. Perceived delay length was averaged across all 20 trials. Shorter delay estimates indicated higher levels of implicit perceived volitional control; however, we reverse-scored this measure so higher scores indicated higher perceived volitional control.

2.2.6. Self-reported assertiveness

Participants remembered their behavior over the last day or so then indicated the extent to which they (a) affected their environment; (b) efficiently achieved their goals; (c) strived to assert and expand themselves; and (d) relied on others to make plans and decisions (reverse-scored; 1 = not at all, 7 = very much so). Reliability was acceptable and items were averaged ($\alpha = 0.74$).

2.2.7. Mate value

Mate value refers to one's perception of their quality as a mate. In Wave 1, self-reported mate value was measured using a 22-item mate value survey (Fisher et al., 2008; e.g., 'Members of the opposite sex are attracted to me') on a 7-point scale (1 = not at all today, 7 = very much so today; $\alpha = 0.84$). In Wave 2, we measured self-report mate value using a 4-item measure by Edlund and Sagarin

(2014) also on a 7-point scale (e.g., 'Overall, how would you rate your level of desirability as a partner?', 1 = extremely undesirable, 7 = extremely desirable; α = 0.79). Items were averaged.

2.2.8. Sociosexual orientation

Sociosexual orientation refers to the willingness to engage in uncommitted sexual relations (Simpson and Gangestad, 1991). We used the measure by Penke and Asendorpf (2008) which assesses attitudes, behaviors, and desires related to casual sex (e.g., 'sex without love is okay'). Scores were aggregated to form an index of sociosexual orientation ($M = 22.33$, $SD = 11.84$, $\alpha = 0.85$), with higher scores indicating a tendency towards casual sexual encounters.

2.3. Data analysis

2.3.1. Hormone assessment

Progesterone and estradiol samples were stored at −20 °C and analyzed by a professional reference laboratory in Dresden, Germany. After thawing, samples were centrifuged at 3000 rpm for five minutes, which resulted in a clear supernatant of low viscosity. Salivary progesterone and estradiol concentrations were measured using commercially available chemiluminescence-immuno-assays with high sensitivity (IBL International, Hamburg, Germany). Intra- and inter-assay coefficients of variations for both hormones were below 12%.

2.3.2. Main effects of fertility

To investigate the effect of fertility on the dependent variables measured across both waves, we ran a series of repeated-measures ANOVAs with fertility as a repeated effect. We controlled for session 1 fertility as a between-subject factor, as Wave 2 sessions were not counter-balanced by fertility. For the clothing task, we added clothing type (sexy, non-sexy) as a second repeated effect.

2.3.3. Within- and between-women hormone effects

2.3.3.1. Case removal and outliers. We excluded hormone values for one participant due to possible blood contamination in both samples and one participant due to known medication interactions. All outliers for the independent variables above ± 3-*SD*s from the grand mean were winsorised, as were all hormone values above ± 3-*SD*s from the fertility group mean (estradiol) or the cycle phase mean (progesterone; progesterone levels across the follicular phase are low and only rise in the luteal phase; Porerfield and White, 2007, pp. 237–238). Winsorised values equated to a maximum of 2.6% of cases.

2.3.3.2. Normalization of distributions. All independent variables showing significant positive skew were transformed using a logarithmic transformation; skewness statistics are in the electronic Supplementary materials (ESM). Age, sociosexual orientation, and mate value were grand mean centered. We computed a sexy clothes buying intentions score by subtracting non-sexy clothing scores from sexy clothing scores; higher scores represented greater interest in buying sexy versus non-sexy clothing. Estradiol and progesterone were *Z*-score standardized by the grand mean.

2.3.4. Statistical models

We used linear mixed regression models with maximum likelihood estimation in SPSS version 23 to analyze hormone effects. Linear mixed regression models are appropriate for analyzing nested data with correlated error terms (Twisk, 2006, p. 2). In our data, observations were recorded at fertile and non-fertile time points (Level-1) which were nested within women (Level-2). We first tested the fixed zero-order effects of estradiol and progesterone in separate models. We accounted for subject variation by including a random intercept in all models and tested for random regression slopes for all hormones. We determined suitable error covariance matrices for all zero-order models by comparing fit indices and choosing the matrix with the lowest −2 log likelihood ratio, and where relevant, a significant random slope ($p < 0.05$). Zero-order models were inspected for overly influential data points by examining and removing standardized residuals above ± 3. A maximum of 2.7% of data points were removed.

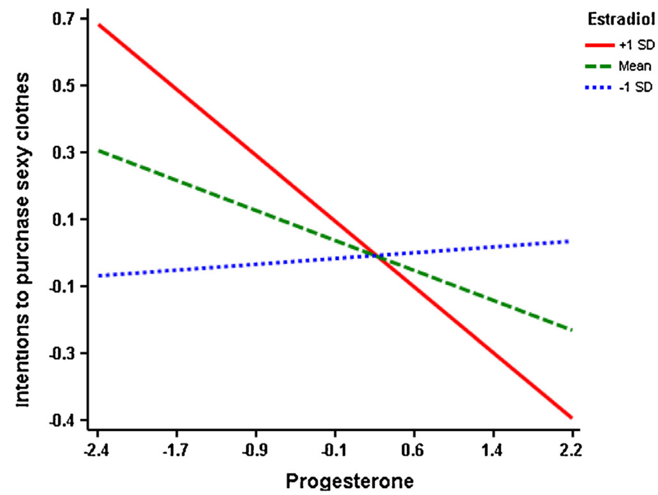

Fig. 1. Interaction effect of estradiol and progesterone on predicted buying intentions for sexy clothes.
Note. SD = standard deviation. The graph plots the effect of estradiol and progesterone on predicted interest in buying sexy versus non-sexy clothes (i.e., the model from Table 2). The effect is significant only when estradiol is high (+1-SD). Both estradiol and progesterone were *Z*-score standardized.

After examining zero-order effects, we entered all hormone values in a combined final model to test the effect of each hormone when the influence of the other hormone was statistically controlled. We again tested and retained random slopes when $p < 0.05$. We also added an estradiol × progesterone interaction term to these final models to account for interaction effects between estradiol and progesterone (Sollberger and Ehlert, 2016). We modelled interaction effects using Interaction Software version 1.7.2211. We did not include the ratio of estradiol to progesterone in these final models due to multicollinearity with other hormone values, $rs \geq 0.80$.

We conducted sensitivity tests examining between-subject individual differences by comparing models with and without the fixed main effects of age, relationship status, mate value, and sociosexual orientation. We also tested the significance of between-session saliva testing confounding variance by comparing models with and without the interaction effect of estradiol or progesterone with hours since waking, time of day, and ethnicity (including the corresponding lower order term). Because interaction terms suffer from reduced statistical power, we retained covariates with p-values < 0.10 (Twisk, 2006). In the event that models yielded multiple covariates, all variables were added to a second model and only retained if p-values were < 0.10. Formal regression equations are in Appendix A and all final combined models with included covariates are in Table 2.

3. Results

3.1. Effects of fertility (Estimated with LH tests)

Table 1 shows the differences between the fertile and non-fertile sessions on the dependent variables measured at both waves. When fertile, women reported behaving more assertively

($p = 0.027$, $\eta_p^2 = 0.05$) and implicitly associated themselves with high sexual availability ($p = 0.005$, $\eta_p^2 = 0.09$) than when not fertile. Fertile women were interested in buying clothing generally ($p = 0.032$, $\eta_p^2 = 0.05$), but fertility-level effects were irrespective of clothing sexiness and not qualified by any interaction effects ($ps \geq 0.329$). When fertile, women reported higher mate value than when not fertile ($p = 0.007$, $\eta_p^2 = 0.07$).

3.2. Hormone models

3.2.1. Self-report assertive behavior

The zero-order effect of progesterone on self-report assertive behavior revealed that self-report assertive behavior was marginally negatively predicted by progesterone, $B = -0.11$, 95% Confidence Interval (CI) [-0.24, 0.02], $t(88.56) = -1.68$, $p = 0.096$, and significantly positively predicted by mate value, $B = 1.25$, CI [1.04, 1.47], $t(90.81) = 11.51$, $p < 0.001$, but not sociosexual orientation ($p = 0.767$) or the zero-order effect of estradiol ($B = 0.07$, $p = 0.198$). When controlling for other hormone predictors, estradiol significantly and positively predicted self-report assertive behavior and progesterone significantly and negatively predicted self-report assertive behavior, see Table 2. Women reported they behaved more assertively when estradiol and mate value were high and progesterone was low.

3.2.2. Implicit perceived volitional control of one's actions

Perceived volitional control of one's actions was positively predicted by estradiol, $B = 0.30$, CI [.11, 0.50], $t(61.52) = 3.13$, $p = 0.003$. Scores were not predicted by the zero-order effect of progesterone, $p = 0.360$, or by mate value or sociosexual orientation ($ps \geq 0.209$). When controlling for all hormone predictors, estradiol retained its significant positive effect, and the effect of progesterone was significant and negative (Table 2). Women implicitly perceived they had more volitional control of their own actions when estradiol was high and progesterone was low.

3.2.3. Implicit assertiveness

Implicit assertiveness was marginally positively predicted by the zero-order effect of estradiol, $B = 0.20$, CI [-0.02, 0.43], $t(90.34) = 1.79$, $p = 0.076$. Implicit assertiveness was not predicted by the zero order effect of progesterone ($p = 0.755$); or by mate value or sociosexual orientation ($ps \geq 0.131$). When controlling for all hormone effects, the effect of estradiol was larger, positive, and statistically significant, see Table 2. Women implicitly associated themselves with high assertiveness as estradiol increased.

3.2.4. Implicit sexual availability

Implicit sexual availability was not predicted by the zero-order effect of estradiol, progesterone, or by mate value ($ps \geq 0.266$), but was positively predicted by sociosexual orientation, $B = 0.25$, CI [.11, 0.39], $t(68.68) = 3.51$, $p = 0.001$. No hormone value was significant when controlling for the effect of the other hormone (see Table 2).

3.2.5. Interest in buying sexy clothes

Interest in buying sexy versus non-sexy clothing was negatively predicted by the zero-order effect of progesterone, $B = -0.16$, CI [-0.26, −0.05], $t(76.68) = -2.96$, $p = 0.004$. Interest in buying sexy clothes was not predicted by the zero-order effect of estradiol ($p = 0.370$), or by mate value or sociosexual orientation ($ps \geq 0.432$). However, estradiol and progesterone interacted to predict buying interest in sexy clothes, see Table 2. Estradiol modulated the relationship between progesterone and sexy clothes buying interest: When estradiol was low, progesterone did not predict buying interests ($p = 0.826$). However, when estradiol was high, progesterone negatively predicted buying interests, $B = -0.24$, CI [-0.44, −0.04], $t(110) = -2.40$, $p = 0.018$. Women were more interested in buying sexy clothes only when progesterone was low and estradiol was high, see Fig. 1.

3.3. Relationship between assertiveness and sexual availability

To determine whether the associations between high estradiol, low progesterone, and high assertiveness were related to women's mating goals, we analyzed partial correlations between assertiveness and sexual availability controlling for Time 1 versus Time 2. Self-reported assertive behavior positively correlated with interest in buying sexy clothes, $r_{partial}(115) = 0.26$, $p = 0.005$, and with implicit sexual availability, $r_{partial}(115) = 0.19$, $p = 0.038$. Neither implicit assertiveness measure correlated with interest in buying sexy clothes or sexual availability, $ps \geq 0.222$.

4. Discussion

We examined whether women were more assertive when they were fertile and whether this relationship was associated with fluctuating estradiol and progesterone. We also investigated whether fertility-induced high assertiveness corresponded with sexual motivation. Consistent with the fertility-assertiveness hypothesis, women were more assertive and sexually available when they were fertile compared with non-fertile. Fertile women were also more interested in buying clothes. Further analyses revealed that most of these effects were positively associated with high estradiol and low progesterone, a hormonal profile reflective of high fertility. When estradiol was high and progesterone was low, women reported behaving more assertively, demonstrated more implicit assertiveness, and associated themselves with high assertiveness words. High estradiol and low progesterone also positively correlated with greater interests in buying sexy versus non-sexy clothes.

Results held when controlling for mate value, sociosexual orientation, ethnicity, age, and relationship status. We also found that self-reported assertiveness and sexual availability were positively correlated. These findings suggest that fluctuating ovarian hormones affect assertiveness and sexual availability in women. High assertiveness during the fertile window may be a psychological adaptation that promotes mate selectivity when conception risk is highest.

4.1. High estradiol and low progesterone predict high assertiveness

The current work investigated women's assertiveness using three novel measures. Self-reported assertiveness incorporated theoretical conceptualizations of assertiveness and required participants to reflect on their assertive behavior. The assertiveness SC-IAT measured implicit associations between the self and assertiveness. IATs are an appealing measurement tool because they do not require introspective self-awareness (Greenwald et al., 2002). The intentional binding task measured participants' perceived volitional control of their actions and their perceived ability to influence the environment with respect to their goals (Moore and Obhi, 2012). Because the SC-IAT and intentional binding task were implicit, they were less affected by task demands and expectations than the self-report assertiveness measure (Wilson and Dunn, 2004).

Consistent with the fertility-assertiveness hypothesis, estradiol was positively associated with all of the assertiveness outcomes. This finding is consistent with work suggesting that estradiol is positively associated with characteristics related to assertive behavior (Hromatko et al., 2008; Stanton and Schultheiss, 2007; Ziomkiewicz et al., 2012). Low progesterone was also negatively correlated with two of the three assertiveness measures. These findings suggested that women experience generally greater assertiveness when estradiol is high and progesterone is low, a pattern of hormones reflective of the period of high fertility. Positive correlations between assertiveness and sexual availability further suggested that fertility-influenced high assertiveness may be sexually motivated.

The fertility-assertiveness hypothesis proposes that high assertiveness during the fertile window may confer women increased reproductive success. High assertiveness is relevant to asserting one's wishes, making decisions, and influencing one's external environment. Exhibiting more assertiveness when fertile could thus facilitate women approaching and discerning the quality of potential mates, as well as making their own mate preferences known. In this sense, high assertiveness during the fertile window may promote mate selectivity and safeguard against indiscriminate mate choice when conception risk is highest. Such a notion is consistent with past research suggesting that women reduce behaviors which could limit their ability to actively choose mates when they are fertile (Bröder and Hohmann, 2003; Guéguen, 2012).

Fertility-influenced increases in assertiveness may also provide some protection against unwanted sexual advances. Sexual selection theory emphasizes that some mating strategies are conditional on the costs and benefits associated with enacting a particular strategy in a particular situation. For example, men may be more likely to coerce or exploit women into having sex when the costs are low and the benefits are high (Buss and Duntley, 2008). By exhibiting more assertiveness when fertile, women may be perceived as harder to cajole, more able to resist unwanted sexual advances, and more likely to seek retribution for sexual transgressions. Consistent with this notion, recent evidence demonstrates that men perceive that women are harder to sexually victimize when they possess high assertiveness qualities (Blake et al., 2016a).

4.2. Ovarian hormones and sexual availability

Fertility level effects indicated that women were more interested in buying clothing when they were fertile, irrespective of whether the clothing was sexualized or not. This finding is consistent with research suggesting that fertile women show increased interest in adornment and elevating their attractiveness (Durante et al., 2008; Saad and Stenstrom, 2012), yet inconsistent with past work suggesting that women wear more provocative or revealing clothing during the *peri*-ovulatory phase of the menstrual cycle (Durante et al., 2011; Haselton et al., 2007). Further investigation revealed that although there was no group level effect for clothing type, interests in buying sexy versus non-sexy clothes specifically increased in participants with high estradiol and low progesterone. These hormone effects extend past research showing a positive association between fertility and interest in provocative or revealing clothing (Durante et al., 2011; Haselton et al., 2007) by suggesting that one mechanism underlying this relationship is high estradiol and low progesterone.

Implicit associations between the self and high sexual availability increased when women were fertile and positively correlated with sociosexual orientation. These findings are consistent with studies showing that fertile compared to non-fertile women are more interested in attracting mates and are more sexually motivated. For example, fertile women exhibit increased attractiveness via appearance styling (Schwarz and Hassebrauck, 2008), are more flirtatiousness (Cantú et al., 2014), and have greater courtship intentions (Durante and Li, 2009; Pillsworth and Haselton, 2006). Studies frequently show that fertile women are perceived as more attractive to others (Havlíček et al., 2006; Puts et al., 2013). These past findings are consistent with the present findings showing that women's implicit sexual availability was greater when they were fertile.

4.3. Limitations

The fertility-assertiveness hypothesis suggests that fertility-induced high assertiveness supports women's mating goals. We interpret the main finding—that women are more assertive when fertile—as consistent with the notion that high assertiveness during peak fertility supports women's mate selectivity. We believe this interpretation is a parsimonious framework for our findings because a core component of assertiveness is to assert one's desires to achieve intended outcomes. We acknowledge, however, that we did not measure mate selectivity in the current study and that this interpretation is theoretical. Fertility-induced high assertiveness may facilitate other mating-relevant behaviors, such as the ability to assert one's mate value in intrasexually competitive environments.

Although we found that women were more sexually open when fertile, this effect was not correlated with ovarian hormone concentrations. This null result is surprising because estradiol is associated with increased sexual motivation in women (Roney and Simmons, 2013) and with increased sexual functioning, either uniquely or in concert with testosterone (e.g., Alexander et al., 2004; Sherwin et al., 1985). The relationship between estradiol and sexual functioning is similarly documented in primate species whose ovarian function is comparable to humans (Wallen et al., 1984). That neither estradiol nor progesterone predicted implicit sexual availability associations is inconsistent with these past results.

It is possible that limitations of the timing of our hormone sampling precluded the detection of increased sexual availability. Roney and Simmons (2013) found that current day sexual desire was predicted by estradiol and progesterone measured on days prior to the current day. By only measuring current day estradiol and progesterone, our saliva sampling schedule may have precluded capturing the relationship between ovarian hormones and implicit sexual availability. The sexual availability SC-IAT may have also measured trait- and not state-dependent sexual availability. The strongest predictor of sexual availability was sociosexual orientation, which shows good test-rest reliability over a one-year period (Penke, 2011). Investigations with alternate measures of sexual motivation, and with other hormones (e.g., testosterone) would be informative. Although evidence linking testosterone and women's sexual functioning is mixed (Alexander et al., 2004; Sherwin, 1991), testosterone is implicated in women's intrasexual competitiveness (Hahn et al., 2016). We cannot rule out the possibility that testosterone influenced our dependent measures.

Although assertiveness findings were relatively convergent across measures, we did not measure actual behavior. One potential criticism is that the assertiveness measures may not adequately reflect women's actual behavior. We address this limitation by highlighting that the assertiveness measures comprised self-report assertiveness, an assertiveness SC-IAT, and an intentional binding task. A *meta*-analysis of 122 research reports demonstrates that IATs are good predictors of behavior in socially sensitive contexts, but that explicit measures may predict actual behavior more accurately when contexts are not socially sensitive (Greenwald et al., 2009). Whether participants considered their assertive behavior to be a socially sensitive matter is unclear, but in either case, the SC-IAT and self-reported assertiveness measures yielded generally convergent findings. Further, the intentional binding effect is dissociable from subjective experience and is associated with shifts in actual behavior (Moore and Obhi, 2012). That both self-report assertiveness and the intentional binding findings yielded convergent results strengthens the notion that our assertiveness measures were a good proxy for behavior.

Although self-report assertiveness positively correlated with sexual availability and interest in buying sexy clothes, we did not find the same pattern of results for the other assertiveness measures. This result may be because the self-report assertiveness measure was explicit whereas the other two measures were implicit. It is not unusual for implicit and explicit measures to produce contrasting findings (Nosek, 2007). Sexual availability may have a greater effect on explicit and consciously accessible assertiveness constructs than assertiveness measured at the implicit level. Future work may wish to investigate this possibility.

4.4. Future directions

Future research investigating associations between fertility-induced high assertiveness and intrasexual competitiveness would be informative. Hormonal changes associated with fertility are implicated in women's interest in holding high status positions over other women (Durante et al., 2014) and female intrasexual competition (Durante et al., 2008, 2011). Fertility-induced high assertiveness may facilitate these behaviors and women's status-seeking generally. Such an account is consistent with research suggesting that women in the follicular phase of the menstrual cycle are more sensitive to social signals and interactions that might enhance mating success (Macrae et al., 2002). Process evidence examining what fertility-induced high assertiveness facilitates is an important future direction for the current findings. We expect that fertility-induced high assertiveness confers women a range of reproductively-relevant benefits.

Assertiveness and interest in buying sexy clothing may also be affected by women's mood. There is a consistent pattern of observable fluctuation in mood across the female reproductive cycle, with increased progesterone and allopregnanolone (a metabolite of progesterone) linked to cyclic negative mood in certain women (Andréen et al., 2009). Assertiveness and interest in wearing or buying sexy clothes may be reduced when women feel worse. Alternatively, women may be less interested in clothes that are provocative when mood is low. Future research investigating assertive dispositions and motivations for wearing sexualized clothing while controlling for women's mood would be informative.

Our findings raise the possibility that hormonal contraceptives which reduce estrogens and increase progesterone may reduce women's assertiveness. Likewise, by increasing estrogens, hormone replacement medication may increase feelings and expressions of high assertiveness. Adverse increases and decreases in assertiveness may also occur alongside the rapid rises and drops in estrogens associated with declining ovarian function throughout menopause. These unexamined notions highlight the paucity of research on endogenous ovarian hormones and women's social behavior. Although these proposed effects may be small and our own work warrants replication, future work could promote knowledge in this area.

4.5. Conclusion

Results support the fertility-assertiveness hypothesis, whereby women exhibit more assertiveness when estradiol is high and progesterone is low (i.e., when they are fertile). Women are more sexually motivated when fertile and interested in buying sexy clothes when high estradiol is combined with low progesterone. These findings suggest that high assertiveness in women is influenced by ovarian hormones and associated with high sexual motivation. High assertiveness during fertile periods may be a psychological adaptation that supports women's mate selectivity and protects against unwanted sexual advances.

Role of funding source

Preparation of this manuscript was supported by a *Future Fellowship* (FT140100291) from the Australian Research Council to Thomas Denson. Khandis Blake was supported by an *Australian Postgraduate Award*. The funding bodies had no further role in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Acknowledgements

We thank Zoe Menczel-Schrire and Hanan Youssef for their help collecting data for this project.

Appendix A.

An example of a formal regression equation for the mixed model is as follows:

Level 1 equation:

$$\text{BuyingInterests}_{ti} = \pi_{0i} + \pi_1 \text{estradiol}_{ti} + \pi_2 \text{progesterone}_{ti} + \pi_3 \text{estradiol}_{ti} * \text{progesterone}_{ti} + \varepsilon_{ti}$$

Level 2 equations:

$$\pi_{0i} = \beta_{00} + u_{0i}$$

$$\pi_1 = \beta_{10+} u_{1i}$$

$$\pi_2 = \beta_{20}$$

$$\pi_3 = \beta_{30}$$

So that:

Buying Interests$_{ti}$ = β_{00} + β_{10}estradiol$_{ti}$ + β_{20}progesterone$_{ti}$ + β_{30}estradiol$_{ti}$*progesterone$_{ti}$ + u_{0i} + u_{1i}estradiol$_{ti}$ + ε_{ti}Where

β_{00} = Interceptforbuyinginterests

β_{10} = Regressionslopeforestradiolattime$t$forperson$i$

β_{20} = Regressionslopeforprogesteroneattime$t$forperson$i$

β_{30} = Regressionslopeforestradiol $*$ progesteroneattime$t$forperson$i$

u_{0i} = Varianceofinterceptforbuyinginterestsforperson$i$

u_{1i} = Randomregressionslopeforestradiolforperson$i$

ε_{ti} = Errorterm(residual)associatedwithtime$t$forperson$i$

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