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Hormones and Borderline Personality Features

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Abstract

Borderline personality is diagnosed in clinical settings three times more often in women than in men, and symptom severity in women appears sensitive to circulating sex steroid levels. In non-human mammals, prenatal hormones contribute to the development of sex-linked behavior and their responsiveness to postnatal hormones. Therefore, this study examined the hypothesis that prenatal hormones may influence the development of borderline personality traits by measuring a marker of perinatal androgen action, the 2D:4D ratio, and salivary hormone levels in 58 men and 52 women. Participants completed the Borderline Features Subscales (BOR) of the Personality Assessment Inventory, gender role questionnaires, and four sex-linked cognitive tasks. Digit ratios were a significant predictor of the affective component of borderline personality, such that in both sexes 2D:4D ratios suggestive of weaker perinatal androgen action contributed to greater borderline personality features overall and greater affective instability. In addition, women reporting greater affective instability showed larger changes in estradiol across the session, consistent with the influence of stress and emotional reactivity on hormonal function. These findings are consistent with an increasing body of research suggesting that hormonal factors associated with the expression of typical gender-linked behavior may also contribute to the expression of gender-linked maladaptive behavior.

1. Introduction

Hormonal factors in prenatal life promote the sexual differentiation of the mammalian brain and the expression of sex-linked reproductive and social behavior, such that higher levels of androgens in prenatal life are associated with the expression of more male-typical behavior across a variety of species (Breedlove et al., 1999). In humans, increasing evidence indicates that prenatal hormones also contribute to the behavioral variability between (and within) the sexes and the subsequent responsiveness of some behaviors to fluctuations in postpubertal sex steroid levels (Collaer & Hines, 1995). Although most research on human behavior has focused on the role of hormones in normative behavior that differ between the sexes (e.g., sexual behavior, social play, and cognitive abilities), the expression of maladaptive gender-linked traits may also be influenced by the sexual differentiation of brain systems that regulate social and cognitive behavior (for review, see Alexander & Peterson, 2001; Morey, Alexander, & Boggs, 2005).

Findings from research on the 2D:4D ratio, a phenotypic trait that appears sensitive to the degree of perinatal androgen action (for review, see McIntyre, 2006), are consistent with that hypothesis. For example, smaller 2D:4D ratios (i.e., stronger perinatal androgen action) have

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been observed in individuals with male-linked disorders, including autism and childhood hyperactivity (Manning, Baron-Cohen, Wheelwright, & Sanders, 2001; Williams, Greenhalgh, & Manning, 2003). In contrast, larger 2D:4D ratios (indicative of more female-typical levels of prenatal hormones) have been observed in individuals with female-linked disorders or related traits, including depression and eating disorders (Bailey & Hurd, 2005; Klump et al., 2006)

Borderline personality is a disorder diagnosed in clinical settings three times more commonly in women than in men (American Psychiatric Association, 2000). Borderline personality traits in women also worsen following oral contraceptive use and during phases of the menstrual cycle marked by increasing estrogen levels (De Soto, Geary, Hoard, Sheldon, & Cooper, 2003). Together, these findings suggest that early sexual differentiation of the brain may contribute to the expression of borderline personality in women and men. To investigate the possibility that perinatal hormones influence the pathogenesis of borderline personality, the association between digit ratios and features of borderline personality was measured in women and men. As borderline personality has been described as an extreme form of gendered behavior (Skodol, 2000) and gender role measures have been previously associated with prenatal hormones (Collaer & Hines, 1995), the present study also considered the relations among borderline personality and measures of sex-linked social and cognitive behavior. Specifically, it was hypothesized that larger (i.e., more female-typical) digit ratios and more female-typical gender role behavior would be associated with higher scores on a measure of borderline personality.

2. Methods

2.1. Participants

Fifty-eight men and 52 women were recruited from introductory psychology courses or from the university community¹. All participants provided informed consent and received \$15 (or partial course credit when appropriate) after completing the protocol that was approved by the Institutional Review Board for research on human subjects.

2.2. Measures and Procedures

2.2.1 Behavioral Measures—All participants were tested individually in a session lasting approximately 90 minutes. Borderline personality features were assessed using the Personality Assessment Inventory (PAI; Morey, 1991), which includes four subscales (24 items total) measuring affective instability (BOR-A), identity problems (BOR-I), negative relationships (BOR-N), and self-harm (BOR-S). Although no sex differences in this measure were found in the normative sample of the PAI (Morey, 1991), the apparent sensitivity of this measure to hormone levels in women (De Soto et al., 2003) suggests that the BOR scales may be sensitive to other hormonal factors.

The Bem Sex-Role Inventory (BSRI; Bem, 1981), the Pre-School Activities Inventory (PSAI; Golombok & Rust, 1993), and the Occupation, Activities, and Traits-Attitudes and Personal Measure (OAT-AM and OAT-PM; Liben & Bigler, 2002) measured typical gender role behavior. Briefly, the BSRI consists of 60 items and two scales measuring psychological masculinity (e.g., “independent” and “assertive”) and femininity (“affectionate” and “soft-spoken”), such that higher scores on a scale indicate a stronger endorsement of that personality dimension. The PSAI is a 24-item retrospective measure of gender-linked activity preferences (e.g., played with “guns” or “dolls,” “played house,” “enjoyed rough and tumble play”), such

¹Of these, 4 men and 9 women were unable to complete the entire test battery (some gender-role and psychopathology measures were initially unavailable) and so a subset of the data analyses was conducted on the smaller number of participants.

that higher scores on this measure indicate stronger male-typical play preferences and lower scores indicate stronger female-typical play preferences. The OAT-AM and OAT-PM each consist of three, 25-item scales measuring the strength of gender-linked attitudes and behaviors with regards to occupational interests (e.g., “engineer” and “secretary”), involvement in activities (e.g., “ride a motor cycle” and “bake cookies”), and personality characteristics (e.g., “enjoys science” and “emotional”).

Participants also completed (in a randomized order) two cognitive tasks that show a small or moderate female advantage (location memory and spatial working memory) and two cognitive tasks that show a large male advantage (mental rotation and targeting). The Silverman and Eals Location Memory Task (Silverman & Eals, 1992) consists of a stimulus card displaying 27 common objects and two response cards measuring object identity and location memory, respectively. Participants are given the stimulus card and allowed one minute to study the objects. After time has elapsed, they are given the first response card, which displays the 27 original objects and 20 new objects, and are asked to identify the added items. A second response card, displaying the 27 original objects but exchanging the positions on seven pairs of objects, measures the ability to identify objects that have changed spatial location. The other female-advantage task was the spatial working memory task (Duff & Hampson, 2001), a measure similar to the card game “Memory.” Participants are required to locate pairs of colored dots dispersed in a 5 × 4 wall-mounted array.

The Re-Drawn Vandenberg and Kuse Mental Rotations Test (MRT-A; Peters et al., 1995; Vandenberg & Kuse, 1978) consists of 24 items displaying a sample block design and four possible response choices. Participants are asked to identify the two responses that are rotated representations of the sample figure within the imposed time constraints (3 min. per 12 test items separated by a 2 min. rest interval). Targeting was measured by the ability to throw a small ball at a target located 10 ft. away (Watson & Kimura, 1991). The distance from the center for each of 10 trials was averaged to yield an accuracy score. All tasks were administered and scored according to the procedures described in the previous research.

2.2.2 Hormone Indicators—Digit ratios were obtained by measuring with digital vernier calipers the lengths of the index and ring finger (in millimeters from the basal crease to the tip of the finger) from digitally scanned images of the right hand. Finger lengths were averaged across two judges' measurements (which showed excellent rater agreement, $rs > .93$).

Estradiol (in women) and testosterone (in women and men) levels were measured in saliva samples collected at the beginning and end of test sessions. Participants (who avoided alcohol, dental work for 24 hours pre-testing, and eating or brushing their teeth for 3 hours pre-testing) passively drooled into a small vial. Saliva samples (< 15 mL) were then stored at -80° C. Samples were shipped overnight on dry ice to Salimetrics Inc. (State College, Pennsylvania), where hormone levels were measured in duplicate using enzyme immunoassays. Women not taking oral contraceptives ($n=35$) also provided information about their cycle length and last menstruation. For these individuals, testing was determined to have occurred in the follicular phase for 17 women and in the luteal phase for 18 women.

2.3. Results

2.3.1 Sex Differences—Men and women were similar in age (Men: $M = 19.67$ years, $SD = 1.85$, range = 18-26 vs. Women: $M = 20.69$ years, $SD = 6.12$, range = 18-50 years). The group of women included three much older individuals and so the data were re-analyzed without those participants. In all instances, the exclusion of the three women from the data analyses produced only a small increment in the magnitude of the effects reported below.

The expected sex differences in gender role behavior, spatial ability, and hormone levels were generally confirmed in this research (these data are available on request). To summarize, men compared to women endorsed more male-typical childhood activities on the PSAI, $F(1, 93) = 252.574, p < .001$, more male-typical attitudes and behavior on the OAT-PM, $F(1, 93) = 17.515, p < .001$, the OAT-AM, $F(1, 93) = 13.018, p < .001$, and the BSRI masculine scale, $F(1, 93) = 5.506, p < .025$. Women endorsed more female-typical behavior on the OAT-PM, $F(1, 93) = 64.843, p < .001$, and the BSRI feminine scales, $F(1, 93) = 18.402, p < .001$. Men also performed significantly better than women on the two spatial/cognitive tasks traditionally showing a large (Cohen's $d > .80$; Cohen, 1977) male advantage: mental rotation, $F(1, 101) = 29.320, p < .001$, and targeting, $F(1, 101) = 52.871, p < .001$. Women showed the expected smaller ($d < .30$) and non-significant advantage on the two traditionally female-linked spatial/cognitive tasks: spatial location memory, $F(1, 74) = .029, ns$, and spatial working memory, $F(1, 101) = 1.873, ns$. Also as expected, men had significantly higher levels of salivary testosterone, $F(1, 104) = 75.926, p < .001$, and had smaller digit ratios than women. However, the sex difference in 2D:4D ratio did not reach statistical significance, $F(1, 108) = 2.096, ns$, (Women: $M = .97, SD = .03$, vs. Men: $M = .96, SD = .03, d = .28$).

2.3.2 Multivariate Analyses—As expected, men and women did not differ in overall borderline symptoms, $F(1, 93) = .579, ns$, affective instability, $F(1, 93) = .114, ns$, negative relationships, $F(1, 93) = 2.737, ns$, identity conflict, $F(1, 93) = .315, ns$, or self-harm, $F(1, 93) = .205, ns$, (Table 1). To evaluate digit ratio effects on borderline personality, men and women were divided into high versus low digit ratio groups. Groups were created by a median split within each sex and resulted in 46 “feminine” 2D:4D individuals (27 men and 19 women) and 51 “masculine” 2D:4D individuals (27 men and 24 women). Multivariate Analysis of Variance (MANOVA) with the PAI Borderline Subscales as the dependent variables and sex (men vs. women) and digit ratio (feminine vs. masculine) as factors showed again no effects of sex on borderline symptoms. However, that analysis did show an effect of digit ratios on symptom scores in both women and men. More specifically, a significant main effect of digit ratio was found for the BOR-full scale, $F(1, 93) = 4.356, p < .05$, and the BOR-A subscale, $F(1, 93) = 9.371, p < .01$, of the PAI. Larger digit ratios compared to smaller, more masculine digit ratios were associated with greater borderline personality characteristics overall ($M = 51.86, SD = 12.01$ vs. $M = 47.33, SD = 9.21, d = .42$) and greater affective instability ($M = 52.70, SD = 11.57$ vs. $M = 46.15, SD = 9.21, d = .63$). A similar but non-significant trend was found for the BOR-N subscale, $F(1, 93) = 3.530, p < .10$, ($M = 51.92, SD = 12.74$ vs. $M = 47.91, SD = 9.71, d = .35$).

2.3.3 Correlational Analyses—Correlations between measures of borderline traits and digit ratios are reported in Table 1. Five women did not provide amounts of saliva sufficient to permit measurement of estradiol at the two time points. However, on average, salivary measures of hormones did not vary across time 1 and time 2 in women (Estradiol: $F(1, 46) = 2.304, ns$; Testosterone: $F(1, 49) = 1.118, ns$) and men (Testosterone: $F(1, 57) = .931, ns$) and no significant associations were found between average estradiol or testosterone levels and borderline scores in either women or men (i.e., all $r_s < .20$). In contrast, correlations between residualized change scores in estradiol levels in women from time 1 to time 2 were significantly correlated with scores on the BOR-A subscale, $r(38) = .39, p = .01$.

2.3.4 Hierarchical Regression Analyses—Two separate hierarchical regression analyses were conducted using the two scales that appeared most sensitive to digit ratios (i.e., the BOR-full scale and the BOR-A subscale). For each model, the BSRI masculine and feminine scales were entered at the first step, cognitive abilities showing the largest sex differences (i.e., mental rotation and targeting scores) were entered at the second step, 2D:4D ratio and testosterone levels were entered at the third step, and sex was entered at the fourth

step. Hormone measures and sex were entered last to determine if they added any significant contribution to scale scores beyond measures of sex-linked behavior. Results of these analyses showed that the variance in the BOR-full scale could not be significantly accounted by any of the four models or predictor variables. However, the variance in BOR-A scores was associated with the 2D:4D ratio. At the first step, the BSRI masculine and feminine scales accounted for a small but non-significant portion of the variance in affective instability scores, $F_{change} = 1.482$, $R^2 = .031$, *ns*. At the second step, addition of mental rotation and targeting performance did not significantly improve the model, $F_{change} = 1.382$, $R^2 = .060$, *ns*. However, inclusion of hormonal measures at the third step produced a near-significant F_{change} , $F_{change} = 2.780$, $R^2 = .116$, $p < .10$. Examination of individual beta weights suggests that digit ratio, $\beta = .244$, $p < .025$, is significantly contributing to the variance in BOR-A scores. Finally, the addition of sex at the fourth step did not significantly improve the model, $F_{change} = .093$, $R^2 = .117$, *ns*. Results are summarized in Table 2.

3. Discussion

In this study, digit ratios suggestive of weaker perinatal androgen action (McIntyre, 2006) were associated with greater borderline symptoms overall and greater affective instability. The analysis of the relative contribution of gender-linked cognitive and social behavior to symptom scores found the proxy measure of perinatal androgen action to be the only significant predictor of the affective component of borderline personality. Further, consistent with previous research showing an association between changing estrogen levels and borderline personality traits in women (DeSoto et al., 2003), greater change in salivary estradiol was observed in women reporting greater affective instability on the PAI. The general results of this investigation, therefore, support the hypothesis that hormonal factors are associated with borderline personality features and provide preliminary support for the role of hormones in the expression of maladaptive behavior in women and men.

Hormonal effects are thought to be most evident on behaviors that show reliable sex differences (Collaer & Hines, 1995). Although we found an association between more female-typical digit ratios and borderline personality traits, no sex differences in borderline personality scale scores were observed in this investigation or in prior research on the PAI (Morey, 1991). Significantly, in some previous research on digit ratios and psychopathology similar associations between digit ratios and behaviors not strongly associated with sex or gender have been observed. Larger (i.e., more female-typical) 2D:4D ratios, for example, have been found in individuals with schizophrenia (Arato, Frecska, Beck, An, & Kiss, 2004), a disorder thought to be either more prevalent in men or showing equal prevalence rates in men and women. Similarly, adolescent boys with schizotypal personality have larger digit ratios relative to unaffected individuals (Walder, Andersson, McMillan, Breedlove, & Walker, 2006).

It may be important in reconciling these paradoxical findings with current understandings of hormone-behavior relations that the digit ratio effects documented in this study were most apparent on the affective component of borderline personality. Emotional processing shows a female advantage in children and adults (McClure, 2000). Further, compared to the other features of borderline personality (negative relationship, impulsivity/self-harm, and identity conflict), mood dysregulation is most closely related to affective traits associated previously with more female-typical digit ratios, including neuroticism, depression, and anxiety (Bailey & Hurd, 2005; Fink, Manning & Neave, 2004). Therefore, it is possible that any influence of prenatal hormones on borderline personality may be driven primarily by an atypical sexual differentiation of brain regions integral to mood and behavioral regulation (e.g., the amygdala and hypothalamus). This speculation is supported by other research showing that sex-specific patterns of activation occur in the amygdala following exposure to emotional stimuli (Cahill et al., 2001; Canli, Desmond, Zhao, & Gabrieli, 2002; Killgore & Yurgelun-Todd, 2001) and

recent evidence that borderline personality is associated with an altered brain morphology in systems for emotional processing, including the amygdala (Schmahl & Bremner, 2006).

The proposed relationship between hormone levels and emotional processing in borderline personality is also supported by other findings from this investigation showing that the measure of within subject change in estradiol levels across the test session showed a positive association with scores on the PAI measure of affective instability. This association is consistent with other research (DeSoto et al., 2003) suggesting that measures of hormonal change but not absolute levels of circulating hormone levels are related to symptom ratings in women. In the earlier report, measures of hormonal change from week 1 to week 2 of the menstrual cycle, a time of follicular development and increasing estrogen levels, were associated with higher symptoms scores on the PAI. These findings suggested that women with borderline personality may be adversely affected by changes in estrogen levels, a possibility consistent with estrogen modulation of neurotransmitter systems and brain areas implicated in that disorder (McEwen, 2001). In the present investigation, measures of borderline personality features were obtained prior to the documented hormonal change that followed a relatively short period of behavioral and cognitive testing (90 mins). If behavioral testing is indeed a social stressor, then we speculate that the responsiveness of the hypothalamic-pituitary-axis to stress (Ferin, 1999) may be exaggerated in women with affective instability. If so, then women with borderline personality relative to unaffected women would experience more variability in gonadal steroid secretion in response to stressors and ultimately greater disruption in reproductive function, as measured by cycle irregularity, abnormal luteal phase, and infertility (Champagne, 2006). Our findings suggest that it may be informative in future research on hormones and personality to include such measures of women's reproductive function.

In general, the results of the present study suggest a relationship between hormonal factors and affective instability associated with borderline personality, as measured by the PAI. However, it should be noted that the sample of women and men in this research were generally young and healthy, variables that could potentially influence the interpretation of the results. Further, although the magnitude of the effects of dichotomized digit ratios on symptom scales were moderate and consistent with the results of the regression analysis using continuous data, it is possible our methods resulted in some spurious significance. A stronger test of the proposed relations between hormones and affective processing in borderline personality will require replication in research measuring hormonal factors, reproductive function, and sex-linked emotional processes across reproductive development in individuals from a variety of clinical populations.

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Table 1
Mean Scores (*SD*) on Measures of Borderline Personality in Women and Men

Measure	Correlations with Digit Ratio	Means		Effect Size
		Men (n = 54)	Women (n = 43)	
BOR Scale	$r = .206^*$	48.85 (11.08)	50.27 (10.54)	$d = .13$
BOR – Affective Instability	$r = .268^*$	49.10 (10.77)	49.45 (11.09)	$d = .03$
BOR – Negative Relationships	$r = .148$	48.25 (10.46)	51.76 (12.27)	$d = .31$
BOR – Identity Conflict	$r = .172$	46.15 (10.54)	47.20 (10.32)	$d = .10$
BOR – Self-harm	$r = .020$	53.87 (8.68)	53.17 (8.55)	$d = .08$

Note. BOR = Borderline Features Scale of the Personality Assessment Inventory.

*
 $p < .05$.

**
 $p < .01$.

Table 2

Hierarchical Regression Analysis Exploring the Contribution of Gender Role Measures, Spatial Ability, Hormone Levels, and Sex to Scores on the Borderline Personality-Affective Instability Subscale of the PAI

Step and Independent Variable	<i>B</i>	<i>SE B</i>	<i>β</i>
Step 1			
BSRI masculine scale	-1.46	1.44	-.10
BSRI feminine scale	-2.42	1.66	-.15
Step 2			
BSRI masculine scale	-1.15	1.45	-.08
BSRI feminine scale	-3.25	1.74	-.20
Mental Rotation	-.26	.25	-.12
Targeting	.37	.46	.09
Step 3			
BSRI masculine scale	-.53	1.48	-.04
BSRI feminine scale	-3.28	1.74	-.20
Mental Rotation	-.29	.25	-.13
Targeting	.20	.48	.05
2D:4D	78.84	33.56	.24*
Average Testosterone	.00	.02	-.004
Step 4			
BSRI masculine scale	-.59	1.50	-.04
BSRI feminine scale	-3.15	1.80	-.20
Mental Rotation	-.31	.26	-.14
Targeting	.27	.53	.07
2D:4D	78.92	33.73	.24*
Average Testosterone	-.003	.02	-.02
Sex	-1.13	3.71	-.05

Note. BSRI = Bem Sex-Role Inventory.

$R^2 = .031$ for Step 1 (*ns*); $\Delta R^2 = .029$ for Step 2 (*ns*); $\Delta R^2 = .056$ for Step 3 ($p < .10$); $\Delta R^2 = .001$ for Step 4 (*ns*).

* $p < .05$.