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## **Dopamine and Norepinephrine Responses to Film-Induced Sexual Arousal in Sexually Functional and Sexually Dysfunctional Women**

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*This study was designed to assess potential differences between sexually functional and dysfunctional women in dopamine (DA) and norepinephrine (NE) responses to erotic stimuli. Blood levels of homovanillic acid (HVA; the major metabolite of DA) and NE were taken during the showing of a nonsexual and a sexual film from 9 women with female sexual arousal disorder and hypoactive sexual desire disorder and from 13 sexually functional women. We assessed sexual arousal subjectively using a self-report scale and physiologically using a vaginal photoplethysmograph. HVA levels significantly decreased in sexually functional and dysfunctional women during the erotic versus during the neutral film. NE levels were not significantly different for either group of women during the neutral and erotic films. Sexually dysfunctional women had significantly higher levels of NE during both the neutral and erotic films compared with functional women. Subjective or physiological arousal differences between neutral and erotic films were not significantly different between functional and dysfunctional women.*

Dopamine (DA) and norepinephrine (NE) are neurotransmitters implicated in the female sexual response. Although comparatively little data exists on their role in female versus male sexual function, a growing literature suggests that these transmitters play a prosexual role in female sexuality.

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Evidence for a facilitatory effect of DA on female sexual behavior comes from an isolated case report of increased sexual behavior noted in a woman receiving levodopa/carbidopa (drugs that increase DA) treatment for Parkinson's disease (Uitti et al., 1989) and from reports of delayed or inhibited orgasm in women receiving antipsychotic medications that decrease DA activity (e.g., trifluoperazine, fluphenazine, thioridazine; see, e.g., Shen & Sata, 1990). Segraves et al. (2001) noted an increase in sexual desire among women with hypoactive sexual desire disorder (HSDD) treated with the dopamine reuptake inhibitor bupropion (150 mg/day for 1 week, followed by 300 mg/d for 7 weeks) after they failed to respond to placebo. Consistent with this finding, using a double-blind, placebo-controlled study design, Segraves, Clayton, Croft, Wolf, and Warnock (In press) reported significant increases in sexual desire, arousal, and orgasm after 4 weeks' treatment with bupropion among 76 women with HSDD.

Animal studies suggest dopamine may also impact sexual responding at a peripheral level. Tarcan, Siroky, Park, Goldstein, and Azadzoi (2000) examined the effects of systemic apomorphine (a nonselective DA receptor agonist) on the hemodynamic mechanism of clitoral and vaginal engorgement in the rabbit. The vaginal/clitoral branch of the pelvic nerve was stimulated electrically, and maximal increases in clitoral intracavernosal and vaginal wall blood flows and pressures were recorded. The authors concluded that systemic administration of apomorphine may improve clitoral and vaginal engorgement.

With regard to NE influences on female sexual function, Rosen, Phillips, Gendrano, and Ferguson (1999) found a facilitatory effect of the nonselective  $\alpha_1$ - and  $\alpha_2$ -adrenergic antagonist phentolamine mesylate on vaginal pulse amplitude (VPA) and subjective sexual arousal responses in six postmenopausal women with female sexual arousal disorder (FSAD). A facilitatory influence of phentolamine mesylate on VPA responses was also noted in a larger sample of postmenopausal women with FSAD receiving hormone replacement therapy (Rubio-Aurioles et al., 2002). Alpha adrenoceptor antagonists block presynaptic autoregulatory receptors, with a consequent increase in NE release and stimulation of beta-adrenoceptors.

At a peripheral level, physiological research suggests that enhanced sympathetic outflow impairs genital responses necessary for physiological sexual arousal (for review, see Meston & Bradford, In press). Because it is generally accepted that NE is the dominant neurotransmitter of the sympathetic nervous system (SNS), this would suggest an inhibitory role of NE on genital responses. In humans, however, drugs that increase and decrease SNS outflow have been shown to enhance and inhibit physiological sexual arousal, respectively. For example, ephedrine, a drug that acts centrally as an  $\alpha$ - and  $\beta$ -adrenergic agonist and peripherally to increase SNS outflow, significantly increased VPA responses, compared with placebo in sexually functional women (Meston & Heiman, 1998). Conversely, clonidine, an

antihypertensive drug that acts centrally as an  $\alpha_2$  adrenergic agonist and peripherally blocks SNS outflow, inhibited VPA in functional women under conditions of heightened autonomic arousal (Meston, Gorzalka, & Wright, 1997).

If DA and NE play a prosexual role in the female sexual response, it is feasible that disruptions in these systems could lead to impaired sexual function in women. Given dopamine's well-established role in the anticipation of reward (e.g., Koob, 1992), one would expect disruptions in central DA systems to most likely impact desire mechanisms. Women with HSDD may simply find sexual activity, or the anticipation of sexual activity, less rewarding, and this may, in part, be linked to a blunted DA response in sexual situations. At a peripheral level, disruptions in DA and NE systems could adversely impact sexual arousal by impairing the genital vasocongestive response. This would provide a physiological explanation for the etiology of comorbid HSDD/FSAD.

To date, only a few studies have examined NE responses to sexual stimuli in women, and no studies have examined DA responses to sexual stimuli in women. Moreover, with the exception of one study that found no differences between healthy controls and women with HSDD in levels of 3-methoxy-4-hydroxyphenyl-glycol (a metabolite of NE; Piletz et al., 1998), there have been no studies that have compared DA or NE responses to sexual stimuli among women with and without sexual dysfunction. An understanding of whether such differences exist could help elucidate the underlying etiology of sexual desire and arousal difficulties in women and aid in the development of effective agents for treating such sexual concerns.

The present study was designed to investigate the role of DA and NE in female sexual responding. The primary purpose was to assess whether DA and NE changes with sexual stimuli differ between women with coexistent HSDD and FSAD versus healthy controls. We assayed blood levels of NE and homovanillic acid (HVA; the major metabolite of DA) taken during exposure to a neutral, nonsexual film and during a sexually explicit film while recording self-report and VPA sexual responses. Because participants were aware that they would be viewing an erotic film immediately following the neutral film, the neutral film assay should be considered indicative of neurotransmitter levels in *anticipation* of sexual activity as opposed to resting baseline levels. On the basis of animal evidence that shows DA neurons fire in anticipation of reward and then decline to prior levels (Schultz, Dayan, & Montague, 1997), we predicted that DA levels in sexually functional women would be lower during the erotic film versus during the neutral film. On the basis of the findings of Exton et al. (2000), which showed NE levels significantly increased with exposure to an erotic film in sexually functional women, and the findings of Ende Gertner, Hwang, and Kadi (1989), which showed increased NE levels following sexual intercourse that were beyond levels raised in anticipation of sexual activity, we predicted that NE levels would

be higher in functional women during exposure to the erotic film versus during the neutral film. In sexually dysfunctional women, we expected a similar general pattern of responses to emerge but to be substantially lower than those seen in functional women.

## METHOD

### Participants

Women who responded to local advertisements were interviewed by a trained clinical psychology student. They were first asked whether they were currently experiencing any sexual difficulties and, if so, to describe what they were and whether they were distressed by them. The women were then interviewed to determine whether they met criteria for a Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR), American Psychiatric Association, 2000) sexual dysfunction, including HSDD, FSAD, female orgasmic disorder, dyspareunia, and vaginismus. The women were also asked if they were currently taking any medications or herbal remedies, had ever been diagnosed with a psychological disorder, had a history of drug or alcohol abuse, were currently experiencing any psychological distress, considered themselves to be homosexual in orientation, and whether they were currently sexually inactive. Women who responded affirmatively to any of these questions were excluded from participation. Eligible participants were told that the purpose of the investigation was to examine the physiological effects of viewing brief visual stimuli containing erotic content. Approximately 90 participants called in response to the advertisements. Of these, 60 either chose not to participate in the study or were excluded because they did not meet the inclusion criteria.

Women were considered sexually dysfunctional if they reported current sexual desire or arousal concerns that they found distressing and if they met DSM-IV-TR criteria for HSDD and FSAD. Women with coexistent HSDD and FSAD were chosen as the experimental group because DA and NE mechanisms are expected to impact both desire and arousal mechanisms. Recent reports indicate a high coexistence of FSAD and HSDD among women with sexual concerns (e.g., Meston, 2003; Riley & Riley, 2000; Segraves & Segraves, 1991). Women were considered sexually functional if they did not report any sexual concerns or distress or meet DSM-IV-TR criteria for any of the sexual disorders noted above. On the basis of these criteria, we considered 15 women to be sexually functional and 15 to be dysfunctional. Data from 5 women were excluded because of difficulties during the blood draw (i.e., unable to find the vein, veins collapsing, or simply not enough blood drawn), and data from 3 women were excluded because of technical difficulties with the vaginal photoplethysmograph. Data was complete for 9 women with FSAD and coexistent HSDD (mean age 31.4  $\pm$  5.7 years, range

25–41 years) and 13 sexually functional women (26.6  $\pm$  5.5 years, range 21–42 years).

### Design and Procedure

The procedure consisted of a single 1-hr experimental session. The laboratory room used for data collection had an adjoining, private, locked participant room. An intercom system between the participant and experimenter rooms allowed for communication with participants at all times. The participant room was equipped with a television and a recliner in front of it at a distance that the woman can sit comfortably in complete privacy, with a full view of the screen. Participants were asked to complete the questionnaires, insert the plethysmograph, and notify the experimenter via the intercom when they were ready for testing to begin.

Blood samples were drawn by a registered phlebotomist (using lavender top ethylenediamine tetra-acetic acid, an anticoagulant, monoject tubes) 2 min after the film began (1 min “relax,” 1 min neutral film) and 10 min after the erotic films began. All samples were immediately mixed by inversion 5 times and placed in ice water for 5 min. The samples were then placed in a refrigerated centrifugation device ( $-5^{\circ}\text{C}$ ) at  $1500 \times g$  for 10 min. Following centrifugation, we removed clear supernatant plasma via pipette and placed it in screw-capped cryotubes in a freezer at  $-80^{\circ}\text{C}$ . At a later date, the samples were shipped on dry ice to a laboratory (Analytical Psychopharmacology Laboratories, Nathan Kline Institute, Orangeburg, NY) and assayed for HVA and NE using high-performance liquid chromatography with electrochemical detection. Although HVA levels in bodily fluids (e.g., blood, urine) most likely reflect only major changes in central DA activity, examining peripheral levels of HVA is currently believed to be the most direct way to assess the changing activity of central DA in living humans (Amin, Davidson, & Davis, 1992). Results from multiple studies suggest that approximately 25% of total plasma HVA derives from central DA sources (Amin et al., 1992).

Participants were instructed to abstain from food and exercise (including sexual activity) for 14 hours prior to their participation in the study and to travel by car or public transport to the appointment in order to avoid physical exertion from walking or cycling. Diet and exercise are known to affect plasma catecholamine levels; however, fasting for 14 hours overnight has been shown to control for dietary variables (Amin et al., 1992). All appointments were scheduled between 8:00 a.m. and 10:00 a.m. to control for potential circadian influences on catecholamine metabolism. Appointments were scheduled during the luteal phase of the menstrual cycle in order to control for potential menstrual cycle influences on sexual arousal and NE levels. HVA levels do not change significantly throughout the phases of the ovulatory cycle in women (Abel, Veronica, Sherwood, & Murray, 1996).

The women were paid \$50 at the end of the study session as compensation for their time. The study was approved by the Institutional Review Board at the University of Texas at Austin.

## Apparatus and Materials

### FILM STIMULI

Film stimuli consisted of a 14-min audiovisual film that included: (a) a 1-min display of the word “relax,” (b) 3 min of a travel film (neutral stimuli), and (c) 10 min of an erotic film. The erotic film depicted a heterosexual couple engaging in foreplay and sexual intercourse and has previously been shown to induce sexual arousal in women in our laboratory (Meston, 2004).

### PHYSIOLOGICAL SEXUAL AROUSAL

We measured physiological sexual response using vaginal photoplethysmography (Sintchak & Geer, 1975) to detect changes in VPA, an indicator of short-term changes in vaginal wall engorgement. We sampled VPA at a rate of 60 samples per sec during the entire 3 min of neutral film and 10 min of erotic film, band-pass filtered (0.5–30 Hz), and recorded the results using the software package AcqKnowledge III, Version 3.2 (BIOPAC Systems, Inc., Santa Barbara, CA) and a Model MP100WS data acquisition unit (BIOPAC Systems, Inc.) on a Dell Pentium computer. Using the same procedures as previous studies of this nature (e.g., Meston & Heiman, 1998), we deleted psychophysiological artifacts related to movement or contractions of the pelvic muscles using the computer software program following visual inspection of the data. We computed VPA raw scores for both the neutral and erotic films by averaging across the entire 180 s of the neutral-film and 600 s of the erotic-film stimuli.

### SUBJECTIVE SEXUAL AROUSAL

We measured subjective levels of sexual arousal using a modified version of Heiman and Rowland's (1983) film scale. The scale consists of 17 items measuring the following: physical sexual arousal (4 items; e.g., genital wetness or lubrication), psychological sexual arousal (2 items; e.g., sexually aroused), positive affect (4 items), negative affect (4 items), autonomic arousal (2 items), and anxiety (1 item). Participants rated each of the items on a 7-point Likert scale according to the degree to which they experienced the sensations.

### SEXUAL FUNCTIONING

We used the Female Sexual Function Index (FSFI; Rosen et al., 2000) to further assess and validate current levels of sexual function. The FSFI is a brief, 19-item self-report measure of female sexual function that provides scores on six domains of sexual function, as well as a total score. The assessed

domains have been confirmed using factor analyses and include: desire (2 items), arousal (4 items), lubrication (4 items), orgasm (3 items), satisfaction (3 items), and pain (3 items). The FSFI has been shown to reliably discriminate between FSAD and control patients (Rosen et al., 2000), and women with DSM-IV–diagnosed HSDD and/or female orgasmic disorder and healthy controls (Meston, 2003) on each of the six domains of sexual function as well as on the Full Scale score.

## RESULTS

### Demographics

Likelihood ratios indicated that the two groups did not significantly differ on race/ethnicity,  $LR(3) = .238, p = .50$ , or marital status,  $LR(3) = 7.44, p = .07$ . Analysis using Kendall's Tau-c indicated the two groups did not significantly differ on level of education,  $T = -.30, p = .15$  but differed significantly on reported length of current relationship,  $T = -.645, p < .001$ , with sexually dysfunctional women reporting a longer length of current relationship. There were no significant age differences between groups,  $t(20) = -2.00, p = .06$ .

We ran independent sample *t*-tests between groups for each domain score and the full scale score of the FSFI as well as for the full score. Participants differed significantly on self-reported levels of desire,  $t(20) = 7.00, p < .001$ ; arousal,  $t(20) = 8.52, p < .001$ ; lubrication,  $t(20) = 4.62, p < .001$ ; orgasm,  $t(20) = 2.71, p = .01$ ; and satisfaction,  $t(20) = 5.88, p < .001$ , and had significantly lower full scale FSFI scores than did sexually functional women,  $t(20) = 6.94, p < .001$ . The two groups did not differ on self-reported levels of pain associated with sexual activity,  $t(20) = .97, p = .34$ ; both groups were within the normal range on this domain. These findings further validate the designation of women as sexually functional and dysfunctional (see Table 1 for participant characteristics).

### Sexual and Affective Responses to the Neutral and Erotic Films

#### PHYSIOLOGICAL SEXUAL AROUSAL

To examine whether the erotic films increased physiological sexual arousal, we conducted a 2 (Film: Neutral vs. Erotic)  $\times$  2 (Group: Sexually Functional vs. Sexually Dysfunctional) repeated measures analyses of variance (ANOVA) on raw VPA scores. Results revealed significant differences between physiological responding during the neutral and erotic portions of the film,  $F(1, 20) = 12.52, p = .003$ . Participants showed much greater physiological response (VPA) during the erotic than during the neutral film segments. The main effect for Group was not significant,  $F(1, 20) = 2.06, p = .17$ , and the interaction between Film and Group was not significant,  $F(1, 20) = 2.47, p = .14$ . See Figure 1 for VPA means ( $+/-SEM$ ) by Group and Film.

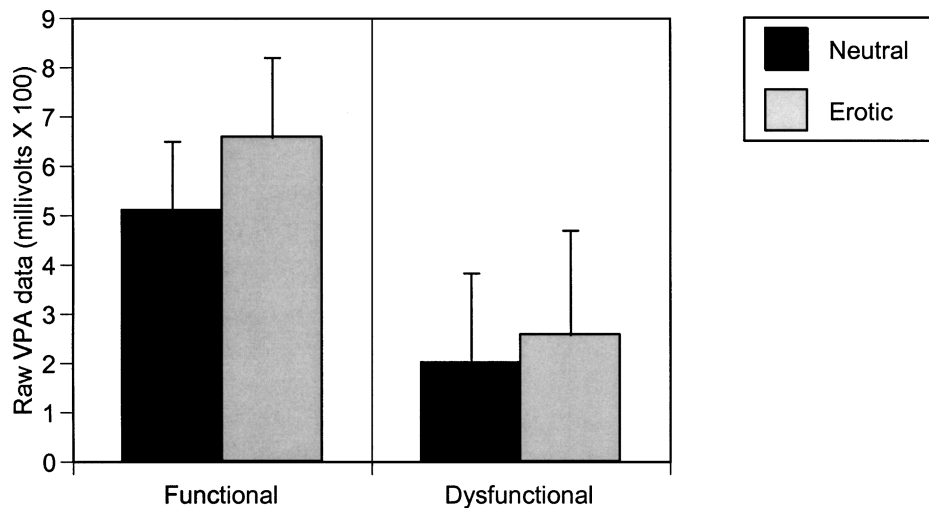


**TABLE 1.** Means (+/– SDs) Participant Characteristics

	Sexually functional participants <i>N</i> = 13	Sexually dysfunctional participants <i>N</i> = 9	<i>P</i> value
Age			
Mean (SD)	26.62 (5.49)	31.44 (5.68)	.06
Range	21–42	25–41	
		<i>n</i> (%)	
Race			.50
Caucasian	7 (53.8)	5 (55.6)	
Hispanic	4 (30.8)	4 (44.4)	
Native American	1 (7.7)	0 (0)	
Other	1 (7.7)	0 (0)	
Education			.15
High school graduate	1 (7.7)	0 (0)	
Some college	5 (38.5)	1 (11.1)	
2 year degree	1 (7.7)	2 (22.2)	
4 year degree	5 (38.5)	5 (55.6)	
Advanced degree	1 (7.7)	1 (11.1)	
Marital status			.07
Single, never married	11 (84.6)	3 (33.3)	
Married	1 (7.7)	4 (44.4)	
Divorced	0 (0)	1 (11.1)	
Separated	1 (7.7)	1 (11.1)	
Current involvement in sexual relationship	13 (100)	9 (100)	
Length of relationship			<.001
0–6 months	2 (15.4)	0 (0)	
6–12 months	2 (15.4)	0 (0)	
1–2 years	4 (30.8)	0 (0)	
3–5 years	3 (23.1)	4 (44.4)	
5–10 years	1 (7.7)	3 (33.3)	
>10 years	1 (7.7)	2 (22.2)	
		Mean (SD)	
Female sexual function index			
Full scale	83.85 (7.46)	56.00 (11.42)	<.001
Desire	8.15 (1.46)	4.44 (0.73)	<.001
Arousal	17.85 (1.77)	10.56 (2.24)	<.001
Lubrication	18.85 (1.34)	13.89 (3.55)	<.001
Orgasm	12.08 (3.50)	8.11 (3.18)	<.05
Satisfaction	13.31 (2.84)	6.22 (2.68)	<.001
Pain	13.62 (1.39)	12.78 (2.64)	.34

#### SUBJECTIVE SEXUAL AND AUTONOMIC AROUSAL

To examine whether the erotic films increased subjective ratings of arousal, we first conducted an omnibus test using a Doubly-Multivariate Design with Film as the within-subject factor, Group as the between-subject factor, and the following as dependent variables: subjective physical sexual arousal, subjective psychological sexual arousal, and subjective autonomic sexual arousal. Results revealed a significant main effect for Film,  $F(3, 17) = 9.70$ ,  $p < .001$ .



**FIGURE 1.** Mean vaginal pulse amplitude responses to neutral and erotic films ( $\pm$  SEM) for sexually functional and dysfunctional women.

The main effect for Group,  $F(3, 17) = 1.09$ ,  $p = .39$ , and the interaction between Film and Group,  $F(3, 17) = 1.60$ ,  $p = .23$ , were not significant. Follow-up 2 (Film)  $\times$  2 (Group) ANOVAs revealed significant increases between neutral and erotic films for subjective physical sexual arousal,  $F(1, 20) = 26.65$ ,  $p < .001$ , subjective mental sexual arousal,  $F(1, 20) = 4.83$ ,  $p = .04$ , and subjective autonomic arousal,  $F(1, 20) = 16.28$ ,  $p = .001$ . There was no significant main effect for Group, and the interaction between Group and Film was not significant.

#### AFFECT AND ANXIETY

We conducted an Omnibus test using a Doubly-Multivariate Design with Film as the within-subject factor, Group as the between-subject factor, and the following as dependent variables: positive affect, negative affect, and anxiety. Results revealed a significant main effect for Film,  $F(3, 17) = 7.52$ ,  $p = .003$ . The main effect for Group,  $F(3, 17) = 1.12$ ,  $p = .37$ , and the interaction between Film and Group,  $F(3, 17) = .37$ ,  $p = .78$ , were not significant. Follow-up 2 (Film)  $\times$  2 (Group) ANOVAs indicated that both positive and negative affect significantly increased after viewing the erotic film,  $F(1, 20) = 4.97$ ,  $p = .04$ , and  $F(1, 20) = 11.08$ ,  $p = .004$ , respectively. Subjective reports of anxiety did not significantly differ between neutral and erotic films,  $F(1, 20) = .07$ ,  $p = .79$ . The main effect for Group was not significant, and the interaction between Group and Film was not significant.

## Neurotransmitters Levels During the Neutral and Erotic Films

### HVA LEVELS

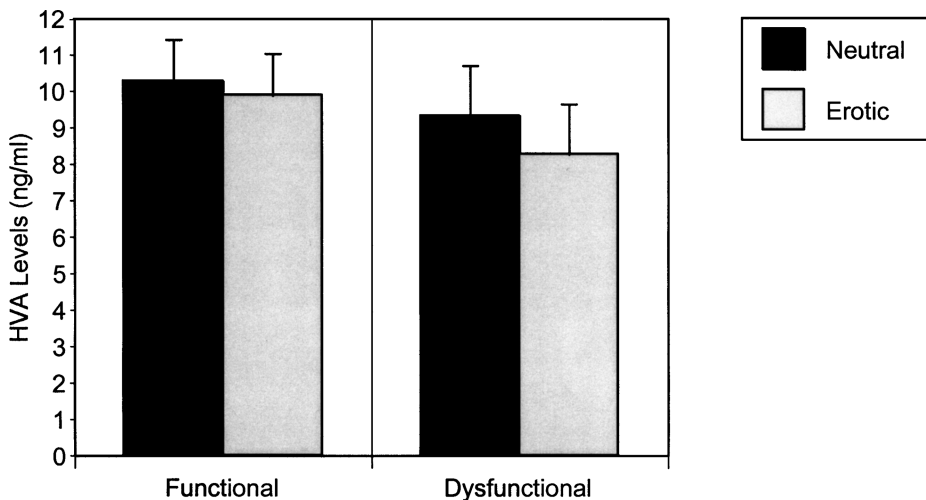
Results from a 2 (Film)  $\times$  2 (Group) ANOVA conducted on HVA blood levels revealed a significant decrease between samples drawn during the neutral and those drawn during the erotic films,  $F(1, 20) = 5.98$ ,  $p = .02$ . The main effect for Group was not significant,  $F(1, 20) = .56$ ,  $p = .46$ , and the interaction between Group and Film was not significant,  $F(1, 20) = 1.34$ ,  $p = .26$ . See Figure 2 for means ( $\pm$ SEM) by Film.

### NE LEVELS

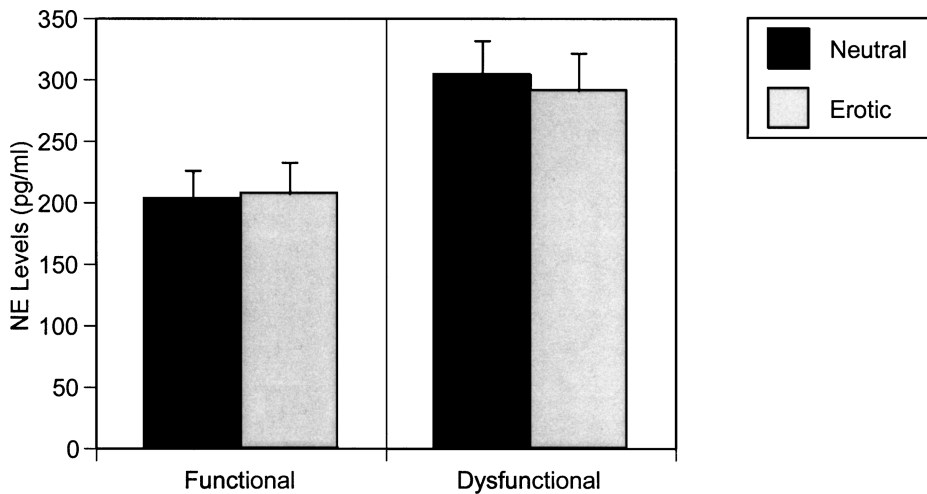
Results from a 2 (Film)  $\times$  2 (Group) ANOVA revealed a significant main effect for Group,  $F(1, 20) = 7.75$ ,  $p = .01$ . Sexually dysfunctional women had overall higher levels of NE than did sexually functional women. There were no significant differences in NE levels drawn during the neutral and erotic films,  $F(1, 20) = .06$ ,  $p = .80$ , and the interaction between Group and film was not significant,  $F(1, 20) = .25$ ,  $p = .62$ . See Figure 3 for means ( $\pm$ SEM) by Group and Film.

## Correlations between Sexual Arousal and Neurotransmitter Levels

We conducted separate Pearson correlations for sexually functional and dysfunctional women between physiological sexual arousal, HVA, and NE difference scores and between psychological sexual arousal, HVA, and NE difference scores. Among sexually functional women, correlations between psychological sexual arousal and HVA levels,  $r(11) = -.61$ ,  $p = .06$ , and



**FIGURE 2.** Mean homovanillic acid levels ( $\pm$ SEM) by film for sexually functional and dysfunctional women.



**FIGURE 3.** Mean norepinephrine levels ( $\pm$  SEM) by film for sexually functional and dysfunctional women.

psychological sexual arousal and NE levels,  $r(11) = .14$ ,  $p = .7$ , were not significant. Correlations between VPA and HVA levels,  $r(11) = -.14$ ,  $p = .66$ , and between VPA and NE levels,  $r(11) = .17$ ,  $p = .60$ , also were not significant. Among sexually dysfunctional women, correlations between psychological sexual arousal and HVA, and between psychological sexual arousal and NE levels did not reach significance,  $r(7) = .32$ ,  $p = .40$ ,  $r(7) = .36$ ,  $p = .35$ , for HVA and NE, respectively. Correlations between VPA and HVA, and VPA and NE levels also did not reach significance,  $r(7) = -.50$ ,  $p = .25$ ,  $r(7) = -.65$ ,  $p = .11$ , for HVA and NE, respectively.

## DISCUSSION

This study assessed DA and NE responses to sexual stimuli in women and was the first to examine potential differences between sexually functional and dysfunctional women in sexually relevant changes in these neurotransmitters. Sexual arousal was induced by exposing participants to a sexually explicit film. The finding of significant increases in both physiological (VPA) and subjective indices of sexual arousal to the erotic films indicate that the stimuli were effective in eliciting sexual arousal responses among both sexually functional and sexually dysfunctional participants.

Consistent with our hypotheses, blood levels of HVA were significantly decreased during the erotic versus neutral films among functional and dysfunctional women, providing preliminary evidence that DA levels change with exposure to sexual stimuli and that these levels are detectable in plasma samples. Whether or not the changes in HVA reflect alterations in central or peripheral transmitter levels or, alternatively, an increase in the metabolism of

dopamine cannot be determined from blood assays, and we believe more direct measures of central DA (i.e., spinal fluid) require assessment techniques too intrusive for the study of sexual responding. It has been estimated that approximately 25% of plasma HVA derives from central sources (Amin et al., 1992). Evidence that plasma HVA does, in fact, reflect changes in central DA metabolism is provided by studies that showed that DA receptor antagonists and agonists affect both central and plasma HVA in similar ways (e.g., Bowers, 1991) and that destruction of central dopaminergic pathways is closely reflected in plasma HVA levels (Bacopoulos, Hattox, & Roth, 1979). It seems likely, then, that the decreases in DA noted here reflect central alterations at least in part.

Our hypothesis that the erotic films would increase levels of NE was not supported. Exton et al. (2000) reported increases in blood levels of NE in 9 sexually functional women between neutral and erotic films. In that study, levels of NE assayed after 10 min of viewing an erotic film were significantly higher than levels assayed after 20 min of viewing a neutral film. NE levels remained significantly elevated throughout the remaining 10 min of the erotic film and throughout the following 20 min of a second neutral film. In the current study, levels of NE did not differ between levels collected after 2 min of nonsexual stimuli and levels collected after 10 min of erotic film. Differences in the method and time frame of blood draws, or the control of potential menstrual cycle fluctuations in the current study, but not Exton et al.'s, could possibly account for the discrepant findings between studies. With regard to the latter point, to date there has been no conclusive evidence as to whether NE levels change across the menstrual cycle. Some studies have reported no changes in plasma NE levels across the menstrual cycle (e.g., Hoehe, 1988), whereas others have reported significantly increased plasma NE during the luteal phase (e.g., Blum et al., 1992). It also should be noted that, in the current study, participants were told that they would be viewing an erotic film and were anticipating this while viewing the nonsexual film. In Exton et al.'s study, it is not clear whether participants were anticipating the onset of an erotic film. If they were not, it is possible that levels of NE collected in the current study during the neutral film represent substantially higher levels than would be seen during resting baseline because of subjects' expectancy of sexual arousal. This would be consistent with the findings of Ende et al. (1989), who reported more than twice the levels of urinary vanillylmandelic acid (the final metabolite of epinephrine and norepinephrine) in women about to engage in sexual intercourse (expectancy condition) compared with levels obtained from women during a nonsexual control condition. This would also be consistent with that fact that levels of NE during the neutral film were substantially higher in the current study than in Exton et al.'s study.

Our prediction that women with HSDD and FSAD would show substantially lower DA and NE responses to sexual stimuli was not supported.

Overall, HVA levels during the neutral and erotic films did not differ significantly between sexually functional and dysfunctional women, and levels of NE were significantly higher among dysfunctional women than among functional women during both the neutral and erotic films. Explanations for the higher levels of NE noted among dysfunctional women are highly speculative. One possibility is that the dysfunctional women were more anxious about viewing an erotic film or having their sexual responses measured than were functional women. If so, the higher levels of NE noted among dysfunctional women could be a byproduct of heightened sympathetic nervous system arousal as a consequence of anxiety arousal more than sexual arousal, per se. Indeed, a number of studies have reported significant increases in NE with anxiety exposure in women (e.g., Lindheim et al., 1992). Inconsistent with this explanation, however, is the fact that subjective reports of anxiety did not differ significantly between functional and dysfunctional women. One would expect that if dysfunctional women were substantially more stressed about being in a sexual scenario than were functional women, it would be reflected in these self-report ratings. It may, of course, also be the case that sexually dysfunctional women have an unusually reactive adrenergic system under novel situations or have unusually high overall resting NE levels. Further studies are needed to assess whether women with FSAD and HSDD and women without have meaningfully different NE levels under nonsexual baseline conditions.

In conclusion, the finding that significant differences emerged in NE responses between functional and dysfunctional women in a sexual situation suggests a measurable difference in neurotransmitter responses between women with and women without sexual difficulties. These findings are limited by the fact that we did not assay catecholamine levels under nonanticipatory sexual baseline conditions. Further examination of catecholamine responses using an indwelling catheter to assess multiple samples across varied sexual and nonsexual testing scenarios may provide further insight into the etiology of sexual desire and arousal difficulties in women.

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