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Effects of fragrance on female sexual arousal and mood across the menstrual cycle

CYNTHIA A. GRAHAM,[a] ERICK JANSSEN,[b] AND STEPHANIE A. SANDERS[b]

[a]Department of Psychology, Indiana University, Bloomington, USA
[b]The Kinsey Institute for Research in Sex, Gender, and Reproduction, Indiana University, Bloomington, USA

Abstract

The effects of fragrance on sexual response in women were investigated using subjective and physiological measures of sexual arousal and of mood. Responses were obtained from female participants in three different fragrance conditions (female fragrance, male fragrance, and a "blank" or neutral substance), as they viewed erotic and sexually neutral films, and fantasized about sexual situations. Each woman was tested twice: during the midfollicular and periovulatory phases of her menstrual cycle. Menstrual cycle phase effects were apparent; self-report data indicated greater sexual arousal and more positive mood during the periovulatory than during the follicular phase. Results demonstrated a positive effect of the male fragrance on genital arousal during erotic fantasy, but this finding was apparent only during the follicular phase testing session. This effect did not appear to be mediated by any effects of fragrance on mood.

Descriptors: Female sexual arousal, Olfaction, Fragrance, Menstrual cycle, Vaginal photoplethysmography

Olfactory stimuli are known to be important in the sexual behavior of most nonhuman mammalian species (Keverne, 1978; Vandenbergh, 1983). The importance of olfaction in human sexuality is less clear, although recent studies investigating the role of odors on sexual behavior (Cutler, Friedmann, & McCoy, 1998) and on mate selection (Wedekind, Seebeck, Bettens, & Paeke, 1995) suggest that its role may have been underestimated. Fragrances are used widely by men and women, ostensibly to enhance sexual attractiveness, but little other than anecdotal evidence of their effects exists. The focus of the study reported here was on possible effects of fragrance on sexual arousal in women.

If olfactory cues do affect sexual responses in humans, how are these effects mediated? The possibility that has received the most speculation is that olfactory stimuli have direct effects on the brain. Recently, the vomeronasal organ (VNO), the anatomic locus for the reception of pheromonal stimuli in nonhuman mammals, was identified as present in humans (Garcia-Velasco & Mondragon, 1991); however, as yet evidence for behavior change in response to VNO stimulation in humans is lacking. Another possible mechanism is that the meaning of particular odors are acquired through learning, and their effects are dependent on the context in which they are perceived (Kirk-Smith & Booth, 1987); few studies have investigated this possibility. Lastly, odors might be influential because of their mediating effects on mood. A number of recent studies have found that odors can affect mood significantly (Ehrlichman & Bastone, 1992; Miltner, Matjak, Diekmann, & Brody, 1994; Schiffman, Sattely-Miller, Suggs, & Graham, 1995) and it was for this reason that the present study focused on mood enhancement as the possible mechanism underlying any effects of fragrance on sexual arousal. Fragrance, although not necessarily intrinsically erotic, might be an effective modulator of sexual arousal induced by other types of sensory stimulation. This effect would accord well with the observation that consumers use scent as one of many sensory inputs to set a mood (e.g., dim light, soft music).

There is some evidence for menstrual cycle-related changes in the emotional evaluation of odors (Hummel, Gollisch, Wildt, & Kobal, 1991) and in olfactory sensitivity, with maximal sensitivity around ovulation (Doty, Snyder, Huggins, & Lowry, 1981). Sexual arousability in women has also been found to fluctuate over the menstrual cycle. Inconsistent findings in this area may have been due to the failure of most investigators to determine cycle phase accurately, particularly the periovulatory phase (Hedricks, 1994). In the present study, it was considered important to accurately establish, and to control for, menstrual cycle phase. Another methodological issue in experimental design of the present study was to select sexual stimuli that were moderately, rather than maximally, arousing, to avoid ceiling effects that might obscure possible additional effects of the fragrances.

The aim of the current study was to assess whether fragrance could enhance the effects of erotic stimuli (erotic film and sexual fantasy) on subjective and genital responses in women at two distinct phases of the menstrual cycle (the periovulatory and the midfollicular phases). In addition to sexuality variables, mood was assessed carefully as a potential mediating factor in any observed effect of fragrance. A number of studies have found that the am-

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Address reprint requests to: Dr. Cynthia A. Graham, Psychology Department, Indiana University, 1101 E. 10th Street, Bloomington, IN 47405-7007, USA. E-mail: cygraham@indiana.edu.

plitude of the eyeblink or "startle" response to a loud noise varies systematically with a person's emotional state, with the amplitude significantly reduced during situations with positive emotional valence, and enhanced during negative emotional states (Jansen & Frijda, 1994; Lang, Bradley, & Cuthbert, 1990). In addition to the use of subjective ratings of mood, we measured the startle reflex during the different stimulus conditions to assess the participant's affective state.

Our primary hypothesis was that fragrance would enhance sexual arousal and that it would do so by increasing positive mood. We also expected that any positive effects of fragrance would be more pronounced during the periovulatory, than the follicular phase, of the menstrual cycle. Two fragrances were included—one designed for men and one for women—in part to assess the generality of any fragrance-related effects, and also to minimize participants' expectations that we were interested in the effects of fragrance (versus no fragrance) on sexual arousal. Given the lack of previous data, no specific hypotheses regarding effects of the male versus female fragrances were made. Lastly, in the light of previous research (Laan, Everaerd, van Aanhold, & Rebel, 1993; Laan, Everaerd, van Berlo, & Rijs, 1995), we expected that both subjective and genital levels of sexual arousal would be higher in response to the erotic film stimulus, than during sexual fantasy.

Method

Participants

Recruitment was carried out through advertisements in a student newspaper and a campus family housing newsletter. To deemphasize the focus on possible effects of fragrance, the study was described as "a study on changes in sexual arousal and sense of smell over the menstrual cycle." Telephone screening interviews established whether a woman was eligible to participate. Eligibility requirements were: at least 18 years of age; not using birth control pills or any other hormonal medications; regular menstrual cycles (21–35 days in length); sexually attracted to men; not using any psychotropic medication; nonsmoker; no known allergies to fragrances; no breathing problems or asthma; no known medical conditions that affect sense of smell.

A total of 69 women were screened, of whom 20 decided against taking part and 9 were ineligible. Ten of the 20 women who decided against participating cited aspects of the procedure about which they felt uncomfortable; specifically, the vaginal device (5), the erotic films (4), and the electrodes (1). Two women mentioned the time commitment required, and 8 provided no reason for their decision against taking part. Forty women were entered into the study. Their mean age was 26.9 years (SD = 7.5 years; range = 19–45 years). All of the women reported having had sexual activity with a man, and 37 (92.5%) had experienced coitus. Twenty-seven (67.5%) were in a current heterosexual relationship. Thirty-six (90.0%) of the women described their sexual orientation as heterosexual, 3 (7.5%) as bisexual, and 1 (2.5%) gave an "uncertain" response. The mean number of sexual partners during the past year was 2.6 (SD = 2.6). Twenty-six (65.0%) of the participants reported having engaged in sexual activity at least once a week during the past year; most (33; 82.5%) reported having masturbated during the past month. Thirty-seven (92.5%) of the women reported some previous exposure to sexually explicit films and 36 (90.0%) to sexually explicit photographs.

Seven of the 40 women did not complete any testing sessions after attending the initial interview. An additional 5 women completed only the follicular testing session. Twenty-eight women completed both follicular and periovulatory testing sessions. Comparison of the 33 women who completed at least one testing session with the group of 7 women who did not attend following the initial visit ("nonattenders") revealed some differences. The women who attended a testing session were more likely to have reported having "ever seen" sexually explicit photographs ($\chi^2 = 5.4$, $p = .02$) and sexually explicit films ($\chi^2 = 3.2$, $p = .07$), compared with nonattenders. There was also a trend for attenders to report sexually explicit films as being more arousing than nonattenders ($\chi^2 = 8.0$, $p = .09$). Although we failed to obtain any information on reasons why women dropped out after attending the initial interview, it is worth noting that six of these seven women were scheduled to have their first testing session during their periovulatory phase, and only one during her follicular phase. The most likely explanation for this difference is that the use of the ovulation detection kits to establish periovulatory phase demanded an investment of time and effort on the part of participants that was not required for the follicular phase testing. Another indication that women who dropped out may not have wanted to invest much time and effort was that all of the five women who completed only one testing session were in the group tested first during their follicular phase, that is, they failed to return to attend their periovulatory phase session.

Design

There were three different fragrance conditions: female fragrance, male fragrance, and a control or "blank" condition. During exposure to *each* of these fragrances, participants' responses to two types of stimuli (erotic film and sexual fantasy) were evaluated. Before the first stimulus presentation, participants viewed a neutral film excerpt (taken from a documentary about cats); their responses during the last 3 min of the neutral film constituted the "initial baseline." Between each subsequent stimulus presentation, there was a 3-min "return-to-baseline" interval when again a sexually neutral film was presented.

Each participant was tested twice: during the periovulatory and the follicular phases of their menstrual cycle. Women were randomly assigned to first testing during the periovulatory phase or first testing during the follicular phase. A 2 (Group: periovulatory session first, follicular session first) × 2 (Phase: follicular, periovulatory) × 2 (Stimulus: film, fantasy) × 3 (Fragrance: male, female, control) mixed between- and within-subjects factorial design was used, with group as the between-subjects variable.

The order of presentation of the fragrances, the two experimental stimuli (film/fantasy), the order of film clips, and the phase of menstrual cycle for first testing was counterbalanced across participants, determined through the use of Latin squares (Kirk, 1968).

Assessment of Menstrual Cycle Phase

To establish menstrual cycle phase, menstrual bleeding diaries and ovulation detection kits ("Clearplan Easy") were used. Periovulatory testing sessions were scheduled as soon as possible, and not later than 2 days after, a positive ovulation kit result. Follicular phase testing sessions were scheduled as soon as possible, and not later than 2 days after, the last day of menses.

Fragrances

Fragrance stimuli consisted of commercially available perfumes. The fragrances were provided by International Flavors and Fragrances, Inc. (Union Beach, NJ). Pilot ratings of five fragrances (two male and three female) were obtained from 20 female students, who rated the odors in terms of the following scales: appealing, sexy, feminine, sensual, masculine, and pleasant. Weighted

scores for rankings of the "sexiness" variable were obtained for each fragrance. The final choice of one female fragrance and one male fragrance was made by choosing the fragrance with the highest weighted score. The two fragrances selected for the study were also ones that yielded the highest ratings on "feminine" (female fragrance) and "masculine" (male fragrance) qualities. The female fragrance belonged to the category known as "aldehydic floral" and the male fragrance to the "fresh fougere" category. The concentrations used were the same as the market products (20% for the female and 5% for the male fragrance); ethyl alcohol was used for the dilution.

For each condition, an equal amount of the fragrance (sterilized water for the control) was added to four porous polyethylene pellets that were contained in a glass. The pellets were immersed for 1 min and then placed on a glass plate for 6 min before being wrapped in a cotton ball. They were then inserted into a small linen sachet. These sachets, containing the pellets that had been impregnated with the relevant fragrance/control substance, were attached to a thin necklace, which the woman wore around her neck. A small paper "shield" prevented any of the odors from contaminating the participant's clothing.

Erotic Stimuli

Erotic film. Three films involving consensual heterosexual activity were used; from these, six excerpts were selected, each depicting similar combinations of petting (1 min), oral sex (1 min), and vaginal intercourse (1 min). During each testing session, participants were presented with three different 3-min positive erotic film excerpts with background music. Two of the three films used were taken from commercially available films produced and directed by a woman. These films can be considered to differ from typical "male-oriented" erotic films in that the sexual partners have equal roles as far as sexual desire and sexual pleasure are considered (Laan, Everaerd, van Bellen, & Hanewald, 1994).

Sexual fantasy. For the sexual fantasy stimulus, participants were asked to look at a television screen that showed a two-color background and the same background music as for the erotic film stimulus was presented. Because of the eyeblink response measurement, women were required to keep their eyes open. The following instructions were given: "For the next 3 minutes we would like to ask you to fantasize about pleasant sexual situations. You may fantasize about anything you wish; we will not ask you about the content of your fantasies. You could, for example, fantasize about real-life experiences, about situations you would like to be in, but also about the erotic clips you have been watching. The idea is that you fantasize about situations that are both pleasant and sexually arousing to you. Please keep your eyes open and look at the television screen."

Measures

Genital response. Genital responses were measured using a photometric device (Sintchak & Geer, 1975). This measurement device is made of clear acrylic plastic and is shaped like a menstrual tampon. The photoplethysmograph contains an infrared light-emitting diode and a photo transistor as a light detector. Changes in blood volume within the vaginal tissue were recorded as changes in the output of the light detector. The alternating current (AC) signal was taken as a measure of vaginal pulse amplitude (VPA). The AC signal was high-pass filtered (3 Hz) and digitized (40 Hz) using a Contact Precision Instruments (CPI) system and an IBM-compatible (486) computer. The photoplethysmograph probe was warmed up for 45 min before insertion. Depth of the probe and orientation of the light emitting diode was predetermined by a small acrylic plate attached to the photoplethysmograph (Laan, Everaerd, & Evers, 1995). Both the photoplethysmograph and the placement device were sterilized in a solution of Cidex-activated glutaraldehyde between uses (Geer & Janssen, in press). VPA was recorded and digitized continuously during baseline and stimulus conditions. The CPI PSYLAB software enables offline visual inspection of the VPA signal, and after removal of movement artifacts, the calculation of peak-to-trough amplitude for each pulse.

Subjective measures. Unipolar visual analogue scales (VAS) were used to provide ratings of mood and sexual arousal. The sexual arousal items rated were: (a) sexually aroused (overall), that is, the "mean" level of arousal during the stimulus presentation; (b) sexually aroused (strongest feelings), that is, the maximum level of arousal reached during the stimulus presentation; (c) genital sensations (tingling/warmth); (d) vaginal lubrication ("wetness"); (e) desire for sex with a partner; and (f) desire to masturbate. The mood items were: (a) interested; (b) happy; (c) sexy; (d) attractive; (e) confident; (f) disgusted. Ratings were made from 0 (not at all) to 10 (very strongly) on a 100-mm line. Participants were asked to mark a vertical line on the scale to represent the intensity of their mood and sexual arousal. VAS were completed before the first stimulus presentation (for all variables except sexual arousal "strongest feelings"), and after each stimulus presentation.

Following each stimulus presentation, participants also evaluated the relevant fragrance. Ratings were made, using VAS, on the dimensions of pleasantness, sexiness, appeal, and intensity.

Startle response. Acoustic startle probes were presented binaurally through a headphone, each probe consisting of a 50-ms burst of 120-dBA white noise with near instantaneous rise time. Participants were told that they would hear a few brief loud sound bursts. A total of nine startle probes were presented during each 3-min film excerpt, with three startles per minute (at 5 or 15 s, 25 or 35 s, and 45 or 60 s). One randomized scheme of startle presentations was used for all participants. To enhance unpredictability of startle probes, 10 additional startle stimuli were presented during the return-to-baseline intervals. Eyeblink responses were recorded from orbicularis oculi electromyogram (EMG) activity with Ag/AgCl disk electrodes. One electrode was placed 1 cm under the outer commissure of the eye fissure. A second electrode was placed 1 cm medial and slightly below the first so that the electrode pair ran parallel to the lower edge of the eyelid. The ground electrode was placed midforehead, approximately 3–4 cm above the upper borders of the inner brows. Raw EMG was digitized using the same system as was used for the photoplethysmograph. A sampling rate of 400 Hz was used in a time window from 100 ms prior to onset, to 600 ms after onset of blink-eliciting stimuli.

Postexperimental interviews. At the end of each session, women were asked about their reactions to the experimental procedures. They were also asked if they knew what type of fragrance (i.e., male or female) was contained in each of the three necklaces. During the second postexperimental interview, participants' expectancies concerning the objectives of the study were assessed. Women were asked to rate (on a 0–100 scale) the extent to which they thought the focus of the study was on: (a) menstrual cycle-related changes in olfactory sensitivity; (b) differences in sexual response between the two menstrual cycle phases; (c) effects of fragrance on

sexual response; and (d) differences between the effects of male and female fragrances on sexual response.

Procedure

Study approval was obtained from the Indiana University Human Subjects Committee. Women were paid $100 for their participation ($40 for the first session and $60 for the second). Even if a woman withdrew before completion of the study, she was paid for any testing session she attended.

Women were given written instructions to refrain from using any perfume, antiperspirant/deodorant, or scented soap on the day of testing. They were also asked to contact us if they developed any conditions that might interfere with their sense of smell (e.g., a cold). Testing sessions took approximately 90 min each.

Women were informed that their responses would be recorded while they were wearing three different necklaces. They were told that each necklace may contain a male or a female fragrance, or a substance that they may or may not smell. Throughout testing women were seated in a recliner chair, next to a small table that held a clipboard and an intercom, used to communicate with the experimenter. The female experimenter provided instructions on how to insert the genital device. Women were asked to try to keep still, especially during the film presentations and during fantasy, and to try to avoid contracting their pelvic muscles. Then, after the experimenter had left the room, the participant inserted the device in private. A disposable sheet and towel was placed by the woman over her lap. When the participant signaled that the device was in place, the female experimenter reentered the room to attach the electrodes that were used to measure the startle response. Following electrode attachment, the experimenter left the room and a 15-min adaptation period was started. During this adaptation period, which ended with a 3-min baseline measurement phase, the participant viewed the sexually neutral film.

Before each stimulus presentation, women were given the appropriate necklace (male, female, or control) to wear and after questionnaire completion, the experimenter came into the room to remove the necklace. For the 3-min neutral film ("return to baseline") presentation, no necklace was worn. The above procedure was repeated for each fragrance condition.

At the end of each testing session, the postexperimental interview was completed and payment arrangements made. Following the second session participants were told the identity of the three necklaces and were debriefed regarding the purpose and hypotheses of the study.

Data Reduction and Data Analysis

For comparison of subgroups (Group 1 vs. 2; and attenders vs. nonattenders) with respect to background variables, Chi-squared analyses and *t* tests for independent samples were used.

The VPA experimental data were averaged over 20-s intervals, resulting in 18 data points within each fragrance by stimulus condition. In total, two 20-s averages could not be determined reliably because of the presence of movement artifacts. These averages were replaced by the mean of the other 19 means of that condition for that participant. For four women VPA data of one film or fantasy condition were missing due to technical failure. For these four conditions, the baseline and response were replaced by the mean of the two other film or fantasy conditions for that participant. For all baseline data, only the last three 20-s intervals were used for analyses.

For the VPA data, in addition to the *initial* baseline, analysis of the return-to-baseline periods were done, using repeated-measures analysis of variance (ANOVA), with group as the between-subjects variable, and phase (follicular, periovulatory), and "return to baseline" measurements (six in total) as the within-subjects variables. This analysis, carried out to determine whether baseline responses changed over the course of the testing session, revealed a highly significant main effect of change over time, $F(1,5) = 11.59$, $p = .0005$, $\epsilon = 0.26$. VPA baselines increased over time (i.e., they did not return to initial baseline levels). To account for these baseline differences, analysis of covariance (ANCOVA) was used to analyze changes in VPA response across the different experimental conditions. The mean of the return-to-baseline periods (i.e., interstimulus presentations) were used as the covariates.

Startle response data were averaged within each fragrance by stimulus condition, and separate univariate repeated-measures ANOVAs were performed for the follicular and periovulatory phases.

For analysis of baseline (i.e., prestimulus) subjective data, each set of variables (i.e., mood, sexuality) was subjected to a repeated-measures multivariate analysis of variance (MANOVA), with group as the between-subjects variable and phase (follicular, periovulatory) the within-subjects variable. Univariate tests were carried out only when significant effects for the MANOVA were found. To assess participants' responses to stimuli, the same method of analysis was followed, but with fragrance (female, male, control) and stimulus (film, fantasy) as additional within-subjects variables. The following VAS items were used for the MANOVA on sexuality variables: sexually aroused "overall"; sexually aroused "strongest" (only for the experimental data); genital sensations; and vaginal lubrication. Two variables—"desire for sex with a partner" and "desire to masturbate"—were not included in the multivariate analysis, but in univariate tests. For the MANOVA on mood, all of the positive VAS mood items (happy, interested, confident, attractive, sexy) were included. A separate univariate test for the VAS variable "disgusted" was carried out.

The Greenhouse–Geisser epsilon procedure was applied to all repeated-measures ANOVAS to correct for the violation of the sphericity assumption in repeated-measures designs, and epsilons (ϵ) are provided for all p values (Vasey & Thayer, 1987). Following significant F ratios for each variable, univariate contrast analyses were performed, using the Greenhouse–Geisser correction.

BMDP (Biomedic Data Processing) (4v) was used for the multivariate MANOVAS, analyses of covariance and follow-up tests (ANCOVA) (BMDP, 1990). SuperANOVA (Abacus, 1989) was used for univariate analyses and post hoc tests.

Results

Comparison of Groups 1 (first testing in follicular phase) and 2 (first testing in periovulatory phase) on demographic, menstrual cycle, and sexuality variables revealed no significant differences.

Fragrance Ratings

For "intensity" ratings, a main effect for fragrance was highly significant, $F(2,26) = 90.68$, $p = .0001$, $\epsilon = 0.80$. As expected, the male and female fragrances were rated as much more intense than the control substance. Contrasts also showed that participants rated the male fragrance as significantly more intense than the female fragrance, $F(1,26) = 10.03$, $p = .009$. A phase by stimulus interaction effect almost reached significance, $F(1,26) = 3.95$, $p = .06$, $\epsilon = 1.0$. Contrasts indicated that when women were in the follicular phase, they perceived both fragrances as more intense during sexual fantasy, than during the erotic film presentation, $F(1,26) = 4.77$, $p = .04$; during the periovulatory phase, there were no dif-

ferences in the perceived intensity of fragrances across film and fantasy conditions.

For the hedonic ratings, all univariate tests revealed a main effect of group, pleasantness: $F(1,26) = 14.67$, $p = .0007$; sexiness: $F(1,26) = 6.19$, $p = .02$; appeal: $F(1,26) = 8.31$, $p = .008$. Women whose first testing took place during the periovulatory phase gave higher (i.e., more positive) ratings for the fragrances than those who were first tested during the follicular phase.

There was also a main effect of fragrance for ratings of sexiness, $F(2,26) = 3.59$, $p = .04$, and a trend in this direction for ratings of pleasantness, $F(2,26) = 3.06$, $p = .07$, and appeal, $F(2,26) = 2.62$, $p = .11$, $\epsilon = 0.80$. Contrasts demonstrated that in each case only the comparison between the male fragrance and the control fragrance was significant. Women rated the male fragrance as sexier, more pleasant, and more appealing than the control fragrance.

Genital Responses

Initial baseline. Analysis of the initial baseline levels of VPA found no significant effect of phase, but a main effect of group, $F(1,25) = 5.26$, $p = .03$. There was also a significant Group × Phase interaction, $F(1,25) = 9.89$, $p = .004$, $\epsilon = 1.0$, with Group 1 showing higher levels of VPA during the follicular phase, and Group 2 during the periovulatory phase (i.e., higher levels of genital arousal during the first testing session).

Response to stimuli. To assess changes in VPA responses, difference scores were calculated between the initial baseline and mean VPA response during experimental conditions. These were subjected to a 2 (Group) × 2 (Phase) × 2 (Stimulus) × 3 (Fragrance) analysis of covariance (ANCOVA), with mean return-to-baseline periods as covariates.

For VPA, results of the ANCOVA revealed a significant main effect for the covariate, $F(1,49) = 22.57$, $p = .0001$. There was a stimulus main effect, $F(1,24) = 13.34$, $p = .001$; as expected, erotic film led to larger VPA responses than sexual fantasy. The only other significant effect found was a Phase × Stimulus × Fragrance interaction effect, $F(2,49) = 3.83$, $p = .03$ (see Figures 1 and 2). Contrasts indicated that, for erotic fantasy, when testing occurred during the follicular phase, the male fragrance was associated with larger increases in VPA than either the control, $F(1,49) = 6.00$, $p = .02$, or the female fragrance, $F(1,49) = 6.33$, $p = .02$, conditions. Conversely, in response to sexual film, during the periovulatory phase, the female fragrance resulted in smaller increases in VPA than the control fragrance, $F(1,49) = 5.52$, $p = .03$; the male versus control fragrance comparison was nonsignificant. Thus, our prediction—that any positive effects of fragrance found would be more pronounced during the periovulatory phase than the follicular phase—was not supported.

In addition to the above analysis, which utilized difference scores, an analysis was undertaken using the absolute VPA response during each condition, with the preceding baselines as covariates. This analysis yielded a pattern of results identical to the above findings.

Subjective Arousal

Initial baseline. Multivariate analysis of the baseline (i.e., prestimulus) ratings found no significant main effects or any interaction effects.

Response to stimuli. Multivariate analysis of the sexual arousal scores yielded a Fragrance × Stimulus interaction effect, $F(8,19) = 2.65$, $p = .04$, indicating that there were differential effects of the fragrances, dependent upon the stimulus (film/fantasy) condition. There was also a significant four-way interaction, Group × Phase × Stimulus × Fragrance: $F(8,19) = 3.11$, $p = .02$. As the multivariate analysis showed significant interaction effects, univariate repeated-measures ANOVAs for each of the subjective sexual variables were carried out; the results are summarized below.

There were consistent main effects for phase: sexually aroused "overall," $F(1,26) = 6.09$, $p = .02$, sexually aroused "strongest feelings," $F(1,26) = 7.46$, $p = .01$, genital sensations, $F(1,26) = 5.74$, $p = .02$, vaginal lubrication, $F(1,26) = 5.52$, $p = .03$, and desire for sex with a partner, $F(1,26) = 9.12$, $p = .006$, $\epsilon = 1.0$. For all of these variables, women had higher ratings (i.e., indicating

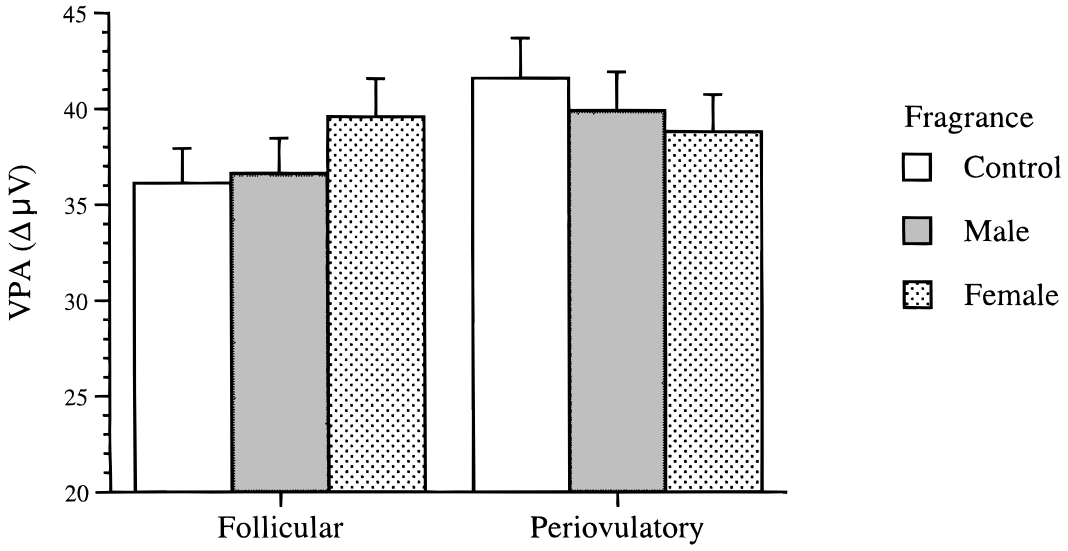

Figure 1. Mean genital response (±SEM) with erotic film stimulus.

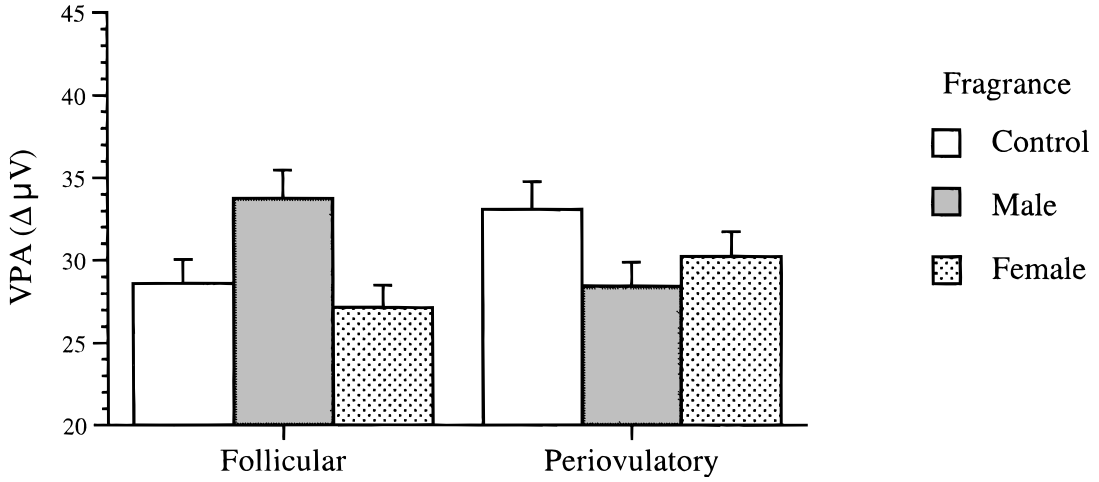

Figure 2. Mean genital response (±SEM) with sexual fantasy stimulus.

greater sexual response) during the periovulatory phase than during the follicular phase.

Main effects for stimulus were highly significant: sexually aroused "overall," $F(1,26) = 6.83$, $p = .02$, sexually aroused "strongest feelings," $F(1,26) = 9.75$, $p = .004$, genital sensations, $F(1,26) = 9.01$, $p = .006$, vaginal lubrication, $F(1,26) = 7.96$, $p = .009$, and desire for sex with a partner, $F(1,26) = 4.48$, $p = .04$, $\epsilon = 1.0$. For all these variables, the erotic film elicited stronger feelings of sexual arousal than sexual fantasy. It is worth noting here that mean ratings of sexual arousal during the erotic film stimulus fell above the midpoint (i.e., above 50 on the 100-mm scale), indicating that the women's responses were comparable to levels obtained in most previous studies of female sexual arousal (e.g., Laan, Everaerd, & Evers, 1995). For sexual fantasy, mean levels of sexual arousal were somewhat lower, but close to the midpoint.

No main effects for fragrance were found. However, an interaction between fragrance and stimulus for sexually aroused "strongest feelings" almost reached significance, $F(2,26) = 2.77$, $p = .07$, $\epsilon = 0.99$. Inspection of the means showed that during erotic fantasy, the male fragrance elicited higher levels of arousal than both control and female fragrances (see Figure 3). During the erotic film, however, the male and female fragrances were associated with lower subjective arousal ratings than the control con-

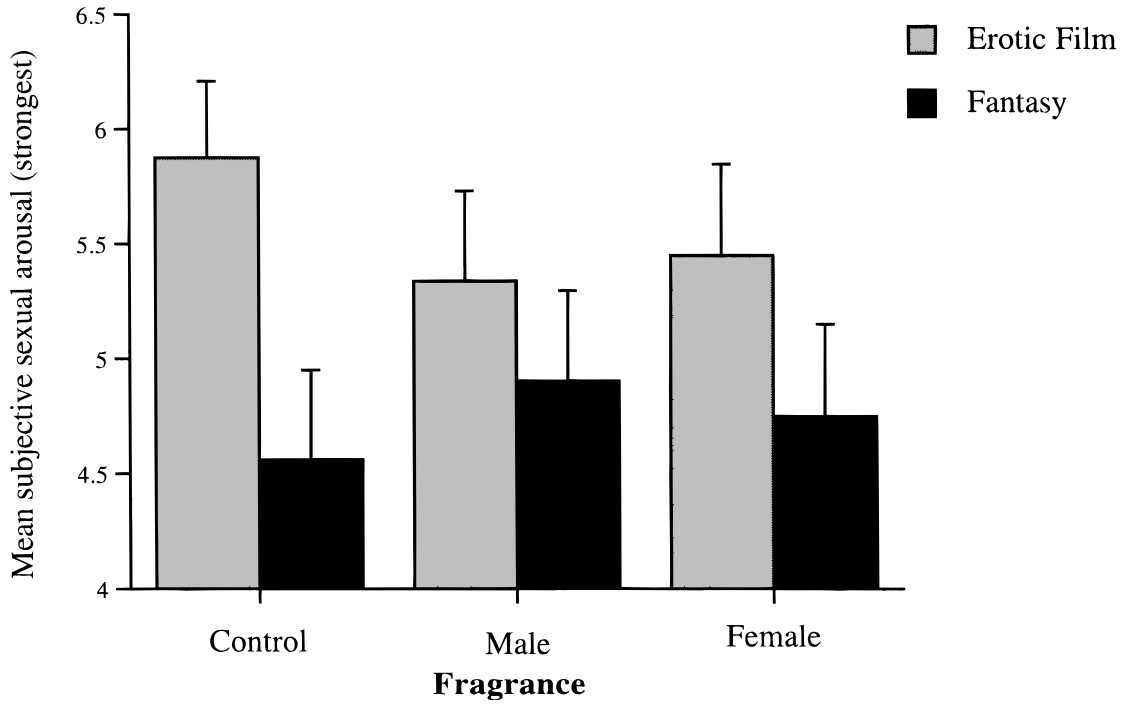

Figure 3. Mean subjective sexual arousal (strongest) (±SEM) with different fragrance stimuli.

dition. Contrasts revealed that only the difference between the male and control fragrances during the film stimulus reached significance, $F(1,26) = 4.49$, $p = .04$.

There were also highly significant Group × Phase effects for sexually aroused "overall," $F(1,26) = 8.03$, $p = .009$, sexual arousal "strongest feelings," $F(1,26) = 8.88$, $p = .006$, genital sensations, $F(1,26) = 7.04$, $p = .01$, vaginal lubrication, $F(1,26) = 7.80$, $p = .01$, and desire for sex with a partner, $F(1,26) = 10.34$, $p = .004$, $\epsilon = 1.0$. Participants in Group 2 (tested first during the periovulatory phase) rated themselves as more aroused during the periovulatory phase session, than during their second, follicular phase session. In contrast, Group 1 (tested first during the follicular phase) showed similar levels of arousal across their two sessions.

Subjective Mood

Initial baseline. Multivariate analysis of the baseline scores revealed no main effect of phase, but a significant Group × Phase interaction, $F(5,22) = 5.54$, $p = .002$. Univariate tests revealed significant Group × Phase effects for two variables: happy, $F(1,26) = 11.74$, $p = .002$, $\epsilon = 1.0$, and interested, $F(1,26) = 28.42$, $p = .0001$, $\epsilon = 1.0$. Group 2 participants reported being happier and more interested at the start of their first (periovulatory) session than their second (follicular) session, whereas the baseline ratings for Group 1 were much more similar across their two visits.

Response to stimuli. Multivariate analysis of experimental mood ratings found a main effect of phase, $F(5,22) = 2.68$, $p = .05$. Interestingly, there were no differences in reported mood between fragrance (male, female, control) conditions or stimulus (erotic film, fantasy) presentations (i.e., no main effects for fragrance or stimulus).

Univariate tests showed significant phase effects for three mood variables: happy, $F(1,26) = 8.63$, $p = .007$, interested, $F(1,26) = 6.27$, $p = .01$, and confident, $F(1,26) = 6.67$, $p = .02$, $\epsilon = 1.0$. A Group × Phase interaction effect was found for interested, $F(1,26) = 4.98$, $p = .04$; this interaction effect almost reached significance for happy, $F(1,26) = 3.22$, $p = .09$, and sexy, $F(1,26) = 3.12$, $p = .09$, $\epsilon = 1.0$. Group 2 participants reported being happier, more interested, and sexier during their first (periovulatory) session than during their second (follicular) session; in contrast, women in Group 1 showed similar ratings on these variables across their two sessions.

Startle Response

For the startle response analyses, data from 10 of the 33 participants had to be rejected because they did not consistently show a startle response. Separate univariate analyses of the follicular and periovulatory sessions, with stimulus (neutral film, sexual film, and fantasy), and fragrance (female, male, control) the within-subjects variables were performed. Group was not included as a between-subjects variable because of the smaller number of participants. There were significant main effects of stimulus, follicular: $F(2,32) = 4.93$, $p = .02$, $\epsilon = 0.96$; periovulatory: $F(2,26) = 17.77$, $p = .0001$, $\epsilon = 0.99$; both the erotic film and fantasy led to reductions in startle reflex amplitude, in comparison with initial baseline (neutral film). Contrast analyses showed significant differences between neutral and erotic film for both follicular, $F(1,32) = 9.39$, $p = .005$, and periovulatory, $F(1,26) = 33.26$, $p = .0001$, phases. Differences between initial baseline and erotic fantasy were also significant, follicular: $F(1,32) = 4.52$, $p = .04$; periovulatory: $F(1,26) = 17.59$, $p = .0003$. No main effect of fragrance or any interaction effects were found.

Postexperimental Interviews

Despite the presence of the genital device and the attached electrodes, most (81.8%) women reported that they had felt "at ease" during the testing session. Women rated the degree to which the vaginal device and the sound bursts, used to assess the startle reflex, interfered with attending to the films, or with their ability to fantasize, on a scale from 0 ("not at all") to 100 ("very strongly"). The vaginal device interfered little with women's ability to attend to the films (mean rating 5.3, $SD = 11.9$) or to fantasize about sexual experiences (mean 7.7, $SD = 14.9$). The sound bursts were perceived as more distracting than the vaginal device (mean ratings 40. 3, $SD = 30.4$, and 45.5, $SD = 35.6$, for the film and fantasy conditions, respectively).

Assessment of women's beliefs about what type of fragrance was contained in each of the three necklaces revealed that 17 (60.7%) were able to identify the male fragrance category correctly, and 21 (75.0%) the female fragrance category. For the control necklace, however, 6 (21.4%) participants believed that this necklace contained a male fragrance, and 7 (25.0%) a female fragrance.

Regarding beliefs about the focus of the study, the item that obtained the highest mean rating (on a 0–100 scale) was "exploring differences in sexual response between the two menstrual cycle phases" (mean rating 80.4, $SD = 15.4$); the lowest rating was for the study's focus being on "differences between the effects of 'male' and 'female' fragrances on sexual response" (mean rating 61.7, $SD = 24.9$).

Discussion

Although the findings from this study suggest a positive influence of a male fragrance on female sexual arousal, the effect was observed only during the erotic fantasy condition, and was significant only for the measure of genital arousal and not for subjective arousal. Also, contrary to our hypothesis that any fragrance effects would be most apparent in the periovulatory phase, it was only during the follicular phase that the male fragrance was associated with increased genital response. In fact, during the periovulatory phase, there was a trend for highest VPA (greater arousal) during exposure to the control fragrance, compared with both male and female fragrances; this difference was evident in responses to both film and fantasy stimuli. The results are therefore complex and in need of replication. If these findings were to be replicated, then this difference between the follicular and periovulatory phases becomes potentially interesting. If olfactory acuity is enhanced during the periovulatory phase, then perhaps women perceived the fragrances as overly intense, and even unpleasant, during this phase of their cycle.

Although not reaching significance, the findings for the self-report measures of sexual arousal were similar to those for genital arousal: during sexual fantasy there was a consistent trend for the male fragrance to be associated with higher ratings of sexual arousal than both the female and control fragrances. However, in addition, during erotic film, the male fragrance was associated with significantly lower ratings for subjective sexual arousal than the control fragrance.

Contrary to our predictions, and somewhat surprisingly, there were no significant effects of fragrance on subjective mood, as assessed by VAS. Few studies have examined the relationship between mood and sexual arousal in women; however, one recent study found no evidence that positive mood was an important factor in facilitating sexual arousal (Laan, Everaerd, Berlo, et al.,

1995). There were also no significant effects of fragrance on the amplitude of the startle response (used as a physiological index of mood). In fact, the only significant finding related to the startle response was that both erotic film and fantasy led to a reduction in startle reflex amplitude (indicating a positive emotional state), compared with the initial baseline. However, it is important to bear in mind that the number of participants involved in the startle analyses were small.

Returning to the three possible mechanisms whereby fragrance may affect sexual arousal, our data provided no support for the hypothesis that odors are influential because of their mediating effects on mood. Whether fragrances are arousing because of their association with past sexual activity, or whether the mechanism involves a direct effect of olfactory stimuli on the brain remains an open question; either explanation would be consistent with our findings, but our data provide no direct support in favor of one of these mechanisms.

Consistent with previous studies, subjective and physiological levels of sexual arousal were greater during the erotic film than during the sexual fantasy condition. However, the possibility that there was a "ceiling effect" during the erotic film condition that obscured any positive effect of the male fragrance is unlikely, as the male fragrance was associated with lower levels of subjective sexual arousal than the control substance. One possibility is that the fragrance was perceived as a "distraction" during the erotic film, whereas during fantasy, it may have enhanced the ability to engage in sexual fantasies (e.g., by eliciting memories of previous encounters with male partners). Interestingly, when women were in the follicular phase, they perceived both fragrances as more intense during sexual fantasy than during erotic film.

For genital arousal, VPA levels were higher during the baseline of the first testing session, compared with the second. However, there were no main effects of menstrual cycle phase, either at baseline or during the stimulus presentations.

For the subjective data, there were interesting Group $\times$ Phase effects. Women whose first testing was during the periovulatory phase gave more positive ratings for male and female fragrances in both testing sessions than those tested first during the follicular phase. Also, for the subjective data, there was a consistent interaction between the first testing session and phase of the menstrual cycle. Women tested first during their periovulatory phase reported higher levels of sexual arousal during the first testing session, compared with their second; those whose first testing session took place during their follicular phase, on the other hand, showed similar levels of sexual arousal across both sessions. Slob, Ernste, and van der Werff ten Bosch (1991) found that women tested for the first time in their follicular phase were sexually more aroused (on both subjective and genital measures) by erotic film than women tested first during their luteal phase; there was no assessment made during the periovulatory phase. Clearly, more attention should be paid to the issue of cycle phase at first testing in future research.

For subjective mood, across both groups, women rated their mood better (i.e., happier, more confident, and more interested) during periovulatory than during follicular phase sessions. The few prospective studies that have looked at changes in positive mood across the menstrual cycle have shown consistently an increase in positive mood through the follicular phase, reaching a peak around ovulation and declining in the late luteal phase (Sanders, Warner, & Backstrom, 1983). There was also a trend for women who were tested first during the periovulatory phase to report feeling "happier" and "sexier" during their first session; in contrast, women tested for the first time during the follicular phase showed less marked differences in mood ratings across their two sessions.

Generalization of these findings is limited for a number of reasons. Firstly, it is now well established that participants in sexuality studies tend to hold more liberal and positive views regarding sexuality, and also to have higher mean levels of sexual activity than nonparticipants (Catania, Gibson, Chitwood, & Coates, 1990). Indeed, we found that women who withdrew from the study before attending any testing sessions were less likely to report having ever seen sexually explicit films and photographs. Regarding fragrance effects, we chose to study one male and one female fragrance; it is not possible to generalize beyond these fragrances, although further research might investigate whether other colognes in the same fragrance categories would have similar effects. In the present study, the male fragrance was rated as more intense than the female fragrance; future studies comparing male and female fragrances should attempt to control for the intensity of the fragrances. A final methodological issue concerns the use of the VPA measure to index genital arousal. Although vaginal photoplethysmography is the method used most widely for monitoring vaginal blood flow, it is not without problems. In this study VPA, which measures pulsatile blood flow, was utilized as the index of genital arousal. VPA was chosen over vaginal blood volume (VBV), reflecting slowly developing changes in VBV, because of previous work indicating that VPA is the more sensitive measure of the two (Laan, Everaerd, & Evers, 1995). In common with other researchers, we found that VPA levels did not return to initial baseline during "return-to-baseline" periods. Previous studies have attempted to deal with this problem by providing distraction tasks between stimulus presentations, or by increasing the length of interstimulus intervals, but this has overcome the problem only partially (Laan, Everaerd, & Evers, 1995). Clearly, future research should focus on methods to overcome this methodological problem.

Although this study was relatively small and exploratory, our findings suggest that a male fragrance might enhance female sexual arousal during erotic fantasy and that this effect did not appear to be mediated by mood. The findings raise many questions; future studies might investigate whether there are complementary effects of female fragrance on male sexual arousal, or whether a male fragrance also enhances male arousal.

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