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7 Duration of Oral Contraceptive Use Predicts Women's Initial and Subsequent Subjective
8 Responses to Sexual Stimuli

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Abstract

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Recent work suggests that a woman's hormonal state when first exposed to visual sexual stimuli (VSS) modulates her initial and subsequent responses to VSS. The present study investigated whether women's initial hormonal state was related to their subjective ratings of VSS, and whether this relationship differed with VSS content. We reanalyzed previously collected data from 14 naturally cycling (NC) women and 14 women taking oral contraceptives (OCs), who subjectively rated VSS at three hormonal time-points. NC women's ratings of 216 unique sexual images were collected during the menstrual, periovulatory, and luteal phases of their menstrual cycles, and OC women's ratings were collected at comparable time-points across their pill-cycles. NC women's initial hormonal state was unrelated to their ratings of VSS. OC women's initial hormonal state predicted their ratings for VSS with minimal contextual information and for images depicting female-to-male oral sex. Specifically, women who entered the study in the third week of their pill-cycle (OC-3 women) rated such images as less attractive at all testing sessions than did all other women. OC-3 women were also the only women to rate decontextualized VSS as *unattractive* at all testing sessions. These results corroborate previous studies in which women's initial hormonal state was found to predict subsequent interest in sexual stimuli. Future work, with larger samples, should more directly investigate whether OC-3 women's negative assessment of specific types of VSS reflects a reaction to the laboratory environment or a broader mechanism, wherein OC women's sexual interests decrease late in their pill-cycle.

Keywords: oral contraceptives, visual sexual stimuli, menstrual cycle, subjective response

Introduction

Ovarian steroids modulate a number of components of female sexuality. In naturally cycling (NC) women, levels of sexual desire, rates of masturbation, and frequency of paired sexual interaction fluctuate across the menstrual cycle – peaking just prior to ovulation when estradiol (E2) is high and progesterone (P4) is low, and decreasing in the luteal phase, when P4 is high and E2 is low (Adams, Gold, & Burt, 1978; Harvey, 1987; Guegen, 2009; Matteo and Rissman, 1984; Roney and Simmons, 2013). Women taking oral contraceptives (OCs) do not ovulate, do not experience similar fluctuations in E2 and P4, and do not experience comparable cyclic peaks in sexual behaviors (Speroff and Darney, 2010; Adams et al., 1978). Indeed, OC women’s relatively low and sustained levels of estrogens and high levels of progestins are thought to be partially responsible for some OC users’ reportedly lower levels of sexual desire (Battaglia et al., 2012; Sanders et al., 2001).

Despite fairly consistent findings of cyclic fluctuations in NC women’s sexual desire and behavior in naturalistic settings, laboratory assessments of the relationship between ovarian steroids and sexual response have yielded mixed results (e.g. Chivers et al., 2010; Slob et al., 1991; Slob et al., 1996; Suschinsky et al., 2014; Wallen and Rupp, 2010). Recent work indicates that inconsistent laboratory findings regarding women’s sexual response across their menstrual cycles may reflect that in within-subjects studies, a woman’s hormonal state when she begins the study influences her sexual response during each test session more greatly than does her hormonal state at time of testing. That is, laboratory studies appear to be subject to a “carry-over effect”, wherein a woman’s hormonal state when first tested affects both her initial response and her responses in later test sessions. The carry-over effect of women’s initial hormonal state has now been reported for two different measures of genital arousal and one cognitive measure of

sexual interest (Slob et al., 1991; Slob et al., 1996; Suschinsky et al., 2014; Wallen and Rupp, 2010), suggesting this phenomenon is more than just an artifact of laboratory testing.

Using labial temperature as a measure of sexual arousal, Slob and colleagues (1991, 1996) found that NC women who began their studies in the periovulatory phase showed greater genital response to visual sexual stimuli (VSS) across all testing sessions than did NC women who began in the luteal phase of their cycles. Suschinsky and colleagues (2014) recently found a similar pattern of hormonal effects in NC women using vaginal pulse amplitude (VPA), a measure of vaginal blood flow also thought to indicate sexual arousal. Rather than absolute differences in genital arousal between women who started the study in the follicular phase versus the luteal phase, however, Suschinsky and colleagues (2014) found an interaction between women's initial hormonal state and the content of the sexual stimuli. Specifically, the authors found that women who began the study in their follicular phase showed markedly greater VPA to films depicting penile-vaginal intercourse (PVI) than to films depicting female-to-male oral sex across two test sessions, whereas women who began the study in their luteal phase showed similar VPA responses to PVI films and films depicting female-to-male oral sex.

Previous work in our laboratory showed the carry-over effect is not specific to genital arousal, but is also seen in an implicit measure of sexual interest—how long women look at sexual images (Wallen and Rupp, 2010). NC women who began the study in their periovulatory phase looked longer at the sexual images in each of the three sessions than did women who began in the luteal phase of their cycles. Similar to Slob and colleagues' (1991) original study, we also found support for the carry-over effect in women taking OCs. OC women who began the study in the pill-free week of their pill-cycles looked longer at the sexual images across all three sessions than did women who were currently taking the pill at the time of their first test session.

Because OC women's endogenous levels of E2 rise during the pill-free phase of their pill-cycles, and their levels of progestins drop, it is not surprising that the pill-free group of OC women showed the most sexual interest (Bayer, 2012; Roney and Simmons, 2013). It is, however, of interest that the OC women who began in their pill-free week maintained the most interest across testing sessions, given that OCs substantially alter women's hormonal milieu (Sanders et al., 2001).

Taken together, these data provide support for the notion that a woman's hormonal state when first exposed to sexual stimuli affects her physiological arousal to and her interest in those stimuli, and that, in a laboratory setting, these effects persist for at least one month. Interestingly, all studies reporting carry-over effects included a subjective measure of sexual arousal or interest, but in none of the prior studies was a carry-over effect evidenced with the subjective measure. Indeed, to date, no study has reported hormonal modulation of subjective response to VSS in a laboratory setting (e.g. Shreiner-Engel, Shriaviah, Smith, and White, 1981; Bruce, Hoon, and Kinchloe, 1982; Slob et al., 1991, 1996; Wallen and Rupp, 2010; Suschinsky et al., 2014).

Because subjective ratings reflect sociocultural influences and are often collected via limited, discrete numerical scales, it seems likely that it would be more difficult to detect hormonal effects with subjective, as compared to physiological, responses, which are harder to inhibit and are typically measured with a continuous scale (e.g. Rellini, et al., 2005). Indeed, discordance between women's subjective responses to VSS and their physiological and cognitive responses is not specific to studies of the carry-over effect (see Chivers, et al., 2010 for a meta-analysis), and there is evidence that the discrepancies between physiological and subjective response patterns are reduced when a continuous measure of subjective arousal is used instead of a Likert-scale.

Data suggest that subjective responses differ both with the nature of the assessment method and with the sexual content of the stimuli. Specifically, women's subjective responses to sexual stimuli are at times discordant with their stated sexual preferences as well as with their physiological responses, but this discordance is not seen with certain types of sexual images (Chivers, et al., 2007; Hamann, et al., 2014; Sape et al., 2014). For example, heterosexual women will report subjective arousal to images depicting solo nude women, as well as to images depicting nude men, but Sape and colleagues (2014) recently showed that for sexual images with little contextual information, that depict only aroused genitals, women show subjective responses that correspond with both their stated sexual preferences and with their physiological responses.

Our laboratory previously found evidence that stimulus content, and particularly the amount of contextual information, may also be an important factor to consider in testing and detecting hormonal effects on subjective response patterns. Similar to Sape and colleagues (2014), we used a set of VSS that consisted of images from either a broad perspective, showing contextual elements of the sexual scene, or from a close-up view that essentially included only genitals (termed here "decontextualized images"; Rupp and Wallen, 2009). Unlike the images used by Sape and colleagues (2014), however, decontextualized and contextualized images depicted couples engaged in PVI and oral sex, rather than solitary actors. With this stimulus set, we found that although NC women and OC women did not differ overall in their mean subjective ratings of the VSS, they did differ in their ratings of decontextualized images (Rupp and Wallen, 2009). Specifically, OC women rated decontextualized images of sexual acts as less sexually attractive than did NC women.

NC and OC women in this study provided subjective ratings at three different hormonal time-points in their cycles; however, because the primary interest in Rupp and Wallen (2009) was to investigate potential sex differences in content preferences of VSS, NC and OC women's subjective ratings were collapsed across cycle phases. The purpose of the present study was therefore to analyze subjective ratings from the NC and OC women in Wallen and Rupp (2010) and Rupp and Wallen (2009), taking into account women's hormonal state when they entered the study and the content of the VSS. For this study, we were particularly interested in women's responses to decontextualized images. We expected that NC women who began the study in the periovulatory phase of their cycle would show the most positive responses to decontextualized images across all cycle phases, whereas OC women who began the study during their pill-cycle would show the least positive response to these images.

Method

Details regarding the collection of this dataset can be found in Rupp and Wallen, 2009 and Wallen and Rupp, 2010. Here, we provide a brief summary of those collection methods, as well as details of the specific methods for the present study.

Participants

Data for this retrospective study came from 30 women (ages 23 – 35): 15 naturally cycling (NC) women, and 15 women currently taking an oral contraceptive (OC). All participants included in the present analyses were recruited from graduate and professional schools in the Atlanta, GA metropolitan area. For participation in the original study, potential participants were asked to complete a packet containing a consent form and a questionnaire regarding contraceptive use, sexuality, and previous experience with visual sexual stimuli (Rupp and Wallen, 2010). The questionnaire was comprised of questions selected from the Brief Index

of Sexual Function (BISF; Taylor, Rosen, and Leiblum, 1994) and the Sexual Permissiveness subscale of the Sexual Attitudes Scale (Hendrick and Hendrick, 1987). Questions from the BISF inquired about the subject's level of sexual motivation in the last month and her experience with sexual stimuli using a 0 – 6 Likert scale (0 = none, 6 = very extensive). The Sexual Permissiveness subscale was used to assess the degree to which the subject's regarded their sexual attitudes as liberal or conservative (0 - 6, with higher numbers indicating more liberal attitudes). Because all images used in the study depicted sexually explicit sexual acts between heterosexual couples, only potential subjects who self-identified as heterosexual and had some previous experience with sexually explicit images were recruited for participation in the study.

Stimuli

Subjects viewed 216 sexually explicit images – 72 unique images during three separate test sessions. These 216 images were selected from a larger group of 364 images that were downloaded from free, publicly available websites. In order to find a sufficient number of stimuli that depicted a range of sexual acts and camera perspectives, a stimulus set was generated instead of using previously screened sexual stimuli from the International Affective Picture System (IAPS; Lang et al., 2008), which is fairly limited. The final stimulus set was created from the 216 images that received the highest mean sexual attractiveness ratings during a pilot test. In the pilot, seven men and seven women who were not subjects in the study and rated 364 images for level of sexual attractiveness (-1 – 3, with -1 indicating the image was negative [not sexually attractive at all], and 3 indicating the image was highly sexually attractive). The image sets used in the three test sessions did not differ by mean pilot ratings of image sexual attractiveness ($F(2, 215) = 0.55, p = 0.58$; overall mean $\pm$ SD = 2.09 ± 0.55 ; Rupp and Wallen, 2007). The order of

the images within each test session was computer randomized for each individual, such that each participant saw the 72 images for that test session in a unique order.

The stimulus set included opposite-sex couples engaged in either penile-vaginal intercourse (PVI) (144 images) or oral sex (36 male-to-female images, 36 female-to-male images). The images varied in the nature of the context depicted in the image; a subset of the photographs (54 images) were decontextualized, and consisted only of close-up images of the sexual act (genitals only in the case of PVI images, and genitals and the opposite-sex partner's face or head in the case of oral sex images). For every decontextualized image in the stimulus set, there was an image that depicted the same actors, engaging in the same sex act, but with a wider camera perspective that typically included the majority of the participant's bodies and more contextual elements (e.g. setting details, such as furnishings or items on walls). Although the stimulus set consisted of markedly more contextualized (162 images) as compared to decontextualized images, NC and OC women's ratings of the 54 contextualized that were specifically matched to the decontextualized images did not differ in overall mean from their ratings of all contextualized images in the stimulus set (Mean $\pm$ SD, NC women's ratings of all contextualized = 6.11 ± 1.75 and specifically matched = 6.19 ± 1.8 , $p > 0.05$; OC women's ratings of all contextualized = 6.04 ± 2.01 and specifically matched = 6.05 ± 2.13 , $p > 0.05$), and were not more variable than their ratings of all contextualized images in the stimulus set (as tested with coefficients of variation (CV), CV for NC women's rating of all contextualized = 28.81 and CV for specifically matched = 29.08, $p > 0.05$; CV for OC women's ratings of all contextualized = 33.28 and CV for specifically matched = 35.21, $p > 0.05$). We therefore included all rated contextualized images from the dataset in the present analyses.

Procedure

Study Design

Subjects attended three testing sessions. NC women attended one session in each stage of their menstrual cycles: the menstrual phase, periovulatory phase, and luteal phase. NC women's cycle phases were approximated based on an average 28-day cycle – the menstrual phase was considered to be days 1-5, the periovulatory phase days 9 -13, and the luteal phase days 20 -25. Periovulatory and luteal phase assignments were subsequently confirmed via hormonal assay of women's blood P4 levels. Due to a laboratory assay error, E2 could not also be used to confirm cycle phase. Although OC women do not experience hormonal fluctuations as NC women do, OC women's testing sessions were scheduled the same number of days from menstruation as were NC women's. OC women were therefore tested during the pill-free week of their pill-cycles, approximately one week into their pill-packs (termed here "OC-1 women"), and three weeks into their pill-packs (termed here "OC-3 women").

NC and OC women were randomly assigned to their first test session, such that on average, 1/3 of NC women ($n = 6$) and 1/3 of OC ($n = 5$) women first visited the lab in their menstrual phase, 1/3 of NC ($n = 4$) and 1/3 of OC ($n = 5$) women first visited in their periovulatory / one-week pill phase, and 1/3 of NC ($n = 4$) and 1/3 OC ($n = 4$) women first in their luteal / three-week pill phase. Although subjects varied regarding the phase of their first test session, all subjects attended the three sessions in the same order (i.e. if the woman started in the periovulatory phase, her next testing session was during the luteal phase; if she started in the luteal phase, her next session was the menstrual phase, etc). Similar to other studies of the carry-over effect, all participants attended all testing sessions within one month (e.g. all participants experienced only one menstruation during the study) (Slob, et al., 1991; Slob et al., 1996).

Testing

At the beginning of each test session, subjects completed a questionnaire that assessed state anxiety (State Trait Anxiety Inventory; Spielberger and Gorsuch, 1983). Before beginning testing, subjects also provided a blood spot sample, which was later assayed for P4 by Yerkes Primate Endocrine Core Laboratory, using commercially-available radioimmunoassay (RIA) kits by Diagnostic Systems Laboratories (Webster, TX; P4 intra-assay coefficients of variation 5.44%). More details regarding blood spot collection can be found in Wallen and Rupp, 2010.

After providing a blood spot, subjects viewed 72 sexual images on a laptop (Dell Inspiron 1024 x 768 pixel screen resolution). Subjects were told they may look at each image as long as they wished, and could advance to the next image by pressing the space-bar on the keyboard. All subjects viewed each stimulus set twice; during the first viewing, the subjects' gaze patterns and eye fixations were tracked with Gaze tracker software (Eye Response Technologies, Charlottesville, VA). Analyses of the eye-tracking data can be found in Wallen and Rupp (2010) and Rupp and Wallen (2007; 2009). During the second viewing, subjects' eyes were not tracked, and they were asked to rate each image for perceived level of sexual attractiveness on a 9-point scale (1 = extremely sexually unattractive, 2 = highly sexually unattractive, 3 = moderately sexually unattractive, 4 = slightly sexually unattractive, 5 = neither sexually attractive or unattractive, 6 = slightly sexually attractive, 7 = moderately sexually attractive, 8 = highly sexually attractive, 9 = extremely sexually attractive). These ratings are those analyzed in the present paper. Subjects were not provided with explicit instructions beyond to rate the "sexual attractiveness" of the image, and were thus allowed to individually determine what factors contributed to sexual attractiveness. The subject was separated from the female experimenter by an opaque curtain during the rating session. Once the subject finished viewing all images, a tone sounded to indicate the conclusion of the session and signal the experimenter to enter the room.

At the end of each testing session, the subject was monetarily compensated (\$15 for first testing session, \$20 for the second, and \$25 for the third), and the next testing session was scheduled.

Data Analysis

In this retrospective study, we were interested in whether a woman's hormonal state when she enters a study is related to her subjective ratings of VSS across test sessions, and whether the strength of this relationship differs with the content of the VSS. Given our previous findings that indicated contextual information may be of particular importance for OC women, we were specifically interested in whether a woman's initial hormonal state differentially affects her subjective response to contextualized versus decontextualized images. We previously found that OC women as a group rated decontextualized images as less attractive than did NC women. In the present analyses we determined whether either group of women's ratings for these images were related to their initial hormonal states. In order to test whether NC and OC women's initial hormonal state was related to their ratings of images, and whether this effect varied with image content, we performed a 2 (pill use [NC women vs. OC women]) X 3 (initial cycle phase [menstrual vs. periovulatory/OC-1 vs. luteal/OC-3] X 2 (context [contextualized vs. decontextualized]) mixed-factor analysis of variance (ANOVA). Because prior work suggests that women may be particularly sensitive to the sexual act depicted in VSS, we were also interested in investigating whether women's initial hormonal state differentially affects women's subjective rating of certain sexual acts. Specifically, given that female initiated sexual behaviors appear to be particularly subject to hormonal influence, we tested whether women's initial hormonal state would be a better predictor of response to images depicting female-to-male oral sex (i.e. an active female sexual behavior) rather than images depicting male-to-female oral sex (Wallen, et al., 1984; Adams et al., 1978). In order to test whether women's initial hormonal

state differentially affects their ratings based on the sexual act, we used a 2 (pill use [NC women vs. OC women]) X 3 (initial cycle phase [menstrual vs. periovulatory/OC-1 vs. luteal/OC-3]) X 2 (act [female-to-male vs. male-to-female]) mixed-factor ANOVA on women's ratings for images depicting female-to-male oral sex and images depicting male-to-female oral sex. In the presence of a main effect or interactions, we performed follow-up ANOVAs and t-tests.

Effect size estimates were calculated as η^2 (Brown, 2008) for ANOVA results and Cohen's d (Becker, 2000; Cohen, 1988) for pairwise comparisons. Results are expressed as mean $\pm$ standard deviation of the mean, unless otherwise stated. A probability of $p \leq 0.05$ was considered significant.

Results

Participants

14 NC women and 14 OC women completed all three testing sessions. Due to technical error, however, subjective ratings were not collected for one of the sessions for one NC woman. NC women and OC women did not differ in their previous experience viewing sexual images (Mean $\pm$ SD, NC: 1.89 ± 0.88 , OC: 1.93 ± 0.90 , $p = 0.92$, $d = -0.04$) or sexual attitudes (Mean $\pm$ SD, NC: 49.50 ± 13.34 , OC: 47.79 ± 10.81 , $p = 0.80$, $d = 0.14$). NC women randomly assigned to initial hormonal phase groups did not differ in their previous experience viewing sexual images (Mean $\pm$ SD, Menstrual: 1.58 ± 0.58 , Periovulatory: 1.88 ± 1.03 , Luteal: 2.38 ± 1.10 , $p = 0.41$, $\eta^2 = 0.14$) or sexual attitudes (Mean $\pm$ SD, Menstrual: 52.17 ± 12.43 , Periovulatory: 57.75 ± 12.82 , Luteal: 37.25 ± 9.19 , $p = 0.08$, $\eta^2 = 0.38$). OC initial hormonal phase groups also did not differ in amount of VSS viewing experience (Mean $\pm$ SD, Menstrual: 2.20 ± 1.15 , Periovulatory: 1.90 ± 0.89 , Luteal: 1.63 ± 0.63 , $p = 0.67$, $\eta^2 = 0.07$) or sexual attitudes (Mean $\pm$

SD, Menstrual: 46.20 ± 13.33 , Periovulatory: 48.20 ± 10.73 , Luteal: 49.25 ± 11.62 , $p = 0.93$, $\eta^2 = 0.01$).

Test cycle phase

There was no main effect of women's cycle phase at time of testing on subjective ratings of any of the images ($F(2, 77)$'s < 1.10 , p 's > 0.34 , η^2 's < 0.03 for all images), nor was there an interaction between OC usage and test cycle phase for subjective ratings of any of the images ($F(2, 77)$'s < 0.18 , p 's > 0.85 , η^2 's < 0.005 for all images).

Initial cycle phase: Contextualized and decontextualized images

The mixed-factor ANOVA revealed a main effect of context ($F(1, 77) = 50.06$, $p < 0.001$, $\eta_p^2 = 0.39$), an interaction between context and OC status ($F(1, 77) = 28.25$, $p < 0.001$, $\eta_p^2 = 0.27$), an interaction between context and initial cycle phase, ($F(1, 77) = 6.99$, $p = 0.002$, $\eta_p^2 = 0.15$), and three-way interaction between context, OC status, and initial cycle phase ($F(1, 77) = 6.11$, $p = 0.001$, $\eta_p^2 = 0.14$). To probe the interaction, we performed follow-up analyses.

As displayed in Figure 1, NC and OC women did not differ in their ratings for contextualized images ($F(1, 77) = 0.06$, $p = 0.81$, $\eta_p^2 = 0.001$). There were also no differences in women's who started in different hormonal phases ($F(2, 77) = 1.30$, $p = 0.28$, $\eta^2 = 0.03$) nor an interaction between these factors ($F(2, 77) = 0.44$, $p = 0.65$, $\eta^2 = 0.01$).

Summed across all test sessions, analyses revealed a main effect of OC use ($F(1, 77) = 20.04$, $p < 0.001$, $\eta^2 = 0.21$), a main effect of initial cycle ($F(2, 77) = 8.11$, $p < 0.001$, $\eta^2 = 0.17$) and a significant interaction between OC use and initial hormonal phase ($F(2, 77) = 5.51$, $p = 0.006$, $\eta^2 = 0.13$) for decontextualized images. As shown in Figure 2, NC women's subjective ratings did not differ by their initial hormonal phase for decontextualized images ($F(2, 38) = 1.97$, $p = 0.15$, $\eta^2 = 0.09$). OC women who were first tested in their menstrual (pill-free) phase

did not differ from any NC women in their ratings for decontextualized images, (all t 's < 1.54 , p 's > 0.13 , d 's < 0.53). OC women who began the study in the first week of their pill-cycle rated images lower than did NC women who began in their menstrual phase ($t(30) = 2.89$, $p = 0.007$, $d = 0.99$), but they did not rate them significantly lower than did NC women who began in their periovulatory phase ($t(25) = 1.10$, $p = 0.28$, $d = 0.43$, see Figures 3 and 4 for comparison).

OC women who were first tested in the third week of their pill-pack (OC-3 women) rated the images as less attractive than did NC women who began the study at any cycle phase, and the differences were strikingly large (menstrual phase: $t(27) = 8.12$, $p < 0.001$, $d = 2.98$; periovulatory phase: $t(22) = 4.21$, $p < 0.001$, $d = 1.72$; luteal phase: $t(22) = 5.64$, $p < 0.001$, $d = 2.30$). OC-3 women rated decontextualized images as less attractive than did all other OC women ($F(2, 39) = 9.37$, $p < 0.001$, $\eta^2 = 0.33$). As shown in Figure 2, OC-3 rated the images as less attractive than did women who began testing after one week of pills (OC-1 women) ($p = 0.04$, $d = 0.91$), and much less attractive than did women who were in their menstrual (pill-free) phase, $p < 0.001$, $d = 2.27$). OC-3 women were also the only women to rate the images without context as *unattractive* ($t(11) = -5.24$, $p < 0.001$, as compared to a neutral rating, Figure 2).

Initial cycle phase: *Images depicting male-to-female oral sex and female-to-male oral sex*

The mixed-factor ANOVA revealed a main effect of sexual act ($F(1, 77) = 14.78$, $p < 0.001$, $\eta_p^2 = 0.16$), no interaction between sexual act and OC status ($F(1, 77) = 1.37$, $p = 0.25$, $\eta_p^2 = 0.02$), an interaction between sexual act and initial cycle phase, ($F(1, 77) = 3.20$, $p = 0.05$, $\eta_p^2 = 0.08$), and no three-way interaction between sexual act, OC status, and initial cycle phase ($F(1, 77) = 0.94$, $p = 0.40$, $\eta_p^2 = 0.02$). Because OC women and NC women did not experience hormonally comparable “initial cycle phases”, we included OC status as a factor in the follow-up

ANOVAs, to accurately characterize the nature of the interaction between sexual act and initial cycle phase.

As illustrated in Figure 3, NC and OC women did not differ in their subjective ratings of images depicting male-to-female oral sex ($F(1, 77) = 0.04, p = 0.85, \eta^2 < 0.001$) and there were also no differences between subjective ratings of women who started in different hormonal phase groups ($F(2, 77) = 0.28, p = 0.75, \eta^2 = 0.01$), nor an interaction between these factors ($F(2, 77) = 0.59, p = 0.56, \eta^2 = 0.01$).

Analyses of female-to-male oral sex images revealed no main effect of OC usage ($F(1, 77) = 1.94, p = 0.17, \eta^2 = 0.02$), nor an interaction between OC usage and initial hormonal phase, $F(2, 77) = 0.17, p = 0.84, \eta^2 = 0.003$. In contrast to images of male-to-female oral sex, there was a main effect of initial hormonal state ($F(2, 77) = 4.22, p = 0.02, \eta^2 = 0.10$). Although there was a significant main effect, and no interaction, follow-up analyses revealed no significant differences between NC women who started in different cycle phases ($F(2, 38) = 1.31, p = 0.28, \eta^2 = 0.06$, Figure 4), and revealed only OC women's ratings differed significantly with start phase ($F(2, 38) = 3.16, p = 0.05, \eta^2 = 0.14$), such that women who were first tested in the menstrual (pill-free) phase rated the images significantly more attractive than did OC-3 women ($p = 0.05, d = 0.93$, Figure 4). Follow-up analyses revealed that OC-3 women also rated female-to-male oral sex images less attractive than did NC women who began in the menstrual phase of their cycle ($t(27) = 3.12, p = 0.004, d = 1.21$), and NC women who began in their periovulatory phase ($t(22) = 3.12, p = 0.03, d = 0.98$), but not NC women who began in their luteal phase, $t(22) = 1.56, p = 0.13, d = 0.64$.

Discussion

Women's initial hormonal state was related to their subjective ratings of sexual images, but only in OC women. Further, the relationship between women's initial hormonal state and their subjective ratings varied with the nature of and context of the sexual act depicted. OC-3 women rated decontextualized images as less sexually attractive than did all other women in the study. Of particular note is that OC-3 women were also the only group of women to, on average, rate these images as *unattractive*. The effects of women's initial hormonal condition persisted across testing sessions, such that OC-3 women continued to rate decontextualized as unattractive in their second and third testing sessions, even though their hormonal condition in these later sessions was markedly different than in their initial session. OC women's initial hormonal condition also affected their ratings of images depicting female-to-male, but not of male-to-female oral sex – OC-3 women rated these images as less attractive than did OC women who entered in the pill-free week of their cycle, and as less attractive than did NC women who began in their menstrual or periovulatory phase. No similar relationships were found in NC women, who rated all groups of images positively and showed no relationship between their initial hormonal condition and their subjective VSS ratings.

The relationship between women's hormonal state and subjective ratings of images identified here supports a growing body of literature, indicating that in within-subjects laboratory studies, a woman's hormonal state when she enters the study is better predictor of her sexual response across testing sessions than is her hormonal state at time of testing (Slob et al., 1996; Slob et al., 1991; Wallen and Rupp, 2010; Suschinsky, Bossio, & Chivers, 2014). That the relationship between women's initial hormonal state and their ratings of VSS was not apparent for all women or all sexual stimuli in the study raises the question of what is unique about the interaction between OC use and these two sets of images, such that duration of OC exposure

within the pill cycle decreases how attractive women find decontextualized sexual images and images depicting female-to-male oral sex.

OCs are comprised of synthetic estrogens and progestins. These synthetic steroids increase in concentration in the blood over the course of a women's pill-cycle and alter the levels of a number of endogenous hormones, such as E2, P4, testosterone, allopregnanolone, and sex hormone binding globulin (Bayer, 2010; Sanders et al., 2001; Rapkin, et al., 2006). OC-3 women therefore differ hormonally in a number of ways from women in the other experimental groups. Because P4 is the steroid that accounts for the greatest amount of the variance in NC women's self-reported sexual desire (Roney and Simmons, 2013), we focus here on the potential role of P4, or P4-like progestins, in modulating OC women's subjective response.

OC-3 women are unique in that they had experienced fairly high plasma levels of progestins for two weeks prior to their first testing sessions. Other OC women had experienced either relatively low levels of progestins immediately before the time of testing (in the case of the group that started during their menstrual phase) or only one week of progestins prior to testing. NC women's P4 levels were assumedly low for the entire follicular and periovulatory phases of their cycles. Indeed, only NC women who began the study in the luteal phase were exposed to high P4 levels before their initial testing time. The luteal phase, however, lasts approximately 14 days, suggesting NC women who entered the study during their luteal phase experienced high P4 for, at maximum, of 10 days before initial testing (Stricker et al., 2006). It is therefore likely that OC-3 women experienced the most sustained exposure to progestins preceding initial testing of any group in the study.

It is possible that OC-3 women were also experiencing greater progestational activity *during* their first testing session than were women in the other experimental groups. Although it

is often assumed that women taking monophasic OCs experience fixed levels of progestins across their pill-cycles, data indicate that serum levels of progestins are higher in their third week of taking OCs than in their first week (e.g., Bayer HealthCare Pharmaceuticals Inc., 2012; Warner Chilcott, 2009). Given OC women's blood levels of progestins in the third week of a pill-cycle, and the binding affinity of a number of OC progestins for the P4 receptor, it is also possible that late in their pill-cycle, women taking certain OCs experience greater progestational activity than do NC women in the luteal phase of their cycles (Bayer HealthCare Pharmaceuticals Inc., 2012, Warner Chilcott, 2009, and Sitruk-Ware, 2006; as compared to Stricker et al., 2006).

Because P4 negatively mediates self-reported daily levels of sexual desire (Roney and Simmons, 2013), it is possible that progestins also mediated OC women's self-reported reactions to sexual stimuli here, but that in a laboratory context, progestin mediation becomes apparent only under very specific conditions. In the present study, we did not use a measure of sexual arousal or determine how much sexual desire an image elicited in women. Rather, we used a sexual attractiveness rating, to assess how appealing or aversive women found the sexual stimuli. With this metric, we found that OC use was specifically related to women's responses to images that were devoid of all contextual information except for the genitals, and for images depicting female-to-male oral sex.

In an eye-tracking study with these same OC users, we found that OC women as a group were more likely fixate on contextual elements of the images than they were on any other elements of the image (Rupp and Wallen, 2007). For decontextualized images, which focused almost exclusively sexual anatomy, subjects were unable to divert their attention to the background or other nonsexual aspects of the scene. It is therefore possible that these images,

with their blunt and inescapable sexual content, require greater sexual desire to be found sexually attractive, and are thus more likely to be seen as unattractive if women's sexual interest or desire is relatively low. That OC-3 women found these images to be particularly sexually unattractive may thus reflect lower intrinsic sexual desire.

As with ratings of decontextualized images, lower ratings of female-to-male oral sex images may also reflect decreased sexual desire, as mediated by progestins. Images depicting female-to-male oral sex differ from other sexual images, in that they depict an active female sexual behavior. When viewing sexual images, women reportedly imagine themselves as the women in the sexual scenes depicted (Janssen, Carpet, and Graham, 2003; Rupp and Wallen, 2009). If women used such viewing strategy with images depicting female-to-male oral sex, it is likely women would imagine initiating sexual behavior, unlike images of intercourse or images of male-to-female oral sex, where women could more easily imagine themselves as the recipient of male-initiated sexual behavior. Previous work shows female-initiated sexual behavior is strongly influenced by ovarian steroids – it peaks at ovulation and is suppressed by OCs (Adams et al., 1978; Van Goozen et al., 1997). In contrast, partnered and receptive sexual behaviors do not appear to be under as tight hormonal control. Ovarian steroids may thus exert clearest effects on subjective ratings of images depicting active female sexual behaviors.

A limitation of the current study is the small sample size for each hormonal group. These analyses were based on a dataset that was not originally collected to test the carry-over effect and thus not powered to do so. Although this aspect of the design makes the significant effects particularly striking, it also makes it difficult to interpret the absence of effects. For example, it is possible menstrual effects on subjective response for NC women would emerge with a larger sample. Additionally, because OC women in this study also exhibited eye-gaze patterns to

suggest that they were particularly interested in contextual aspects of the sexual images, and the clearest effects of OCs were for ratings of decontextualized images, it would be good to replicate and extend this work with a larger sample of OC women, to ensure this was not an idiosyncratic preference of this group of OC women. It is of note, however, that post-hoc analyses indicated that OC-3 women were no more variable in their ratings of decontextualized images than were any other group of women in the study (as indicated by comparisons of coefficients of variation, all p 's > 0.30). Nonetheless, because we did not control for the type of OC used by women in the study, we are limited in the generalizability of these findings for OC women. Without control over the type of OC used, it is unknown whether these effects are representative of one or multiple generations or brands of OCs. Finally, because some OC women experience adverse physical side-effects of pill-use, such as bloating or headaches, and we did not ask women about their physical state at time of testing, it is unknown whether the negative subjective responses identified here are related only indirectly to OC use, via some physiological side-effect.

The data presented here do, however, reflect the fourth measure of sexual response in which a carry-over effect of women's initial hormonal state has been found. Presently, the mechanism(s) underlying this carry-over effect of women's initial hormonal condition are unknown; however, it is possible these results reflect a conditioned response to a laboratory setting or to sexual stimuli themselves. Indeed, classical sexual conditioning has been reported in experimental and field settings for nonhuman animals and humans (as reviewed in Pfaus, Kippin, and Centeno, 2001; Hoffmann, Peterson, and Garner, 2012). The nature, however, of the conditions and mechanisms via which these potential conditioning effects operate here and how they interact with hormonal state remain to be explored. It would be informative in future work

on the carry-over effect to follow women across more than one month, so as to determine whether carry-over effects are “reset” after a particular interval of time.

There are recent data to support the idea that the carry-over effect identified here may have real-world analogs. Specifically, Roberts and colleagues (2012) found that women who met their partners while taking OCs reported less attraction to and sexual satisfaction with their partners than did women who were NC when they met their partners. Indeed, there is increasing evidence of decreased sexual satisfaction and altered mate choice patterns in women taking OCs (Weilling, et al., 2012; Alvergne and Laummaa, 2010; Little, et al., 2013). What at first glance appears to be a curious artifact of laboratory testing may thus in fact be tapping into a naturally occurring process by which steroids affect the nature of mate selection and sexual relationships between men and women. This is, however, a question that should be more directly addressed in future work, with larger and more diverse samples of women.

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Figure Captions

Figure 1. A) Naturally cycling (NC) women's ($n = 14$) mean subjective ratings ($\pm$ SE) for contextualized images across all test sessions, as divided by women's initial hormonal phase. B) Women taking oral contraceptives' (OCs) ($n = 14$) mean subjective ratings ($\pm$ SE) for contextualized images across all test sessions, as divided by women's initial hormonal phase. Subjective ratings did not differ by NC or OC women's initial hormonal phases or across test sessions.

Figure 2. A) Naturally cycling (NC) women's ($n = 14$) mean subjective ratings ($\pm$ SE) for decontextualized images, as divided by women's initial hormonal phase. B) Women taking oral contraceptives' (OCs) ($n = 14$) mean subjective ratings ($\pm$ SE) for decontextualized images across all test sessions, as divided by women's initial hormonal phase. Subjective ratings did not differ by NC women's initial hormonal phase or across test sessions. Women who entered the study after taking OCs for three weeks (OC-3) ($n = 4$) rated these images as less attractive than did women who had been taking OCs for one week (OC-1) ($n = 5$) ($*p < 0.05$, $d = 0.90$), and much less attractive than did women who were in their menstrual (pill-free) phase ($n = 5$) ($***p < 0.001$, $d = 2.29$). OC-3 women also rated decontextualized images lower than did NC women who started the study in their menstrual phase ($n = 6$) ($p < 0.001$, $d = 2.98$), periovulatory phase ($n = 4$) ($p < 0.001$, $d = 1.72$), or luteal phase ($n = 4$) ($p < 0.001$, $d = 2.30$). They were the only women to rate the images as significantly unattractive ($++ p < 0.001$).

Figure 3. A) Naturally cycling (NC) women's ($n = 14$) mean subjective ratings ($\pm$ SE) for images depicting male-to-female oral sex, as divided by women's initial hormonal phase. B) Women taking oral contraceptives' (OCs) ($n = 14$) mean subjective ratings ($\pm$ SE) for images

660 depicting male-to-female oral sex, as divided by women's initial hormonal phase. Subjective
 661 ratings did not differ by NC or OC women's initial hormonal phases or across test sessions.
 662 *Figure 4.* A) Naturally cycling (NC) women's ($n = 14$) mean subjective ratings ($\pm$ SE) for
 663 images depicting female-to-male oral sex, as divided by women's initial hormonal phase. B)
 664 Women taking oral contraceptives' (OCs) ($n = 14$) mean subjective ratings ($\pm$ SE) for images
 665 depicting female-to-male oral sex, as divided by women's initial hormonal phase. For NC
 666 women, subjective ratings did not differ by initial hormonal phase or across test sessions. OC-3
 667 women ($n = 4$) rated images depicting female-to-male oral sex as less attractive than did women
 668 who started the study in the menstrual (pill-free) phase of their cycle ($n = 5$) ($*p = 0.05$, $d = 0.93$).
 669 OC-3 women also rated these images less attractive than did NC women who began the study in
 670 their menstrual phase ($p < 0.005$, $d = 1.21$) ($n = 6$) or periovulatory phase ($n = 4$) ($p < 0.03$, $d =$
 671 0.98).

Figure 1

Figure 2

Figure 3

Figure 4