

Field conditioning of sexual arousal in humans

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Background: Human sexual classical conditioning effects are less robust compared with those obtained in other animals. The artificiality of the laboratory environment and/or the unconditioned stimulus (US) used (e.g. watching erotic film clips as opposed to participating in sexual activity) may contribute to this discrepancy. The present experiment used a field study design to explore the conditioning of human sexual arousal.

Method: Seven heterosexual couples were instructed to include a novel, neutrally preferred scent as the conditioned stimulus (CS+) during sexual interaction and another novel scent during non-sexual coupled-interaction (e.g. watching a movie, studying together). Seven control couples used both scents during non-sexual interaction. Conducted over a 2-week period, both experimental and control couples had three sexual interactions (oral sex and/or intercourse). In addition, experimental couples had three, while the controls had six, non-sexual interactions. Genital responding to and affective preference for the odors were assessed in the laboratory before and after the experience in the men.

Results: We observed significantly increased genital responding to the CS+ in the experimental relative to the control group; however, conditioned responses were not much stronger than those obtained during laboratory conditioning. Experimental males also showed a trend for decreased preference for the CS-odor. They may have learned that this odor predicted that sexual interaction with their partner would not occur.

Conclusion: The present study provides another demonstration of conditioned sexual arousal in men, specifically an instance of such learning that happened in a real-world setting. It also suggests that inhibitory learning may occur, at least with the affective measure.

Keywords: *sexual classical conditioning; humans; evaluative conditioning*

Only a narrow range of stimuli can be regarded as primarily or ‘inherently’ sexual. Cues typically acquire arousing properties through experience. While a few studies have shown that stimuli can become sexually competent through mere exposure (e.g. Dewsbury, 1981; Lisk & Baron, 1982), social learning (e.g. White, 2004) or verbal learning (e.g. Roche & Barnes, 1998), experimental research on learned sexual preferences most often employs classical (Pavlovian or respondent) and/or operant (instrumental) conditioning paradigms.

Classical conditioning consists of learning about the relationship between an initially ineffective or neutral cue (the conditioned stimulus, CS) and a biologically significant stimulus (the unconditioned stimulus, US). Although originally thought of as a reflexive process with limited applicability to higher-level human behavior, modern learning theorists recognize that classical

conditioning serves a number of important functions (Rescorla, 1988). For example, it can prepare us for the interaction with biologically significant cues or events (signal or expectancy learning; Timberlake, 2001), and it can alter the preference for stimuli associated with such cues or events (evaluative conditioning; Baccus, Baldwin, & Packer, 2004; De Houwer, Baeyens, & Field, 2005; De Houwer, Thomas, & Baeyens, 2001; Dijksterhuis, 2004; Gawronski & Bodenhausen, 2006; Karpinski & Hilton, 2001; Livingston & Drwecki, 2007). Furthermore, the growing trend in social and cognitive psychology to acknowledge that many of our actions and even subjective experiences may be ‘automatically’ rather than volitionally controlled (Bargh & Chartrand, 1999) supports a role of classical conditioning in human behavior.

Numerous studies using a range of non-human species demonstrate conditioning of sexual physiology (e.g. Adkins-Regan & MacKillop, 2003; Graham &

Desjardins, 1980; Hollis, Pharr, Dumas, Britton, & Field, 1997; Mahometa & Domjan, 2005; Matthews, Domjan, Ramsey, & Crews, 2007) as well as behavior (e.g. Snowdon, Tannenbaum, Schultz-Darken, Ziegler, & Ferris, 2011; for review, see Coria-Avila, 2012; Domjan & Akins, 2011; Domjan & Holloway, 1998; Pfaus, Kippin, & Centeno, 2001; Pfaus, Kippin, & Coria-Avila, 2003). Furthermore, numerous case studies indicate that behavior or response modification techniques can alter patterns of human sexual arousal/behavior (e.g. see Akins, 2004; Gaither, Rosenkranz, & Plaud, 1998 for review). Yet, relatively few experiments have shown that Pavlovian procedures can be used to modify human sexual experience. Only a handful of published studies convincingly show cue conditioned sexual arousal in men (Hoffmann, Janssen, & Turner, 2004; Lalumière & Quinsey, 1998; Plaud and Martini, 1999) and in women (Both, Brauer, & Laan, 2011; Both, Laan, et al., 2008; Both, Spiering, et al., 2008; Hoffmann et al. 2004).

Moreover, human sexual conditioned responses (CRs) are relatively weak. While the learning and/or expression of conditioning may indeed be more robust (and potentially more impactful) in non-humans, parametric differences could also contribute to this discrepancy in the strength of sexual learning. For example, non-human research tends to employ sexually naïve subjects (although recently Snowdon et al. 2011 found equivalent sexual learning in naïve and experienced marmosets), which is not (as) feasible in human work. However, another factor that could moderate the strength of sexual conditioning and that we can manipulate is the conditions for learning. Perhaps, the artificiality of the laboratory environment and/or experimental parameters may hinder sexual conditioning or its expression in people. Previous human sexual conditioning studies have been conducted in the laboratory using multiple brief presentations of visual conditioned stimuli (e.g. non-sexual and sexual images) and visual unconditioned stimuli (e.g. erotic film) with short intertrial intervals. The present study used a field conditioning procedure in which precise control over how learning proceeded was exchanged for more naturalistic parameters.

Specifically, our design afforded a more appropriate context for sexual arousal (participant's residence), a CS that could be readily integrated with actual sexual interaction (an olfactory cue presented on their sexual partner as well as ambiently in the room), more natural temporal parameters (longer intertrial intervals), and a stronger and more effective US (partnered sexual interaction). Further, in addition to assessing changes in genital responding, a measure of affective preference was included. This was considered particularly appropriate for the present study since evaluative or affective learning (i.e. changes in valence of stimuli) may be stronger in real-world settings (Baeyens, Wrzesniewski,

De Houwer, & Eelen, 1996; Öhman & Mineka, 2001; Rozin, Wrzesniewski, & Byrnes, 1998). We predicted that compared to controls, men who experienced a novel, neutrally preferred scent paired with sexual interaction on three occasions would show increased genital responding to and increased preference for the olfactory CS.

Method

Participants

Participants were obtained from a mid-western college campus via email solicitation. The email indicated that we were seeking sexually active couples that included at least one male partner. They were told that they would be participating in a study on the processing of odors during interpersonal interaction. For the duration of the study (approximately 2 weeks) partners were required to spend at least a few hours together per day, to engage in genital sexual activity three times, to refrain from masturbation, and to be sexually monogamous. In addition, they were told that one/the male partner would need to participate in two laboratory sessions in which they would view erotica while wearing a device to measure genital responding and would be paid \$70 if they completed the study. Sixteen heterosexual couples (mean age = 20 years) were recruited and 14 of them completed the study. Target subjects were the male partners. Learning was only assessed in men because our previous studies found that compared to women they were more likely to agree to wear genital monitors and were more likely to show sexual conditioning. The present study was approved by our institutional human subject committee.

Apparatus

During the laboratory sessions to assess genital arousal, olfactory cues were presented discretely to the subject's nasal cavity via an oxygen cannula attached to an olfactometer. The olfactometer used an air compressor (DeVilbiss model 8650D) that delivered a temperature and humidity controlled air stream into one of five 250-ml flasks. Four of the flasks contained individual odorants, 0.05 ml of geranium and 0.05 ml of basil essential oil (from Nature's Alchemy), and 0.5 ml strawberry and 0.3 ml lemon extract (from McCormick's) while the fifth delivered a clean air stream. Changes in genital responding were assessed using an electromechanical strain gauge (Janssen, Prause, & Geer, 2007; Behavioral Technologies, Inc., Salt Lake City, UT, USA).

Procedure

The experiment was divided into three phases. The baseline and testing sessions occurred in the laboratory and the intervening conditioning session occurred in the 'field,' e.g. participant or partner residence.

Baseline session

Separate appointments to meet in the laboratory were made for each member of the couple. Both partners were told that the study was about men's sensitivity to odors under various conditions including different types of interpersonal interaction.

Non-target (female) partner

The women were given a written instruction sheet and were asked not to show it to nor discuss the details with their partner. They were also given two white cotton tank tops, two 12 cm² aroma fans (Pure Essence), vials containing geranium and basil essential oils, several 1 cc syringes for measuring odors, plastic zip lock bags to store scented t-shirts and fans, and 6–9 post interaction surveys. The women were asked not to change any scented products they use on their bodies (e.g. perfume, hair products, lotions, deodorants), clothes (e.g. laundry detergent) or in their residence (e.g. air fresheners, incense) for the duration of the study. Finally they were given the cell phone number of a laboratory assistant to call at anytime with questions.

Target male partner

Males were told to wear loose-fitting pants to their laboratory sessions. Upon arrival they were taken to a private experimental room where they were instructed on how to place an electromechanical strain gauge on their penis, which they were told was to verify sexual arousal during erotic films and on how to position a disposable oxygen cannula for odor presentation. The experimenter left the room and the subject placed the devices on themselves. While reclining in a lounge chair and listening to relaxing music accompanied by *Media Player* visuals on a computer screen in front of them, the participant was exposed to three 15-sec olfactometer-based presentations of basil and geranium odors in a random order with 1 min interstimulus interval (ISI). This procedure was repeated with two different odors (lemon and strawberry) while participants were exposed to a short excerpt from a non-sexual film and again during a sexual film. The film exposure conditions were implemented for consistency with the cover story. Odors different from the conditioned stimuli were used to prevent latent inhibition. Finally, participants rated the pleasantness on a 14-cm visual analog scale (anchored by unpleasant and pleasant with 7 cm representing neutral) of the two CS as well as the two control odors that were presented on cotton (in the same concentration that were in the flasks) placed in 20 ml vials. This initial laboratory session took approximately 30 min.

Conditioning session

Couples assigned to the experimental group included either geranium or basil during sexual interaction

(CS+) and the other scent during non-sexual interaction (CS-). CS+ and CS- were counterbalanced between couples. Control couples used both scents separately during non-sexual interaction and no novel odor during sexual activity. Conducted over a 2-week period, both experimental and control couples had three sexual interactions during this time. In addition, experimental couples had three, while the controls had six, non-sexual interactions. A sexual interaction was defined as a situation in which genital contact occurred, that the male had a full erection and potentially (but not necessarily) an orgasm. Examples included oral sex on either/both partner(s) and intercourse. A non-sexual interaction was defined as a situation that lasted for at least 30 min in which the couple was physically close (they could also touch, kiss, and cuddle) but did not interact sexually. Examples included studying together, watching a movie, and playing video games. The female partner was responsible for orchestrating 'conditioning,' although as previously stated neither partner knew the true nature of the study. Women were told to try to alternate activities (sexual and non-sexual) and to spread them out (more than 12 h apart). Ten minutes prior to an interaction, women were instructed to distribute 0.05 cc of the appropriate odor on one of the t-shirts and 8–10 drops of the same odor on the aroma fan pad. They were instructed to place the fan in an inconspicuous location to attempt to keep the t-shirt on or near them during the interaction. Soon after the interaction odors were cleared (e.g. the shirt, fan, and syringes stored in their bags), the couple filled out separate post-interaction questionnaire. These brief surveys consisted of a few questions regarding if and when olfactory cues were noticed during the interaction and asked the participants to rate the pleasantness of the odor as well as their level of sexual arousal experienced during the interaction. The questionnaires were administered for consistency with the cover story as well as for a manipulation check. Once couples had completed the conditioning protocol, men were told to contact the laboratory assistant promptly to set up an appointment for the final phase of the study.

Testing session

Men returned to the laboratory for their final session, which was similar to the baseline testing sessions except that odorants were presented in a different order in genital as well as odor preference testing. Couples were paid upon completion of this final session and submission of the post-interaction surveys.

Results

Men reported their level of sexual arousal during sexual and non-sexual activities on post-interaction surveys using a 14-cm long visual analog scale anchored by 'Not aroused' and 'Highly aroused.' A 2 × 2 (group × activity type) mixed factor analysis of variance (ANOVA)

on these data confirmed that sexual interactions were significantly more arousing than non-sexual interactions, $F(1,12) = 92.89, p < 0.001$, for the main effect of activity type, and this did not differ by group, that is, there was no main effect of group nor interaction between activity and group (see Fig. 1). Hence, the US was effective in inducing significant subjective sexual arousal in all participants.

Control subjects did not experience an odor paired with sexual interaction and hence there was no distinction between CS+ and CS- for these men. In order to perform analyses, we arbitrarily assigned geranium as the CS+ for four control subjects and basil for the other three (as was the case for those in the experimental group).

Change in penile circumference (mm) to the odorants were calculated by subtracting peak penile tumescence occurring 7 sec prior to odor presentation from peak tumescence that occurred during odor presentation plus the 30 sec immediately following it. These change scores were averaged separately across baseline and test sessions, and the average genital response to each odor during the baseline session was subtracted from the average response during the test session for each subject. As can be seen in Fig. 2, there was a significant increase in genital responding to the CS+ in the experimental relative to the control group. A 2×2 ANOVA revealed a significant main effect of CS, $F(1,12) = 5.57, p = 0.04$, and of group, $F(1,12) = 8.49, p = 0.01$, but no significant interaction, $F(1,12) = 1.66, p = 0.22$. However, a t -test showed that experimental men showed significantly greater arousal to the CS+ than control men, $t(12) = 2.99, p = 0.01$.

Changes in affective preference scores were generated by subtracting the odor pleasantness rating provided during the baseline session from the rating given during the test session. As can be seen in Fig. 3, participants showed an increased preference for partner-paired odorants. However, experimental subjects did not appear to show this increase for the CS- odor. The 2×2 ANOVA revealed a borderline significant main effect of CS, $F(1,12) = 3.93, p = 0.07$, and a paired t -test showed a trend for differential CS preference in the experimental men,

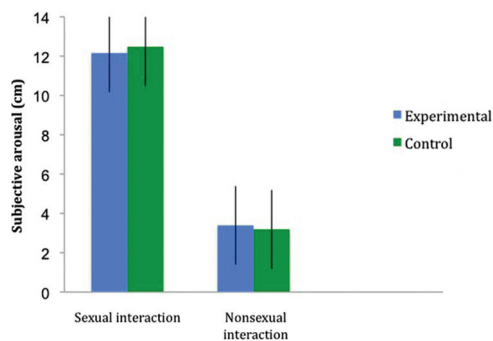


Fig. 1. Subjective sexual arousal to sexual vs. non-sexual interaction in experimental and control men.

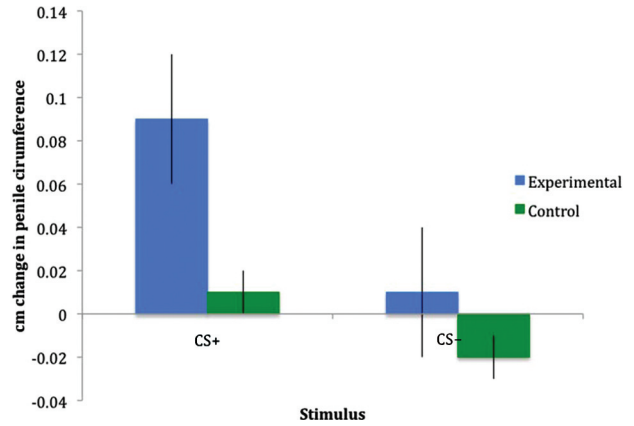


Fig. 2. Changes in genital responding to the CS+ and CS- odors in experimental and control men.

$t(6) = 2.03, p = 0.09$. Changes in affective preference for the control odors were quite variable across participants. A 2×2 (odor \times group) ANOVA yielded no significant effects.

Two experimental men guessed the hypothesis of the study and two control men had a partial sense of the study objective. Neither the genital nor the affective preference data differed between ‘aware’ and ‘unaware’ subjects.

Discussion

The present study provides another demonstration of conditioned sexual arousal in men, specifically an instance of such learning in a real-world setting. Men who experienced a novel, initially neutrally preferred scent on their partners and ambiently in the room during three sexual interactions that occurred over a 2-week period showed increased genital responding to that odor relative to controls and relative to another odor that was paired with non-sexual interaction. However, somewhat unexpectedly, genital CRs were not stronger than those

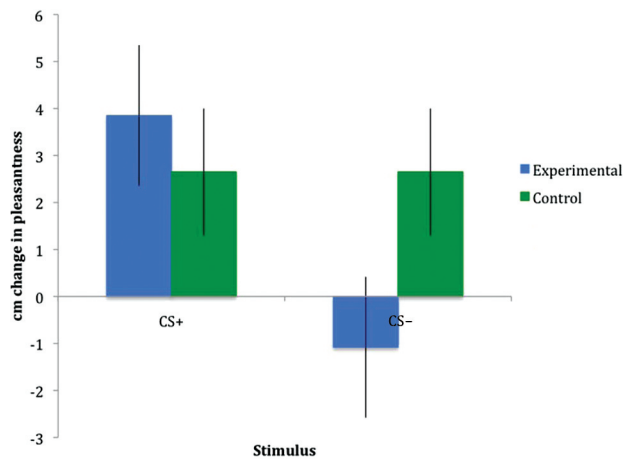


Fig. 3. Changes in odor preference for the CS+ and CS- odors in experimental and control men.

obtained during laboratory-based sexual conditioning. One reason for the relatively weak learning may have been that the participants, although instructed to contact the laboratory assistant as soon as they finished the study, did not return to the laboratory for testing until several days after completion of conditioning. In fact, one experimental subject was not tested until 17 days after and one control subject was not tested until 11 days after completion (mean retention interval = 5.9 days). Although there was no correlation between retention interval and strength of the genital CR, there is a fair amount of individual difference in conditionability (cf. Hoffmann, 2011), and in the present study the number of participants was low. Further, differences in context and in odor presentation between conditioning and testing could have contributed to the weak CRs. Nonetheless, subjects retained the CR for at least several days. Most human sexual conditioning studies assess learning on the same day as conditioning; hence, the present study showed longer-term retention than has been typically documented (see Kantorowitz, 1978).

Measures of affective learning are relatively new to human sexual conditioning research, only appearing in studies using female subjects (i.e. Both, Brauer, & Laan, 2011; Both, Laan, et al., 2008; Both, Spiering, et al., 2008), although we have employed such instruments with both men and women in several (yet) unpublished studies. Evidence of evaluative sexual conditioning has been equivocal and, if found, affective CRs are usually modest in strength. Despite training in a more naturalistic setting, results from the present study are consistent with this trend. We found a similar increase in preference for partner-paired odors in the control group and the sexually paired odor in the experimental group. As may have been the case for the genital CRs, differences in context and in odor presentation between conditioning and testing could have contributed to the weak affective CRs. Interestingly, we found no increase in odor pleasantness for the CS- odor in the experimental men. Although we did not confirm that the CS- became a conditioned inhibitor, men may have learned (either consciously or unconsciously) that this odor predicted that sexual interaction with their partner would not occur.

Another reason for weak human sexual conditioning could have been that the conditioned stimuli were arbitrary as opposed to biologically prepared. Hoffmann et al. (2004) found that a photograph of a female abdomen was a more effective CS than the photograph of a gun, at least for men. Using putative human pheromones may have resulted in larger CRs (Kelahan, Kohl, & Hoffmann, 2008).

Although human sexual CRs are not as robust as those found in other species, such learning has been documented using visual and now olfactory conditioned stimuli,

various unconditioned stimuli (e.g. erotic film, vibrogenital stimulation, masturbation and partnered sexual interaction), and genital as well as subjective measures in both men and women. With modern developments in learning theory (e.g. expectancy learning, Rescorla, 1988; affective learning, De Houwer et al., 2001; Behavioral Systems Theory, Timberlake, 2001) it seems appropriate to renew the investigation of contributions and limitations of conditioning processes to explaining how cues acquire erotic meaning. Establishing reliable procedures for obtaining conditioned arousal in humans, employing different measures of learning, and examining more variations in conditioning phenomenon are the first steps in this process. Such research may help us to better understanding the impact that erotic stimuli have on sexual arousal and subsequent behavior, potentially allowing us to alter such responses to improve sexual functioning. Such information could have direct application to managing sexual risk taking, sexual compulsion, and undesired paraphilic (e.g. fetishistic) behavior as well as for recovering sexual function after traumatic experience.

Conflict of interest and funding

The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

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