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The Influence of Subjective Sexual Arousal and Disgust on Pain

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ABSTRACT

Current models propose that inhibited sexual arousal is a key component in maintaining sexual pain in women with Genito-Pelvic Pain/Penetration Disorder. It thus follows that enhancing sexual arousal may be an effective strategy to modulate pain, but this effect has not been successfully demonstrated with women, although it has been successful with men. This study built on previous works and examined if the pain-killing effect of sexual arousal might have been undermined by concurrently-elicited disgust. We tested whether women experience disgust as well as sexual arousal when viewing sex stimuli, and whether disgust has an exacerbating effect on pain. Female participants ($N = 164$) were randomly distributed to watch a porn, disgust, or neutral train-ride film. A cold pressor test (CPT) was utilized to induce pain at the same time that participants viewed their respective film. Pain was indexed by the duration that participants kept their hand in the cold water, and by self-reported pain intensity at the time they quit the CPT. The results showed no differences in pain across conditions. The sex stimulus elicited substantial disgust as well as sexual arousal, and there was a negative correlation between the two emotions. Disgust was not found to increase pain compared to both the neutral and sex conditions. Thus, the findings provide no support for a pain-modulatory effect of subjective sexual arousal on pain in women. This might, however, be due to the sex stimulus having elicited an ambivalent state between an appetitive and aversive emotion concurrently.

Introduction

Although sexual behavior is for most a source of pleasure, for women with Genito-Pelvic Pain/Penetration Disorder (GPPPD) it can be painful and unpleasant. GPPPD is the combined diagnostic category in the DSM-5 for what was previously referred to as vaginismus and dyspareunia, altogether defined by difficulty with vaginal penetration, genito-pelvic pain during intercourse, fear of pain/vaginal penetration, and tension of the pelvic floor muscles during penetration (American Psychiatric Association, 2022). These symptoms may greatly undermine sexual functioning as well as one's relationship satisfaction and general quality of life. The high prevalence of women with such pain-related symptoms (14 to 34% in young women, and up to 45% in older women (van Lankveld et al., 2010)) reveals the urgency in understanding the factors involved in the persistence of (sexual) pain in women, with the ultimate aim to provide clues for therapeutic interventions to ameliorate the condition of women with GPPPD symptomatology.

Sexual Arousal & Pain

Building on the Fear-Avoidance model of pain perception, which posits that fear of pain can fuel avoidance of the pain-inducing stimulus (Lethem et al., 1983), the Cognitive Behavioral model of dyspareunia suggests that women who experience pain during sex often get stuck in a vicious cycle where the initial experience of pain, or memories thereof, fuel inflated pain expectancies which, in turn, inhibit sexual arousal (Bergeron et al., 2016; Both et al., 2017; Brauer et al., 2007; Payne et al., 2005; Thomtén et al., 2014). Weakened sexual arousal, both objective (i.e., relevant to unpleasant stimulation) and subjective (i.e., relevant to increased negative affect during sex), can, in turn, increase sexual pain; for example, via lessening vaginal lubrication, and via reflexive contractions of the pelvic floor muscles. If sexual intercourse is then nonetheless pursued (e.g., for the sake of not disrupting the intimacy), this can ultimately exacerbate pain (Brauer et al., 2014; E. T. M. Laan et al., 2021). Following this perspective, inhibited sexual arousal is seemingly a key component in the maintenance of sexual pain, and heightening sexual arousal before sexual approach or penetration might be a potential lead to reducing pain.

In accordance with this proposition, several experimental studies conducted in women have demonstrated that pain can be significantly reduced during pleasurable sexual activity. For example, it has been shown that, in a lab setting, female participants (exclusive of participants with gynecological contraindications) tolerated gradually painful finger compression significantly more when experiencing pleasure through vaginal self-stimulation (by use of a pressure transducer) – and even more so if it led to an orgasm (Whipple & Komisaruk, 1985). Similarly, in a later study utilizing a within-subjects design, female participants claiming they could orgasm using imagery alone were exposed (in the laboratory) to a 10 min guided

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sexual imagery audiotape, genital self-stimulation for 10 min, and self-induced sexual imagery for 10 min. After each sex condition was a 5 min control "resting" condition. Pain tolerance was measured during all conditions using a finger compression device that would gradually increase in force, and stop when the participants alerted the investigator that they could no longer tolerate it. The findings showed that orgasms following both genital self-stimulation and following imagery led to a significant increase in pain tolerance, compared to the "resting" control condition (Whipple et al., 1992).

Taken together, a bidirectional negative relationship between sexual arousal and pain could reasonably be assumed, potentially pointing to a way out of the vicious cycle. However, when assessing the relationship between pain and subjective sexual arousal without orgasm, a series of experimental studies failed to find evidence that subjective sexual arousal can reduce pain in women. One study, for instance, found that an erotic auditory stimulus presented in a lab setting actually increased pain induced by a cold pressor test (CPT) in sexually experienced, premenopausal, heterosexual women (King & Alexander, 2000). They suggested that, perhaps, mild sexual arousal might have a hyperalgesic effect in women, compared to the analgesic effect caused by high sexual arousal in the previous studies. However, another study presented visual slides as (mild) erotic stimuli, thereby priming the female participants in the lab prior to inducing pain by a cold pressor test, but no analgesia (and no hyperalgesia) was found in this study either (Meagher et al., 2001). It could be surmised that the reason for these paradoxical results could be that subjective sexual arousal elicited by the visual slides and auditory tapes was not potent enough. Indeed, recent research has shown that erotic photos or audiotapes elicit weaker sexual arousal in women than an audiovisual film might elicit (Chivers et al., 2010). Furthermore, in both aforementioned studies, the sexually arousing stimulation stopped upon conducting the CPT; it might therefore well be that sexual arousal did not persist during the pain-eliciting task.

In order to test whether these potential explanations are valid, a subsequent study (Lakhsassi et al., 2022) used a pornographic film instead of an auditory or pictorial stimulus in order to elicit sexual arousal. In addition, to ensure that the elicited sexual arousal would persist during the pain stimulation, the film continued to play during the CPT. Yet, this study also failed to find support for the hypothesis that subjective sexual arousal modulates pain. Although the erotic film was generally highly successful in eliciting sexual arousal throughout the experiment (with mean self-reported ratings of more than 50%), the experienced pain during the CPT was not generally weaker than in the control condition (Lakhsassi et al., 2022). However, because the time participants kept their hand in the cold water was not assessed in this study, it cannot be ruled out that pain modulation via sexual arousal might have increased the duration at which they could tolerate the cold water while maintaining a similar level of pain at the time of withdrawal. Thus, to arrive at more solid conclusions about the apparent failure of subjective sexual arousal to modulate pain, it would be critical to replicate this study while measuring the latency to remove the hand from the ice-cold water during a CPT, along with assessing subjective pain at withdrawal.

Further, Lakhsassi et al.'s (2022) study did not include a measure of subjective disgust. There is, however, considerable evidence that, in women especially, pornographic materials may elicit disgust along with sexual arousal (e.g., Meagher et al., 2001). The evidence shows that women on average, irrespective of any sexual dysfunction, tend to be less aroused and more vulnerable to negative emotion (inclusive of disgust) in response to viewing porn clips designed for men, versus those made by women for women (Janssen et al., 2003; E. Laan et al., 1994; Mosher & MacIan, 1994). Moreover, an fMRI study has shown that healthy women can experience both feelings of sexual arousal and disgust simultaneously in response to viewing pornographic stimuli (Borg et al., 2014); two emotions that have the capacity to inhibit one another (Borg et al., 2012; Pawłowska et al., 2020).

In other words, pornographic materials may have the potential to elicit both approach (e.g., sexual arousal) and avoidance motivational states (e.g., disgust) (de Jong et al., 2013). Depending on which motivational state dominates in a given sexual context, the experience of pain symptoms may be differentially affected. In line with this, motivational priming theory proposes that emotions belong to one of two competing motivational categories: appetitive/approach-related motivational (APM) states, or aversive/avoidance-related motivational (AVM) states (Lang, 1995; Lang et al., 1997). The former would have evolved for survival purposes – that is, increasing motivation to have sex, eat, or nurture. The latter would have evolved for defensive purposes against possible threats (Bradley et al., 2001; Lang, 1995). These competing states can, in turn, either augment or reduce the sensations of pain. Specifically, while pain may be augmented in an AVM state, it is conversely reduced in an APM state (de Wied & Verbaten, 2001; Lang, 1995; Meagher et al., 2001; Rhudy & Meagher, 2000; Zelman et al., 1991), likely due to APM state emotions generally involving an increase in the release of endogenous opioids, which are natural and potent analgesics (Loh et al., 1976; Szechtman et al., 1981; Whipple & Komisaruk, 1985). Sexual arousal, for instance, has been found to be highly associated with opioid release during sexual activity and orgasm, and has also been presumed present during sexual arousal prior to engaging in sexual activity (van Furth & van Ree, 1996). Yet, if an AVM state emotion, such as disgust, is simultaneously elicited, the pain-reducing effects of an APM state emotion might be compromised. It may thus be possible that no robust pain-reducing effects were found when presenting women with pornographic stimuli during a CPT due to porn-elicited disgust (partly) counteracting the pain modulatory effect of sexual arousal (cf. Meagher et al., 2001).

In order to test whether the failure to find a robust pain modulatory effect of sexual arousal could indeed be attributed to concurrently elicited disgust, it would be important to replicate this earlier study while including a measure of disgust. Moreover, it would be helpful to more generally examine whether, in line with motivational priming theory (cf. Lang, 1995), disgust would augment pain. This would not only help to differentiate the impact of sexual arousal from that of disgust on pain, but may also help optimize the current model of GPPPD. Thus far, the cognitive behavioral model of dyspareunia emphasizes the role of low sexual arousal and pain expectancies on the persistence of pain symptoms (cf. Both et al.,

2017). Yet, to the extent that sexual behavior may also elicit disgust, motivational priming theory would predict that this could augment pain. If so, disgust might be a relevant source of sexual pain. Thus, the current study's approach of testing the direct influence of disgust on pain could complement the findings of an indirect impact of disgust on pain via inhibition of sexual arousal (Borg et al., 2019; Pawłowska et al., 2020).

Earlier work testing the impact of disgust on pain (within the context of a CPT) had found evidence that disgust indeed decreases the threshold for pain intensity; the authors did not, however, find robust evidence for disgust lowering women's pain tolerance (Meagher et al., 2001). As previously suggested with regard to sexual arousal, the lack of an effect on pain tolerance could potentially be due to the fact that the emotional state was primed prior to the pain stimulation, and may therefore perhaps not have persisted during the pain exposure. Moreover, it could likewise be that pictorial slides might elicit limited feelings of disgust in comparison to a film stimulus. Therefore, as suggested for sexual arousal, it would be important here, too, to utilize a strong disgust elicitor in this replication, and to ensure that this emotional state will persist during the pain stimulus.

Aim of Current Study

In order to test the proposed explanations for the failure of previous research to find a robust pain-modulatory influence of subjective sexual arousal on pain in female participants, the current study replicated and extended Lakhsassi et al.'s (2022) earlier study while addressing its limitations by: (i) including a measure of CPT duration, in addition to pain intensity upon withdrawal of the CPT, (ii) implementing a measure of disgust alongside sexual arousal in order to test whether the failure to find a pain-reducing effect of sexual arousal on pain in previous studies could be explained by concurrently-elicited disgust, and (iii) including a disgust film stimulus in order to test if disgust per se indeed increases pain as indexed by both (higher) subjective pain and (lower) CPT duration. We tested the following hypotheses: First, that the SEX condition would elicit substantial levels of both sexual arousal and disgust, which might explain the failure of this condition to attenuate subjective pain. This would replicate the results of previous work (Lakhsassi et al., 2022). Second, that heightened disgust in the DISGUST condition would increase pain (as indexed by reduced CPT duration and increased subject pain upon withdrawal).

Method

Participants

A G*Power 3.1 analysis determined that a minimum sample size of 159 participants needed to be recruited to achieve a statistical power of 0.8, and to detect a difference between conditions with an effect size of 0.25 within a Fixed-Effects One-Way Analysis of Variance (ANOVA) and an Analysis of Covariance (ANCOVA) with three conditions. Thus, we randomly recruited 174 female participants to account for potential exclusions. Eligible participants were predominantly heterosexual English-speaking women aged 18 and over. All participants were compensated for their time with a financial reward or with student credits. The study was approved by the Ethical Committee of Psychology (ECP approval code: PSY-2122-S-0204) and pre-registered on AsPredicted (#87260).

Participants registered for the study through the University participant pool for first-year psychology students ($n = 108$) and through social media ads targeting student group chats and pages ($n = 66$). They were then randomly allocated to one of three conditions in a between-group experimental design; SEX ($n = 58$), DISGUST ($n = 58$), and NEUTRAL ($n = 58$). Ten participants were subsequently excluded from the analyses due to researcher or participant error during the experiment (e.g., used left hand instead of their dominant hand which may have caused discomfort, or had their experiment interrupted). This resulted in a final sample of 164 participants (SEX ($n = 53$); DISGUST ($n = 55$); NEUTRAL ($n = 56$)), reaching a statistical power of 0.82 to detect a difference between conditions with an effect size of 0.25.

Materials

Film Stimuli

Three film stimuli were displayed on a 90×52 centimeters desktop screen to induce sexual arousal, a neutral state, or disgust. These included: (i) the same erotic film used in Lakhsassi et al.'s (2022) previous study in order to maintain consistency in the methodology, featuring a heterosexual couple engaging in foreplay (2min30) and intercourse (3min30); (ii) the same black-and-white film stimulus used in this previous study, featuring a train traveling in the outdoors; and (iii) a portion of MTV's Jackass video successfully used as a disgust-eliciting stimulus in previous studies (e.g., de Jong et al., 2011), involving an egg-eating and milk-drinking contest leading to vomiting and gagging. All films had a (maximum) duration of six minutes.

Tepid Water Bath

A plastic container (39 × 28) filled with tepid water at a temperature ranging between 27–30 degrees Celsius ($M = 28.74$, $SD = 0.50$) was used to standardize all participants' hands to a baseline temperature prior to beginning the experiment, given that some participants could arrive with cold hands due to weather conditions. A kettle was readily available in the lab in order to continuously warm the water to the target temperature.

Cold Pressor Test

For the purpose of this study, a CPT was constructed in order to induce pain (Mitchell et al., 2004). The set-up involved a coolbox (36 × 39) completely filled with water in order to ensure that the participant's hand could be fully submerged. Medium-sized ice cubes (i.e., equivalent to 6–7 medium-sized Ziploc bags filled with ice cubes) were used to cool the water temperature to a standardized level varying between 1.9 and 2 degrees Celsius.[1] The temperature was continuously calibrated

[1]We adjusted the CPT from the Lakhsassi et al. (2022) study by lowering the temperature from ~4 degrees Celsius to ~2 degrees Celsius in order to create similar conditions to Meagher et al.'s (2001) study, which found that CPT pain was modulated after inducing sexual arousal in men.

using ice cubes or warm water. An aquarium pump was steadied onto the bottom of the coolbox, and a plastic tube was attached to it in order to circulate water from the bottom of the coolbox all the way to the top, where the participant's hand would be located. Two thermometers were secured on both sides of the coolbox, on both sides of the participant's hand, in order to monitor the target temperature. Lastly, a live-feed webcam was secured above the CPT in order for the researcher to be able to see when the participant began placing their right hand into the CPT, and when they removed their hand from the CPT. An ice-maker machine and refrigerator were readily available in the laboratory in order to continuously generate ice cubes between participants and store them for the next testing day.

Measures

Manipulation Check

Two computerized visual analogue scales (VAS) ranging from 0 (= not at all) to 100 (= very strongly) assessed whether the film manipulation had successfully induced the intended emotional state prior to beginning the CPT (i.e., "how sexually aroused are you?," and, "how disgusted are you?"), and once after finishing the CPT (i.e., "how sexually aroused were you during the experiment?," and, "how disgusted were you during the experiment?"). Accordingly, participants across all conditions were asked to rate their levels of sexual arousal and disgust on two separate occasions; these questions were displayed in semi-random (balanced) order, in order to prevent any systematic biases.

Pain

Pain intensity was measured with an on-screen subjective measure asking "how much pain did you feel?" on a VAS ranging from 0 (= "not at all painful") to 100 (= "very strong pain"). CPT duration was objectively measured via an e-prime software-programmed timer, which recorded the time from the moment the participant touched the water to the moment the participant removed their hand from the water.

Procedure

Upon their arrival to the two-room laboratory, participants were asked to confirm their booking identification number, confirm that they were aged 18 or over, sanitize their hands (to keep the CPT hygienic), and were subsequently invited to read the information and consent forms in Room A (Experiment room) and sign upon agreement. During this time, the researcher ensured that the CPT and tepid water baths were at their target temperatures by monitoring the temperature on an internally-developed temperature device with two digital resistance-based thermometers (one in the coolbox, and one in the tepid water bath) from Arduino hardware and software company, in which the temperature signal was measured using a physiological amplifier (Porti 7, from TMSi), with Polybench software. Once informed consent was obtained, participants were asked to remove all jewelry from their right hand, and, if applicable, to remove their wristwatch irrespective of which hand it was on (the latter request was to avoid a sense of competitiveness were the participant to time their CPT performance).

Participants were subsequently shown to Room B (Researcher room) where they were introduced to the second researcher and assured of complete privacy during the experiment (i.e., shown that windows were blinded, the door separating both rooms would be closed, and that there was a webcam on the researcher's screen that – as they could observe – only showed a live feed of the CPT and their hand in it, nothing else). Next, they were escorted back to Room A, and seated facing the desktop with the CPT on their right-hand side.

Once the experimental procedure was explained to the participants and all questions were answered, the participants were asked to submerge their right hand until wrist-level in the tepid water bath for 1 minute. Afterwards, they dried their hands, wore their headphones, and were asked to press the space bar to begin the experiment once the researcher had left the room, after which one of the three films described in the information form would begin to play. They were asked to focus all their attention on the film. Participants were subsequently left alone, lights were switched off, and both thermometers were placed into the CPT for temperature reliability purposes before the experiment began.

One minute and 45 seconds into viewing the film, participants would notice arrows pointing downwards on the screen; these arrows acted as a signal for participants to mind the bottom of the screen, where two consecutive VASs (i.e., manipulation check) about their emotional states were awaiting them. Participants had a maximum of 6 seconds to respond to each one in order to minimize the amount of distraction from the film; they were informed that the scales would disappear after a few seconds, and instructed to try to answer the questions based on their first feeling before the scales disappeared. Next, at the 2-minute mark since the start of the film, a brief instruction appeared at the bottom of the screen requesting that they commence the CPT (i.e., "Place your hand in the water bucket and leave it in for as long as you can tolerate"). Participants were to submerge their right hand fully into the water in one go, up until their wrist, and rest their arm while continuing to view the film. Once they could no longer tolerate the cold, they could remove their hand and dry it with napkins. The maximum CPT time was set to 4 minutes. The film would stop immediately after the hand was removed from the CPT (or after 4 minutes), and the participants were presented with three additional VASs about their experienced pain and emotional state. The first VAS assessed pain intensity, and the latter randomized two VASs were additional manipulation checks for the induced emotional state throughout the experimental manipulation. Once all three scales were responded to, the screen read "End of Experiment," and the participant could knock on the door to let the researcher know they were finished. See Figure 1 for a visual illustration of the precise timing for each step within the experiment.

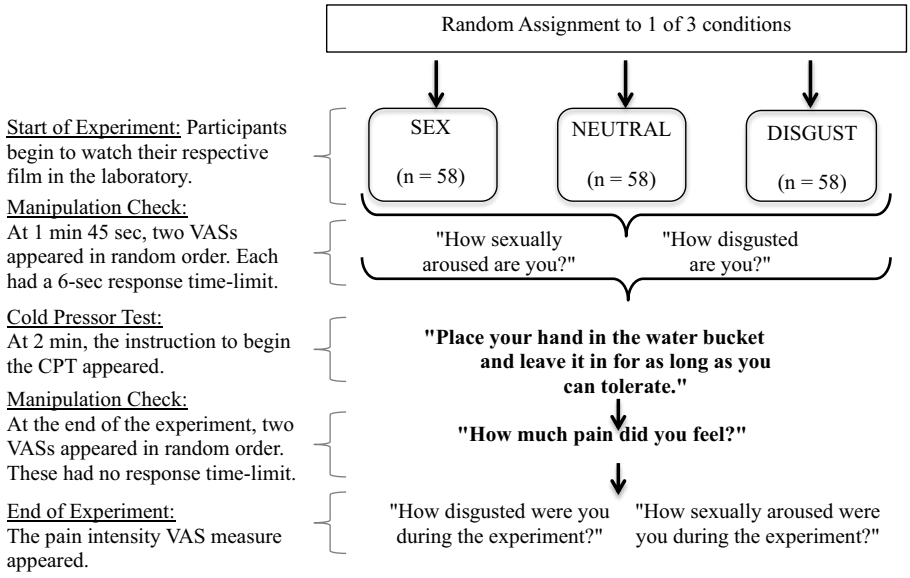

Figure 1. Flow diagram: Experiment, step-by-step procedure.

Data Analyses

As a manipulation check, the sexual arousal and disgust VAS responses at 1 min. 45 sec were both subjected to a one-way ANOVA with Condition as a 3-level factor to test if the sex film would elicit stronger sexual arousal compared to both other conditions, and if the disgust video would elicit stronger disgust than both other conditions. We then subjected the post-CPT VAS scores of subjective sexual arousal and disgust to a one-way ANOVA to verify if the experimental film stimuli had successfully induced the intended emotional states relevant to each of the three conditions throughout the experiment. We also computed descriptive statistics to illustrate the effectiveness of each respective film.

Prior to testing our hypotheses, ANOVA assumptions were assessed; we used Q-Q plots and histograms to determine whether the normality of residuals assumption was met, and the Levene's test to determine whether the homoscedasticity assumption was met. In order to test the effect of the SEX condition on pain intensity and CPT duration, we have conducted a between-group one-way ANOVA on subjective pain ratings across conditions, and a between-group one-way ANOVA on CPT duration across conditions.[2] All statistical analyses were performed on SPSS Statistics (version 28).

We have additionally conducted exploratory analyses to examine how sexual arousal and disgust might interact with one another and with pain. Specifically, we conducted correlational analyses between sexual arousal and disgust before the CPT and after the CPT in order to assess whether these two emotional states negatively correlate with one another, and thereby potentially hinder one another if experienced at the same time. Next, we conducted correlational analyses to assess the strength of subjective sexual arousal and disgust in the SEX condition to examine their relationship with experienced pain and CPT duration. Finally, a correlational analysis was conducted to examine the strength of the relationship between experienced disgust and pain in the DISGUST condition. All of these analyses were performed before and after removal of outliers following the pre-registered 1.5× interquartile range rule.

[2]The pre-registered analysis of covariance with disgust as a covariate was not possible to implement given that disgust ratings varied across groups; this was overlooked during the pre-registration.

Results

Assumptions

Histogram and Q-Q plot analyses for CPT duration showed that the unstandardized residuals across conditions were positively skewed, and those for subjective pain intensity were negatively skewed. This did not affect the analyses, given that ANOVA remains robust against normality deviations (Ghasemi & Zahediasl, 2012). Furthermore, a Levene's test based on the mean showed that the homogeneity of variances assumption was not violated for subjective pain intensity (Levene's statistic $(2, 161) = 0.42$, $p = .66$) or for CPT duration (Levene's statistic $(2, 161) = 1.44$, $p = .24$).

Missing Data

Missing data were identified for the mid-experiment VAS only ($n = 14$ for the sexual arousal VAS; $n = 22$ for the disgust VAS). A missing data analysis confirmed that there was no pattern linked to these missing data ($p = .15$ for the disgust VAS association to the sexual arousal VAS; $p = .64$ for the sexual arousal VAS association with the disgust VAS). This goes in accordance with the reports of several participants who, post-experiment, stated that their distraction with the movie and short time interval to respond to the question had led them to miss answering the VAS.

The analysis further confirmed that these data were missing at random, but not completely. Indeed, more missing data were observed in the SEX condition (20.8% and 15.1% per

VAS), followed by the DISGUST condition (12.7% and 7.3% per VAS), followed by the NEUTRAL condition (7.1% and 3.6% per VAS), potentially speaking to the (differential) distractibility of each film stimulus.

Manipulation Checks

Emotional State Induction Prior to the CPT

One-way ANOVAs were conducted to assess whether the intended emotional state was successfully induced prior to commencing the CPT. The ratings of sexual arousal prior to the CPT were significantly higher (F (2, 147) = 145.06, $p < .001$) in the SEX condition ($M = 44.67$, $SD = 24.14$) compared to the DISGUST ($M = 1.80$, $SD = 3.24$) and NEUTRAL conditions ($M = 3.48$, $SD = 6.18$). Likewise, the ratings of disgust prior to the CPT were significantly higher (F (2, 139) = 188.88, $p < .001$) in the DISGUST condition ($M = 77.46$, $SD = 18.04$) compared to the SEX ($M = 35.62$, $SD = 24.51$), and the NEUTRAL conditions ($M = 7.08$, $SD = 10.74$). A Tukey post hoc test additionally confirmed that the pornographic film induced a substantial amount of disgust relative to the neutral film ($p < .001$).

Emotional State Induction After the CPT

Additional one-way ANOVAs were conducted to assess whether the intended emotional state was successfully induced throughout the experiment by assessing the subjective ratings immediately after the CPT. The ratings of sexual arousal post-CPT were significantly higher (F (2, 161) = 92.28, $p < .001$) in the SEX condition ($M = 38.85$, $SD = 26.88$) compared to the DISGUST ($M = 0.67$, $SD = 1.61$) and NEUTRAL conditions ($M = 3.59$, $SD = 9.21$). The ratings of disgust post-CPT were significantly higher (F (2, 161) = 162.39, $p < .001$) in the DISGUST condition ($M = 77.15$, $SD = 18.82$) compared to the SEX ($M = 36.21$, $SD = 27.55$) and NEUTRAL conditions ($M = 6.59$, $SD = 13.74$). Once again, a Tukey post hoc test determined that the pornographic film induced a substantial amount of disgust relative to the neutral film ($p < .001$).

Hypothesis Testing

Influence of Sexual Arousal & Disgust on Pain

One-way ANOVAs showed that there were no significant differences in subjective pain intensity (F (2, 161) = 1.22, $p = .30$, partial $\eta^2 = 0.02$) or in CPT duration (F (2, 161) = 0.71, $p = .50$, partial $\eta^2 = 0.01$) between conditions (see Figures 2 and 3 for a depiction of the mean scores). Similarly, the outcomes did not meaningfully change following exclusions of outliers, categorized as data points that extended 1.5 times the interquartile range. That is, neither subjective pain intensity (F (2, 148) = 0.41, $p = .67$, partial $\eta^2 = 0.005$) nor CPT duration (F (2, 147) = 0.42, $p = .66$, partial $\eta^2 = 0.006$) significantly differed across conditions.[3]

Exploratory Analyses

Relationship Between Sexual Arousal and Disgust in the SEX Condition

In order to assess whether a relationship existed between sexual arousal and disgust, we computed Pearson's p-m correlations between the two emotional states as measured just before the start of the CPT, as well as immediately after finishing the CPT. A significant negative correlation was found between sexual arousal and disgust, both before ($r = -0.49$, $p = .003$, $n = 42$) and after the CPT ($r = -0.35$, $p = .01$, $n = 53$), indicating that higher disgust was indeed related to lower sexual arousal (and vice versa).

Strength of Sexual Arousal and Disgust on Pain in the SEX Condition

Post hoc, we tested whether pain intensity and CPT duration varied as a function of experienced disgust and experienced sexual arousal within the SEX condition. Specifically, we tested the relationship of sexual arousal and pain while statistically controlling for disgust (and vice versa). A series of regression analyses (with and without outliers) were conducted to see whether sexual arousal and disgust could predict pain intensity and CPT duration. Although the assumptions of normality and homoscedasticity were violated, this did not prevent us from carrying out these analyses, as regression analyses are relatively robust against such violations (Ernst & Albers, 2017). The assumption of no multicollinearity was met.

Subjective Pain Intensity. Table 1 depicts a correlational matrix demonstrating the correlational findings between sexual arousal, disgust, and pain intensity prior to conducting the regression and controlling for the other independent variable. A multiple regression analysis subsequently showed that pre-CPT sexual arousal and disgust did not significantly explain the variance in pain intensity (F (2, 33) = 1.27, $p = .30$, $R^2_{\text{Adjusted}} = 0.02$), and neither sexual arousal ($Beta = 0.31$, $t(35) = 1.59$, $p = .12$) nor disgust ($Beta = 0.16$, $t(35) = 0.82$, $p = .42$) showed an independent relationship with pain intensity. After removing 1.5×IQR outliers, the results remained non-significant (F (2, 29) = 2.19, $p = .13$, $R^2_{\text{Adjusted}} = 0.07$). Furthermore, post-CPT sexual arousal and disgust could not explain the variance in pain intensity (F (2, 50) = 0.67, $p = .52$, $R^2_{\text{Adjusted}} = -0.01$) within the sex condition, and neither sexual arousal ($Beta = 0.17$, $t(52) = 1.11$, $p = .27$) nor disgust ($Beta = 0.01$, $t(52) = 0.06$, $p = .96$) showed an independent relationship with pain intensity. After removing 1.5×IQR outliers, the results remained non-significant (F (2, 45) = 3.12, $p = .054$, $R^2_{\text{Adjusted}} = 0.08$). Although after removing the outliers, disgust still did not show an independent relationship with pain intensity ($Beta = 0.09$, $t(47) = 0.60$, $p = .55$), it appeared that sexual arousal did ($Beta = 0.38$, $t(47) = 2.44$, $p = .02$). The

[3]It was pre-registered that, in this study, we would post hoc re-analyze the hypothesis upon exclusion of participants that were less than 30% sexually aroused/disgusted in the SEX/DISGUST conditions, respectively, or felt more than 30% sexually aroused/disgusted in the NEUTRAL condition. However, participants were not excluded because any threshold for exclusion would be arbitrary and could bias the results given that characteristics associated with low arousal reports may also be associated with participant pain ratings.

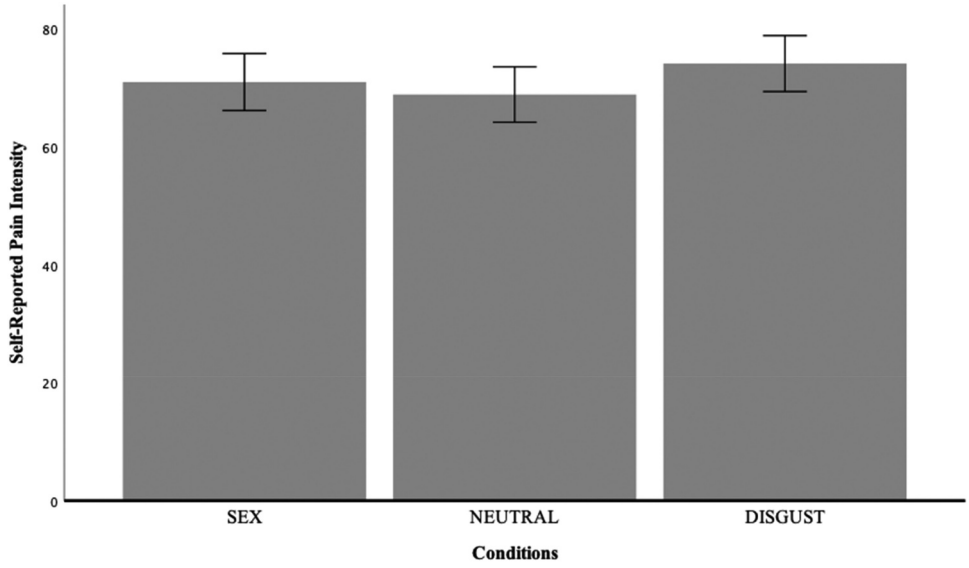

Figure 2. Self-reported pain intensity as a function of condition.
No significant difference in pain intensity was found between conditions.

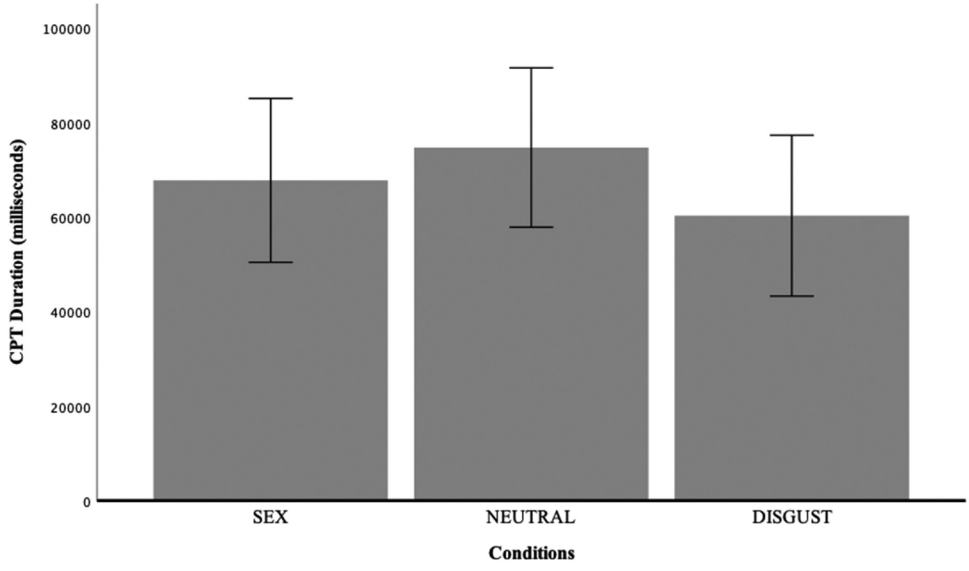

Figure 3. CPT duration as a function of condition.
No significant difference in CPT duration was found between conditions.

Table 1. Bivariate Pearson correlation matrix.

	Pre-CPT		Post-CPT	
Correlations	Disgust	Sexual Arousal	Disgust	Sexual Arousal
Pain Intensity	.021	.189	−.049	.162
Pre-CPT Disgust		−.485**	.878**	−.424**
Pre-CPT Sexual Arousal			−.331*	.869**
Post-CPT Disgust				−.347*

No significant correlations were found between subjective pain and either emotional state.
*Correlations between sexual arousal and disgust are significant at the .05 level (2-tailed).
**Correlations between sexual arousal and disgust are significant at the .001 level (2-tailed).

positive beta (unexpectedly) indicated that higher sexual arousal was associated with higher pain intensity.

Table 2. Bivariate Pearson correlation matrix.

	Pre-CPT		Post-CPT	
Correlations	Disgust	Sexual Arousal	Disgust	Sexual Arousal
CPT Duration	.178	−.326*	−.039	−.424**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

CPT Duration. The same sets of analyses were conducted with CPT duration as the dependent variable. Table 2 depicts a correlational matrix demonstrating the correlational findings between sexual arousal, disgust, and CPT duration prior to conducting the regression and controlling for the other independent variable. Regression analyses subsequently showed that for the

pre-CPT measures, the equation was not significant (F (2, 33) = 2.48, p = .10, R^2_{Adjusted} = 0.08). After removing 1.5×IQR outliers, however, the model became significant (F (2, 29) = 3.55, p =.04, R^2_{Adjusted} = 0.14), yet neither sexual arousal (*Beta* = −0.14, t(31) = −0.71, p = .49) nor disgust (*Beta* = 0.35, t(31) = 1.78, p = .09) showed an independent relationship with CPT duration. For post-CPT sexual arousal and disgust, the equation was significant (F (2, 50) = 7.02, p = .002, R^2_{Adjusted} = 0.19). Specifically, sexual arousal showed an independent relationship with CPT duration (*Beta* = −0.50, t(52) = −3.73, p < .001). The negative beta unexpectedly indicated that relatively strong sexual arousal was associated with relatively low CPT duration. Disgust did not show an independent relationship with CPT duration (*Beta* = −0.21, t(52) = −1.59, p = .12). After removing 1.5×IQR outliers, the results were non-significant (F (2, 43) = 1.16, p = .32, R^2_{Adjusted} = 0.007) with neither sexual arousal (*Beta* = −0.17, t(45) = −1.04, p = .30) nor disgust (*Beta* = 0.09, t(45) = 0.53, p = .60) reaching significance.

Strength of Disgust on Pain in the DISGUST Condition

We also tested the strength of disgust on pain intensity and CPT duration in the DISGUST condition. The results of two-tailed Pearson's correlations revealed that disgust assessed just prior to the start of the CPT (r = .23, p = .12, n = 48) as well as after the CPT (r = .18, p = .18, n = 55) did not significantly correlate with pain intensity. Similarly, disgust assessed just prior to the start of the CPT did not significantly correlate with CPT duration (r = −.13, p = .37, n = 48), although disgust after the CPT did show a negative association, indicating that higher disgust was related to lower CPT duration (r = −.30, p = .03, n = 55). After removing 1.5×IQR outliers, the results relative to CPT duration were no longer significant, while the results relative to pain intensity were only significant pre-CPT (r = 0.30, p = .04, n = 45).

Discussion

The present study replicated and expanded Lakhsassi et al.'s (2022) previous study, which tested whether subjective sexual arousal would attenuate pain in women within the context of a cold pressor test. Further, this study assessed whether disgust would conversely increase pain in women. The main findings can be summarized as follows: (i) the sexual arousal manipulation did not result in reduced pain intensity and increased CPT duration, thereby replicating the findings of Lakhsassi et al.'s (2022) study, and (ii) the disgust manipulation did not result in increased pain intensity and reduced CPT duration.

Previous studies have suggested that genital stimulation and orgasm can significantly reduce pain in women, pointing to subjective sexual arousal as a possible candidate mechanism underlying this effect (Whipple & Komisaruk, 1985; Whipple et al., 1992). While some support for this hypothesis does already exist, the evidence has thus far been restricted to men (Meagher et al., 2001). Studies have yet to provide evidence that subjective sexual arousal also modulates pain in women. Several propositions have been made as to why no evidence was found (e.g., using relatively low intensity erotic stimuli, such as erotic slides or auditory erotica, and presenting the erotic stimulus prior to the pain stimulus rather than simultaneously). One study therefore utilized an audiovisual erotic film stimulus in order to elicit a stronger feeling of sexual arousal (Chivers et al., 2010), and requested participants to continuously view it while participating in the CPT, thereby ensuring that the induced emotion persisted throughout the pain stimulus. Despite efforts for a more potent subjective sexual arousal induction via an audiovisual stimulus (rather than pictorial or auditory), no clear support for the hypothesis that subjective sexual arousal has a pain-modulatory effect in women was found (Lakhsassi et al., 2022).

Further propositions as to why no support was found in these recent studies include the possibility of gender response differences to common erotic stimuli. For example, the erotic stimuli may have elicited feelings of disgust in combination with sexual arousal in women especially (Lakhsassi et al., 2022; Meagher et al., 2001). The present replication study was therefore designed to test this proposition, as well as to assess the role that disgust may have on sexual arousal and pain. Specifically, we tested whether the erotic film used in Lakhsassi et al.'s (2022) study does indeed elicit meaningful levels of disgust on top of sexual arousal, and examined whether the relationship between sexual arousal and pain would be moderated by feelings of disgust. Additionally, the pure disgust condition allowed us to directly test the causal influence of disgust on pain. Finally, a measure of CPT duration was added in addition to self-reported pain ratings upon withdrawing their hand from the water, in order to assess whether this may have been differentially influenced by sexual arousal or disgust.

Consistent with the view that perhaps concurrently elicited disgust might have undermined the effect of sexual arousal on pain, we found that the erotic stimulus that was utilized in the previous study (Lakhsassi et al., 2022) did indeed elicit substantial levels of disgust. The concurrently elicited disgust might have rendered the sex stimulus ambivalent, which might explain why no significant differences were found for pain intensity and CPT duration between the sex and neutral conditions in this study. More specifically, on average, the erotic stimulus was rated 44.67% sexually arousing and 35.62% disgusting prior to the start of the CPT. Once the CPT was stopped, participants rated themselves (retrospectively) on average as 38.85% sexually aroused and 36.21% disgusted. In other words, participants were seemingly almost as disgusted as they were sexually aroused by the time they finished viewing the erotic stimulus. This finding is in line with previous works showing that the same visual erotic stimulus can elicit both feelings in women (Borg et al., 2014; Heiman, 1980; Janssen et al., 2003; E. Laan et al., 1994; Mosher & MacIan, 1994). The nearly identical levels of sexual arousal and disgust, however, led us to speculate that the nature of the film might not have been well catered to a female audience given its faster escalation in sexual activity. For example, female participants have been found to prefer films featuring a slower, gentler pace in sexual activity – that is, longer scenes of foreplay featuring growing partner attraction, glances at one another, kissing, and undressing (E. Laan et al., 1994). Conversely, our film clip had a shorter segment of foreplay, which included oral sex and mutual

masturbation – behaviors that are more likely to elicit disgust due to their contamination propensities (de Jong et al., 2013). Perhaps, then, this contributed to the high feelings of disgust reported, and the ambivalent affective state consequently elicited might have hindered the manipulation's effect on pain. Future research should make use of films designed by women for a female audience in order to minimize negative affect when assessing the potential influence of subjective sexual arousal on pain.

Contrary to our expectations, the correlational data were not consistent with the idea that sexual arousal has a negative relationship with pain. Rather, it was found that CPT duration decreases as subjective sexual arousal increases, and that this effect did not vary as a function of concurrently experienced disgust. Nonetheless, it is noteworthy that, on the flip side, feelings of disgust as a response to the vomiting film were also found to be negatively associated with CPT duration, alluding to the idea that disgust could in fact exacerbate pain, as suggested by previous works (Meagher et al., 2001). Taken together, it can then still be argued that an erotic clip that does not elicit disgust concurrently with sexual arousal may show pain-modulatory effects. It would therefore be critical for future research to additionally compare the analgesic influence of erotic films with, versus without, disgust-eliciting properties.

Alternatively, the difference between findings in men and women could also potentially be explained by sex differences in the opioid system's response during analgesia. For instance, it has been found in animal studies that morphine injections in male and female rats had differing analgesic effects, where males consequently had significantly greater analgesic effects than female rats, compared to when they were administered saline. Furthermore, these effects also appear to depend on the phase of the estrous cycle, in which case opioids might function less potently for females compared to when they are in the diestrus phase (Bernal et al., 2007; Loyd et al., 2008). Thus, it remains possible that sex differences in opioid mechanisms could help explain the differences in pain-modulation via sexual arousal found in men and women.

The disgust film had no significant causal impact on pain intensity or CPT duration. The absence of a significant effect might possibly be attributable to the selected stimulus. Although the film successfully induced high levels of subjective disgust, it might not have also induced high levels of general (non-sexual) arousal. Generally, negatively-valenced stimuli are found to influence motivational priming effects more potently when they also elicit high arousal levels (Bradley et al., 2001; Cuthbert et al., 1996). For instance, in comparison to disgust stimuli that depict mutilated bodies (e.g., Meagher et al., 2001), our vomiting stimulus may not have induced comparable enough levels of arousal to replicate previous findings of pain modulation. On the other hand, van Overveld et al. (2009)'s findings comparing physiological responses to different types of disgust stimuli suggest that the stimulus used in this study might be just as arousing as the stimulus depicting mutilated bodies. Evidently, both types of disgust can elicit similar physiological responses, as measured by saliva production, T-wave amplitude, and EMG activity. Although our disgust stimulus was substantially subjectively disgusting (with mean subjective ratings of more than 70%), subjective and physiological disgust might not always be aligned; indeed, previous findings have shown that although subjective feelings toward different disgust stimuli may differ, the physiological arousal levels can remain comparable (van Overveld et al., 2009). Future studies might consider including physiological and/or self-report indices of arousal to assess the level of disgust and arousal elicited by such a stimulus. Finally, in order to more directly test the relevance of subjective general arousal in the impact of disgust on pain, it would be important to compare different types of disgusting stimuli, and not only to assess their disgust-eliciting properties, but also their potency to elicit general arousal.

Strengths & Limitations

The current study expands on the previous Lakhsassi et al. (2022) study in that it is a well-powered study with two indices of pain, a CPT designed to align with previous work that found a significant effect of sexual arousal on pain in men, and indices of both sexual arousal and disgust across films. While this study has demonstrated that an erotic stimulus may easily elicit feelings of disgust in women (alongside sexual arousal), the findings are limited by the fact that we had not also used an erotic film that elicits sexual arousal without concurrently eliciting disgust. It should also be acknowledged that the level of subjective sexual arousal elicited in the SEX condition in the present study seemed lower than that of the original Lakhsassi et al. (2022) study, which utilized the same film. Perhaps this might partly be explained by a difference in instructions before the experiment, in that the participants in the former study were informed that they may be asked to view pornography (i.e., eliciting an appetitive affective state), while, in the present study, they were informed that they may be asked to watch pornography *or* a film depicting vomiting and gagging (i.e., eliciting an aversive and appetitive state). This difference in instruction may have primed a disgust perspective on the erotic film. The negative correlation found between subjective sexual arousal and disgust in the SEX condition is consistent with the idea that higher levels of disgust are generally accompanied by lower levels of sexual arousal. Future research might consider preventing such a priming effect.

Furthermore, the mechanism of sexual arousal (that is, direct genital stimulation versus an audiovisual erotic stimulus, or use of fantasy) might also have an influence beyond the intensity of subjective sexual arousal. Genital stimulation and fantasy, for instance, could potentially minimize or eliminate feelings of disgust, seeing as the content of one's own imagination would be less likely to involve unexpected disgust-inducing content, such as those potentially found in a pornographic film. Whipple et al.'s (1992) study, for example, showed a greater pain reduction in response to self-induced imagery or genital self-stimulation, in comparison to guided imagery. This finding hints at the likely possibility that having control over one's fantasy content would optimize pleasurable feelings whilst minimizing non-pleasurable ones. Conversely, it also remains possible that the mechanism of sexual arousal might matter beyond concurrent negative emotions (like disgust), especially among a female sample. Future studies could aim to clarify these questions by asking participants to

rate their emotions during different methods of inducing sexual arousal.

Finally, the current study utilized a non-clinical female sample. Thus, while we presumed that a possible effect between subjective sexual arousal and pain could hint at a similar effect in a clinical GPPPD sample, it cannot be ruled out that these two samples may differ in their response to sexual arousal. Future research directly comparing a clinical versus a non-clinical sample could answer this question. Additionally, it is noteworthy that pain sensitivity may differ across body regions. Thus, while we have selected a CPT as a pain stimulus, akin to previous works attesting that this may be the preferred stimulus to test the affective-motivational aspects of pain (Zelman et al., 1991), it cannot be ruled out that pain sensitivity might differ across body regions (e.g., genital pain), or that varying types and levels of pain intensity could potentially respond differently to subjective sexual arousal. These questions would require further scrutiny in future studies utilizing vulvovaginal pain to more closely relate the findings to women suffering from GPPPD.

Conclusion

In conclusion, the current findings provide no support for the view that subjective sexual arousal might reduce the impact of experimentally-induced CPT pain in women; yet, since the erotic stimulus used to elicit sexual arousal had also elicited a nearly similar level of disgust, it remains to be tested whether subjective sexual arousal – in the absence of concurrently-elicited disgust – would be effective in reducing pain in women.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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