Visual attention and sexual arousal in women with and without sexual dysfunction

Julia Velten a, *, Sonia Milani b, Jürgen Margraf a, Lori A. Brotto b

a Mental Health Research and Treatment Center, Department of Clinical Psychology and Psychotherapy, Faculty of Psychology, Ruhr University Bochum, Bochum, Germany
b Department of Obstetrics and Gynaecology, University of British Columbia, Vancouver, Canada

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ABSTRACT

Attention to sexual stimuli is a prerequisite to process such stimuli as sexually-meaningful and is an important means to facilitate sexual arousal. Attending to sexual cues is crucial for healthy sexual functioning. Studies suggest that sexual dysfunction is associated with less attention towards sexual stimuli. The goal of this study was to use an eye-tracking-based free-viewing paradigm to investigate whether women with sexual dysfunction visually attend to the genital area in dynamic sexual stimuli (i.e., erotic videos) differently than women with subclinical sexual function or those with typical sexual functioning. A total of 69 women (M age = 27.77, SD = 8.00) with clinical (n = 30), subclinical (n = 23), and typical (n = 16) levels of sexual functioning watched four 1-min video clips depicting heterosexual couples engaging in vaginal intercourse or cunnilingus while the total fixation duration on the genital area as well as their subjective and genital sexual arousal were recorded. As hypothesized, the clinical group fixated on the genital area less than women with typical sexual functioning. A longer total fixation duration on the genital area was followed by increases in subjective arousal and genital arousal. The relationship between attention and arousal was not moderated by sexual functioning group. This study provides first evidence of the role of sustained visual attention for facilitating sexual arousal in women with and without sexual dysfunction.

1. Introduction

Attention is a cognitive and behavioral process where some sensory input is processed faster or deeper and has a greater chance of influencing behavior than other sensory input (Egeth & Yantis, 1997; Lamme, 2003). Attention has been compared to a bottleneck to account for the fact that the amount of attentional resources that can be used at one time is limited. Concerning the visual modality, selective attention has been defined as “the selective use of information from one region of the visual field at the expense of other regions” (Henderson, 1992, p. 206). Visual attention can be “grabbed” by emotionally-salient and biologically-relevant stimuli (Calvo & Lang, 2004) with saliency being shaped both by genetics and visual experience (i.e., long-term memory that has influenced sensory processing; Lamme, 2003). As less than 1% of visual input data can enter the attentional bottleneck, the vast majority of visual information is not perceived, leading to inattentional blindness (Chabris & Simons, 2010). Attention is, however, not a passive process. While it can be drawn to external stimuli based on their properties, individuals can also consciously direct their attention to certain targets based on prior knowledge and their goals (Lamme, 2003).

Numerous empirical studies have underscored the relevance of attention for facilitating sexual arousal (i.e., a state comprising physiological changes and emotional expression that motivates sexual behavior; Chivers, 2010) in women with (Lykins et al., 2011; Prause & Heiman, 2010) and without sexual dysfunction (Anderson & Hamilton, 2015; Beck & Baldwin, 1994; Salemink & Van Lankveld, 2006). Sexual dysfunctions are defined in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as frequent, long-lasting, and distressing problems concerning desire, arousal, orgasm, or pain (American Psychiatric Association [APA], 2013) and are associated with a variety of negative mental and physical health outcomes (e.g., depression, sexually transmitted infections; Mitchell et al., 2013). Clinically relevant sexual dysfunction affects about 4% of women per year (Mitchell et al., 2016) while a much higher proportion of the
population experience persistent sexual difficulties that do not meet the threshold set by the DSM-5, because they do not elicit clinically significant personal distress or are only experienced on some occasions or over a shorter period of time (APA, 2013). These subthreshold or subclinical sexual concerns are very prevalent among women and may affect between 23 and 73% of women per year (Briken et al., 2020; Mitchell et al., 2016).

While empirical evidence suggests differences in both initial and sustained visual attention towards sexual stimuli between women with and without sexual dysfunction (e.g., Velten et al., 2020), it has yet to be determined whether visually attending to sexual stimuli is as effective in facilitating sexual arousal in women with sexual dysfunction as it is in those without. Improving our knowledge on how visual attention influences sexual arousal in clinical groups is key for improving evidence-based psychological treatments targeting attentional processes (i.e., cognitive behavioral or mindfulness-based interventions). First, we will present theories that provide a framework for the role of attentional processes in sexual arousal and sexual functioning. Then, we will summarize relevant empirical studies using different methodological approaches (i.e., self-report measures, experimental attention manipulation, and eye-tracking technology) and will describe how these findings relate to the role of attention for sexual arousal in women with sexual dysfunction.

1.1. Models on the role of attention for sexual arousal

Several theoretical models emphasize the relevance of attention for sexual arousal (Barlow, 1986; Basson, 2001a; Janssen, Everaerd, Spiering, & Janssen, 2006; Toates, 2009). According to Toates’ incentive-motivation model (2009), a sexual stimulus is subjected first to a basic perceptual analysis, then is compared to representations held in memory (e.g., the meaning attached to the stimulus), and finally is associated with conscious intentions (e.g., to further attend to this stimulus or focus on something else). While Toates’ model focusses on sexual motivation rather than arousal, Janssen’s (2000) model describes the relevance of attentional processes for sexual arousal specifically. According to the information processing model, attention is drawn toward a sexual cue by pre-attentive or unconscious activation of implicit memories by the stimulus and then sustained by deliberate or controlled attentional processes that depend on the individuals’ intentions and require conscious awareness. A focus of attention on sexual cues (e.g., an attractive partner or an erotic picture) can facilitate sexual arousal whereas distraction that diverts attention from such cues can lead to reductions in arousal (Janssen et al., 2000).

Taking these models into consideration, Dewitte (2016) has presented an emotion-motivational model of sexual arousal (see Fig. 1) that combines the processes involved in the generation of sexual responses.

According to this model, sexual arousal is triggered by a stimulus that pre-attentively captures attention and is automatically appraised as sexually meaningful. Such automatic appraisals can trigger genital sexual arousal (e.g., increased blood flow to the genitals, vaginal lubrication) as well as increased cognitive elaboration. Both automatic and conscious appraisals interact with attentional processes and can lead to increased, deliberate attention towards the sexual stimulus. When this results in a positive evaluation, subjective sexual arousal (SSA)—a mental state of feeling sexually excited or turned-on—is experienced, which can lead to further increases in genital sexual arousal. These sexual responses may then increase the motivation to engage in sexual activities (Dewitte, 2016). The model also acknowledges that automatic and deliberate processes can operate in parallel or conflicting ways resulting in discordance between SSA, genital sexual arousal, and sexual behaviors (Chivers et al., 2010). While the emotion-motivational model focusses state factors experienced in sexual situations, it also offers insights into the etiology of sexual dysfunctions, because such dysfunctions can be caused or maintained by disturbances in the cognitive processes (i.e., attention and appraisal) described in the model (Dewitte, 2016). For example, problems with low desire can emerge when a person fails to notice a sexual stimulus, their attention is diverted by non-sexual distractions, or when perceived sexual stimuli lack rewarding properties (Prause, Janssen, & Hetrick, 2008). Dysfunctions pertaining to symptoms of genito-pelvic pain can be sustained when, for example, a sexual stimulus is appraised as threatening rather than pleasant, resulting in women to direct their attention elsewhere (e.g., at non-sexual cues or at interoceptive perceptions of pain; Desrochers, Bergeron, Khalife, Dupuis, & Jodoin, 2009).

Fig. 1. An emotion-motivational model on sexual arousal based on the models of Barlow (1986), Janssen et al. (2000) and Öhmann (1993) by Dewitte (2016) Printed with permission from Wiley.
1.2. Self-report studies

There is ample evidence from studies using self-report questionnaires for the relevance of attentional processes for both sexual arousal and sexual dysfunction in women. Self-reported cognitive distraction during sex was associated with less sexual satisfaction and less consistent orgasms in a sample of young adult women (Dove & Wiederan, 2000). In 170 women from the general population, a lack of erotic thoughts during sex, as well as disengagement thoughts (e.g., I am not getting aroused), and sexual passivity — subsumed as cognitive distraction — were strongly associated with orgasmic problems (Cuntim & Nobre, 2011; Moura, Tavares, & Nobre, 2020). A facet of sexual inhibition (i.e., the tendency to prevent sexual arousal in situations where it might be disadvantageous to pursue sexual behavior; Bancroft, Graham, Janssen, & Sanders, 2009; Bancroft & Janssen, 2000) that describes increased distractibility during sex was associated with lower genital sexual arousal (Velten, Scholten, Graham, Adolph, & Margraf, 2016) as well as a greater risk for developing sexual problems (Bloemendaal & Laan, 2015; Velten, 2017; Velten, Scholten, Graham, & Margraf, 2017). Research about sexual mindfulness (i.e., the ability to bring one’s attention to experiences in the present moment in a nonjudgmental way during sexual activity; Adam, Heeren, Day, & de Sutter, 2015; Kabat-Zinn & Hanh, 2009) suggests that women who are able to attend to internal (e.g., emotions, cognitions) and external stimuli (e.g., sights, sounds) during sex have higher sexual satisfaction (Leavitt, Lefkowitz, & Waterman, 2019). Mindful women may experience better sexual functioning because they experience less distractions by body concerns and performance anxiety during sex (Arora & Brotto, 2017). To sum up, women who report being easily distracted during sex are more likely to experience difficulties with sexual arousal or functioning. However, these self-report studies did not specifically provide information on the role of visual attention and questionnaires may be subject to retrospective biases, demand effects, or socially desirable responding (Huberman, Suschinsky, Lalamière, & Chivers, 2013).

1.3. Experimental studies

Over the last four decades, numerous experimental studies have been conducted to examine the role of attention in sexual arousal (Tavares, Moura, & Nobre, 2020). While reaction-time based paradigms have been used to investigate initial or automatic attention (e.g., Dewitte, 2016; van Lankveld, Bandell, Bastin-Hurek, van Beurden, & Araz, 2018; Zahler et al., 2020), experimental instructions or cognitive distractions have been used to manipulate sustained or deliberate attention towards sexual cues (Barlow, 1986; Beck & Baldwin, 1994; Meston, 2006). In a sample of 25 sexually healthy women, Beck and Baldwin (1994) found that about 40% were able to suppress genital sexual arousal while watching erotic films by reducing the amount of attention directed at the stimuli with cognitive strategies such thinking non-sexual thoughts. In a sample of 22 women with varying levels of sexual desire, participants exhibited lower levels of subjective and genital sexual arousal to an erotic film presented in poor quality (e.g., picture flickering, poor sound) than to a high-quality film. As differences in arousal did not emerge between higher and lower desire women, the authors concluded that a lack of sexual desire is not likely to be caused by differential attention to sexual stimuli (Prause & Heiman, 2010). In experimental studies on the relevance of mindfulness for sexual arousal, women reported higher sexual arousal during an erotic film after being instructed to attend to sensations in their genitals or in their body as compared to a mental-imagery control instruction (Velten, Margraf, Chivers, & Brotto, 2018; Velten, Brotto, et al., 2020). Taken together, experimental studies confirm the importance of attending to sexual stimuli to facilitate sexual arousal while not being as informative concerning the role of sustained visual attention towards sexual cues.

1.4. Eye tracking and visual attention toward sexual stimuli

Eye-tracking methodology provides a continuous measure of visual attention as indexed by eye gaze (Henderson, 2003; Lin, Rossell, & Castle, 2011) and is therefore uniquely suited to investigate the role of attention for sexual arousal and sexual dysfunction in women. Advantages of eye-tracking methodology include non-invasiveness, robustness, and a high temporal resolution (Lin et al., 2011). Compared to (most) reaction-time based measures that target initial or automatic attention, eye-tracking allows for the assessment of more sustained or controlled aspects of attention (Velten et al., 2020).

So far, eye-tracking studies have explored the impact of different sexual stimuli to assess gender differences (Dawson & Chivers, 2016; Dewitte, 2016), the role of sexual orientation (Dawson, Fretz, & Chivers, 2017; Morandini et al., 2019), and comparisons between sexual and non-sexual stimuli (Bolmont, Cacioppo, & Cacioppo, 2014; Lykins, Meena, & Kambe, 2006). A 2015 review (Wenzlaff, Birken, & Dekker, 2016) found that among the 34 studies that used eye tracking in sex research only one study involved a clinical sample (Lykins et al., 2011). Comparing women with low sexual desire to those experiencing painful intercourse (i.e., dyspareunia) and to those without sexual complaints, Lykins et al. (2011) found that women with dyspareunia attended significantly less to sexual scene regions (defined as the full bodies of the male and female) than the two other groups. In 2020, another study was published comparing women with clinical, subclinical, and normal (i.e., typical) sexual functioning. In this study, participants watched a series of 10 pictures depicting heterosexual couples engaging in vaginal intercourse while their eye-movements were recorded. One out of two indices of sustained attention (i.e., total fixation duration) indicated that women in the clinical group attended less to the sexual scene regions (defined as the area showing aroused male and female genitals) in the pictures than women with typical sexual functioning (Velten, Milani, et al., 2021). To the best of our knowledge, no published study has compared the relationship between sustained attention towards dynamic sexual stimuli (i.e., a genital area in erotic videos) and concurrently measured sexual arousal. Further, differences in the attention- arousal relationship in women with and without sexual dysfunction have not been investigated.

1.5. Current study

This study used eye-tracking methodology to investigate whether women with and without sexual dysfunction direct their attention differently to genital areas in erotic videos and whether sustained attention towards the genital area is associated with higher levels of subjective and genital sexual arousal. Towards this goal, four videos showing either vaginal intercourse between a man and a woman or cunnilingus were presented while genital and subjective arousal as well as eye movements were measured. As women may experience varying degrees of sexual functioning which may not always align with the presence or absence of a clinical sexual dysfunction diagnosis, we decided to compare three groups: Group 1 were women who met DSM-5 criteria for Female Sexual Interest/Arousal Disorder and/or Genito-Pelvic Pain/Penetration Disorder, and fell below clinical cut-off scores on validated measures of sexual functioning and sexual distress. The typical sexual functioning group included women who did not meet criteria for any DSM-5 sexual dysfunction and scored above the clinical cut-offs on validated measures of sexual functioning and sexual distress. The third group (i.e., subclinical) included women who endorsed some but not all of the criteria met by women in Group 1. This group represents a substantial proportion of the female population who may experience some sexual difficulties but do not experience clinically significant distress, and do not necessarily seek treatment for their concern (Mitchell et al., 2016).

Based on the findings outlined above, we expected that women with sexual dysfunction would attend less (i.e., shorter total fixation
duration) to the genital area in the videos compared to women with typical sexual functioning (Hypothesis 1). Women with subclinical sexual dysfunction were expected to have total fixation durations between these two groups. We also expected visual attention to the genital area to be associated with higher levels of SSA (Hypothesis 2) and genital sexual arousal (Hypothesis 3). Time-lagged predictors were included in models for Hypotheses 1 to 3 to explore the direction of effects between sexual arousal and visual attention. In the models for Hypotheses 2 and 3, we also included interaction terms and explored whether the relevance of visual attention for sexual arousal differed between sexual functioning groups. To explore sexual functioning in a continuous instead of categorical manner, another set of analyses were conducted separately for intercourse and cunnilingus films using continuous measures of sexual desire and sexual pain in the full sample.

2. Method

2.1. Participants

Adult cis-gender women 19 years or older who were fluent in English, with mostly or exclusively heterosexual orientation, normal or corrected-to-normal vision, pre-menopausal hormonal status, were not taking any medication that might interfere with sexual response (e.g., hormonal contraception, antidepressants), and without current major mental disorders that might interfere with sexual response or the experimental procedure (e.g., current major depression, psychosis, substance abuse) were eligible for this study. Participants were recruited from advertisements placed online (i.e., university paid-studies list, hospital electronic mailing lists, Facebook, Instagram, online discussion boards), in local newspapers, and on flyers posted throughout the community (i.e., coffee shops, community centers, university boards). The study coordinator also invited participants of previous studies who had provided consent to be contacted for future studies. During a telephone screening conducted by a trained research assistant, the inclusion and exclusion criteria were assessed and a brief, standardized interview was conducted to screen for major mental disorders, and to assess for the diagnosis of a sexual dysfunction (for details, please refer to the Procedure section). Of the 115 women who expressed interest in the study, 107 participated in the telephone screening. Of these, 10 women did not meet the inclusion criteria and 19 did not proceed to schedule the in-lab assessment. Seventy-eight women provided written consent and completed both the questionnaires and the in-laboratory assessment. Due to technical problems, eye-tracking data were not measured in 9 participants. Valid subjective arousal data was not available in 2 participants. For 10 women, genital arousal data were not available (7 women indicated that they did not feel comfortable with inserting a vaginal plethysmograph and data of 3 women were lost due to technical problems). All women with valid eye-tracking as well as either subjective or genital arousal data were included in this study (N = 69).

2.2. Instruments and measures

2.2.1. Eye tracker

Eye movements were measured using a SensoMotoric Instruments (SMI) Red 500 eye tracker in combination with SMI’s Experiment Suite software program. The SMI Red 500 is a contact-free, remote sensor eye-tracker that measures bright and dark pupil tracking using an infrared camera. It is used in combination with a standalone 22’ monitor (resolution of 1920 x 1080). The eye tracker automatically compensates for small head movements, so it is not necessary to immobilize the head using a chin rest. The system is compatible for use with most eyeglasses and contact lenses. It also has a built-in detector to identify saccades (i.e., rapid changes in gaze location), blinks, and fixations (i.e., very low-velocity eye movements that correspond to a person staring at a particular point). The algorithm measures the distance between neighboring gaze points and calculates the eye movement velocity for all the eye movements sampled for each individual. Raw data points are assigned to the same fixation if the velocity remains below a set threshold or are assigned to a new fixation when the velocity rises above this threshold (dispersal threshold of 30 pixels corresponding to 0.9° and a minimum temporal duration of 100 ms).

2.2.2. Measure of visual attention

Controlled or deliberate attention towards the genital area was assessed by investigating total fixation duration, defined as the total time spent viewing a specific area. A longer total fixation duration is indicative of greater attentional capture and engagement (Anderson, Bothell, & Douglass, 2004; Dawson & Chivers, 2016; Henderson, 2003).

2.2.3. Self-report measures

We used the Female Sexual Function Index (FSFI; Rosen et al., 2000) to measure overall sexual function and assist with classifying women to one of the three groups. This validated 19-item scale asks about the frequency and intensity of six domains of sexual response (i.e., desire, lubrication, arousal, orgasm, satisfaction, and pain) and generates a total score. The FSFI has been found to have good discriminant validity, correctly identifying 71% of women with sexual dysfunction using a cut-off score of 26.55 (Wiegel, Meston, & Rosen, 2005). In this study, Cronbach’s alpha was .96 for the total scale. To investigate the relevance of low desire and pain symptoms, two FSFI subscales were used in our analysis. The FSFI-Desire consists of two items assessing the intensity and frequency of sexual desire. Items are scored on a 5-point Likert-scale from 1 to 5 with a total score ranging from 2 to 10. Women scoring below the clinical cut-off of 5 are deemed at risk for a sexual desire disorder (Gerstenberger et al., 2010). The FSFI-Pain subscale consists of three items assessing the frequency and severity of discomfort or pain during and following vaginal penetration. Items are scored on a 6-point Likert-scale from 0 to 5. As no clinical cut-off has been established a score of 3.9 was used to identify women with significant pain symptoms (Koops & Brikken, 2018).

We also administered the 13-item Female Sexual Distress Scale-Revised (FSDS-R; DeRogatis, Clayton, Lewis-D’Agostino, Wunderlich, & Fu, 2008) which measures women’s distress associated with their sexual functioning. Total scores range from 0 to 52, with higher scores indicating greater distress. The FSDS-R has been found to have excellent discriminant validity, correctly identifying 93% of women with sexual dysfunction using a cut-off score of 10 (DeRogatis et al., 2008). In this study, Cronbach’s alpha was .95.

2.2.4. Sexual functioning groups

To compare visual attention patterns by sexual function status, three sexual function groups were created. (1) A clinical group of participants with low sexual functioning included women who met three criteria: a diagnosis of at least one sexual dysfunction as determined via a structured telephone interview with a trained study coordinator, low sexual functioning as determined by a FSFI total score below 26.55, and high sexual distress as indicated by a FDSR-R score above 10. (2) A typical sexual functioning group consisted of participants who did not meet any of these criteria. (3) A subclinical group were women who met one or two, but not all three criteria (e.g., no clinical diagnosis, but low function and high distress). These participants represent a group that experiences subclinical sexual concerns (e.g., difficulties with sexual arousal, some distress about their sexual lives) that do not meet the threshold of a sexual dysfunction (Mitchell et al., 2016).

2.2.5. Dynamic sexual stimuli

The stimuli presented in this study were downloaded from a
commercial website and consisted of ten 1-min video clips of heterosexual couples engaged sexual activities as well as female masturbation (Data on fellatio and masturbation videos are presented elsewhere). Data of two videos’ showing vaginal intercourse in different positions (i.e., woman on top, rear-entry penetration) and two videos showing cunnilingus (i.e., stimulation of the female genitals using the tongue or lips) were analyzed. As no comparisons between different stimuli were performed, corrections for contrast or luminance were not conducted. The scenes were edited and cut so that they each contained only one perspective (i.e., no shifts between different camera angles). Similar videos from the same website were validated in the context of a previous study using a sample of 22 heterosexual women who found the stimuli moderately sexually arousing and pleasant. They did not include depictions of fetish, degradation, or violence and as such, we referred to the stimuli as “female friendly”. Importantly, the pilot study also indicated that the stimuli did not evoke significant negative emotions, such as anxiety, disgust, shame, or guilt (Velten et al., 2016).

2.2.6. Genital sexual arousal

Vaginal pulse amplitude (VPA) was used as a measure of genital sexual arousal using a vaginal photoplethysmograph equipped with an orange-red spectrum light source (Behavioral Technology Inc., Salt Lake City, UT) during the experimental procedure. The signal was sampled at 200 Hz, band pass filtered (0.5–30 Hz), and recorded continuously during the stimulus presentation. Data were acquired and processed using a data acquisition unit Model MP150 and AcqKnowledge version 3.8.1 (BIOPAC Systems, Inc., Santa Barbara, CA).

2.2.7. Subjective sexual arousal

Subjective sexual arousal was measured continuously during stimulus presentation with an arousometer that was constructed by a local engineer modeled after the one described by Rellini, McCall, Randall, and Meston (2005). The device consisted of a computer mouse mounted on a plastic track with 10 intervals, affixed to the armrest of the reclining chair. Women were instructed to use the device continuously to indicate changes in mental sexual arousal from 7 (highest level of arousal) to 0 (no sexual arousal) and −2 (sexually turned off) during the duration of the erotic film clips. Similar devices have been used to assess subjective sexual arousal in previous laboratory studies (Velten et al., 2018). In addition, participants were asked to rate the videos for sexual arousal (“how sexually arousing did you find this video?”) and liking (“how much did you like the video?”) on a scale from 0 (not arousing at all, and not at all, respectively) to 9 (extremely arousing, and very much, respectively) immediately after each of the film clips. To assess an overall explicit evaluation of the videos, a mean score of arousal and liking was calculated (van Lankveld et al., 2018).

2.3. Procedure

Potential participants received a consent form via email and were asked to review the study information and eligibility criteria prior to scheduling a telephone-based screening interview. During the interview women were asked about their sexual functioning and criteria for two sexual dysfunctions from the 5th edition of the DSM-5, namely Female Sexual Interest/Arousal Disorder and Genito-Pelvic Pain/Penetration Disorder, were assessed (APA, 2013). Eligible participants then scheduled an appointment for the in-laboratory assessment at a time when they were not menstruating. Participants also received a link to an online questionnaire that included sociodemographic variables and measures of sexual functioning to be answered before the appointment. Informed consent was obtained electronically as part of the online questionnaire as well as on paper after receiving extensive information about the testing procedure right before the assessment. The study took place in a sexual psychophysiology laboratory located in an academic medical center and all participants were tested by a female researcher. Participants were seated in a comfortable chair facing a computer monitor equipped with the SMI eye tracker at a viewing distance of approx. 60 cm. The researcher then provided a thorough overview of the procedures. The researcher left the room while participants inserted a vaginal plethysmograph used to measure genital sexual arousal. They then informed the researcher via intercom of their readiness. The researcher then initiated the study sequence. First, a 5-point calibration procedure was executed to ensure the eye tracker was properly calibrated. This required participants to follow the calibration fixation dot with their eyes as closely as possible. Upon completing the calibration procedure, a 5-min nature documentary was presented to assess baseline levels of arousal. After this, a picture paradigm lasting approx. 15 min and including a presentation of sixty sexual pictures was conducted (Velten, Milani, et al., 2020). Following that, participants watched a series of ten erotic film clips while their sexual responses were measured. After each video, women were asked how much they liked and how arousing they found the clip. After the session, women were asked to remove the vaginal probe, place it in a plastic bag, and inform the researcher via intercom when they were finished. After a debriefing period, participants received a reimbursement of $25 CAD. All procedures were approved by the Clinical Research Ethics Board at the University of British Columbia and the Vancouver Coastal Health Research Institute. All procedures were carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki (2013).

2.4. Data preparation

Offline, photoplethysmography data were band-pass filtered (0.5–20 Hz). Then, in agreement with standardized procedures, movement artifacts, defined by sudden and drastic changes in VPA, were visually identified and deleted by being marked as missing for data analysis (Prause & Janssen, 2006). Data inspection and manual artifact rejection were performed using ANSLAB Version 6.0 (Wilhelm & Peyk, 2005). To correct for baseline differences, VPA (in volts) during the erotic films was subtracted from VPA during an initial baseline phase (i.e., nature documentary). Arousometer data were inspected for invalid values before data analysis. Twelve participants showed values below −2 (lowest value −3) and/or above 7 (highest value 9).2 Outliers were corrected to −2 and 7, respectively.

We used SMI’s BeGaze™ software to create an area of interest for the genital area in each video. To accommodate for movement in the videos, the area of interest was adjusted frame-by-frame to cover an oval area covering both male and female genitalia in the intercourse films and female genitalia as well as parts of the man’s face in the cunnilingus films. The oval area of interest for the genital area was sized such that it covered an additional 1 cm around the perimeter of the actual genitals. A trained research assistant also used the BeGaze™ software to inspect gaze patterns of participants to make sure that all fixations around the genital area were covered by the area of interest. In order to address our hypotheses and to assess the time course of both sexual arousal and visual attention, data were analyzed using 10 s bins.

2.5. Data analysis

For descriptive purposes, we calculated means and standard deviations for all demographic and questionnaire variables. To account for the hierarchical structure of the data set, we used a multilevel modelling

1 In one additional intercourse video the genital area was not visible for more than 20 s and an additional cunnilingus video depicted a female couple. Both videos were excluded from this analysis.

2 Discussion among research personnel revealed that these values were most likely attributable to an experimenter accidently moving a laptop mouse associated with the recording laptop.
approach (Raudenbush & Bryk, 2002) for investigating the relationships between total fixation duration, SSA, VPA, and sexual functioning groups. We applied two-level models where repeated measurements were nested within participants. All models were estimated using maximum-likelihood estimation and slopes and intercepts were allowed to vary across time (i.e., 10 s bins) and videos to allow for differences in the baseline levels and time courses of attention and arousal. We specified the covariance matrices of all models as first-order autoregressive structures to fit our model to the correlation between the repeated measures within participants (Singer & Willett, 2003). Predictors were group- or grand-mean centered before analysis. We also computed semipartial η² effect sizes representing the variance in outcomes that is uniquely explained by the model parameter of each fixed effect (Page-Gould, 2016). For estimates of fixed effects, 95% confidence intervals were reported.

3. Results

3.1. Participant characteristics

Participants were on average 28 years old (M = 27.77, SD = 8.00, range = 19 to 54) and described their ethnicity as either Caucasian, East Asian, South Asian, or Other. About half of the participants were in a committed relationship or married (n = 34, 51%) and the majority indicated an exclusively (n = 43, 63%) or predominantly (n = 23, 34%) heterosexual orientation. The sample was highly educated with 24% having a post-graduate degree and 33% (n = 22) having graduated a 4-year college program. Most participants were students (n = 26, 39%), or either working full-time (n = 19, 28%) or part-time (n = 14, 21%).

3.2. Preliminary analysis

3.2.1. Sexual functioning

Out of the 69 women in this study, 30 met all three criteria of sexual dysfunction (i.e., clinical diagnosis, low function, high distress), 16 met none, and 23 met some but not all. As expected, the three sexual functioning groups significantly differed on their level of sexual functioning as measured with the FSFI, F (2,52) = 56.27, p < .001, partial η² = 0.68 (Clinical: M = 17.95, SD = 3.32; Subclinical: M = 24.29, SD = 3.78; Typical function: M = 29.11, SD = 1.42). There were also significant group differences in sexual distress, F (2,65) = 53.83, p < .001, partial η² = 0.62 (Clinical: M = 27.10, SD = 8.95; Subclinical: M = 11.65, SD = 7.84; Typical function: M = 4.00, SD = 3.07). These large differences in validated measures of sexual function and distress support our classification of women into sexual function groups.

3.2.2. Video rating

Across groups, participants evaluated the intercourse (M = 4.47, SD = 2.17) and cunnilingus (M = 4.76, SD = 2.38) videos neither positively nor negatively. Sexual functioning groups, however, differed in their evaluation of videos (Intercourse: F (2,65) = 9.76, p < .001, R² = 0.23; Cunnilingus: F (2,65) = 3.28, p = .044, R² = 0.09). Post-hoc Scheffé-tests did not reveal significant group differences for the cunnilingus videos. For the videos depicting vaginal intercourse, post-hoc tests showed that the clinical group evaluated the videos less positively than both the subclinical (p = .004) and typical functioning groups (p < .001), which did not differ from each other.

3.3. Sexual arousal and attention

To provide descriptive values for the average level of visual attention towards the genital area and sexual arousal, mean values across all four study stimuli are reported (see Fig. 2).

Across groups, women fixated on the genital area for an average of 4.09 s (SD = 1.69) out of every 10-s bin. Their levels of sexual arousal were 2.78 (SD = 1.75) and 0.23 (SD = 0.14) for SSA and VPA, respectively. Using these mean values, no significant group differences between visual attention, F (2,66) = 1.30, p = .279, SSA, F (2,64) = 2.05, p = .138, or VPA, F (2,55) = 0.33, p = .721, emerged.

3.4. Prediction of visual attention

Total fixation duration during a previous 10-sec bin was a strong predictor of total fixation duration in the next 10-sec period (see Table 1). Concurrent but not time lagged SSA was a significant predictor of total fixation duration. Neither time lagged nor concurrent VPA predicted total fixation duration. Compared to the reference category of typical sexual functioning both clinical and subclinical participants fixated on the genital area for a shorter total duration. A pairwise comparison of group differences showed that women with typical sexual functioning fixated for a longer total duration on the genital area than both subclinical, and clinical participants, while no differences between subclinical and clinical groups emerged.

3.5. Prediction of subjective sexual arousal

SSA during the previous 10 s bin (i.e., time lagged SSA) was a strong predictor of SSA (see Table 2). Time lagged but not concurrent total fixation duration predicted SSA. Compared to the reference category (i.e., typical sexual functioning), clinical but not subclinical participants showed lower SSA. The impact of total fixation duration on SSA was not moderated by sexual functioning group.

3.6. Prediction of genital sexual arousal

VPA during the previous 10 s bin (i.e., time lagged VPA) was a positive predictor of VPA (see Table 3). Time lagged but not concurrent total fixation duration predicted VPA. Estimates of fixed effects

Fig. 2. Mean values of total fixation duration, subjective sexual arousal, and genital sexual arousal in clinical, subclinical, and typical sexual functioning groups. Error bars reflect standard errors.

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Pain subscales as fixed predictors were calculated.

0.06 to 0.30; SSA:

indicated that neither sexual functioning group, nor interactions between group and total fixation duration predicted VPA.

3.7. Additional analyses

To further explore whether the relevance of two continuously measured facets of sexual functioning (i.e., low sexual desire and sexual pain) for visual attention (i.e., total fixation duration) and sexual arousal (i.e., SSA and VPA) differed between films showing vaginal intercourse or cunnilingus, a series of models with only the FSFI-Desire and FSFI-Pain subscales as fixed predictors were calculated.

For intercourse films, a longer total fixation duration on the genital area as well as higher SSA were predicted by lower sexual pain (total fixation duration: b (SE) = .18 (0.06), t (176.78) = 2.86, p = .005, CI = 0.06 to 0.39; SSA: b (SE) = 0.48 (0.18), t (190.09) = 2.73, p = .007, CI = 0.13 to 0.83) but not by sexual desire (total fixation duration: b (SE) = 0.21 (0.13), t (176.78) = 1.69, p = .092, CI = −0.04 to 0.46; SSA: b (SE) = 0.16 (0.36) t (190.09) = 0.46, p = .649, CI = −0.54 to 0.87).

For cunnilingus films, a longer total fixation duration was predicted by higher sexual desire, b (SE) = 0.56 (0.16), t (151.80) = 3.49, p < .001, CI = 0.24 to 0.88, but not by sexual pain, b (SE) = 0.10 (0.08), t (151.80) = 1.25, p = .215, CI = −0.06 to 0.26. Neither sexual desire, b (SE) = 0.38 (0.29), t (164.44) = 1.31, p = .193, CI = −0.19 to 0.94, nor sexual pain, b (SE) = 0.14 (0.14), t (164.44) = 1.00, p = .317, CI = −0.14 to 0.42, predicted SSA.

The intercourse and cunnilingus films showed similar effects for VPA. Specifically, lower sexual pain was a significant predictor of VPA (intercourse: b (SE) = 0.01 (0.004), t (145.86) = 2.16, p = .032, CI = 0.0008 to 0.02; cunnilingus b (SE) = 0.01 (0.004), t (138.47) = 2.87, p = .005, CI = 0.004 to 0.021). Sexual desire did not predict VPA (intercourse: b (SE) = 0.002 (0.009), t (145.87) = 0.21, p = .833, CI = −0.16 to 0.02; cunnilingus: b (SE) = −0.005 (0.008), t (138.32) = −0.57, p = .569, CI = −0.02 to 0.01).

4. Discussion

The goal of this eye-tracking study was to shed light on the relationship between sustained visual attention and sexual arousal in a sample of women with and without sexual dysfunction. Towards this goal, four 1-min videos showing either vaginal intercourse or cunnilingus were presented while eye-movements as well as subjective and genital sexual arousal were measured continuously. The eye-tracking analysis targeted sustained attention towards the genital area as indexed by total fixation duration.

4.1. Prediction of visual attention

Hypothesis 1 was supported as women with both clinical and
subclinical sexual dysfunction fixated less on the genital area than women with typical sexual functioning. Clinical and subclinical participants did not differ from each other. This finding underlines the dimensional nature of sexual functioning and suggests that the attentional bias towards sexual stimuli (Strahler, Baranowski, Walter, Huebner, & Stark, 2019) may be contingent on women having typical or high sexual functioning as even subclinical sexual difficulties may result in women attending less to the sexually explicit content. Our follow-up analysis suggested that both the type of stimulus material as well as different aspects of sexual functioning may impact the degree to which women direct their attention towards sexual stimuli. In videos depicting vaginal intercourse, women with symptoms of sexual pain attended significantly less to the genital area. This finding is in line with previous studies as well as clinical experience showing that women who experience sexual pain actively avoid vaginal intercourse (Desrochers et al., 2009).

The fear avoidance model suggests that women with chronic genital pain catastrophize about pain and actively avoid situations that might lead to sex, despite also showing a hypervigilance and initial attentional bias for coitus-related pain stimuli (Payne et al., 2005).

The lower fixation on viewing vaginal intercourse would align with this theory given that viewing the film might elicit fear (about painful intercourse) and then avoidance behavior (less sustained visual attention). On the other hand, oral sex (i.e., cunnilingus) may be not as associated with memories of painful experiences given that this activity does not necessarily include vaginal penetration, and as a result may not have elicited fear in women who experience vaginal pain. This explains why lower pain did not predict viewing behavior for the cunnilingus film. This interpretation is supported by self-report data as women with clinically significant pain symptoms (Koops & Briken, 2018) evaluated intercourse videos but not cunnilingus videos more negatively than women without pain (data available by the first author upon request).

In contrast, women with low sexual desire attended less to the area that showed female genitals in the cunnilingus videos. Some women with low desire issues may participate in sexual activity for interpersonal reasons (e.g., emotional intimacy with a partner, avoidance of conflict) rather than pursuit of their own personal physical pleasure (Basson, 2001b). In other words, it is possible that the incentive value of receiving oral stimulation may not be as high for low desire women (Meana, 2010; Meston & Buss, 2007). By contrast, women with typical or high levels of sexual desire would be more likely to experience incentive rewards (i.e., pleasure) from cunnilingus and would have attended to this activity more during the videos.

4.2. Prediction of subjective sexual arousal

Hypothesis 2 was supported as more attention towards the genital area predicted higher SSA. This finding supports the notion that directing attention towards a sexual stimulus elicits feelings of arousal (e.g., Beck & Baldwin, 1994; Prasse & Heiman, 2010) and is thus consistent with the emotion-motivational model (Dewitte, 2016). We speculate that the longer duration of viewing the erotic films allowed for both automatic and then conscious appraisal of those stimuli as being sexual. Our study also showed that clinical participants experience lower SSA, a finding that has been shown in some (Chivers et al., 2010; Meston, 2006) but not all (Hasty, Stanton, & Meston, 2018) laboratory-based studies, and is consistent with the diagnostic criteria for Female Sexual Interest/Arousal Disorder (APA, 2013) which include impairments in sexual arousal as a characteristic. Our follow-up analysis indicated that these group differences may depend on characteristics of the stimulus material and may be driven by symptoms of sexual pain. Specifically, for women affected by sexual pain symptoms, SSA was lower in videos depicting vaginal intercourse, but not in videos depicting cunnilingus—again because the vaginal penetration scenes would have elicited fear and anxiety, avoidance behavior, and then a resulting lower level of sexual arousal. This elicited fear, anxiety, and avoidance would not have been expected with the cunnilingus films, and explains why SSA was not impacted by women’s baseline levels of pain.

4.3. Prediction of genital sexual arousal

Hypothesis 3 was supported as more attention towards the genital area predicted higher VPA. Sexual functioning groups did not differ with respect to their VPA levels. This finding is in line with previous studies showing that sexual difficulties may not result in differences in vaginal blood-flow as measured with VPA (Bloemers et al., 2010). The post-hoc analysis concerning sexual pain and desire as continuous measurements showed, however, that experience of sexual pain with intercourse was actually associated with lower VPA. In other words, women who reported baseline sexual pain, regardless of whether they had a sexual dysfunction diagnosis, had lower VPA. Given evidence that VPA is an automatic and reflective response to sexual stimulation (Susichinsky, Lalumière, & Chivers, 2009), this finding that the presence of pain elicited lower VPA suggests that the mechanisms underlying this effect are automatic, and not conscious or intentional. For intercourse videos, the findings concerning SSA, VPA, and visual attention aligned, in that women with sexual pain experienced lower levels of arousal on both levels and attended less to the genital area. For cunnilingus videos, however, the pattern of results differed as women with sexual pain experienced reduced VPA despite unaffected levels of SSA and visual attention. These findings of the influence of baseline pain on attention-elicited sexual arousal that were dependent on the type of erotic stimulus is very interesting as they have implications for our theories about the etiology of genito-pelvic pain. Women who experience a lack of physical arousal response—in the form of reduced vaginal blood flow which might result in a lack of lubrication (Dawson, Sawatsky, & Lalumière, 2015)—may be prone to experience pain with sexual activity despite attending to sexual stimulation and feeling aroused mentally. To shed light on the role of low VPA as a cause for or consequence of genital pain, studies should assess women’s VPA levels before and after treatment for genito-pelvic pain and see whether reductions in pain symptoms are associated with an increased genital arousal response.

4.4. Additional research questions

To provide data on the direction of effects, we compared contemporaneously measured predictors with time-lagged predictors (e.g., the levels of predictors in the 10-sec bins before the dependent variable) in our models. Significance of a time-lagged predictor implies that changes in the predictor are followed by changes in the outcome variable. Attending to the genital area in the 10-sec interval before, led to increases in both SSA and VPA. On the other hand, neither time lagged SSA or VPA added to the explanation of visual attention. While this pattern of results suggests can be interpreted in that attention towards a sexual stimulus is a means to facilitate sexual arousal, rather than vice versa, experimental manipulation (e.g., providing instructions to focus on genital area, background, or faces) is needed to determine causality.

As part of our models for testing Hypotheses 2 and 3, we found that visual attention on the genital area elicited sexual arousal (i.e., SSA and VPA) equally in women with and without sexual dysfunctions. This finding has implications for the role of cognitive processes in triggering sexual arousal as described in the emotion-motivational model (Dewitte, 2016). Studies using indirect measures assessing conscious appraisal of sexual stimuli (Velten, Blackwell, Margraf, & Woud, 2019; Zahler et al., 2020) suggested that women with sexual dysfunction interpret those stimuli more negatively than women without sexual dysfunction. More research is needed to determine whether there are direct pathways from attention to sexual arousal or whether these associations are affected by negative sexuality-related appraisals in clinical participants.
4.5. Clinical implications

An implication of the finding that women with clinical and subclinical sexual dysfunction attend less to sexual stimuli suggests that treatment efforts should focus on increasing attention to sexual cues, while simultaneously addressing women’s emotional and cognitive appraisals of those stimuli. It may be that reduced attention to sexual stimuli perpetuates sexual symptoms, which in turn, negatively impacts motivation to engage in sex, and then further reduces attention to those sexual stimuli. This vicious circle might be interrupted by teaching women the benefits to her sexual experience by simply increasing attention to erotic triggers. Another clinical implication of the finding relates to the choice women might make if they wish to engage with erotic visual stimuli. In order to experience a higher level of sexual arousal, we might recommend that women without sexual pain and/or with low levels of desire might select films depicting sexual intercourse, whereas women with genital pain and/or typical sexual desire might select films centering on a woman’s pleasure, such as those showing cunnilingus.

4.6. Limitations and future research

The structure of the data did not allow for an investigation of the relationship between continuously measured sexual arousal and initial visual attention (e.g., time to first fixation on the genital area). Future studies should address this shortcoming by, for example, allowing sexual arousal levels to return to baseline between stimulus presentations and including a larger number of stimuli for which measures of initial attention can be measured. Further, a more sophisticated approach to modeling the interdependencies between visual attention and sexual arousal over time would have been to use a random-intercept cross-lagged panel model. Such a model uses cross-lagged correlations as a way to study causal influences in repeated measurements. Unfortunately, these models require a sample of at least 100 (or better 500) subjects (Hamaker, Kuiper, & Grasman, 2015). As research has shown women to incorporate contextual information of sexual stimuli into their sexual response (Dawson & Chivers, 2018), visual attention towards other areas of interest (e.g., male and female faces) should be investigated for their role in facilitating sexual arousal. Generalizability of these findings is limited by the fact that women were allowed to participate in this study without inserting a vaginal plethysmograph. Although women were not required to disclose the reason for their unwillingness to use the device, participants with severe pain symptoms may have been less likely to provide genital response data. All participants in this study identified as cis-gender women and reported an opposite-sex attraction. Moreover, we utilized stimuli depicting opposite-sex actors engaging in sexual activity. Future studies must endeavor to increase the sexual diversity of both the recruited samples as well as the range of stimuli used in order to understand whether these findings are specific to one’s gender-sex, and to the nature of the erotic stimuli.

5. Conclusion

To the best of our knowledge, this is the first study to use eye-tracking technology to investigate the relationship between visual attention and sexual arousal in women. First, women with sexual dysfunction attended less to sexual stimuli than women with typical sexual functioning. Second, visually attending to sexual stimuli was an effective means to facilitate subjective and genital sexual arousal in women with and without sexual dysfunction alike. Targeting cognitive distraction during sex and teaching women to attend to sexual stimulation may be a promising way to improve their physical and subjective feelings of sexual arousal and thereby improve their sexual functioning.

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Availability of data and material

All data analyzed during this study will be made publicly available on the Open Science Framework (https://osf.io/7w48n/).

CRediT authorship contribution statement

Julia Velten: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. Sonia Milani: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Supervision, Visualization, Project administration, Funding acquisition. Jürgen Margraf: Conceptualization, Methodology, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. Lori A. Brotto: Conceptualization, Methodology, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare no conflict of interest.

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