



# Visual Attention and Sexual Function in Women

Sonia Milani<sup>1</sup> · Samantha J. Dawson<sup>1</sup> · Julia Velten<sup>2</sup> 

Accepted: 1 June 2021 / Published online: 8 July 2021  
© The Author(s) 2021

## Abstract

**Purpose of Review** Theoretical models situate attention as integral to the onset and regulation of sexual response and propose that problems with sexual response and subsequent sexual dysfunction result from insufficient attentional processing of sexual stimuli. The goal of this paper is to review literature examining the link between attentional processing of sexual stimuli and sexual function in women. Specifically, we sought to understand whether women with and without sexual dysfunction differ in their visual attention to sexual stimuli and examined the link with sexual response, which would support attention as a mechanism underlying sexual dysfunction.

**Recent Findings** Across women with and without sexual concerns, sexual stimuli are preferentially attended to relative to nonsexual stimuli, suggesting that sexual stimuli are more salient than nonsexual stimuli. Differences between women with and without sexual dysfunction emerge when examining visual attention toward the most salient features of sexual stimuli (e.g., genital regions depicting sexual activity). Consistent with theoretical models, visual attention and sexual response are related, such that increasing attention to sexual cues facilitates sexual arousal, whereas reduced attention to sexual stimuli appears to suppress sexual arousal, which may contribute to sexual difficulties in women.

**Summary** Taken together, the research supports the role of visual attention in sexual response and sexual function. These findings provide empirical support for interventions that target attentional processing of sexual stimuli. Future research is required to further delineate the specific attentional mechanisms involved in sexual response and investigate whether these are modifiable. This knowledge may be beneficial for developing novel psychological interventions targeting attentional processes in the treatment of sexual dysfunctions.

**Keywords** Female sexual function · Sexual dysfunction · Visual attention · Eye-tracking · Cognitive distraction

## Introduction

Sexual function is defined as the absence of difficulty when moving through the different stages of sexual response (i.e., desire, arousal, and orgasm), including an absence of pain with sexual activity, as well as subjective feelings of satisfaction and pleasure during partnered and solitary sexual

behavior [1]. Sexual dysfunction involves recurrent problems with sexual response that are distressing to the individual [1]. Contemporary models of sexual response posit that attentional processes, which operate at different stages of awareness and control, are required for sexual arousal [2•, 3, 4]. In this paper, we review literature on how attentional processes — specifically visual attention to sexual stimuli — differ between women with and without sexual dysfunction. First, we situate attention as a key component in sexual response by providing an overview of the emotion-motivational model (EMM) [2•]. Second, we review experimental studies that examine the role of attention on sexual response in samples of women without sexual dysfunction, providing initial support for the EMM. Third, we focus on the limited research examining patterns of visual attention in women with varying levels of sexual functioning. We conclude by reviewing gaps in the current state of knowledge, discussing the clinical implications for interventions that capitalize on attentional mechanisms, and reflecting on research areas that have not yet been explored.

---

This article is part of the Topical Collection on *Female Sexual Dysfunction and Disorders*

---

✉ Julia Velten  
Julia.Velten@rub.de

<sup>1</sup> Department of Psychology, University of British Columbia, Vancouver, Canada

<sup>2</sup> Mental Health Research and Treatment Center, Department of Clinical Psychology and Psychotherapy, Faculty of Psychology, Ruhr University Bochum, Massenbergr. 9-13, 44787 Bochum, Germany

## Emotion-Motivational Model

Sexual response is an emotional state involving physiological responses (e.g., genital response), cognitive processes (e.g., attention to sexual stimuli), affective responses (e.g., excitement), and motivation behaviors (e.g., sexual desire) [5, 6]. Given that attention acts early on in the emotion regulation process, several theoretical models situate attention as a key component in the initiation and regulation of sexual arousal [3, 4, 7]. The EMM highlights the dynamic and multi-faceted processes involved in sexual response [2]. According to this contemporary model, genital arousal is triggered by sexually salient stimuli that are pre-attentively processed and automatically capture attention. Automatic appraisals of the stimuli as sexual and rewarding facilitate genital arousal, through increased or decreased attentional engagement. Genital arousal reinforces maintenance of attention and facilitates the conscious appraisal of sexual stimuli. The evaluation of sexual stimuli as meaningful (e.g., past experiences with the stimulus), along with emotional state of the individual (e.g., strength of sexual motivation), further determines how sexual response unfolds. When such appraisals result in positive or rewarding interpretations, subjective awareness of sexual arousal and desire follows. Working in a reciprocally reinforcing manner, the ongoing subjective and physiological responses may trigger motivation to engage in sexual behaviors [2]. Conversely, any negative or unrewarding interpretations experienced during this process may divert attention away from relevant sexual stimuli and thus impede sexual response and contribute to difficulty with sexual arousal, desire, and orgasm (i.e., sexual dysfunction).

The EMM can be a useful model for conceptualizing sexual dysfunction. For example, imagine a woman who presents with problems of low sexual desire and difficulties with arousal. It is possible she may not notice a sexual stimulus (e.g., her partner's naked body) or notices her partner but perceives the nudity to be nonsexual (e.g., not arousing and not indicative of sexual activity), and as a result, she may not experience an automatic genital response. In the absence of a genital response, her attention may be maintained on nonsexual stimuli (e.g., her to-do list). This may result in the conscious appraisal of her nude partner as unrewarding or perhaps even evoke negative emotions, if memories of unfulfilling sexual encounters are triggered. These negative appraisals may further shift her attention away from her partner, impeding genital response, and preventing subjective sexual arousal and desire. Given the absence of sexual arousal, it is unlikely she would be motivated to initiate or be receptive to sexual activity. If she does engage in sexual activity, her lack of sexual response (e.g., genital arousal/lubrication and sexual desire) coupled with her lack of approach motivation may result in an unfulfilling sexual encounter, which may instigate or perpetuate her sexual dysfunction. Taken together, the EMM not

only specifies the intermediary processes by which sexual response unfolds but also has implications for mechanisms underlying sexual dysfunction [8].

## Experimental Studies of Attention

Generally speaking, attention is used to prioritize and select the most motivationally charged stimuli for further processing [9]. There is strong evidence to suggest that sexual stimuli automatically attract attention and demand the allocation of attentional resources, which makes sense given that they are among some of the most emotionally salient stimuli in the environment [10]. In this section, we review studies utilizing different methodologies to assess the various components of attention. These include studies using reaction-time methods, studies of arousal where attentional focus is experimentally manipulated, and studies of visual attention assessed using eye-tracking. Together, these data support the role of automatic and controlled attention in the onset and regulation of sexual response.

Different reaction-time-based tasks have been used to examine attentional bias, defined as the tendency for emotionally salient (sexual) stimuli to capture attention and be preferentially processed relative to other less salient (nonsexual) stimuli [11]. In general, reaction-time tasks require participants to react as quickly as possible to a secondary task (e.g., the location of a target in the dot probe or the font color of the word in the emotional Stroop). It is expected that the salience of the stimuli (e.g., sexual vs. nonsexual) will either enhance or interfere with performance on the secondary task. For example, in dot probe tasks, when two stimuli compete for attention at opposite screen locations, faster responses to the target appearing in the same location as the salient sexual stimulus indicate attentional capture, whereas slower responses to the target appearing at the location of the non-salient, nonsexual stimulus demonstrate difficulty disengaging attention from the salient stimulus [11]. Studies using cueing tasks (e.g., dot probe and spatial cueing) have yielded contradictory results. While one study found no evidence for an automatic attentional capture toward sexual stimuli [12], others reported either faster responses to sexual stimuli (e.g., attentional capture) or slower responses due to difficulty disengaging from sexual stimuli [13, 14].

Attentional biases have also been explored in clinical samples of women with sexual function concerns. Using a modified dot probe task to assess attentional biases elicited by sexual words, one study found that women with poor sexual function exhibited an attentional bias whereas women high in sexual function did not [15]. Specifically, women with sexual function difficulties (i.e., Female Sexual Function Index < 27) were faster to identify probes that replaced sexual words compared to nonsexual words, suggesting that sexual words

captured and sustained attention. The authors hypothesized that similar to other psychopathologies (e.g., anxiety), female sexual dysfunction may be associated with an attentional bias toward disorder-relevant stimuli, specifically that sexual stimuli evoke a threat response that facilitates faster detection of such stimuli [15]. Pain-hypervigilance has been examined in women with and without vulvar vestibulitis syndrome (VVS; a sexual pain condition) using an emotional Stroop task involving neutral and pain-related words [16]. Compared with pain-free women, women with VVS displayed greater interference (i.e., slower response times) for pain-related words, suggesting that women with sexual pain experience hypervigilance for pain-related stimuli. Attentional biases assessed via the dot probe task have been examined in women with and without hypoactive sexual desire disorder (HSDD) [17]. The authors hypothesized that compared to healthy controls, women with HSDD would be faster to detect dots that replaced sexual images, indicative of an attentional bias consistent with sexual stimuli capturing attention [18]. Surprisingly, they found that both groups of women exhibited similar attentional biases, consistent with attentional (dis)engagement with sexual stimuli (i.e., slower response times), rather than attentional capture.

Attentional biases have been used as a means to examine treatment efficacy for sexual dysfunction. A study involving women with HSDD compared pre- and post-treatment attentional biases to sexual stimuli using the emotional Stroop task [19]. Pre-treatment women with HSDD did not exhibit an attentional bias to sexual words (i.e., similar response times for both sexual and nonsexual words). After treatment with testosterone and a PDE-5 inhibitor, women with HSDD showed an attentional bias, such that sexual words interfered with color naming (i.e., slower response times). This study is important in that it reveals a possible attentional mechanism underlying sexual dysfunction that is modifiable with treatment. Indeed, women with HSDD may lack an attentional bias (e.g., sexual stimuli are not salient and thus do not capture attention) and this may prevent activation of the sexual response system. Together, the evidence indicates that attentional mechanisms may be important for the underlying symptoms of sexual dysfunction. The equivocal findings in reaction-time studies are likely due to the variability in paradigms used (e.g., dot probe and emotional Stroop), which actually capture different attentional mechanisms—cueing and attentional filtering. Although studies using reaction-time tasks have generally supported that sexual stimuli command attentional resources, the link between these attentional mechanisms and sexual outcomes has not been thoroughly investigated. Given the role of attention in the initiation and regulation of sexual arousal, we might predict that cueing tasks, which use different classes of stimuli to experimentally manipulate orienting of attention, may be associated with the initial activation of genital arousal. Filtering tasks, rely on emotionally salient stimuli capturing

and sustaining attention thereby reducing one's ability to attend to other stimuli, may be more strongly associated with the regulation of sexual arousal.

Over the last several decades, researchers have also manipulated the allocation of attentional resources available for stimulus processing using a variety of tasks (e.g., dichotic listening, instructional, performance demand, or use of distractions). The goal of these studies was to elucidate the role of voluntary or directed attention in women's sexual response. For example, under experimental conditions instructing women to increase their sexual arousal or to focus on pleasure rather than pain, women reported increases in sexual arousal [20, 21]. Further, women's subjective feelings of sexual arousal while viewing erotic video stimuli increased after practicing mindfulness exercises encouraging women to focus their attention on bodily sensations [22, 23]. Whereas directed attention to internal and external sexual stimuli can facilitate sexual arousal, cognitive distraction can divert attention away from such stimuli and hinder sexual response. Indeed, compared to conditions where attention is maintained on sexual stimuli, auditory (e.g., dichotic listening) or visual (e.g., picture flickering) distractions presented during the sexual stimulus presentation have been found to weaken both subjective and physiological sexual arousal in women [24–28]. Although these studies demonstrate the importance of attention to and distraction from sexual stimuli in sexual arousal, they reveal nothing about the specific attentional mechanisms because they situate attention as an independent rather than dependent variable. As well, the distractors used in these experiments lack ecological validity and may not be accurate representations of real-life distractors that may affect women experiencing sexual dysfunction.

## Visual Attention to Sexual Stimuli

Visual attention is defined as the selective orienting to information from one region of the visual field at the expense of other regions in the same field [29]. Eye-tracking technology enables the direct recording of automatic and controlled eye movements and provides a continuous measure of attention allocation in real time [30–32]. Eye-tracking enables the assessment of initial or automatic attention through the latency to first fixation. This is an index of attentional capture or how quickly a stimulus captures attention, and according to the EMM is thought to trigger the onset of a sexual response [2•]. Sustained or controlled attention is assessed most commonly through total fixation duration. This is an index of the overt orienting and sustained attentional processing or the total amount of time spent looking at a stimulus and is thought to regulate sexual response over time.

Visual attention is a central component of most sexual experiences and sex researchers have relied on eye-tracking to

examine visual processing of sexual stimuli as it relates to sexual interest, arousal, and attentional biases underlying sexual (dys)function. There is robust evidence to suggest that sexual stimuli capture more visual attention than nonsexual stimuli [33, 34•, 35]. Studies presenting participants with sexual (e.g., nude) and nonsexual (e.g., fully clothed) images of male and female targets have revealed a compelling attentional bias in favor of sexual stimuli. Specifically, sexual stimuli elicit longer gaze times relative to nonsexual stimuli [32, 33]. Other paradigms focused on examining visual attention to preferred and nonpreferred sexual targets reveal different patterns dependent on the stage of attentional processing (i.e., initial versus controlled attention) [35, 36•, 37•, 38, 39]. Both preferred and nonpreferred stimuli elicit an initial attentional bias, suggesting that sexual stimuli regardless of their sexual relevance in terms of gender cues automatically capture attention [35, 36•, 37•]. Patterns of controlled attentional bias, however, seem to differ as a function of the eye-tracking paradigm. Specifically, in studies presenting single images of male or female targets, or dyads engaging in sexual activity, both preferred and nonpreferred targets garner similar degrees of visual attention [35, 39]. In studies using a forced-attention paradigm — where two single target images are simultaneously presented and compete for attention — only preferred sexual stimuli elicit a controlled attentional bias [35, 36•, 37•]. Notably, patterns of controlled attention are strongly correlated with self-reported attraction ratings to sexual images ( $r = .47$  to  $.49$ ), consistent with the EMM [35].

Recently, researchers have begun exploring whether visual attention patterns elicited by sexual stimuli differ as a function of whether or not a woman has a sexual dysfunction. The overarching hypothesis is that sexual dysfunction may arise if sexual stimuli do not attract or command attentional resources because this would inhibit the activation of sexual response or the proliferation of the response over time. In a sample of women with acquired ( $n = 16$ ) and lifelong ( $n = 9$ ) sexual interest/arousal disorder (SIAD) [40], Brown et al. [41••] examined attentional bias for sexual stimuli. When a sexual and nonsexual image were simultaneously presented to compete for attention (e.g., forced-attention paradigm), women with SIAD — regardless of subtype — exhibited a controlled attentional bias, such that they looked more at the sexual compared to nonsexual images. That is, compared to nonsexual stimuli, sexual stimuli were prioritized by the visual attention system and commanded attentional resources for women whom sexual stimuli may not be appraised as positive and associated with reward as per the EMM.

Velten and colleagues [42••, 43••] investigated gaze patterns of women with clinical ( $n = 30$ ), subclinical ( $n = 23$ ), and normal ( $n = 16$ ) levels of sexual function. Women with clinical levels of sexual function met DSM-5 criteria for SIAD and/or genito-pelvic pain/penetration disorder (GPPPD) [40]. Women with subclinical levels did not meet full diagnostic

criteria for SIAD and/or GPPPD but scored below the clinical cut-off for sexual function (Female Sexual Function Index  $< 26.55$ ) and above the clinical cut-off for sexual distress (Female Sexual Distress Scale-Revised  $> 11$ ). The goal was to determine if women with sexual dysfunction attend differently to sexual stimuli (static images and dynamic videos) and if this may be a mechanism contributing to their sexual dysfunction. The authors hypothesized that women with clinical and subclinical sexual dysfunction would look less at the genital regions of sexual stimuli compared to women with normal sexual functioning. Results demonstrated that compared to healthy controls, women with sexual dysfunction attended less to the genital regions of sexual stimuli across static and dynamic stimuli. While these findings may indicate that the salient aspects of sexual stimuli did not capture or maintain attention in women with sexual dysfunction, the reported effects were small and not observed across all dependent variables (e.g., different eye-tracking measures). Consistent with the EMM, across all women, attention toward sexual cues facilitated sexual arousal, such that longer gaze durations on the genital regions of sexual videos was followed by increases in both subjective and physiological sexual arousal [43••].

Given that distraction has been hypothesized as a mechanism contributing to sexual dysfunction [7], some researchers have sought to examine how distraction, rather than attention, influences visual processing of sexual stimuli. In the same study described above [42••], eye movements were recorded during the presentation of sexual images where distracting objects (e.g., a to-do list or household item) were placed within a sexual image. Contrary to the hypothesis, across all women, the presence of distracting objects did not influence attention toward the genital regions of sexual stimuli, suggesting that distractibility from visual sexual cues may not be a key mechanism underlying sexual dysfunction [42••]. Another study evaluated visual attention patterns as a function of specific sexual concerns using static images depicting couples engaged in foreplay [44]. When comparing women without sexual complaints ( $n = 20$ ) to women with low sexual desire ( $n = 14$ ) and those experiencing painful intercourse ( $n = 20$ ), women with genital pain looked significantly less at the sexual scene regions (i.e., the full bodies of the male and female in the sexual images) than women with low sexual desire and those with no sexual complaints. Consistent with Velten et al. [42••], there were no group differences in attention to distractor objects within sexual images. They concluded that among women who experience pain with intercourse, there may be an avoidance of sexual stimuli, which may contribute to their sexual difficulties [44].

Recent studies examining attentional biases among women with sexual dysfunction have contradictory findings, as sexual stimuli seem to both automatically capture attention [15] and command less voluntary attention [42••, 43••]. First, these paradigms assess different mechanisms: in reaction-time



tasks, the primary variable of interest is response time, whereas in eye-tracking paradigms, gaze (e.g., total fixation duration) is assessed. The former is capturing more reflexive automatic attentional processes, whereas the latter is capturing more consciously controlled processes. Second, our visual system is typically inundated with many stimuli that compete for attention simultaneously and our attentional system prioritizes information based on saliency and stimulus complexity. Compared to paradigms using sexual and nonsexual words, stimuli containing images and videos depicting sexual activity contain many more cues and as such are more cognitively demanding to process. In fact, there is evidence to suggest that contextual cues differentially influence attentional processing of sexual stimuli, particularly in women [36]. Thus, methodological differences may be responsible for the somewhat equivocal findings on the role of attention in sexual dysfunction.

Taken together, the evidence suggests that visual attention is biased toward sexual stimuli and that such stimuli facilitate sexual arousal among women with and without sexual dysfunction. However, salient aspects of sexual stimuli (e.g., genital regions depicting sexual activity) appear to produce varied patterns of attention among women with and without sexual difficulties. This provides preliminary support for the hypothesis that differences in patterns of sexual response and sexual function may be the result of differences in attentional processing of stimulus cues depicting reward salience (i.e., the regions of stimuli that indicate sexual activity). Additional support for the EMM is that visual attention patterns correlate with sexual outcomes, such that increasing attention to sexual stimuli — particularly salient features — facilitates sexual arousal. Conversely, the EMM hypothesizes that reduced attention (e.g., looking less) to sexual stimuli may impede physiological sexual arousal and reduce vaginal lubrication, which in turn may set the stage for lower levels of sexual desire and/or the experience of pain with intercourse [2].

### Limitations to Studies of Visual Attention

Although studies of visual attention have shed light on our understanding of attentional mechanisms involved in sexual dysfunction, the research is not without limitations. The links between visual attention and sexual dysfunction as proposed in the EMM have yet to be comprehensively examined. Specifically, the few existing studies have focused on two sexual dysfunctions, namely low desire and genital pain. As such, our understanding of how attention relates (or not) to problems with orgasm, or specific genito-pelvic pain conditions, such as vaginismus (involuntary spasms of the pelvic floor muscles) or provoked vestibulodynia (pain to the vulvar vestibule that is provoked by touch or sexual activity) [40], is limited. The dearth of studies investigating the integration of

visual attention and sexual outcomes is problematic because although attention may differ across women with varying levels of sexual function, it does not reveal if these attentional differences translate into the downstream effects on sexual response as per the EMM. Specifically, if the goal when treating sexual dysfunction is to augment sexual outcomes (including arousal, desire, and satisfaction), then identifying direct links between attentional mechanisms and sexual outcomes is necessary to determine if addressing attention will ameliorate the deficits seen among women with sexual dysfunction. It is challenging to draw strong conclusions from the few existing visual attention studies given the relatively small sample sizes within each group. Small samples limit variability in gaze and outcomes, producing less reliable estimates. Lastly, even if visual attention is a key mechanism in sexual response, viewing sexual stimuli on a screen, particularly in a laboratory setting, does not necessarily simulate sexual interaction in the real world. Thus, the lack of ecological validity in the experimental design may not reflect how sexual stimuli are processed in actual sexual situations. Solutions for future research might include ambulatory measures or virtual reality methodology which enables first-person point of view stimuli that may better mimic real-life situations.

### Clinical Implications and Future Directions

Despite the relative paucity of research examining visual attention and sexual function, preliminary data support our understanding of attentional processes involved in sexual (dys)function consistent with the EMM. If sexual stimuli fail to capture attention, sexual response will not be activated, and if sexual stimuli fail to sustain attention, sexual response will be insufficient for sexual activity, thereby contributing to sexual dysfunction. It follows that attention to sexual stimuli is a key factor in the development and maintenance of sexual dysfunction, and in order to enhance arousal and sexual response, attention to sexual stimuli may need to be targeted in intervention.

Current interventions for sexual dysfunction incorporate attentional aspects. For example, sensate focus (i.e., focusing on one's own sensations and perceptions during arousal instead of goal-oriented behavior) and cognitive-behavioral therapy (i.e., replacing unhelpful cognitions that arise before, during, and after sex with more balanced thoughts) each attempt to augment sexual response through attentional or cognitive mechanisms [45, 46]. Experimental studies investigating other interventions that target aspects of attentional focus such as mindfulness-based interventions also find benefit for sexual response [47, 48]. Mindfulness involves bringing one's attention to experiences in the present moment in a nonjudgmental way during sexual activity [49] and is thought to benefit sexual response by reducing judgmental distracting

thoughts and tuning in to present moment awareness of the experience. Indeed, mindful attention toward bodily sensations (e.g., genital arousal) is associated with higher levels of sexual arousal in women [22, 23]. Although mindfulness benefits sexual response, the exact mechanisms by which this occurs remain unclear. Thus, exploring the relative contribution of directing visual attention to external stimuli versus directing cognitive attention to internal cues may be a fruitful avenue to explore in future investigations. To do this, we recommend a comprehensive examination of all aspects of sexual response, including attention (i.e., eye-tracking), sexual arousal measurements (i.e., self-report and physiological), and sexual motivation (i.e., approach and avoidance motivation), including experimental manipulations of attentional focus. Such examinations may generate important knowledge about the specific mechanisms that influence the various aspects of sexual response (e.g., genital response, subjective sexual arousal, and sexual desire) and as such may result in more tailored clinical recommendations for different sexual function problems. Given the finding that the presence of visual distractors on attention does not differ as a function of sexual dysfunction, other types of distraction that do not rely on the visual system (e.g., cognitive distraction) may be more relevant. We would predict that cognitive distractions (e.g., non-sexual thoughts) may be more strongly linked with problems with low sexual desire because attention is not focused on the present moment impairing sexual response. As such, cognitive distractions might be a relevant treatment target for women with low sexual desire. There is some evidence supporting visual avoidance and fear of sexual cues among women with genital pain conditions, which may interfere with their sexual response. Thus, visual attention to sexual cues and linking these cues with pleasure rather than pain may be the focus of treatment for women with genital pain conditions.

Findings from visual attention research might also pave the way for the development of novel interventions to augment sexual response by directly targeting attentional mechanisms. Attentional bias modification (ABM) training interventions involve modifying attentional biases that are elicited by negative or threatening stimuli by training individuals to preferentially attend to neutral or positive stimuli [50]. ABM has demonstrated clinical utility in reducing symptoms of depression and anxiety using both reaction-time and eye-tracking methodologies [51, 52]. In recent years, some studies have failed to successfully modify attentional bias, in large part due to the adoption of less rigorous approaches that focus on ABM outcomes, rather than the process of eliciting change [53]. ABM has not yet been examined in the context of sexual dysfunctions, but we believe it could be a promising avenue to explore following careful consideration of the processes required to modify attentional bias. In contrast to ABM for depression and anxiety that reduces attentional bias elicited by emotionally salient stimuli (i.e., negative or threatening stimuli), ABM training for sexual

dysfunction would involve strengthening attentional biases toward sexual stimuli in order to facilitate sexual arousal. While more research is required to evaluate the extent to which modifications to attention contribute to changes in sexual response and subsequently symptoms of sexual dysfunction, treatments addressing sexual concerns would likely benefit from targeting attentional processing of sexual stimuli.

## Conclusion

Although the field is nascent and in need of more comprehensive examinations to determine which aspects of visual attention are most relevant for sexual response and functioning, research has elucidated some basic aspects to enhance our knowledge. Attention is a key mechanism involved in the initiation and regulation of sexual response. Specifically, controlled visual attention correlates with sexual outcomes, such that increasing attention to sexual stimuli facilitates sexual arousal. Attentional processing of sexual stimuli appears to be impaired in some women with sexual dysfunction. Existing treatments that target attention are effective in improving sexual response and reducing sexual dysfunction. Future research that better delineates specific attentional mechanisms, their possible modification, and the relationship with sexual response outcomes may be beneficial for generating new attention-based interventions to treat sexual dysfunction.

**Funding** Open Access funding enabled and organized by Projekt DEAL.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Fielder R. Sexual functioning. In: Gellman MD, Turner JR, editors. *Encycl Behav Med* [Internet]. New York, NY: Springer; 2013 [cited 2021 Apr 19]. p. 1774–7. Available from: [https://doi.org/10.1007/978-1-4419-1005-9\\_668](https://doi.org/10.1007/978-1-4419-1005-9_668)

2. Dewitte M. Gender differences in implicit processing of sexual stimuli. *Eur J Personal.* 2016;30:107–24 **This paper presents the emotion-motivational model and situates attention as a key component of sexual response.**
3. Janssen E, Everaerd W, Spiering M, Janssen J. Automatic processes and the appraisal of sexual stimuli: toward an information processing model of sexual arousal. *J Sex Res.* 2000;37:8–23.
4. Toates F. An integrative theoretical framework for understanding sexual motivation, arousal, and behavior. *J Sex Res.* 2009;46:168–93.
5. Bancroft J. Sexual arousal. *Encycl Cogn Sci.* 2003.
6. de Jong DC. The role of attention in sexual arousal: implications for treatment of sexual dysfunction. *J Sex Res.* 2009;46:237–48.
7. Barlow DH. Causes of sexual dysfunction: the role of anxiety and cognitive interference. *J Consult Clin Psychol.* 1986;54:140–8.
8. Zahler L, Meyers M, Woud ML, Blackwell SE, Margraf J, Velten J. Using three indirect measures to assess the role of sexuality-related associations and interpretations for women's sexual desire: an internet-based experimental study. *Arch Sex Behav.* 2021.
9. MacLeod J, Stewart BM, Newman AJ, Amell KM. Do emotion-induced blindness and the attentional blink share underlying mechanisms? An event-related potential study of emotionally-arousing words. *Cogn Affect Behav Neurosci.* 2017;17:592–611.
10. Spiering M, Everaerd W. The sexual unconscious. 2007; *The psychophysiology of sex:*166–84.
11. Yiend J. The effects of emotion on attention: a review of attentional processing of emotional information. *Cogn Emot Routledge.* 2010;24:3–47.
12. Imhoff R, Barker P, Schmidt AF. To what extent do erotic images elicit visuospatial versus cognitive attentional processes? Consistent support for a (non-spatial) sexual content-induced delay. *Arch Sex Behav.* 2020;49:531–50.
13. Kagerer S, Wehrum S, Klucken T, Walter B, Vaitl D, Stark R. Sex attracts: investigating individual differences in attentional bias to sexual stimuli. *PLoS One.* 2014;9 [cited 2021 Apr 20]; Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4169562/>.
14. Prause N, Janssen E, Hetrick WP. Attention and emotional responses to sexual stimuli and their relationship to sexual desire. *Arch Sex Behav.* 2008;37:934–49.
15. Beard C, Amir N. Attention bias for sexual words in females with low sexual functioning: a brief report. *J Sex Marital Ther.* 2010;36:216–26.
16. Payne KA, Binik YM, Amsel R, Khalifé S. When sex hurts, anxiety and fear orient attention towards pain. *Eur J Pain Lond Engl.* 2005;9:427–36.
17. Diagnostic and statistical manual of mental disorders. 4th ed. Washington, DC: American Psychiatric Association; 2000.
18. Brauer M, van Leeuwen M, Janssen E, Newhouse SK, Heiman JR, Laan E. Attentional and affective processing of sexual stimuli in women with hypoactive sexual desire disorder. *Arch Sex Behav.* 2012;41:891–905.
19. Bloemers J, van Rooij K, Poels S, Goldstein I, Everaerd W, Koppeschaar H, et al. Toward personalized sexual medicine (part 1): integrating the “dual control model” into differential drug treatments for hypoactive sexual desire disorder and female sexual arousal disorder. *J Sex Med.* 2013;10:791–809.
20. Beck JG, Baldwin LE. Instructional control of female sexual responding. *Arch Sex Behav.* 1994;23:665–84.
21. Brauer M, ter Kuile MM, Laan E. Effects of appraisal of sexual stimuli on sexual arousal in women with and without superficial dyspareunia. *Arch Sex Behav.* 2009;38:476–85.
22. Velten J, Margraf J, Chivers ML, Brotto LA. Effects of a mindfulness task on women's sexual response. *J Sex Res United States: Routledge.* 2018;55:747–57.
23. Velten J, Brotto LA, Chivers ML, Hirschfeld G, Margraf J. The power of the present: effects of three mindfulness tasks on women's sexual response. *Clin Psychol Sci SAGE Publications Inc.* 2020;8:125–38.
24. Adams AE, Haynes SN, Brayer MA. Cognitive distraction in female sexual arousal. *Psychophysiology.* 1985;22:689–96.
25. Anderson AB, Hamilton LD. Assessment of distraction from erotic stimuli by nonerotic interference. *J Sex Res.* 2015;52:317–26.
26. Elliott AN, O'Donohue WT. The effects of anxiety and distraction on sexual arousal in a nonclinical sample of heterosexual women. *Arch Sex Behav.* 1997;26:607–24.
27. Prause N, Heiman J. Reduced labial temperature in response to sexual films with distractors among women with lower sexual desire. *J Sex Med.* 2010;7:951–63.
28. Salemink E, van Lankveld JJDM. The effects of increasing neutral distraction on sexual responding of women with and without sexual problems. *Arch Sex Behav.* 2006;35:179–90.
29. Henderson JM. Visual attention and eye movement control during reading and picture viewing. In: Rayner K, editor. *Eye Mov Vis Cogn Scene Percept Read* [Internet]. New York, NY: Springer; 1992 [cited 2021 Apr 20]. p. 260–83. Available from: [https://doi.org/10.1007/978-1-4612-2852-3\\_15](https://doi.org/10.1007/978-1-4612-2852-3_15)
30. Andersen NE, Dahmani L, Konishi K, Bohbot VD. Eye tracking, strategies, and sex differences in virtual navigation. *Neurobiol Learn Mem.* 2012;97:81–9.
31. Hall C, Hogue T, Guo K. Differential gaze behavior towards sexually preferred and non-preferred human figures. *J Sex Res.* 2011;48:461–9.
32. Henderson JM, Weeks PA, Hollingworth A. The effects of semantic consistency on eye movements during complex scene viewing. *J Exp Psychol Hum Percept Perform.* 1999;25:210–28.
33. Lykins AD, Meana M, Kambe G. Detection of differential viewing patterns to erotic and non-erotic stimuli using eye-tracking methodology. *Arch Sex Behav.* 2006;35:569–75.
34. Milani S, Brotto LA, Kingstone A. “I can see you”: the impact of implied social presence on visual attention to erotic and neutral stimuli in men and women. *Can J Hum Sex.* 2019;28:105–19 **This study highlights that sexual stimuli command attentional resources and are viewed longer than nonsexual stimuli.**
35. Nummenmaa L, Hietanen JK, Santtila P, Hyönä J. Gender and visibility of sexual cues influence eye movements while viewing faces and bodies. *Arch Sex Behav.* 2012;41:1439–51.
36. Dawson SJ, Chivers ML. Gender-specificity of initial and controlled visual attention to sexual stimuli in androphilic women and gynephilic men. *PLoS One.* 2016;11:e0152785 **Using a robust forced-attention paradigm, this study illustrates that patterns of initial and controlled visual attention to preferred and nonpreferred targets differ in women. This study also revealed a strong positive correlation between controlled attention and self-reported attraction.**
37. Dawson SJ, Chivers ML. The effect of static versus dynamic stimuli on visual processing of sexual cues in androphilic women and gynephilic men. *R Soc Open Sci.* 2018;5 [cited 2020 Oct 22]; Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6030282/>. **This study demonstrates that contextual cues differentially influence visual attention to sexual stimuli and this is particularly true for women.**
38. Dawson SJ, Chivers ML. The effect of task demands on gender-specificity of visual attention biases in androphilic women and gynephilic men. *Personal Individ Differ.* 2019;146:120–6.
39. Lykins AD, Meana M, Strauss GP. Sex differences in visual attention to erotic and non-erotic stimuli. *Arch Sex Behav.* 2008;37:219–28.
40. Diagnostic and statistical manual of mental disorders [Internet]. 5th ed. American Psychiatric Association; 2013 [cited 2021 Apr 20]. Available from: <https://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425596>

41. •• Brown N, Peragine D, VanderLaan D, Kingstone A, Brotto LA. Cognitive processing of sexual cues in asexual individuals and heterosexual women with desire/arousal difficulties. *PLoS One*. 2021; **This study reveals that heterosexual women with and without sexual desire/arousal difficulties visually attend more to sexual stimuli relative to nonsexual stimuli when both are presented simultaneously.**
42. •• Velten J, Milani S, Margraf J, Brotto LA. Visual attention to sexual stimuli in women with clinical, subclinical, and normal sexual functioning: an eye-tracking study. *J Sex Med*. 2021;18:144–55 **This study presents evidence that visual attention to sexual stimuli differs in women with and without sexual difficulties.**
43. •• Velten J, Milani S, Margraf J, Brotto LA. Visual attention and sexual arousal in women with and without sexual dysfunction. *Behav Res Ther*. 2021; **This study elucidates the link between visual attention and sexual arousal, consistent with the EMM.**
44. Lykins AD, Meana M, Minimi J. Visual attention to erotic images in women reporting pain with intercourse. *J Sex Res*. 2011;48:43–52.
45. Fenn K, Byrne M. The key principles of cognitive behavioural therapy. InnovAiT SAGE Publications. 2013;6:579–85.
46. Masters WH, Johnson VE. Human sexual inadequacy. Little, Brown, and Company.: Boston, MA; 1970.
47. Brotto LA, Bergeron S, Zdaniuk B, Driscoll M, Grabovac A, Sadownik LA, et al. A comparison of mindfulness-based cognitive therapy vs cognitive behavioral therapy for the treatment of provoked vestibulodynia in a hospital clinic setting. *J Sex Med*. 2019;16:909–23.
48. Stephenson KR. Mindfulness-based therapies for sexual dysfunction: a review of potential theory-based mechanisms of change. *Mindfulness*. 2017;8:527–43.
49. Kabat-Zinn J, Hanh TN. Full catastrophe living: using the wisdom of your body and mind to face stress, pain, and illness: Random House Publishing Group; 2009.
50. Jones EB, Sharpe L. Cognitive bias modification: a review of meta-analyses. *J Affect Disord*. 2017;223:175–83.
51. Hakamata Y, Lissek S, Bar-Haim Y, Britton JC, Fox N, Leibenluft E, et al. Attention bias modification treatment: a meta-analysis towards the establishment of novel treatment for anxiety. *Biol Psychiatry*. 2010;68:982–90.
52. Mogg K, Bradley BP. Anxiety and attention to threat: cognitive mechanisms and treatment with attention bias modification. *Behav Res Ther*. 2016;87:76–108.
53. Grafton B, MacLeod C, Rudaizky D, Holmes EA, Salemink E, Fox E, et al. Confusing procedures with process when appraising the impact of cognitive bias modification on emotional vulnerability. *Br J Psychiatry J Ment Sci*. 2017;211:266–71.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.