To what extent do erotic images elicit visuospatial versus cognitive attentional processes?

Consistent support for a (non-spatial) Sexual Content-Induced Delay

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**ACCEPTED FOR PUBLICATION at
ARCHIVES OF SEXUAL BEHAVIOR**

**Please cite authoritative version to be published under:
<https://doi.org/10.1007/s10508-019-01512-0>**

The reported research and preparation of this paper was supported by a DFG Grant (IM147/3-1) awarded to Roland Imhoff. All experimental scripts, raw and aggregated data as well as results of additional analyses can be found on the Open Science Framework under <https://osf.io/6uqyv>. Correspondence should be addressed to Roland Imhoff, Social and Legal Psychology, Binger Str. 14-16, 55122 Mainz, Germany, or to roland.imhoff@uni-mainz.de.

ABSTRACT

It is almost a cultural truism that erotic images attract our attention, presumably because paying attention to erotic stimuli provided our ancestors with mating benefits. Attention however, can be narrowly defined as visuospatial attention (keeping such stimuli in view) or more broadly as cognitive attention (such stimuli taking up one's thoughts). We present four independent studies aiming to test the extent to which erotic images have priority in capturing visuospatial attention (as exhibited in quicker reactions to stimuli presented in locations where erotic images appeared previously), respectively cognitive attention (as exhibited in delayed responding after erotic images, independent of their location). To this end, we specifically modified spatial cueing tasks to disentangle visuospatial attention capture from general sexual content induced delay (SCID) effects – a major drawback in the previous literature. Consistently across all studies (total $N = 399$) we found no evidence in support of visuospatial attention capture but reliably observed an unspecific delay of responding for trials in which erotic images appeared (irrespective of cue location). This SCID is equally large for heterosexual men and women and reliably associated with their self-reported sexual excitability.

Keywords: erotic cognition, visual attention, spatial cueing, sexual content induced delay, sexual excitability; SES

INTRODUCTION

In virtually all of human's waking moments, a multitude of stimuli compete for their attention. As individuals cannot continuously process the full amount of information they are surrounded by, some information is filtered out, whereas other information has a processing advantage. A general principle in attention research postulates that particularly goal-relevant stimuli quickly catch people's attention (e.g., Vogt, De Houwer, & Crombez, 2011). This has led some scholars to propose that our cognitive system should be particularly prone to detect and attend stimuli that are relevant for human survival (e.g., Öhmann, Flykt, Esteves, 2001) – in an almost hard-wired fashion. Following from this, as a sexually reproducing species, humans should be equipped with a cognitive apparatus to prioritize attention to potentially mating-relevant cues (e.g., Maner, Gailliot, & DeWall, 2007). Indeed, it is almost a cultural truism that erotic images capture attention and people „stare“ at images of attractive sexual partners without intentionally planning to do so. In the present research, we propose to systematically differentiate between visuospatial attention (the above-mentioned „staring“) and non-visuospatial attention (e.g., allocate cognitive resources). To this end, we will review the literature and discuss the available findings with regard to these two forms of attention. We will then present four experimental studies to empirically address this issue. In an exploratory fashion, we also will test whether and which of these processes are linked to sexuality-related individual differences.

Two forms of attention to sexual stimuli

Humans constantly have to decide which particular types of information in their social ecology “need to get noticed and analyzed in detail and which are downplayed and ignored” (Fox, Derakshan, & Standage, 2011; p. 16). Focusing one's attention thus means to prioritize the allocation of cognitive resources. These resources can take the form of sensory focus or working

memory capacity to cognitively process the information. In the following, we refer to the first kind of attention as *visuospatial attention*, specifically denoting the process of directing one's gaze to a certain spatial position, in our case: visually fixating sexually relevant information. Even in the absence of visuospatial attention, however, sexual content can bind cognitive resources and thus evoke a delay (e.g., longer reaction times [RT]) in consecutive information processing (e.g., Geer & Bellard, 1996; Geer, Judice, & Jackson, 1994). In lack of a well-formulated process theory, we will rely on the phenomenological description of *sexual content induced delay* (SCID) as introduced by Geer and colleagues to refer to the non-visuo-spatial attention. For both forms, we are interested in stimulus-driven control of attention, thus attention evoked by a class of certain stimuli (here sexual), rather than perceiver's goal-driven attention to certain stimuli. As such, we are predominantly interested in early and fast reactions to sexual stimuli in the absence of a concrete goal to process these. Although work on contingent capture phenomena has suggested that such presumably stimulus-driven processes are moderated by perceiver-driven goals to do so (e.g., Folk, Remington, & Johnston, 1992), other scholars have insisted that sexual images can attract attention, even if perceivers have an explicit goal for this effect not to show (e.g., financial incentivization; Most, Smith, Cooter, Levy, & Zald, 2007).

Visuospatial attention for sexually relevant stimuli

Although there are many theoretical reasons to presume a human tendency to watch and visually attend to potential sexual partners (e.g., Bailey, Gaulin, Agyei, & Gladue, 1994 for an evolutionary psychology-informed account) and there are some empirical pointers in this direction (e.g., Aquino & Arnell, 2007; Maner et al., 2007; Prause, Janssen, & Hetrick, 2008), additional scrutiny may help putting such claims in perspective. The current research on so-called "viewing time" effects may serve as an example from the recent literature: The effect that

people take longer to evaluate a person's sexual attractiveness when this target person belongs to a sexually preferred category is highly robust (Imhoff, Schmidt, Nordsiek, Luzar, Young, & Banse, 2010; Schmidt, Babchishin, & Lehmann, 2017; Welsch, Schmidt, Turner, & Rettenberger, 2018) and has frequently been attributed to a similar attentional mechanism (e.g., Kalmus & Beech, 2005). Recent research, however, has questioned this mechanism of attentional adhesion (Imhoff et al., 2010) and provided support for the notion that the alleged "viewing" times are indeed predominantly an artefact of the task at hand and, thus, are more exactly referred to as decision times (Imhoff, Schmidt, Weiß, Young, & Banse, 2012). To evaluate the sexual attractiveness of targets from non-preferred categories it is sufficient to detect a single mismatch (e.g., wrong age, wrong gender) to give a quick negative response, whereas in case of targets for a sexually preferred category, respondents need to confirm adequate age and adequate gender before they can actually evaluate the individual features to evaluate attractiveness.

Eye-tracking studies, however, focus on the position of eye gaze and are thus a relatively pure measure of visuospatial attention. Such studies show evidence in support of the notion that sexually relevant stimuli are visually attended to (e.g., Fromberger et al., 2012). Most eye-tracking studies, however, tap into relatively deliberate and controlled oculomotoric processes by summing up gaze time and number of fixations over a considerable time span, way beyond what one would call automatic (e.g., Lykins, Meana, & Kambe, 2006; but see Oberlader, Ettinger, Banse, & Schmidt, 2017 for very early oculomotoric processing). In terms of response latencies, this limitation also applies to first fixations in paradigms presenting two stimuli concurrently (e.g., Fromberger et al., 2013; Vázquez-Amézquita et al., 2019). As such, it is not clear whether these processes are actually stimulus-driven or the result of deliberate goal-driven decisions on side of the participants.

There are, however, tasks that unambiguously tap into stimulus-driven visuospatial attention, as they equip participants with a task-goal for which the sexual content of the distracting cues is irrelevant. In a typical dot probe trial, two allegedly irrelevant cues compete for attention at opposite screen locations before a to-be-identified (or -located) target stimulus appears at either one of these locations. Faster and more accurate responding if the target appears at the location of one class of cues (e.g., sexual stimuli) is thus attributable to visuospatial attention and not explainable by SCID (which would create slightly longer RTs on every trial that involved an erotic image, independent of target location). Although there are initial findings that men (but not women) exhibit a visuospatial attentional bias for erotic depictions of their preferred gender (Snowden, Curl, Jobbins, Lavington, & Gray, 2016), these effects are generally very small (Kagerer, Wehrum, Klucken, Walter, Vaitl, Stark, 2014) and qualified by a host of (partially unpublished) findings showing no such bias in healthy participants (e.g., Mechelsmann et al., 2014; Nemetschek, 2013; Seehus, 2015) or even in the reverse direction (Prause et al., 2008). The study by Prause and colleagues (2008) is also interesting in another regard: Although not interpreted in this way by the authors, they report generally longer RTs for trials, which involved at least one sexual image, a finding very much in line with the above-mentioned SCID phenomenon (a similar finding of general slowing in trials with sexual stimuli has also been reported by Brauer, van Leeuwen, Janssen, Newhouse, Heiman, & Laan, 2012).

Being distracted without necessarily watching: Sexual Content Induced Delay (SCID)

Other experimental paradigms consistently show stimulus-driven attentional priority to sexually relevant stimuli even when visuospatial attention can be ruled out as an explanatory mechanism. For instance, in rapid serial visual presentation (RSVP) paradigms a computer typically displays a continuous stream of stimuli, including a target stimulus which has to be

categorized (e.g., Arnell, Killman, & Fijavz, 2007; Most et al. 2007) or remembered (e.g., Anderson, 2005). Importantly, when this target stimulus is preceded by a sexually relevant stimulus (with a certain lag), performance on the primary (non-sexual) task is impaired, an effect labelled “attentional blink”. Sexual content is more potent to induce this effect than other positive, negative, or even highly threatening stimuli (Arnell et al., 2007). Similarly, sexual (as opposed to other emotionally-relevant) words led to slower classification of the parity of directly aligned signs (Aquino & Arnell, 2007). As another example, the extent to which participants were subjectively aroused in response to sexually relevant but task-irrelevant material corresponded almost perfectly with their delay in responding to auditorily presented non-sexual task-relevant stimuli (Koukounas & Over, 1999).

Other effects may rest on visuospatial attention but maybe also be driven by SCID. For instance, the Choice Reaction Task (CRT; Wright & Adams, 1994) presents images varying in sexual relevance (men vs. women; nude vs. clothed) and respondents have to identify the location of a White dot superimposed on the image. Respondents typically take longer for this location task if presented images are sexually relevant to them and this may be because their visuospatial attention is captured by the image (rather than the to-be-detected dot). Alternatively, however, the image might just produce a SCID effect in responding, independent of visuospatial attention.

What exactly underlies SCID effects, why would a sexual stimulus delay consecutive responding to an unrelated task? To the largest extent, the available literature has asserted that an understanding “of what mechanisms are at work in SCID still is necessary” (Geer & Bellard, 1996; p. 393) and in fact, “the underlying mechanisms are unclear” (Geer & Melton, 1997, p. 296). There have been, however, speculations that the observed hesitancy is attributable to

regulation processes of the sexual response and specifically tap into inhibitory tendencies (e.g., Dewitte, 2016). This reasoning builds on the idea that in the regulation of sexual responses, a behavioral activation system is typically accompanied by inhibitory control (e.g., Spiering, Everaerd, & Laan, 2004). In this logic, women show greater SCID effects than men, because it was evolutionary adaptive for them to inhibit sexual responses in response to low quality mating partners (Both, Everaerd, & Laan, 2003). A similar reasoning underlies the idea that the SCID effect results from the anxiety to make an error as “sexual material has the potential for evoking embarrassing or disturbingly inappropriate responses” (Geer & Melton, 1997; p. 311). Here, also, the delay in responding is the result of a form of inhibitory control.

While this is generally conceivable, there is currently little evidence that strongly supports these claims. Alternatively, SCID may be conceived of as an attentional phenomenon whereby sexual stimuli occupy attentional resources. One might speculate that due to the highly rewarding potential of the stimuli (plus their relevance for potential later social interactions), SCID is a byproduct of making “headroom” for further appraisal of the stimulus in terms of its mating-relevance (and thus side-tracking all other tasks). This, however, would allow the prediction that men and women show this effect equally (as reported by Spiering et al., 2004). This explanation also deviates from the above-cited with regards to individual differences that should be associated with the SCID effect. From a perspective of the dual control model of sexual response (Bancroft & Janssen, 2000) the former explanation of SCID effects would associate it with sexual inhibition. The latter reasoning, however, would predict that particularly people who are easily aroused by sexual stimuli and easily attracted to sexual opportunities should show a SCID effect (as this may be one mediating mechanism). Translating this to sexuality scales would predict an association with high sex drive or – in the language of the dual control model – sexual

excitation (rather than inhibition; Janssen, Vorst, Finn, & Bancroft, 2002). We included sex-related measures in all studies to explore these two possibilities.

Disentangling SCID from visuospatial attention

In the present research we sought to directly test the evidence for visuospatial attention and SCID in response to sexually relevant stimuli by employing a task somewhat reminiscent of the dot probe paradigm, the Modified Spatial Cueing task (MSCT; Fox, Russo, Bowles, & Dutton, 2001). In a typical MSCT setup, three boxes are horizontally aligned on the screen (left, center, right). An initial fixation cross in the center sets participants' attention to a neutral starting point at the beginning of each trial, which is followed by a task-irrelevant cue trial in a box on either side of the screen. Again, shortly thereafter (for the relevance of stimulus-onset asynchrony see below) the task-relevant target stimulus appears either in the same (validly cued) or the opposite box (invalidly cued). Participants indicate by a key press either the location or shape of the target stimulus (for a critical discussion of such location or identification tasks see Imhoff, Lange, & Germar, 2018). Although the cue is not relevant for the primary task, responses tend to be faster and more accurate for validly (vs. invalidly) cued trials. This difference is commonly attributed to the visuospatial attention to the cue and – at least in theory – the task can distinguish processes of quick visuospatial attentional switching (or engagement with a stimulus; fast responses on valid trials) from a bias to keep the stimulus in view (reduced disengagement from the stimulus; slow responses on invalid trials). However, validly cued trials are in fact often undiagnostically fast, so that most evidence in the literature shows effects of delayed visuospatial attentional disengagement rather than orienting. Importantly, within the same experimental setup, MSCT tasks also allow a test of SCID processes via main effects of cue stimuli (see below).

Stimulus onset asynchrony and inhibition of return. There is an exception to this principle as a function of the time span between appearance of the cue and appearance of the target stimulus (i.e., stimulus onset asynchrony; SOA). If this time is longer than 1000ms, this typically yields inhibition of return (IOR) effects: Participants orient their visuospatial attention to the cue but after a certain time (e.g., ~ 950ms) turn it toward the other location. If the target stimulus appears there now, it can quickly be identified whereas if it appears at the initially attended location, responses are delayed. This IOR effect leads to a typical pattern of longer responses for validly cued than invalidly cued trials, an aspect we will come back to in discussing our present research.

What makes the MSCT well-suited to explore the role of visuospatial attention is the fact that there are – as alluded to above – effective ways to isolate SCID-like effects of general response slowing due to certain stimuli (e.g., threatening stimuli; Mogg, Holmes, Garner, & Bradley, 2008) from visuospatial attention. Based on the criticism that – if validly cued trials are undiagnostically fast – longer RTs on invalid trials can be due to visuospatial attentional capture or general response slowing, Mogg and colleagues (2008) proposed to include a central cue condition. Presenting all stimuli in the center of the screen should allow an estimation of the general slowing due to a stimulus. Accordingly, including central cues allows a calculation of the overall slowing produced by a particular type of stimuli (Fox, Derakshan, & Standage, 2011).

Utilizing such a Modified Spatial Cueing Task to better understand attention to sexual stimuli allows several insights. If people exhibit visuospatial orienting towards sexual (compared to neutral stimuli), we would expect faster responses for validly cued trials with sexual cues than neutral cues and slower responses for invalidly cued trials with sexual (compared to neutral) cues

in paradigms with short SOAs. Furthermore, this effect should be relatively independent of cue display duration.

If, however, people show a reduced disengagement of visuospatial attention (more or less deliberate continuation of watching sexual cues), we would expect longer latencies for sexual vs. neutral cues for invalidly cued trials but not faster responses on validly cued trials. In addition, these effects might be particularly pronounced for long SOAs (due to the IOR explained above). If people engage in reduced visuospatial attentional disengagement from sexual stimuli, they might not disengage their attention from initially attended locations if a sexual cue appeared there. This would effectively attenuate an IOR effect. Another indication for a reduced disengagement might come from a change in protocol. If (as regularly done in attentional cueing research) the cue is only briefly displayed for 150ms, disengagement effects should be diminished.

Finally, there is the possibility of a SCID effect. As argued above, it is conceivable that many findings on the distracting nature of sexual stimuli are not actually driven by visuospatial attention but brief internal (distracting) processes triggered by sexual stimuli. Although in the existing literature on the SCID phenomenon explications of its exact nature are theoretically weakly developed, such processes are in principle observable in spatial cueing paradigms. To address the possibility that sexual cues slow down responding without actually capturing visuospatial attention we included centrally cued trials. If sexual cues also delay responding on centrally cued trials, this delay cannot be caused by visuospatial attention. To merge this condition randomly with others, however, we kept the identification task constant (at the periphery) as suggested by Fox and colleagues (2011). It might thus be argued that shifting visuospatial attention from the center of the screen to either of the two sides might also cause

delayed responding due to the necessary visuospatial attention shift. While this is a possibility, this shift is smaller than the one from the opposite side of the screen and the delay should thus be smaller than for invalidly cued trials¹.

The present research

Testing three variants of cue display duration (between-subjects), two different SOA lengths (within-subjects), differences between men and women, and correlational associations with measures of sex drive were examined in the present set of studies. Specifically, Studies 1a/b were planned as direct replication attempts to bolster MSCT reliability utilizing samples of heterosexual men. To eliminate alternative explanations based on (subtle) spatial distances between cue and target location, Study 2 extended these findings by including women and presenting the target *on* the (valid) cue instead of directly adjacent to it. Study 3 utilized a standard MSCT paradigm with only brief cue displays before the target appeared. This would effectively rule out visuospatial attention effects as defined above but would allow attentional orienting and SCID to show. In all studies, we included sexuality related scales for exploratory reasons.

We report all data exclusions, all manipulations, and all measures in the studies. The presented four studies were conducted in the order presented here. We conducted one additional study that tested a new hypothesis that evolved during the research process but needs further replication before being strongly interpreted and thus will be part of another project. All experimental scripts, anonymized data (deleted), and analysis codes are available at

¹ As one analytic strategy one can subtract the latencies for centrally cued trials from the ones for validly and invalidly cued trials. Invalidly cued trials should then be positive (more delay than centrally cued trials) and validly cued trial should be negative (less delay than centrally cued trials). Such analyses were conducted for all studies, but for reasons of brevity and as they provide little additional information we do not report them in full detail here, but on the OSF project page.

<https://osf.io/6uqyv>. Stimulus materials cannot be shared openly as they might fall under copyright protection.

Study 1a

METHOD

Participants. A sample of 55 German speaking men were recruited on campus at the University of Bonn. Participants were informed that the experiment would include sexual imagery and take measures of their sexual interests. Consent was obtained prior to the experiment, in which the participants were informed about the collection and storage of data in an anonymised form as well as their right to withdraw from the experiment at any time without consequence. Participants received no compensation for their participation. As the stimuli in this study exclusively portrayed women, we restricted our sample to heterosexual men. Participants positioned their sexual orientation (explicitly referring not only to previous behaviour but also fantasies) on a scale from 0 (exclusively heterosexual) to 6 (exclusively homosexual) with the addition of a response option to indicate complete lack of sexual desire and contact (Kinsey, Pomeroy & Martin, 1948; Kinsey, Pomeroy, Martins, & Gebhard, 1953). Five participants who indicated moderate to strong homosexual tendencies, or asexuality by indicating a score higher than three were excluded. The final sample in this study consisted of $N = 50$ predominantly heterosexual men (Kinsey scale, $M = .24$, $SD = .52$) aged between 18 and 47 years ($M = 25.98$, $SD = 5.52$).

Design. The study was programmed and run using Inquisit 3. The main measure used in this study was a Spatial Cueing task (Posner, Snyder & Davidson, 1980; Fox et al., 2001) that was modified with the addition of central trials. In this paradigm, the primary task is to identify a neutral stimulus (“*u*” or “*n*”) as probe targets by pressing the respective button on the keyboard

as quickly as possible. These characters were used as they differ only with in their vertical orientation in both a visual sense and their location on a standard keyboard, making position matching interferences unlikely. On any given trial the location of the probe target would appear randomly on either the left or the right side of the screen. However, prior to the probe targets appearance a sexual or non-sexual stimulus appeared on the screen, either on the same side of the screen and just beside where the probe was to appear (valid cue), at the opposite side (invalid cue) or in the centre of the screen (central cue, always invalid). Participants were instructed to ignore these stimuli and focus solely on the quick and accurate identification of the probe. The short period of time between appearance of the cue and the probe target, referred to as the stimulus onset asynchrony (SOA), was also varied between 250ms and 1000ms for different trials. Until a response was given to the probe target the cue remained visible on screen (Figure 1). The complete within-subjects design included 20 trials per each condition resulting from a 3 (cue validity: valid, invalid or central) by 2 (SOA: 250ms or 1000ms) by 2 (cue content: sexual vs. neutral) by 2 (target position: left vs. right), adding up to 480 trials in total. Half of these 480 trials had a “n” as target, whereas in the other half it was an “u”, pairing of these with specific trials was counterbalanced between participants.

Stimuli. The cues consisted of forty sexual stimuli depicting semi- or fully nude young attractive women, and forty non-sexual stimuli composed of images of fully clothed elderly women. Stimuli were collected from web resources for this experiment by a group of five research assistants who picked them from a larger number of stimuli by consensual agreement among themselves and two of the authors (see Figure 2 for examples). To validate this selection, 49 heterosexual men ($M_{\text{age}} = 29.45$) recruited via MTurk rated these images on a scale from 1 (not sexually attractive at all) to 10 (very sexually attractive). On average, the sexual stimuli

were rated as clearly more sexually attractive, $M = 6.14$, $SD = 1.94$, than the non-sexual stimuli, $M = 1.11$, $SD = 0.41$, $t(48) = 17.18$, $p < .001$, Cohen's $d_z = 2.45^2$.

Scales. For exploratory purposes, we included several sexuality-related scales to allow further exploration of the data. Different scales tapping into the related constructs sexual desire, sexual preoccupation, and sexual excitation were included to explore whether sex drive in heterosexual men is associated with a) automatic attention orientation towards sexual stimuli, b) deliberately prolonged attentional engagement with sexual stimuli, or c) the extent to which they show SCID.

Total Sexual Outlets (TSO). The number of total sexual outlets (TSO) was recorded to measure the frequency of sexual behavior that resulted in orgasm. Two measures were used for this purpose, one inquired about the average number of orgasms achieved per week in the last six months (TSO1) and the second asked the maximum amount of achieved orgasms per week since the age of 15 (TSO2). Values above 40 were removed as visual inspection of the distribution showed a clear discontinuity at this value. Unexpectedly, these two items were not significantly correlated, $r = .163$. As this was unexpected and we merely had included them on an exploratory base, we continued to average the two items as an indicator of orgasm frequency.

Sexual drive. In order to measure the intensity of sexual desire the Sexual Drive Inventory-2 (SDI-2; Spector, Carey & Steinberg, 1996) was added. This scale consists of 14 items measuring both partner-related (dyadic) and solitary (autoerotic) sexual desire. It has a number of

² Sexual and neutral stimuli did not differ in contrast, $t(78) = 0.84$, $p = .399$, but sexual stimuli were overall brighter $M = 181.40$, $SD = 32.16$, than neutral stimuli, $M = 153.19$, $SD = 38.62$, $t(78) = -3.55$, $p = .001$. To control for this we included brightness as an additional factor in the omnibus ANOVAs of Studies 1a and 1b (by splitting each stimulus category in two halves of brighter vs. less bright stimuli). The main effect of sexual content remained intact in both studies (Study 1a: $F(1,49) = 47.97$, $\eta_p^2 = .50$, $p < .001$; Study 1b: $F(1,92) = 112.49$, $\eta_p^2 = .55$, $p < .001$), but there was no main effect of brightness (Study 1a: $F(1,49) = 0.64$, $\eta_p^2 = .01$, $p = .430$; Study 1b: $F(1,92) = 0.20$, $\eta_p^2 = .00$, $p = .657$). We also calculated an individual index of a brightness-induced delay to correlate it with the measured scales. There was neither a correlation with SES (Study 1a – SOA 250: $r = .14$, $p = .319$; Study 1a – SOA 1000: $r = -.15$, $p = .295$; Study 1b – SOA 250: $r = .00$, $p = .971$; Study 1b – SOA 1000: $r = .01$, $p = .914$), nor with any other measured scale (all $ps > .05$).

items measuring the frequency of sexual thoughts in these two situations. Respondents indicated how often they had these desires on an eight-point Likert scale, ranging from 0 (not at all) to 7 (more than once a day). An example item would be, “During the past several months, how often would you have liked to have engaged in sexual activity with another person (for example, touching each other’s genitals, giving or receiving oral stimulation, sexual intercourse, etc.)?”. It also includes items to measure the intensity of these sexual desires using a nine-point Likert scale from 0 (no desire) to 8 (strong desire). For instance, asking “How strong is your desire to engage in sexual behavior by yourself?”. An overall score was generated by summing across items that measure dyadic and autoerotic desires separately, resulting in two SDI scores. For both scores higher values indicated higher levels of dyadic, $\alpha = .75$, and autoerotic desire, $\alpha = .84$, respectively.

Sexual inhibition and excitation. The Sexual Inhibition/Sexual Excitation (SIS/SES) Scales for men (Janssen et al., 2002) was implemented to measure both sexual excitatory and inhibitory aspects of sexual control theorized to underlie sexual response and behaviors. The questionnaire is comprised of 45 items divided in 20 items measuring Sexual Inhibition due to threat of performance failure (SIS1), 14 items measuring Sexual Inhibition due to the threat of performance consequences (SIS2), and eleven items for Sexual Excitation (SES). Examples of items are respectively “If I am concerned about pleasing my partner sexually, I easily lose my erection”, and “When I think of a very attractive person, I easily become sexually aroused”. All items were measured on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). Two items were reverse coded as appropriate after which, all scores were summed and averaged for each factor to create three distinct scores (SIS1: $\alpha = .81$, SIS2: $\alpha = .79$, SES: $\alpha = .82$) with higher scores indicating higher levels of sexual inhibition and excitation.

Sexual Preoccupation. To tap into the individual amount of absorption with sexual thoughts, five items (e.g., “I think about sex more than anything else”) of sexual preoccupation were taken from the Sexuality Scale developed by Snell and Papini (1989), $\alpha = .90$. These were completed on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) and were embedded in fifteen purpose-designed items developed for exploratory purposes. For reasons of brevity, we will not further delve into these items and their factor structure but full analyses are available on the OSF page.

Trait self-control. Participants also completed the ten-item Trait self-control (TSC) scale from the German Self-Regulatory Skills Questionnaire (Imhoff, Schmidt, & Gerstenberg, 2014). Items like “I usually think carefully before doing anything” were completed on the same 5-point Likert scale ranging from “strongly disagree” to “strongly agree” and averaged to form a reliable index of effortful self-control, $\alpha = .77$.

Data treatment. Response times (RTs) were removed for erroneous trials (4.9%) and truncated by removing latencies under 200ms (0.6%) and above the Tukey criterion (third quartile of RT plus 1.5 x interquartile range; 1053ms, 5.3%) for the right tail of the distribution. The following difference scores were calculated in an effort to gain individual differences in responding that were not contaminated by general reaction speed: For both SOAs and cue type separately we subtracted response times for valid trials from RTs for invalid trials (validity difference scores). Higher scores indicate visuospatial attention to these cues for short SOAs and a weaker IOR for long SOAs. These can only be specific for sexual cues when this effect is larger for sexual than neutral cues. We therefore created double difference scores by subtracting the validity difference score for neutral cues from that for sexual cues (sexual attention score). Higher scores on this measure indicate the extent to which sexual cues are more potent to attract

(short SOA) and hold (long SOA) attention than neutral cues. To assess individual differences in the degree to which sexual stimuli are distracting in the non-visuospatial sense but in the sense of SCID, we subtracted all averaged latencies for neutral trials from all averaged latencies for sexual trials (SCID score).

Procedure. Upon arrival participants were sat in front of a computer in a laboratory setting. Before the main body of the experiment, participants were asked for their informed consent to the use of the resulting data and general willingness to participate. Following this, they completed the scales described above. The main task was then explained in detail including six practice trials to allow participants to get properly acquainted with the procedure before the main task started. The main batch of 480 trials followed after participants indicated they understood the procedure and had no further questions. Upon completion of this main task participants were presented a potentially sexually stimulating video³ before being asked to indicate their age, gender, and their sexual orientation on the Kinsey scale. Finally, they were debriefed and thanked for their participation.

RESULTS

In the omnibus 3 (cue validity) x 2 (cue content) x 2 (SOA) factorial repeated measures ANOVA⁴ support for both visuospatial attention orienting and adhesion would translate to a significant three-way interaction of all factors, whereas a SCID effect would create a main effect of cue content. Although both these effects (as well as others, see Table osm.1) were significant,

³ This video of a woman performing a sexual striptease was originally included to have a behavioral measure of sexual motivation. As participants were told they were not required to watch the whole video and could continue whenever they had seen enough we assumed that longer duration would indicate a greater motivation to get sexually aroused. Upon inspection of the results, however, it became apparent that virtually all participants had opted to watch the entire video, therefore offering almost no variability between participants.

⁴ Mauchly's test indicated violations of sphericity for the main effect of cue validity, $\chi^2(2) = 13.66$, $p = .001$, the interaction of cue validity with cue content, $\chi^2(2) = 8.34$, $p = .015$, as well as the interaction of cue validity with SOA, $\chi^2(2) = 32.41$, $p < .001$, that led to corrected degrees of freedom based on Greenhouse-Geisser estimates of sphericity; $\epsilon = .80$, $\epsilon = .67$, and $\epsilon = .86$ respectively.

this alone is non-informative regarding the assumed processes as interactions can rest on different patterns. We thus proceeded by analyzing short and long SOAs separately.

Short SOA (250 ms). As expected, invalid cues delayed responding and valid cues accelerated responding in comparison to central cues. Whereas this main effect of cue validity, $F(1.58, 77.40) = 302.33, p < .001, \eta^2 = .861^5$, is not indicative of any specific reactions to sexual content, the main effect of cue content, $F(1, 49) = 43.57, p < .001, \eta^2 = .471$, indicated overall longer RTs if the task-irrelevant cue was of sexual nature. This effect can only be interpreted as clear evidence of a SCID effect, however, if the delay due to sexual imagery was equally large at all cue locations. This, however, was not the case as indicated by an interaction of cue validity and cue content, $F(2, 98) = 16.985, p < .001, \eta^2 = .257$. Contrary to the notion that sexual images capture visuospatial attention (and might therefore evoke shorter RTs as valid cues and longer RTs as invalid cues), valid sexual cues delayed responding compared to valid neutral cues to a greater extent than invalid sexual cues compared to neutral invalid cues, $F(1, 49) = 6.078, p = .017, \eta^2 = .110$. In general, the effect of cue content was greatest for central cues and this was also significantly greater than for invalid cues, $F(1, 49) = 39.641, p < .001, \eta^2 = .447$ (Figure 3).

Long SOA (1000ms). In combination with the descriptive means the significant effect of cue validity⁶, $F(1.38, 67.52) = 6.12, p = .009, \eta^2 = .111$, suggested an IOR effect: Validly cued trials evoked on average longer RTs than invalidly cue trials (Figure 1). More meaningful in the current context, sexual images again led to longer RTs than neutral images, $F(1, 49) = 24.75, p < .001, \eta^2 = .336$. Dissecting the significant interaction of cue validity and cue content, $F(2, 98) = 14.13, p < .001, \eta^2 = .224$, revealed an IOR effect for neutral stimuli, (mean difference =

⁵ Greenhouse-Geisser corrected degrees of freedom, $\epsilon = .79$, due to violation of sphericity assumption for cue validity, $\chi^2(2) = 14.86, p = .001$.

⁶ Greenhouse-Geisser corrected degrees of freedom, $\epsilon = .689$, due to violation of sphericity assumption for cue validity, $\chi^2(2) = 28.81, p < .001$.

30.68ms, $SE = 7.71$, $p < .001$, $d_z = .563$), but not for sexual stimuli, (mean difference = 6.28ms, $SE = 7.32$, $p = .395$, $d_z = .121$). Such IOR effects are typically produced because at some point participants disengage their visuospatial attention from the cue and switch to the other side (where the target will appear in invalid trials). The fact that the effect of cue content (larger RTs for sexual than for neutral cues) was larger for invalidly cued trials than either validly cued trials, $F(1, 49) = 14.38$, $p < .001$, $\eta^2 = .227$, or centrally cued trials, $F(1, 49) = 28.501$, $p < .001$, $\eta^2 = .368$, suggests that the sexual nature of cues prevented participants from showing this disengagement, effectively speaking for visuospatial attentional adhesion to sexual stimuli in case of long SOAs (Figure 3).

Correlational analyses. In order to investigate the associations between the various latency scores and the sexual measures in an exploratory fashion, intercorrelations were calculated (Table 1). Although the sample size falls short of allowing robust estimations of correlations, two coefficients seem noteworthy as they suggest differential effects in the MSCT patterns as a function of a self-reported variable: Participants with high scores in sexual excitability (SES) showed particularly pronounced SCID scores under short SOAs and particularly slow disengagement from sexual stimuli under long SOAs.

DISCUSSION

Study 1 provides first indications for two potential processes: visuospatial attentional adhesion and SCID-like processes. The first of these is likely to underlie the fact that under long SOA conditions participants were faster to respond after invalid than valid trials if the cues were neutral but failed to show this effect if the cues were sexual. In other words, they switched visuospatial attention to the opposite side of the screen if the cue was neutral but continuously engaged their attention with sexual stimuli. When SOAs were short, we observed an unexpected

interaction and a main effect of cue content: On average participants always took longer if the cue was sexual in nature. We did not observe any “typical” attentional cueing effect in that – under short SOAs – emotionally relevant, arousing cues led to more pronounced effects of cue validity (due to longer reactions to invalid cues, shorter reaction to valid cues or both). Although we observed a common cue validity effect and an interaction of cue validity with cue content, the exact pattern of this interaction is opposite to expectations.

With regard to individual differences, we find that both experimental effects stressed above are particularly pronounced for men who describe themselves as easily sexually excitable. Given the fact that the observed correlations rested on comparably small number of cases (see Schönbrodt, & Perugini, 2013 for recent recommendations) and were in opposition to previous effects in the literature (Conaglen, 2004), we aimed at directly replicating the study with a larger sample.

Study 1b

Study 1b is essentially a direct replication of Study 1a with a larger sample to bolster the reliability of our initial findings.

METHOD

Participants. Participants were recruited on campus at the University of Cologne with the same information about the study and conditions of participation (including informed consent and anonymity). A total of 110 German-speaking men were recruited for a small compensation of four euros. A total of eight incomplete cases were identified and dropped from the dataset. Furthermore, nine participants scoring higher than “3” on the Kinsey scale were excluded from analysis for the same reasons as in study 1a. Consequently, $N = 93$ predominantly heterosexual

men (Kinsey scale; $M = 0.23$, $SD = 0.45$) aged between 17 and 43 years of age ($M = 24.46$, $SD = 4.34$) made up the final sample.

Stimuli, materials, and data treatment. The stimuli, materials, procedure, and data treatment (Errors, 5.8%; <200ms, 1.3%; Tukey 1024ms, 4.6%) were identical to Study 1a.

RESULTS

The omnibus ANOVA again yielded a main effect of cue content as well as the three-way interaction among other significant effects (details in Table 2). We again focus on separate analyses of short and long SOAs to provide a more comprehensible description of the data.

Short SOA (250ms). As in Study 1a, significant main effects of validity⁷, $F(1.79, 164.57) = 598.370$, $p < .001$, $\eta^2 = .867$, cue content, $F(1, 92) = 90.32$, $p < .001$, $\eta^2 = .495$, and their interaction, $F(2, 184) = 61.41$, $p < .001$, $\eta^2 = .400$, were found. Virtually identical to Study 1a, the pattern of means (Figure 2) was contrary to predictions of visuospatial attentional orienting toward sexual stimuli: Again, the delay produced by sexual content was largest for central cues, followed by valid cues, and was non-existent for invalid cues.

Long SOA (1000ms). In contrast to Study 1a, the data yielded no IOR effect, as valid cues did not provoke longer latencies than invalid cues, $F(1, 92) = .808$, $p = .371$, $\eta^2 = .009$. The overall main effect of cue validity⁸ in the ANOVA, $F(1.59, 146.15) = 5.814$, $p = .004$, $\eta^2 = .059$, was partially driven by the fact that – unexpectedly – central cues led to the longest reaction times. Mirroring Study 1a, sexual stimuli elicited longer response latencies than neutral stimuli, $F(1, 92) = 77.37$, $p < .001$, $\eta^2 = .457$, and this effect was again moderated by cue location, $F(2, 184) = 12.104$, $p < .001$, $\eta^2 = .116$. In line with expectations and speaking to visuospatial attentional dwelling on sexual stimuli, this difference was greatest for invalid cues (Figure 4),

⁷ Greenhouse-Geisser corrected, $\epsilon = .89$, due to significant Mauchly test, $\chi^2(2) = 11.43$, $p = .003$.

⁸ Greenhouse-Geisser corrected, $\epsilon = .79$, due to significant Mauchly test, $\chi^2(2) = 27.27$, $p < .001$.

and the response time advantage of valid compared to invalid cues for sexual stimuli, (mean difference = -13.02ms, $SE = 4.687$, $p = .007$, $d_z = -.288$), was fully absent for neutral stimuli, (mean difference = 5.81ms, $SE = 4.564$, $p = .206$, $d_z = .132$). Thus, participants only disengaged their visuospatial attention from the irrelevant cues (and thus showing an IOR effect) within the first second, if that cue was not sexual in nature. For sexual stimuli however, this again did not occur pointing towards visuospatial attentional adhesion to these stimuli and even produced a reversed effect.

Correlational analyses. As expected with a larger sample size, the number of significant correlations increased (Table 1b). As in the previous study and corroborating the formerly found associations, the SCID effect under short SOAs was associated with sexual excitability and sex drive, as was the same score for long SOAs. The Validity Difference Sexual Score for long SOAs showed a negative correlation with sexual inhibition (SIS-2), suggesting that men who described themselves as sexually inhibited showed particularly little attentional dwelling on sexual images.

DISCUSSION

The results of Study 1b largely confirmed our findings from Study 1a and thus bolster the reliability of both the evidence for visuospatial attentional adhesion (apparent in the long SOA condition) and the SCID phenomena. Although the sheer number of potential analytical strategies increases the complexity of data interpretation here, three bottom line conclusions are conceivable: First, independent of SOA and cue location, responses take longer for trials with sexual images than non-sexual images. We interpret this previously not well-documented effect as akin to the SCID effect. Second, if they have sufficient time, heterosexual men dwell on sexual images (as indicated by a lack of an IOR effect for sexual images under long SOA

conditions). Third, it is precisely this visuospatial dwelling that shows the most consistent correlations with indicators of high sex drive across both studies.

Despite these promising findings, the current studies also have some limitations. First, and most obviously, both samples rely on exclusively heterosexual men, a group overrepresented in much of sexual cognition research. The reasons for this are manifold. Heterosexual men typically produce clearer patterns/stronger effects of sexual preferences than heterosexual women (Chivers, 2017). Nevertheless, to further explore attention effects in sexual information processing in a more generalizable way, we included heterosexual women in the following two studies and changed the stimuli accordingly. We thus continued our research program by focusing on short SOA effects and testing both heterosexual men and women as participants.

Study 2

Study 2 was conducted to better understand the processes of visuospatial sexual orienting and SCID in a sample of heterosexual men and women. In addition to broadening our participant population and adapting the stimuli accordingly (see below), we also slightly altered the experimental procedure. In the first two studies, the cue picture always remained on the screen until a response was given and thus the target stimulus needed to be presented right next to the cue rather than at the same position as the cue. This may of course be seen as problematic as even in validly cued trials, participants had to shift their attention slightly from the cue to the directly adjacent target. It is thus conceivable that the fact that sexual stimuli delayed responding to the same extent irrespective of cue validity is in fact not speaking to the notion that we observed an (attention-independent) SCID, but that attention shifts cause the same delay independent of the actual distance they have to travel. In Study 2, we thus positioned the target

directly on the cue. To avoid perception problems due to reduced color contrasts, however, all cue stimuli were black and white pictures and the target stimuli were presented in red ink.

METHOD

Participants. Participants were recruited around the campus of the University of Cologne and informed about the sexual imagery and inquiries about sexuality as well as the right to withdraw without consequences, and the anonymized collection and storage of data. All participants provided their consent and received four Euros as compensation. One incomplete case was dropped from the analyses. Eleven participants who scored higher than “3” on the Kinsey scale were further excluded from analyses. The final sample consisted of $N = 163$ predominantly heterosexual participants (Kinsey scale; $M = 0.33$, $SD = .60$) aged between 17 and 53 years ($M = 23.90$, $SD = 6.12$) with 84 (52%) women.

Stimuli and Procedure. Stimuli in this study consisted of 80 black and white pictures purposefully selected from the internet. As previous research established that heterosexual women are more receptive to sexual activities than mere poses (Chivers, Seto, & Blanchard, 2007), we selected 40 sexual images that showed sexual interactions (cunnilingus, petting, intercourse; Figure 5 for examples) of a man and a woman, whereas the other 40 neutral images depicted a man and a woman in non-sexual interactions (e.g., cooking, playing chess, walking, skiing, brushing teeth; Figure 5 for examples). Twenty men and 21 women ($M_{age} = 26.59$) who did not participate in the main study rated these images on a scale from 1 (not sexually attractive at all) to 10 (very sexually attractive). As expected, the erotic scenes received higher ratings, $M = 5.85$, $SD = 1.84$, than the non-erotic scenes, $M = 1.55$, $SD = 0.60$, $t(40) = 17.12$, $p < .001$, $d_z = 2.71^9$.

⁹ As for the previous stimulus sets, there was no difference in contrast, $t(78) = 0.98$, $p = .330$, but in brightness, $t(78) = 4.63$, $p < .001$. Opposite to the stimuli used in Studies 1a and 1b, however, sexual stimuli were less bright, $M =$

The paradigm used was similar to the previous studies with the notable exception that the target probe now appeared on the cue position as opposed to slightly besides of it (see above for a detailed description of the alterations). In contrast to the previous studies, we dropped the long SOA trials and reduced the centrally cued trials by half (as these served as mere control trials) to shorten the overall duration of the study. Thus, the length of the SOA was set to 250ms in all trials with stimuli remaining on screen until a response was given. This design resulted in a 2 (participant gender) x 2 (cue content: sexual vs. neutral) x 3 (cue validity: valid vs. central vs. invalid) x 2 (target position: right vs. left) mixed-model ANOVA design with 20 trials per cue content by target position conditions for valid and invalid conditions, but only 10 for central cued trials. This resulted in a total of 200 trials.

Scales. To further reduce study length, we focused on those scales that showed the clearest patterns in the previous study thus only including the Kinsey scale, the sexual preoccupation measure, and the SIS/SES scales. As some phrases in the SIS/SES are gender specific, we used the SIS/SES version for women (Carpenter, Janssen, Graham, Vorst & Wicherts, 2008) for women.

Data treatment. As in the previous studies, latencies for erroneous responses (6.7%) were removed from the dataset and the remaining latencies were truncated under 200ms (0.5%) and above the Tukey criterion (1359 ms; 3.9%).

RESULTS

102.66, $SD = 43.78$, than neutral stimuli, $M = 143.88$, $SD = 35.37$. Entering brightness as a factor in the ANOVA again left the main effects of sexual content intact (Study 2: $F(1,159) = 62.03$ $\eta_p^2 = .28$, $p < .001$; Study 3: $F(1,91) = 4.23$ $\eta_p^2 = .04$, $p = .043$), but also yielded a main effect of brightness in Study 2, $F(1,159) = 20.79$ $\eta_p^2 = .12$, $p < .001$, but not Study 3, $F(1,91) = 0.25$ $\eta_p^2 = .00$, $p = .621$. An index of brightness-induced delay showed no correlation with SES (Study 2: $r = .05$, $p = .537$; Study 3: $r = .07$, $p = .485$), nor with any other measured scale (all $ps > .05$). The consistency of our findings concerning the SCID effect (despite opposite confounding of sexual content with brightness across studies) and the lack of correlation between scales and reactions to brightness speak against the notion that our finding might be resting on a spurious effect due to confounds with brightness.

As in the previous studies with short SOAs, invalid trials were overall slower than central trials which again were slower than valid trials, $F(1.78, 287.09) = 50.82, p < .001, \eta^2 = .240$.¹⁰ Also as in previous studies, sexual cues provoked longer latencies than neutral cues, $F(1, 161) = 66.06, p < .001, \eta^2 = .291$ (Figure 6). Again, speaking against visuospatial attention orienting as the underlying mechanism, this delay due to sexual cues was not greater for invalid trials or smaller for valid trials, as indicated by a non-significant interaction of the two factors, $F(1.89, 304.71) = .834, p = .43$.¹¹ As the interaction of cue validity and participant gender, $F(1.78, 287.09) = 8.21, p < .001, \eta^2 = .049$, indicated different patterns for men and women, we analyzed the latencies separately for men and women. These showed that the delay in responding due to sexual cues was comparably large in men, $F(1, 78) = 31.293, p < .001, \eta^2 = .286$, and women, $F(1, 83) = 34.96, p < .001, \eta^2 = .296$, but men showed greater cue validity effects, $F(1.81, 141.26) = 46.70, p < .001, \eta^2 = .374$, than women, $F(1.72, 142.58) = 10.39, p < .001, \eta^2 = .111$.

Correlational analyses. As in the previous two studies, the SCID-like effect was significantly associated with SES (Table 2). This association between the SCID index and SES was not significantly different for men and women, as indicated by the interaction of gender and SES to predict the SCID effect, $B = -13.88, SE = 15.14, p = .361$. Although significant correlations between the Validity Difference Sexual Score and a number of sexual self-report measures invited speculation, it is important to note that virtually identical correlations were obtained for the neutral validity difference score. There is thus no indication of specific attention to sexual stimuli as a function of sexual inhibition or preoccupation.

DISCUSSION

¹⁰ Greenhouse-Geisser corrected, $\epsilon = .89$, due to significant Mauchly test, $\chi^2(2) = 20.75, p < .001$.

¹¹ Greenhouse-Geisser corrected, $\epsilon = .95$, due to significant Mauchly test, $\chi^2(2) = 9.35, p = .009$.

Study 2 again did not support the notion of greater visuospatial attentional orienting toward sexual stimuli. Instead, we observed a tendency of generally slower responses if cues were of a sexual nature. This effect was reliable across men and women and is noteworthy for at least two reasons: First, it eliminates the possibility that the lack of differential cueing effects was due to participants not perceiving the sexual nature of the images (e.g., presented too small) or the images not being explicit (and therefore arousing) enough. Clearly, sexual cues had an influence, just not one on the typical indicator of visuospatial attention. Instead, this pattern is very well in line with the SCID effect – an admittedly unspecified delay in responding due to sexual stimuli. Sexual stimuli thus seem to trigger internal processes that may be distracting or attention-costly rather than specifically capturing visuospatial attention.

This interpretation is supported by the data but there is one loophole in the argument. To enhance processing of the sexual stimuli, we always kept the cue stimuli on display until a response was given. It is thus conceivable that participants did indeed merely watch the image longer, also when the target stimulus appeared right on top of it. Although one would probably still expect at least somewhat longer delays if the target then appeared on the opposite side of the screen, we cannot fully rule out that the delay was still due to visuospatial attention to the sexual stimuli. We also stress the fact that our implemented designs so far deviated from prototypical protocols of spatial cueing tasks. In classical studies, the cue is presented for only a brief time (100ms or 250ms in Fox et al., 2001; 150ms in Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008) and taken away before the target stimulus appears. We had deliberately chosen to keep it on the screen to make sure that participants had a chance to recognize the comparatively complex cue stimuli, also in light of the previous suggestions that “a longer presentation time may be important” (Fox et al., 2001; p. 696) to detect cue-specific individual

differences in attentional processing. Nevertheless, we decided to closely follow a previously employed protocol in Study 3 to provide a stricter test of the attentional orienting hypothesis.

Study 3

We conducted an additional study utilizing the same images as in Study 2 but with a slightly adapted protocol, closely following the one used by Vogt and colleagues (2008). As before, an effect of visuospatial attention orienting toward sexual stimuli should become apparent in an interaction of cue validity and cue content, whereas a sheer main effect of cue content would speak to a SCID effect.

METHOD

Participants. A sample of 103 German speaking students were recruited on campus in Cologne. The sexual nature of the study was conveyed during recruiting and was repeated in the consent form presented prior to the experiment with additional information on data security and participant rights. Four euros were awarded as compensation for participation in the study. Ten participants scored higher than “3” on the Kinsey scale and were therefore excluded. The final sample was composed of $N = 93$ heterosexual participants ($M = .44$, $SD = .67$) aged between 17 and 43 years ($M = 23.62$, $SD = 4.50$) and included 48 (52%) women.

Stimuli and Materials. All stimuli materials and the procedure were identical to that used in Study 2. The protocol of the paradigm was also identical to the one used in Study 2 with one minor adjustment: The SOA was reduced to only 150ms and stimuli disappeared from the screen as soon as the probe appeared. In addition, the protocol now included interim trials after each quarter of the main trial block, offering a guide as to how many trials were left for the participants and to give them a short break.

Data treatment. As in previous studies, we removed erroneous responses (7.9%) as well as latencies under 200ms (1.1%) and above the Tukey criterion (1062ms; 2.2%).

RESULTS

Similar to all previous studies and in line with the general logic of cueing paradigms, there was an increase in response time from valid via central to invalid trials, $F(1.29, 117.22) = 92.88$, $p < .001$, $\eta^2 = .505$.¹² Replicating our previous studies, sexual cues yielded longer latencies than neutral cues, $F(1, 91) = 4.33$, $p = .04$, $\eta^2 = .045$, even if this effect was notably smaller than in previous studies. Importantly, however, the critical interaction term again failed to reach significance, $F(2, 182) = 1.10$, $p = .334$. Overall, men were faster than women, $F(1, 91) = 5.61$, $p = .02$, $\eta^2 = .058$, but gender did not interact with any of the other factors (Figure 7).

Correlational analyses. As in all previous studies, the only significant correlations between MSCT scores and self-report scales revealed that participants with high scores on sex drive and SES showed a more pronounced SCID-effect (Table 3). This was more pronounced for men, $r(48) = .377$, $p = .008$, than women, $r(45) = .148$, $p = .332$, but the interaction term of gender and SES on SCID probing this difference failed to reach conventional levels of significance, $B = -15.65$, $SE = 7.89$, $p = .051$.

DISCUSSION

Study 3 again provided support for the general delay due to sexual stimuli, but no support for a differential effect of cue content contingent on cue validity. This and the previous studies thus converge in establishing support for a non-specific SCID in the absence of visual attention effects for short SOAs.

General Discussion

¹² Greenhouse-Geisser corrected, $\epsilon = .64$, due to significant Mauchly test, $\chi^2(2) = 72.41$, $p < .001$.

Across several variations of a Modified Spatial Cueing paradigm, including different SOAs, different stimuli, and men and women, three main findings can be summarized: First, we find no evidence for an automatic visuospatial attention orienting to sexual stimuli. Second, in trials with long SOAs, reduced IOR effects for sexual stimuli indicate processes of attentional dwelling or reduced disengagement from sexual stimuli. Third, across three procedural realizations of the MSCT, across men and women, and across different stimuli we consistently find support of a SCID-like effect: a response slowing after presenting sexual stimuli independent of visuospatial cueing. Somewhat surprisingly, an indicator of this slowing shows noteworthy robust correlations with self-reported sexual excitability and sex drive.

What concrete implications do these findings have now? First, we would argue that currently there is no sufficiently convincing evidence that humans have an automatic tendency to attend to sexual stimuli. Many previous findings utilizing allegedly “visuospatial attention” paradigms (e.g., attentional blink, choice reaction time) are well compatible with other forms of attention than visuospatial (i.e., cognitive distraction). This cognitive distraction is what we termed a SCID-like effect in the present paper. One notable exception that is clearly not just based on cognitive distraction but has an automatic visuospatial component is the Cued Pro- and Antisaccade Paradigm (CPAP; Oberlader et al., 2017). In this paradigm, men (but not women) were faster to follow the instruction to execute a prosaccade to a sexually preferred target. However, while latencies faster than 200ms suggested that this interference rests on an automatic, not deliberately controlled process, one important difference to our current approach is that these prosaccades were not spontaneous, i.e., participants were not free to direct their visuospatial attention wherever they felt. Strikingly, the corresponding difference measure in Oberlader et al. (2017) indicating sexual-relevance of stimulus categories was also positively

associated with a self-reported sex drive measure ($r = .29, p < .03$). Future research might enhance a better understanding on this differentiation between prompted and unprompted automatic processes.

Other eye-Tracking paradigms than the CPAP typically measure spontaneous viewing behavior in terms of (uncued first) fixation latencies that cannot be considered very automatic in the sense of early information processing (e.g., Fromberger et al., 2012; Fromberger et al., 2013). The total amount of fixation and dwelling time over a course of several seconds may be better comparable to attentional dwelling, a deliberate and non-automatic dedication of visual attention to erotically pleasing material. In trials with long asynchronies between cue onset and the appearance of the target (Studies 1 and 2), participants engaged in such attentional dwelling on sexual images to the extent that they did not show the typical IOR effect expected for such long latencies and observed for non-sexual stimuli. Taken together, these findings suggest that people willfully and deliberately dedicate their visuospatial attention to sexual images, and that this happens to a greater extent if they describe themselves as high in sex drive and SES as well as low in sexual inhibition (although not all of the correlations are significant at $p < .01$, the pattern of direction is highly consistent).

Most consistently across all studies, we find what we labelled a SCID effect, a cognitive distraction that is not attributable to visuospatial attentional binding and generalizes to men and women equally (for similar delayed responding to sexually relevant targets in a mouse-tracking paradigm see Bartels, Lister, Imhoff, & Banse, 2019). In fact, in contrast to gender differences in many other domains of sex research (e.g., Baumeister, 2000; Chivers et al., 2007 ; Imhoff, Bergmann, Banse, & Schmidt, 2013), we have no evidence that men and women react differently in this regard. Our results consistently point to a correlation between SCID and sexual excitation

for both men and women. This may speak to the notion that SCID is a by-product of sexual approach motivation and preparation. Independent of whether this speculation has some validity, gaining a better understanding of SCID effects is an important task for future research.

Limitations and Outlook

Despite an internally consistent pattern of results, the present research has several limitations. For one, the absence of evidence for attentional orienting effects should not be confused with evidence for absence. We can thus not be reasonably confident that such effects do not exist but merely that we did not find any significant effects in support of them. This may be partially attributable to the fact that for the first three studies we deviated from standard procedures in typical cueing paradigms. This was partially based on the rationale (and according recommendation) to increase the display time of the comparatively small cue image while keeping the SOAs in the typical range. In our defense, though, the final study followed a relatively well-established MSCT protocol and provided no support of visuospatial attention orienting effects either. Another limitation is the relatively small sample size for the reported correlations. Robust estimates of bivariate correlation require substantially larger samples than we had for most of our studies (Schönbrodt & Perugini, 2013). In this regard, it may seem all the more surprising, that we observed reliable correlations (between SES and the SCID effects) that varied within a relatively small range (from .21 to .45). Subjecting these four (*r*-to-*z*-transformed) correlations (for Studies 1a and 1b including only the short SOA SCID) to a miniature meta-analysis yielded no evidence of heterogeneity of the true effect size, $Q(3) = 3.354$, $p = .340$, and an average effect of $r = .30$, 95% CI [.20, .40], $p < .001$. If our speculation above is true, that SCID effects reflect making headspace for sexual mate selection, this would mean that people scoring high on sexual excitability are not only easily aroused but more ready

to engage in sexual partnering at another level as well. In that case, future research might show that SCID effects are smaller to non-existent when the primary task is already an appraisal of the stimulus in terms of mating relevance (and thus there are synergies with automatic processes), but larger when the primary task is unrelated. In fact, this notion resonates with the finding that indirect latency-based measures of sexual interests whose primary task incorporates active processing of sexually relevant features (i.e., task-relevant measures) yield higher validity than such measures with primary tasks relying on active processing of non-sexual stimuli features (i.e., task-irrelevant measures; Rönspies et al., 2015; Schmidt, Imhoff, & Banse, 2015).

Finally, although our sexual stimuli were clearly perceived as more sexually attractive than our neutral stimuli, they did not receive ratings at the extreme end of sexual attractiveness. This introduces a possibility that instead of a linear model of visuospatial attention (increasingly more visuospatial attention to increasingly more sexual attractive stimuli), a threshold model should be applied (visuospatial attention to only extremely sexually relevant stimuli). Future research may test this notion with designs varying the explicitness of sexual stimuli.

Conclusion

Across four independent studies, including heterosexual men and women, no evidence for the popular notion that sexual images automatically bind visuospatial attention was yielded. Instead, across all studies we find an unspecific delay of responding for trials in which sexual images appeared. Importantly, and not in line with binding of visuospatial attention, this effect was equally large for validly as well as invalidly cued trials in a spatial cueing paradigm. This SCID effect is robust, equally large for men and women, and reliably associated with participants' self-reported sexual excitability.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Human and Animal Rights

This article does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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Table 1a
Descriptives and intercorrelations of MSCT and self-report measures from Study 1a.

	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
SOA 250ms																	
1. Validity Difference Sexual	115.52	41.91															
2. Validity Difference Neutral	132.01	56.30	.57														
3. Sexual Attention Score	-16.48	47.28	.21	-.69													
4. SCID Score	20.51	21.97	.06	.08	-.05												
SOA 1000ms																	
5. Validity Difference Sexual	-6.28	51.76	.14	.07	.43	.39											
6. Validity Difference Neutral	-30.68	54.51	-.21	-.15	-.01	.22	.64										
7. Sexual Attention Score	24.40	45.50	.41	.26	.05	.18	.38	-.48									
8. SCID Score	23.70	33.69	-.00	-.36	.43	.40	.59	.40	.20								
Scale																	
9. TSO	8.41	4.98	.04	-.02	.06	-.10	.06	.12	-.08	-.10							
10. Sexual Drive – Dyadic	4.95	.76	.10	.17	-.12	-.08	.17	.19	-.03	.09	.29						
11. Sexual Drive – Solitary	3.24	1.51	.25	.23	-.05	-.01	.05	.07	-.03	.09	-.02	.24					
12. SES	2.81	.32	.10	.07	.00	.45	.39	.25	.14	.34	.03	.26	.19				
13. SIS-1	2.06	.42	.10	.08	.00	-.20	-.14	-.15	.03	-.03	-.20	-.12	.01	-.36			
14. SIS-2	2.62	.50	.22	-.08	.29	.00	-.20	-.14	-.06	.03	-.20	-.21	-.25	-.27	.35		
15. Sexual Preoccupation	2.76	.97	-.01	.22	-.27	-.02	.16	-.02	.14	.07	.19	.70	.34	.32	-.11	-.48	
16. Trait Self-Control	3.44	.57	-.02	.05	-.08	.27	-.04	-.07	.04	.11	-.09	-.01	-.30	-.01	.02	.17	.02

Note. $N=50$. Correlations $|r| \geq .28$ significant at .05, $|r| \geq .37$ at .01 (only the latter printed in bold).

Table 1b
Descriptives and intercorrelations of MSCT and self-report measures from Study 1ba.

	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
SOA 250ms																	
1. Validity Difference Sexual	99.47	39.75															
2. Validity Difference Neutral	116.36	41.01	.60														
3. Sexual Attention Score	-16.90	36.29	.42	-.48													
4. SCID Score	22.17	22.50	.12	.24	-.14												
SOA 1000ms																	
5. Validity Difference Sexual	13.02	45.20	.12	.13	-.01	.29											
6. Validity Difference Neutral	-5.81	44.02	.11	.05	.07	-.02	.50										
7. Sexual Attention Score	18.83	44.46	.02	.08	-.07	.31	.52	-.48									
8. SCID Score	22.91	25.11	.07	.28	-.23	.46	.29	.04	.25								
Scale																	
9. TSO	8.94	5.65	.12	.17	-.05	.19	.07	.18	-.11	.38							
10. Sexual Drive – Dyadic	4.57	1.18	.16	.12	.03	.10	.17	-.03	.20	.31	.47						
11. Sexual Drive – Solitary	3.30	1.35	.07	.16	-.10	.35	.18	.05	.13	.11	.42	.47					
12. SES	2.65	.37	.14	.20	-.07	.36	.14	-.05	.20	.35	.37	.52	.51				
13. SIS-1	2.07	.45	-.09	-.10	.01	-.04	.11	.06	.05	.01	.06	-.09	.09	.10			
14. SIS-2	2.56	.47	-.01	-.03	.02	-.14	-.31	-.11	-.21	-.11	-.17	-.22	-.21	-.20	.41		
15. Sexual Preoccupation	2.71	.99	.17	.07	.10	.22	.22	.05	.17	.28	.36	.70	.37	.45	.03	-.22	
16. Trait Self-Control	3.19	.72	.00	.06	-.07	.07	.02	-.01	.03	-.10	-.15	-.19	-.15	-.04	.11	.06	-.12

Note. $N=93$. Correlations $|r| \geq .21$ significant at .05, $|r| \geq .27$ at .01 (only the latter printed in bold).

Table 2
Descriptives and intercorrelations of MSCT and self-report measures from Study 2.

	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.
SOA 250ms									
1. Validity Difference Sexual	43.17	80.66							
2. Validity Difference Neutral	39.04	79.22	.53						
3. Sexual Attention Score	4.13	77.85	.50	-.47					
4. SCID Score	24.72	38.77	.14	.22	-.08				
Scale									
5. SES	2.47	.41	.16	.16	.01	.21			
6. SIS-1	2.27	.39	-.21	-.19	-.02	.00	-.06		
7. SIS-2	2.83	.50	-.24	-.15	-.10	-.04	-.34	.46	
8. Sexual Preoccupation	2.18	.88	.24	.27	-.02	.12	.53	-.14	-.37

Note. *N*=163. Correlations $|r| \geq .16$ significant at .05, $|r| \geq .21$ at .01 (only the latter printed in bold).

Table 3
Descriptives and intercorrelations of MSCT and self-report measures from Study 3.

	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
SOA 150ms												
1. Validity Difference Sexual	43.94	48.75										
2. Validity Difference Neutral	46.28	46.25	.76									
3. Sexual Attention Score	-2.33	33.07	.41	-.28								
4. SCID Score	3.27	15.19	.32	.29	.07							
Scale												
5. TSO	5.98	5.66	-.02	-.02	.00	.00						
6. Sexual Drive – Dyadic	4.22	.96	.12	.14	-.02	.28	.38					
7. Sexual Drive – Solitary	2.85	1.57	.03	.01	.04	.02	.44	.51				
8. SES	2.51	.40	.12	.09	.05	.28	.22	.66	.60			
9. SIS-1	2.24	.40	-.01	-.05	.06	.01	-.28	-.27	-.06	-.07		
10. SIS-2	2.80	.47	.11	.09	.03	.05	-.36	-.35	-.28	-.26	.30	
11. Sexual Preoccupation	2.38	.86	-.05	.03	-.10	.10	.24	.58	.47	.58	-.30	-.21

Note. *N*=93. Correlations $|r| \geq .21$ significant at .05, $|r| \geq .27$ at .01 (only the latter printed in bold).

Figure captions

Figure 1. Example of an invalidly cued, sexual trial.

Figure 2. Example stimuli used in Studies 1a and 1b.

Figure 3. Means and standard errors of response latencies in ms separately for cue content and validity with SOAs of 250ms and 1000ms (Study 1a).

Figure 4. Means and standard errors of response latencies in ms separate for cue content and validity with a SOA of 250ms and 1000ms, separately (Study 1b).

Figure 5. Example stimuli used in Studies 2 and 3.

Figure 6. Means and standard errors of response latencies in ms separate for cue content and validity for men and women separately (Study 2).

Figure 7. Means and standard errors of response latencies in ms separate for cue content and validity for men and women, separately (Study 3).

Figure 1

Figure 2

Example Stimuli for Studies 1a and 1b

Sexual stimuli

Non-sexual stimuli

Figure 3

Figure 4

Figure 5**Example Stimuli for Studies 2 and 3****Sexual stimuli** **Non-sexual stimuli**

Figure 6

Figure 7