



Turning off hot feelings: Down-regulation of sexual desire using distraction and situation-focused reappraisal

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ARTICLE INFO

Keywords:

Emotion regulation
Sexual desire
Late positive potential
Distraction
Reappraisal

ABSTRACT

Despite the frequent need to down-regulate sexual desire, existing studies are scarce, and focus on strategies that involve disengagement from processing sexual stimuli. Accordingly, the present study compared the efficacy of down-regulating sexual desire via disengagement (attentional distraction) and engagement (situation-focused reappraisal) strategies. Utilizing Event Related Potentials, we measured the Late Positive Potential (LPP) – an electro-cortical component that denotes processing of arousing stimuli, showing decreased amplitudes during successful down-regulation. Additionally, we explored whether the sexual-intensity level of stimuli (validated in a pilot study) impacts the efficacy of, and individuals' behavioral preferences for distraction and situation-focused reappraisal. Supporting our predictions, relative to passive watching, both strategies successfully attenuated self-reported desire and LPP amplitudes, with a marginal trend ($p = .07$) showing stronger LPP attenuation during distraction compared to reappraisal. While sexual-intensity did not moderate regulatory efficacy, as predicted, disengagement-distraction preference increased for sexually-intense relative to sexually-mild stimuli. Broad implications are discussed.

1. Introduction

Sexual desire is a powerful force that occupies our daily lives and takes over our thoughts on a regular basis (Regan & Atkins, 2006). However, in most daily-life situations, acting on sexual desire is not possible, either because of conflicting social norms and morals, or potential unwelcome outcomes. It is therefore clear that sexual desire needs to be controlled or regulated to a large extent. Surprisingly, though, studies on down-regulation of sexual desire (e.g., Moholy, Prause, Hajcak, Rahman, & Fong, 2015) remain sparse.

Down-regulation of potent sexual stimuli can be achieved via a variety of means or strategies. A central aspect that differentiates between down-regulation strategies is the degree to which they involve disengagement from- versus engagement with- emotional information processing (Parkinson & Totterdell, 1999; see also Ochsner & Gross, 2005; Sheppes, Brady, & Samson, 2014). While disengagement strategies generally operate by redirecting attention or action away from emotional information, engagement strategies generally operate by attending to- and working with- emotional information. One clear disengagement down-regulation strategy is distraction, which involves early attentional disengagement from emotional processing by producing unrelated thoughts (Van Dillen & Koole, 2007). Related to the

present focus, disengagement from sexually eliciting films using distraction successfully attenuated physiological sexual arousal (Nolet, Rouleau, Benbouriche, Carrier Emond, & Renaud, 2016).

Moving from clear disengagement, one widely established regulatory category is cognitive reappraisal, which generally involves directing attention to- and processing of- emotional information, while trying to reduce its negative impact (Buhle et al., 2014; Gross, 1998, 2015; Ochsner & Gross, 2008). However, cognitive reappraisal is a heterogeneous category that includes several sub-types or tactics, which considerably differ in their engagement level (see McRae, Ciesielski, & Gross, 2012; Ochsner & Gross, 2008 for a review). Specifically, self-focused reappraisal is a relatively disengaging form of reappraisal, because it involves adopting a distanced or detached point of view towards emotional situations (e.g., Ochsner et al., 2004; Schönfelder, Kanske, Heissler, & Wessa, 2014). By contrast, situation-focused reappraisal is a relatively engaging form of reappraisal, because it operates through involvement with emotional situations, by reinterpreting their initial meaning (e.g., Moser, Hartwig, Moran, Jendrusina, & Kross, 2014; Shafir, Schwartz, Blechert, & Sheppes, 2015).

Empirical support for engagement level differences between these two reappraisal tactics comes from studies that examined down-regulation of non-sexual contents. Specifically, while self-focused

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reappraisal recruits neural systems that are associated with internally focused, self-referential processing, situation-focused reappraisal recruits neural systems involved in processing of external situations (Ochsner et al., 2004). Furthermore, relative to self-focused reappraisal, enhanced engagement with emotional stimuli via situation-focused reappraisal was shown to result in better memory of emotional contents (Willroth & Hilimire, 2016), and in increased neural processing of emotional stimuli (Qi et al., 2017, but see also Willroth & Hilimire, 2016 for somewhat different neural findings). Last, compared to self-focused reappraisal, situation-focused reappraisal tended to be less effective in reducing emotional responding (Shiota & Levenson, 2012). Existing studies on down-regulation of sexual desire via cognitive reappraisal have only examined the efficacy of the more disengaging strategy of self-focused reappraisal, showing that it successfully reduced self-reported, physiological and neural sexual arousal (Beauregard, Levesque, & Bourgouin, 2001; Both, Laan, & Everaerd, 2011; Koukounas & Over, 2001; Winters, Christoff, & Gorzalka, 2009).

Taken together, to date the limited empirical evidence on down-regulation of sexual stimuli has focused on the relatively disengaging strategies of distraction and self-focused reappraisal. Though disengagement strategies are clearly useful and important, in many real-life emotional situations, engagement with emotional information and making sense of it is required for long-term adaptation (Denny, Inhoff, Zerubavel, Davachi, & Ochsner, 2015; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011; see also Wilson & Gilbert, 2008 for a review). Therefore, it is important to examine whether strategies like situation-focused reappraisal, which are clearly engaging, would successfully attenuate sexual desire, and whether they would be as effective as clear disengagement strategies, such as distraction.

Indirect evidence for the relative effectiveness of distraction and situation-focused reappraisal comes from studies that examined down-regulation of *unpleasant* emotions (e.g., Shafir et al., 2015; Shafir & Sheppes, 2018; Thiruchselvam et al., 2011). These studies have utilized the Late Positive Potential (LPP), an Event Related Potential (ERP) component that becomes evident approximately 300 ms following stimulus presentation, and is typically maximal at centro-parietal midline electrode sites (e.g., Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Shafir et al., 2015; Shafir & Sheppes, 2018; Speed, Levinson, Gross, Kiosses, & Hajcak, 2017; Weinberg & Hajcak, 2010. See Hajcak, MacNamara, & Olvet, 2010 for a review). The LPP is enhanced in response to emotionally arousing stimuli, but decreases in amplitude during successful down-regulation of arousing stimuli, as compared to passively watching them (Hajcak et al., 2010). It was consistently found that relative to passive watching, both disengagement distraction and engagement situation-focused reappraisal led to attenuated LPP amplitudes in response to unpleasant stimuli, and that distraction resulted in stronger LPP attenuation, compared to situation-focused reappraisal (e.g., Shafir et al., 2015; Shafir & Sheppes, 2018; Thiruchselvam et al., 2011). Additional neuroimaging studies showed that relative to passive watching, both distraction and situation-focused reappraisal successfully attenuated amygdala activity (Hermann, Kress, & Stark, 2017; McRae et al., 2010), with some findings showing that relative to situation-focused reappraisal, distraction down-regulated amygdala activity to a greater extent (McRae et al., 2010).

In the more closely related context of down-regulating *pleasant* stimuli (including erotic), to our knowledge no study has compared between the efficacy of distraction and situation-focused reappraisal. We are aware of a single study that compared between distraction and a general reappraisal instruction, which allowed participants to use both self and situation-focused reappraisals (Kanske, Heissler, Schönfelder, Bongers, & Wessa, 2010). Results showed that both distraction and reappraisal were successful in reducing subjective emotional experience and amygdala activation in response to pleasant stimuli, and that compared to reappraisal, distraction more successfully decreased amygdala activation. While important, this study could not isolate the efficacy of the relatively more engaging situation-focused reappraisal

from disengaging self-focused reappraisal, and it did not differentiate between sexual and other types of pleasant stimuli (i.e., in addition to erotic pictures, stimuli contents included exciting pictures of sport scenes, affiliative pictures of children etc.). The latter content distinction is important because relative to other pleasant stimuli, sexual stimuli more strongly activate the appetitive motivational system (Bradley, Codispoti, Cuthbert, & Lang, 2001), as manifested in particularly enhanced LPPs (Prause, Steele, Staley, & Sabatinelli, 2014; Weinberg & Hajcak, 2010), and as such sexual stimuli may pose stronger regulatory challenge.

Accordingly, the main goal of the present study was to examine, for the first time, the efficacy of disengagement distraction and engagement situation-focused reappraisal, in down-regulation of sexual desire. We focused on the LPP during down-regulation, because it proved highly sensitive in revealing differences between distraction and situation-focused reappraisal (e.g., Shafir et al., 2015; Thiruchselvam et al., 2011), and because it adequately captures enhanced neural responses to arousing sexual stimuli (Prause et al., 2014; Prause, Steele, Staley, Sabatinelli, & Hajcak, 2015). In addition to examining the LPP during down-regulation, we measured self-reported desire following down-regulation. Consistent with the aforementioned studies, we predicted that relative to passive watching, both distraction and situation-focused reappraisal would successfully attenuate LPP amplitudes and self-reported sexual desire, but that distraction would be more successful than situation-focused reappraisal.

In addition to examining down-regulation of sexual desire via distraction and situation-focused reappraisal, we wished to also explore whether the efficacy of these strategies is influenced by the intensity level of sexual stimuli. Our recent conceptual account (Sheppes & Gross, 2011) and supporting studies examining down-regulation of *unpleasant* emotions (Shafir et al., 2015; Shafir, Thiruchselvam, Suri, Gross, & Sheppes, 2016) have demonstrated that the enhanced effectiveness of distraction over situation-focused reappraisal is particularly noticeable when down-regulating intense rather than mild unpleasant stimuli. Accordingly, we wished to test our hypothesis that the enhanced effectiveness of distraction would be stronger when down-regulating sexually-intense versus sexually-mild stimuli.

To that end, we first conducted a pilot study in which we validated a new set of pictures, with two major objectives: first, because most previous emotion regulation studies have used pictorial sets (i.e., IAPS: Lang, Bradley, & Cuthbert, 2008) that are significantly less appetitive than sexual pictures easily accessed via the internet nowadays (e.g., Krompinger, Moser, & Simons, 2008; Schönfelder et al., 2014), we wished to create a contemporary set of stimuli (see Prause et al., 2014, 2015 for further discussion). Second, we wished to create two distinct categories of pictures that clearly differed in their sexual desire ratings (i.e., sexually-intense versus sexually-mild). Given that the LPP was shown to be highly sensitive to differences between unpleasant intense and mild stimuli (Shafir et al., 2015), we predicted that relative to sexually-mild stimuli, sexually-intense stimuli would produce higher LPPs as well as self-reported desire ratings.

Beyond moderating regulatory effectiveness, emotional intensity significantly influences individuals' behavioral selection between distraction and situation-focused reappraisal (Sheppes & Levin, 2013). Specifically, because distraction more effectively blocks potent emotional information before it gathers force, it was preferred over situation-focused reappraisal when facing intense relative to mild unpleasant (Sheppes & Levin, 2013) as well as pleasant stimuli (Hay, Sheppes, Gross, & Gruber, 2015; Martins, Sheppes, Gross, & Mather, 2016; Sheppes, Scheibe et al., 2014). In the present study, we explored whether in the specific context of down-regulating sexual desire, distraction over situation-focused reappraisal choice would increase for sexually-intense relative to sexually-mild stimuli.

In summary, the first research question of the present study was whether down-regulation of sexual desire using distraction and situation-focused reappraisal modulates neural and self-reported responses

to sexual stimuli. We hypothesized that relative to passive watching, both strategies would successfully attenuate LPP amplitudes as well as self-reported sexual desire. The second research question was whether distraction and situation-focused reappraisal differ in their effectiveness. It was hypothesized that distraction would be more effective than situation-focused reappraisal, as manifested in enhanced LPP as well as self-reported sexual desire attenuation. The third research question was whether sexually-intense and sexually-mild stimuli, taken from our new validated pictorial set, produce different neural and self-reported responses. We hypothesized that sexually-intense stimuli would result in enhanced LPPs and self-reported sexual desire, relative to sexually-mild stimuli. The fourth research question was whether regulatory effectiveness is influenced by the sexual-intensity of the stimuli. We hypothesized that the enhanced effectiveness of distraction over situation-focused reappraisal would be stronger when down-regulating sexually-intense relative to sexually-mild stimuli. Finally, in our fifth research question we explored whether regulatory choices are influenced by the sexual-intensity of the stimuli. We hypothesized that distraction over situation-focused reappraisal choice would increase for sexually-intense relative to sexually-mild stimuli.

2. Method

Below we report how we determined our sample size, all data exclusions, all manipulations, and all measures that were collected in the study. The study was approved by the institutional review board of Tel-Aviv University.

2.1. Participants

Thirty healthy heterosexual adults completed the experiment. Sample size was **pre-determined** with reference to prior emotion regulation studies conducted in our lab, which focused on the LPP (c.f. Dorman Ilan, Shafir, Birk, Bonanno, & Sheppes, 2018; Shafir et al., 2015; Shafir & Sheppes, 2018). Additionally, a formal power analysis was conducted using MorePower 6.0 (Campbell & Thompson, 2012). Specifically, we computed the sample size needed to detect the highest order two-way interaction predicted (i.e., Sexual-intensity X Instruction interaction), applying the conventional high power of 0.8 and an alpha of 0.05. Considering previous closely related designs that involved pleasant (including erotic) stimuli, two within factors and the LPP as an outcome, (e.g., Baur, Blank, Larson, & Lynnam, 2015; Schönfelder et al., 2014), we selected an estimated effect size of $\eta_p^2 = 0.15$ for the expected two-way interaction. The analysis indicated that a sample of 30 participants was required to detect a reliable interaction effect, which suggests that our pre-determined sample size was adequately powered.

All participants had normal or corrected-to-normal vision and reported no mental or neurological disorder. Given our interest in down-regulation of their sexual desire, prior to arrival we also confirmed that participants were not expressing aversion to sexual pictures. Following a-priori criterion of > 30% rejected trials due to EEG artifacts (Shafir et al., 2015, 2016) and *prior* to data analyses, one participant (with mean rejection rate of 39.4%) was excluded from the analyses. Therefore, the final sample consisted of 29 participants (mean age 24.6 years, 19 men).

2.2. Stimuli

Of the 360 pictures that were tested in the pilot study (participant $N = 20$, see Supplementary materials for full details), we chose 180 sexual pictures. Pictures were divided into two distinct intensity categories, based on significant differences in desire ratings [$F(1,89) = 165.51$, $p < .001$, $\eta_p^2 = .65$]. Specifically, sexually-intense pictures ($n = 90$, $M_{\text{desire}} = 6.59$, $SE = 0.04$) depicted one man and one woman, completely or partially nude, engaged in an explicit sexual act (e.g., penetrative sex), whereas sexually-mild pictures ($n = 90$,

$M_{\text{desire}} = 5.55$, $SE = 0.07$) depicted one man and one woman, dressed, engaged in a notably less explicit sexual behavior (e.g., kissing).

2.3. Procedure

Following initial EEG setup, we explained to participants that in real-life, down-regulation of sexual desire is clearly needed in cases where it cannot be materialized or if acting on it would lead to negative outcomes. We additionally explained to participants that during the experiment, they would be asked to down-regulate their sexual desire using two different strategies. Participants then learned how to implement distraction, situation-focused reappraisal and watch (two examples for each instruction), followed by a six trial practice phase. To ensure understanding of the instructions, participants were asked to talk out loud how they implement each instruction and were corrected by the experimenter as needed. Furthermore, we rightfully informed participants that the experimenter was watching them from outside the experimental room (via a web cam that videotaped their faces) throughout the whole session. This procedure enabled us to make sure that participants are concentrated on the task, and, importantly, that they do not look away from the sexual pictures at any time.

Down-regulation instructions closely adhered to instructions commonly used in previous studies in our lab that examined distraction and situation-focused reappraisal (e.g., Hay et al., 2015; Martins et al., 2016; Sheppes, Scheibe et al., 2014). Specifically, Distraction instructions involved disengaging attention by trying to think of something that is emotionally neutral and completely unrelated to the picture (e.g., thinking about everyday tasks, geometric shapes or familiar streets). During distraction, participants were instructed to try their best to vividly visualize the unrelated neutral thought, while keeping their eyes on the picture throughout its presentation.

Situation-focused reappraisal instructions involved engaging with the content of the sexual picture, but trying to interpret its initial meaning in ways that lower the sexual desire that may arise (e.g., by thinking that the partners are not passionate about their sexual interaction, that they are experiencing boredom, that the sexual interaction is coercive etc.). Furthermore, in the present study we did not allow participants to form "reality challenge" reappraisals, that involve doubting the authenticity of the emotional situation (e.g., imagine being the director of an erotic film or thinking that the sexual partners are actors; see McRae et al., 2012), because this reappraisal tactic is considered relatively disengaging (see Sheppes, Scheibe et al., 2014 for empirical support).

During Watch, participants were instructed not to change how they feel, but rather to allow themselves to experience the natural sexual desire that may arise (e.g., to think about how tempting the sexual interaction is, about the attractiveness of the sexual partners etc.).

The EEG task consisted of 150 trials (divided to 5 equally-long blocks, separated by breaks) that were equally divided into the 6 experimental conditions according to two independent variables: Sexual-intensity (Intense, Mild) and Instruction (Distraction, Situation-focused Reappraisal, Watch). Pictures were randomly presented (with no more than two consecutive trials of the same sexual-intensity), and were randomly assigned to instructions.

Each trial (Fig. 1a for complete details) began with a fixation cross (jittered between 2100 and 2900 ms), followed by a cue screen (2500 ms) containing information about the sexual-intensity of the upcoming picture ("Intense" or "Mild") and the required instruction ("Distraction", "Reappraisal" or "Watch", c.f. Dorman Ilan et al., 2018; Shafir et al., 2015), followed by a jittered 400–800 ms black screen. The picture was then presented (5000 ms) and participants were instructed to implement the required instruction. The offset of each picture was followed by a 1–9 rating scale (until response) in which participants rated their level of *desire* on a 1–9 scale (with anchors of 1 = "not feeling desire at all" and 9 = "feeling extreme desire"). We focused on self-reports of sexual desire because they constitute a high order

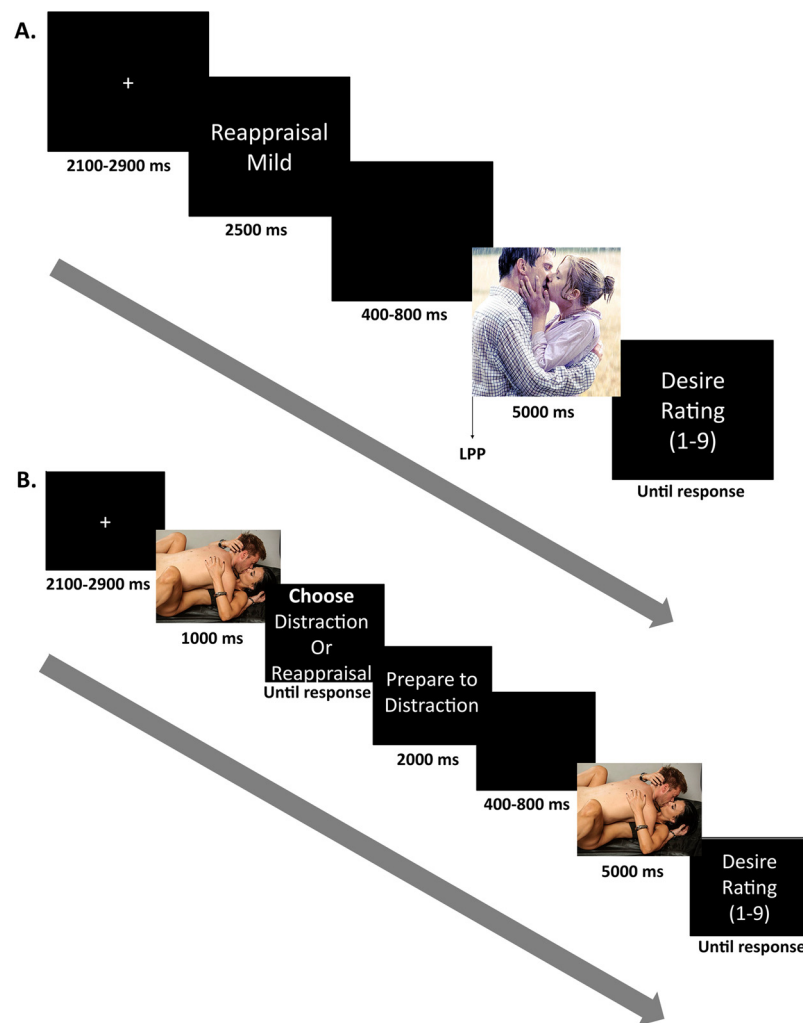


Fig. 1. Trial structures of the EEG task (A) (an example of a sexually-mild situation-focused reappraisal trial), and the emotion regulation choice task (B) (an example of a sexually-intense distraction choice trial).

construct that integrates affective, motivational and cognitive components, relative to sexual arousal ratings (Hardy, 1964; Moholy et al., 2015; Whalen, 1966. See Hofmann & Nordgren, 2015 for a review). This focus provides a rich characterization of sexual down-regulation that cuts across several units of analysis, ranging from measures of direct online neurobiological arousal (LPP), through behavioral regulatory choices, to higher order self-reported ratings of desire.

Following the EEG task, participants completed a behavioral emotion regulation choice task (Sheppes, Scheibe et al., 2014) in which they freely choose between distraction and situation-focused reappraisal for sexually-intense and sexually-mild pictures (15 trials each, different from those used in the EEG task). Pictures were randomly presented (with no more than two consecutive trials of the same sexual-intensity).

Each trial (Fig. 1b for complete details) began with a fixation cross (jittered between 2100 and 2900 ms), followed by a brief preview (1000 ms) of the picture. Then, a choice screen (until response) was presented, during which participants were asked to choose whether they prefer to regulate their desire via distraction or situation-focused reappraisal. Participants were instructed to choose the regulatory strategy which they assume would be more efficient in reducing their desire in reaction to each picture. Then, the chosen strategy appeared on the screen (2000 ms), followed by a jittered 400–800 ms black screen. The picture was then presented again (5000 ms) and participants were instructed to implement their chosen strategy. The offset of each picture was followed by a 1–9 rating scale (until response) in

which participants rated their level of desire on a 1–9 scale (with anchors of 1 = “not feeling desire at all” and 9 = “feeling extreme desire”). Note that we included post-choice desire ratings in order to remind participants that their regulatory choices were aimed at reducing their desire, but we did not analyze these ratings because they are uninterpretable in emotion regulation choice tasks (see Supplementary materials for full explanation).

For exploratory purposes, at the end of the experiment we also measured resting-state EEG activity, as well as several questionnaires: Patient Health Questionnaire depression module (PHQ9; Kroenke, Spitzer, & Williams, 2001), Sexual Desire Inventory (SDI; Spector, Carey, & Steinberg, 1996), Barratt Impulsiveness Scale-11 (BIS-11; Patton, Stanford, & Barratt, 1995), Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991), and Pornography Craving Questionnaire (PCQ-12; Kraus, 2013).

2.4. EEG recording and processing

EEG was recorded using a Biosemi ActiView recording system (Biosemi, Amsterdam, Netherlands), from 32 electrode sites (Fp1, Fp2, Fp3, Af3, Af4, Afz, F1, F3, Fz, Fc1, Fc2, Fcz, C1, C3, C2, C4, Cz, Cp1, Cp2, Cp3, P1, P3, P2, P4, Pz, O1, O2, Poz, T7, T8, F2, F4), as well as one electrode on each of the left and right mastoids. Electrooculogram was recorded from two electrodes placed approximately 1 cm to the left and right of the external canthi and one electrode placed beneath the left

eye. The voltage from each electrode site was referenced online with respect to the CMS/DRL electrodes. EEG data was sampled at 256 Hz.

Offline signal processing was performed using EEGLAB and the ERPLAB (Delorme & Makeig, 2004; Lopez-Calderon & Luck, 2014). All electrodes were re-referenced to the average activity of the left and right mastoids. Continuous EEG data was band-pass filtered (cutoffs: 0.05–20 Hz; 12 dB/oct rolloff) and corrected for eye-blinks using an Independent Component Analysis (ICA) approach (Mennes, Wouters, Vanrumste, Lagae, & Stiers, 2010). For analyzing the LPP, a 200 ms pre-picture baseline was subtracted from the 5000 ms post-picture presentation waveform. Trials containing activity exceeding 80 μ V within 200 ms were rejected. The mean rejection rate (2.51%, SE = 0.01) did not significantly vary between conditions [all F s < 2.21, all p 's > .11]. In line with previous studies (e.g., Speed et al., 2017; Weinberg & Hajcak, 2010. See Hajcak et al., 2010 for a review), the LPP was quantified at centro-parietal electrodes. Specifically, congruent with prior studies conducted in our lab (e.g., Shafir et al., 2015; Shafir & Sheppes, 2018), the LPP was measured as the average activity of Pz and CPz electrodes, between 300 (when it becomes evident) and 5000 ms (end of picture presentation). In addition to analyzing the LPP during down-regulation of sexual stimuli, for exploratory purposes we also analyzed neural activity during anticipation for upcoming down-regulation.

The efficacy of distraction and situation-focused reappraisal in attenuating LPP amplitudes and self-reported sexual desire was examined using a 2×3 repeated measures analyses of variance (ANOVAs) with Sexual-intensity (Intense, Mild) and Instruction (Distraction, Situation-Focused Reappraisal, Watch) as repeated-measures factors. In cases where sphericity was violated, as indicated by Mauchly Sphericity Test, we used the Greenhouse and Geisser (1959) correction (epsilon (ϵ) and uncorrected degrees of freedom are reported; Picton et al., 2000). Significant effects were followed by planned follow-up analyses comparing each down-regulation strategy to the watch control condition, and also comparing between the two down-regulation strategies. A significance level of 5% (two-sided) was selected. We additionally computed zero order correlations between LPP amplitudes and self-reported desire ratings in the six experimental conditions (i.e., the three instructions in each sexual-intensity level).

3. Results

3.1. LPP

Confirming our first prediction that both distraction and situation-focused reappraisal would be effective in down-regulating sexual desire, we found a significant main effect of Instruction [$F(2,56) = 9.41$, $p < .001$, $\eta_p^2 = .25$. See Fig. 2a and b]. As expected, relative to watch ($M = 6.12$, $SE = 0.75$), both distraction ($M = 3.32$, $SE = 0.85$) [$F(1,28) = 16.17$, $p < .001$, $\eta_p^2 = .37$] and situation-focused reappraisal ($M = 4.52$, $SE = 0.85$) [$F(1,28) = 7.27$, $p = .01$, $\eta_p^2 = .21$] attenuated LPP amplitudes. Regarding our second prediction, we found a marginally significant effect, with an expected trend showing that distraction more strongly attenuated the LPP, relative to situation-focused reappraisal [$F(1,28) = 3.43$, $p = .07$, $\eta_p^2 = .11$]. Additionally, providing support for our third prediction, we found a significant main effect of Sexual-intensity [$F(1,28) = 6.49$, $p = .02$, $\eta_p^2 = .19$. See Fig. 3a and b], where relative to sexually-mild pictures ($M = 4.03$, $SE = 0.72$), sexually-intense pictures ($M = 5.28$, $SE = 0.81$) resulted in enhanced LPPs, denoting increased processing of the sexually-intense category. Counter to our fourth prediction that regulation patterns would be influenced by the sexual-intensity level of the pictures, there was no Sexual-intensity $\times$ Instruction interaction [$F(2,56) < 1$. See Table 1 for all means of all conditions].

3.2. Self-reported sexual desire

Congruent with the LPP results, and confirming our first prediction, we found a significant main effect of Instruction [$F(2,56) = 93.45$, $p < .001$, $\epsilon = 0.62$, $\eta_p^2 = .77$. See Fig. 2c], where relative to watch ($M = 5.04$, $SE = 0.2$), both distraction ($M = 3.55$, $SE = 0.19$) [$F(1,28) = 122.6$, $p < .001$, $\eta_p^2 = .81$] and situation-focused reappraisal ($M = 3.59$, $SE = 0.21$) [$F(1,28) = 86.65$, $p < .001$, $\eta_p^2 = .76$] attenuated self-reported sexual desire, but, counter to our second prediction, we found no differences between the strategies [$F(2,56) < 1$]. Congruent with the LPP results, and confirming our third prediction regarding the increased desirability of the sexually-intense pictures, we found that relative to sexually-mild pictures ($M = 2.72$, $SE = 0.22$), sexually-intense pictures ($M = 5.4$, $SE = 0.23$) resulted in enhanced self-reported desire ratings [$F(1,28) = 117.06$, $p < .001$, $\eta_p^2 = .81$. See Fig. 3c]. This analysis also revealed a significant Sexual-intensity $\times$ Instruction interaction [$F(2,56) = 20.06$, $p < .001$, $\epsilon = 0.73$, $\eta_p^2 = .42$. See Table 1, Fig. 4]. Follow-up contrasts showed that differences between watch and down-regulation strategies were larger for sexually-intense relative to sexually-mild pictures [$F(1,28) = 25.34$, $p < .001$, $\eta_p^2 = .48$]. Specifically, additional simple main effect analyses showed that relative to watch, distraction and situation-focused reappraisal more strongly attenuated self-reported sexual desire for sexually-intense pictures [$F(1,28) = 117.45$, $p < .001$, $\eta_p^2 = .81$], than for sexually-mild pictures [$F(1,28) = 52.86$, $p < .001$, $\eta_p^2 = .65$].

No significant correlations were found between LPP amplitudes and self-reported desire ratings [all r 's < |0.27|, all p 's > 0.16].

3.3. Behavioral regulatory choices

Supporting our fifth prediction, and extending previous findings, we found that the preference for choosing distraction over situation-focused reappraisal significantly increased for sexually-intense ($M = 56.14\%$, $SE = 5.08\%$) relative to sexually-mild ($M = 40.45\%$, $SE = 3.89\%$) pictures [$F(1,28) = 4.34$, $p = .046$, $\eta_p^2 = .13$].

4. Discussion

Despite its importance, little is known about cognitive down-regulation of sexual desire. Current studies have mainly focused on relatively disengaging regulatory strategies, with no study examining the efficacy of a clearly engagement regulation in attenuating sexual desire, and whether it can be as effective as disengagement regulation. The present study thus examined the efficacy of two strategies that significantly differ in their level of disengagement versus engagement, distraction and situation-focused reappraisal, in down-regulating sexual desire, using neural (LPP) and self-reported (desire ratings) measures. Additionally, we wished to explore the role of sexual-intensity in the efficacy and choice of distraction and situation-focused reappraisal.

As predicted, relative to passive watching, both distraction and situation-focused reappraisal successfully attenuated LPP amplitudes, as well as self-reported desire ratings. These results extend previous findings demonstrating the efficacy of these two strategies when regulating unpleasant (Hermann et al., 2017; McRae et al., 2010; Shafir & Sheppes, 2018; Thiruchselvam et al., 2011) as well as pleasant (Kanske et al., 2010) emotional stimuli. Moreover, extending previous studies that focused on down-regulation of sexual desire, we provide the first evidence for the efficacy of situation-focused reappraisal, a clearly engagement down-regulation strategy. This finding is important because in many real-life emotional situations, engagement with emotional information and making sense of it is required for long-term adaptation (Denny et al., 2015; Hermann et al., 2017; Thiruchselvam et al., 2011; see Wilson & Gilbert, 2008 for a review).

Additionally, there was a marginally significant effect ($p = .07$) suggesting that relative to situation-focused reappraisal, distraction

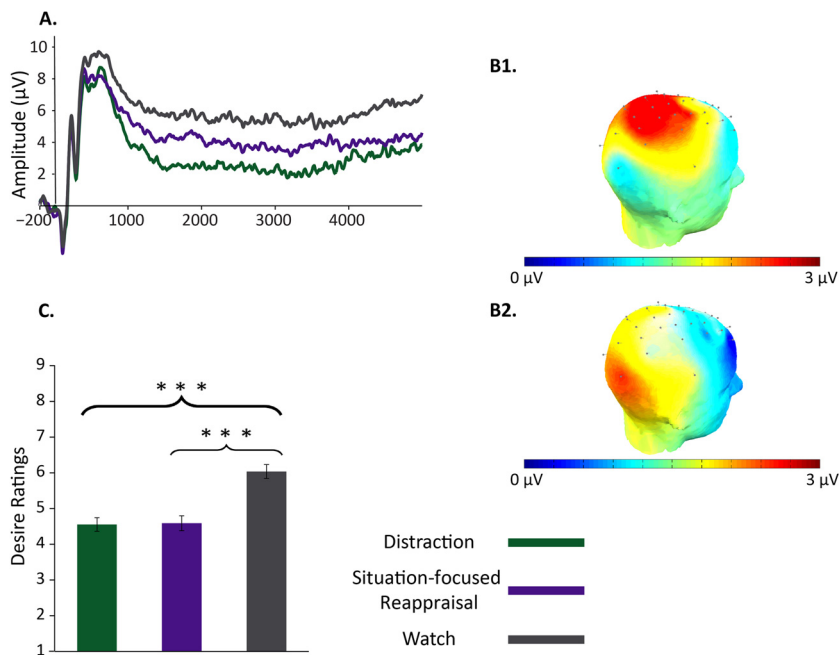


Fig. 2. (A) Picture-locked LPP amplitudes for distraction, situation-focused reappraisal and watch (collapsed across sexual-intensity levels). Waveforms are averaged across Pz and CPz electrodes. The x-axis runs from the beginning of the baseline (–200 ms pre-picture onset) to the end of the picture presentation (5000 ms). (B1.2) Head maps of the LPP topographical distribution. Voltage difference scores for the main effect of Instruction were calculated as: map B: (averaged watch conditions)–(averaged distraction conditions) and map D: (averaged watch conditions)–(averaged situation-focused reappraisal conditions). (C) Self-reported desire ratings (y-axis) for distraction, situation-focused reappraisal and watch (collapsed across sexual-intensity levels). ***, $P < .001$. Error bars represent standard errors.

more strongly attenuated LPP amplitudes. Although this trend should be treated with caution because it was only marginally significant, it is in line with previous studies that used *unpleasant* stimuli and found that attentional disengagement via distraction led to stronger LPP modulation, compared to situation-focused reappraisal (e.g., Shafir & Sheppes, 2018; Thiruchselvam et al., 2011).

What can explain the lack of clear superiority of distraction over situation-focused reappraisal when down-regulating sexual desire? It may be that, as opposed to disengaging attention from unpleasant stimuli, in the case of sexual stimuli – the attentional disengagement mechanism in distraction conflicts with the opposite basic tendency of the appetitive motivation system to engage attention (Bradley et al.,

2001). At the same time, it may also be that situation-focused reappraisal was particularly successful in the present context that involved down-regulating a relatively homogenous content of sexual desire. Specifically, the process of actively finding alternative re-interpretations for sexual stimuli in situation-focused reappraisal is simplified, because a particular reinterpretation may be suitable across stimuli that are roughly similar in content.

Finding increased LPPs and self-reported desire ratings in response to sexually-intense relative to sexually-mild pictures confirmed that sexually-intense pictures were indeed more arousing and desirable, and also provided convergent validity for the sexual-intensity categorization of the pilot study. However, unexpectedly, regulation effectiveness was

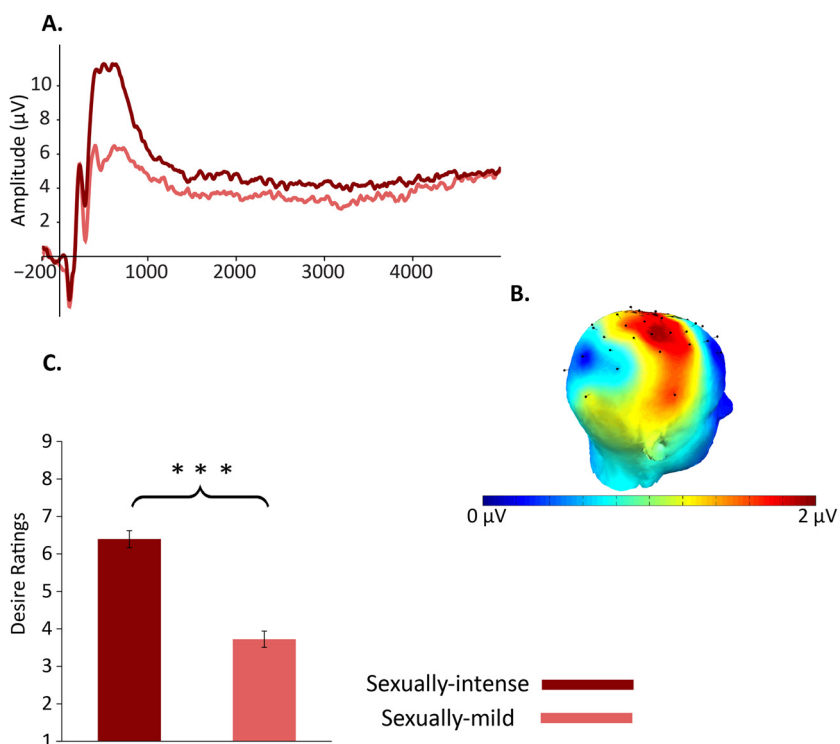


Fig. 3. (A) Picture-locked LPP amplitudes for sexually-intense and sexually-mild pictures (collapsed across instructions). Waveforms are averaged across Pz and CPz electrodes. The x-axis runs from the beginning of the baseline (–200 ms pre-picture onset) to the end of the picture presentation (5000 ms). (B) Head map of the LPP topographical distribution. Voltage difference score for the main effect of Sexual-intensity was calculated as: (averaged sexually-intense conditions)–(averaged sexually-mild conditions). (C) Self-reported desire ratings (y-axis) for sexually-intense and sexually-mild pictures (collapsed across instructions). ***, $P < .001$. Error bars represent standard errors.

Table 1

Means (standard errors) of LPP amplitudes and self-reported sexual desire during implementation of distraction, situation-focused reappraisal and watch, for sexually-intense and sexually-mild pictures.

	Sexually-intense			Sexually-mild		
	Distraction	Situation-focused Reappraisal	Watch	Distraction	Situation-focused Reappraisal	Watch
LPP (300–5000)	4.26 (1.04)	4.76 (0.95)	6.81 (0.9)	2.37 (0.82)	4.29 (0.96)	5.43 (0.81)
Self-reported desire	4.77 (0.25)	4.79 (0.28)	6.62 (0.19)	2.33 (0.20)	2.39 (0.21)	3.45 (0.27)

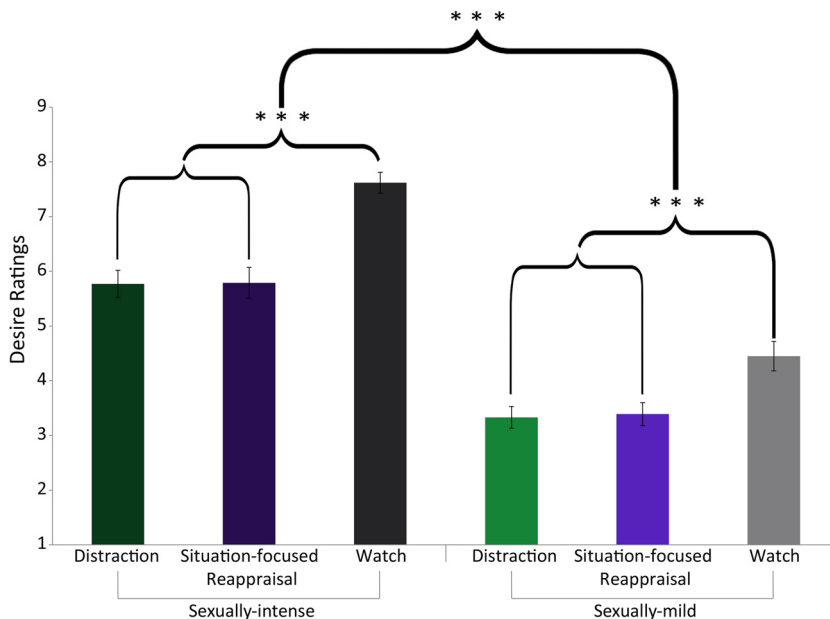


Fig. 4. Self-reported desire ratings (y-axis) following distraction, situation-focused reappraisal and watch, for sexually-intense and sexually-mild pictures. ***, $P < .001$. Error bars represent standard errors. Note that while differences between watch and down-regulation strategies in both sexual-intensities were significant, with p 's smaller than .001, differences were larger for sexually-intense relative to sexually-mild pictures.

not influenced by sexual-intensity level of the pictures. It could be that matching the contents of the two sexual-intensity categories, so that both would depict couples engaged in an intimate interaction, resulted in excessively intense sexually-mild category. Supporting this possibility, LPP differences between unpleasant intense and mild stimuli were considerably larger (c.f., $\eta_p^2 = 0.82$ in Shafir et al., 2015) than LPP differences between sexually-intense and mild stimuli in the present study ($\eta_p^2 = .19$).

Last, as predicted, sexual-intensity level had a significant influence on regulatory preferences. Specifically, we found that individuals' preference for disengaging via distraction over engaging via situation-focused reappraisal increased for sexually-intense relative to sexually-mild stimuli. These results transcend previous studies that measured emotion regulation choices with nonspecific unpleasant and pleasant stimuli (Hay et al., 2015; Martins et al., 2016; Sheppes, Scheibe et al., 2014).

Several limitations of the present study should be noted. First, because the current study is the first to examine the efficacy of both disengagement and engagement regulation in the context of sexual desire, we chose to only focus on down-regulation, which is central in daily life. Nonetheless, it would be important for future studies to examine the efficacy of up-regulation strategies, especially among some clinical populations such as depressed individuals, who are characterized by low levels of sexual drive (Beck & Alford, 2009; Mathew & Weinman, 1982). On the other hand, another important extension of the present study would be to explore the efficacy of down-regulation strategies in attenuating sexual desire among individuals with high sexual desire levels. Since these individuals appear to allocate more attention to sexual stimuli (e.g., Prause, Janssen, & Hetrick, 2008), they may have difficulties down-regulating their sexual desire, particularly

using disengagement down-regulation strategies such as distraction.

Second, we made considerable efforts to match the sexually-intense and the sexually-mild categories, so that both would depict scenes that are sexual, yet significantly differ in their degree of explicitness (e.g., a couple kissing versus a couple having penetrative sex). However, since we did not measure romantic feelings, we cannot fully rule out the possibility that in addition to clearly differing in sexual desire level, the two categories also differed in romantic feelings. In this regard, it is important to mention prior work on down-regulation of romantic feelings that generally support the predictions and findings of the present study (Langeslag & Sanchez, 2018; Langeslag & Van Strien, 2016). Specifically, these studies showed that relative to passive watching, down-regulation of romantic feelings via distraction and situation-focused reappraisal successfully decreased LPP amplitudes (Langeslag & Sanchez, 2018; Langeslag & Van Strien, 2016). Future studies should examine similarities, but also potential differences, between down-regulation of romantic feelings and sexual desire.

Third, we found no correlations between self-reported sexual desire and LPP amplitudes. It should be noted that while in some prior studies LPP findings coincide with self-reported experience ratings (e.g., Hajcak & Nieuwenhuis, 2006; Thiruchselvam, Hajcak, & Gross, 2012), in many other studies they do not (e.g., Ellis, Schroder, Patrick, & Moser, 2017; Langeslag & Sanchez, 2018; Thiruchselvam et al., 2011). This discrepancy may be partially related to the notion that neural and self-reported measures represent two different units of analyses. Specifically, while the LPP represents online modulation during down-regulation, subjective self-reports of sexual desire depict the end point of the down-regulation processes (see Shafir et al., 2016 for a thorough discussion on this point).

Fourth, because we informed participants that they would be asked

to down-regulate their sexual desire, it could be that their reports of reduced sexual desire following regulation may be influenced by demand characteristics. However, it bears noting that explaining to participants that the regulatory strategies they would implement are aimed at reducing their emotions is a standard procedure in emotion regulation research (e.g., Shafir et al., 2015; Shafir & Sheppes, 2018; Speed et al., 2017; Willroth & Hilimire, 2016). Importantly, in the present study, the LPP results were consistent with the self-reported desire ratings results. Specifically, regulation strategies successfully attenuated not only self-reported desire ratings, but also LPP amplitudes. Given that the LPP is a neural measure that is less prone to reporting biases, concerns regarding participants reporting successful regulation due to demand characteristics are toned down.

Last, while some other studies that examined down-regulation of sexual stimuli have focused on men only (e.g., Beauregard et al., 2001; Nolet et al., 2016), we used a mixed sample. However, because our sample was unbalanced (i.e., it consisted of mainly men), we were not able to adequately assess gender differences. Future studies that wish to examine gender differences in down-regulation of sexual desire should use balanced samples.

Despite these apparent limitations, the current findings have important implications for daily life. Specifically, in modern times, fully acting on sexual desire is not possible during most daily life situations due to conflicting norms and morals (Hofmann & Nordgren, 2015). Therefore, individuals often need to regulate their sexual desire. While existing studies focus on the efficacy of relatively disengagement regulatory strategies, our findings demonstrate for the first time that sexual desire can be effectively down-regulated via clearly engagement regulation as well. This is important because in many daily life situations, it is not possible to disengage attention from contexts that give rise to sexual desire. For instance, individuals might need to regulate sexual desire towards a colleague during work related interactions using engagement like strategies, because in such situations fully disengaging attention is not an option.

Relatedly, because in most daily life situations, sexual desire cannot be fully materialized, down-regulating sexual desire may be highly practiced. While highly practiced, it may also be challenging because sexual stimuli elicit strong activation of the appetitive motivational system. While these two conflicting notions may coexist, it is important to note that in reality, although down-regulation of sexual desire *should* be highly practiced, it seems that rates of pornography consumption, sexual harassments and sexual violence are extremely high (e.g., Abrahams et al., 2014; Eberstadt & Layden, 2010). This suggests that down-regulation is not trivial, and highlights the importance of further examining regulatory strategies that seem effective.

To conclude, the present study tested, for the first time, the efficacy and choice of two strategies that clearly represent disengagement versus engagement regulation – distraction and situation-focused reappraisal, in down-regulating sexual desire. Our main findings demonstrated that relative to passive watching, both strategies were successful in attenuating LPP amplitudes and self-reported desire ratings. Moreover, individuals' preferences for disengaging via distraction over engaging via situation-focused reappraisal increased for sexually-intense relative to sexually-mild stimuli.

Acknowledgments

G. Sheppes is supported by the Israel Science Foundation (Grant No. 1130/16). We wish to thank Chen Salhov and Henny Amir for research assistance.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.biopsycho.2018.07.007>.

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