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# Excitation Transfer Between Sexual Arousal and Other Emotions in a Community Sample

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## Abstract

Excitation transfer, the transfer of arousal from one emotion to another, might be a mechanism in the development of unusual sexual interests. In this pilot study, we investigated whether we could induce excitation transfer between various emotions and sexual arousal in a laboratory setting with 30 male volunteers. We induced low-level sexual arousal in four different emotional states (aggression/dominance, endearment, fear, disgust) and a neutral state. Sexual arousal was measured using penile plethysmography and self-report. Although there was no mean group effect, possibly due to large interindividual variations, 60% of the subjects showed more sexual arousal in response to sexual stimulation in at least one of the emotional states than in the neutral state. Excitation transfer was most prominent with aggression/dominance and least prominent with disgust. Genital excitation transfer was strongly related to lower penile reactivity and to higher self-reported erotophilia. This pilot study paves the way for further research into excitation transfer as a mechanism to increase the salience of stimuli that otherwise would not have been sexual in nature.

**Keywords** Excitation transfer · Sexual deviance · Genital sexual arousal · Penile plethysmography · PPG

## Introduction

Statistically speaking, unusual sexual interests refer to any sexual interest deviating from the norm, the norm being the most frequent sexual interest in the population. Although certainly not inherently problematic, unusual sexual interests can be experienced as a heavy burden by individuals, for instance when it traverses their relationships, or by society, when it concerns

inappropriate or illegal stimuli (i.e., “sexual deviance”; Fernandez et al., 2012). To date, very little is known about the etiology of sexual interests in general and unusual sexual interests specifically. In this study we explore excitation transfer between various emotions and sexual arousal and possible parameters associated with excitation transfer effects, to assess whether and how excitation transfer can be researched as a possible factor in the development of unusual sexual interests, or, eventually, sexual deviance.

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## Incentive Motivation and Excitation Transfer

In the previous century, the study of sexual desire often adopted a Freudian approach where desire was seen as an intrinsic drift or lust (Both et al., 2007; Freud, 1953). A different, more modern approach to sexual desire is the incentive motivational model, which entails that sexual arousal and desire result from the processing of a competent stimulus, for example, an attractive member of the preferred sex (Both et al., 2007; Toates, 2014). Sexual arousal is seen as an emotional reaction to a stimulus, comparable to other emotional responses such as fear, that is instigated by stimuli appraised as dangerous (Both et al., 2007; Smid & Wever, 2019). Processing stimuli with emotional significance results in excitation of emotion systems and in action

readiness expressed in bodily reactions that prepare for adequate behavioral responses (LeDoux, 2012). The incentive motivational approach of sexual arousal enables us to include insights acquired in emotion research, such as the process of excitation transfer, first described by Zillmann (1971). If an emotion surges while another lingering emotion is still present, it will “inseparably combine with the excitatory reaction to the present stimuli and thereby intensify both emotional behavior and emotional experience” (Zillmann, 1996, p. 250). In other words, excitation will transfer from one emotion to another, resulting in a stronger emotional experience, because the remaining arousal of one prior emotion is cognitively (mis)attributed to another subsequent emotional stimulus.

With regard to unusual or deviant sexual interests, it leaves one wondering how certain stimuli that seem very nonsexual in nature, such as young children, pain, or dead bodies, could trigger sexual desire. It is suggested that through excitation transfer, sexual salience could be attributed to stimuli that would otherwise not be sexual in nature (Smid & Wever, 2019). As such, excitation transfer could contribute to the very beginning of unusual sexual interests. Being in an emotional state facilitates emotional learning. Activated emotional systems facilitate the attention to emotionally significant stimuli, as well as retrieval of relevant memories and strengthening of previously learned responses, from which new learning occurs (LeDoux, 2012). Repeatedly co-occurring experiences become associated at the brain level (Löwel & Singer, 1992). If an emotional stimulus is repeatedly coupled with a sexual stimulus, learning and conditioning processes might ultimately make the stimulus potent enough to induce sexual arousal itself (Brom et al., 2014a; Pavlov, 1927; Skinner, 1937). This repeated co-occurrence of sexual arousal and other emotional arousal does not have to be coincidental. An individual may purposefully strive for it because it worked well before, especially if other, more common stimuli, do not induce the desired level of sexual arousal. Sexual excitement and gratification are such strong reinforcers that even sexually irrelevant stimuli can become associated with sexual reward (Brom et al., 2014a). This way, unusual stimuli like pain (masochism) or emotions like disgust (coprophilia) may become associated with sexual arousal. It is unlikely and not claimed here that excitation transfer between sexual arousal and another emotion equals definite unusual sexual interests; however, it could be one of the working mechanisms in the very early stages of stimulus appreciation and appreciation motivation (Wang & Lang, 2012).

### Empirical Support for Excitation Transfer

Currently, most research into excitation transfer is carried out in the media and advertisement domain, where the interaction between arousal and valence of television shows and response to subsequent advertisements is researched (Wang & Lang, 2012). From this, it seems that both of the

transferring emotions do not necessarily have to be of comparable valence. Also, the optimal window in experimental studies seems to be within the first two minutes after initial arousal induction (Wang & Lang, 2012).

Much of the research into sexual excitation transfer is quite dated; yet, these studies indicate that sexual arousal can indeed transfer to or from other emotions. For example, it is generally accepted that there is a bidirectional relation between feelings of affection or love and sexual desire (Diamond, 2003). Furthermore, some studies found that emotional arousal induced by, for instance, rollercoaster rides (Meston & Frohlich, 2003), exciting sports films (Staley & Prause, 2013; White et al., 1981), or arousing music (Marin et al., 2017) transferred to feelings of affection or increased attractiveness of (potential) partners.

Most studies regarding sexual excitation transfer consider the transfer between sexual stimuli and aggression. For instance, it was found that pre-exposure to erotic videos led to more aggressive behavior in male students than neutral pre-exposure (Zillmann, 1971; Zillmann et al., 1981). A meta-analytic review concluded that sexual stimuli and, to a larger extent, violent sexual stimuli increase subsequent aggressive behavior (Allen et al., 1995). Vice versa, it was found that listening to both sexually aggressive and nonsexually aggressive stories increased penile tumescence in male students more than listening to neutral stories (Malamuth et al., 1986). These studies indicate that transfer from sexual arousal to aggression is possible, as is transfer from aggression to sexual arousal.

Other studies investigated the transfer between fear and sexual arousal. It was found that, compared to a neutral state, video-induced anxiety increased subsequent genital sexual arousal in response to an erotic video in women (Hoon et al., 1977) and men (Wolchik et al., 1980). Likewise, fear of receiving an electric shock while watching erotic films increased erectile response in men (Barlow et al., 1983). Dissimilar results have been found as well, for instance in a study with women, who showed less genital sexual arousal after a pain threat than in a neutral condition (Brauer et al., 2007). Another study injected male volunteers with epinephrine as a “physiological analogue of clinical anxiety” (Lange et al., 1981, p. 449). The authors found that injected subjects showed the same erectile response as subjects receiving no injection during a sexual video and decreased erections after the video. A possible explanation for these discrepancies could be the existence of a curvilinear relationship between emotional arousal and sexual arousal, where both too low or too high emotional arousal would inhibit sexual arousal. Such a curvilinear relationship has been found in a study in which women with moderate state anxiety showed increased sexual arousal when watching an erotic video compared to women with either low or high state anxiety (Bradford & Meston, 2006).

Finally, Zillmann (1996) mentioned a ceiling effect: If a sexual stimulus induces the maximum sexual arousal under the given circumstances, then the transfer of another emotion has no room to further increase that sexual arousal. This was also illustrated by a recent study that compared genital responses in 48 male students exposed to consensual and violent sexual audio stimuli (Lalumière et al., 2017). The induction of both a happy and a sad mood increased genital response to the violent sexual stimuli but not to the consensual sexual stimuli, as these apparently had already reached their maximum.

## The Current Study

In conclusion, most research into *sexual* excitation transfer with male samples is from the previous century. Given its hypothesized role in the development of unusual or deviant sexual interests (Smid & Wever, 2019), it is relevant to renew and expand the investigation of this mechanism. In this pilot study we primarily aimed to assess whether it is possible to induce excitation transfer between emotions and sexual arousal in a community sample of healthy adult men. We hypothesized that sexual arousal in response to sexual stimulation, at least for some men, would be higher in an emotional state than in a nonemotional, neutral state. Additionally, we aimed to explore the optimal parameters to create this effect, to pave the way for larger-scale follow-up studies. Therefore, we focused on the following secondary research questions, which will be illustrated below:

- (a) Do excitation transfer effects vary between two different test conditions, i.e., consecutive vs. simultaneous, found in the literature (i.e., Barlow et al., 1983; Zillmann, 1996)?
- (b) Do excitation transfer effects vary between different emotions?
- (c) Are specific subject characteristics associated with excitation transfer effects?

Regarding (a), in accordance with Zillmann (1996) and most other studies that create excitation transfer in a consecutive approach (e.g., Lange et al., 1981), the combined arousal effect is attributed to the most recent stimulus. Initial anxiety followed by sexual arousal will result in stronger sexual arousal, but initial sexual arousal followed by anxiety will result in stronger anxiety and less sexual arousal (Hoon et al., 1977). The findings of Barlow et al. (1983), however, are slightly different. Participants watching an erotic video showed larger erectile responses when they *simultaneously* anticipated an electric shock. Even though the consecutive Zillmann method is most frequent in previous research findings, the simultaneous Barlow method appears intuitively closer related to sexual deviance, since deviant stimuli are usually present throughout and not just preceding the deviant sexual activity. Therefore, we included both methods in our

experimental procedure. We hypothesized that both methods would be able to induce excitation transfer.

Regarding (b), emotions that increase sympathetic arousal are considered more obvious candidates for enhancing sexual arousal than emotions that decrease sympathetic arousal (Toates, 2014). We included four different emotions: aggression/dominance, endearment, fear, and disgust. These emotions can be organized across a valence axis, contrasting positive and negative value, and an activation axis, contrasting increased sympathetic arousal and decreased sympathetic arousal (Damen et al., 2008; Kreibig, 2010; Lalumière et al., 2017; Mikels et al., 2005; Wang & Lang, 2012). Moreover, various unusual or deviant sexual interests can be traced to these four emotions. Aggression/dominance, a more instrumental kind of aggression, can be seen as the feeling of having the upper hand, being the victor, and as such represents a subjectively positive emotion that increases sympathetic arousal (Hamer et al., 2007; Kreibig, 2010; Schachter, 1957). This emotion appears to play a role in sexual interest in rape, sadism, and BDSM (Fedora et al., 1992; Pfattheicher & Schindler, 2015). Fear represents a negative emotion that increases sympathetic arousal (Aue et al., 2007; Baldaro et al., 1996; Kreibig, 2010). This emotion might be reflected in sexual interests such as masochism [cf. the mechanism described in Rozin et al., (2013)] or “extended” exhibitionism, i.e., having sex while at risk of being seen (Joyal & Carpentier, 2017; p.165), where a component of fear of pain, discovery, or embarrassment seems present. Endearment represents a positive emotion that decreases sympathetic arousal (Boiten, 1998; Eisenberg et al., 1988; Kreibig, 2010; Tsai et al., 2002). It is suggested that this emotion may play a role in pedophilia (Cantor & McPhail, 2016; Smid & Wever, 2019). An often stated claim of pedophiles is that not sexual attraction per se, but rather affection and endearment primarily or initially draw them toward a child (Collings, 1997; Martijn et al., 2020; Schmidt, 1991). Likewise, recent neuropsychological findings indicate that child stimuli activate nurturing brain areas in pedophilic men and not in healthy controls (Ponseti et al., 2018). Disgust represents a negative emotion that decreases sympathetic arousal (Cisler et al., 2009; Kreibig, 2010) and seems to play a role in extremely rare sexual interests like coprophilia (sexual attraction to feces) or necrophilia (sexual attraction to corpses) (Joyal & Carpentier, 2017). We hypothesized that aggression/dominance and fear, emotions that increase sympathetic arousal, would show higher excitation transfer effects than endearment and disgust (Toates, 2014).

Regarding (c), we explored several subject characteristics in relation to excitation transfer. Firstly, decreased erectile functioning could be a motivator to seek excitation transfer: One needs stronger stimuli to achieve sexual arousal or gratification (Smid & Wever, 2019). Also, higher sympathetic arousal has been related to smaller erections (Harte, 2013), less orgasms through normal intercourse (Costa & Brody, 2012), and more problematic erectile functioning (Rowland, 2010; Turan &

Gürel, 2020). Therefore, we hypothesized that excitation transfer would be associated with decreased erectile functioning and increased resting state sympathetic arousal. Furthermore, there is a high comorbidity between various deviant sexual interests (Dawson et al., 2016; Joyal & Carpentier, 2017). Also, sexual stimuli activate the brain in a largely nonspecific manner (Both et al., 2007). Therefore, we expect that excitation transfer would be associated with an underlying sensitivity to unusual sexual interests in general (i.e., “erotophilia,” the love of any erotic stimulus; Fisher et al., 1988).

## Method

### Participants

The sample consisted of  $N=30$  male volunteers, aged 19–40. Given that  $N=12$  is a rule of thumb for pilot studies where inferential statistics are calculated (Julious, 2005), two groups of  $n=15$  (total  $N=30$ ) seemed sufficient and allowed for 20% drop out in each group. Subjects were recruited in the Netherlands by advertorials on university sites and campuses, advertorials on social media outlets, and snowball sampling from the experimenters’ social networks. Potential subjects were informed that they would join a study about the influence of emotions on sexual arousal and were screened on the following indication criteria: no cardiovascular problems, no organic erectile dysfunctions, and age within the range 18–40 years. All subjects reported having the Dutch nationality and completing at least secondary education. Subjects were alternately assigned to the Barlow condition ( $n=15$ ) or the Zillmann condition ( $n=15$ ). There were no a priori differences between the two conditions regarding age, educational level, relationship status, or sexual orientation (see Table 1).

## Measures

### Sexual Arousal Induction

Sexual arousal was induced with genital vibrostimulation. This enabled the simultaneous presentation of sexual stimuli and emotional film fragments in the Barlow condition (see Procedure section). Vibrostimulation is known to induce significantly less sexual arousal than erotic film clips (Janssen et al., 1994) which matched our purpose to avoid possible ceiling effects in sexual arousal that would leave too little room for excitation transfer (Lalumière et al., 2017; Zillmann, 1996). Genital vibrostimulation was administered following the procedure used by Brom et al. (2014b). Participants were instructed to place a hands-off ring-shaped vibrator just below the coronal ridge of the penis. In each experimental block, vibrostimulation was induced for 40 s. In order to prevent measurement issues due to extremely low levels of genital sexual arousal, vibrostimulation was combined with a 20-s erotic film fragment, which started 10 s prior to vibrostimulation and continued 10 s parallel to the vibrostimulation. The preceding erotic film fragments were five different fragments originating from the same erotic movie, depicting heterosexual coitus, and were presented in a different order for each participant. The total duration of sexual arousal induction was 50 s per experimental block. This procedure was tested beforehand in a small ( $N=10$ ) feasibility sample. The vibration and film stimuli were presented using the stimulus delivery and experiment control software Presentation (NeuroBehavioral Systems, CA, USA).

### Emotion Induction

Emotional arousal was induced by means of film fragments, which is the most common method to induce emotions (Kreibig, 2010). Four different emotional film fragments of 30 s were

**Table 1** Demographic information of the total sample and condition subgroups

	Total ( $N=30$ )	Barlow ( $n=15$ )	Zillmann ( $n=15$ )	Effect size $d$ or OR	95% CI [LB, UB]
Age, $M(SD)$	25.50 (5.24)	26.47 (6.20)	24.53 (4.05)	$d=0.38$	[-1.43, 2.19]
<i>Last completed education, %(n)</i>					
Secondary Education	36.70 (11)	33.40 (5)	40.00 (6)	OR=0.75	[0.17, 3.33]
High School/Bachelor	30.00 (9)	40.00 (6)	20.00 (3)	OR=2.67	[0.52, 13.66]
University/Master	33.30 (10)	26.70 (4)	40.00 (6)	OR=0.55	[0.12, 2.55]
<i>Relationship status, %(n)</i>					
Single	60.00 (18)	66.70 (10)	53.30 (8)	OR=1.75	[0.40, 7.66]
< 2 yr Partner	23.30 (7)	20.00 (3)	26.70 (4)	OR=0.69	[0.12, 3.79]
> 2 yr Partner	16.70 (5)	13.30 (2)	20.0 (3)	OR=0.62	[0.09, 4.34]
<i>Sexual orientation, %(n)</i>					
Exclusively Hetero	73.30 (22)	66.70 (10)	80.00 (12)	OR=0.50	[0.10, 2.63]
Predominantly Hetero	13.30 (4)	20.00 (3)	6.70 (1)	OR=3.50	[0.32, 38.23]
Other	13.30 (4)	13.40 (2)	13.40 (2)	OR=1.00	[0.12, 8.21]

presented. Aggression/dominance was induced by a fight scene from the movie “Transporter 3” (2008). Fear was induced by a film fragment of a shark attack. Endearment was induced by a film fragment of a kitten. Disgust was induced by a cannibalism scene from the movie “Hannibal” (2001). Also, a 30-s neutral film fragment was composed of scenes from a nature documentary containing time-lapse recordings of forests, meadows, and icebergs. The emotional film fragments were prior validated in a stimulus validation study ( $N=171$ ) and proved to effectively induce the intended emotions (film fragments and report available upon request).

### Sexual Arousal Assessment

**Genital Sexual Arousal** Indium/gallium-in-rubber strain gauges (Behavioral Technology INC, Salt Lake City, USA) were used to assess changes in penile circumference (penile plethysmography; PPG). PPG is a common and validated measure of male genital sexual arousal (Bancroft et al., 1966; Janssen et al., 2007; Merdian & Jones, 2011) and has been used in previous studies in the same sexology laboratory (Both et al., 2020; Brom et al., 2014b, 2015, 2016). Increases in penile circumference result in corresponding changes in resistance. Changes in electrical output caused by expansion of the gauge were recorded by a continuous DC signal registered by the software program Vsrrp98 (Molenkamp, 2011). The participants were instructed to place the indium/gallium gauge halfway up the shaft of the penis, between the vibrator ring and the body. Research has indicated that PPG assessment is experienced by participants as relatively noninvasive (Huberman & Chivers, 2015). In the current study, we asked subjects during the exit interview how comfortable they felt during the experiment: 27% of the subjects reported feeling “very comfortable,” 43% “comfortable,” 17% “neutral,” 13% “uncomfortable,” and no-one indicated “very uncomfortable.”

For each participant, we calculated the percentage penile increase in response to sexual stimulation relative to the baseline status at the start of each experimental block. The percentage increase in the neutral block was used as a measure of penile reactivity. Penile reactivity represents the reactivity to mere, plain sexual stimulation without added emotion, and as such was used a physiological indication of general sexual functioning. To calculate the final genital excitation transfer scores, we subtracted the percentage penile increase in the neutral block (i.e., penile reactivity) from the percentage penile increase in each emotional block, resulting in four excitation transfer scores regarding aggression/dominance, endearment, fear, and disgust. As such, positive genital excitation transfer scores indicated that sexual arousal was higher in the emotional blocks than in the neutral block.

**Subjective Sexual Arousal** In addition to the genital assessment of sexual arousal, participants rated the extent to which they felt sexually aroused on a 10-point scale, ranging from 1 (not at all aroused) to 10 (extremely aroused), following each sexual arousal induction. To calculate subjective excitation transfer scores, we subtracted the sexual arousal rating in the neutral block from the sexual arousal rating in each emotional block. As such, positive subjective excitation transfer scores indicated that sexual arousal was higher in the emotional block than in the neutral block.

### Sympathetic Arousal Assessment

**Heart Rate** Heart rate data were recorded continuously using Vsrrp98 software (Molenkamp, 2011) and electrode placement according to a standard Lead-II configuration (Nikolić et al., 2018). Heart rate is reported in mean number of beats per minute. Heart rate during the emotional manipulation was used as a manipulation check to verify whether the emotional films had the intended reactions. Heart rate during the three-minute pre-experimental resting phase was used as a measure of resting state sympathetic arousal.

**Self-Assessment Manikin** In addition to the physiological assessment of sympathetic arousal, in each block participants rated their affective reaction to each of the emotional film clips and the neutral film clip by means of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). The SAM directly assesses valence, arousal, and dominance of a stimulus using graphic depictions. Only the SAM scores regarding arousal and valence were used in this study. The valence dimension is depicted by five manikins ranging from smiling to unhappy. The arousal dimension is depicted by five manikins ranging from aroused, wide-opened, excited, to relaxed, sleepy. Subjects indicate their rating by marking the corresponding figure on each dimension (1–5), where higher scores indicate more positive value and more emotional arousal. Judgments from the SAM show sufficient content validity when compared to other measures (Bradley & Lang, 1994).

### Self-Reported Sexual Functioning

The International Index of Erectile Function (IIEF) is a 15-item self-report questionnaire that assessed sexual and erectile functioning (Rosen et al., 1997). A sample question is: “How often were you able to get an erection during sexual activity.” Items 1–10 were rated on a 6-point Likert scale ranging from 0 (not at all, negative) to 5 (always, positive), and items 11–15 were rated on a 5-point scale ranging from 1 (weakly, unsatisfied) to 5 (strongly, very satisfied). Sum scores range from 15 to 85, and lower sum scores indicate more problematic sexual functioning. The IIEF has shown good test–retest reliability and construct

validity (Rosen et al., 1997). In the current study, the IIEF showed very high internal consistency with Cronbach's  $\alpha=0.93$ .

### Self-Reported Sexual Interests

The Sexual Opinion Survey (SOS) is a 21-item self-report questionnaire that rated interest in sexual behaviors along a dimension ranging from erotophobia, i.e., a negative evaluation of sex, to erotophilia, i.e., a positive evaluation of sex (Fisher et al., 1988). A sample question is: "I think it would be very entertaining to look at hard-core pornography." We adapted the SOS by adding four items, specifically reflecting sexual interests associated with the emotional stimuli used in the current study, for example: "The thought of engaging in unusual sexual practices involving *fear* is highly arousing"; and likewise for aggression/dominance, endearment, and disgust (not further reported upon in this paper). Items were rated on a 7-point Likert scale, ranging from 1 (strongly agree) to 7 (strongly disagree). For the sake of consistency with the other measures, ultimately all SOS scores were reversed such that higher sum scores (maximum score 175) reflected more erotophilia and lower sum scores (minimum score 25) reflected less erotophobia. In previous research, the original SOS showed good internal consistency (Cronbach's  $\alpha=0.88$ ) and good convergent and discriminant validity (Fisher et al., 1988). In the current study, the SOS showed low internal consistency with pretest SOS Cronbach's  $\alpha=0.38$ . Deletion of the added items did not considerably improve the internal consistency.

### Procedure

This experiment was carried out in a sexology laboratory of a university medical center. All subjects signed the informed consent form. Subjects digitally completed demographic questions regarding age, educational level, relationship status, and sexual orientation, and the pretest questionnaires IIEF and SOS (the Sexual Inhibition/Excitation Scales [Janssen et al., 2002] were also part of the study but are not reported upon in this paper). The researcher then adjusted the heart rate electrodes to the subject's bare chest. The researcher provided instructions for the subject to adjust the penile strain gauge and vibrating ring to his penis and left the subject in private in the experimental room to prepare for the experiment. The experimental room consisted of a comfortable chair from which subjects could view the television screen on which the emotional stimuli and questions were projected, along with a side table with a mouse to answer the on-screen questions. The experiment consisted of the induction of sexual arousal by means of a short sexual film fragment followed by penile vibrostimulation and the induction of emotional arousal by means of film fragments in five different blocks presented in a different order for each participant: an aggression/dominance block, endearment block, fear block, disgust block, and a neutral block with nature documentary

fragments. Subjects were alternately assigned to the Barlow et al. (1983) condition with simultaneous emotion induction and sexual arousal induction, or the Zillmann (1996) condition in which sexual arousal induction followed emotion induction.

Each experiment started with a three-minute neutral nature film in order for the subject to get adjusted to the setting. Then, each of the five experimental blocks started with one more minute of neutral film: the baseline window for each experimental block. After this, in the Barlow condition, the sexual arousal induction (total 50 s) preceded (20 s) and paralleled the emotional film fragment (30 s). In the Zillmann condition, the sexual arousal induction (50 s) followed the emotional film (30 s). Following this, subjects indicated their subjective level of sexual arousal on the television screen with the mouse. Then, subjects rated arousal and valence of the emotional film fragment with the SAM. The subjects' levels of emotional and sexual arousal were then during two minutes returned to baseline with a simple counting task, i.e., counting backward from a given number, and neutral film fragments. Heart rate and penile circumference were recorded throughout the experiment.

After the experiment, subjects were given the time they needed to recover, remove the strain gauge and vibration ring, and get dressed. Subsequently, they were asked to fill out the posttest questionnaire SOS (not reported in this paper) and an exit interview in which they rated the strength of the emotional stimuli and the erotic stimuli. Afterward, subjects were fully debriefed regarding the rationale behind the study. Subjects received a €35 gift card for their participation. The procedure was approved by the Institutional Review Board of the Free University Medical Center in Amsterdam, the Netherlands, and follows the ethical standards from the 1964 Declaration of Helsinki and its later amendments.

### Data Preparation

#### Genital Arousal

Genital sexual arousal was assessed during a baseline window and a response window in each experimental block. The baseline window was the 60-s window at the start of each block, prior to the emotion induction and sexual arousal induction. The response window was the 60-s window starting with the vibrostimulation. For the data preparation, we followed the procedures described in Huberman and Chivers (2015) and Barlow et al. (1983). This means that within these 60-s windows, we averaged data across 15-s epochs, yielding 4 data points for the baseline window and 4 data points for the response window. We selected the epochs with the highest mean, indicating the maximum genital reaction within the baseline and the response windows. The use of the maximum reaction is appropriate when assessing sexual reactions that may not be sustained for prolonged time (Huberman & Chivers, 2015). With these highest epochs, we calculated the

percentage increase from baseline to response for each of the four emotional blocks and for the neutral block.

### Heart Rate

Heart rate scores were calculated in a similar manner to genital arousal scores. For the manipulation check, we used the 60-s window following the start of each emotional and neutral film fragment. Heart rate data were averaged across 15-s epochs, from which the highest epoch was used as outcome measure. As such, heart rate during emotional blocks was compared to heart rate during the neutral block. For the resting state sympathetic arousal, we used the highest of the 15-s epochs during the three-minute resting phase at the start of the experiment (cf. Harte, 2013; Lorenz et al., 2012; Stanton & Meston, 2017).

### Statistical Analyses

#### Manipulation Check

Nonresponders on the PPG assessment were defined as those subjects whose percentage penile increase in response to sexual stimulation was zero or negative on all emotional blocks and the neutral block. (NB. Negative responses could exist when their sexual arousal after sexual stimulation, i.e., in the response window, was lower than their sexual arousal without sexual stimulation, i.e., in the baseline window.) These nonresponders were discarded from the analyses of genital sexual arousal. Nonresponders on subjective sexual arousal were defined as those subjects who scored 1 (lowest score) on self-reported sexual arousal in all emotional blocks and the neutral block, and were discarded from the analyses of subjective sexual arousal. Furthermore, in order to verify whether the emotion manipulation succeeded as intended, analyses of variance (ANOVAs) were used to compare heart rate scores, SAM arousal scores, and SAM valence scores between the experimental blocks. The emotional manipulation check for heart rate could only be calculated for condition Zillmann, because in condition Barlow the sexual vibro-stimulation coincided with emotional manipulation and could cause interference.

#### Main Analyses

To assess whether excitation transfer was induced, an ANOVA was used to test whether genital sexual arousal (percentage increase) differed between the neutral, aggression/dominance, endearment, fear, and disgust blocks. A second ANOVA was used to test whether subjective sexual arousal differed between the blocks. Since the effects may be not linear, we also explored the effects on the individual level. The total sample was divided into a subgroup of subjects

showing genital excitation transfer in at least one of the emotional blocks (excitation transfer group) and a subgroup showing no genital excitation transfer in any of the emotional blocks (no-excitation transfer group) and likewise for subjective excitation transfer. With these subgroups, two separate ANOVAs were used to test again if genital sexual arousal and subjective sexual arousal differed between the emotional and neutral blocks.

For the whole group, a MANOVA was used to assess whether overall genital and subjective excitation transfer scores (i.e., sexual arousal in emotional block minus neutral block) differed between condition Barlow and Zillmann. Also, a Chi-square test was used to assess whether the frequency of the occurrence of excitation transfer effects differed between condition Barlow and Zillmann. To compare excitation transfer effects across the different emotions, we calculated Pearson correlations between both genital and subjective excitation transfer scores in the various emotional blocks. Finally, to explore the relation between excitation transfer and various subject characteristics, we calculated Pearson correlations between both genital and subjective excitation transfer scores and resting state sympathetic arousal (heart rate), penile reactivity (percentage penile increase in the neutral block), self-reported erectile functioning (IIEF scores), and self-reported erotophilia (SOS scores). All statistical analyses were performed using *IBM SPSS Statistics 21*. Effect sizes are reported according to Cohen's standards, where  $d = 0.20$  is considered a small effect,  $d = 0.50$  medium, and  $d = 0.80$  large effect (Cohen, 1992), together with the 95% confidence intervals of  $d$ .

## Results

### Manipulation Check

Two subjects from condition Barlow qualified as nonresponders on genital sexual arousal. One subject from condition Zillmann qualified as a nonresponder on subjective sexual arousal. Heart rate did not differ significantly between the emotional blocks in condition Zillmann,  $F(4, 70) = 0.43$ ,  $p = 0.788$ ,  $d = 0.31$ , a small effect size. However, heart rate changes were in the expected directions, with aggression and fear slightly increasing and endearment and disgust slightly decreasing sympathetic arousal, relative to neutral. SAM emotional arousal scores differed significantly between emotional blocks for the whole sample,  $F(4, 145) = 7.95$ ,  $p < 0.001$ ,  $d = 0.94$ , a large effect size. As expected, aggression/dominance and fear caused increased arousal and endearment caused decreased arousal. Contrary to expectations, subjects reported increased arousal to the disgust film (while heart rate data pointed in the opposite direction). SAM emotional valence scores differed significantly between the experimental blocks,  $F(4, 145) = 36.38$ ,  $p < 0.001$ ,  $d = 2.00$ ,



a large effect size. In agreement with expectations, valence was positive (higher scores) for aggression/dominance and endearment, and negative (lower scores) for fear and disgust. Online Supplement Table S1 displays means, standard deviations, and effect sizes of heart rate and SAM scores. We conclude that the emotional manipulations could be improved, but were sufficiently successful.

### Excitation Transfer Effects

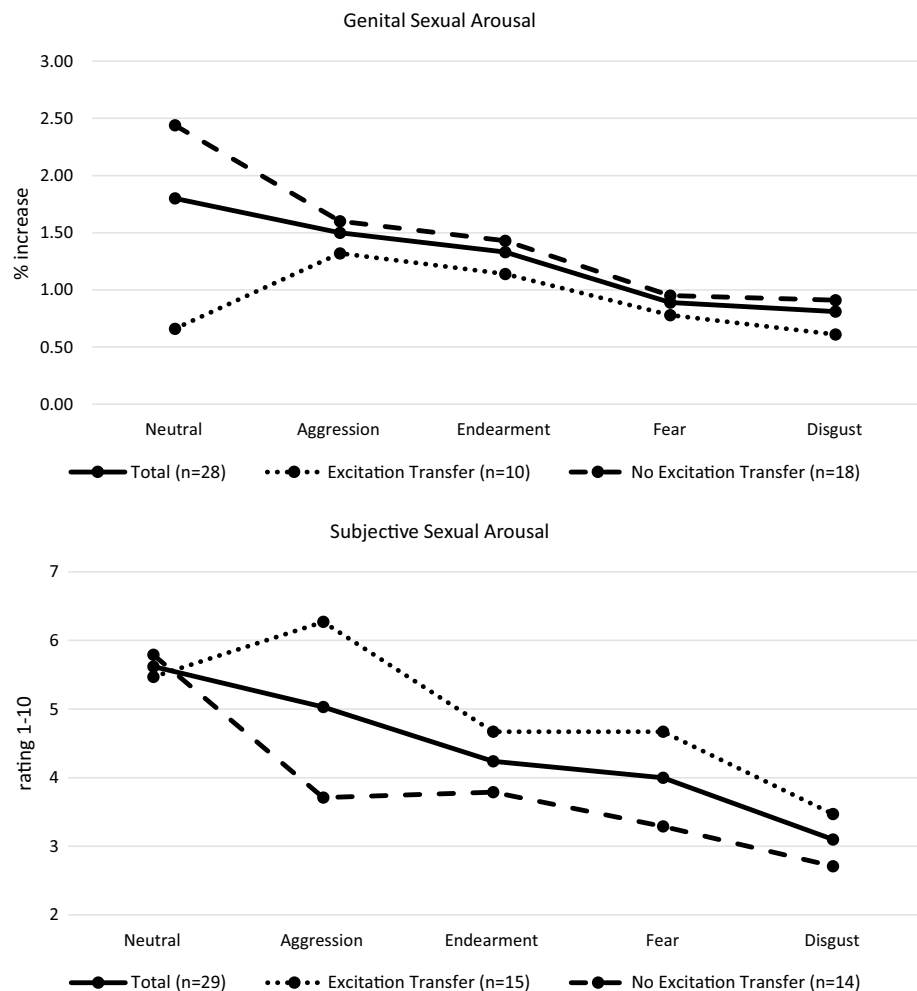
Genital sexual arousal differed significantly between the experimental blocks,  $F(4, 135)=3.49, p=0.010, d=0.64$ , a medium effect. Post hoc tests showed that genital sexual arousal was higher in the neutral block than in the endearment, fear, and disgust blocks (see Fig. 1 and Online Supplement Table S2). Also, subjective sexual arousal differed significantly between the experimental blocks,  $F(4, 140)=6.54, p<0.001, d=0.86$ , a large effect. Post hoc tests showed that subjective sexual arousal was higher in the neutral block than in the endearment, fear, and disgust blocks. Thus, on the group level, no-excitation transfer

could be discerned, as the average sexual arousal was lower in all emotional blocks than in the neutral block.

Comparable results were found when repeating the analyses with a split sample (excitation transfer group vs. no-excitation transfer group), with the exception that genital sexual arousal did not differ significantly anymore between the experimental blocks in the excitation transfer group,  $F(4, 45)=1.25, p=0.304, d=0.67$ , a medium effect. From Fig. 1 (and online supplement Table S2) it is visible that the excitation transfer group showed lower genital sexual arousal on all blocks than the no-excitation transfer group, with remarkably lower genital arousal on the neutral block (a large effect,  $d=1.49$ ), a difference much larger than the differences on the other emotions. Conversely, subjective arousal was higher on all experimental blocks for the excitation transfer group than for the no-excitation transfer group.

Looking at individual scores, 18 out of the 30 subjects (60%) displayed some type of excitation transfer (see Table 2). Regarding genital sexual arousal, 10 out of 28 subjects (36%) scored higher in at least one emotional condition than in the neutral condition. Regarding subjective sexual arousal, 15 out of 29 subjects (52%) scored higher in at least one emotional condition than in

**Fig. 1** Genital and subjective sexual arousal scores in the experimental blocks. *Note.* All blocks were presented in quasi-randomized order (different order for each subject)



the neutral condition. These subgroups overlapped partly: Seven subjects (23%) showed excitation transfer on both genital arousal and subjective arousal.

A post hoc power analysis indicated that, with a moderate effect size, a potential follow-up study would need 21 participants who showed excitation transfer. As 60% of our sample showed excitation transfer, this translates to a sample size of  $N=35$ . This number is likely a lower bound estimate as suggested changes in the procedure may lead to a different outcome.

### Comparison of Condition Barlow and Zillmann

Condition Zillmann and Barlow did not have significantly different effects on genital or subjective excitation transfer scores, Wilks'  $\Lambda(2, 106)=0.99, p=0.760, d=0.14$ , a small effect. Also, there was no significant difference between the frequency of the occurrence of excitation transfer (as in Table 2) in both conditions; genital  $\chi^2(3)=0.22, p=0.975$ ; subjective  $\chi^2(3)=0.80, p=0.850$ .

### Comparison of the Different Emotions

Figure 1 (and online supplement Table S2) shows that in general, aggression produced the highest sexual arousal levels in the excitation transfer group, followed closely by endearment. Table 2 shows that aggression/dominance also caused excitation transfer most frequently, followed by endearment and fear, and disgust caused excitation transfer the least. Furthermore, the genital excitation transfer levels in the various emotional blocks showed significant medium to large inter-correlations ( $p < 0.012, r$  between 0.47 and 0.77), as did the subjective excitation transfer levels in the various emotional blocks ( $p = 0.054, r$  between 0.36 and 0.61), indicating that subjects who showed higher levels of excitation transfer in one emotional condition were more likely to also show higher levels of excitation transfer in other emotional conditions. The overall correlation between genital and subjective excitation transfer was  $r=0.38, p=0.049$ , indicating a moderate agreement between genital and subjective assessment of excitation transfer.

**Table 2** Frequency of occurrence of excitation transfer per emotion

	Genital excitation transfer			Subjective excitation transfer		
	Total ( $n=10/28$ )	Barlow ( $n=4/13$ )	Zillmann ( $n=6/15$ )	Total ( $n=15/29$ )	Barlow ( $n=6/15$ )	Zillmann ( $n=9/14$ )
Aggression	8	3	5	11	5	6
Endearment	8	3	5	3	1	2
Fear	7	2	5	6	3	3
Disgust	5	2	3	2	0	2

### Subject Characteristics

Pearson correlations are displayed in Table 3. Additionally, resting state sympathetic arousal (HR) was not related to penile reactivity ( $r = -0.04, p = 0.835$ ) but did show a moderate and significant negative correlation with self-reported erectile functioning on the IIEF ( $r = -0.38, p = 0.038$ ). The two measures of erectile functioning, i.e., penile reactivity and IIEF scores, showed a small-moderate intercorrelation ( $r = 0.18, p = 0.335$ ).

### Discussion

The current study assessed whether it was possible to create excitation transfer between sexual arousal and other emotions in a sample of healthy adult men. Also, we investigated whether excitation transfer effects varied between the two conditions Barlow and Zillmann, whether effects varied between different emotions, and whether effects were associated with specific subject characteristics. On a group level, we found no-excitation transfer, as subjects were less sexually aroused in the emotional blocks than in the neutral block. Looking at individual scores, however, 60% of the subjects showed excitation transfer between at least one emotion and sexual arousal. This indicates that there were large individual differences, which were averaged out on the group level. This is for instance comparable to the relatively large variance reported by Brauer et al. (2007), who could not find an effect on the group level either. In line with our expectations, there was no evidence to indicate that either the Zillmann

**Table 3** Pearson correlations between subject characteristics and excitation transfer

	Genital excitation transfer ( $n=28$ )		Subjective excitation transfer ( $n=29$ )	
	<i>R</i>	<i>p</i>	<i>R</i>	<i>p</i>
Penile Reactivity (% increase)	-.79	<.001	-.28	.145
Erectile Functioning (IIEF)	-.23	.240	-.06	.774
Resting State Sympathetic Arousal (HR, bpm)	.20	.317	.01	.948
Erotophilia (SOS)	.56	.002	.33	.078

(1996) condition, with consecutive emotional and sexual stimuli, or the Barlow et al. (1983) condition, with simultaneous emotional and sexual stimuli, was more effective in creating excitation transfer.

Earlier studies did find excitation transfer on the group level—e.g., Cantor et al. (1975) with subjective arousal and Barlow et al. (1983) with genital arousal. While the current sample was of comparable nature and size, there are also some differences. Both the sexual and emotional stimuli in the prior studies were likely stronger: Barlow et al. used the actual threat of an electrical shock, and Cantor et al. recorded increased heart rate after physical exercise. Our manipulation check showed that the strength of the emotional responses could be improved, especially the physiological response (heart rate) to the emotional manipulation. In the Cantor et al. study, the sexual stimuli also lasted longer (3 min) than our 50 s. We deliberately aimed for low-level sexual arousal to avoid a ceiling effects and to leave room for transfer (cf. Lalumière et al., 2017; Zillmann, 1996), yet, in doing so we may have come near the opposite. It is notable that there was still a large significant correlation between penile reactivity and genital excitation transfer (less reactivity was associated with higher excitation transfer) that cannot be explained in the light of such a floor effect. Future research should include stronger stimuli to assess whether this relationship still exists when sexual and emotional arousal are higher. We were restricted to using vibrostimulation to enable simultaneous presentation to the emotional film fragments in the Barlow condition; however, future studies might use visual stimuli as these generally produce the strongest sexual arousal effects (Cabral et al., 2018).

Overall, emotional arousal more often transferred to subjective, self-reported sexual arousal than to genital sexual arousal. Sixty percent of the participants showed some form of excitation transfer, 36% showed excitation transfer between at least one emotion and genital sexual arousal, 52% showed excitation transfer between at least one emotion and subjective sexual arousal, and 23% showed both types of transfer. These results suggest that subjective sexual arousal was more easily manipulated than physiological, genital sexual arousal. It must be considered that conscious processing of emotions may be an enforcing condition for excitation transfer. This emphasizes the important role of cognitive control on sexual arousal and emotion processing (Toates, 2009). Subjective and genital excitation transfer was moderately correlated (overall  $r=0.38$ ). These relations are lower than previous findings regarding subjective and genital sexual arousal ( $r=0.66$ ), which can be due to the low-level sexual arousal and the relatively young sample in the current study (Chivers et al., 2010). It seems important to use both physiological and subjective measures, since they may diverge quite substantially.

## Comparison of the Different Emotions

Aggression/dominance was the most effective emotion to induce excitation transfer in terms of both intensity and frequency, whereas disgust was the least effective. This is partly according to our expectations that aggression/dominance and fear, emotions that increase sympathetic arousal, would show higher/more excitation transfer effects. Also, this is in accordance with the relative prevalence of associated sexual interests, where for instance BDSM (dominance) is more common than urophilia or coprophilia (disgust) (Dawson et al., 2016; Joyal & Carpentier, 2017).

Endearment did not cause excitation transfer in many participants, but when it did, it caused relatively large excitation transfer effects, specifically to genital sexual arousal. This is interesting given the hypothesized link between pedophilia and intense feelings of endearment toward children (Cantor & McPhail, 2016; Smid & Wever, 2019). A recent neurobiological study (Ponseti et al., 2018) showed over-responding to nurturing stimuli in pedophilic subjects in various motivational brain areas also related to the mating domain (e.g., the left anterior insula). This functional overlap of nurturing and sexual processing led the authors to the tentative conclusion that the functional division between the domains of nurturing and mating behavior in pedophilia may be incomplete. These and the current results emphasize that feelings of endearment or nurturement and excitation transfer are a relevant topic for future research in pedophilic samples.

Previous literature finds that disgust lowers physical arousal (Kreibig, 2010) and the same trend was visible in our heart rate data. Subjectively, participants in our study rated the disgusting film fragment as *more* emotionally arousing than the neutral film fragment. It is possible that the disgust film included a scare/shock effect, which may have resulted in higher self-reported emotional arousal. Subjects from both the stimulus validation study and the exit interview however reported that they distinctively found the disgust film fragment “disgusting.” The possible discrepancy between physiological and subjective effects of disgust warrants further investigation.

## Subject Characteristics

Several subject characteristics were related to excitation transfer. According to our hypothesis, especially genital excitation transfer was strongly related to decreased penile reactivity. Excitation transfer subjects did not show much larger sexual reactions on the emotional blocks, but rather, they showed distinctively lower reactions on the neutral block (penile reactivity). A similar trend was visible on self-reported erectile functioning (IEEF). These results provide tentative support for the “deficiency perspective” described by Smid and Wever (2019): For subjects that are less easily sexually aroused in general, extra emotional loadings may be specifically useful to facilitate sexual arousal.

In agreement with our hypothesis, higher resting state sympathetic arousal (heart rate) was moderately related to lower self-reported erectile functioning and larger genital excitation transfer effects, albeit the latter not significantly. Future aims may include larger sample sizes to increase statistical power when investigating the effects of the various parameters. To increase variance, these samples may also include subjects that have substantially higher than average baseline sympathetic arousal, as is often the case in samples with psychiatric symptoms (Bergman et al., 2020; Pereira-Morales et al., 2019; Thorsen et al., 2016).

Finally, our cognitive, self-report measures showed that more erotophilia (interest in various sexual activities) was strongly related to especially genital excitation transfer effects, which was in agreement with our expectations. It must be noted that the internal consistency of the Sexual Opinion Scale (SOS) was low, which indicates a large variability in answers within respondents; therefore, caution must be used when generalizing these results. Also, excitation transfer scores in all emotional blocks were substantially intercorrelated. It seems that a general excitation transfer susceptibility might exist, rather than a specific and exclusive preference for one specific stimulus, which provides a possible explanation for the notable overlap between deviant sexual interests as found in the literature (Dawson et al., 2016; Joyal & Carpentier, 2017; Wilpert, 2018). Openness toward various forms of sexuality could be a relevant factor in one's proclivity to excitation transfer, either as a cause, a consequence or both. Further research is needed to replicate and extend these findings.

### Limitations

Using a relatively young and well-educated sample to provoke excitation transfer in a laboratory setting limits generalizations to a broader population or real-life settings. Yet, a substantial part of the current healthy community sample was prone to excitation transfer between sexual arousal and other emotions. Pilot testing proved to be valuable: Follow-up studies should consider the reliability of the SOS, the strength of the emotional manipulation, and whether to incorporate a simultaneous or consecutive design (Barlow vs. Zillmann). Clearly larger-scale replications are needed; however, it is a strength that this pilot study explored individual patterns beyond the group level. This paves the way for research in more sexually diverse samples.

### Clinical Implications

If the current results are replicated, this provides more understanding about a mechanism that may play a role in the development of unusual sexual interests and maybe, eventually, deviant sexual interests. Possible research or

clinical avenues include the deficiency perspective, which points attention to more problematic general sexual functioning as possible facilitator of unusual sexual interests. Our results underscore research findings that, alongside a physiological component, cognitive appraisal and learning processes are important working mechanisms in sexual arousal and the appreciation of sexual stimuli (e.g., Brom, 2016; Toates, 2009). Sole pharmacological treatment of unusual sexual interests, for instance in sex offenders, might have adverse effects when penile reactivity is simply decreased and paves the way to consciously or unconsciously search for stronger emotional stimuli to feed the lacking sexual arousal. The finding that lower penile reactivity was related to more excitation transfer also implies that low PPG responders should not be excluded from analyses, as is often done in research (Meridian & Jones, 2011), without thorough consideration.

### Conclusion

This study aimed to create and measure excitation transfer between subjective and genital sexual arousal and various emotions in healthy men. The experimental manipulation resulted in the majority of the subjects being more sexually aroused by sexual stimulation in at least one emotional state than in the neutral state, although interindividual variability was large and effects were averaged out on the group level. Men with lower general erectile functioning seemed more susceptible to excitation transfer than men who were more easily sexually aroused. A general openness toward sexuality was associated with this mechanism. Our results indicate that for some people, excitation transfer increased the salience of stimuli that otherwise would not have been sexual in nature. This is important knowledge in the understanding of sexual behavior and the development of unusual sexual interests.

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### Declarations

**Conflict of interest** The authors declare that they have no conflict of interest.

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

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