Modulation of spinal reflexes by sexual films of increasing intensity

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Abstract
Sexual arousal can be viewed as an emotional state generating sex-specific autonomic and general somatic motor system responses that prepare for sexual action. In the present study modulation of spinal tendious (T) reflexes by sexual films of varying intensity was investigated. T reflexes were expected to increase as a function of increased film intensity. Through use of a between-subjects design, participants were exposed to three erotic films of low, moderate, and high intensity or to three films of moderate intensity. Self-report and genital data confirmed the induction of increasing versus stable levels of sexual arousal. Exposure to the films of increasing intensity resulted in increasing T reflexes. The results indicate that T reflex modulation is sensitive to varying levels of sexual arousal and may be of use in research on behavioral mechanisms underlying appetitive motivation.

Descriptors: Emotion, Motivation, Sexual arousal, T reflex, Reflex modulation

It was previously shown that the Achilles Tendon (T) reflex is modulated by emotional arousal (Bonnet, Bradley, Lang, & Requin, 1995), with positive and negative emotional stimuli facilitating T reflexes. Consistent with these findings we found that appetitive sexual films enhance T reflexes to the same extent as aversive films (Both, Everaerd, & Laan, 2003; Both, Spiering, Everaerd, & Laan, 2004). In the present study we investigated whether increasing emotional intensity of sexual stimuli instigates increasing action tendency strength, reflected in increased somatic motor activity, as measured by the T reflex.

According to incentive motivation models, sexual motivation is the result of the activation of a sensitive sexual response system by sexual stimuli in the environment or by internal representations of these stimuli (Everaerd, Laan, Both, & Spiering, 2001; Singer & Toates, 1987). Once the system is activated by an attractive sexual stimulus, responses are initiated that prepare for sexual action. The strength of these responses is determined by the sensitivity of the system, as well as by the attractiveness of the stimulus. The generation of appetitive behavior is accompanied by activity in somatic motor, autonomic, and endocrine systems (Robbins & Everitt, 1999), and this activity may include non-specific as well as emotion-specific responses (Bradley, 2000). To investigate whether sexual excitement is accompanied by preparation for action, we previously measured, in addition to sex-specific genital responses, somatic motor preparation in response to appetitive sexual and aversive films by means of T reflex modulation (Both et al., 2003). The T reflex is hypothesized to be involved in appetitively and defensively motivated action and, in contrast to the startle reflex, does not vary with the hedonic valence of an affective state. Rather, T reflexes are augmented in states of action, and modified primarily by differences in states of arousal (Bonnet et al., 1995; Brunia & Boelhouwer, 1988; Brunia & van Boxtel, 2000). Therefore, modulation of the T reflex offers a window on the generation of action. In our previous study, exposure to a sexually appetitive film induced genital responses and generated feelings of sexual arousal and subjective approach tendencies. Moreover, processing of either sexual or anxiety films augmented T reflexes, and T reflex magnitude was facilitated by sexual films to the same extent as by anxiety films. These data supported the view that sexual arousal is an emotional state, resulting in sex-specific autonomic and somatic motor system responses, preparing the organism for action.

The purpose of the present study was to investigate whether exposure to sexual films that vary in emotional intensity results in different levels of activation in the somatic motor system. Intensity is an important component of emotion because the strength of action tendency may determine, among other factors, whether emotions lead to actual behavior (Frijda, Ortony, Sonnemans, & Clore, 1992). Also, as is noted by Frijda et al., it is often the
intensity of emotion and the consequential behavior that may be considered as maladaptive. For example, too much, but also too little, fear can be problematic for a person or his or her social environment. Likewise, too much and too little sexual arousal and desire may be troubling. Studying the strength of action tendencies, and factors that influence it, will be useful in research on appetitive behavior and related problems such as addiction or hypo- or hyperactive sexual desire.

T reflexes can be elicited by a hammertap on the heel tendon, which results in a reflexive electromyographic (EMG) response in the soleus muscle of the lower leg. All things being equal, taps of a constant force lead to reflex amplitudes of constant size. Supraspinal excitatory or inhibitory influences on the involved motoneuron pool (or other elements) of the reflex arc are reflected in an increase or decrease in reflex amplitude. Thus changes in reflex amplitude are a peripheral manifestation of supraspinal processes influencing spinal excitability (Brunia & van Boxtel, 2000). It is known that T reflexes are augmented after the presentation of a loud noise or a bright light, as well as during reaction time tasks and mental arithmetic (Brunia & Boelhouwer, 1988), which has been interpreted as due to the effects of nonspecific arousal and are consistent with the hypothesis that T reflexes are modulated by emotional arousal.

Bonnet et al. (1995) studied the modulation of T reflexes during the presentation of pictures that varied in hedonic valence and in intensity. As expected, T reflexes were significantly augmented when elicited during processing of emotional pictures (both pleasant and unpleasant) as compared with neutral pictures. For unpleasant pictures, both low and high arousal stimuli augmented T reflexes and to a comparable extent. For the pleasant pictures, only reflexes elicited during highly arousing stimuli were significantly augmented. Similar to Bonnet et al., we hypothesized that emotional stimuli, more specifically sexual films, automatically initiate action tendencies, reflected in increased spinal excitability, and therefore expected that the strength of the action tendency would be associated with emotional intensity. T reflexes were measured during exposure to sexual films of low, moderate, and high intensity. We used film excerpts that have been previously found to evoke distinct and increasing levels of genital arousal in women (Laan, Everaerd, van der Velde, & Geer, 1995). To check for the induction of emotional intensity levels as intended, we measured genital response, subjective emotional responses, and subjective action tendencies. To determine whether increased T reflex magnitude is a function of emotional stimulus intensity and to rule out the possibility that reflex magnitude simply increases over time (i.e., independent from stimulus intensity), we included a control condition in which participants were exposed to three identical erotic film excerpts of moderate intensity. In a previous study, we found that repeated exposure to 21 identical erotic film excerpts resulted in stable levels of genital arousal in women (Laan, Everaerd, van der Velde, et al., 1995). Thus, in the experimental condition, participants were exposed to three sexual film excerpts of increasing intensity, which were expected to evoke increasing levels of genital arousal, subjective sexual arousal, subjective approach tendencies, and T reflex amplitude. In the control condition, participants were exposed to three identical sexual film excerpts of moderate intensity, which were expected to result in stable levels of genital arousal, subjective sexual arousal, approach tendencies, and T reflex amplitude.

Method

The data were collected at two sites (Tilburg University, N = 11; University of Amsterdam, N = 34). For the increasing intensity condition (N = 29), 11 participants were from the Tilburg University and 18 were from the University of Amsterdam. In the stable intensity condition (N = 16) all participants were from the University of Amsterdam. Stimulus materials and experimental procedures were identical at the two sites. Also, apart from some differences in technical setup, response measurement was identical at the two sites. Subjective action tendencies were measured from the 24 participants at the University of Amsterdam.

Participants

Participants were 45 women, mainly psychology students, who received course credit or were paid for their participation. Mean age of the participants was 22.9 years (range = 19–28 years, SD = 2.5 years). Forty-one (91%) had an exclusively heterosexual or predominantly heterosexual orientation, and 4 (9%) participants considered themselves to be bisexual. Twenty-seven participants (60%) had a steady heterosexual relationship. All participants had experienced sexual contact with a partner, and for 41 (91%) participants this included coitus. The majority of the participants (71%) had seen erotic films once or twice prior to participation. Two (4%) participants had never seen an erotic film, 2 (4%) participants had seen erotic films once, and 9 (20%) participants had seen erotic films regularly prior to participation.

Before participation all participants received written information including a description of the procedure and the physiological measures. Informed consent, in which confidentiality, anonymity, and the opportunity to withdraw from the experiment without penalty were assured, was obtained from all participants.

Design

A 2 (condition) × 3 (film presentation) design was employed, with increasing intensity versus stable intensity condition as a between-subjects variable, and first, second, third film presentation as a within-subject variable. Participants were randomly assigned to either the increasing or stable intensity conditions.

Materials and Response Measurement

Stimulus materials. The film excerpts consisted of 3-min videotapes with sound. Each 3-min tape consisted of three 1-min scenes. All excerpts originated from films directed and produced by Candida Royalle. Films produced by Candida Royalle are designed for women, and tend to be more female initiated and female centered than typical erotic movies. Earlier studies in our laboratory have shown that female-centered erotic films evoke similar levels of genital response, but less feelings of shame, guilt, and aversion in women compared to male-centered erotic films (Laan, Everaerd, van Bellen, & Hanewald, 1994; Laan, 2004).

The low intensity film depicted erotic kissing, the moderate intensity film showed kissing and caressing, and the high intensity film depicted intercourse. In the increasing intensity condition, participants saw the low intensity film first, then the moderate intensity film, and then the high intensity film clip. In the stable intensity condition, participants saw the moderate intensity film clip three times. As noted before, a previous study showed that

1The patterns of the results were identical when we excluded the 4 participants who indicated themselves as bisexual.
the low, moderate, and high intensity film clips evoked distinct and increasing levels of genital arousal in women (Laan, Everaerd, van der Velde, et al., 1995).

Physiological recordings. T reflexes and genital responses were recorded continuously during baselines and film viewing.

T reflex measurement was carried out in accordance with standard methods and procedures for evoking T reflexes (Desmedt, 1973). Participants sat in an individually adjusted chair with their legs held in a fixed position. The knee was maintained in a fixed, semi-flexed position (120°), and the angle of the ankle joint was 90°. The feet were strapped to foot pedals to obtain nearly isometric contractions of the soleus. The Achilles tendon of the right leg was hit by a small rubber hammer (10-ms duration) at a right angle to the tendon, at the level of the lateral malleolus. The hammer was connected to a Brüel and Kjæer 4809 vibration exciter. T reflexes were elicited at a constant rate of one every 5 s during baselines and film presentations, resulting in 24 reflexes during each 2-min baseline, and 36 reflexes during each 3-min film presentation period. Surface electrodes (Ag/AgCl electrodes, 2 cm² contact area) were placed (3 cm apart) upon the soleus muscle, along the longitudinal axis of the calf; the proximal electrode of the pair was placed 2 cm distal to the insertion of the gastrocnemius muscle on the Achilles tendon.

Genital response was measured using a vaginal photoplethysmograph assessing vaginal pulse amplitude (the AC component of the signal) and vaginal blood volume (the DC component). Because earlier research has shown that vaginal pulse amplitude is the superior measure in terms of both convergent and divergent validity (Laan, Everaerd, & Evers, 1995), only vaginal pulse amplitude data were used. Depth of the probe and orientation of the light emitting diode were controlled by a device (a 9- x 2-cm plate) attached to the base of the photoplethysmograph. Participants were instructed to insert the photoplethysmograph such that the plate touched their labia. The vaginal photoplethysmograph was sterilized in a solution of Cidex-activated glutaraldehyde between uses (Geer, 1980).

Ratings. Prior to film presentation and after each film excerpt, ratings of subjective sexual arousal and emotional experience were collected. Participants were asked to assess on a 7-point scale: (a) overall sexual arousal, (b) strongest feeling of sexual arousal, and (c) strongest genital sensations. The extremes were not sexually aroused at all and very strongly sexually aroused for items a and b, and no sensations in my genitals and orgasm for item c.

Emotional experience was measured by a questionnaire consisting of 21 emotions (including sexual emotions). Participants were asked to indicate on a 7-point scale (not at all and very strong as extremes) to what extent they had experienced these emotions while watching the film excerpt. In an earlier study, factor analysis had indicated that the 21 emotions could be divided into 7 emotions reflecting lust (Cronbach’s α = .87), avoidance (Cronbach’s α = .75), protection (Cronbach’s α = .81), and attention (Cronbach’s α = .76; Laan & Everaerd, 1995).

Procedure Each participant was tested individually by a trained female experimenter. On arrival at the laboratory, the participant read and signed an informed consent form and completed a questionnaire about sexual experience, sexual orientation, and sexual problems. The experimenter then explained all the details of the experimental procedure and attached the electrodes. After adjusting the chair, the experimenter determined the intensity of mechanical stimulation necessary to elicit reflexes. Then the intensity was adjusted to obtain, at rest, a reflex EMG whose amplitude was between 25% and 50% of the estimated maximum T reflex. After the experimenter had left the room, the participant inserted the vaginal probe. After the participants signaled (using a one-way intercom system) that the transducers had been placed, feelings of sexual arousal and emotional experience were rated.

Following a 2-min baseline period, the first film excerpt was presented, and then participants rated their feelings of sexual arousal and emotional experience, and their action tendencies. This was followed by a 3-min interfilm interval period. To facilitate a return to baseline, participants completed a concentration task (simple arithmetic problems) during the interfilm interval period. Then the next film excerpt was presented with the same procedure, until all three film excerpts were shown.

At the end of the experiment an exit interview was administered. Participants were asked about their reactions to the experimental procedure, the T reflex elicitation, and the use of the genital device.

Data Reduction, Scoring, and Analysis EMG was sampled across baselines and subsequent film presentation periods. The mean T reflex amplitude elicited during each baseline period and each film presentation period was calculated. T reflexes during film viewing were expressed as a percentage of the baseline magnitude (film reflex magnitude/baseline reflex magnitude x 100).

Vaginal pulse amplitude was also sampled across baselines and the subsequent film presentation periods. Data were entered into a computer program, developed by Bert Molenkamp (Technical Support, Department of Psychology, University of Amsterdam), that enables off-line graphical inspection of the data. Artifacts in the channel monitoring vaginal pulse amplitude are caused by movements of the lower part of the body or by voluntary or involuntary contractions of the pelvic muscles. Because artifacts show an extreme increase in vaginal pulse amplitude, they can be detected by visual inspection. Visual inspection
revealed that, as in our previous studies using T reflex measurement, reflex elicitation did not result in an increase in artifacts in the channel monitoring vaginal pulse amplitude. After artifact removal, mean amplitude levels during each baseline period and each film presentation period were calculated. Vaginal pulse amplitude was then expressed as a percentage of baseline amplitude (film vaginal pulse amplitude/baseline vaginal pulse amplitude × 100).

For emotional experience, the items belonging to the lust factor were averaged, thus creating a lust score. For action tendency ratings, only the approach and avoidance factors were used for further analysis. The approach items and the avoidance items were averaged, thus creating an approach and an avoidance score.

Due to difficulties in evoking satisfactory reflexes or technical problems, data were missing in the analysis of the increasing intensity condition for 4 participants in the T reflex data, 5 participants in the vaginal pulse amplitude data, and 1 participant in the subjective action tendencies data. In the stable intensity condition, data were missing for 4 participants in the T reflex data and for 3 participants in the vaginal pulse amplitude data.

Sexual arousal and emotional experience ratings were submitted to MANOVAs (General Linear Model in SPSS) with film presentation as the within-subjects variable and condition as the between-subjects factor. Likewise, approach and avoidance tendency ratings, vaginal pulse amplitude, and T reflex magnitude were submitted to ANOVAs. Following significant F ratios for each dependent measure, univariate contrast analyses (comparisons between all possible pairs) were performed to test for specific film effects.

Results

T Reflex Magnitude

The interaction of condition and film presentation did not reach significance in the analysis of T reflex magnitude, F(2,70) = 2.29, p = .11. Nonetheless, a priori hypotheses predicting effects of intensity for those viewing increasingly arousing films, but not for those in the stable condition, supported conducting separate tests for each condition. Consistent with predictions, increasing film intensity affected the magnitude of the T reflex, resulting in a significant effect of film presentation, F(2,48) = 3.57, p < .05. Figure 1 illustrates T reflex magnitude in the increasing intensity and stable intensity conditions. Reflexes elicited during the high intensity film were not significantly larger than reflexes during the moderate intensity film, t(25) = 1.7, p = .1, and reflexes during the moderate intensity film were not larger than reflexes during the low intensity films, t(25) = 1.42, p = .17. However, reflexes elicited during the high intensity film were significantly larger than reflexes elicited during the low intensity film, t(24) = 2.18, p < .05. In the stable intensity condition, on the other hand, there was no effect of film presentation on T reflex magnitude (p > .55).

Genital Responses

Intensity of film had the predicted effect on genital responses (Figure 2). There was a main effect of film presentation on vaginal pulse amplitude, F(2,70) = 7.28, p < .001, a main effect of condition, F(1,35) = 7.67, p < .01, and an interaction of condition and film presentation, F(2,70) = 7.45, p < .005. As expected, vaginal pulse amplitude increased as film intensity increased in the increasing intensity condition, F(2,46) = 15.13, p < .001, but did not change significantly in the stable intensity condition, p > .9. In the increasing intensity condition, genital responses during the moderate intensity film were stronger than during the low intensity film, t(25) = 3.76, p < .005, and genital responses during the high intensity film were stronger than responses during the low intensity film, t(23) = 4.7, p < .001, or moderate intensity film, t(23) = 2.64, p < .05.

Ratings

Subjective ratings are shown in Table 1. The interaction of condition and film presentation was significant for rated sexual arousal, multivariate F(6,170) = 5.36, p < .001, feelings of lust, F(2,86) = 10.04, p < .001, and rated approach tendencies, F(2,62) = 3.4, p < .05. For all three measures, comparisons indicated that when films increased in sexual intensity, the high intensity film prompted the highest sexual arousal, lust, and reports of tendency to approach, and that the moderate film similarly elicited higher ratings for all three measurements than the low intensity film. In the stable condition, film presentation had no significant effects on rated arousal, feelings of lust, or tendency to approach.

Discussion

In the present study, exposure to sexual films of high emotional intensity elicited higher levels of reported sexual and geni-
Table 1. Mean (SD) Ratings of Sexual Arousal, Lust, and Action Tendencies in Response to the Low, Moderate, and High Intensity Sexual Films, for the Increasing Intensity and Stable Intensity Conditions

<table>
<thead>
<tr>
<th>Subjective ratings</th>
<th>Low intensity film</th>
<th>Moderate intensity film</th>
<th>High intensity film</th>
<th>Moderate intensity film</th>
<th>Moderate intensity film</th>
<th>Moderate intensity film</th>
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</thead>
<tbody>
<tr>
<td>Sexual arousal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall sexual arousal</td>
<td>2.4 (0.8)</td>
<td>3.5 (0.9)</td>
<td>4.0 (1.4)</td>
<td>3.4 (1.4)</td>
<td>3.4 (1.4)</td>
<td>3.2 (1.8)</td>
</tr>
<tr>
<td>Strongest sexual arousal</td>
<td>2.8 (0.9)</td>
<td>3.9 (1.2)</td>
<td>4.6 (1.6)</td>
<td>3.8 (1.7)</td>
<td>4.1 (1.6)</td>
<td>3.6 (1.9)</td>
</tr>
<tr>
<td>Emotional experience</td>
<td>2.3 (1.0)</td>
<td>3.2 (1.4)</td>
<td>3.9 (1.5)</td>
<td>3.4 (1.8)</td>
<td>3.3 (1.9)</td>
<td>3.4 (2.0)</td>
</tr>
<tr>
<td>Lust</td>
<td>1.9 (0.9)</td>
<td>2.4 (1.1)</td>
<td>2.9 (1.4)</td>
<td>3.0 (1.2)</td>
<td>3.2 (1.5)</td>
<td>2.9 (1.6)</td>
</tr>
<tr>
<td>Action tendencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>1.9 (0.9)</td>
<td>2.2 (1.0)</td>
<td>2.5 (1.2)</td>
<td>2.5 (0.9)</td>
<td>2.7 (1.1)</td>
<td>2.6 (1.1)</td>
</tr>
<tr>
<td>Avoidance</td>
<td>2.3 (0.7)</td>
<td>2.2 (0.8)</td>
<td>2.2 (0.5)</td>
<td>2.3 (0.8)</td>
<td>2.1 (0.8)</td>
<td>2.2 (0.6)</td>
</tr>
</tbody>
</table>

Note: For each dependent measure, means with common character in superscripts are significantly different at p < .01 (sexual arousal and emotional experience ratings: increasing intensity condition df = 28, stable intensity condition df = 15) (action tendency ratings: increasing intensity condition df = 16, stable intensity condition df = 15).

1 = not sexually aroused at all; 7 = very strongly sexually aroused
2 = no sensations in my genitals; 7 = orgasm
3 = not at all; 7 = very strong
4 = not at all; 5 = very strong

Sexual arousal and T reflex augmentation, compared to low arousal films. Thus T reflex reactivity was modified by the parameter of emotional arousal, more specifically by sexual arousal. The results obtained in this study corroborate the enhancing effect of emotional arousal on T reflex strength reported by Bonnet et al. (1995) and the effect of sexual arousal on T reflex magnitude that we reported previously (Both et al., 2003, 2004). Moreover, we found that emotional intensity influences action tendency strength, as reflected both in ratings of approach tendencies and in somatic motor activity. This indicates that T reflex modulation may be a useful method to investigate the strength of action tendencies elicited by appetitive sexual stimuli.

Both genital responses and ratings indicated that sexual films evoked the intended patterns of sexual arousal levels. Exposure to three erotic film excerpts of low, moderate, and high intensity resulted in increasing levels of genital arousal and in increasing levels of rated sexual arousal and feelings of lust. In contrast, exposure to three sexual film excerpts of moderate intensity resulted in stable levels of genital arousal, ratings of sexual arousal, and feelings of lust. Therefore we conclude that the method was successful in the induction of sexually emotional states of increasing intensity.

In our view, sexual emotions, like emotions in general, can be conceived of as action tendencies. Sexual excitement will generate an action tendency for sexual behavior, which may be experienced as being attracted to or pushed toward sexual objects or behaviors. Therefore we expected sexual films to evoke ratings of approach tendencies, and we expected approach tendencies to vary as a function of film intensity. Indeed, sexual films evoked subjective approach tendencies, and ratings of approach tendencies increased in response to increasing film intensity. In contrast, ratings of avoidance tendencies were not affected by the intensity of the sexual film.

Similar to subjective ratings of action tendency strength, somatic motor preparation, reflected in T reflex magnitudes, showed a pattern of increasing strength with increases in sexual arousal. T reflexes elicited during the high intensity sexual film were higher than T reflexes elicited during the low and moderate intensity sexual films. In contrast, in the stable intensity condition, T reflex magnitudes did not differ between films, indicating that T reflex augmentation in the increasing intensity condition reflected the increased emotional intensity of the sexual film excerpts.

Although T reflex magnitude differed between high and low arousal films in the increasing intensity condition, T reflex magnitude did not strongly differ between the high and the moderate intensity films or between the moderate and low intensity films. On the other hand, vaginal pulse amplitude, as well as ratings of sexual arousal and lust, did differentiate between the three levels of sexual arousal in the increasing intensity condition. Thus, although T reflex magnitude showed modulation by increasing sexual arousal, it appears to be difficult to differentiate between varying levels of arousal, possibly due to relatively high variance in reflex reactivity.

The current study shows that subjective sexual and genital responses, as well as subjective action tendencies and somatic motor activity, are modulated by sexually appetitive films of varying intensity. This supports the view that sexual motivation is an emergent property, the outcome of the processing of sexual stimuli, and that the strength of the emerging responses varies as a function of stimulus intensity. Although the results regarding T reflex modulation indicate that it may be difficult to catch subtle differences in emotional arousal in reflex magnitudes, reflex modulation might be a useful tool in research on appetitive motivation. According to Berridge (1996), distinct neurobiological processes underlie the valence and arousal dimension of motivational responses. Robinson and Berridge (2001) suggested that sensitized arousal reactions to incentive stimuli play a role in the development of addiction. Recently, research on implicit and explicit alcohol-related cognitions showed implicit arousal associations in heavy drinkers, possibly reflecting a sensitized psychomotor-activating response to drug cues (Wiers, van Woerden, Smulders, & de Jong, 2002). As an index of psychomotor arousal, T reflex modulation may be of use in research on the behavioral mechanisms underlying appetitive motivation in humans and related problems like substance addiction and hypo- or hyperactive sexual desire.
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