Motor preparation and sexual action: a psychophysiological perspective on sexual motivation
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Modulation of spinal reflexes by sexual stimuli of increasing intensity

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 stimuli of varying intensity was investigated. T reflexes were expected to increase as a function of increased stimulus intensity. Following a between subjects design participants were exposed to 3 erotic stimuli of low, medium, and high intensity, or to 3 identical stimuli of medium intensity. In addition to T reflexes, genital arousal, emotional experience, and subjective action tendencies were monitored. Self-report and genital data confirmed the induction of increasing versus stable levels of sexual arousal. Exposure to the stimuli 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.

Note: We thank Esther van Driel, Lot Holleman, and Edmee Nijdam for their assistance in data-collection and data-reduction.
Introduction

Previously it was shown that the Achilles Tendon (T) reflex is modulated by negative and positive emotional stimuli (Bonnet, Bradley, Lang, & Requin, 1995). In line with these findings our research group showed that appetitive sexual stimuli enhance T reflexes to the same extent as aversive stimuli (Both, Everaerd, & Laan, 2003). In the present study it was investigated whether appetitive sexual stimuli of increasing emotional intensity instigate rising levels of action tendency strength reflected in increased somatic motor activity.

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 (Singer & Toates, 1987). Once the system interacts with an attractive sexual stimulus responses will be activated 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. Interaction with an incentive changes the affective state of an organism; it inflames motivation by producing affect (Singer & Toates, 1987). Bindra (1974) already pointed to the similarity of motivational and emotional states. In his view 'motivational state and emotional state are interchangeable terms' (Bindra, 1974, p. 201). Currently, several emotion theorists view emotion as fundamentally an action disposition, as a tendency to act in relation to the emotional stimulus (Frijda, 1986; Lang, 1993; LeDoux, 2001). In this view emotions serve to satisfy concerns, and therefore result in motivational states or action tendencies. The motivational state or action tendency is reflected in the physiological changes that accompany emotion. We assume that sexual excitement, in this respect, does not deviate from other emotions. Sexual excitement serves to satisfy concerns, and generates a tendency for sexual behavior (Everaerd, Laan, Both, & Spiering, 2001).

The generation of appetitive behavior will be accompanied by activity in somatic motor, autonomic, and endocrine systems (Robbins & Everitt, 1999), and that activity may include nonspecific 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 stimuli by means of T reflex modulation (Both, Everaerd, & Laan, 2003). The T reflex is supposed to be involved in appetitively and defensively motivated action, and is therefore, in contrast to the startle reflex, not sensitive to the valence of an affective state. T reflexes are augmented in states of action, and modified by differences in arousal (Bonnet, Bradley, Lang & Requin, 1995; Brunia & Boelhouwer, 1988; Brunia & van Boxtel, 2000). Therefore T reflex modulation offers a window on the generation of action. In our previous study, as expected, exposure to a sexually appetitive stimulus induced genital responses, and generated feelings of sexual arousal, as well as subjective approach tendencies. Processing of both sexual and anxiety stimuli facilitated T reflexes, and reflexes were augmented by a sexual stimulus to the same extent as by anxiety stimuli. These data supported our view of sexual arousal as 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 stimuli of varying intensity results in different levels of activation in the somatic motor system. Intensity is an important component of emotion since 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. (1992), 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 disorders like for example addiction, or hypo- or hyper-sexual desire disorder. Possibly T reflex modulation may provide a window on the strength of action tendencies, and on individual or contextual factors influencing this strength. However, before studying individual differences in, or the effect of manipulations on the strength of action tendencies through T reflex modulation, the modulation of T reflexes by varying levels of emotion intensity has to be determined. Therefore in the present study it was investigated whether exposure to
sexual stimuli of increasing intensity results in increasing levels of sexual arousal and T reflex augmentation.

T reflexes can be elicited by a hammertap at the heel tendon, which results in a reflexive electromyographic (EMG) response in the soleus muscle of the lower leg. The magnitude of the EMG response reflects the number of motoneurons currently activated in the pool that innervates the soleus muscle. Since the sensitivity of the muscle spindle is controlled by fusimotoneurons, the activity of these neurons is also reflected in the T reflex. When circumstances are held equal, taps of a constant force lead to reflex amplitudes of constant size. Supraspinal excitatory or inhibitory influences on the 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, or during reaction time tasks and mental arithmetic (Brunia & Boelhouwer, 2000). These facilitations are interpreted as due to the effects of nonspecific arousal, and indicated that T reflexes may be modulated by emotional arousal.

Bonnet et al. (1995) studied the modulation of T reflexes during the presentation of pictures from 'The International Affective Picture System' designed by Lang, Öhman, and Vaitl (1988). The pictures from this system are designed to induce emotions varying in valence (positive to negative) and in intensity (low to high). As expected, T reflexes were significantly augmented when elicited during processing of emotional pictures (either negative or positive) as compared with neutral pictures. Both low or high arousal unpleasant stimuli augmented T reflexes, and to a comparable extent. However, for the pleasant pictures, only the reflexes elicited during high arousal stimuli were significantly augmented. Reflexes elicited during low arousal pleasant stimuli did not differ from those elicited during neutral pictures. Bonnet et al. concluded that this suggests that unpleasant stimuli are more closely associated with action engagement than are pleasant pictures, at least when intensity is low. However, they also noted that the affective ratings used to categorize the pictures on the basis of arousal were obtained from different subjects than from whom the T reflexes were elicited. Therefore, although unlikely, it cannot be ruled out that the latter sample would have rated the stimuli
differently, which might have affected the obtained reflex magnitude pattern.

Similar to Bonnet et al. we hypothesized emotional stimuli, more specifically sexual stimuli, to automatically generate action tendencies, reflected in increased spinal excitability, and we expected the strength of the action tendency to be associated with stimulus intensity. T reflexes during exposure to sexual stimuli of low, medium, and high intensity were monitored. To elicit the sexual states we used film excerpts that previously showed 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 show that increased T reflex magnitudes are a function of emotional stimulus intensity, and to rule out that responses increase over time independent from stimulus intensity, we added a control condition in which participants were exposed to three identical erotic film excerpts of medium intensity. Previously it was found that repeated exposure to 21 identical erotic film excerpts resulted in stable levels of genital arousal in women (Laan, Everaerd, van der Velde, & Geer, 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 medium 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. Part of the increasing stimulus condition data was obtained at the Psychonomics section of the Tilburg University (N=11). Additional data for the increasing stimulus condition were collected at the department of Clinical Psychology of the University of Amsterdam (N=18), where also the data of the stable stimulus condition were collected (N=16). Stimulus materials and experimental
procedures were identical at the two sites. Also, apart from some differences in technical set-up, response measurement was identical at the two sites. Subjective action tendencies, though, were measured only 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). Eighteen (40%) participants had a heterosexual orientation, 23 (51%) participants had a predominantly heterosexual orientation, and 4 (9%) participants considered themselves to be bisexual. Twenty-seven participants (60%) had a steady partner. All participants had experienced sex with a partner, and 41 (91%) had experienced coitus. The majority of the participants (71%) had seen erotic films once or twice prior to participation. Two (4%) participants had never seen erotic film, 2 (4%) participants had seen erotic films once, and 9 (20%) participants had seen erotic film regularly prior to participation.

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

Design
A 2 x 3 between-subjects repeated measures design was employed, with condition (increasing intensity versus stable intensity) as between-subjects variable, and stimuli as within variable. At the Amsterdam site participants were randomly assigned to the increasing and 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. The low intensity stimulus depicted erotic kissing, the medium stimulus showed kissing and caressing, and the high intensity stimulus depicted intercourse. In the increasing condition the participants saw the low
intensity stimulus first, then the medium intensity stimulus, and then the high intensity film clip. In the stable condition the participants saw the medium intensity film clip three times. As noted before, a previous study showed that the low, medium, and high intensity film clips evoked distinct, and increasing levels of genital arousal in women (Laan, Everaerd, van der Velde, & Geer, 1995). All excerpts were originating from films directed and produced by Candida Royalle. Films produced by Candida Royalle are aimed at women, and are more female initiated and female centered than regular erotic movies. Earlier studies in our laboratory have shown that female-centered erotic film evokes less feeling of shame, guilt and aversion in women compared to male centered erotic film (Laan, Everaerd, van Bellen, & Hanewald, 1994; Laan, 2004).

*Physiological recordings.* T reflexes and genital responses were recorded continuously during baselines and stimulus presentations. T reflexes were elicited with a hammer. The 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 hammer at a right angle to the tendon, at the level of the lateral malleolus. The hammer was connected to a Brüel and Kjaer 4809 vibration exciter. T reflexes were elicited at a constant rate of one every 5s during baselines and stimulus presentations, resulting in 24 reflexes during each 2-min baseline, and 36 reflexes during each 3-min stimulus 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 VPA (vaginal pulse amplitude, the AC component of the signal) and VBV (vaginal blood volume, the DC component). Since former research has shown that VPA is the superior measure in terms of both convergent and divergent validity (Laan, Everaerd, & Evers, 1995), only VPA 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 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).

**Subjective measurements.** Prior to stimulus presentation and after each film excerpt data 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 item 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 (with 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 = .82), 4 emotions relating to anger (Cronbach’s α = .85), 8 emotions relating to threat (Cronbach’s α = .71), and 2 emotions reflecting tension (Cronbach’s α = .79) (Laan, Everaerd, & Evers, 1995).

Subjective action tendencies were measured by the Action Tendency Questionnaire (ATQ). This questionnaire was administered at the Amsterdam research site only. Therefore ATQ data were collected only for a part of the increasing stimulus condition participants (N= 18), and for all participants in the stable condition (N= 16). The questionnaire assessed the tendency to execute overt behavior, without necessarily doing so (Frijda, Kuipers, & ter Schure, 1989), and was administered after each stimulus presentation. Participants were asked to assess on 5-point Likert scales (with ‘does not apply to me’ and ‘strongly applies to me’ as extremes) the degree to which 25 statements were applicable to them. The statements varied from statements indicating approach tendencies (e.g., ‘I wanted to approach, to make contact’) to statements indicating avoidance (e.g., ‘I wanted to have nothing to do with something or someone, to be bothered by it as little as possible, to stay away’). Formerly, factor analysis had revealed that the questionnaire could be divided in 4 subscales: approach (Cronbach’s α = .87), avoidance
(Cronbach' s $\alpha = .75$), protection (Cronbach' s $\alpha = .81$), attention (Cronbach' s $\alpha = .76$; Laan & Everaerd, 1995b).

**Procedure**

To help participants make an informed decision about whether to participate in this experiment, they received written information in which all experimental procedures were explained in detail. They were informed about the T reflex elicitation and the genital measure, as well as about the sterilizing procedures.

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 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, they rated their feelings of sexual arousal and emotional experience.

After this a 2-min baseline period followed. Then the first film excerpt was presented. After the film excerpt, participants rated their feelings of sexual arousal and emotional experience, and their action tendencies. This was followed by a 3-min return-to-baseline period. To facilitate return-to-baseline participants completed a concentration task (simple arithmetic problems) during the return-to-baseline period. Then the next film excerpt was showed following an identical 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 stimulus presentation periods. The mean T reflex amplitude elicited during each
baseline period \((X)\) and each stimulus presentation period \((Y)\) was calculated. A percentage of baseline score was calculated (percentage of baseline = \(Y / X \times 100\)) for each stimulus.

VPA was also sampled across baselines and the subsequent stimulus 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 VPA channel are caused by movements of the lower part of the body or by voluntary or involuntary contractions of the pelvic muscles. Since artifacts show an extreme increase in vaginal pulse amplitude they can be detected by visual inspection. After artifact removal mean VPA during each baseline period \((X)\) and each stimulus presentation period \((Y)\) was calculated. Then a percentage of baseline score was calculated (percentage of baseline = \(Y / X \times 100\)) for each stimulus.

For emotional experience the items belonging to each of the described factors were averaged, thus creating a lust, anger, threat and tension 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.

Within-subject and between-subject effects were tested with repeated-measures multivariate and univariate analysis of variance procedures (General Linear Model in SPSS), using a significance level of .05. Subjective sexual arousal and emotional experience were submitted to MANOVA's. Subjective approach en avoidance tendency, genital arousal, 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 stimulus effects.

Results

Responses at exit interviews indicated that, in general, the participants had felt comfortable during the experiment. However, regarding the genital measurement, 5 participants indicated that they felt somewhat
disturbed by the measurement, 1 indicated that she felt slightly disturbed, and 1 participant indicated that she felt strongly disturbed. Regarding the T reflex measurement, 7 participants reported that they felt somewhat disturbed by the measurement, 11 participants indicated that they felt slightly disturbed, and 1 participant reported to be strongly disturbed. The latter participant was not the same as the participant who reported that she felt strongly disturbed by the genital measurement.

Subjective Sexual Arousal, Emotional Experience, and Action Tendencies

Subjective sexual arousal. The stimulus presentations had their intended effect upon subjective sexual arousal ratings (Figure 1). There was a main effect of stimuli, multivariate $F(6,170) = 4.34, p < .001$, and an interaction effect of condition and stimuli, multivariate $F(6,170) = 5.36, p < .001$. In the increasing intensity condition there was an effect of stimuli, multivariate $F(6,110) = 7.71, p < .001$, while in the stable intensity condition there was not ($p > .25$). Comparison of all possible pairs of means of the three subjective sexual arousal items (Table 1) showed that in the increasing intensity condition sexual arousal scores in response to the medium intensity stimulus were higher than to the low intensity stimulus, and that subjective sexual arousal scores in response to the high intensity stimulus were higher than in response to the medium intensity stimulus.

Emotional experience. There was an effect of stimuli on emotional experience, multivariate $F(8,168) = 3.90, p < .001$, and an interaction of condition and stimuli, multivariate $F(8,168) = 3.18, p < .005$. Univariate analysis showed only for feelings of lust a significant effect of stimuli, $F(2,86) = 6.01, p < .005$, and a significant interaction of condition and stimuli, $F(2,86) = 10.04, p < .001$. For the increasing intensity condition there was an effect of stimuli on feelings of lust, $F(2,56) = 19.45, p < .001$, feelings of lust increased over stimuli (Table 1). In the stable condition there was no significant change in feelings of lust. Follow-up comparison of means showed that in the increasing condition feelings of lust in response to the medium intensity stimulus were higher than to the low intensity stimulus, and lust ratings in response to the high intensity stimulus were higher than to the medium intensity and low intensity stimuli (Table 1).
Table 1. Mean (SD) subjective ratings of sexual arousal, emotional experience and action tendencies in response to the low, medium, and high intensity sexual stimuli, for the increasing intensity and stable intensity condition.

<table>
<thead>
<tr>
<th></th>
<th>Increasing Intensity Condition</th>
<th>Stable Intensity Condition</th>
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<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
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<tr>
<td><strong>Sexual arousal</strong></td>
<td></td>
<td></td>
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<tr>
<td>Overall sexual arousal</td>
<td>2.4</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>(0.8)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Strongest sexual arousal</td>
<td>2.8</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>(0.9)</td>
<td>(1.2)</td>
</tr>
<tr>
<td>Strongest genital sensations</td>
<td>2.3</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(1.4)</td>
</tr>
<tr>
<td><strong>Emotional experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lust</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>(0.9)</td>
<td>(1.1)</td>
</tr>
<tr>
<td>Anger</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>(0.4)</td>
<td>(0.3)</td>
</tr>
<tr>
<td>Threat</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>(0.5)</td>
<td>(0.6)</td>
</tr>
<tr>
<td>Tension</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(0.9)</td>
</tr>
<tr>
<td><strong>Action tendencies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>(0.9)</td>
<td>(1.0)</td>
</tr>
<tr>
<td>Avoidance</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>(0.7)</td>
<td>(0.8)</td>
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</table>

Note: For each dependent measure, means with common character in superscripts are significantly different at $p < 0.01$ (sexual arousal and emotional experience ratings: increasing condition $df = 28$, stable condition $df = 15$) (action tendency ratings: increasing condition $df = 16$, stable condition $df = 15$).  

$^11$ = not sexually aroused at all; 7 = very strongly sexually aroused.  

$^21$ = no sensations in my genitals; 7 = orgasm.  

$^31$ = not at all; 7 = very strong.  

$^41$ = not at all; 5 = very strong.
Subjective approach and avoidance tendencies. For 1 participant in the increasing stimulus condition data on subjective action tendencies were missing due to technical problems. There was a main effect of stimuli on subjective approach tendency, multivariate $F(2,62) = 5.3, p < .01$, and an interaction of condition and stimuli, multivariate $F(2,62) = 3.4, p < .05$. In the increasing intensity condition there was an effect of stimuli on subjective approach tendency, $F(2,32) = 7.5, p < .005$. As expected, approach tendency increased in the increasing intensity condition. In the stable intensity condition there was no effect of stimuli on approach tendency. Follow-up comparison of means showed that in the increasing condition subjective approach ratings in response to the medium intensity stimulus were marginally higher than to the low intensity stimulus, and approach ratings in response to the high intensity stimulus were higher than to the medium intensity and low intensity stimuli (Table 1). For subjective avoidance tendencies there was no effect of stimuli, and no interaction of condition and stimuli. In both conditions avoidance tendencies showed a stable pattern (Table 1).

Genital Responses
Due to technical problems VPA data of 5 participants in the increasing stimulus condition, and 3 participants in the stable condition were missing. The stimulus presentations had their intended effect on genital responses (Figure 2). There was a main effect of stimuli on VPA, $F(2,70) = 7.28, p < .001$, a main effect of condition, $F(1,35) = 7.67, p < .01$, and an interaction of condition and stimuli, $F(2,70) = 7.45, p < .005$. VPA was overall higher in the increasing intensity condition. As expected, VPA increased in the increasing intensity condition, $F(2,46) = 15.13, p < .001$, and did not significantly change in the stable condition, ($p > .9$). Comparison of all possible pairs of mean VPA responses showed that, in the increasing stimulus condition, genital responses during the medium intensity stimulus were stronger than during the low intensity stimulus, $t(25) = -3.76, p < .005$, genital responses during the high intensity stimulus were stronger than responses during the low intensity stimulus, $t(23) = -4.7, p < .001$, and genital responses during the high intensity stimulus were stronger than responses during the medium intensity stimulus, $t(23) = -2.64, p < .05$.  

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Figure 1. Mean Vaginal Pulse Amplitude change (and SEM) in response to stimulus 1, 2, and 3, in the increasing and stable intensity condition.

T Reflex magnitude
Due to technical problems, and difficulties in evoking satisfying reflexes, reflex data of 4 participants in the increasing condition, and 4 participants in the stable condition were missing. There was a marginally significant interaction effect of condition and stimuli, $F(2,70) = 2.29, p = .11$. In the increasing intensity condition there was an effect of stimuli, $F(2,48) = 3.57, p < .05$. As expected, T reflex magnitudes increased in response to the stimuli of increasing intensity (Figure 2). In the stable intensity condition there was, as expected, no effect of stimuli on T reflex magnitude ($p > .55$). Comparison of all possible pairs of mean T reflex magnitudes showed that in the increasing intensity condition reflexes during the medium intensity stimulus were not stronger than reflexes during the low intensity stimulus, $t(25) = -1.42, p = .17$. T reflexes during the high intensity stimulus were significantly stronger than reflexes during the low intensity stimulus, $t(24) = -2.18, p < .05$, and reflexes during the high intensity stimulus were marginally stronger than reflexes during the medium intensity stimulus, $t(25) = -1.7, p = .1$. 

66
Figure 2. T Reflex Magnitude (and SEM) in response to stimulus 1, 2, and 3, in the increasing and stable intensity condition.

Discussion

In the present study it was shown that exposure to sexual stimuli of increasing intensity elicits increasing levels of sexual arousal, and increasing levels of T reflex augmentation. 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 reported by our research group (Both et al. 2003). Moreover, we showed that emotion intensity influences action tendency strength reflected in subjective approach tendencies and somatic motor activity. The results show that T reflexes are modulated by varying levels of sexual arousal, which indicates that T reflex modulation may be a workable method to investigate manipulations of, or group differences in, somatic motor activity strength in response to erotic stimuli.

The data regarding genital responses and subjective reports showed that the sexual stimuli evoked the intended levels of sexual arousal. Exposure to three erotic film excerpts of respectively low, medium, and
high intensity, resulted in increasing levels of genital arousal, increasing levels of subjective sexual arousal, and increasing feelings of lust. In contrast, exposure to three sexual film excerpts of medium intensity resulted in stable levels of genital arousal, subjective sexual arousal, and feelings of lust. In the stable intensity condition also feelings of anger slightly increased, and feelings of tension slightly decreased. However, as expected, anger and tension ratings were very low, indicating that the sexual stimuli evoked virtually no feelings of anger and tension. Therefore we may conclude that we were successful in the induction of positive sexually emotional states of increasing intensity.

In our view sexual emotions, as emotions in general, can be conceived of as action tendencies. Therefore we expected sexual stimuli to evoke subjective approach tendencies, and we expected approach tendencies to vary as a function of stimulus intensity. The results regarding subjective action tendencies show that, as expected, the sexual stimuli evoked approach tendencies, and that these approach tendencies increased in response to increasing stimulus intensity. Subjective avoidance tendencies, in contrast, were not affected by sexual stimulus intensity. Thus exposure to the sexually arousing stimuli of varying intensity switched on approach tendencies that varied in strength. These different levels of action tendency strength were accompanied by differences in the degree of somatic motor preparation, reflected in T reflex magnitudes. T reflex magnitudes increased in response to the low, medium, and high intensity sexual stimuli. In contrast, in the stable intensity condition T reflex magnitudes were enhanced by the medium intensity stimulus, but did not significantly differ between stimuli.

Regarding sensitivity of T reflex modulation to differences in emotional intensity we have to note that, in the increasing intensity condition, only the difference in T reflex magnitude during the high and low intensity stimuli reached significance. The difference in reflex magnitude during the high and the medium intensity stimuli was only marginally significant. Thus, very small differences in emotional arousal may, possibly due to relatively high variance in reflex reactivity, be only weakly reflected in the strength of T reflexes.

In contrast to Bonnet et al. (1995), who found that for pleasant pictures only reflexes elicited during high arousal stimuli were significantly augmented, we found that exposure to sexual stimuli of low, medium, and
high intensity resulted in an enhancement of T reflexes of respectively 20, 29, and 41 percent relative to baseline. Bonnet et al. concluded that, when intensity is low, pleasant stimuli are less associated with action engagement than unpleasant stimuli. Although we have to note that erotic film, even an excerpt that shows only erotic kissing, can be expected to be more arousing than still photos that were used by Bonnet et al., our data indicate that pleasant stimuli, at least sexually pleasant stimuli, are associated with action engagement even when intensity is relatively low.

The current study shows that subjective sexual arousal and genital responses, as well as subjective action tendencies and somatic motor activity, are modulated by sexually appetitive stimuli of varying intensity. These results support 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. In addition, the results show that processing of sexual stimuli results in activity within systems involved in general motivated behavior (reflected in T reflex modulation), and in systems involved in specific sexual behavior (reflected in genital responses).

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 & Berridge (1998) suggested that sensitized arousal reactions to incentive stimuli may 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 disorders like substance addiction and hypo- or hyperactive sexual desire.