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ANATOMY & PHYSIOLOGY

C-Tactile Mediated Erotic Touch Perception Relates to Sexual Desire and Performance in a Gender-Specific Way



Johanna Bendas,¹ Janniko R. Georgiadis, PhD,² Gerhard Ritschel, PhD,¹ Håkan Olausson, MD, PhD,³ Kerstin Weidner, MD,¹ and Ilona Croy, PhD^{1,3}

ABSTRACT

Background: Unmyelinated low-threshold mechanoreceptors—the so-called C-tactile (CT) afferents—play a crucial role in the perception and conduction of caressing and pleasant touch sensations and significantly contribute to the concept of erotic touch perception.

Aim: To investigate the relations between sexual desire and sexual performance and the perception of touch mediated by CT afferents.

Methods: Seventy healthy participants (28 men, 42 women; mean age \pm SD = 24.84 \pm 4.08 years, range = 18–36 years) underwent standardized and highly controlled stroking stimulation that varied in the amount of CT fiber stimulation by changing stroking velocity (CT optimal = 1, 3 and 10 cm/s; CT suboptimal = 0.1, 0.3, and 30 cm/s). Participants rated the perceived pleasantness, eroticism, and intensity of the applied tactile stimulation on a visual analog scale, completed the Sexual Desire Inventory, and answered questions about sexual performance.

Outcomes: Ratings of perceived eroticism of touch were related to self-report levels of sexual desire and sexual performance.

Results: Pleasantness and eroticism ratings showed similar dependence on stroking velocity that aligned with the activity of CT afferents. Erotic touch perception was related to sexual desire and sexual performance in a gender-specific way. In women, differences in eroticism ratings between CT optimal and suboptimal velocities correlated positively with desire for sexual interaction. In contrast, in men, this difference correlated to a decreased frequency and longer duration of partnered sexual activities.

Clinical Implications: The present results lay the foundation for future research assessing these relations in patients with specific impairments of sexual functioning (eg, hypoactive sexual desire disorder).

Strengths and Limitations: The strength of the study is the combination of standardized neurophysiologic methods and behavioral data. A clear limitation of the study design is the exclusion of exact data on the female menstrual cycle and the recruitment of an inhomogeneous sample concerning sexual orientation.

Conclusion: The present results provide further evidence that unmyelinated CT afferents play a role in the complex mechanism of erotic touch perception. The ability to differentiate between CT optimal and suboptimal stimuli relates to sexual desire and performance in a gender-specific way. **Bendas J, Georgiadis JR, Ritschel G. C-Tactile Mediated Erotic Touch Perception Relates to Sexual Desire and Performance in a Gender-Specific Way. J Sex Med 2017;14:645–653.**

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Key Words: Touch; Erotic; Gender; C-Tactile Afferents; Sexual Performance; Sexual Desire

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INTRODUCTION

Sex is a reward-directed behavior and, like other pleasures, the sexual response can be parceled into motivational and consummatory components.^{1,2} Sexual desire can be conceptualized as the conscious experience of sexual motivation, although it also can be part of sexual performance. Judged from the high prevalence of sexual dysfunction associated with desire,^{3,4} its occurrence is crucial for human sexual functioning. Although all senses are possible gateways to sexual desire, neurobiological scrutiny

has focused mostly on the way visual and olfactory stimuli excite sexual motivation and desire.^{1,5} For all the strong sexual feelings it can generate, the skin as a proximal gateway to sexual desire has received surprisingly little attention in the scientific literature. Yet, the ability to perceive interpersonal touch as sexually stimulating and pleasurable could be a key component of sexual behavior. Unsurprisingly, a symbiosis between the amount of tactile physical affection and relationship satisfaction and attachment bonds has been reported.⁶

Human-to-human touch is conducted by different peripheral sensory nerve fibers of varying degrees of myelination. A particular class of unmyelinated (C class) sensory fibers, acting as mechanoreceptors (C low-threshold mechanoreceptors), has received much attention in recent decades, being verified as a fundamental element in the conduction of affective interpersonal touch.^{7–10} The so-called C-tactile (CT) fibers also have been associated with body perception¹¹ and social well-being.^{9,12} These and other observations led to the “CT social touch hypothesis”¹³ suggesting that CT afferents are of crucial importance as a mediator in interpersonal touch. CT fibers have been recorded from human skin with exception of glabrous skin (eg, the lip vermilion, soles of the feet, and palms of the hands).¹⁴ However, it is still unknown whether the genital area—covered by glabrous and hairy skin—contains CT fibers.

Previous studies have determined the explicit properties of CT fibers: microneurographic tests, which directly derive electric signals from the small fibers, have shown that the firing rates of the CT afferents are at their highest when roused by a stimulus with a temperature of approximately 32°C¹⁵ and a velocity of 1 to 10 cm/s.^{7,14,16} In the brain, key areas for CT-mediated touch processing are the posterior insular cortex,¹⁰ the orbitofrontal cortex,^{17,18} and the anterior cingulate cortex.^{19,20} This suggests that CT afferent information has direct access to the brain’s emotional and reward system.

In a classic neuroscience textbook, CT afferents were suggested to be involved in the conduction of sexually stimulating or arousing touch.²¹ This hypothesis was recently confirmed in a psychophysical experiment.²² CT optimal stroking frequencies for reported eroticism range from 1 to 10 cm/s, very similar to those of reported pleasantness ratings in previous experiments.^{7,23–25} Furthermore, although the presence of CT afferents in the genital area has yet to be established, it has been shown that erotic genital touch^{26,27} and genital engorgement^{28,29} activate an area in the posterior insula where putative CT sensations are processed.

We examined potential coherences between CT-mediated perception of erotic touch stimuli and individual sexual desire and performance profiles as inferred from questionnaires in a sample of healthy young men and women. CT optimal and suboptimal stroking on the left forearm took place under the same conditions as in previous psychophysical studies.^{7,23–25} The two-point discrimination threshold was included as a measurement of the discriminative aspects of the sense of touch, which are most likely conducted by myelinated A β -fibers.³⁰

Because CT-mediated touch is experienced as rewarding and related to the perception of eroticism, we investigated whether an individual high perceptibility of CT-targeted touch facilitates positive sexual experiences. Therefore, we hypothesized that ratings of CT-specific stroking, but not discriminative touch perception, would correlate positively to sexual desire and sexual performance.

AIM

The relation between CT-mediated touch perception and subjective measurements of sexual desire and sexual performance was investigated.

MAIN OUTCOME MEASURES

Ratings of perceived eroticism of tactile stroking stimuli (overall eroticism), CT-specific stroking (erotic touch differentiation), and two-point discrimination obtained in a laboratory environment were related to self-report data on sexual desire (interactional subscale of Sexual Desire Inventory [SDI]) and sexual performance (duration and frequency of partnered sexual activities, perceived pleasantness of sexual activities, and orgasm frequency in women).

METHODS

Ethical Declaration

The study design was conducted according to the Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects and approved by the ethics committee of Dresden University of Technology.

All participants signed an informed consent and received a small financial compensation.

Participants

Participants were recruited by postings at the local university buildings and the university website. Fluency in the German language for comprehension of instructions and questionnaires as well as subjective health were required. All participants stated that they had a normal sense of touch and normal or corrected-to-normal vision. This was assessed before inclusion in the study. To decrease potential participation bias, participants were not specifically asked about their sexual health before the investigations.

Eighty volunteers participated in the study. Eight were excluded because of mental health issues (based on their questionnaire scores) or reports of experienced sexual violence (all women). Another two participants (one man and one woman) were excluded from the analysis because they stated no sexual activity.

Hence, the final sample was composed of 70 healthy volunteers (42 women, 28 men) 18 to 36 years old (mean age \pm SD = 24.84 \pm 4.08 years) and most were students.

A minimum age of 18 years and a maximum age of 40 years were required, thereby avoiding potential early-onset menopausal hormonal changes in women as a mediating factor in sexual desire. Women were oversampled to control for the influence of hormonal contraception (HC). Twenty-one women used oral contraceptives; another 21 women did not use any HC method. Menstrual cycle phase was not considered. Of all participants, six women stated a bisexual orientation and four men reported a homo- or bisexual orientation. Forty-seven participants (31 women, 16 men) reported being in a relationship at the time of the study session. All those relationships were heterosexual.

Procedure

The study was part of a broader examination of influences of sensory inputs on sexual performance and desire and thus also involved the determination of olfactory thresholds³¹ and assessments of hair follicle density using the Cyanoacrylate Skin Stripping Method.³² All participants performed the psychophysical stroking experiment first, followed by a discriminative touch investigation, and provided a skin sample for the determination of hair follicle density before performing the olfactory threshold assessment. The questionnaires were completed at the end of the session. Olfactory thresholds and hair follicle densities will be presented elsewhere and were not included in the present analyses.

Psychophysical Stroking Experiment

Participants were seated in a comfortable chair in a room with a minimally distracting interior. They were asked to uncover their left forearm and place it in a pronated position on a pillow underneath the approximately 70-mm-wide soft goat hair brush of the Rotary Tactile Stimulator. The Rotary Tactile Stimulator is a robotic device—developed at the University of North Carolina in Chapel Hill (USA) in cooperation with Dancer Design in St Helens (UK)—for delivering touch stimuli with high-precision control of stroking velocity and force.³³ The left forearm as location for the tactile stimulation was chosen to allow for comparison with results from previous studies.^{22,25} This previous work also proved there was no difference in perceived eroticism or pleasantness between the forearm and the inner thigh,²² which justifies the use of forearm stimulation for the investigation of erotic touch perception.

After a calibration of stroking at a normal force of 0.4 N, the experiment was initiated. In total, the stroking protocol involved 18 strokes at six different velocities along an approximately 13-cm-long distance on the dorsal forearm in a proximal-to-distal direction. Presentation order was randomized within and between participants. CT optimal (1, 3, and 10 cm/s) and CT suboptimal (0.1, 0.3, and 30 cm/s) stroking velocities were presented. After each stimulus, the participants were given a 30-second interstimulus interval in which they rated the perceived pleasantness, eroticism, and intensity of the particular stroking velocity on a visual analog scale (VAS). Participants were not instructed to interpret the word *erotic* in any way. Each VAS

was displayed on a piece of paper (A5) as a 10-cm-long black line with the anchors “not at all pleasant/erotic/intense” at the level of 0 cm and “highly pleasant/erotic/intense” at the level of 10 cm. To prevent effects of social desirability, the experimenter was not present during the stroking experiment.

Two-Point Discrimination

To examine the ability to distinguish between two spatially divided tactile stimuli, a metal device (similar to any usual divider) with two tips at alterable distances was used. Because the two-point discrimination threshold is approximately 30 to 45 mm on the forearm of young and healthy individuals,³⁴ we used decreasing distances in steps of 0.5 cm (5, 4.5, 4, 3.5, and 3 cm) and assessed the minimal distance where the two tips were perceived as two in five of five trials. The participants were asked to close their eyes during the test, and the two-point discrimination was tested on the same dorsal area of the left forearm.

Questionnaires

The study design was supplemented by a battery of questionnaires on sexual desire and performance, aiming to cover different levels of sexual function. In this study, sexual desire served as a partner-independent variable, because sexual activity can strongly be influenced by relationship status and the sexual preferences of the partner.³

There were three different sets of questions. For the first set, participants filled in the SDI,^{35,36} which measures sexual desire as a solitary factor and a dyadic factor. Because the dyadic factor describes the desire to act out sexual interactions with a partner, analysis focused on this subscale, which consists of five items with possible answers predetermined on a nine-point scale representing different levels of frequency or need.

In the second set, sexual performance was assessed indirectly. The generally perceived pleasantness of sexual interactions was reported in the answer to the question, “How pleasant do you perceive sexual activities?” using a VAS with the anchor points 0 (not at all pleasant) and 8 (extremely pleasant). Women also answered the question, “What percentage of the time do you have orgasms in any way when you engage in sexual intercourse?” Participants who reported being in a relationship at the time of the study session also were asked to provide information on their sexual activity with the partner by answering questions about the frequency of sexual activities during the past month and the average duration of a sexual interaction with a partner in minutes. These items were based on the anamnestic protocol of a center for sexual therapeutic treatment (Awakenings Center for Sexuality and Intimacy, Raleigh, NC, USA, Watson, 2009).

The third set dealt with potential confounding factors, including pain during sexual intercourse, experiences of erectile dysfunction in men, and experience of sexual violence (Awakenings Center for Sexuality and Intimacy). It also involved the Disgust Sensitivity Scale³⁷; the Big Five Questionnaire assessing

the personality traits of neuroticism, openness, agreeableness, extraversion and conscientiousness³⁸; and the short version of the Patient Health Questionnaire consisting of 15 items determining mental health.³⁹ These factors served as covariates in the analysis if related to the dependent variables of the first and second sets.

Statistical Analysis

All statistical analyses were done using SPSS Statistics 22.0 for Windows (IBM Corp, Armonk, NY, USA).

For the analysis of stroking ratings, a mean value for each stroking velocity was computed from three repetitions per velocity. Linear and quadratic regression analyses were applied to ratings of pleasantness, eroticism, and intensity for the different velocities.

To analyze the relation between erotic touch perception and different manifestations of sexual performance and sexual desire, we introduced two specific measurements of erotic touch perception: the erotic touch differentiation—calculated as the difference between the rating of the stroking velocity at 1 cm/s and the velocity at 30 cm/s—differentiates between CT optimal (1 cm/s) and suboptimal (30 cm/s) stroking stimuli in each participant. The stroking velocity of 1 cm/s was previously observed as the stroking stimulus perceived as most erotic,²² whereas 30 cm/s was previously rated as a poor CT stimulus in microneurographic experiments.¹³ Therefore, higher values for erotic touch differentiation are likely to reflect superior functioning (density, sensitivity) of CT fibers and/or differential central processing of CT input.

The overall eroticism—the mean value of ratings across the different stroking velocities for every participant—shows the overall tendency to rate toward eroticism and thus likely reflects variations in central processing only.

Women with or without HC did not differ in their ratings of perceived eroticism in repeated measurement analysis of variance ($P = .873$). Further, these women did not differ in their manifestation of sexual desire or sexual performance, which was determined using t-tests for independent samples (SDI dyadic factor with HC mean \pm SD = 23.5 \pm 5.9, without HC mean \pm SD = 22.3 \pm 6, $P = .520$ by t-test; SDI solitary factor with HC mean \pm SD = 16.3 \pm 9.9, without HC mean \pm SD = 19.1 \pm 8.2, $P = .324$ by t-test; perceived pleasantness of sexual interactions with HC mean \pm SD = 6.5 \pm 1.25, without HC mean \pm SD = 6.2 \pm 1.5, $P = .507$ by t-test; sexual frequency with HC mean \pm SD = 7 \pm 6, without HC mean \pm SD = 9.6 \pm 5.9, $P = .250$ by t-test). Therefore, the two groups were merged for subsequent analysis.

Rating patterns for perceived eroticism were compared between male and female participants using analysis of variance with the applied velocities (six) as within-subject factors and gender as a between-subject factor. A t-test for independent samples was performed to contrast the overall eroticism between women and men.

Because of the statistically significant difference in the overall ratings of perceived eroticism between men and women, any potential relation between erotic touch perception and sexual performance and desire was analyzed separately for the gender-specific subgroups of the sample.

Possible confounders, such as painful sensations during sexual intercourse, experiences of erectile dysfunction in men, disgust sensitivity, and personality traits, were further related to variables of tactile perception (overall eroticism, erotic touch differentiation, and two-point discrimination) to determine potential underlying effects. If correlated to the dependent measurements, these confounders were included as covariates or controlling factors in a partial correlation. However, correlation analyses and t-test, respectively, showed no relation between measurements of touch perception (overall pleasantness vs eroticism, erotic vs pleasant touch differentiation) and the confounders, except for a positive correlation between overall eroticism and levels of neuroticism ($r = 0.379$, $P = .001$). Hence, neuroticism was controlled for tests of overall eroticism. Other confounders were not included in further analysis.

Relations between erotic touch differentiation, overall eroticism, and two-point discrimination and subjective indices of sexual performance and sexual desire (SDI) were examined using non-parametric correlation analysis (Spearman). Correlations were considered significant at a P value less than .05.

RESULTS

Touch Perception

The ratings for perceived pleasantness and eroticism were well described by a quadratic fit (pleasantness, $F_{1,70} = 120.42$, $P < .001$; eroticism, $F_{1,70} = 160.61$, $P < .001$) with the highest ratings for pleasantness and eroticism at CT optimal stroking velocities of 1 to 10 cm/s. In contrast, the ratings for perceived intensity followed a linear ($F_{1,69} = 31.06$, $P < .001$) and quadratic ($F_{1,69} = 73.51$, $P < .001$) fit, attaining a plateau at the stroking velocity of 1 cm/s (Figure 1).

The median two-point discrimination threshold was 4.0 cm across all participants. Women had a lower threshold (median = 4.0 cm, interquartile range = 1.5 cm) than men (median = 4.5 cm, interquartile range = 1 cm; $P = .006$ by median test).

For further analysis of the relation between touch perception and sexual performance and desire, analysis focused on measurements for erotic touch perception and two-point discrimination.

Erotic Touch Perception and Gender

The ratings of perceived eroticism clearly differed between male and female participants. A significant between-subject effect ($F_{1,69} = 9.99$, $P = .002$; Figure 2) indicated that women rated the perceived eroticism higher than men. Further, a significant within-subject interaction contrast (gender by velocity) for the

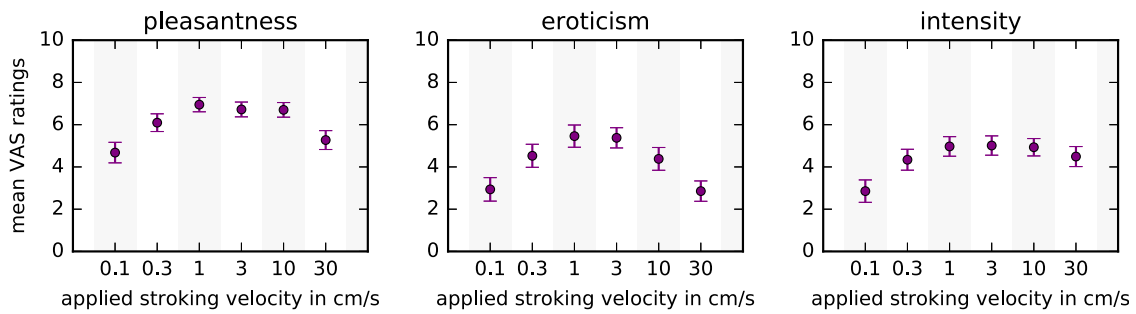


Figure 1. Mean visual analog scale ratings of perceived pleasantness, eroticism, and intensity for the different stroking velocities. Error bars represent 95% confidence intervals. The typical inverted U-shaped curve with the highest ratings in the range of 1 to 10 cm/s—the so-called C-tactile optimized stroking velocities—is found for pleasantness and eroticism. The course of intensity ratings attains a plateau at velocities higher than 1 cm/s. Figure 1 is available in color online at www.jsm.jsexmed.org.

quadratic fit ($F_{1,69} = 4.8, P = .032$) attested to a more distinctive quadratic shape for female compared with male participants (Figure 2).

Erotic Touch Perception and Sexual Desire and Performance in Women

Erotic touch differentiation, indicating higher ratings for CT- compared with non-CT-targeted touch, was positively correlated to the SDI dyadic factor, which represents the desire for sexual interaction with a partner ($r = 0.359, P = .019$; Figure 3 and Table 1). There was no significant relation of erotic touch differentiation to any of the sexual performance variables (sexual frequency and duration, orgasm frequency, and sexual pleasantness, Table 1).

Overall, eroticism and two-point discrimination did not correlate with any of the measurements of sexual desire or performance (Table 1). Partial correlations controlled for

neuroticism did not indicate any relation between overall eroticism and measurements of sexual desire or performance.

Erotic Touch Perception and Sexual Desire and Performance in Men

Erotic touch differentiation did not correlate with sexual desire but correlated negatively with the number of sexual interactions with the partner ($n = 17, r = -0.515, P = .034$; Figure 4 and Table 1) and positively with the reported average duration of sexual intercourse ($n = 18, r = 0.653, P = .003$; Figure 4 and Table 1). A potential influence of relationship length (in months) on those items also was checked with correlation analysis and showed no impact.

For women, the overall eroticism and two-point discrimination did not correlate with any of the measurements of sexual desire or performance (Table 1). Partial correlations controlled for neuroticism also did not indicate any relation between overall eroticism and measurements of sexual desire or performance.

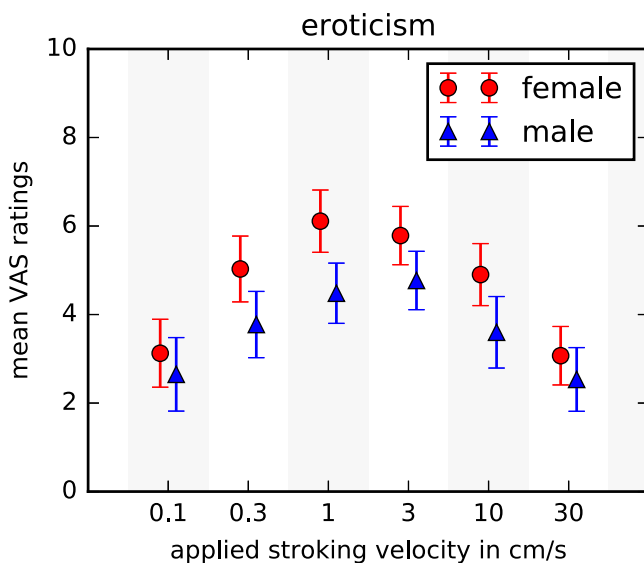


Figure 2. Mean ratings (VAS) of perceived eroticism for the different stroking velocities between men and women. Error bars represent 95% confidence intervals. Women rate the applied stroking touches as more erotic than men. VAS = visual analog scale. Figure 2 is available in color online at www.jsm.jsexmed.org.

DISCUSSION

The present results support the assumption that CT afferents mediate erotic touch perception.²¹ In line with a previous study,²² an inverted U-shaped relation between the ratings for eroticism and stroking velocity was found: the highest eroticism ratings corresponded with stroking velocities known to optimally stimulate CT afferents (note that different scales and anchor points were used compared with Jönsson et al²²). Moreover, the results suggest that CT stimulation can mediate sexual desire and performance (as assessed by sexuality questionnaires) differently in men and women. First, women rated forearm stimulation as more erotic than men did, irrespective of velocity (and thus of the stimulated fiber types). Second, we found gender differences in the way reported sexual parameters correlated to erotic touch differentiation—a measurement reflecting superiorly functioning CT touch processing. In women, erotic touch differentiation was related to a higher desire for sexual interactions. In men, erotic touch differentiation was related to fewer sexual interactions and longer average duration of sexual intercourse. None of those

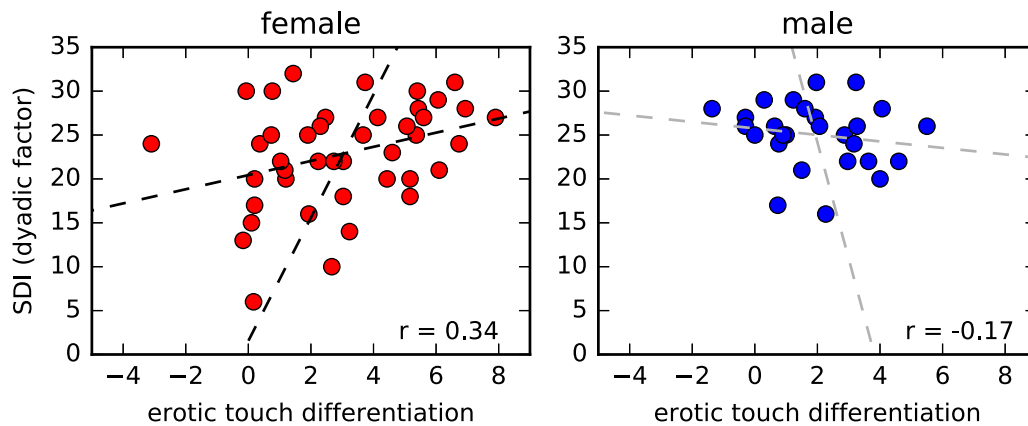


Figure 3. Scatterplots displaying the relation between erotic touch differentiation and sexual desire (SDI dyadic factor) by gender. The dotted lines represent the two regression lines obtained by regressing erotic touch differentiation on sexual desire and vice versa. The depicted r represents the Pearson correlation coefficient. In women, a positive relation between the two factors is presented. SDI = Sexual Desire Inventory. Figure 3 is available in color online at www.jsm.jsexmed.org.

correlations were obtained for overall eroticism or two-point discrimination, implying the CT-mediated erotic touch perception is specific for those outcomes. We interpret these results as showing that women are more likely to interpret slow-moving touch as a sexual cue, whereas men are more likely to interpret it as a sexual reward during sexual performance.

However, some findings seem to be at odds with this interpretation. For instance, there was a stronger association between CT-mediated erotic touch perception and desire for intercourse in women that was not reflected in higher sexual frequency. Likewise, for men, an increase in the differentiation of erotic touch appeared to be associated with the quality of their sexual performance (longer duration), but also with less frequent sexual interactions, and no correlation with sexual desire was found. Contradictory as they might seem, these findings do reflect the fact that motivation and consumption are distinctly represented in the brain^{40,41} and in the sexual domain.¹ They match current concepts of sexual desire and sexual arousal and their concordance in men and women.⁴² For men, the concepts of sexual

arousal and sexual desire seem to be considered less interchangeable than in women: “arousal” marks a clearly distinguishable physical reaction, whereas “desire” implies the incentive motivation to act out the same arousal and engage in sexual activity. Women often typically have less concordant physical arousal and psychological desire. At the same time, sexual desire in women does not invariably mean a desire to engage in sexual activities but rather a “desire to feel desired” or a desire to seek emotional contact and intimacy with a partner.^{42,43}

Some limitations of the present study design should be mentioned: the female menstrual cycle (eg, average duration of the cycle and menstrual bleeding or current phase of the cycle) as a potential mediating factor in the measurements of sexual performance and sexual desire in women was sparsely assessed, and the inhomogeneous composition of the sample group concerning sexual orientation (with only a small share of bi- or homosexual orientation) was insufficient for analyses on possible differential effects in CT function in more specific subgroups.

Table 1. Results of gender-specific non-parametric correlational analysis between measurements for erotic and discriminative touch and sexual desire and sexual performance*

	Women			Men		
	Erotic touch differentiation	Overall eroticism	2-Point discrimination	Erotic touch differentiation	Overall eroticism	2-Point discrimination
Sexual desire						
SDI dyadic	0.359 [†]	0.303	0.158	-0.199	0.230	0.277
Sexual performance						
Duration of intercourse	-0.159	0.084	-0.160	0.653 [‡]	-0.319	0.049
Frequency of intercourse	-0.106	-0.110	-0.215	-0.515 [†]	0.298	0.093
Sexual pleasantness	0.215	0.139	0.133	-0.074	-0.309	0.037
Orgasm frequency	-0.247	-0.022	0.042	—	—	—

SDI = Sexual Desire Inventory.

*Correlation coefficients (r) are listed.

[†] $P < .05$; [‡] $P < .01$.

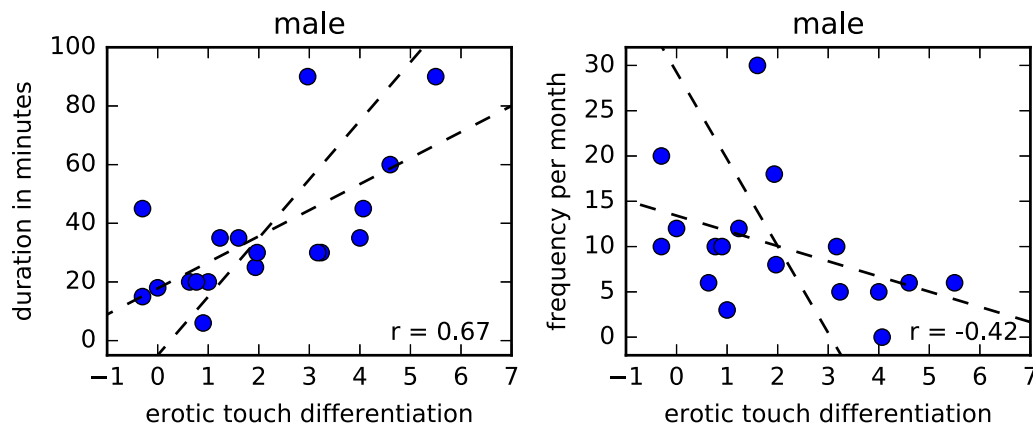


Figure 4. Relation between erotic touch differentiation and the estimated average duration of sexual intercourse (in minutes) and the amount of sexual intercourse during the past month in men only. The dotted lines represent the two regression lines obtained by regressing erotic touch differentiation on sexual desire and vice versa, respectively. The depicted r represents the Pearson correlation coefficient. A significant positive correlation between erotic touch differentiation and the duration of sexual intercourse is presented. Further, a negative relation between erotic touch differentiation and the sexual frequency is presented. Figure 4 is available in color online at www.jsm.jsexmed.org.

Nonetheless, the present results provide evidence for CT-mediated erotic perception in women and furthermore propose that CT afferents mediate different phases of the sexual response differently in men and women. The next question is whether such a difference would be driven by peripheral or central mechanisms or an interaction of the two. Although gender differences are subtle, women seem to outperform men in pleasantness and eroticism ratings for CT-mediated touch, which has been reported.^{24,33} The present findings suggest that erotic touch perception is independent from individual factors such as personality traits or disgust sensitivity. This could be indicative of a larger role for peripheral nervous system function in this phenomenon rather than top-down effects. However, a functional magnetic resonance imaging study in young heterosexual men showed that the gender of the agent providing CT stimulation (of the inner thigh) had a profound effect on somatosensory brain function, suggesting that expectancy does play a significant role in CT-mediated erotic perception.⁴⁴ Further, top-down factors, such as an individual's disgust perception, shape the brain's response to touch by enhancing discriminative aspects of touch and suppressing CT-related aspects.⁴⁵

Determining the mechanism behind the relation of CT touch perception and sexual performance is not conclusive. It is equally plausible to suggest that the peripheral CT function affects sexual parameters and vice versa in a conditioning way. However, the latter was not found in our data in which the correlations between erotic touch differentiation and sexual performance in men were controlled by the length of relationship in months, which showed no subjacent relation.

In summary, sexual interactions mark an expression of emotional intimacy and close contact in interpersonal relationships. We can confirm the notion that erotic touch perception relates to the peripheral characteristics of unmyelinated CT

afferents.²² Erotic touch is perceived strongest at velocities that are known to optimally activate CT fibers. These specialized afferents most likely conduct the affective shape of the tactile perception and thus moderate the emotional evaluation of touch that is interpreted as erotic.

CLINICAL IMPLICATIONS

Low sexual desire is one of the most common sexual complaints in women.³ With approximately 30% of women at a reproductive age affected,⁴ there is a distinct demand for enlightenment in the processes affecting the sensitive construct of sexual desire in women. However, there is an explicit lack of treatment options, although there are promising attempts of research leading the way toward therapeutic psychoeducation for mindfulness-based treatment.⁴⁶ Whether such mindfulness-based therapy options could be applicable for a training of erotic touch differentiation, potentially enhancing female sexual desire, is conceivable.

Our results also show a relation between CT perception and enhanced duration and lower frequency of sexual intercourse in men. If men could be trained in CT perception, then they might enhance the quality of their sexual relationships by better aligning with the needs of their partner. Prevalent male sexual dysfunctions, such as psychogenic erectile dysfunction and premature ejaculation, which affect up to 15% of men,⁴⁷ could be targets of such an approach.

Future research in this field might be able to assess the same coherence for clearly defined groups of men and women with specific impairments of sexual functioning, such as hypoactive sexual desire disorder and arousal or orgasmic disorders.

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Category 3

(a) Final Approval of the Completed Article

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REFERENCES

- Georgiadis JR, Kringelbach ML. The human sexual response cycle: brain imaging evidence linking sex to other pleasures. *Prog Neurobiol* 2012;98:49-81.
- Georgiadis JR, Kringelbach ML, Pfau JG. Sex for fun: a synthesis of human and animal neurobiology. *Nat Rev Urol* 2012;9:486-498.
- Beutel M, Stöbel-Richter Y, Brähler E. Sexual desire and sexual activity of men and women across their lifespans: results from a representative German community survey. *BJU Int* 2008;101:76-82.
- Shifren JL, Johannes CB, Monz BU, et al. Help-seeking behavior of women with self-reported distressing sexual problems. *J Womens Health* 2009;18:461-468.
- Stoléru S, Fonteille V, Cornélis C, et al. Functional neuroimaging studies of sexual arousal and orgasm in healthy men and women: a review and meta-analysis. *Neurosci Biobehav Rev* 2012;36:1481-1509.
- Gulledge AK, Stahmann RF, Wilson CM. Seven types of nonsexual romantic physical affection among Brigham Young University students. *Psychol Rep* 2004;95:609-614.
- Löken LS, Wessberg J, Morrison I, et al. Coding of pleasant touch by unmyelinated afferents in humans. *Nat Neurosci* 2009;12:547-548.
- McGlone F, Wessberg J, Olausson H. Discriminative and affective touch: sensing and feeling. *Neuron* 2014;82:737-755.
- Morrison I, Löken LS, Olausson H. The skin as a social organ. *Exp Brain Res* 2010;204:305-314.
- Olausson H, Lamarre Y, Backlund H, et al. Unmyelinated tactile afferents signal touch and project to insular cortex. *Nat Neurosci* 2002;5:900-904.
- Lloyd DM, Gillis V, Lewis E, et al. Pleasant touch moderates the subjective but not objective aspects of body perception. *Front Behav Neurosci* 2013;7:207.
- Björnsdotter M, Morrison I, Olausson H. Feeling good. On the role of C fiber mediated touch in interoception. *Exp Brain Res* 2010;207:149-155.
- Liljencrantz J, Olausson H. Tactile C fibers and their contributions to pleasant sensations and to tactile allodynia. *Front Behav Neurosci* 2014;8:37.
- Vallbo AB, Olausson H, Wessberg J, et al. A system of unmyelinated afferents for innocuous mechanoreception in the human skin. *Brain Res* 1993;628:301-304.
- Ackerley R, Backlund Wasling H, Liljencrantz J, et al. Human C-tactile afferents are tuned to the temperature of a skin-stroking caress. *J Neurosci* 2014;34:2879-2883.
- Vallbo AB, Olausson H, Wessberg J. Unmyelinated afferents constitute a second system coding tactile stimuli of the human hairy skin. *J Neurophysiol* 1999;81:2753-2763.
- McGlone F, Olausson H, Boyle JA, et al. Touching and feeling. Differences in pleasant touch processing between glabrous and hairy skin in humans. *Eur J Neurosci* 2012;35:1782-1788.
- Sailer U, Tricoli C, Häggblad G, et al. Temporal dynamics of brain activation during 40 minutes of pleasant touch. *Neuroimage* 2016;139:360-367.
- Lindgren L, Westling G, Brulin C, et al. Pleasant human touch is represented in pregenual anterior cingulate cortex. *Neuroimage* 2012;59:3427-3432.
- Case LK, Laubacher CM, Olausson H, et al. Encoding of touch intensity but not pleasantness in human primary somatosensory cortex. *J Neurosci* 2016;36:5850-5860.
- Kandel ER, Schwartz JH, Jessell TM, et al. Principles of neural science. 5th ed. New York: McGraw Hill Professional; 2013.
- Jönsson EH, Backlund Wasling H, Wagnbeck V, et al. Unmyelinated tactile cutaneous nerves signal erotic sensations. *J Sex Med* 2015;12:1338-1345.
- Ackerley R, Carlsson I, Wester H, et al. Touch perceptions across skin sites. Differences between sensitivity, direction discrimination and pleasantness. *Front Behav Neurosci* 2014;8:54.
- Croy I, Angelo SD, Olausson H. Reduced pleasant touch appraisal in the presence of a disgusting odor. *PLoS One* 2014;9:e92975.
- Tricoli C, Olausson H, Sailer U, et al. CT-optimized skin stroking delivered by hand or robot is comparable. *Front Behav Neurosci* 2013;7:208.
- Georgiadis JR, Farrell MJ, Boessen R, et al. Dynamic subcortical blood flow during male sexual activity with ecological validity: a perfusion fMRI study. *Neuroimage* 2010;50:208-216.

27. Georgiadis JR, Holstege G. Human brain activation during sexual stimulation of the penis. *J Comp Neurol* 2005;493:33-38.
28. Ferretti A, Caulo M, Del Gratta C, et al. Dynamics of male sexual arousal: distinct components of brain activation revealed by fMRI. *Neuroimage* 2005;26:1086-1096.
29. Mouras H, Stoléru S, Moulier V, et al. Activation of mirror-neuron system by erotic video clips predicts degree of induced erection: an fMRI study. *Neuroimage* 2008;42:1142-1150.
30. Wessberg J, Olausson H, Fernström KW, et al. Receptive field properties of unmyelinated tactile afferents in the human skin. *J Neurophysiol* 2003;89:1567-1575.
31. Hummel T, Sekinger B, Wolf SR, et al. 'Sniffin'sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chem Senses* 1997;22:39-52.
32. Pagnoni A, Kligman AM, el Gammal S, et al. Determination of density of follicles on various regions of the face by cyanoacrylate biopsy: correlation with sebum output. *Br J Dermatol* 1994;131:862-865.
33. Essick GK, McGlone F, Dancer C, et al. Quantitative assessment of pleasant touch. *Neurosci Biobehav Rev* 2010;34:192-203.
34. Nolan MF. Two-point discrimination assessment in the upper limb in young adult men and women. *Physical Ther* 1982;62:965-969.
35. Kuhn W, Koenig J, Donoghue A, et al. Psychometrische Eigenschaften einer deutschsprachigen Kurzversion des Sexual Desire Inventory (SDI-2). *Z Sexualforsch* 2014;27:138-149.
36. Spector IP, Carey MP, Steinberg L. The Sexual Desire Inventory. Development, factor structure, and evidence of reliability. *J Sex Marital Ther* 1996;22:175-190.
37. Schienle A, Schäfer A, Stark R, et al. Disgust sensitivity in psychiatric disorders: a questionnaire study. *J Nerv Ment Dis* 2003;191:831-834.
38. Digman JM. Personality structure—emergence of the 5-factor model. *Annu Rev Psychol* 1990;41:417-440.
39. Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. *JAMA* 1999;282:1737-1744.
40. Berridge KC, Kringelbach ML. Affective neuroscience of pleasure: reward in humans and animals. *Psychopharmacology* 2008;199:457-480.
41. Berridge KC, Kringelbach ML. Neuroscience of affect: brain mechanisms of pleasure and displeasure. *Curr Opin Neurobiol* 2013;23:294-303.
42. Bancroft J, Graham CA. The varied nature of women's sexuality: unresolved issues and a theoretical approach. *Horm Behav* 2011;59:717-729.
43. Basson R. The female sexual response: a different model. *J Sex Marital Ther* 2000;26:51-65.
44. Gazzola V, Spezio ML, Etzel JA, et al. Primary somatosensory cortex discriminates affective significance in social touch. *Proc Natl Acad Sci U S A* 2012;109:E1657-E1666.
45. Croy I, Drechsler E, Hamilton P, et al. Olfactory modulation of affective touch processing—a neurophysiological investigation. *Neuroimage* 2016;135:135-141.
46. Brotto LA, Basson R. Group mindfulness-based therapy significantly improves sexual desire in women. *Behav Res Ther* 2014;57:43-54.
47. Moreira ED, Hartmann U, Glasser DB, et al. A population survey of sexual activity, sexual dysfunction and associated helpseeking behavior in middle-aged and older adults in Germany. *Eur J Med Res* 2005;10:434.