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How Hot Are They? Neural Correlates of Genital Arousal: An Infrared Thermographic and Functional Magnetic Resonance Imaging Study of Sexual Arousal in Men and Women

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ABSTRACT

Background: The few studies that have examined the neural correlates of genital arousal have focused on men and are methodologically hard to compare.

Aim: To investigate the neural correlates of peripheral physiologic sexual arousal using identical methodology for men and women.

Methods: 2 groups (20 men, 20 women) viewed movie clips (erotic, humor) while genital temperature was continuously measured using infrared thermal imaging. Participants also continuously evaluated changes in their subjective arousal and answered discrete questions about liking the movies and wanting sexual stimulation. Brain activity, indicated by blood oxygen level-dependent (BOLD) response, was measured using functional magnetic resonance imaging.

Outcomes: BOLD responses, genital temperature, and subjective sexual arousal.

Results: BOLD activity in a number of brain regions was correlated with changes in genital temperature in men and women; however, activation in women appeared to be more extensive than in men, including the anterior and posterior cingulate cortex, right cerebellum, insula, frontal operculum, and paracingulate gyrus. Examination of the strength of the correlation between BOLD response and genital temperature showed that women had a stronger brain-genital relation compared with men in a number of regions. There were no brain regions in men with stronger brain-genital correlations than in women.

Clinical Translation: Our findings shed light on the neurophysiologic processes involved in genital arousal for men and women. Further research examining the specific brain regions that mediate our findings is necessary to pave the way for clinical application.

Strengths and Limitations: A strength of the study is the use of thermography, which allows for a direct comparison of the neural correlates of genital arousal in men and women. This study has the common limitations of most laboratory-based sexual arousal research, including sampling bias, lack of ecologic validity, and equipment limitations, and those common to neuroimaging research, including BOLD signal interpretation and neuroimaging analysis issues.

Conclusions: Our findings provide direct sex comparisons of the neural correlates of genital arousal in men and women and suggest that brain-genital correlations could be stronger in women. **Parada M, Gérard M, Larcher K, et al. How Hot Are They? Neural Correlates of Genital Arousal: An Infrared Thermographic and Functional Magnetic Resonance Imaging Study of Sexual Arousal in Men and Women. J Sex Med 2017;XX:XXX–XXX.**

Key Words: Genital Arousal; Functional Magnetic Resonance Imaging; Sexual Arousal; Gender Differences; Thermography

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INTRODUCTION

Sexual arousal is typically defined as an emotional or motivational state that can be inferred from central, peripheral, or behavioral responses. These responses have been measured subjectively through rating scales and symptom reports or physiologically using peripheral methods such as penile plethysmography or vaginal photoplethysmography. The discordance, especially for women, between subjective and physiologic measures of arousal has motivated researchers to develop newer and more reliable measurement methodologies. Despite these developments, there is often significant discrepancy between subjective and physiologic measures[1] and controversy about which are the best measurement techniques.

The development of neuroimaging technologies such as positron-emission tomography and functional magnetic resonance imaging (fMRI) has provided new methodologies for assessing the physiologic correlates of sexual arousal. These methodologies are important because they are directed toward the measurement of sexual arousal in the brain, which is most likely the control center for all sexual arousal and behavior. Thus far, this line of research has suggested that separate brain networks are responsible for psychogenic sexual arousal (ie, mental arousal) and physiologic sexual arousal.[2] A recent quantitative meta-analysis by Poeppl et al[2] also pointed at strong sex differences in the neural processing of sexual stimuli and ultimately at the existence of significant differences in the functional neuroanatomy of sexual behavior in heterosexual men and women.

Most studies in the neuroimaging literature have correlated self-report measurements of sexual arousal with neural measurements. Although this is a reasonable strategy, it ignores the genital component of arousal. In fact, we found only 6 studies for men[3–8] and 1 study for women[9] that investigated the neural correlates of genital arousal. The studies of men correlated brain activation with measures of penile erection and reported significant brain activity in the anterior cingulate, insula, amygdala, hypothalamus, and secondary somatosensory cortices. The 1 study of women by Arnow et al[9] did not find significant correlations between brain activity and genital response measured by vaginal photoplethysmography. They suggested that low correlations between brain activity and vaginal response are reflective of the low concordance between subjective and genital arousal in women in general.

These studies have significant methodologic problems. All but 1[4] used relatively short erotic stimuli usually presented in block designs with control stimuli. As Georgiadis and Kringelbach[10] pointed out, this is a problem in the fMRI sexual arousal literature in general because the use of such short stimuli limits the validity of brain measurement to the early stages of sexual arousal. A 2nd problem relates to the comparability of the type of stimuli used to induce sexual arousal. 3 studies[5,6,8] used erotic video clips, Moulier et al[6] used photographs, and Georgiadis et al[7] used tactile stimulation from a partner. In the study by Moulier et al,[6] a control condition used photographs of nude or swimsuit-dressed children. A 3rd problem relates to the devices used to measure penile arousal. The "penile pressure cuff" used by Arnow et al,[4] the "pneumatic device" used by Ferreti et al,[5] and the "erectometer" used by Georgiadis et al[7] were developed by the investigators and have not been generally validated for the measurement of sexual arousal. How these 3 measures compare and how they are related to the volumetric measures used by Moulier et al[6] and Mouras et al[8] is not known. A 4th problem is the comparability of these different measures of penile arousal with vaginal photoplethysmography. Because studies comparing men and women use different instrumentation, sex is confounded with measurement method, thereby making the data collected hard to interpret. This is a particularly important issue because in the 1 fMRI study of genital arousal in women, the investigators cited potential sex differences as the reason for failing to find correlations between brain activity and vaginal photoplethysmography.

The development of thermography has recently provided a potential solution to most of these problems. In a series of studies, Kukkonen et al[11,12] demonstrated that thermography is a reliable and valid peripheral physiologic measure of sexual arousal. Thermography provides a continuous measurement of genital temperature that reflects blood flow changes indicative of arousal. This continuous measurement of temperature is comparable between sexes and is easily correlated with other continuous measures such as subjective arousal or fMRI. Use of this methodology would allow men and women to be tested using the same paradigm with the same equipment in an fMRI environment.

A recent fMRI sexual arousal study by Parada et al[13] used thermography and addressed many of the methodologic issues mentioned earlier. This fMRI study of men and women included continuous measurement of subjective arousal and of genital temperature over a relatively long period (2 successive periods of 5-minute sessions) of sexual arousal. They found that a subset of regions within the parietal lobe was positively correlated with subjective ratings of sexual arousal intensity. There were no sex differences in these parietal regions, which are known to be involved in multiple attentional processes, including in the monitoring of internal bodily sensations and in the processing of sensory information from the genitals.

The report of this study focused on the brain correlates of subjective sexual arousal but did not address the data related to the thermographic correlates. Therefore, the goal of the present report is to present these data. As far as we are aware, these are the first fMRI data investigating peripheral physiologic sexual arousal in which an identical methodology was used for men and women.

We hypothesized (i) blood oxygen level-dependent (BOLD) signal in the anterior cingulate, insula, amygdala, hypothalamus, and secondary somatosensory cortices would be significantly correlated with penile temperature during the viewing of erotic videos; (ii) the same regions would be activated in women when