

EVALUATION

Neural Representation of Subjective Sexual Arousal in Men and Women

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ABSTRACT

Introduction: Studies investigating brain indices of sexual arousal have begun to elucidate the brain's role in processing subjective arousal; however, most research has focused on men, used discrete ratings of subjective arousal, and used stimuli too short to induce significant arousal in women.

Aim: To examine brain regions modulated by changes in subjective sexual arousal (SSA) rating intensity in men and women.

Methods: Two groups (20 men, 20 women) viewed movie clips (erotic or humorous) while continuously evaluating changes in their SSA using a Likert-like scale (0 = not aroused, 10 = most aroused) and answering discrete questions about liking the movies and wanting sexual stimulation. Brain activity was measured using functional magnetic resonance imaging.

Main Outcome Measures: Blood oxygen level-dependent responses and continuous and discrete measurements of sexual arousal.

Results: Erotic movies induced significant SSA in men and women. No sex difference in mean SSA was found in response to the erotic movies on continuous or discrete measurements. Several brain regions were correlated with changes in SSA. Parametric modulation with rating intensity showed a specific group of regions within the parietal lobe that showed significant differences in activity among low, medium, and high SSA.

Conclusion: Multiple regions were concordant with changes in SSA; however, a subset of regions in men and women was modulated by SSA intensity, a subset previously linked to attentional processes, monitoring of internal body representation, and processing of sensory information from the genitals. This study highlights that similar brain regions are activated during subjective assessment of sexual arousal in men and women. The data further highlight the fact that SSA is a complex phenomenon made up of multiple interoceptive and attentional processes.

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Key Words: Brain; Subjective Arousal; Functional Magnetic Resonance Imaging; Sexual Arousal; Sex

INTRODUCTION

Sexual arousal is typically defined as an emotional or motivational state that can be inferred from central, peripheral, or behavioral responses triggered by internal and/or external stimuli.¹ This state has traditionally been measured through subjective verbal or non-verbal responses or through peripheral psychophysiological indices. The degree of discordance between these subjective and psychophysiological indicators of sexual arousal, particularly

in women, has given rise to a large literature examining sex differences in sexual arousal patterns and potential methodologic artifacts (for review, see Chivers et al²). Currently, there is much controversy about the best psychophysiological methodology (eg, plethysmography, ultrasonography, or thermal imaging) to monitor peripheral arousal, and little agreement exists about the essential elements of sexual arousal, which have been defined as ranging from “awareness of genital change” to “feelings of mental excitement.”³

In the past 15 years, the advancement of neuroimaging methods has allowed for the investigation of the subjective and physiologic correlates of sexual arousal, mostly throughout a series of studies using positron emission tomography and functional magnetic resonance imaging (fMRI). In one of the first major reviews on brain activation in response to sexual stimuli in men, Stoléru and Mouras⁴ identified several regions involved in

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the attentional, motivational, emotional, and motor processes occurring in response to viewing sexual stimuli. These brain regions included the occipitotemporal and orbitofrontal cortices, superior and inferior parietal lobules, anterior cingulate, caudate nucleus, left ventral premotor area, putamen, insula, claustrum, and hypothalamus. A recent review by Stoléru et al⁵ that included nine fMRI and three positron emission tomographic studies reported that many of the aforementioned regions activated by sexual stimuli displayed similar activation in men and women, yet 10 of these 12 studies also found regions that were differentially activated in men and women. Furthermore, most studies reported greater brain activation in men, several inconsistencies regarding stimulus type, inclusion of subjective ratings of arousal, number of subjects, and phase of menstrual cycle at time of testing (for review, see Stoléru et al⁵).

Despite broadening our understanding of sexual arousal, the available fMRI studies on the topic are marked by two methodologic problems. The first is their reliance on post hoc subjective measurements rather than continuous measurements of subjective arousal during the sexual stimulus. The second problem is the duration of the stimuli used to induce an arousal response. The existing human brain imaging literature on sexual behavior indicated that only five studies used stimuli longer than 180 seconds (for review, see Georgiadis and Kringelback⁶). Although short stimulus presentations are convenient for measuring the very fast hemodynamic response occurring in the brain within seconds of any stimulus presentation, they are problematic in that they target only the brain response occurring in the very early processing of sexual cues at low levels of sexual arousal. As Georgiadis and Kringelback⁶ pointed out, the study of sexual arousal calls for explicit and long video stimuli because different brain areas are involved once early processing is completed and significant arousal is reached. Longer stimulus presentations have been shown to result in activation of the inferior and superior parietal lobes of the right and left hemispheres and the right frontal lobes (premotor areas), associated with attentional processes and interoceptive attention systems that monitor bodily processes.^{7–11}

Arnou et al¹⁰ were the only group to incorporate continuous assessment of subjective arousal and long visual stimuli (movies) in the fMRI environment. When comparing brain activation between 12 women diagnosed with hypoactive sexual desire disorder and 20 normal control women, they found activation in the middle and inferior occipital cortices and the fusiform gyri was correlated with subjective ratings in the two groups; these regions are associated with visual processing of objects, faces, and bodies and are consistent with those reported by Stoléru et al.⁵ Although the inclusion of continuous subjective ratings provides a starting point for understanding the brain correlates of subjective sexual arousal (SSA), the study by Arnou et al¹⁰ has some important limitations: only women were included; the focus was on sexual dysfunction rather than normal arousal; and the correlation between subjective ratings and brain activation was unclear.

Therefore, the purpose of the present study was to examine the neural representation of SSA using fMRI during the continuous presentation of stimuli that would induce significant levels of sexual arousal in women and men. To assess the relation between brain activation (represented by blood oxygenation level dependent [BOLD] response) and SSA, we used general linear modeling with simple correlations followed by a parametric modulation of subjective ratings of arousal. We hypothesized (i) there would be a significant linear relation between SSA and brain activity in men and women in previously reported regions; (ii) parametric modulation of rating intensities would show a smaller subset of regions specifically involved in SSA that would include the parietal lobes, frontal (premotor) areas, and the insula, associated with attentional processes and interoceptive attention systems for all participants; and (iii) men would show greater activation in these regions.

METHODS

The research ethics board of the university and hospital approved the protocol. Informed consent was obtained from each participant.

Participants

Twenty men (mean age = 23.75 years, SD = 3.38; range = 18–31) and 20 women (mean age = 22.85 years, SD = 3.04, range = 19–30) were recruited through the university's online classified ads, Facebook, and postings on campus. Inclusion criteria were identifying as heterosexual; being capable of becoming easily aroused by heterosexual video stimuli; having at least one prior experience with sexual intercourse and prior exposure to erotic materials; having regular menstrual cycles (women); being a minimum of 5 feet 2 inches tall (for the MRI); and being right handed. Exclusion criteria included the report of current or past problems with sexual arousal; sexual dysfunction (as measured by a score < 15.6 on the Female Sexual Function Index and a score < 3 on the sexual arousal subscale or a score < 38 on the International Index of Erectile Function); sexually transmitted infection; substance abuse; major psychiatric problems; medications known to affect sexual arousal (eg, antidepressants, antihypertensive medication, or hormones); a fear of enclosed spaces; or neurologic conditions. In addition, women could not be pregnant or attempting to conceive. Mean scores on the Female Sexual Function Index for women were 30.65 (SD = 2.685, range = 25.8–36.0); mean scores on the International Index of Erectile Function for men were 64.50 (SD = 10.83, range = 38.0–74.0).

Procedure

After a telephone screening interview and at-home completion of the Female Sexual Function Index scale for women¹² and the International Index of Erectile Function scale for men,¹³ participants came to the testing location, where they completed

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