

BRAIN AREAS ACTIVATED AFTER EJACULATION IN HEALTHY YOUNG HUMAN SUBJECTS

H. N. MALLICK*, S. TANDON[^], N. R. JAGANNATHAN**,
K. K. GULIA AND V. M. KUMAR

*Departments of *Physiology and **NMR,
All India Institute of Medical Sciences,
New Delhi – 110 029, India*

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Abstract : Brain mechanisms for the refractory period that characteristically follows ejaculation in animals and human are poorly understood. The possibility of active inhibition of brain areas being responsible for the post-ejaculatory inhibitory state has not been ruled out. Using Blood Oxygen Level Dependent (**BOLD**) functional magnetic resonance imaging (fMRI) we have mapped brain areas in healthy young volunteers immediately after ejaculation. Functional imaging of the brain for 30 minutes beginning after three minutes of ejaculation induced by masturbation showed spatio-temporal activation in amygdala, temporal lobes and septal areas. The septal areas were observed to be active for a shorter duration than the amygdala and the temporal lobe. Thus the temporal sequence of involvement of the above neural structures may contribute to temporary inhibition of sexual arousal/penile erection during the post-ejaculatory refractory period in humans.

Key words : post ejaculatory refractory period
brain mapping

fMRI
limbic system

INTRODUCTION

Ejaculation represents a major component of male sexual behaviour, which is typically accompanied with orgasmic sensation. Ejaculation is followed by a state of sexual quiescence and it is termed as post ejaculatory refractory period (PERP). The PERP varies from species to species, e.g. from less than 30 seconds in Syrian hamsters (1) to hours or days in some mammals (2). The available literature does not provide sufficient information about the normal

duration of the refractory period in human, which elapses between ejaculation and the ability to achieve another erection. However there are two reports on the duration of PERP in human with erotic stimulation during the intervening period. Aversa et al have reported a duration of 10.8 ± 0.09 min with continuous audiovisual erotic stimulation during the post ejaculatory interval (3). In another study the PERP is reported to be of 19.1 min with audiovisual sexual stimulation during the interval (4). During the first three-quarter of PERP, a

*Corresponding Author : Tel: +91-11-26594881; Fax : +91-11-26588641, 91-11-26588663; E-mail: hmallick@hotmail.com
[^]Present address : National Brain Research Institute, Manesar.

pre-eminent inhibitory state prevails (5). It is difficult to elicit any sexual response during this phase by using any intensity of sexual stimuli in most mammals including human (6). A single report available in experimental animal shows extreme reduction in PERP by midbrain lesions (7). Active inhibition by some neuronal structures may be responsible for this temporary sexually inhibitory state, though there is hardly any evidence to support this proposition. The present study was undertaken to map out any brain areas activated after ejaculation using Blood Oxygen Level Dependent (**BOLD**) functional MRI (fMRI), in young volunteers.

MATERIALS AND METHODS

Six healthy young volunteers (Mean age 22.0±0.5 years) participated in this study. All experiments on human subjects were conducted in accordance with the Declaration of Helsinki and all procedures were carried out with the adequate understanding and written consent of the subjects. The study was approved by the Human Ethical Clearance Committee of All India Institute of Medical Sciences, New Delhi, India.

The subjects were instructed to follow three days of sexual abstinence prior to the study. All the subjects were relaxed and motivated. Each subject masturbated in an isolated chamber leading to ejaculation accompanied by orgasm. Immediately after ejaculation the subject were positioned in the MRI scanner. They were instructed not to sleep during the imaging. All MR experiments were carried out at 1.5 T using a whole body MR scanner (Sonata, Siemens, Erlangen, Germany).

Following the acquisition of localizer images six coronal slices were selected for functional imaging such that the central slice was at the optic chiasma in a mid sagittal section covering the amygdala, temporal lobe and the hypothalamus of the brain. These six slices also covered all the regions of interest, which have not only been previously implicated in various aspects of male sexual behaviour, but also showed activation after ejaculation in the preliminary experiments. In these preliminary experiments the whole brain in the coronal plane was scanned using single shot EPI sequence following ejaculation to identify the brain slices in which neural structures showed maximum activation during PERP. This allowed us to avoid wastage of scan time during actual experiments. The brain slices which showed maximum activation during PERP, were septum, amygdala, anterior commissure, inferior and medial temporal gyri, uncus, superior, middle and inferior temporal gyri.

Functional images were acquired using single shot spin-echo planar imaging (EPI) sequence. The acquisition parameters were: TR = 2500 ms, slice thickness = 5 mm, number of slices = 6, without interslice distance. Functional images were acquired continuously for 30 min after three minutes of ejaculation (total measurements = 600). T1 weighted images of the selected six slices were also acquired to overlay the activation maps obtained from functional images. The signal intensity difference was processed by applying Students' t-test between the initial ten images acquired at three minutes after ejaculation which was the start of the EPI scan and ten images acquired at the 30th, 25th, 20th and 15th minute after ejaculation.

Post processing of images

Ten images acquired just at the start of the EPI scan (Three minutes after ejaculation) and ten images acquired at the 30th minute were grouped separately. Parametric Student's t-test was applied on these two groups of images. The threshold of this t-test was adjusted to 1000 (arbitrary units). So a hyperintense bright signal was observed in all the pixels in which the signal intensity difference between the first ten images taken at three minute and ten images at 30th minute after ejaculation was more than 1000. This functional image was then overlaid on the coronal anatomical images

to identify the brain regions activated. The same post processing protocol was followed to find out the significant signal intensity differences between the initial ten images at the start of the EPI scan and ten images acquired at the 25th minute, 20th minute and 15th minute. This was done to find out if there was a difference in activation in the various neural substrates at these various time intervals during the EPI scan on 30 minutes after ejaculation.

RESULTS

Comparison between ten images taken three minutes after ejaculation and ten

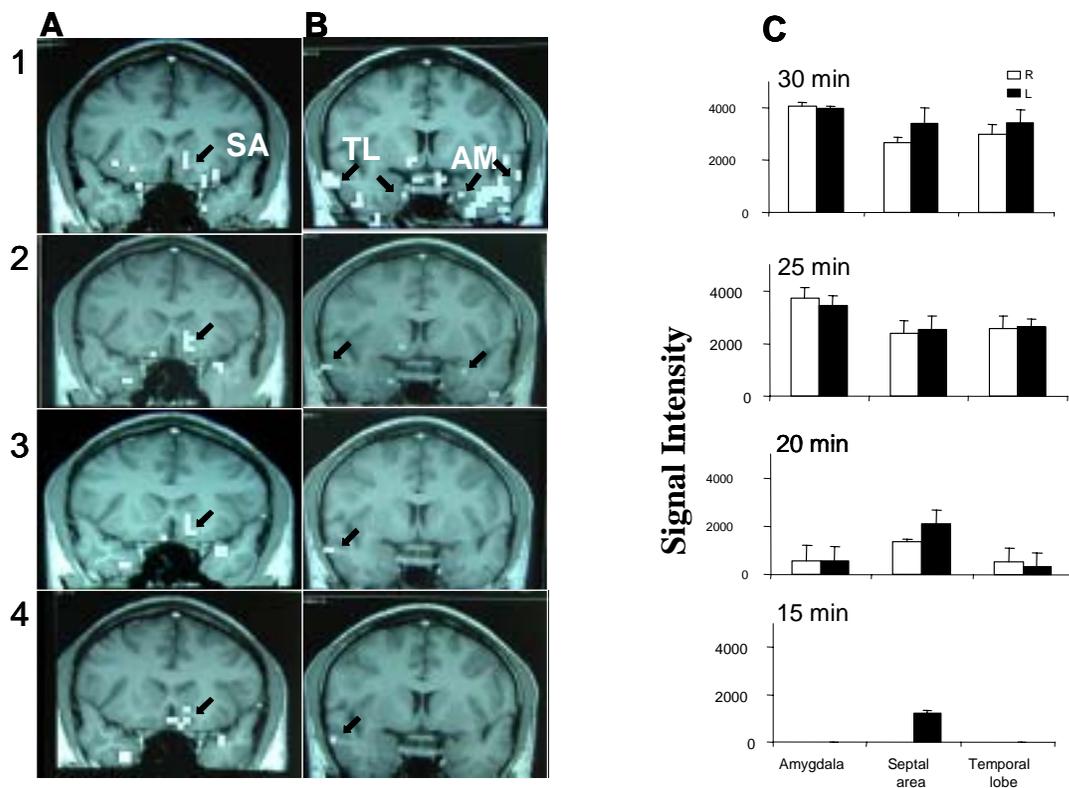


Fig. 1: Activation in different brain areas shown as difference in signal intensities between the ten images acquired at 3 minutes and ten images acquired at 30, 25, 20 and 15 minutes after ejaculation in six young subjects. The coronal sections taken at plane passing through (A) septal area (SA), (B) amygdala (AM) and temporal lobe (TL) with arrows depicting the activation. The sections 1-4 represent the temporal sequence of events at 30, 25, 20 and 15 minutes after ejaculation. The changes in signal intensities in left (L) and right (R) hemispheres in temporal sequence are depicted in C.

images acquired at 30th, 25th, 20th, and 15th minutes after ejaculation during 30 minutes EPI scan, showed maximal activation in the amygdala followed by the temporal lobes and septal areas (Fig. 1). The results also indicate that the amygdala, temporal lobe and septal area were maximally active after ejaculation during initial acquisition as compared to the images acquired after 30 minutes. In one subject there was activation in the preoptic area, cingulate gyrus, frontal gyrus and the insular cortex. Thirty minutes of acquisition of fMR images after ejaculation not only showed spatial activation of brain areas but also exhibited temporal pattern of activation. The amygdala and temporal lobes remained active for about 20 minutes while the septal area was active for about 15 minutes following ejaculation (Fig. 1).

DISCUSSION

Functional imaging of the brain in young adults after ejaculation induced by masturbation showed activation in amygdala, temporal lobe and septal areas. The septal areas were observed to be active for a shorter duration than the amygdala and the temporal lobe. The present study for the first time demonstrates spatio-temporal activation of brain areas during sexual inhibition after ejaculation.

Case studies in humans have shown that bilateral temporal lobe lesion including the amygdala leads to hypersexuality (8, 9). Hypersexuality has been reported in two patients with septal damage (10). Hyposexuality has also been reported in patients with temporal lobe epilepsy (11). These results indicate the possible inhibitory role of amygdala, septum and temporal lobe

in sexual behaviour. Therefore activation of amygdala, septum and temporal lobe observed during PERP in our study, suggests the involvement of these areas in this temporary sexual inhibitory state.

The brain areas activated after ejaculation may be different from brain areas activated at ejaculation (12). A recent PET study has shown that only the right prefrontal cortex gets activated during ejaculation whereas amygdala, temporal lobe and septal area did not show activation (13). On the other hand in another report the areas activated maximum during ejaculation was the meso-diencephalic region (12). They also found deactivation of amygdala and entorhinal cortex during ejaculation. Therefore this study further showed that the brain regions activated during ejaculation and PERP are different. Activation of the preoptic area, cingulate gyrus, inferior frontal lobe and the inferior temporal gyrus was seen in one of the subjects. The preoptic area has been shown not to be involved in sexual inhibition in animals although the lesion of the same area completely abolishes male copulatory behaviour in most of the species studied (14). The cingulate gyrus, the inferior frontal lobe and the inferior temporal gyrus were activated in human subjects during presentation of visual erotic stimuli (15, 16). The cingulate gyrus is involved in attentional processes and the temporal lobe is the visual association area. These areas are thus probably activated during visual erotic stimuli.

The septal area was observed to be active for a shorter duration than the amygdala and the temporal lobe, indicating their temporal sequence of involvement in the

maintenance of PERP. It could be possible that the amygdala, through its connection with the stria terminalis, sends information to the nucleus accumbens septi mediating sexual inhibition during the PERP and this influence is probably withdrawn before subsequent

resetting of amygdala itself. The present study for the first time demonstrates spatio-temporal activation of brain areas involved in sexual inhibition after ejaculation. Clearly, further studies are needed to understand the neurophysiological basis of PERP.

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