fMRI of brain activity during active place avoidance in a task of divided attention

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Introduction

We studied behavioral active place avoidance and brain regional aspects of divided attention in humans during functional Magnetic Resonance Imaging. Based on findings in rats, where the inactivation of one hippocampus by tetrodotoxin (TTX) or cooling leads to the inability to perform the Active Allothetic Place Avoidance Task (AAPA) properly, we hypothesized that the hippocampus plays a role in organizing attention among dynamic objects in humans as well. An appropriate test for this hypothesis is the Dissociated Spatial Attention Task (DSAT), which has been designed by Wesierska et al. (5) This computer based test was adapted to be suitable for functional magnetic resonance imaging (fMRI). We used the DSAT to investigate human behavior and to localize related brain activation with fMRI. This computer-based test for humans (DSAT) assesses the ability for dissociated attention of two separate spatial tasks. It takes place within a computerized game arena. We performed DSAT successfully in the fMRI environment.

Methods

In the DSAT, the subjects' tasks are to memorize the position of a target, to locate it afterwards, and at the same time to avoid collision of a moving cursor with two interfering objects. The subjects operated two push buttons and their aim was to recognize the position of the target and push the right button when the cursor hits it and to avoid collisions of the cursor with the interfering objects by pushing the left button. This task consists of 6 different conditions with increasing complexity. In order to establish normal behavior for the DSAT paradigm, 34 healthy, right handed volunteers (17 male and 17 female, age: 21-28) performed the task in the normal laboratory environment. This behavioral data also served as a proof, that subjects can perform all levels of difficulty of the task. Furthermore the error rates and reaction times were to be compared with those inside the scanner. For the fMRI experiment, a subset of this group (24 subjects, 12 male and 12 female) repeated the experiment inside our 3T Allegra-head-scanner (Siemens, Erlangen). A blipped echo planar sequence was chosen for functional data acquisition (450 scans, FOV 192 x 192 x 125,4 mm3, 38 slices, TE 30 ms, TR 2500 ms, flip-angle 90°,bandwidth 1662 Hz/pixel). For each subject, anatomical images were obtained with an MP-RAGE sequence (1mm isotropic). Both for lab and fMRI experiments, the behavioral data of subjects was analyzed using SigmaStat statistical software 2.03. The SPM2 software (statistical parametric mapping, Friston et al, Wellcome Dept. of. Imag. Science) was used for fMRI data preprocessing and statistical analysis. Periods of equal complexity were represented as blocks in the design matrix, while the operation of each button was modeled as a separate train of events.

Results

Behavioural data in the scanner and outside were comparable, showing that active place avoidance can be studied under scanning conditions. The prefrontal Cortex (PFC) is already known to be involved in the processing of divided attention [1, 2, 3]. Motor behaviour related cerebral activation in M1, premotor areas and SMA served as an internal control. Our results show that the PFC is more activated in divided attention than in focused attention. Notably, we also found activity in the hippocampal formation in all experimental conditions , except for the most complex divided attention task, in which subjects' behavioural data showed the most collisions.

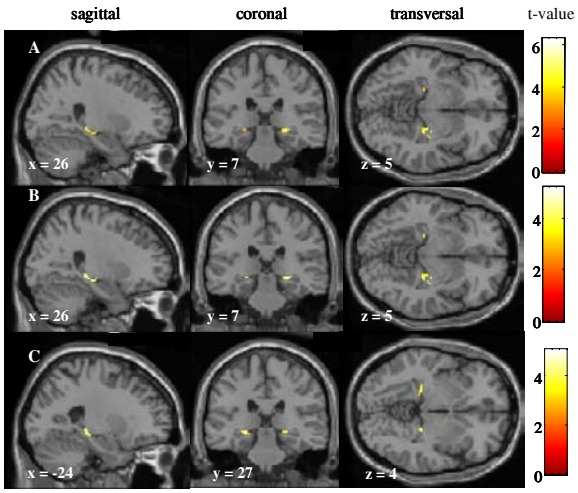

Figure : hippocampal activation in different contrasts.

Conclusion

Our experiment shows activation in the hippocampal area related to divided attention. This finding supports the hypothesis of an extended role for this formation. Furthermore, the DSAT test is a suitable and promising tool for studying brain activity during divided attention in humans. Through comparison with data of 10 patients (3 male and 7 female, age: 36-66) [4] which had received unilateral medial temporal lobe stereotactic thermolesions we found our hypothesis substantiated that the hippocampus plays a role in organizing attention among dynamic objects in humans.

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