Identical stimuli but different cortical activations: fMRI study on active and passive oddball tasks

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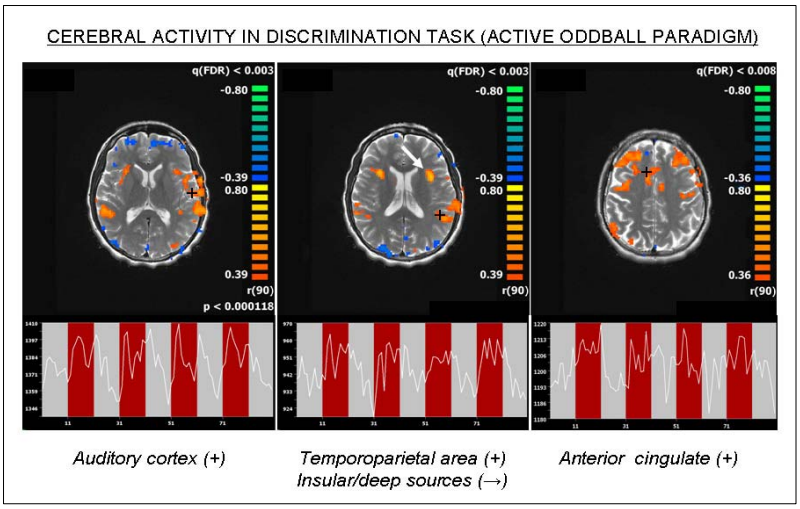
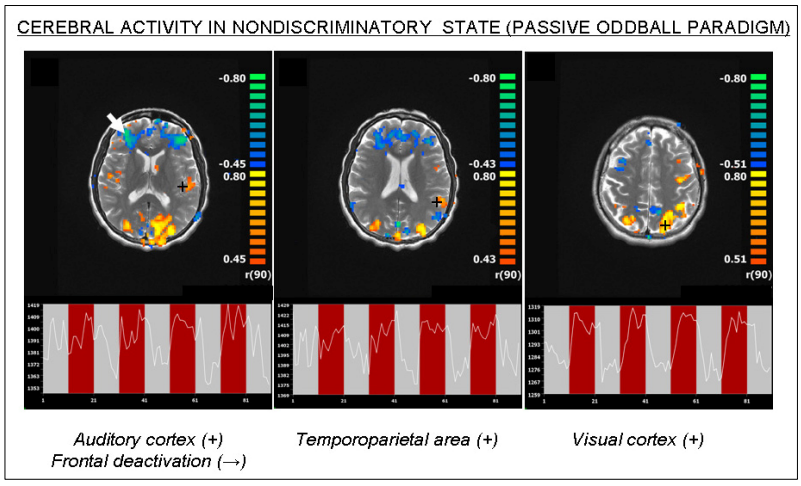
Purpose

In this study two questions were addressed: (1) can the cerebral activity in a discrimination task (active oddball paradigm) and cerebral activity in nondiscriminatory state (passive oddball paradigm) be localized to particular cortical areas using fMRI; (2) does the brain show differential activation during these cognitive states.

Materials and Methods

Subjects: The study was conducted on 8 healthy subjects (age 25.3 ± 3.6). **Task design:** Auditory stimuli (10 ms r/f time, 50 msec duration) consisted of 2000 Hz tones with an occurrence probability of 20% (n = 48). Rare stimuli were embedded within a series of 1000 Hz tones that had a probability of 80% (n = 192). In the active oddball (OB-a) paradigm, the task was to mentally count the occurrence of the rare stimuli. Stimuli were presented binaurally using Stim (Neuroscan, Compumedics, USA) and Silent Scan audio system (SS-3100, Avotec, USA). In the passive oddball paradigm (OB-p), the subjects performed an irrelevant visual counting task while the stimulation continued. To improve the statistical power of the study, alternating blocks of task (oddball paradigm) and control (no stimuli), each with a duration of 30 seconds, were administered during a 4 minutes and 30 seconds session. **Data acquisition:** Structural and functional MRI recordings were obtained using a 1.5 T scanner (Signa Excite, General Electric, USA) and a high resolution 8 channel array coil (InVivo, Intermagnetics, USA). For anatomic reference T2 weighted axial, high resolution 3D T1 weighted images were obtained. For functional (BOLD) images, T2* weighted gradient-echo echoplanar imaging sequence (TR/TE=3000/60) were used. **Analyses:** All imaging data were analyzed using Brain Voyager QX version 1.9 software (Brain Innovations BV, the Netherlands). Data were preprocessed for inter-slice scan time correction, 2D and 3D motion detection and correction, spatial and temporal bandpass filtering in frequency space, Gaussian smoothing in space and time domain, and removal of linear and higher order of trends in time course. Linear correlation and General Linear Models were employed for statistical analyses. Data were then analyzed for each subject and by intersubject averaging of statistical maps using Talairach space and were realigned and coregistered with the appropriate high resolution 3D T1 weighted structural images.





Results

Although identical stimuli were used, cerebral activity in discrimination task (OB-a) was localized to auditory cortex, temporoparietal junction, insular/deep sources, supplementary motor area, middle frontal gyrus and anterior cingulate gyrus. Cerebral activity in nondiscriminatory task, on the other hand, was also localized only to the auditory cortex, and the temporoparietal junction; this paradigm did not produce anterior cingulate, or frontal activations. Activity in visual cortex was the result of the visual distractor.

Discussion

The cognitive requirements of the OB-p task is auditory memory and preattentional change detection. On the other hand, the cognitive requirements of the OB-a task include these three processes and also focused attention, working memory, stimulus recognition and decision for the response to be made (1). In line with these requirements both tasks produced activation in the auditory cortex. However, only the OB-a task led to activation in the general integration area and in the frontal lobes. These observations are concordant with electrophysiological studies that localize relevant generators of auditory target detection tasks to bilateral superior temporal plane, superior temporal gyri, frontal areas and cingulate gyri (2,3).

References

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