Working Memory Load Enhances Attention

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Introduction

Simple paradigms that activate attention are of paramount importance in a clinical setting. In a previous study, we introduced a simple auditory-motor paradigm and we had shown that auditory-attention was separated from motor function using a frequency-based analysis method (1). In this study we increased the working memory load in our paradigm, which resulted in enhanced activation of the attention network.

Materials and Methods

Six volunteers participated in a fMRI paradigm consisting of moving their right hand fingers in response to "start"-"stop" commands every 10 seconds either every time (1st task) or every second time (2nd task or greater attention load). We acquired 21 axial slices with an echo planar T2*-weighted pulse sequence (TR/TE=1sec/50msec, flip angle=90o, FOV=240 mm, matrix=64X64, slice thickness=7mm) on a commercial 3T Siemens scanner (Trio). The response of interest was modeled by convolving box-car functions corresponding to the motor epochs with a synthetic hemodynamic response function composed of the sum of two gamma functions and its temporal derivative (accounting for the hemodynamic response and subsequent undershoot and for slight variations in timing). Multiple linear regression, using a least square approach to estimate the parameters, was used to estimate the effects of interest and other confounding factors (such as low frequency drifts) at every voxel simultaneously. An omnibus voxel-wise analysis will provide an SPM (F)-map.

Results

We acquired increased signal-to-noise data at 3T as compared to our previous 1.5 T acquisitions in agreement with others (2). Activations were seen in the cortical and subcortical components of a previously characterized network, which serves both working memory and selective attention. Direct comparisons showed enhanced activation in the 2nd task, as well as new activated areas possibly related to working memory. Specifically, attention activation was enhanced at basal ganglia, cingulate and superior temporal cortex. Working memory appeared enhanced at the lateral prefrontal cortex (3). The results of a representative adult healthy volunteer are shown in figure below.

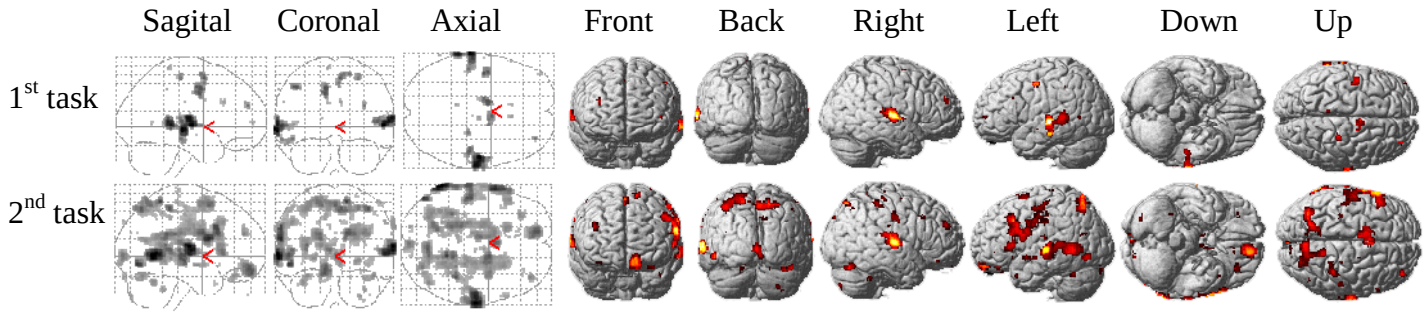

Figure: Projections on the sagital, coronal and axial levels as well as rendered surfaces of a template brain (SPM2) were superimposed with colored activation areas of the two tasks.

Discussion

Our findings support the conclusion that greater working memory load produces significantly enhanced activation in a widely distributed network that serves attention. Attention, working memory, motor, motor priming and motor control (resistance to impulsivity as in any go - non go task) are the cognitive functions predominantly implicated in our task. Inasmuch as both attention and working memory are affected in attention deficit hyperactivity disorder (ADHD), we suggested that our new paradigm can be used as a useful tool for assessing ADHD, especially in children, in the clinical setting. Although it was designed to serve studies involving children with ADHD, it might also be a useful tool that can be applied in the clinical setting in other neuro-developmental or psychiatric disorders.

References

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