PILOT STUDIES IN COGNITIVE FLEXIBILITY AND SET SHIFTING USING FMRI

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Introduction

Cognitive flexibility is considered the ability to adjust behavior based on changing environmental or task demands, and is relevant to the study of certain psychiatric disorders. The current study was performed to pilot fMRI paradigms of cognitive flexibility for future use in a study of autism. The purpose of these tasks is to measure responses to behavioral shift demands (also known as set shifting), as well as the presence of perseverative errors, or a failure to switch behavioral response.

Experimental

Six right-handed young, healthy volunteers participated in this pilot study. Imaging data was collected using the 3T Siemens Allegra at the University of Florida. Each participant received a high-resolution T1-weighted three-dimensional anatomic scan followed by echo-planar functional imaging using the following parameters: TR 2500 ms, TE 30 ms, Flip angle 90°, matrix size 64 x 64, FOV 200 mm, with a resolution of 3.75 x 3.75 mm and slice thickness 3.8 mm, using 38-40 transverse (AC-PC) slices to cover the brain. Functional images underwent pre-processing prior to analysis.

Two different event-related experimental designs were piloted to assess brain responses to shifting behavior, and required participants to switch “cognitive sets” by switching their responses between two to three visually discriminable targets. Correct responses were indicated by a reward of points. Behavioral switches during the task involved a change from one stimulus to another as the “correct response,” and occurred following 4-7 correct consecutive responses. After successfully sorting according to the first rule (e.g., shape), subjects were then required to sort by the other rule (e.g. color). Task design for the current studies was based loosely on previous work (1,2). The first study involved a categorical choice between two abstract pictures (Category task), while the second study involved a choice between the stimuli attributes shape and color (Attributes task). Data were analyzed using a general linear model in Brain Voyager QX, with shift trials, error trials, and correct responses modeled independently. Error trials were defined as any incorrect trial, excluding the first error following a switch. Statistical thresholds used to define significance were t(1015)>4.33 for categories and t(1039)>5.21 for attributes.

Results and Discussion

During both the Category and Attributes tasks, significant clusters of activation in the Supplementary Motor Area (SMA) were consistently found to error and shift trials as compared to correct responses. Additional areas of activation during error and shift trials of both tasks included the anterior insula and bilateral dorsolateral prefrontal cortex. During the Attributes task, a significant deactivation of subgenual and posterior cingulate regions was detected for both error and shift trials. Shift-specific activation patterns were found in the posterior parietal cortex for both tasks and additionally in the dorsal anterior cingulate for the Attributes task. There was also an indication of increased left lateralization of SMA activity specifically during shift trials of the Attributes task that should be further investigated in future studies.

Conclusions

Both paradigms appeared to effectively measure error processing and shifting responses, and regions of activation were similar to those found in previous studies. However, the Attribute task generally resulted in greater statistical thresholds for activation and may be the most effective design for future studies.

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References