Hybrid Block/Event-Related Paradigm for fMRI of a Go/No-Go Task

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Introduction

This study used fMRI to examine activation associated with the go/no-go task. The go/no-go task is emerging as a task of central importance for understanding the neural mechanisms involved in motor response preparation/inhibition and execution abilities important for normal behavior and cognition, and is believed to be relevant to understanding some developmental disorders, in particular Attention Deficit Hyperactivity Disorder (ADHD).

Most fMRI studies using a go/no-go task employed a block design (1-3) that makes it difficult to isolate activation related to "no-go" stimuli. One previous study (4) used an event-related design to discriminate activation related to "no-go" stimuli. In this study, we created a hybrid design: Blocks consisting of frequent "go" events, interspersed with relatively infrequent "no-go" stimulus events, alternated with ten-second "rest blocks," thereby combining an event-related design for "no-go" events with a block-design for responses to "go" stimuli.

Methods

Five normal adults and one child with ADHD participated after approval by the Institutional Review Board of the Johns Hopkins University. Participants used a mirror affixed to the head-coil to view visual stimuli projected onto a rear-projection screen using an LCD projector.

For the task, participants were instructed to fixate on a cross-hair and watch for a red or green object ("space ship") to flash over that central point on the screen. A green object signaled a "go" for which participants were to depress rapidly a response button using their right hand. A red object signaled a "no-go," meaning they were to refrain from pushing the button. Red or green objects appeared every 1.5s and remained on the screen for 200ms. Five rest periods, composed of a 10 second central cross-hair, occurred throughout each experimental run. The ordering of the three conditions (i.e., red, green, or rest) was psuedo-random including the constraint that no more than two "no-gos" appeared in a row. To elicit a prepotent response for the "no-go" trials, the "go" trials occurred with far greater frequency (82%). Two 4 minute and 38 second runs were conducted with each participant.

BOLD fMRI data were acquired in a 1.5 Tesla Gyroscan NT PT-6000 (Philips Medical Systems) following acquisition of anatomic scans: Single-shot gradient-echo echo-planar (EPI) data (TR=2.5s, TE=40ms, FOV=24cm, matrix=64 x 64, FA=70 degrees, 29 coronal slices, slice thickness=4mm, gap=0.5) were acquired.

The images were corrected for timing differences between slices (5,6). Next the data were imported into the Statistical Parametric Mapping (SPM99, Wellcome Department of Cognitive Neurology) under Matlab. Data were coregistered to a mean image, spatially smoothed (7x7x9 mm Gaussian kernel), spatially normalized into a standard space (7), and resampled to 2x2x2 mm voxels. A generalized linear model was constructed using ideal time-signals corresponding to presentation of stimuli, convolved with a canonical hemodynamic response function. This model included both block ("go" vs "rest") and event ("no-go") elements of the paradigm, and a high-pass (drift removal) filter. The data were then regressed onto the model (8-10).

Results

For the group data, the "go"-"rest" contrast demonstrated clear activation in the contralateral (left) primary motor cortex and the ipsilateral cerebellum. By contrast, the "no-go" event-related analysis detected activation in the medial superior frontal region (including supplementary motor area), bilateral cerebellum (in a pattern not unlike that seen for the "go" trials), and inferior parietal lobule (figure 1). Data from the five individual subjects is largely consistent with the group analysis.

Analysis of activation in the single child participant with ADHD shows activation corresponding to a "go"-"rest" contrast in the left primary motor cortex (figure 2A). Activation corresponding to the "no-go" events was detected in left superior frontal gyrus (figure 2B). Similar "no-go" associated prefrontal activation was also observed in the one adult subject who used his non-dominant hand to carry out the task. None of the other adults showed evidence of prefrontal activation corresponding to the "no-go" events.

Discussion

Our group of adults demonstrated the expected pattern of activation for the "go" portion of the task as both the motor cortex and the cerebellum are known to be involved in motor performance. During "no-go" trials, we observed activation in the supplementary motor area and premotor cortices implying their role in motor response preparation (of which inhibition is a part). It is notable that the activation in the prefrontal cortex was apparent only in a single adult subject, a left-hander who responded to the task with a right-hand button push. Such prefrontal activation was also observed in the right-handed child with ADHD (see figure 2B). These findings complement those of Casey et al.(1), in which the volume of prefrontal activation was greater for children compared to adults, and suggest that a more mature or more practiced hand may require less involvement of the prefrontal cortex and more involvement of the supplementary motor region when implementing the "no-go" portion of a go/no-go task.

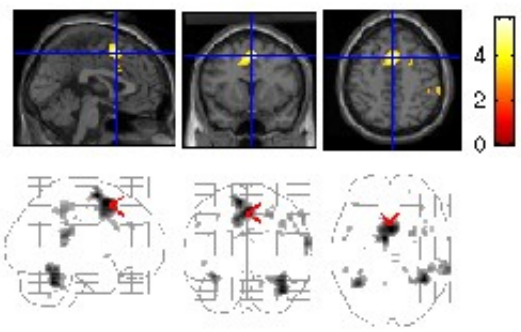

Figure 1. Group "no-go" results (adults).

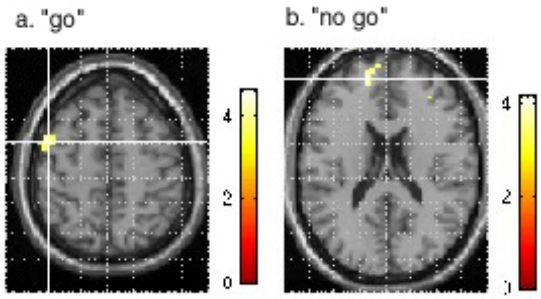

Figure 2. Single-subject results (child with ADHD).

References

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