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PERCEPTION

EVENT-RELATED FMRI OF TACTILE STIMULUS DETECTION

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Introduction

A variety of studies have investigated the effect of vibrotactile frequency, amplitude, and probability of detection on single-unit activity in the primate cortex (e.g., Mountcastle et al., 1969). In this study, we examined the effect of these variables on activation across human cortical regions using event-related fMRI. The event-related fMRI approach facilitated evaluation of the response to relatively brief stimuli (1-sec duration), the derivation of hemodynamic gain functions, and the correlation of correct and incorrect psychophysical responses with the pattern and amplitude of cortical activity.

Methods

Subjects (N = 7) were scanned in a 3 Tesla Siemens scanner with a birdcage head coil. Vibrotactile stimuli were presented to the distal pad of the left-hand 3rd digit. The contactor was a circular flat surface with a beveled edge (inner-diameter, ~3.5mm; O.D. 5mm) driven by a piezoelectric element. Stimuli (12 conditions; 520 trials) were 1-sec duration sine waves of 20 or 100 Hz, administered at 1 of 4 amplitude levels (high, medium, low and none). The tactual loudness of the high 20 Hz stimulus was matched to the medium 100 Hz stimulus in a prior psychophysical study (N = 6 Ss). On the majority of trials (11 of 12 conditions), subjects were visually cued 1-sec prior to stimulation to assess whether a stimulus had been presented. Green visual cues (4/12 conditions) indicated response with a right-handed button press (20 Hz trials only); red visual cues (7/12 conditions) indicated covert performance (20 or 100 Hz). In one condition, a high 100 Hz stimulus was presented without visual cue and with no associated task. Event-related stimuli were ordered and analyzed with the FS-FAST analysis stream, and visualized with Freesurfer software (see Moore et al., 2000 for prior application of this approach to somatosensory cortical imaging).

Results

Subjects reported stimulus presence on 96% of high and 100% of medium amplitude trials, and on 4% of no stimulus trials. Threshold-level detection rates (65%) were recorded for low amplitude stimuli. Within the postcentral gyrus (PoCG) hand area, 6 of 7 subjects showed distinct anterior and posterior activation regions. Both regions revealed amplitude-dependent response functions, with a largely linear relationship between stimulus amplitude and peak response evoked by 100 Hz stimuli, and a thresholded non-linearity in the peak response to high 20 Hz stimuli. The anterior and posterior regions revealed dissociable sensitivity to motor activity, with no motor-related signal increase in the anterior region, and a delayed motor-evoked response, in which all amplitudes of tactile stimuli evoked similar peak signal change, in the posterior region.