A stimulus design allowing separation of main and interaction effects applied to a visual attention task

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Background

Event related functional MRI designs are a sensible alternative to blocked designs as they allow for a more detailed analysis of the relation between stimuli and their BOLD responses. Conventional designs for rapid-event related fMRI generally assume a linear relationship between BOLD effects and neuronal activity. In the current study we present a rapid event related fMRI design that overcomes these limitations (1). The design was applied to an attentional modulation study. Based on previous studies we expected attentional modulation to evoke BOLD responses in visual cortex, as well as affect activation patterns of a subsequently presented stimulus (2).

Method

Five subjects participated in the experiment, performed with a 16-channel detector at 3.0 T (3) using SENSE-EPI with a resolution of 1.75x1.75x3.0 (0.5 gap) mm^3 (TE/TR 40/2000). Task stimuli presentation was based on the m-sequence probe (1), and made use of two important properties of the m-sequence: 1) m-sequences have zero correlation at non-zero lag, 2) multiplication of two non-zero lag m-sequences yields a new m-sequence at distinct lag. Two M-sequences (127 length, 4 s bin size (lags: 0 and 11 bins) were used to control cued attention to the left (presentation of an arrow at 300 ms), and subsequent stimulus presentation (two 100 ms dots with a 100 ms cross (target) or a plus (non-target) in between at both the left and right field) in the first 2s of the bin. A similar approach with two other m-sequences (lags 22 and 33) was used for right field attention in the last 2s of the bin. In each voxel, BOLD impulse response curves were determined per voxel by calculation of the cross correlation of the input function and the measured BOLD-signal. The first 10 time points (scans) of the activation maps for left visual field attention (Latt), right visual field attention (Ratt) , the visual stimulus (Stim) and interaction between attention and stimulus (Lint, Rint) were calculated and spatially normalized into Talairach space. A group averaged t-score was calculated per time point. Regions of interest (ROIs) were determined by thresholding the combined t-maps of attention and stimulus related actiavtion at time point 3 (6 seconds after cue presentation) at a level of t=4.0 (see figure 1).

Results

ROIs were determined in left and right visual cortex (VC), left and right inferior frontal cortex, the anterior cingulated cortex, and in the right fusiform gyrus. This abstracts focuses on the results in the left and right VC. The attentional cue and the visual stimulus evoked similar BOLD-curves in left and right VC. The interaction curve showed a shift from positive during a trial to negative after the trial. We did not find lateralized attentional modulation of activity in visual cortex.

Discussion

Results indicate that neuronal interaction between stimuli can be successfully measured with the presented design. Interaction between attention and stimulus processing was found during the trial. These indicate that attention increases activation related to the subsequent stimulus, as has been found in previous studies. However, late interaction effects were also found, and these effects may pose a serious problem for interpretation of rapid event related designs in which it is assumed that neuronal activation is linearly related to the stimulus. The absence of lateralized modulation of activity may be due to the rapid event-related design, as attentional modulation in visual cortex has previously mainly been studied using block designs (2).

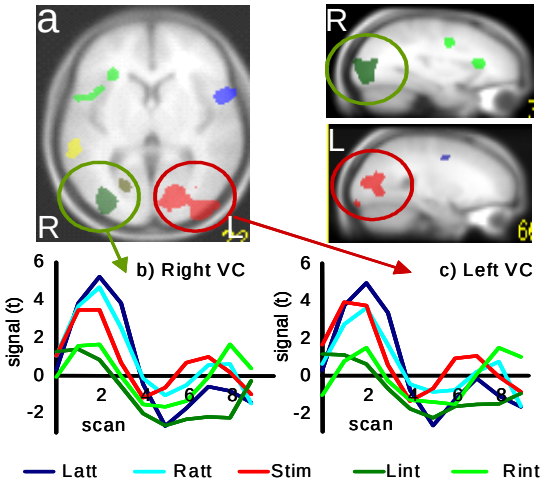

Figure 1: *ROIs in left (L) and right (R) visual cortex (a) and the measured BOLD signals in right VC (b) and left VC (c)*

References

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