# Model fitting and power in fast event related designs

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## Abstract

Event related (ER) designs have become standard in recent FMRI studies. Although they have major benefits in terms of the range of phenomena that can be studied, they can be complicated to analyze and interpret. Recent theoretical studies have addressed power in ER studies, and have suggested that frequent events with random inter-stimulus intervals (ISIs) give high power. However, these simulations have required several assumptions, including independence between events. Therefore we have attempted to replicate the results of these simulations in a real FMRI study.

## Methods

6 Subjects were scanned on a 3T Bruker scanner at the Wolfson Brain Imaging Centre in Cambridge, using a standard EPI protocol, collecting 16 slices with a 2 second TR. Events were flashes of a visual checkerboard lasting 0.5 sec, to which the subject had to respond with a button press with the right hand. ISIs were generated from an exponential distribution with a minimum of 0.6 sec, and means of 1, 2, 3, 4, 6, 8 and 10 seconds, to give 7 different stimulus sets. Subjects were scanned in each of the 7 ISI conditions, for 280 seconds per session. The order of the ISI conditions was randomized across subjects. We used SPM99 to correct the images for slice time offset, realign to the first image in the series, and smooth to 8mm FWHM. In order to identify the visual cortex we performed a standard SPM analysis of the mean ISI=3 session (60s high pass filter, haemodynamic response function (HRF) low-pass filter). We used HRF and temporal derivative (TD) convolution for event modeling, and an F test on both parameters to test for task effects. From this analysis we selected the maximum activated cluster in the occipital cortex with voxels at $p<0.0001$ uncorrected. The region thus identified was used to extract mean time courses in the other ISI sessions. We analyzed these time courses with a similar model, but without low-pass filtering, using the MarsBar SPM toolbox.

## Results

To study the effect of different ISIs, we analyzed the model parameters for the HRF and TD regressors. We also calculated the F statistic for the two regressors, the t statistic for the HRF only, and the root mean squared residual error (RMSE). There was a significant linear trend for the estimated HRF parameter to increase with longer ISI, reflecting apparent greater effect size with longer ISI ($p<0.001$); the effect size for ISI=1 was 60% of that for effect size of ISI=10. The parameter for the temporal derivative showed a complex effect of ISI ($p<0.05$), which was mainly quadratic, with higher values for intermediate ISIs. As for the simulations, there was a trend for F and t statistics to decrease linearly with increasing ISI. The RMSE increased linearly with increasing ISI.

## Conclusion

These results suggest that very short ISIs do result in an increase in detection power, but with a reduction in measured effect size. Error appears to increase with longer ISI. We will discuss the implications of these results for the design and analysis of ER FMRI.