

Reverse BOLD Improves Efficiency for Brain Response to Faces

C. Glielmi¹, G. A. James¹, Z. Li¹, and X. Hu¹

¹Department of Biomedical Engineering, Georgia Institute of Technology / Emory University, Atlanta, GA, United States

INTRODUCTION

Simultaneous electroencephalography (EEG) and fMRI are advantageous because they provide concurrent measures of neural electrical activity at high temporal resolution and hemodynamics at high spatial resolution. For example, several research efforts have focused on complementing EEG and blood oxygenation level-dependent (BOLD) contrast to study brain responses to faces with EEG and fMRI separately [1,2] and simultaneously [3], demonstrating that simultaneous acquisition is possible with sufficient number of trials for averaging. While EEG-only sessions can present trials every 1-3 seconds for efficient averaging, event-related fMRI typically requires much longer interstimulus intervals to accommodate the sluggish BOLD response. EEG averaging requires a large number of trials especially when MRI and ballistocardiogram artifact correction adversely affect data quality. We propose a new stimulation protocol in which long periods of trials are interleaved with missing trials. The missing trials lead to a “reverse BOLD” response and allows for a number of EEG trials per reversed BOLD trial. In this work, we confirm the integrity of the reverse BOLD response by comparing it to the regular BOLD response for visual processing of faces.

METHODS

Image Acquisition: Functional data were acquired for 2 subjects on a Siemens 3T Tim system with an EPI sequence (15 ascending interleaved slices, TE/TR=35/1000 ms, 3.43×3.43×5 mm resolution). Data were acquired with 2 types of blocks: (i) 12 s. face presentation + 2 s rest and (ii) 12 rest + 2 s face presentation. Each face trial lasted 2 seconds during which one stimulus was presented for 200 ms. Each protocol consisted of 16 blocks and was repeated once comprising four total functional scans. Additionally, a T1-weighted anatomical image was acquired using an MPRAGE sequence with 1 mm³ resolution.

Analysis: Data were slice scan time and motion corrected, linearly detrended, coregistered to the high resolution anatomical image, normalized to an MNI template, spatially smoothed (6 mm FWHM kernel) and statistically analyzed using SPM2 (Wellcome Department, University College of London, London, UK) to generate one activation map for each protocol and subject. Structural masks in MNI space were generated for the occipital lobe and fusiform gyrus using the WFU_PickAtlas toolbox [4]. Activation maps were corrected for a false discovery rate (FDR) over a combined ROI consisting of the occipital lobe and fusiform gyrus [5]. FDR thresholds were varied between 0.0001 and 0.05 to explore sensitivity differences between the different stimuli and subjects. Suprathreshold voxels were used to generate average time courses for each subject, stimulus and ROI.

RESULTS AND DISCUSSION

Within each subject, activation extent and localization are similar for reverse and traditional BOLD experiments; for instance, reverse BOLD with 2 seconds of rest in each block (Fig. 1 A/B) and traditional BOLD with 2 seconds of face stimulation (Fig. 1 C/D) show comparable activation in both the primary visual cortex and the right fusiform gyrus. Figure 2 shows time courses for each experiment using the inverse of the reverse BOLD so both are displayed as positive changes. Although the extent of percent signal change varies between subjects, the form and magnitude of the normalized time courses are nearly identical within each subject for each stimulus and ROI (fusiform or occipital lobe).

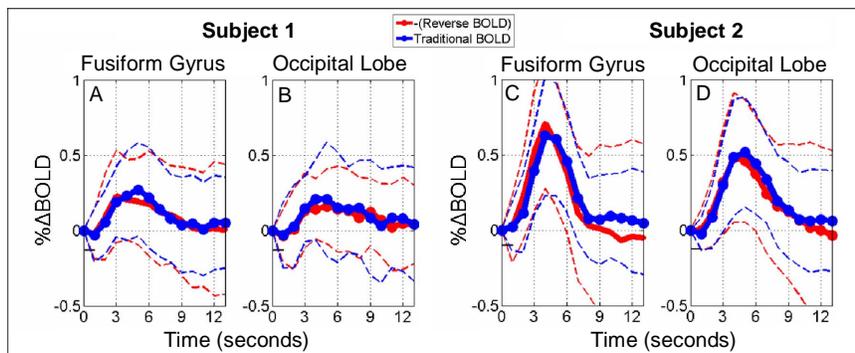


Fig. 2: Mean time courses for suprathreshold voxels for reverse and traditional BOLD averaged over all stimulus blocks (FDR<0.05 and 0.0001 for subjects 1 and 2, respectively). Dotted lines indicate one standard deviation from the mean.

ACKNOWLEDGEMENTS

This work was supported in part by the NIH RO1 EB002009.

REFERENCES [1] Henson, RN *et al.* Cereb. Cortex 2003. [2] Horowitz, S.G. *et al.* NeuroImage 2004. [3] Sadeh, B *et al.* NeuroImage 2008. [4] Maldjian, J.A. *et al.* NeuroImage 2003. [5] Genovese, CR *et al.* NeuroImage 2002.

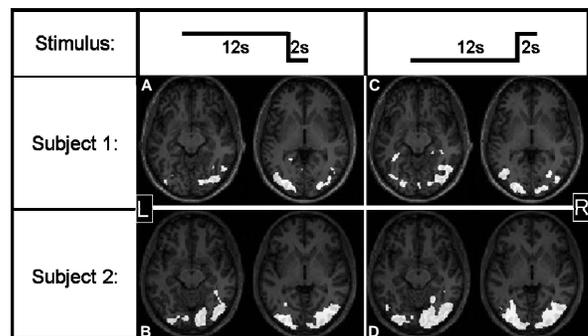


Fig. 1: Activation maps for various stimuli for subject 1 (FDR<0.05, A/C) and subject 2 (FDR<0.0001, B/D).

CONCLUSION

This work demonstrates a “reverse BOLD” design in which event-related rest is placed between periods of visual face processing. Compared to traditional event-related paradigms, the proposed paradigm localizes very similar brain regions with comparable relative BOLD response. This paradigm allows the acquisition of more evoked potential trials. Future work will combine the reverse BOLD protocol with simultaneous EEG to acquire significantly more trials per unit time, improving efficiency and EEG data quality.