Accessing Cortical Inhibitory Processes Through the Delay of the fMRI BOLD Response

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Introduction

Background: The BOLD signal in fMRI lags behind stimulus presentation by a few seconds. It is the hemodynamic delay, and relates to the time it takes for the vascular system to translate the neuronal response into a measurable blood flow and blood volume response. The BOLD delay can however vary with stimulus condition within a given brain region, where vascular factors are the same (Farivar2011, Bartolo2011) suggesting neural factors like inhibition affect the fMRI delay (Farivar2011).

Hypothesis: The fMRI delay contains information about the excitation/inhibition balance during neural activation.

Objective: To modulate inhibition with oriented stimuli and assess the effect on the fMRI delay in primary visual cortex.

Method

Subjects: 6 healthy adults (1 female); normal or corrected-to-normal vision

MRI acquisition:
- Siemens Trio 3T; custom coil with 32-channel dedicated to the occipital cortex (Farivar2016)
- 1mm isotropic resolution GE-EPI: 13 slices; 10% gap; TR=1s; TI=68ms; GRAPPA=3;
- 120 images x 4-6 runs x 3 stimulus condition x 2 sessions per subject

MRI processing:
- Surface reconstruction (Freesurfer) and V1 mask (Benson2012) from T1-weighted MRIs
- Slice timing correction
- Calculation of head motion, EPI-distortion and functional-to-anatomical registration (BBR)
- Application of motion, distortion and registration in one interpolation step (AFNI)

Orientation Preference Maps

Orientation Preference Maps show the relative peak time of BOLD response to orientation preferences.

Results

Delay and amplitude both contain information: both the cortical patterns of amplitudes and delays allowed prediction of stimulus orientation (threshold from 700 perceptions). Combining information from amplitude and delay provided the best performance (Wilkinson Signed Rank Tests).

Discussion

Working model: sub-voxel summation of negative and positive BOLD response components

- Negative BOLD responses occur a little earlier than positive responses (Stimuli2002)
- The combination of the components produces a delay in the measured response

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References:


