Evidence for a capillary origin of the fMRI BOLD refractory effect

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1 INTRODUCTION

Functional magnetic resonance imaging (fMRI) studies have demonstrated that the hemodynamic response (HDR) to a stimulus attenuates upon repeated presentation of similar stimuli at short intervals. It has been proposed that HDR attenuation is caused by a vascular refractory period, which affects regions dependent on either a non-specific or specific effect of large vessels controlling the local microcirculation [1-3]. We investigated possible origins of the fMRI refractory effect in two separate studies. Study 1 investigated whether the fMRI refractory effect depends upon the congruency of consecutively presented stimuli. We used a large number of different stimuli in four conditions, no stimulus, stimulus with similar direction of motion, stimulus with incongruent direction of motion, and a control condition. The HDR was measured using fMRI during a visual motion paradigm. Results showed that congruent motion elicited a robust refractory effect in visual cortex and that incongruent stimuli did not [4].

STUDY 1: Attribute Specificity

Demonstrated that the hemodynamic response (HDR) to a stimulus attenuates upon repeated presentation of similar stimuli at short intervals (less than 6s) [1-3]. Known as the fMRI refractory effect, this attenuation is believed to be caused by a vascular refractory period, which affects regions dependent on either a non-specific or specific effect of large vessels controlling the local microcirculation [1-3].

Time

Still
Up
Up
Still
Down
Down

For each SOA from 2s to 7s:

Still = Net Incongruent

2 METHODS

Study 1:

Subjects:

- 11 young adults; mean age: 25y.

- Experimental task:
  - Subjects viewed horizontal or vertical gratings that moved at 3Hz. Stimuli were presented in a block design with motion stimuli blocked by blocks of no-motion trials.
  - Subjects were asked to fixate on a crosshair in the center of the stimulus.

- Data acquired using fMRI at 4T:
  - Fifty percent of the fMRI images were acquired using a single motion condition, with the other half consisting of a control condition.
  - Anatomical images were obtained using a 3D volume dataset.

- Analyses:
  - Standard fMRI data analysis methods were used to generate functional images of the brain from the fMRI data.
  - The latency of the hemodynamic response was determined for each subject.

Study 2:

Subjects:

- 9 young adults; mean age: 23y.

- Experimental task:
  - Subjects viewed static checkerboard stimuli presented at fixation for 7s.
  - Stimuli were presented every 5s in a block design with four stimulus conditions, no motion, congruent motion, incongruent motion, and a control condition.

- Data acquired using fMRI at 4T:
  - Twenty percent of the fMRI images were acquired using a single motion condition, with the other half consisting of a control condition.
  - Anatomical images were obtained using a 3D volume dataset.

- Analyses:
  - Standard fMRI data analysis methods were used to generate functional images of the brain from the fMRI data.
  - The latency of the hemodynamic response was determined for each subject.

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References

3. The fMRI refractory effect is specific to stimulus attributes: Evidence from a visual motion paradigm. NeuroImage, 23 (1), 402-408.

3 RESULTS

Lateral Temporal-Occipital ROI

Pericalcarine ROI

Congruent

Incongruent

Congruent

Incongruent

CONCLUSIONS

1. Refractory effects were found for motion and static stimuli, with decreased amplitude and increased latency at short SOAs.
2. The amplitude of the fMRI refractory effect is reduced to stimuli with incongruent direction of motion.
3. The fMRI refractory effect does not decrease in amplitude with increasing diffusion weighting.
4. Together, these results indicate that the fMRI refractory effect reflects primarily small-vessel contributions to the BOLD signal.