Human cortical responses to illusory and actual luminance variations

Huseyin Boyaci⁽¹⁾, Fang Fang⁽¹⁾, Dan Kersten⁽¹⁾, and Scott Murray⁽²⁾

- (1) Department of Psychology, University of Minnesota
- (2) Department of Psychology, University of Washington

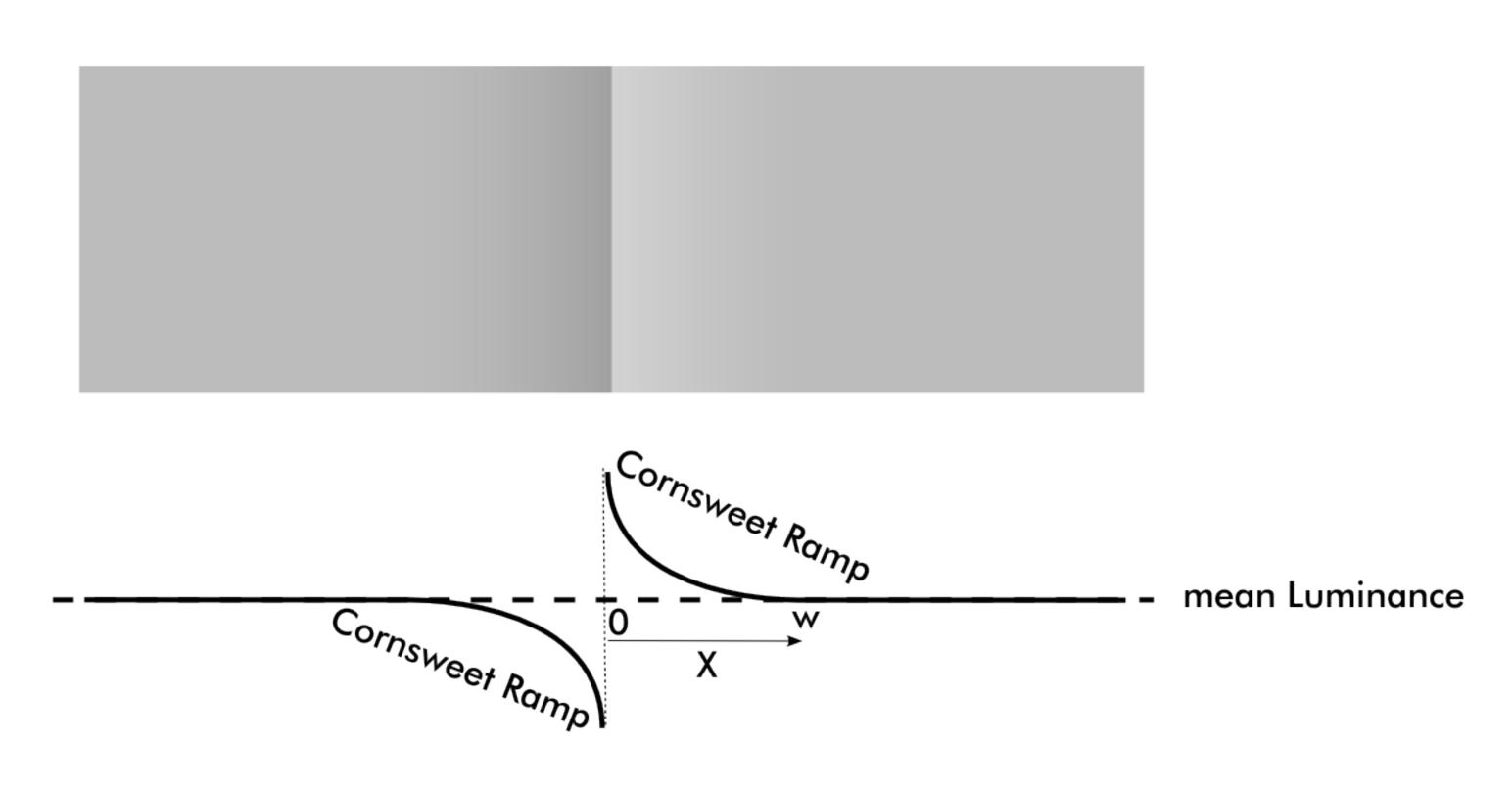
Introduction

We measured human observers' cortical responses to actual and illusory luminance variations with fMRI. We used the Craik-O'Brien-Cornsweet stimulus to elicit the illusory brightness percept. We also adressed the effect of three dimensional configuration in a pilot experiment.

Previous literature suggests mixed results for the activity of early visual cortical areas to illusory brightness variations. A brief list of recent studies and their findings are given in the table below. (Also see recent review article by Komatsu(2006))

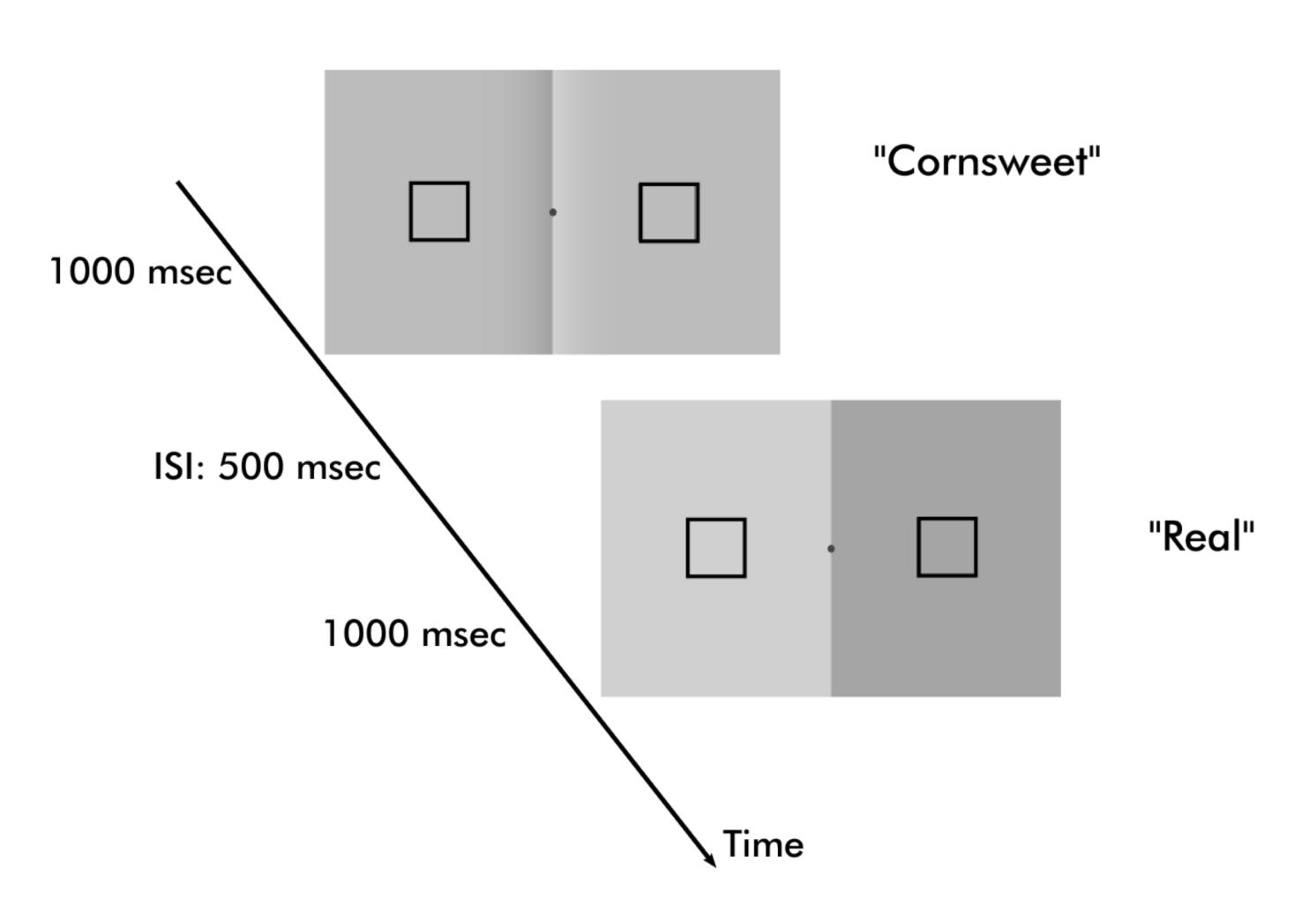
| | Response to uniform luminance variations | | | Response to illusory luminance/color | | |
|---------------------------|--|-----|----------|--------------------------------------|--------|---------|
| | V1 | V2 | V3 - V4 | V1 | V2 | V3 - V4 |
| Rossi et. al (1996) | Yes | _ | _ | Yes | _ | _ |
| Hayness et. al (2004) | Yes | Yes | Yes (V3) | _ | _ | _ |
| Sasaki, Watanabe (2004) | Yes | Yes | Yes | Yes | Yes/No | Yes/No |
| Roe et. al (2005) | Yes/No | Yes | _ | No | Yes | _ |
| Perna et. al (2005) | _ | _ | _ | No | No | No |
| Meng et. al (2005) | _ | _ | _ | Yes | Yes | Yes |
| Cornelissen et. al (2006) | Yes | Yes | _ | No | No | _ |

Cornsweet stimulus



Luminance = mean $\pm (1-X/w)^5*$ mean * Contrast/2

Behavioral Experiment - Magnitude of Cornsweet illusion



Task: Fixate at the fixation mark and indicate the interval in which the luminance difference between the flanks, within the square frames, was larger

Results (inside the scanner)

Contrast of subjectively equivalent "Real"

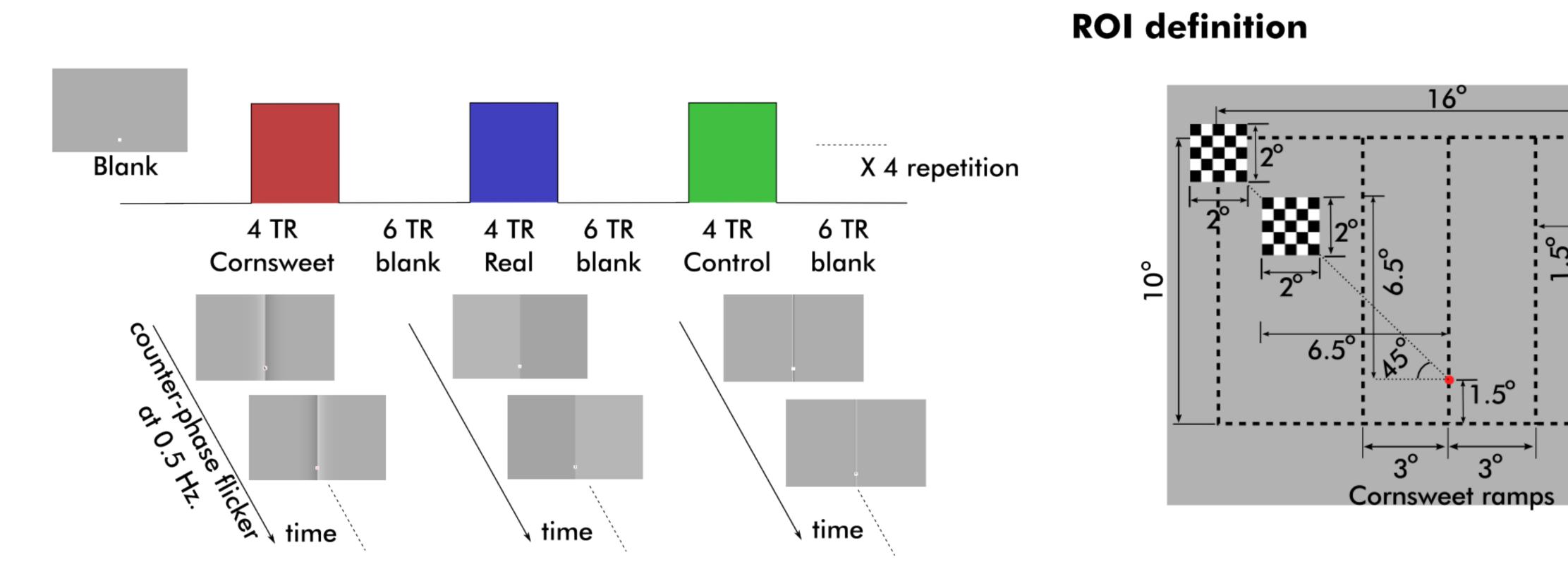
| Cornsweet contrast = 0.6 | | |
|--------------------------|--|--|
| $\xi = 2.75$ | | |
| 0.33 | | |
| 0.32 | | |
| - | | |
| | | |

Contrast at border defined as (max - min) / mean

fMRI stimuli rendered for each subject based on the behavioral results.

(*) Performed only in the lab

FMRI Experiment •



Control stimulus: In order to control for the effect of the contrast border, we used a pattern composed of "squeezed" Cornsweet ramps with a high contrast. This pattern did not elicit a brightness illusion.

Fixation task: For attention control, in half of the scans observers performed an RSVP task during the stimulus period. In the passive view scans the stimulus was exactly the same.

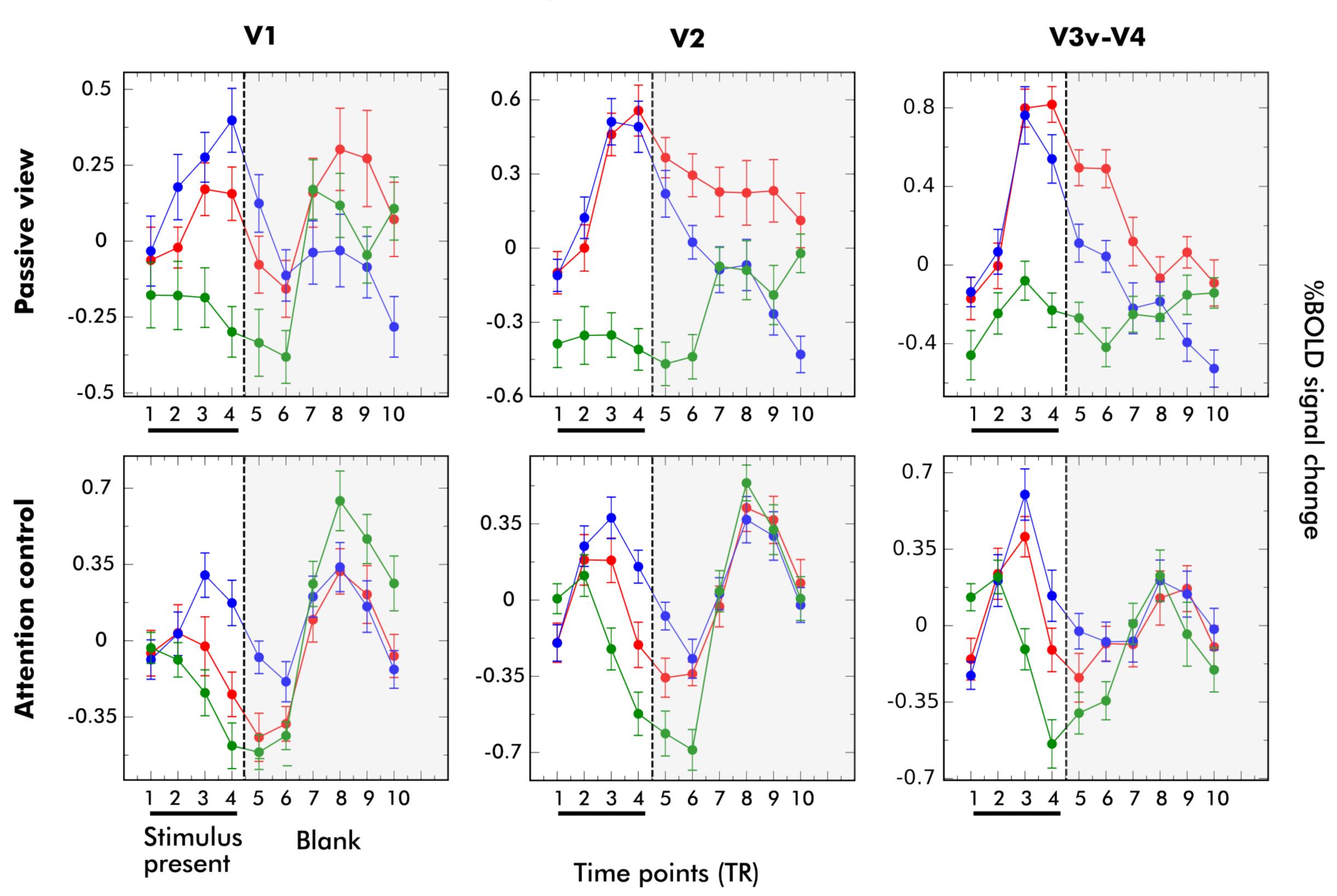
3 Observers;

- 1 Anatomical (3D) scan
- 2 ROI scans
- 5 Attention control, 5 passive view scans

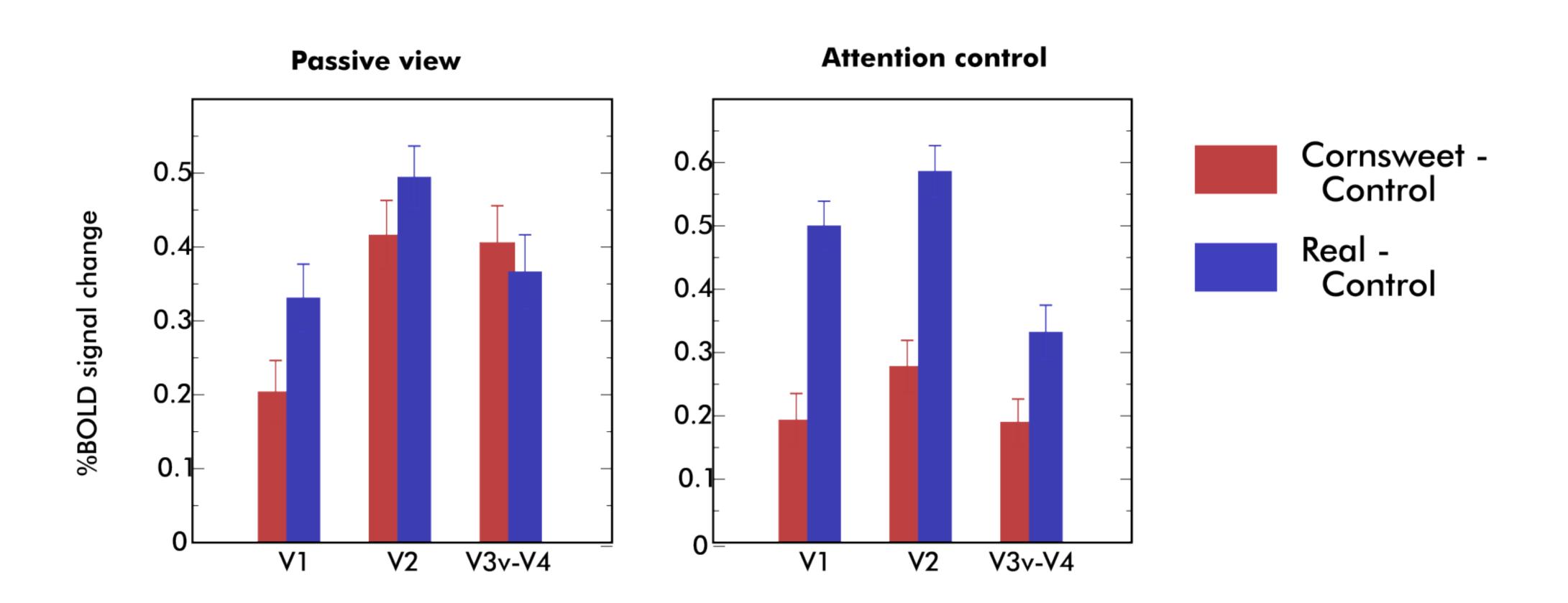
Siemens Trio 3T scanner TR = 2sec.

Results

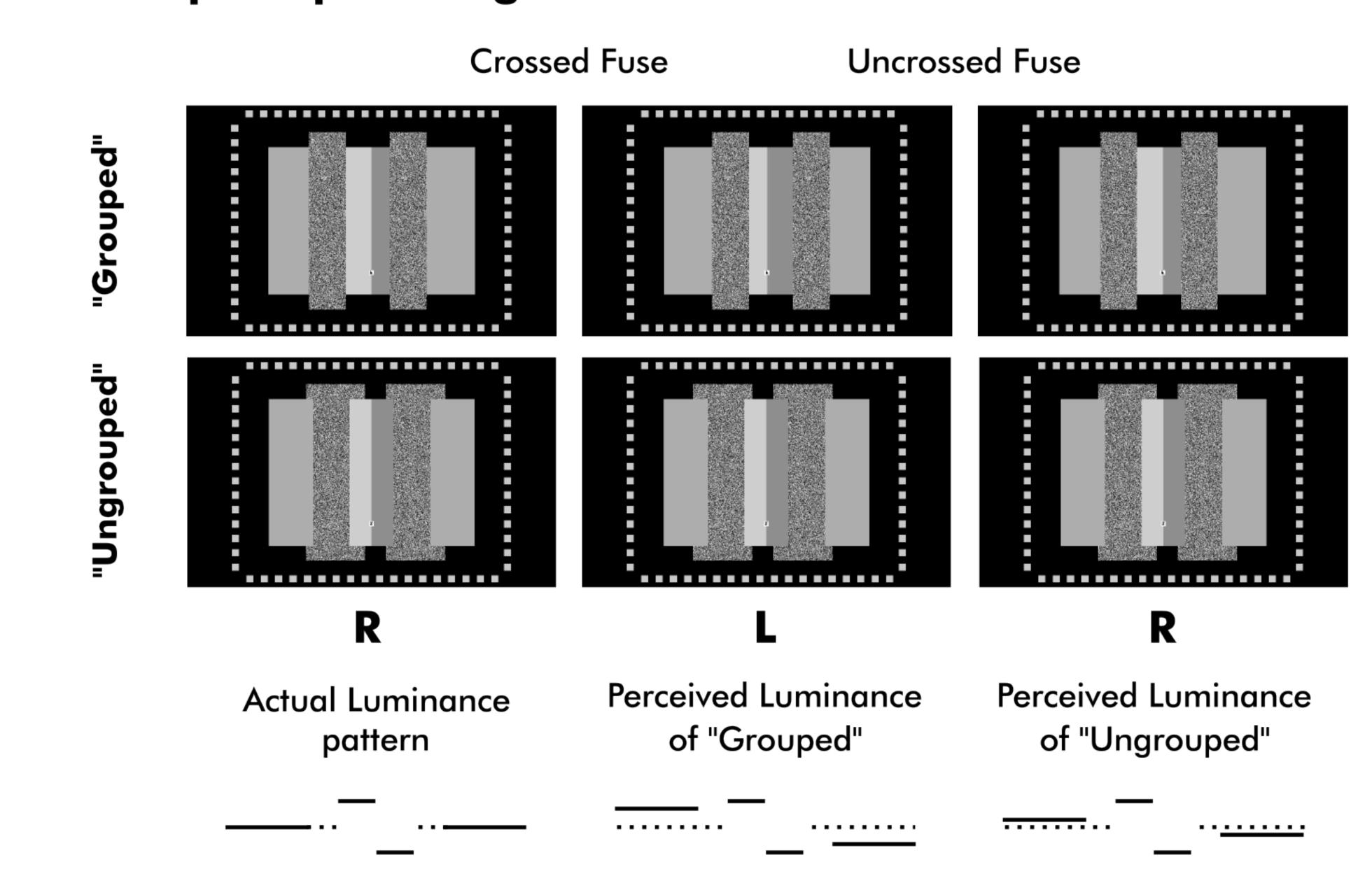
Single observer (HB) (Colors same as in the protocol chart above)



All observers average (3rd and 4th TRs)



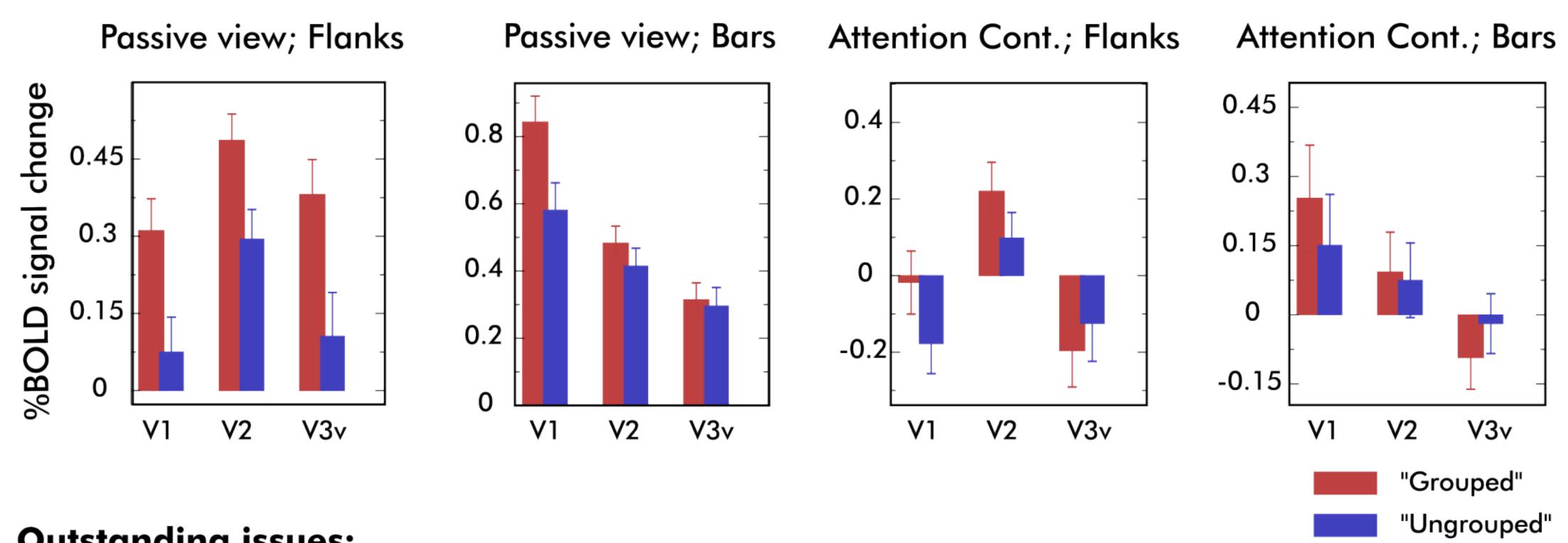
Effect of perceptual organization



fMRI protocol similar to Cornsweet experiment,

Stimuli viewed in stereo using blue-red glasses.

2 ROIs: One on the flanks, one falling within the random dot bar



Outstanding issues:

Only one observer (HB); no thorough psychophysics;

There may be signal differences due to stereo arrangement

Conclusions

We found that the early visual cortical areas respond to illusory brightness variations as well as real luminance variations,

When subjects perform an attentionally demanding fixation task the relative response to illusory brightness (with respect to the real) decreases,

The results are in agreement with previous literature, which found response to illusory brightness variations,

Results of the 3D experiment support the above conclusions. Moreover, they suggest that filling-in as a consequence of amodal complition may become evident as early as primary visual cortex.

References

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