# Stimulus dependent laminar differences in functional CBF in monkey V1

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## Introduction

The relative contributions of excitation and inhibition to fMRI responses remain unknown and may be layer dependent. In principle, inhibition may increase or decrease the BOLD signal depending on the local circuitry [1]. In primary visual cortex (V1) negative BOLD signals and decreases in CBF were shown in the areas adjacent to stimulated regions when ring stimuli were used [2,3]. High-resolution fMRI can exploit the functional segregation in V1 to reveal layer-specific differences. Here, we measured high-resolution BOLD, CBV and CBF in stimulated and adjacent regions in macaque V1.

## Methods

Experiments were performed on a vertical 4.7T Bruker BioSpec on 6 healthy anesthetized monkeys (*macaca mulatta*) weighing 4-9 kg, while the monkeys were viewing rotating checkerboard stimuli (Fig. 1a,d) alternating with a gray screen (block design with 72s on-off periods, 64 images). The methods have been described previously [4,5]. Anesthesia was a balanced remifentanil/mivacurium regimen. CBF was measured using single-shot FAIR [6] at a resolution of 0.5x0.5x3 $mm^3$. TI/TR/TE was 1400/4500/11.6 ms. Data were analyzed using custom routines in MatLab (the MathWorks). All experiments were approved by the Regierungspräsidium BW (DE) and were in full compliance with the guidelines of the EU (EUVD 86/609/EEC).

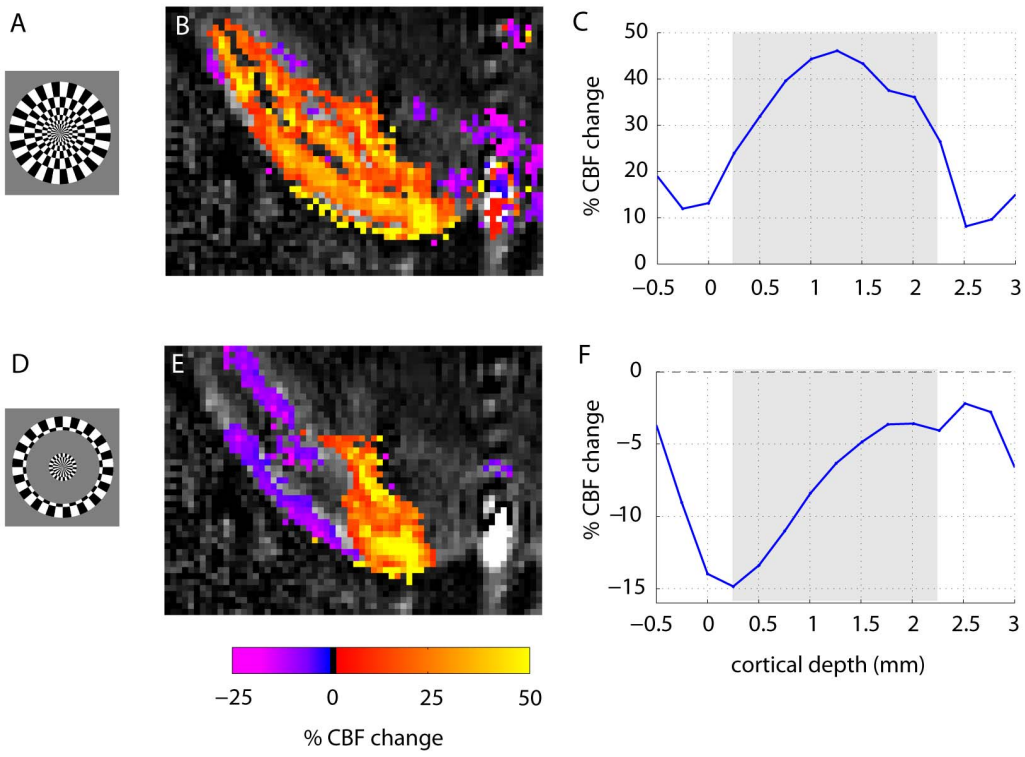


**Figure 1.** Functional CBF in macaque V1 superimposed on baseline CBF. A full field rotating checkerboard (a) induces a positive CBF response (b) that peaks at a depth of ~1 mm, corresponding to cortical layer IV (c). The extent of the cortex is indicated by the gray background. The stimulus in d induces positive and negative CBF responses (e). The laminar profile of the negative CBF response shows a peak at the cortical surface.

## Results

The visual stimulus in Fig. 1d elicits negative BOLD responses in human and monkey V1 [1,2]. Functional CBF (fCBF) shows a similar pattern as the BOLD response, i.e. CBF is increased in stimulated regions and decreased in regions where the BOLD is negative (Fig. 1e) in agreement with earlier studies [2]. The laminar profile of the positive fCBF response has a peak around layer IV (Fig. 1c) as in previous CASL-based fCBF measurements in macaques [7]. In contrast, the negative fCBF response (Fig. 1f) is maximal at the cortical surface, and decreases rapidly to very small or negligible levels in the deeper layers of the cortex (the detection level was about 6%).

## Conclusion

We found laminar differences in the positive and negative fCBF responses. This was matched by laminar differences in BOLD and functional CBV responses, suggesting different neurovascular coupling mechanisms for excitatory and inhibitory stimuli that depend on the location within the cortical sheet.

**Acknowledgements:** We thank Mark Augath for technical support. Supported by the Max-Planck Society

**References:** [1] Logothetis, Nature 453: 869-878 (2008); [2] Shmuel et al., Neuron 36: 1195-1210 (2002); [3] Shmuel et al., Nat. Neurosci. 9: 569-577 (2006); [4] Logothetis et al., Nat. Neurosci. 2: 555-562 (1999); [5] Goense et al., Magn. Reson. Imag. 28: 1183-1191 (2010); [6] Kim, Magn. Reson. Med. 34: 293-301 (1995); [7] Zappe et al., J. Cereb. Blood Flow. Metab. 28: 640-652 (2008).