

# The effect of light and eyes opening on spontaneous activity in the visual cortex

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## Purpose

The phenomenon of resting-state BOLD fMRI activity is as of yet not well understood. In the human visual cortex, the level of this activity is reduced when opening the eyes in low ambient light conditions, either with [1-2] or without [2] visual fixation. However, it is not clear whether this is caused by competitive processes associated with visual input, or state changes inherent to fixation and/or the eyes-open condition. To investigate this, we studied resting-state spontaneous activity while independently modulating these conditions.

## Method

Four conditions (N. scans=115) were investigated: 1) "Fixation" = visual fixation to a fixation dot positioned in the center of a uniform gray image (luminance = 60.0 cd/m<sup>2</sup>), with dim light in the scanner room (0.7 cd/m<sup>2</sup>); 2) "EO-darkness" = resting with the eyes open in darkness (<0.05 cd/m<sup>2</sup>); 3) "EC-darkness" = resting with the eyes closed in darkness (<0.05 cd/m<sup>2</sup>); 4) "EC-light" = resting with the eyes-closed with a white image projected on the screen viewed by the subject (90.0 cd/m<sup>2</sup>; the estimated luminance -primarily red light- perceived by the retina was ~ 9cd/m<sup>2</sup> [3]). The scanner room was completely darkened in conditions 2)-4). Condition 1) was employed as a reference state having reduced amplitude of spontaneous activity with respect to condition 3) [1].

Nine subjects (7m/2f, age 36.3±2.5) participated in the IRB-approved study. GE-EPI SENSE-rate3 BOLD-fMRI was performed at 7T (GE-Medical-Systems) using 32-receive-only-coil-elements and the following parameters: TE/TR=32ms/3s; F.A.=80deg; N. slices=42; voxel-dim:1.25x1.25x2mm<sup>3</sup>. First, a 360 deg-rotating-wedge (Fig.1A) stimulation (retinotopy, N. scans=172) was employed as functional localizer for a region of interest in the visual cortex (ROI<sub>VC</sub>, Fig.1B, p<10<sup>-5</sup>, uncorrected for multiple comparisons).

Pre-processing included slice-timing, motion correction, co-registration between different 4D-volumes, conversion of fMRI signals fluctuations to percentage signal changes (SC, %) relative to their time average, removal of low frequency drifts (polynomials of order three), RETROICOR-correction [4], removal of physiological noise related to the respiration volume-per-unit-time [5] and to the cardiac rate [6], temporal low-pass filtering at f<sub>C</sub>=0.073Hz. As a measure of spontaneous fluctuations amplitude in the visual cortex, we computed the standard-deviation of the average low-pass filtered signal in ROI<sub>VC</sub> (SD<sub>ROI-VC</sub>) in each condition and subject.

## Results

The single-subject SD<sub>ROI-VC</sub> (Fig. 2A) and its group average (± s.e. across subjects, Fig. 2B) show a reduction of spontaneous activity with eyes opening, either in darkness or in light/fixation conditions (p < 0.02). No significant reduction in spontaneous activity is seen with the presentation of light through the eyelids in the eyes closed condition. The spectral amplitude of the average signals in ROI<sub>VC</sub> prior to low-pass filtering (mean ± s.e. across subjects) is shown in Fig. 3C).

## Conclusions

The amplitude of spontaneous activity in the visual cortex is not modulated by competitive processing related to light input onto the retina, but rather is state dependent and reduced by eyes opening with or without fixation. The reduction observed with the eyes open condition might be related to processes such as attention and alertness.

## References

[1] Bianciardi et al, NeuroImage (NI), in press, 2009. [2] McAvoy et al, J Neurophysiol, 100:922-931, 2008. [3] Moseley, Ophthal Physiol Opt, 8:229-230, 1998. [4] Glover et al, MRM, 44:162-167, 2000. [5] Birn et al, NI, 31:1536-1548, 2006. [6] Shmueli et al, NI, 38:306-320, 2007.

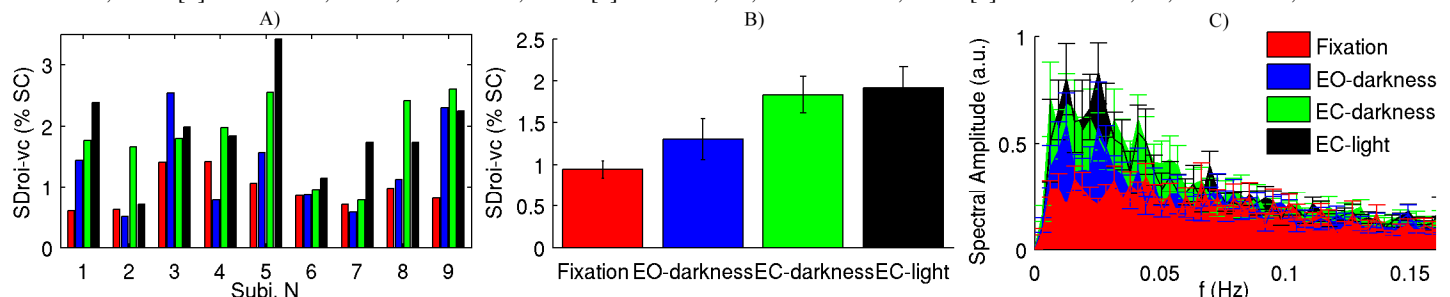


Fig. 2 For each of the four examined conditions, bar plot of the amplitude of spontaneous activity (SD<sub>ROI-vc</sub> in % signal change) A) for each subject and B) averaged (errorbar for the s.e.) across subjects; C) spectral amplitude of average signals in ROI<sub>VC</sub> prior to low-pass filtering. Note that the amplitude of spontaneous activity is modulated by the condition mainly at frequencies lower than 0.06 Hz.

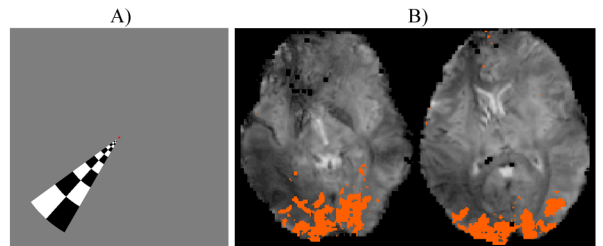


Fig. 1 A) Stimulus employed to localize the visual cortex. The flickering (7.5Hz) B/W wedge (24deg - polar angle - wide) performed a full clockwise rotation in the visual field, covering 30 different positions. B) For an example data-set, areas in the visual cortex (orange, ROI<sub>VC</sub>) responding to the wedge (Fig. 1) in any position of the visual field.