# Rest Conditions in fMRI: exploring the differences

C. K. Schraa-Tam[1], M. Smits[1], A. van der Lugt[1], J. N. van der Geest[2]

[1]Radiology, Erasmus MC Rotterdam, Rotterdam, Netherlands, [2]Neuroscience, Erasmus MC Rotterdam, Rotterdam, Netherlands

## Aim

In this study we explored differences in brain activation between three probable rest conditions used in functional Magnetic Resonance Imaging (fMRI) experiments: 1) when the eyes are open, 2) when the eyes are closed by the subject and 3) when the eyes are kept open but covered externally.

## Introduction

Marx et al. (Neuroimage 2003:19: 924-933) showed that there are considerable and consistent different patterns of brain activation between an open-eyes and a closed-eyes condition that are both often used as rest conditions in a fMRI experiment. We explore the possibility of another rest condition in which the eyes are kept open but are covered externally, as in fMRI experiments that employ goggles for visual stimulation. Using a third condition enables us to explore activation patterns that are common in both open-eyes and closed-eyes conditions.

## Methods

*Image acquisition:* Five healthy volunteers (average age of 30 years) participated in two studies that took place in complete darkness. Image acquisition was done on a 1.5T MRI scanner (Signa CV/I; General Electric, Milwaukee, USA). For each subject, a T1-weighted SE (TR/TE 500/14ms) scan was acquired for anatomical reference, followed by T2*-weighted single shot gradient echo EPI functional scans using a block design. Each volume covered the brain including the complete cerebellum with a 64x64 matrix, 4mm slice thickness with no gap. For the first study (two conditions: close and open eyes), which served as a control experiment, 84 volumes were collected (TR/TE 3750/50ms). Each block lasted 30 seconds during which eight volumes were collected. For the second study (three conditions: close, open and covered eyes), 94 volumes were acquired (TR/TE 3333/50ms). Here each block lasted 20 seconds during which six volumes were collected. For both studies the total running time was six minutes.

*Data analysis:* The imaging data were analyzed with SPM-99 (Statistical Parametric Mapping, Hum Brain Mapp 1995: 2:165-189). The data were preprocessed with realignment and co-registration, then normalized to a standard T1 template image (MNI), and subsequently smoothed using a Gaussian filter with FWHM of 12 mm. For both single-subject and group analyses in the two studies statistical parametric maps were calculated using the general linear model provided by SPM with a haemodynamic model of two and three conditions respectively. The model removes global effects, using a high pass filter (cutoff period of 120s) and a haemodynamic low pass filter for temporal autocorrelation.

## Results

In accordance with Marx et al. (2003) we observed differences in task-related changes in fMRI signal intensity in both single-subject analyses and group analyses (n=5, p<0.001, uncorrected) between the open and closed eyes conditions (close > open & open > close) in our two-conditions control study, However, differences in task-related changes in fMRI signal intensity are also observed in the three conditions study for the same subject comparing (1) eyes covered and eyes open (covered > open & open > covered; fig A), (2) eyes covered and eyes closed (covered > close & close > covered; fig B). Similar brain activities are observed in eyes closed and eyes open (close > open & open > close; fig C) conditions for both the 2-conditions experiment and 3-conditions experiment. When the eyes-covered condition is chosen as a baseline the same pattern of brain activation is seen in both the eyes open and eyes closed condition (open > cover vs. close > cover).

## Conclusions and Discussion

Our results corroborate the previous observations by Marx et al. that there are differences in activation patterns between two often employed resting conditions. However, we also observed different brain activations in a third condition (eyes covered) as compared to the other two. Moreover, the addition of the third condition showed activations that are common to both the open-eyes and closed-eyes condition. Glass brain views showed that ocular motor and attention systems were activated when the eyes are open and uncovered. The visual, somatosensory, vestibular and auditory systems are activated when the eyes are closed. When the eyes are covered but kept open, activations in considerable parts of the cerebellum, thalamus and frontal areas is observed. We conclude that our results emphasize once more the importance of choosing an adequate rest condition in an fMRI experiment.

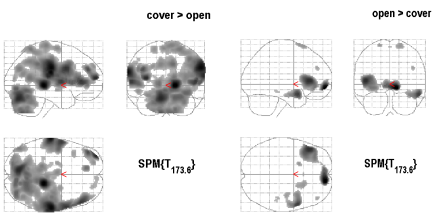


Figure A: three conditions experiment: Glass brain view for group analysis with patterns of BOLD-response in the eyes-covered vs eyes opened and eyes opened vs eyes covered with results exceeding a height threshold of p < 0.001, uncorrected, and with an extent threshold of three voxels.

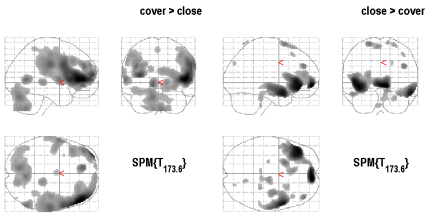


Figure B: three conditions experiment: Glass brain view for group analysis with patterns of BOLD-response in the eyes-covered vs eyes closed and eyes closed vs eyes covered with results exceeding a height threshold of p < 0.001, uncorrected, and with an extent threshold of three voxels.

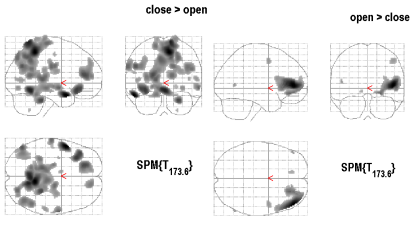


Figure C: three conditions experiment: Glass brain view for group analysis with patterns of BOLD-response in the eyes-closed vs eyes opened and eyes opened vs eyes closed with results exceeding a height threshold of p < 0.001, uncorrected, and with an extent threshold of three voxels.