Presurgical evaluation using Functional Connectivity Resting-State fMRI

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Introduction

Functional connectivity analysis of resting-state fMRI (fcrs-fMRI) has been shown to be a robust non-invasive method for localization of functional areas and networks throughout the brain on an individual level. Its use for preoperative planning could overcome some of the disadvantages of traditional task-evoked fMRI, such as the need for patient cooperation, movement-induction, different paradigms for different functional regions and non-standardized measurements.

This fcrs-fMRI method measures spontaneous (no task) low-frequency (<0.1 Hz) fluctuations of the BOLD-signal over time. When placing a region-of-interest (ROI) somewhere in the brain, we can determine regions with similar low-frequency fluctuations. These regions are said to be functionally connected to the ROI. In practice, we looked at presurgical patients (epilepsy, AVM, tumor) which needed evaluation of motor and visual regions. By placing a ROI in the relevant cortex of the 'non-diseased hemisphere', we aimed at localizing the similar functional area in the 'diseased hemisphere'.

Methods

We acquired fcrs-fMRI data of 10 patients in presurgical evaluation, and compared the results with traditional task-fMRI data. During rest scanning, patients were asked to lie still, close their eyes and not to think of anything in particular. Traditional paradigms were used for task-fMRI (movement of hand, mouth, foot for motor stimulation and checkerboard for visual stimulation). For analysis of the fcrs-fMRI data, a ROI was drawn, based on both task-fMRI results and anatomical considerations. The correlation coefficient of the BOLD signal between the ROI and all other voxels of the brain was calculated.

All imaging was performed on a 3T system (MAGNETOM Trio, Siemens AG, Erlangen, Germany). Resting-state images were acquired using a T2* weighted echo planar sequence sensitive to BOLD contrast with voxel size 3x3x3 mm, TR 2000ms, TE 27ms, 40 slices, 180 measurements. Analyses were performed using Statistical Parametric Mapping 5 (SPM5, http://www.fil.ion.ucl.ac.uk/spm) and Data Processing Assistant for Resting-State fMRI (DPARSF, Yan and Zang, 2010).

Results

Results are shown in Fig 1-10. All fcrs-fMRI results (left image, ROI in red) show good correspondence to the task-fMRI results (right image).
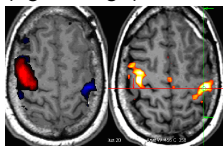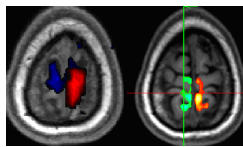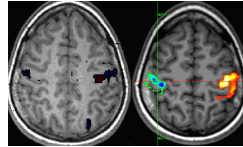

Fig 1 (motor hand)

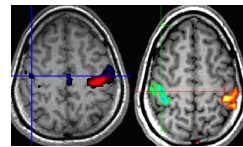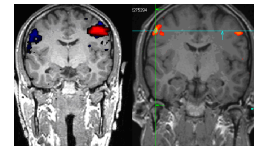Fig 2 (motor foot)

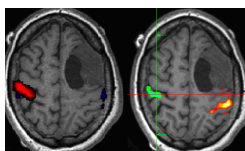Fig 3 (motor hand)

Fig 4 (motor hand)
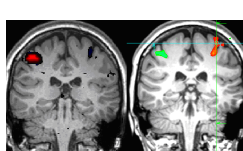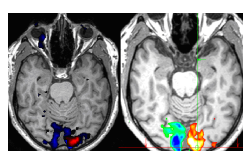

Fig 5 (motor mouth)

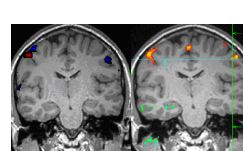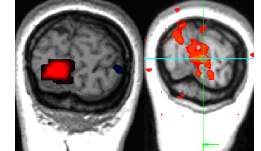Fig 6 (motor hand)

Fig 7 (motor hand)

Fig 8 (visual)

Fig 9 (motor hand)

Fig 10 (visual)

Conclusions

In most of the subjects there is a good concordance between fcrs- and task-fMRI results, i.e. similar regions are found (Fig 1-9). In subject 10 (Fig 10), task-fMRI does not give any good results for visual activation and neither does fcrs-fMRI.

We hereby provide evidence for the potential use of functional connectivity resting-state fMRI data in presurgical planning. This technique has several advantages over traditional task-fMRI.

- the ability to scan patients unable to execute task (sleep, coma, children, elderly, task too difficult,…).
- functional localization of all areas using one measurement (5-7min), without paradigm
- can be used to standardise presurgical fMRI interclinically in the future, and for implementation in the normal clinical protocol

In the future, automatic selection of the ROI should be evaluated. This can be achieved by using automatic analysis methods (ICA, independent component analysis) to determine ROI localization, or by using atlases. Also evaluation of fcrs-fMRI results with CSM (cortical surface mapping) during surgery would be very useful to compare results of both task- and fcrs-fMRI. In this way we can assess the potential ability of fcrs-fMRI in presurgical planning.

References

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