Resting-State Networks Revealed with Whole-head Near-Infrared Spectroscopy

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Introduction

- Correlation analysis of low-frequency fluctuations is well established in fMRI as a method for determining functional connectivity, which in data collected independent of task, have been termed: resting-state networks [1]
- Similar methods have been applied to optical imaging data [2].
- Here we report the correlation analysis of low-frequency oscillations [3] for whole-head near-infrared spectroscopy

Methods

- 4 healthy adults (1 female) with open-eyes rest (2 blocks of 15 min duration)
- NIRS imaging system: DYNOT 232 (by NIRx Medizintechnik GmbH, Berlin, Germany), wavelengths of 760 nm and 830 nm, sf 2.44 Hz
- 20 source, 32 detector fibers provided 80 voxel, inter-optode distance approx. 2.5 cm, whole head coverage (excluding the occipital areas)
- 5 min data were selected, band-pass filtered (0.02-0.08Hz), modified Beer–Lambert law to convert attenuation changes into changes of [oxy]-Hb and [deoxy]-Hb [4]
- global mean of all channels was fitted and regressed out to reduce the extra-cerebral signal (Figure 2)
- correlation analysis was performed for seed-voxel: MNI coordinates of the voxel by probablistic mapping [5] in comparison to [1]

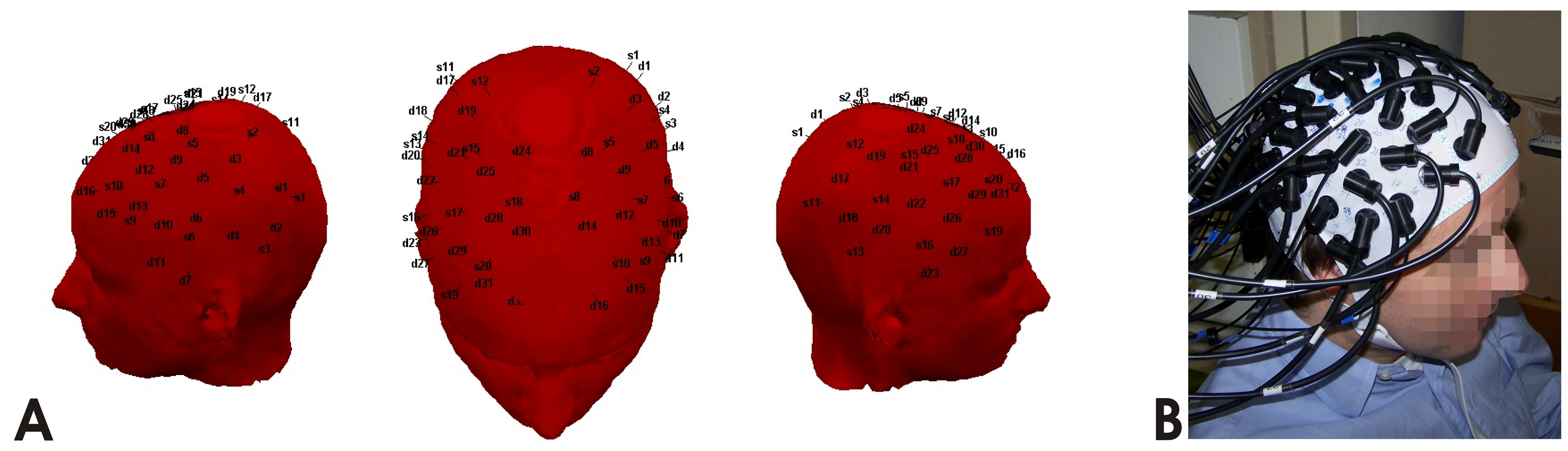

Figure 1: A) schematic overview of the optode position (20 sources (s), 32 detectors (d) leading to 80 voxel between source-detector pairs), B) one subject

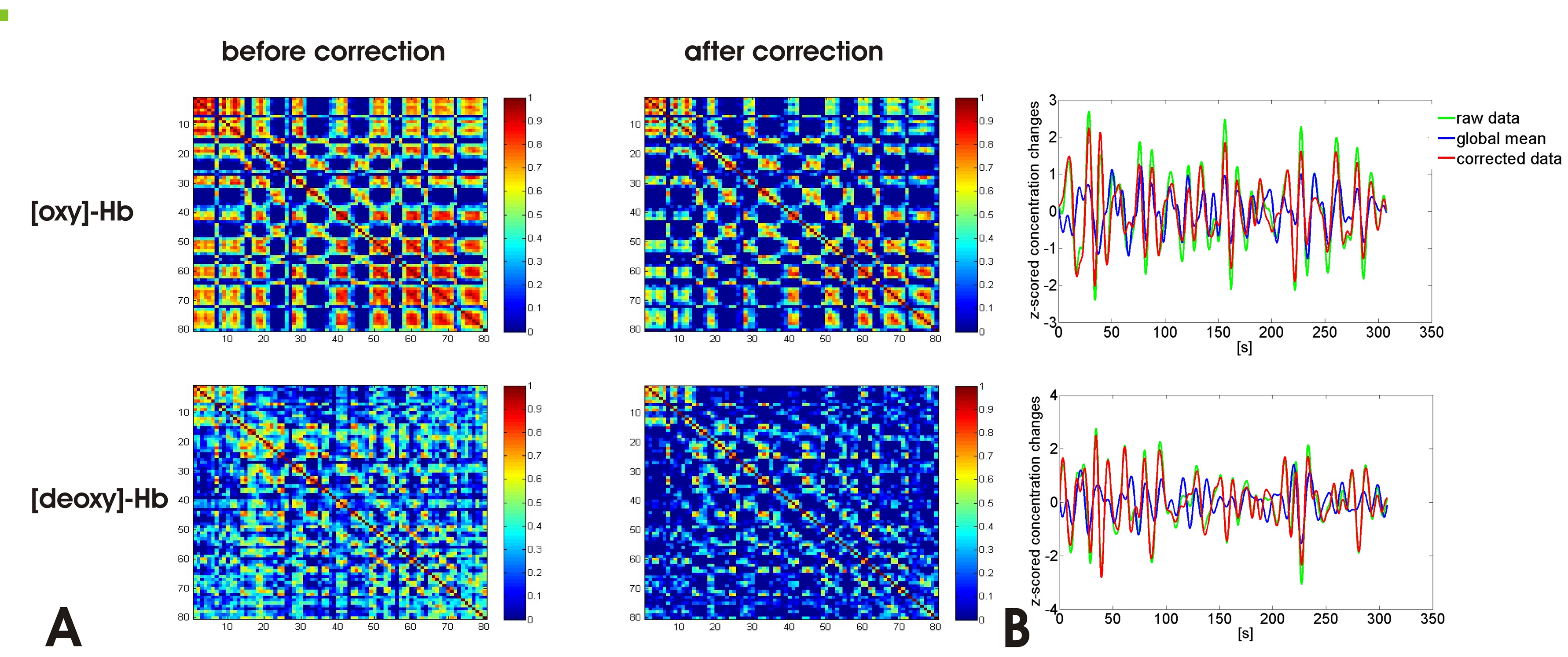

Figure 2: effect of global mean regression: A) correlation coefficients of [oxy]-Hb (top row) and [deoxy]-Hb (bottom row) before (left) and after (right) the correction, B) effect shown for the time course of one voxel

Results

left central seed voxel

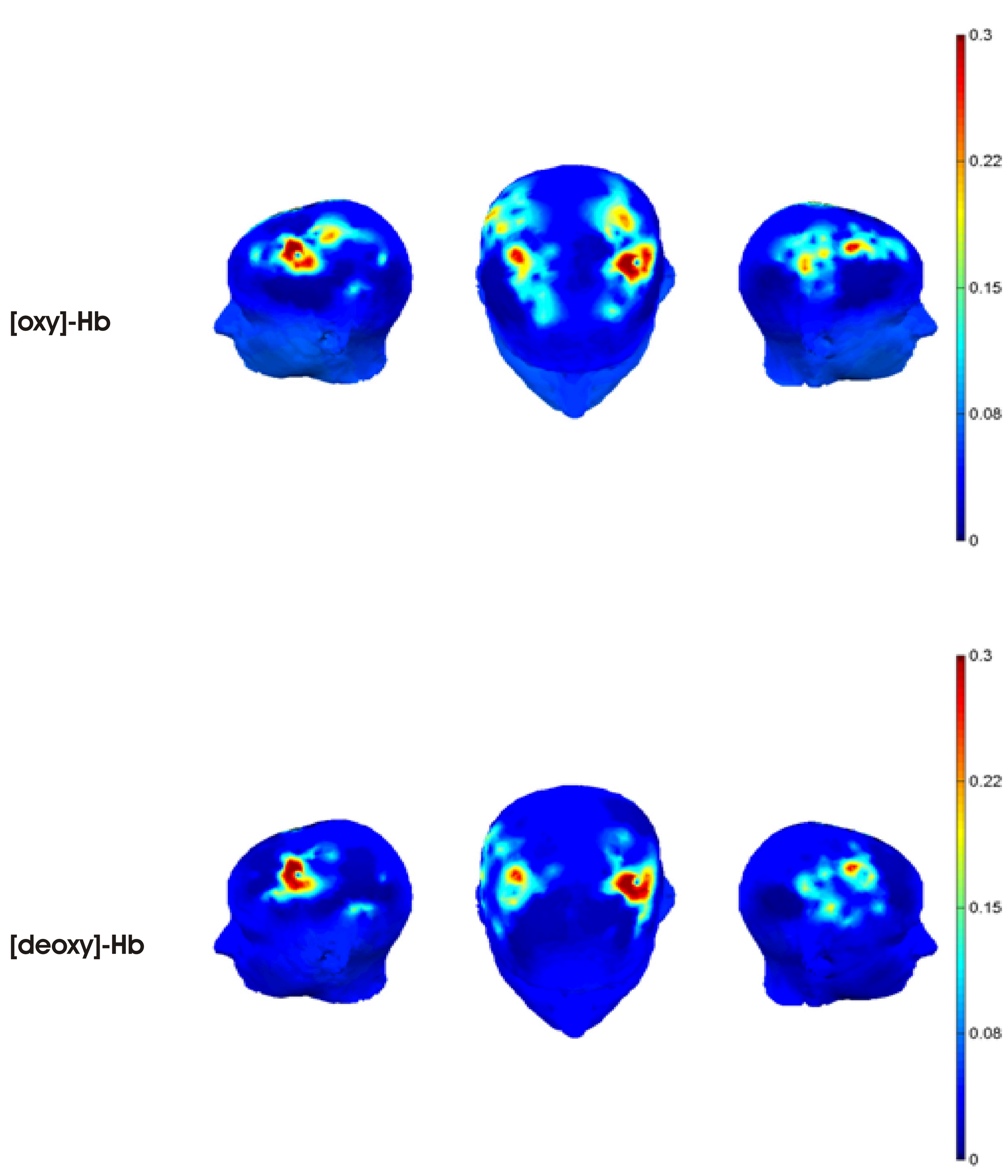

Figure 3: correlation coefficients for a seed voxel in the left motor area ([oxy]-Hb and [deoxy]-Hb)

left temporal seed voxel

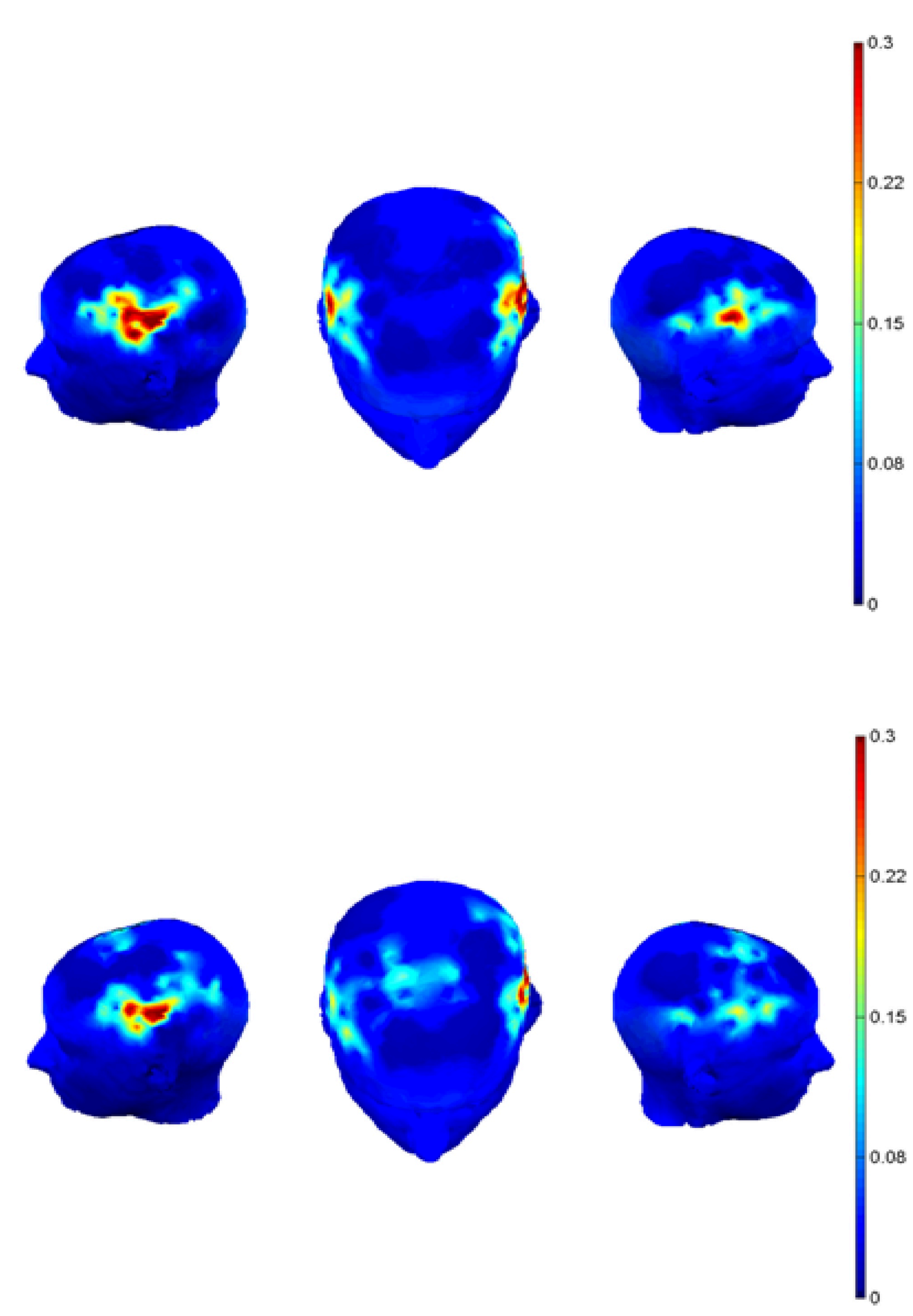

Figure 4: correlation coefficients for a seed voxel in the left temporal area ([oxy]-Hb and [deoxy]-Hb)

left parietal seed voxel

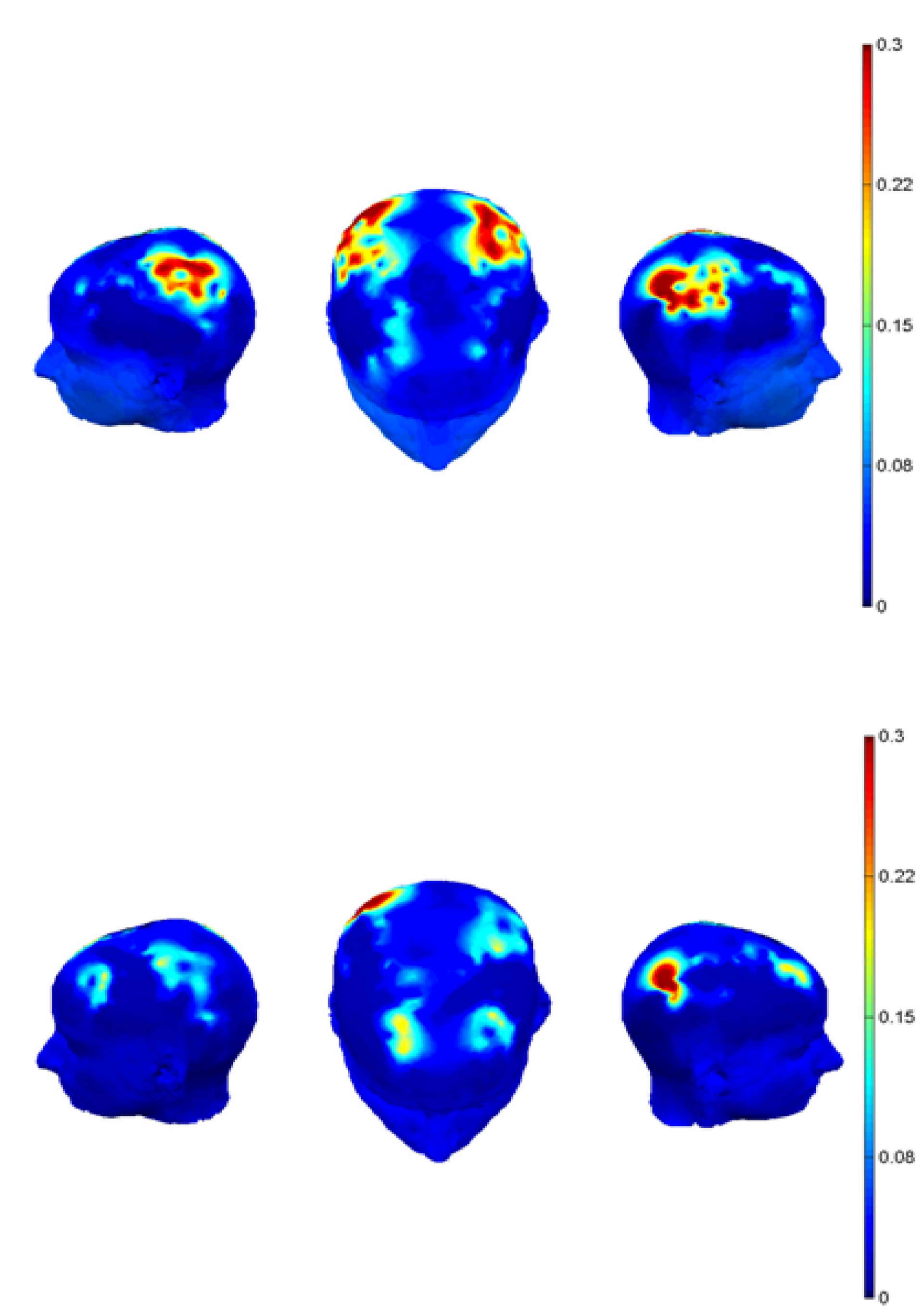

Figure 4: correlation coefficients for a seed voxel in the left parietal area ([oxy]-Hb and [deoxy]-Hb)

Our findings indicate the detection of three well-known functional networks: (1) bilateral motor areas, (2) bilateral temporal lobes and (3) the 'default-mode' network (medial-frontal and bilateral parietal cortical areas). Furthermore, our results show a high intra-subject consistency for both oxygenated and deoxygenated hemoglobin, as well as high inter-subject reliability.

Summary and Discussion

Using optical imaging methods to detect and interpret functional connectivity can be used to cross-validate findings in functional connectivity fMRI and may help to extend the approach to further investigate the developmental effects in children and infants, to facilitate bed-side measurements, or to study patients which cannot be examined by fMRI (e.g. deep-brain stimulation).

To further validate the findings a correlation between functional connectivity and functional activation data is currently being performed. Future work will include data-driven analysis such as independent component analysis (ICA) or principal component analysis (PCA) and a direct comparison of inherent network time courses with EEG data.

References

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