Investigating the origin of hemodynamic fluctuations using high-resolution diffuse optical tomography in humans

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Near infrared spectroscopy and DOT signals are often contaminated with spontaneous low frequency oscillations (LFO) in the 0.1 Hz band and heart beat (HB) signals (1.2Hz). LFO are often described in human brain imaging studies [1] and may represent auto-regulatory processes of cerebral blood flow. Since 2D NIRS cannot separate superficial from deeper layers, we investigate the origin (brain or scalp) of LFO and HB in NIRS signals using 3D DOT.

We used a NIRScoutX (NIRx Medizintechnik, Germany) cw tomography imager (32 sources* 32 detectors, 760 nm & 830 nm). We placed two grids of optical fibers bilateral, pericentrally over C3 and C4 (each side: 16s*16d) achieving 2*256 data channels with a 3.41 Hz sampling frequency. Three subjects performed a 10 min resting task.
Image reconstruction was performed for both hemispheres independently. We reconstructed time series of relative absorption changes using the normalized difference method [2]. The weight matrix was determined using BrainModeler (NIRx Medical Technology LLC) which provides a library of subvolumes from a MRI-scan based finite element mesh (FE) with precalculated inverse parameters. To investigate LFO and HB, the reconstructed time series were band pass filtered at 0.1Hz /1.2Hz and normalized (z-score). We calculated the power spectral density (PSD) for the reconstructed HbO time courses in every node of the FE mesh. For visualization purpose, the results (power at 0.1 Hz and 1.2Hz) were transformed into volumes and superimposed on a brain structure.
We found a high relative fraction of LFO in deeper layers, whereas HB could be seen mainly in superficial layers.
We demonstrate that DOT with a 3D image reconstruction allows a depth profiling of hemodynamic rhythms in the adult head. Monitoring these hemodynamic features and detecting changes in the individual patterns could be an additional module to noninvasively detect changes in cerebral blood flow, e.g. in neurointensive care patients.

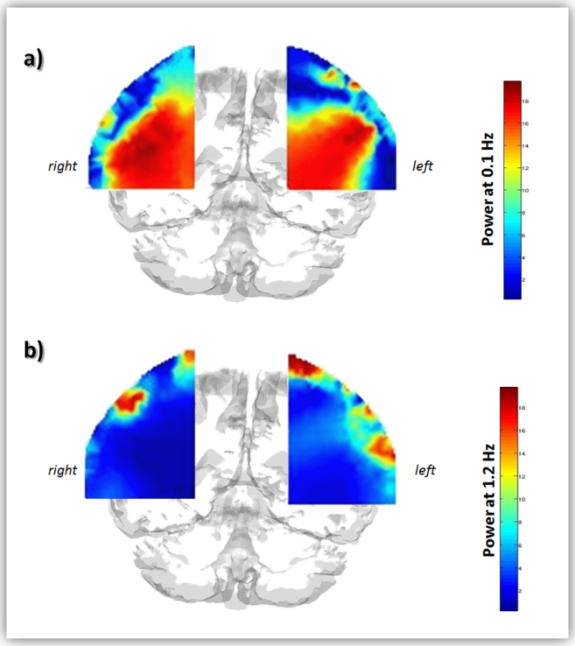

Fig. 1 Result of a PSD of HbO time courses for a) low frequency oscillations and b) heart beat

References

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