Development of a reference phantom for fMRI studies

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Purpose:

The purpose of this work is to develop a phantom which can provide a reference signal for fMRI studies.

Introduction:

Intersession variability is a well known effect in fMRI studies [1] with repeated measurements. This variability makes it difficult to perform longitudinal fMRI studies. The question whether these intersession changes reflect real differences in the 'state of mind' of the subject or have another cause is, to our knowledge, not answered. To access the contribution of variations in the MR-hardware over time to the observed intersession changes we constructed a phantom that can provide a reference signal. The phantom can be placed within the field of view next to the subjects head. Here we report on the construction of the phantom and first measurements with it.

Construction of the phantom:

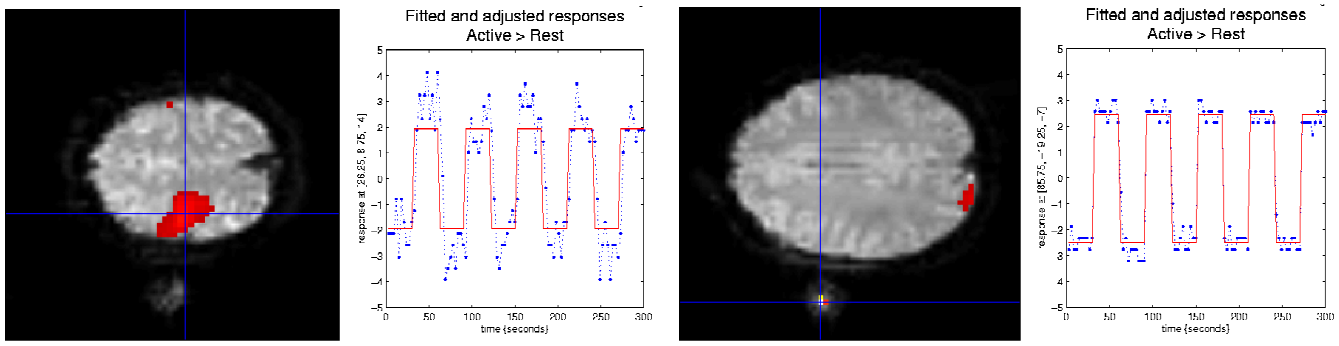
Light produced by a GaAlAs LED, spectral peak at 660 nm, is fed into a 10 m long plastic (PMMA) fiber which has an optimal transmission at 650 nm. At the other end of the fiber a photodiode with a spectral response of 0.23 A/W at 660 nm is attached. All components were supplied by Industrial Fiber Optics Inc, Tempe, AZ, USA. The photodiode is connected to a copper coil, which is placed in a pure agarose gel (2%). The coil consists of 41 turns of 40 μm thick copper wire and has an inner diameter of 1.93 cm. The LED is powered by a current source set to provide 15 mA, resulting in a coil current of approximately 12 μA. In the center of the coil this induces a magnetic field of 33 nT.

Methods:

To demonstrate the functioning of the phantom, measurements were performed on a Philips 3T Intera scanner using a T/R-head coil. A standard multi-slice EPI sequence with the following parameters was used: TE = 35 ms, TR = 3000 ms, voxel size 3.5x3.5x3.5 mm^3, no slice gap. The phantom was placed next to the left-side of the head of a subject who performed a block motor task. The task consisted of opening and closing of the right hand at a self paced rhythm for 30 seconds interleaved with 30 seconds periods of rest, starting with rest. A total of 100 scans was made (5 rest/active periods). The phantom was switched OFF and ON along with the task. Data analysis was done using SPM99 (Wellcome Department, London, UK). The data were realigned, smoothed, using a 8 mm kernel, and statistically analyzed. T-maps were created using a p-value of 0.05 corrected for multiple comparisons.

Results:

The figure shows two slices of a T-map overlaid on the mean EPI image of the subject together with the time courses of the signals at the respective crosshairs.



Discussion:

These first results show that it is possible to construct a phantom that can provide a reference signal for fMRI studies. The signal change induced by the phantom is comparable in magnitude to the observed BOLD-signal. The temporal stability of the phantom signal in these results is better than that of the BOLD-signal. We anticipated that the phantom signal would decrease due to a decreased field homogeneity when the phantom is switched ON. We are surprised by the opposite effect and are in the process of looking for an explanation for this puzzling behavior.

References:

[1] D.J. McGonigle et al. Variability in fMRI: An examination of intersession differences. Neuroimage 2000:11;708-734.