Examination of frequency dependant signal fluctuations in resting state examinations measured with MR-Encephalography

J. Hennig[1], K. Zhong[1], T. Grotz[1], and O. Speck[1]

[1]Dept. of Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany, Germany

MR-Encephalography (MREG) (1) also called inverse MR-imaging (2) allows to monitor physiological changes with very temporal resolution at the cost of spatial resolution by use of simultaneous readout with multiple small RF-coils. One-dimensional encoding under a readout gradients increases spatial information at identical acquisition speed. First results have shown extremely high reproducibility of the measurement with signal fluctuations considerably below 1 %. The purpose of this study was to use the high temporal resolution and reproducibility for a detailed investigation of the nature of what is commonly called 'physiological noise'.

Materials and methods

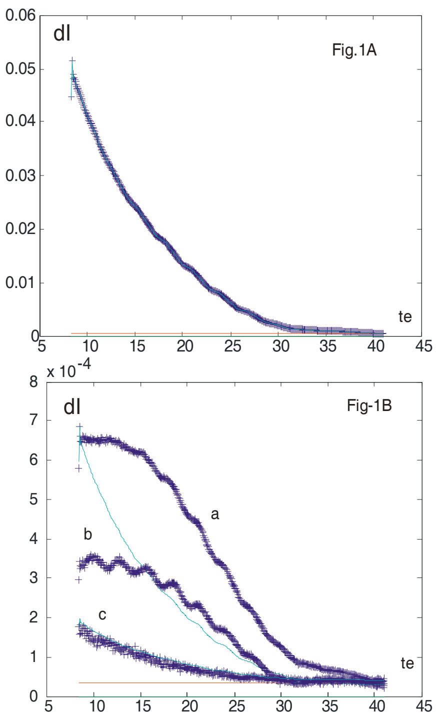

Fig.1 Noise level in different frequency domains measured in ya normal volunteer (s.text)

All experiments were performed on a 3T scanner (Trio, Siemens), Measurements were performed with a gradient spoiled FLASH-sequence with TR=50 ms. Te for acquisition with one-dimensional encoding was set to 25 ms. Signal was acquired over 140s, the first 20s were discarded to ensure a signal stead state. Identical experiments were performed in normal subjects (n=5) and phantoms using a 8-channel visual cortex coil (1) as well as a newly developed 4-channel coil for simultaneous observation of motor and visual cortex.

Results

Fig.1 A shows the total noise measured as the standard deviation over the frequency spectrum of all FIDs along the time axis. Noise (blue cross) correlates extremely well with the mean intensity along the FID (cyan line). Fig.1B shows noise in different frequency bands: (a) 0.3-0.5 Hz represents breathing, (b) 1-1.5 Hz ECG-related fluctuations (scaled by a factor of 2). (c) (18.1-8.5 Hz) represents a frequncy band, which does not show any appreciable intensity in the spectrum, but still scales rather well with the FID. Fig.2 shows noise in experimetns with one-dimensional spatial encoding. Breathing depend fluctuations (blue cross) scale extremely well with the overall profile. ECG-dependant noise (red) shows a distinct peak, which can be allocated to the sagittal sinus. The cyan line shows signal fluctuations at 6-6.5 Hz, which can not be clearly allocated to neither ECG nor breathing.

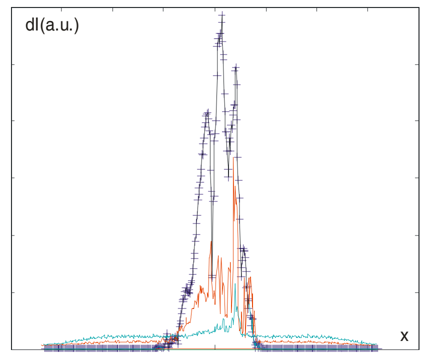

Fig.2 Noise level along spatial coordinate (s.text)

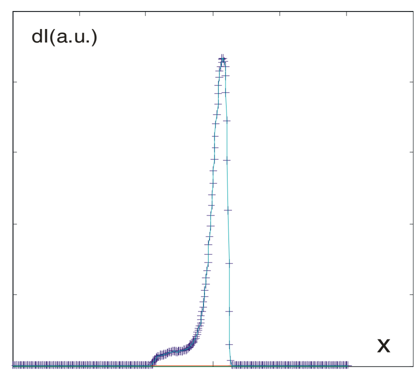

Fig.3 Noise level along spatial coordinate in phantom measurements. (s.text)

Results from phantom measurements show qualitatively similar results: signal fluctuations std(I) scale nicely with signal intensity I with I/std(I)= 273.3 for the results shown in Fig.3. The same applies for FIDs in non-spatially encoded experiments. Total noise scales with the FID (not shown), an example of the fluctuations in frequency bands excluding the baseline is shown in Fig.4.

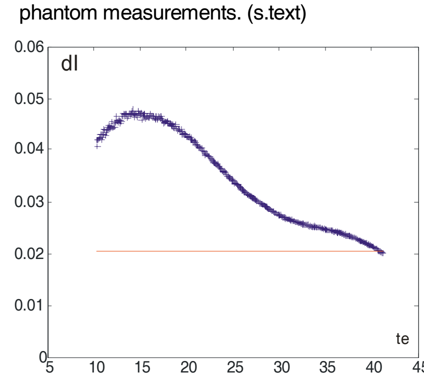

Fig.4 Noise level in the frequency band 1-4 Hz in a phantom measurement.

Discussion

The high sampling rate of MREG-measurements allows to directly distinguish contributions of noise according as a function of frequency. In agreement with known literature, noise in experiments on human subjects is dominated by ECG- and breathing dependant signal fluctuations. The results also show, that even for phantom measurements noise scales with signal intensity. The shape of the noise vs. te shown for breathing and ECG (Fig.1B) in volunteers, but also in high frequency noise in phantoms is indicative for non-reproducibilities in signal amplitude as well as T2*. The commonly used term 'physiological noise' for all intensity dependant signal fluctuations is therefore somewhat misleading.

References:

1 Hennig J, Zhong K, Speck O. Neuroimage. 2006 Oct 27, epub ahead of print
2 Lin FH, Wald LL, et al. Magn Reson Med. 2006 Oct;56(4):787-802.
3 Glover, G.H., Li, T.Q., Ress, D., 2000. Magn Reson Med;44(1):162-167.