EEG Acquisition in Ultra-High Static Magnetic Field up to 9.4T

I. Neuner[1,2], T. Warbrick[1], M. Reske[1], J. Felder[1], A. Celik[1], and N. J. Shah[1,3]
[1]Institute of Neuroscience and Medicine - 4, Forschungszentrum Juelich, Juelich, Germany, [2]Department of Psychiatry and Psychotherapy, JARA, RWTH Aachen University, Aachen, Germany, [3]Department of Neurology, Faculty of Medicine, JARA, RWTH Aachen University, Aachen, Germany

Introduction

At 1.5T and 3T the simultaneous acquisition of electroencephalographic (EEG) and fMRI data has gained momentum due to the synergistic effects of the two modalities with regard to temporal and spatial resolution. Especially patients undergoing neurosurgery for treatment resistant epileptic seizures would benefit from the improved resolution at ultra-high fields and the simultaneous EEG information. However, recording EEG-data in a magnetic field is accompanied by cardioballistic artefacts which increase with B_0. Currently, only EEG-data recorded in fields of up to 7T have been reported. We address the issue of whether EEG-data acquisition is feasible in B_0 fields up to 9.4T and how the cardioballistic artefact evolves with increasing B_0.

Methods

We recorded EEG data in 5 healthy volunteers (2 female, 3 male) aged 23-27 years (mean 25.4, SD 1.8), first outside a human 9.4T scanner (Siemens, Erlangen, Germany) and then inside positioning the scanner table in a field of 4T (1850mm from the isocentre), 7T (1450mm from the isocentre), 8T (1300mm from the isocentre) and at 9.4T (isocentre). One volunteer stopped the experiment after the 8.0T recording due to claustrophobia at 9.4T. At each B_0, volunteers rested for 5 min for adaptation purposes prior to EEG recording. EEG data were recorded with an MR-compatible, 32-channel EEG system (Brainproducts, Munich, Germany). At each B_0, we recorded "resting-state data" (eyes closed) and 5 one-minute epochs with "eyes open" and "eyes closed".

Results

EEG-data were recorded reliably and reproducibly at each field strength. As shown in Figure 1A, the cardioballistic artefact increased in amplitude with increasing B0 with a particularly sharp increase from 8T to 9.4T. Figure 1B displays an overlay of the cardioballistic artefact in the same individual at different fields. Figure 2 displays an epoch out of "resting state" EEG data recorded at 9.4T. Note the huge cardioballistic artefact displayed in blue. Figure 1: A) Amplitudes of the cardioballistic artefact in dependence of B0 field strength B) Overlay of the cardioballistic artefact in the same individual at different B0 fields.

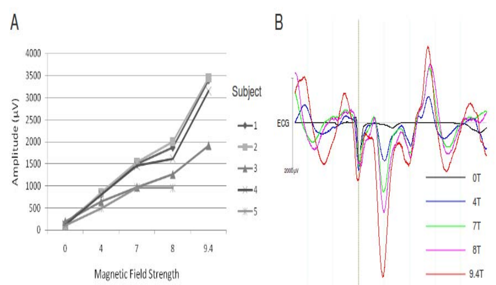

Figure 1: A) Amplitudes of the cardioballistic artifact in dependence of B_0 field strength. B) Overlay of the cardioballistic artifact in the same individual at different B0 fields.

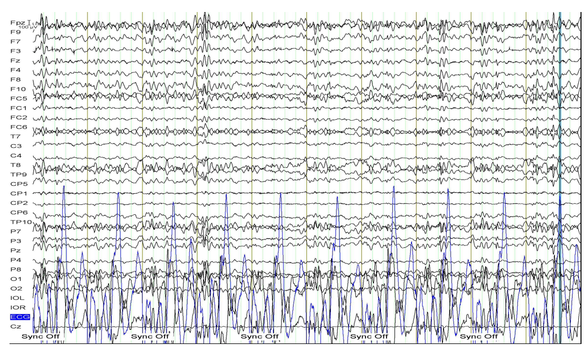

Figure 2: EEG – data recorded in the static 9.4T field

Discussion

EEG data acquisition is feasible at ultra-high magnetic fields of up to 9.4T. The cardioballistic artefact at 9.4T is more pronounced than at lower field strengths. This pattern was reproducible over all volunteers, but the interindividual variability of the artefact was high. In this pilot study we used the Allen subtraction method for correction of the cardioballistic artefact as implemented in Analyzer 2 (Brainproducts, Germany). Further research is necessary to identify the best objective artefact correction scheme for ultra-high fields.