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Exploring the pulse artefact in EEG recordings in a magnetic field of 9.4 T

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Introduction

EEG recordings at ultra-high magnetic fields pose the problem of the pulse artefact. The pulse artefact is produced by cardiac pulse-related movement of the scalp electrodes inside the magnetic field, and the induced Hall-effect caused by movement of blood, an electro-conductive fluid. The fact that the amplitude of the pulse artefact is proportional to the strength of the magnetic field in which EEG is recorded is well described[1,2]. In this study we investigate the components of the pulse artefact in EEG data recorded in a 9.4 T magnetic field.

Methods

- EEG data were recorded from 5 male volunteers inside a 9.4 T human, whole-body MR scanner (Siemens, Erlangen, Germany).
- Electrocardiography (ECG) and photopletismogram (PPG) signals were recorded wirelessly.
- Data analysis included detection of heartbeat, calculation of the pulse artefact amplitude and Independent Component Analysis (ICA).
- Key method 1: ICA was performed using FastICA[3], followed by clustering of the independent components (ICs) using ICASSO[4] (http://research.ics.aalto.fi/ica/icasso/).
- Key method 2: Cross trial phase statistics (CTPS)[5] permitted the identification of ICs related to the pulse artefact, i.e. ICs which were phase-locked to the P-wave (-0.2 to -0.05 s), the QRS-complex (-0.05 to 0.05 s) and the T-wave (0.05 to 0.3 s).

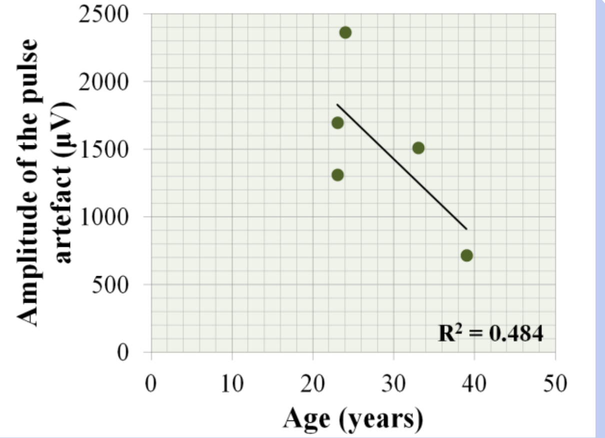

Figure 2. Amplitude of the pulse artefact in relation to age.

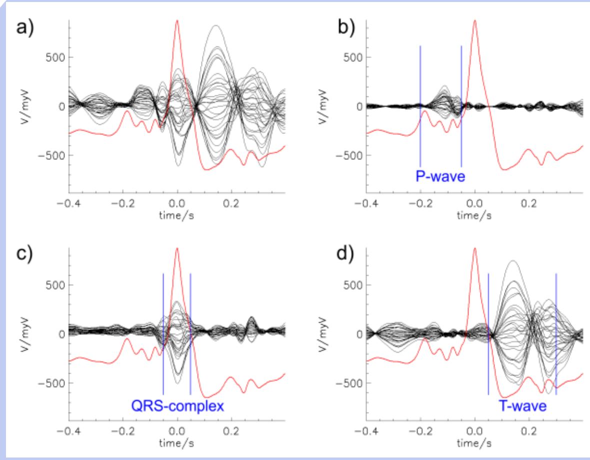

Figure 1. EEG signal of all volunteers (black) averaged with respect to the R-peak of the ECG signals (red). An average of the whole EEG signal is shown in (a). In (b), (c) and (d) are presented the EEG signals reconstructed from the ICs identified as being related to the P-wave, QRS-complex and T-wave respectively.

Results

- It was possible to identify ICs related to the P-wave, the QRS-complex and the T-wave (Figure 1).
- In our sample of healthy male volunteers, there was a trend for decreased pulse artefact amplitude in older volunteers (correlation coefficient R^2 = 0.484). See Figure 2.

Discussion and conclusion

- The pulse artefact could be separated into parts belonging to the phases of the heartbeat.
- The phases of the heartbeat contribute differently to the resulting pulse artefact.
- We identified a link between the amplitude of the pulse artefact and the age of our volunteers.
- The pulse artefact has a strong dependence on what we hypothesize is the arterial compliance.

References

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