Triaxial OPMs: Next generation of wearable MEG?

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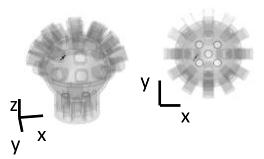
Overview

MEG systems based on SQUID sensors typically measure one component of the neuromagnetic field, due to the complexity of the required geometry of flux transformers. However, newly available commercial OPMs offer the possibility to measure a complete triaxial magnetic field at multiple locations across the scalp. Here, we aimed to test the suitability of such sensors for MEG.

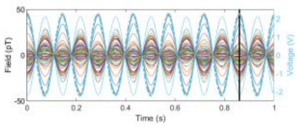
We evaluate the performance of 4 triaxial QuSpin sensors, and their suitability to measure biomagnetic signals from the adult heart, adult brain. Further, in simulation and experiment, we assess the advantages of triaxial OPMs for measurements in infants.

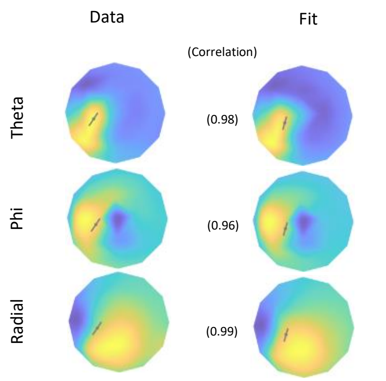
Phantom

- Current-dipole phantom of 11-cm diameter filled with saline solution
- 25 possible slots for OPM placement
- 7-Hz sinusoidal waveform from signal generator
- 8 runs of 5 s each:
  - 1 sensor remained at the same location
  - 3 sensors at different positions in each run
- Dipole fit



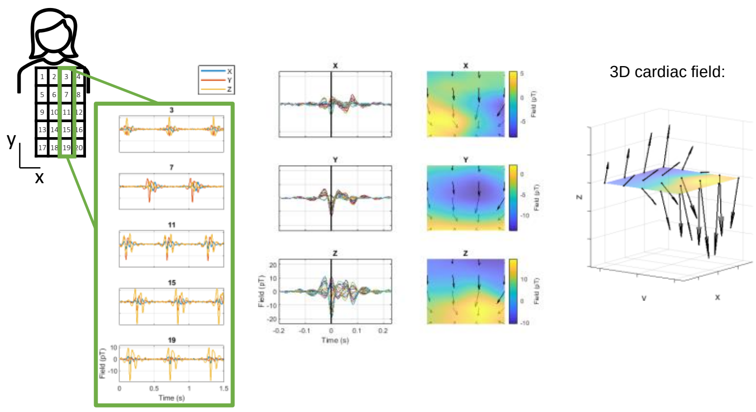
Magnetic field vs dipole strength:





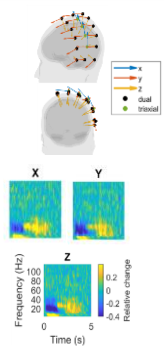
MCG

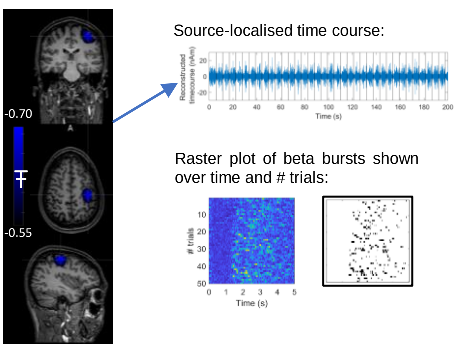
- 1 participant leaning against an MDF plank holding 4 triaxial sensors
- 20 locations were mapped in a 4 x 5 grid (~ 20 cm x 20 cm over the participant's chest)
- 1 stationary reference sensor (dual-axis) used to time the heartbeat
- t=0 set to QRS complex
- Signals averaged and 2D fieldmap generated for x, y and z



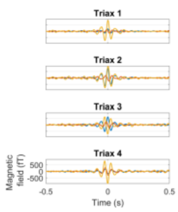
MEG – 3D neuromagnetic fields example

- 1 participant repeated the same motor task 4 times: finger abduction
- ITI: 5 s. 50 trials
- 4 triaxials + 14 dual-axis sensors on flexible cap over left sensorimotor region
- Position and orientation of sensors from Polhemus
- Beamformer:
  - Beta-band-filtered data for covariance matrix
  - Single-shell conductor model
  - Functional image showing location of dipoles exhibiting maximum beta amplitude modulation
- Beta-burst analysis:
  - Threshold: 3·std of amplitude envelope of source-localised time course
  - Phase alignment of bursts
  - Data average across all bursts

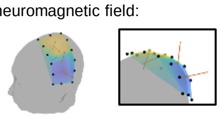




Averaged magnetic fields across bursts for 4 triaxials:

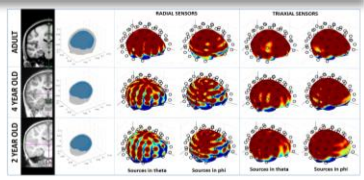


3D neuromagnetic field:



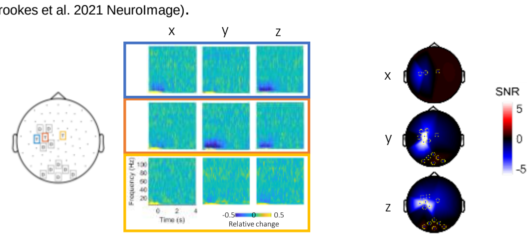
MEG – utility in children

A simulated triaxial OPM-MEG system showed that vector measurement might be particularly useful for studying the infant brain: as the brain of an infant is closer to the sensors than that of an adult, a radial-only system results in gaps in coverage. A triaxial array fills these gaps, providing more uniform coverage.



In addition, previous work suggests that triaxial measurements would be advantageous for rejecting interference (Brookes et al. 2021 NeuroImage).

We tested 3 triaxial OPMs using a 3D-printed helmet in a 5-year-old, during a hand-stroking task to elicit beta changes over the left sensorimotor cortex.



Conclusions

- Triaxial sensors offer similar performance to the conventionally available dual-axis OPMs, but with the added benefit of an additional measurement
- Triaxial OPMs will show utility in scanning infants due to improved coverage and will offer improved rejection of interference

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