Theoretical advantages of a triaxial optically pumped magnetometer MEG system

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Overview

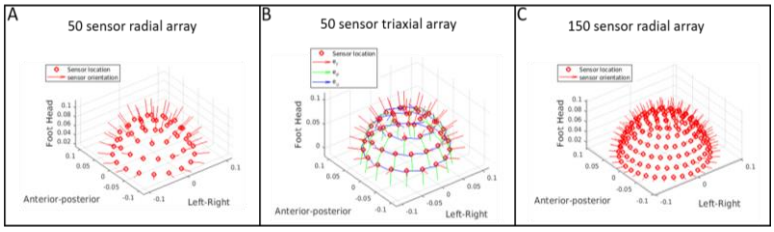
The optically pumped magnetometer (OPM) is a viable means to detect magnetic fields generated by brain activity, enabling a "wearable" MEG scanner platform, adaptable to fit any head size, able to acquire data whilst subjects move, and offering improved data quality at lower cost. Although many studies have shown the efficacy of OPM-MEG, one untapped advantage relates to improved sensor design; specifically, OPMs can be designed to measure magnetic field along multiple axes simultaneously.

Here, we conduct a theoretical analysis of how a triaxial OPM sensor might be exploited in MEG source localisation algorithms.

Three simulated systems

We simulated three different OPM-MEG systems:

- *A 50 channel system with radial sensors*
- *A 150 channel system with radial sensors*
- *A 50 sensor (150 channel) triaxial array*



Reduction of external interference

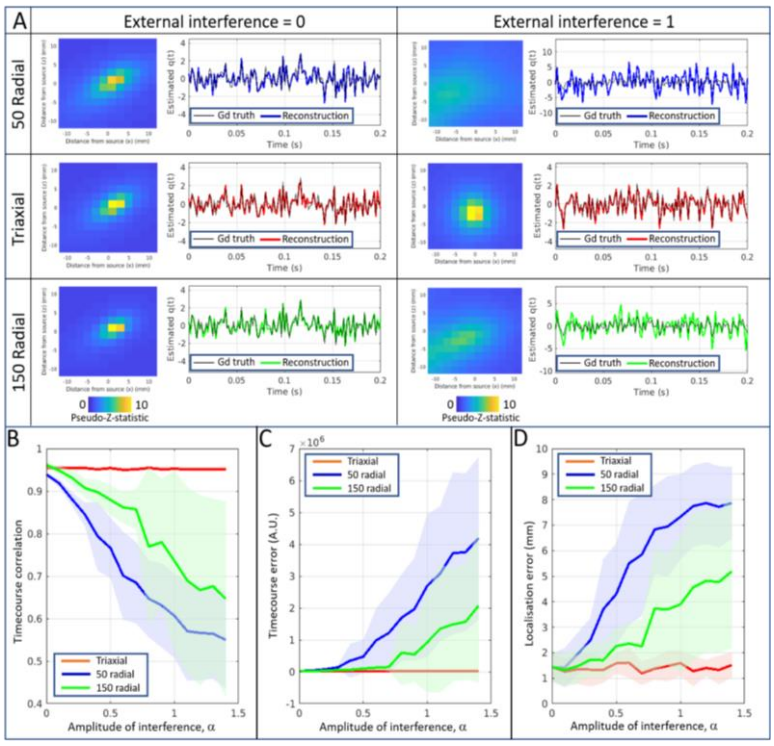
We simulated a brain source, and 80 interference sources with variable amplitude, and used a beamformer to reconstruct the brain source:

A) Beamformer images of a source of interest and line plots showing beamformer reconstructed timecourses (coloured lines) overlaid on the true source timecourses (black).

B) Correlation between the reconstructed and true source timecourse versus interference amplitude.

C) Error on the beamformer timecourse versus interference amplitude.

D) Localisation error versus interference amplitude.



Reduction of movement artifacts

We allowed the three systems to shift in space, simulating head movement. We used three background fields:

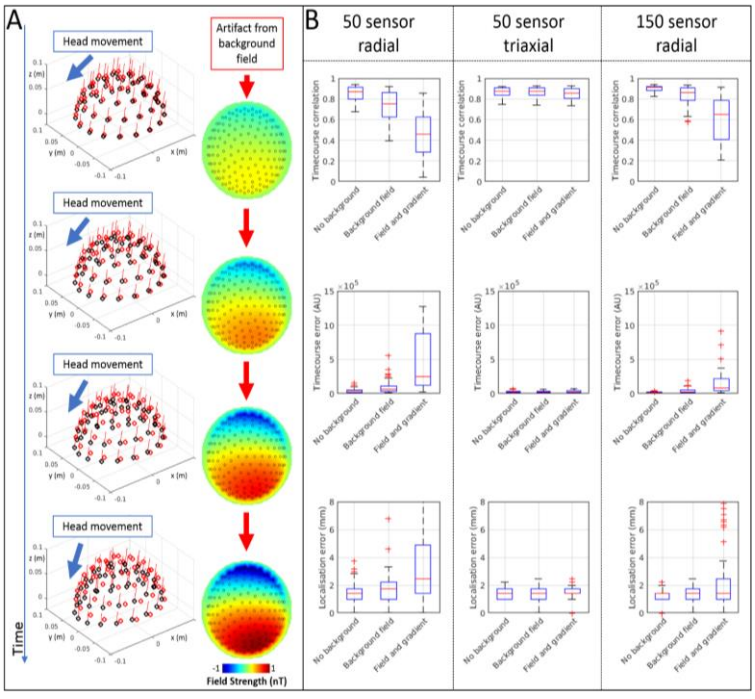
1) Zero field

2) A uniform field

3) A uniform field with a field gradient

A) The motion artefact. The red circles show the sensor locations at time zero. The black circles show the sensor locations at 4 consecutive time points. The red lines show the direction of the background field. Inset maps show the movent artefact.

B) Performance of 3 simulated systems in supressing motion artefact. Top, centre and bottom rows show timecourse correlation, timecourse error and localisation error respectively. Within each plot we show the performance metric for no background field, a uniform field, and a non-uniform field.



Conclusions

- A triaxial system enables more accurate source localisation, and better reconstruction of source timecourses, when MEG data is measured in the presence of interference.
- A triaxial array is more effective at removing artifacts due to head movement in a background field.

OPM-MEG will benefit markedly from the use of triaxial magnetic field sensors.

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