Towards open scanning environments for wearable MEG

Molly Rea[1], Niall Holmes[1], Ryan M. Hill[1], Elena Boto[1], James Leggett[1], Lucy J. Edwards[1], Natalie Rhodes[1], Vishal Shah[2], James Osborne[2], David Woolger[3], Eliot Dawson[3], T. Mark Fromhold[1], Paul Glover[1], P. Read Montague[4], Richard Bowtell[1]and Matthew J. Brookes[1].

[1]University of Nottingham, Nottingham, U.K., [2]QuSpin Inc., Louisville, Colorado, U.S.A., [3]Magnetic Shields Ltd., Kent, U.K., [4]Virginia Tech, Roanoke, Virginia, U.S.A.

As the building blocks of a MEG system, OPMs offer the potential for unrestricted participant movement. However, this potential can only be realised if background magnetic fields are well controlled.

Here we present a magnetic field mapping technique that uses a moving array of OPMs, worn in a rigid helmet, to determine the strength and spatial variation of the background field, which was described via a spherical harmonic model. An equal and opposing magnetic field was then applied via an array of bi-planar, electromagnetic coils [1]. The remnant magnetic field at the centre of the coils was reduced from 1.3 ± 0.3 nT to 0.27 ± 0.09 nT (Fig. 1A), giving a 5-fold reduction in 0—2 Hz interference.

A limitation of this approach was that magnetic field nulling could only be achieved over a fixed volume at the centre of the coil planes due to the coil design, thus restricting scanning to within that central volume. To overcome this, we developed an adaptable, 'matrix coil' active magnetic shielding system [2]. The matrix coil is formed from a series of 48 square unit coils that can cancel the remnant magnetic field at any location within the region bounded by the coil units, since the currents applied to the individual coils can be reconfigured. Initial demonstrations of this matrix coil system enabled mapping of sensorimotor cortex activity in two interacting participants, who were scanned simultaneously whilst playing a 'bat and ball' game (Fig. 1B).

While the matrix coil system affords flexibility in the location of one or more nulled regions, our magnetic field modelling and control technique provides an ultra-low field environment for OPM-MEG studies. Future work will aim to combine these approaches to generate a reconfigurable nulled region with ultra-low remnant magnetic field.

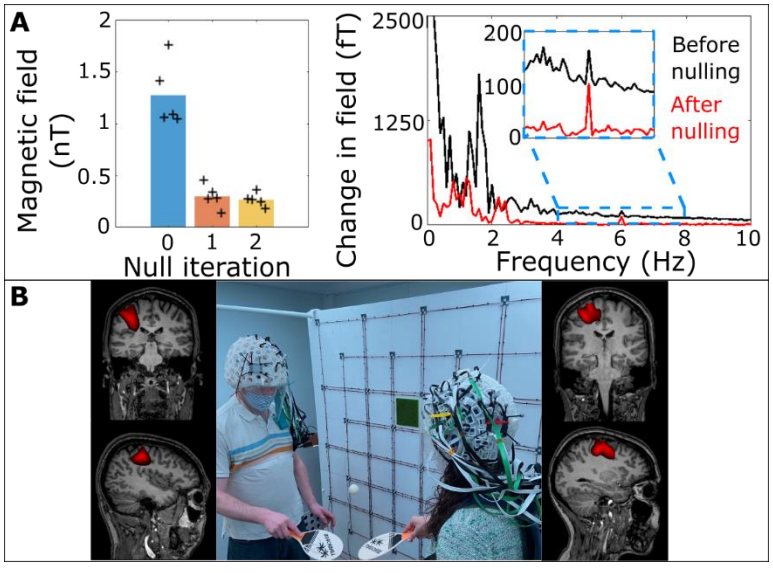

Figure 1: A) *Left:* The norm of the remnant magnetic field is given by the bar chart – before nulling is shown in blue, after one null in orange and after two nulls in yellow. The mean value over 5 repeats is given by the bars, the data by the crosses (+). *Right:* FFT of data from a single sensor during a visual steady-state evoked response experiment with 6 Hz stimulation. SNR of 6 Hz peak is increased while low-frequency artefact was decreased by nulling (red). B) The matrix coil system enables two participants to be scanned while playing a ball game. Images show activity in the left motor regions of both participants.

[1] M. Rea *et al.,* NeuroImage, **241** (2021) [2] Holmes et al., In Submission (2021)