Multi-channel OPM MEG during a visuo-motor task: induced responses and source localisation

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The excellent sensitivity and recent commercialisation (QuSpin Inc.) of optically-pumped magnetometers (OPMs) has inspired an interest in developing the next generation of Magnetoencephalography (MEG) systems. OPM-MEG would allow for a more flexible, user-friendly, less restrictive and non-cryogenic brain imaging tool as well as potentially higher signal-to-noise ratio (SNR) recordings.

Our previous work [1] focused on comparing the performance of a single OPM sensor against a state-of-the art SQUID-based system through repeating measurements. Here, a multi-channel array comprising 8 OPMs mounted in a 3D-printed, head-shaped scanner-cast [1] was used to perform OPM-MEG measurements.

A single subject performed a visuo-motor task: 45 trials of left index finger abduction during the presentation of a vertical grating shown for 2s, followed by a 8s fixation period. The experiment was performed three times: once in the CTF system (SQUID) and twice with the OPMs (once with the scanner-cast fixed relative to the room (OPM-restricted) and once where the subject was seated, but able to freely move their head (OPM-free-moving)). We used a time-frequency analysis of the radial magnetic field to evaluate the oscillatory (induced) response in sensor space in each experiment. We used a scalar beamformer (Synthetic Aperture Magnetometry – SAM [2]) to localise the neural networks responsible for beta frequency (13-30 Hz) power changes (decrease and post-movement rebound).

Panel A in Figure 1 shows the sensor-space induced response in the beta band, averaged across trials, for the three experiments. Only the channel which showed the largest response is shown for each experiment. As expected [3], we observe a decrease in amplitude during finger movement (0-2 s window) and a post-stimulus increase in amplitude (rebound) on movement cessation. Panel B shows the beamformer-reconstructed beta band time courses at the selected locations within the sensorimotor cortex. Note that locations selected include the peak decrease in power, the peak rebound, and a location with little task induced response.

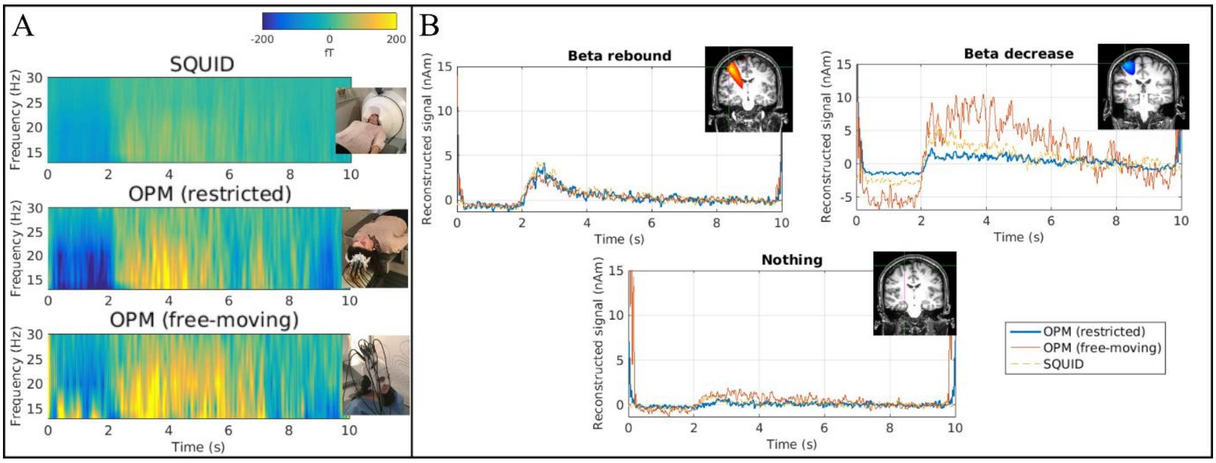

Fig. 1 A) Time-frequency spectra of the three experiments showing the expected decrease in beta power during finger abduction (0-2 s window) and the post-stimulus rebound. B) Beamformer-reconstructed time series at the peak locations of beta rebound and decrease, and also at a location displaying no brain activation.

We have shown the ability to beamform sources to the motor cortex using a multi-channel OPM array, even when the subject's head was unconstrained. Performance could be improved by nulling the ambient static (Earth's) magnetic field, which would potentially allow larger subject movements. OPM-MEG not only offers the advantage of bringing sensors closer to the brain, it also becomes a wearable device. This opens up a wealth of new paradigms and subject groups to investigate; potentially changing the scope of neuroscience experiments possible with MEG.

References

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