The frequency response of an OPM: A steady-state visual evoked response MEG study

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Conventional magnetoencephalography (MEG), based on cryogenically cooled superconducting quantum interference devices (SQUIDs), is one size fits all, and so lacks sensitivity, particularly in younger subjects whose heads are small compared to the (adult optimised) helmet. Optically pumped magnetometers (OPMs), on the other hand, operate without cryogenics; they can flexibly be placed on the scalp, conforming to all head sizes [1] and systems can be made motion robust, allowing participant movement. This makes OPM-MEG an attractive technique for scanning infants, and patient populations. However, OPMs also exhibit lower sensitivity to low frequency signals compared to SQUIDs. During early infancy, neural oscillations are shifted towards lower frequencies [2], and likewise, in clinical populations, low frequency oscillations are a putative biomarker for disease. For OPMs to overtake SQUIDs as a method of choice for MEG, it is critical that their frequency response is evaluated.

Here, we used a visual stimulus, with frequency modulation, to evoke steady state neural responses at 2, 4, 6, 10, 15, 20 and 30 Hz. We hypothesized that, for each evoked frequency, we would be able to quantify the signal to noise ratio of the measured neural response. A single subject took part in the experiment. Data were acquired using a 37 channel OPM-MEG system, and equivalent data were captured using a cryogenic device. In both cases, SNR was quantified at the channel level. We found that the sensitivity of OPMs, even at low frequencies, was comparable to that of a SQUID system, demonstrating that OPMs should be sensitive to the important low frequency oscillations that have neurodevelopmental and clinical value.

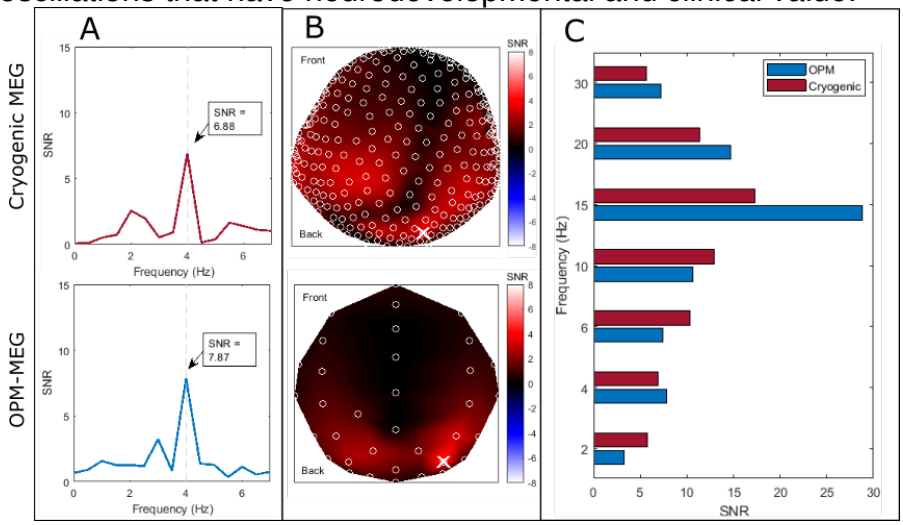

Figure 1: A) SNR of MEG signal Fourier components during 4Hz stimulation. B) Field topography of the 4Hz response. In both cases, the upper panel shows cryogenic MEG, and the lower panel shows OPM. The sensors used are denoted by the white cross. C) SNR at all frequencies studied. Note SNR's are approximately equal for the two systems used.

References

[1] R. Hill, et al., Nature Communications 10.1, 1-11 (2019)

[2] PJ. Marshall, et al., Clinical Neurophysiology 113.8, 1199-1208 (2002)