Towards precise mapping of digit representations in the human somatosensory cortex with high resolution magnetoencephalography

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Introduction. Optically pumped magnetometers (OPMs) have emerged as an alternative to SQUID-based MEG, as they can be more robust to motion artifacts, and can be brought very close to the scalp, thus offering increased sensitivity (Knappe et al., 2016). Previous work developing OPM arrays focused on whole-head arrays to replace traditional MEG systems (Boto et al., 2020; Hill et al., 2020). The current work focuses an OPM array that is spatially dense and optimized to resolve cortical activity in a small patch of cortex. Since the spatial and temporal resolution of our method approaches that of ECoG, we refer to as *magnetocorticography (MCoG)*. Simulation studies from our group suggest that spatially dense OPM arrays can outperform traditional whole-head SQUID-based MEG systems in the detection and localization accuracy of nearby neural sources (Nugent et al, 2022). In the present study, we aimed to assess the capabilities of our OPM array empirically. **Methods.** We measured somatosensory evoked fields (SEF) using pseudo-randomized application of air pulses to the right index, middle and ring fingertips. Six participants received 160 pulses to each finger over 4 runs, with a variable inter stimulus interval (mean= 2.5s, jitter ±500ms). The OPM array was placed and fixated over the left somatosensory cortex, and coregistered to subject-specific MRIs using BrainSight. Four of our six participants underwent a whole-head SQUID-MEG session with the same stimulation paradigm for comparison purposes. All MEG data were filtered to remove the effect of power mains and bandpass filtered (1Hz-95Hz) before epoching data (from -0.3 to1.7 s after stimulus onset). **Results.** SEFs recorded with OPM sensors were larger than SQUID sensors (mean peak 550fT vs 200fT across subject and digits). In addition, we carried out dipole fitting of the early component of the SEFs (30-60ms after stimulus onset). Bootstrapped resampling was used to quantify the accuracy of the estimated dipole sources (with n=1500 iterations). Median goodness-of-fit values ranged between 62.8% and 95.9% for OPM-MEG (72.1%-95.1% for SQUID-MEG), while median dipole amplitudes ranged between 19.2 and 56.2 nA-m for OPM-MEG (20.1-56.3 nA-m for SQUID-MEG) across participants and digits. Mean localization accuracy of dipole sources resulted in similar confidence radii (Jamali and Ross, 2012) across MEG modalities in the left somatosensory cortex (7.1 mm for OPM-MEG vs 5.9 mm for SQUID-MEG, measured across subject and digits) and mean percent overlap between digits (67% overlap for OPM-MEG vs 45% overlap for SQUID-MEG); see Figure 1 for estimated dipole locations and overlap across digits and MEG modalities in one participant. **Conclusion.** Our results show promising localization capabilities of our OPM-MEG array. Future analyses will assess the effect of artifact reduction techniques such as ICA on dipole fitting routines for OPM sensors, together with assessing the agreement between LCMV beamformed images and dipole fits.

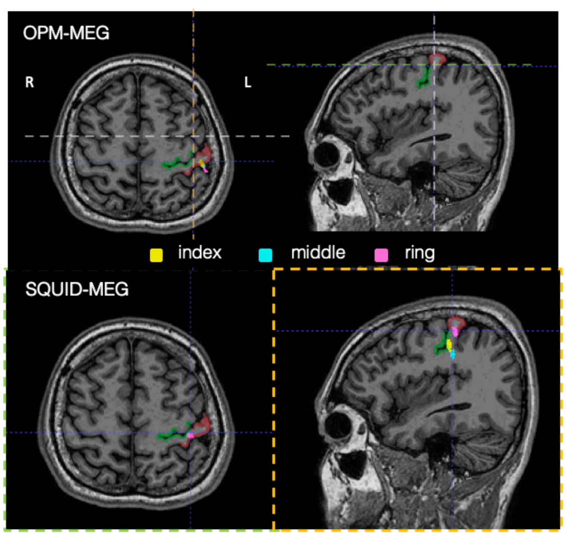

Figure 1. Example of bootstrapped dipole fit locations for each digit and both MEG modalities (single participant).