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Fingermapping in Sensorimotor Cortex with ECoG

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Introduction: Although a somatotopic organization between limbs have been suggested in sensorimotor cortex for a long time, a somatotopy in M1 (primary motor cortex) for individual finger movements is still under debate [1]. That's mainly because of overlapping activations in M1 for different finger movements, which make it difficult to uncover any possible somatotopy [1, 2]. However, in a recent fMRI study from our lab, Schellekens et al. [1] showed that Gaussian population Receptive Field (pRF) models [3] can be applied to the sensorimotor cortex to reveal the somatotopy in finger representations. In this study, we repeated the same experiment with ECoG to explore whether pRF model reveals any somatotopy in that region with direct brain recordings as well, which is very crucial for further BCI applications with finer capabilities.

Material, Methods and Results: We analyzed data from 8 subjects implanted with high-density ECoG electrode grids for epilepsy monitoring. We executed the same task in [1] and used dataglove to mark the finger movements. After electrode localization [4], the electrodes in the sensorimotor cortex from all subjects were projected to the same 2D cartesian surface [5]. We followed the similar procedure in [1] to fit pRF model on high-frequency band (HFB) power; however, we used another gaussian function to reflect temporal aspect of the ECoG data, instead of the hemodynamic response function for fMRI. Obtained somatotopic maps of the electrodes indicating pRF centers and y-coordinates of the electrodes on the common surface are shown in *Figure-1*. In the postcentral gyrus, a somatotopy was found as indicated with a positive slope in the regression line (Fig-1a, $p < 0.05$). In the precentral gyrus, the electrodes were more spread due to inter-subject differences in the electrode coverages. Therefore, the electrodes were split into 2 clusters, and somatotopy was found in both clusters (Fig-1b, $p < 0.05$).

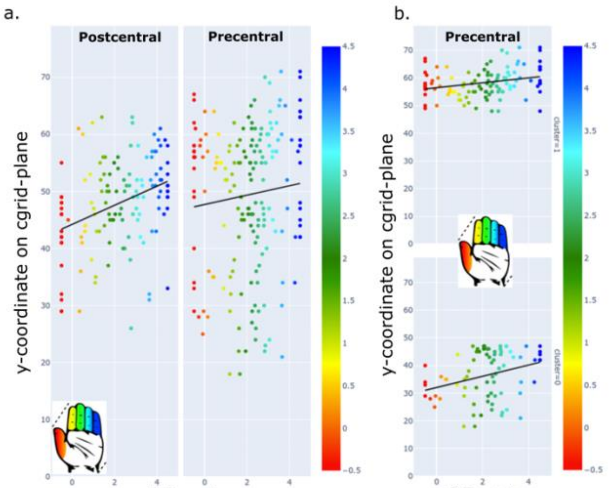

Figure 1. Somatotopic maps with linear regression. *Electrodes from all subjects whose HFB activity are predicted significantly during flexion movements of the fingers (corrected p-val < 0.05) are projected to a common cartesian grid [5]. In the scatter plots, each dot represents an electrode, and x and y axes indicate pRF center and y-coordinate on the cartesian grid of these electrodes, respectively. Colormap reflects the pRF center, as well as the tuning fingers.* ***a. Somatotopic maps in somatosensory cortex.*** *Electrodes in the the postcentral and precentral gyri are shown in the left and right plots, respectively. A regression analysis is performed to explore any positive relation between pRF center and y-coordinate of the electrodes.* ***b. Somatotopic maps in Precentral Clusters.*** *Electrodes in the precentral gyrus are divided into 2 clusters, and regression analysis is performed in each cluster separately.*

Significance: A previous fMRI study [1] from our lab found somatotopy in sensorimotor cortex using pRF method. Using direct brain recordings, our results also support these findings, and that is an important step towards a more reliable invasive BCI applications with finer capabilities.

References

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