Title: Small scale heterogeneity of high frequency LFP aids movement decoding

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Abstract text

Several types of neural signals have been used to decode movement. Inherent to each type is a set of advantages and drawbacks. Local field potentials (LFP), for example, exhibit high signal stability over time relative to single unit activity (SUA). However, this comes at the expense of high correlation on small spatial scales. In the present work, we show how high frequency LFP (HF-LFP) serves as a good middle-ground between SUA and LFP for movement decoding.

Based on our previous work, we hypothesized that much of the heterogeneity of activity on the level of single units might persist at the level of neural populations. Since HF-LFP has been shown to be correlated with population spiking dynamics, we surmised that it would be an ideal signal to test this hypothesis.

To this end, we analyzed neural recordings from two adult male rhesus macaque monkeys (*Macaca mulatta*) while performing a reach-to-grasp task. Neural data was recorded via four Utah arrays, implanted in the left/right ventral premotor cortices (PMv), the left/right dorsal premotor cortices (PMd), and the left primary motor cortex (M1). Spectral electrode amplitude and pairwise Pearson correlation were calculated from band-passed versions of the signal, effectively defining eight frequency bands, ranging from theta (4-7 Hz) to HF-LFP (200-500 Hz). We then used a machine learning classifier to determine decoding accuracy for various portions of the reach-to-grasp movement. The characterized behavioral states were: Baseline (rest), Pre-reach (motor preparation), Reach, Grasp, and Post-grasp (reward retrieval). Moreover, we defined three metrics of heterogeneity: effect variance (EV), effect coherence (EC) and Δn_PCA. EV is the within-region variance of the Baseline-normalized spectral amplitude. EC describes the proportion of electrodes exhibiting an increase in spectral amplitude relative to Baseline and is standardized such that 0 implies a 50/50 increase/decrease split and 1 indicates either a 100/0 or 0/100 increase/decrease split. Lastly, Δn_PCA describes the difference in the number of principal components (relative to Baseline) required to capture 95% variance of the within-region neural activity.

Our results indicate HF-LFP, even from a single electrode, can be leveraged to decode and characterize brain states ranging from motor preparation to execution. Multinomial logistic regression yielded high classification accuracies across several frequency bands with the HF-LFP band boasting near perfect

accuracy for the Grasp and Reach states. Furthermore, we show that heterogeneity (EV, EC, Δn_PCA) varies as a function of brain area, behavior, and frequency band. Lastly, multiple linear regression revealed that within-region heterogeneity of HF-LFP was associated with increased decoding strength.