BITS Pilani
K K Birla Goa Campus
Dept. of Computer Science and Information Systems

CS F433: COMPUTATIONAL NEUROSCIENCE

Local field potentials reflect cortical population dynamics in a region-specific and frequency-dependent manner

PRESENTERS

Shreyas V (CS + MSc Chem), Garvit Arora (CS + MSc Chem),
Shreyash Patel (CS + MSc Phy), Abhrajeet Mukherjee (CS + MSc Phy)

SUPERVISOR

Prof. Basabdatta Sen Bhattacharya

ABSTRACT

The spiking activity of populations of cortical neurons is well described by the dynamics of a small number of population-wide covariance patterns, termed 'latent dynamics'. These latent dynamics are largely driven by the same correlated synaptic currents across the circuit that determine the generation of local field potentials (LFPs). The paper explores the frequency-dependent relationship between latent dynamics and LFPs across different regions of primate sensorimotor cortex during reaching tasks

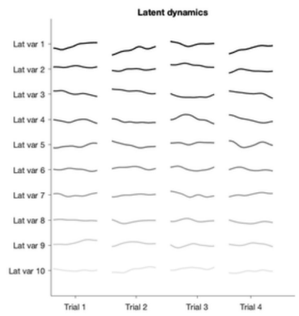
INTRODUCTION

- **Objective**: Investigate the relationship between local field potentials (LFPs) and latent dynamics, offering insights into neural population activity.
- **Significance**: Understanding this connection illuminates how shared circuit biophysics shape both LFPs and latent dynamics.
- **Hypotheses**:
  - Expect a robust association between LFPs and latent dynamics due to shared circuit biophysics.
  - Anticipate frequency-dependent differences in LFP bands reflecting behavior correlations.
  - Predict stable associations over short timescales, indicating consistency in circuit biophysics.
  - Hypothesize region-specific relationships due to differences in inputs, function, and cytoarchitecture across sensorimotor cortical areas.

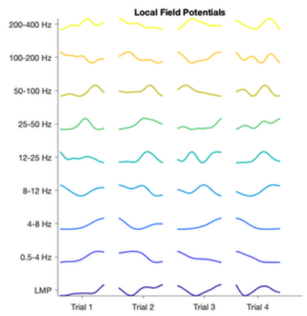
BEHAVIORAL TASK AND NEURAL RECORDINGS

- **Task**: Four monkeys (C, M, H, and L) were trained in a reaching task. They moved a cursor from a central to an outer target upon an auditory cue, receiving a liquid reward.
- **Implants**: Monkeys had one or two 96-channel microelectrode arrays. C and M had dual implants in arm regions, while H and L had single implants.
- **Recording**: Neural spiking and Local Field Potentials (LFP) were simultaneously recorded and manually sorted.
- **Analysis**: Firing rates of neurons were represented in a high-dimensional space. Principal Component Analysis (PCA) identified dominant population-wide patterns.

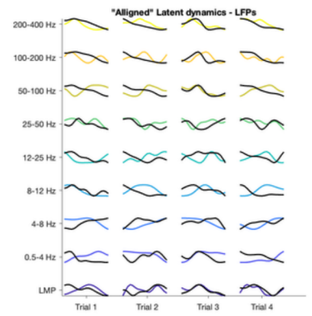
RESULTS



M1 latent dynamics during four reaches to different targets

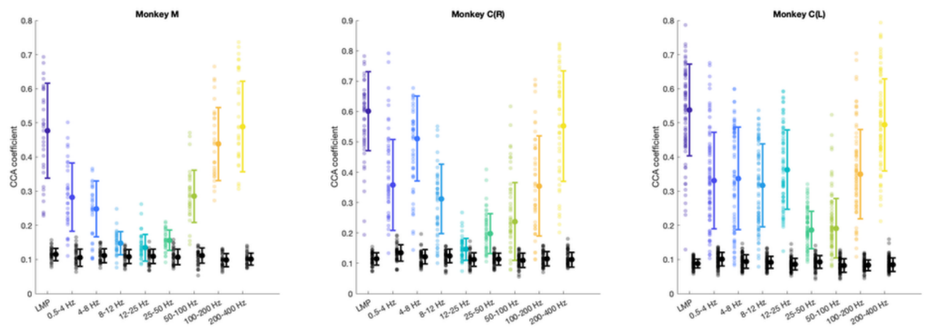


Example LFP power in each of the nine bands



Canonical correlation analysis (CCA) 'alignment'

CORRELATION between LFP & Latent Dynamics



For More graphs, please scan the QR code at the top right corner of the poster. Graphs along with their explanation are available under the results folder

METHADOLOGY

- **Fast Fourier Transform Analysis of LFP** - FFT analyzed LFP from conductance and membrane potential, using Scipy and Periodogram, validating similar results for frequency analysis.
- **Converting Spike Data to LFP** - Spike data was transformed into firing rates, squared to reduce variance, and smoothed with a Gaussian kernel, while LFP was constructed by averaging firing rates, assuming equidistant recording electrodes.
- **Cross-Correlation Analysis of LFPs** -Cross-correlation analysis quantified correlations between LFP from firing rates and LFPs from membrane potentials and conductances, adjusting dimensions and identifying maximum correlation at various time lags.

THE LFP-LATENT DYNAMICS CORRELATION PROFILES IN PRIMARY MOTOR CORTEX ARE FREQUENCY DEPENDENT

Frequency-Dependent Relationship: The correlation between LFPs and latent dynamics in the primary motor cortex varied with frequency. Strong correlations were observed in low and high frequency bands, while mid-range bands (8–50 Hz) showed negligible correlations. These frequency-dependent correlations remained consistent across sessions.

Predictive Power for Behavior: The correlation between LFPs and latent dynamics predicted the predictive ability of LFP bands for behavior. Using standard linear decoders, hand velocity was predicted from electrodes within each LFP band or from latent dynamics. Some LFP bands showed high predictive accuracy comparable to latent dynamics. Accurate decoders were correlated with similarity to latent dynamics, suggesting predictive patterns.

THE LFP-LATENT DYNAMICS CORRELATION PROFILES ARE STABLE BETWEEN MOVEMENT PLANNING AND EXECUTION

Stability Across Movement Phases:

- The correlation profiles between LFPs and latent dynamics remained stable between movement planning and execution phases.
- Repeating the CCA alignment procedure during the instructed delay epoch revealed virtually identical correlation profiles.

Inter-Trial Interval Analysis:

- During the inter-trial interval, when monkeys were not actively engaged in behavior, we repeated the alignment procedure.
- During this period, M1 exhibited decreased neuronal firing and correlation due to reduced engagement in movement generation.

THE LFP-LATENT DYNAMICS CORRELATION PROFILES CHANGE BETWEEN PRIMARY MOTOR AND PREMOTOR CORTICES

- **Cortical Variation:** Comparison between primary motor cortex (M1) and premotor cortex (PMd) reveals distinct correlation profiles between LFPs and latent dynamics.
- **Movement Planning Insight:** During movement planning, PMd exhibits a unique correlation pattern at 12–25 Hz, absent in M1 despite similar power spectra.

CONCLUSIONS

Therefore, the frequency-dependent relationship between LFPs and latent dynamics changes across cortical regions but, within a region, remains stable across different behavior-related processes those regions are involved in.

REFERENCES

Gallego-Carracedo, C., Perich, M. G., Chowdhury, R. H., Miller, L. E., & Gallego, J. Á. (2022). Local field potentials reflect cortical population dynamics in a region-specific and frequency-dependent manner. Elife, 11, e73155.

CONTACT

f20201350@goa.bits-pilani.ac.in, f20202113@goa.bits-pilani.ac.in, f20201157@goa.bits-pilani.ac.in, f20200872@goa.bits-pilani.ac.in