of 27% (22%) of the variance in reaching path length in Monkey K (S). This indicates that the degree to which monkeys can correct their reach before moving can be partly explained simply by how far motor cortical activity has progressed toward generating that movement before the target changes.

III-99. Dynamic range adaptation in motor cortical neurons

Robert Rasmussen[1] ROB@RGRASMUS.COM
Andrew Schwartz[1] ABS21@PITT.EDU
Steven Chase[2] SCHASE@CMU.EDU

[1]University of Pittsburgh
[2]Carnegie Mellon University

Neurons from various sensory regions have been shown to demonstrate gain control or dynamic range adaptation in response to changes in the statistical distribution of their input stimuli. Although a similar phenomenon has been observed in single neurons in primary motor cortex (M1) during an isometric force task (Hepp-Raymond, et. al. Exp Brain Res 1999 128:123-133), the mechanisms behind this dynamic range adaptation are not well understood. We designed an experiment to test whether populations of neurons in M1 reconfigure their activity to adapt to changes in the statistics of motor output. We trained two monkeys to control a computer cursor using a brain-computer interface (BCI) in both two- (2D) and three- (3D) dimensions. During each recording session, the subject performed blocks of trials under 2D and 3D control with the same neurons. These tasks were designed to share 8 identical targets in the xy-plane. We computed the dynamic range of individual neurons as the difference between the trial-averaged maximum and minimum firing rates to these 8 identical targets, and compared the dynamic range when the targets were presented in a 2D context or a 3D context. The majority of neurons in M1 exhibited an increased dynamic range to the targets presented in the 2D context relative to their dynamic range during 3D. To identify the mechanism behind this finding, we investigated whether these dynamic range increases were correlated across the population in a manner that might reflect changes in the intended movement. Instead, our data are better explained by individual, uncorrelated changes in dynamic range within single neurons. These contextual changes in tuning provide evidence that the activity of M1 neurons operates as a high-level control signal, encoding context-relevant information within a limited dynamic range.

III-100. Pushing in the wrong direction: optogenetic perturbation misaligns with motor cortical dynamics

Daniel O'Shea[1] DJOSHEA@STANFORD.EDU
Werapong Goo[1] WGOO@STANFORD.EDU
Paul Kalanithi[1] PKALANITHI@STANFORD.EDU
Ilka Diester[2] ILKA.DIESTER@ESI-FRANKFURT.DE
Karl Deisseroth[1] DEISSERO@STANFORD.EDU
Krishna Shenoy[1] SHENOY@STANFORD.EDU

[1]Stanford University
[2]Ernst Strungmann Institute

Several reports have recently demonstrated optogenetic modulation of behavior in primates; however, these behavioral effects are modest relative to electrical stimulation. We asked whether the contrast between strong neural modulation and weak behavioral modulation results from a misalignment between the optogenetic perturbation and the patterns of neural activity relevant to the behavioral task. Optogenetic excitation of dorsal premotor (PMd) cortex slows reaction times in an instructed-delay reaching task when delivered at the go cue, but leaves movement kinematics essentially unaltered. We report here that optogenetic stimulation of PMd and primary motor cortex (M1) delivered during movement similarly leaves unaltered reach kinematics. We recorded neuronal pop-

ulation responses to stimulation and found that many units displayed firing rates increased by 25-200 Hz out to 3 mm from the light source. The variance of these stimulation-induced changes in neural firing rates was 6.4-13.2 times the variance exhibited normally during non-stimulated trials. We applied PCA to non-stimulated firing rates to find a low-dimensional subspace explored by task-activity, consistent with previous reports. We found that the majority (83.1-91.6%) of stimulation-induced variance affected patterns of neural activity orthogonal to this task subspace, providing direct evidence that unexplored directions of neural activity may indeed be irrelevant to task performance. Furthermore, we used demixing PCA to demonstrate that the remaining stimulation variance primarily affects reach-condition independent modes of task-related activity. Consequently, only 4.4-6.2% of overall stimulation projects onto condition-dependent modes of task-related activity, which likely mitigates the behavioral impact. These results suggest that better aligning the vector of optogenetic perturbation with behaviorally-relevant axes of neural activity, e.g. via genetic and anatomical opsin targeting or spatial light patterning, could enhance behavioral modulation and more informatively probe the relationship between neural activity and behavior.