point along the speed-accuracy axis. Work is underway to obtain neuronal recordings in behaving rats in order to unravel the computations performed at the critical stages in the sensation-decision pathway.

III-97. Dynamic motor-related input to visual interneurons in Drosophila

Anmo Kim AKIM03@ROCKEFELLER.EDU
Gaby Maimon MAIMON@ROCKEFELLER.EDU
Rockefeller University

Active locomotion, like flight or walking, leads to an increase in the response gain of visual neurons in flies and mice. In addition to such long-term modulations in sensory processing, can motor actions influence visual processing on faster timescales in these model organisms, akin to how saccadic eye movements modulate primate vision every few hundred milliseconds? In this study, we describe a dynamic motor-related input to visual neurons in Drosophila. We glued flies to a custom platform and performed whole-cell patch clamp recordings during tethered flight from two specific classes of fourth-order visual neurons: horizontal system (HS) cells and vertical system (VS) cells. We found that in addition to their visual responses, HS cells show transient motor-related potentials during rapid left or right turns of the wings. These potentials were clear even in the absence of visual input, while flies viewed a blank screen and made spontaneous turns. The potentials appeared at the early phase of each wing turn event but did not persist during maintained turns. The amplitudes of the transient potentials were positively correlated with the magnitudes of the turns. The transient potentials were cell type specific — strongest in one HS cell, moderate in the other two, and very weak in VS neurons. We developed an algorithm to cull hundreds of individual rapid wing-turn events and motor-related potentials, and we measured their relative timing. Transient potentials were essentially synchronous with wing turns, but many individual potentials clearly initiated prior to detectable changes in wingbeat amplitude, suggesting an internal origin for the signal. In sum, we describe a cell-type-specific motor-related input to the fly visual system, which serves to modulate vision during rapid flight turns. This efference-copy-like signal in a genetic model organism provides an attractive platform to study the functions of dynamic motor signals in sensory processing.

III-98. Motor cortical activity predicts behavioral corrections following last-minute goal changes

Katherine Ames KCAMES@STANFORD.EDU
Krishna Shenoy SHENOY@STANFORD.EDU
Stanford University

Studies of motor preparation and execution often separate these processes using delayed reaches. However, moving in an unpredictable environment requires behavioral flexibility in order to respond to new information. The motor system is therefore presumably able to perform computations typically associated with motor preparation (such as target selection) even while executing a movement. To probe the the motor system's response to task goal changes, we had monkeys (K, S) perform a delayed-reaching task in which on 20% of trials the target changed locations after the go cue but before movement. Both monkeys exhibited a variety of reaches on switch trials: some were initiated toward the new target, while others traveled in the direction of the original target before diverting to the new target. The time between the target switch and movement onset was a strong predictor of whether the motor system would need to correct the reach online: the less time between the target switch and movement onset, the further the arm would travel in the wrong direction. We examined whether neural activity provides a signature of commitment to a given reach. We recorded neural activity in M1 and PMd. We generated a vector connecting the average preparatory activity and the average movement-onset activity for a given non-switch reach. The position of the neural state along this vector shows how close neural activity has come to initiating this reach. Projecting neural activity at the time of the target switch onto this vector explains an average

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-