Neural activity in primary motor cortex as a monkey performs a virtual balancing task

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It is now cliché for neuroscientists to talk of reaching for a cup of coffee. Likewise, many tasks studied in motor neuroscience focus on the simple act of reaching. However, once we pick up the coffee, the task becomes more complex, requiring continual adjustments driven by sensory feedback. We understand remarkably little about the motor control of this and other sensory-driven tasks we perform daily. This work attempts to shine more light on this aspect of neural control, examining primary motor cortical (M1) activity as monkeys performed a sensory-driven, one-dimensional virtual balancing task.

The balancing task starts with monkeys using their hand to control a cursor, moving it to the center of a screen in front of them. Once the trial starts, the cursor's motion becomes unstable: at each time step, the horizontal cursor velocity is proportional to the sum of horizontal hand and cursor positions, referenced to the center of the screen. Left alone, the cursor would fly towards the edge of the screen. Therefore, the monkey's task was to counteract this instability by moving his hand opposite to the cursor. To be rewarded, the monkey had to keep the cursor within 5 cm of the center for 6 s.

For comparison, we interleaved balancing trials with simple reach-to-target trials. As expected, behavior during balancing trials was far more nuanced than the reach trials–each balancing trial was unique, despite being confined to left-right movements. In the neural activity, we found that balancing had less variance and higher dimensionality than center-out reaching, perhaps corresponding to the fine, sensory-driven adjustments required to complete the task. Further, while the relationship between neural activity and arm movement was similar in the two tasks, we identified a neural signature corresponding to which of the two tasks the monkey was about to perform, suggesting a separate "neural preparation" prior to balancing.

As a field, motor neuroscience has focused on the neural activity behind relatively simple tasks. This balancing task offers a window into the neural activity underlying the generation of feedback-driven behaviors, offering a stepping stone towards understanding the complex tasks we perform in our daily lives.