Presentation Abstract

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Presentation Title:	Brain-machine interface performance is mediated by an internal model of decoder velocity gain
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Topic:	++D.18.d. Neuroprosthetics: Control of real and artificial arm, hand, other grasping devices

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Abstract: Imagine moving a computer cursor to select an icon. If you use your own laptop, then you know how fast the cursor will move in response to your trackpad input; this allows you to select the icon quickly and precisely. If you instead reach for an unfamiliar laptop with a higher cursor velocity gain, you will move the cursor too quickly and overshoot the icon. Conversely, if the velocity gain is less than you expect, you will move the cursor too slowly. This example illustrates the control theory-inspired view that the motor system learns an internal model to predict the resulting sensory consequences when a physical plant (e.g. the arm) is driven by its motor commands. There is considerable evidence of internal model use when the motor system moves the body, but the field is just beginning to ask whether similar computational strategies are used to control a brain-machine interface (BMI) (Golub et al., 2012). Whereas that study manipulated the mapping between neural activity and cursor movement direction, we instead changed the BMI's velocity gain and observed how a subject's performance depends on whether they are given the opportunity to learn this gain. Two macaques were implanted with 96-channel arrays in both primary motor and dorsal premotor cortex. They first performed a 2D point-to-point cursor task with their hand. We used these data to train a velocity Kalman filter that decoded multiunit spikes to move the cursor. We varied the decoder by scaling its output velocity by 0.5 ("slow"), 1 ("normal"), or 2 ("fast") while the monkey performed the task. During the blocked condition (BC) a given decoder gain was presented for prolonged use. During the interleaved condition (IC), one of the three gains was randomly chosen for each trial with no overt cue as to which gain was being used. We predicted that performance using each gain would be better during BC than IC trials in a manner akin to the example of using a familiar versus a frequently changing laptop cursor. We found performance differences between IC and BC trials indicative of the monkeys having a better internal model of the velocity gain during BC than IC BMI use. Times to target were 9% (12%) faster on BC compared to IC trials for monkey R (J) using the slow decoder, and 22% (17%) faster when using the fast decoder. Mean cursor speeds in the first 300 ms of fast decoder trials were 9% (11%) faster in IC than BC trials, leading to 74% (88%) further target overshoot distance. Conversely, the monkeys drove the slow decoder 9% (13%) slower in IC compared to BC trials. These results suggest that BMIs can be a platform for investigating internal model use in the motor system, and that adept BMI performance may be mediated by learning the properties of the BMI.

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