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Presentation Abstract

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Presentation Title: Increasing brain machine interface performance by online auto-delete based on motor cortical activity

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Abstract: Brain machine interfaces (BMIs) aim to provide greater independence for people with paralysis (e.g., communicating via cortical control of a computer cursor). Currently, a BMI user must correct on-screen keyboard typing errors, by subsequently selecting the “delete” key. Error detection based on neural activity alone could be used to automatically delete incorrect selections by decoding the user’s recognition of the error. To pursue this idea we asked (1) if motor cortical activity correlates with task outcome and, if so, (2) can we decode outcome on single-trials to increase BMI performance? We trained a rhesus macaque (J) to control a BMI cursor and acquire a color-tagged target in an 8×8 keyboard-like target grid. The monkey selected the correct target by holding the cursor over it for 250 ms. He received feedback of the task outcome (via auditory tone and a liquid reward on successful trials) 600 ms after target selection. We delayed this feedback in order to separate neural signals reflecting the monkey’s recognition of the task outcome from neural signals related to explicit task feedback. To address (1) above, we decoded the task outcome using a support vector machine to classify neural activity's principal components (PCs). Across four days (10,500 trials), his success rate was 80 ± 0.01% (mean ± SEM). When error detection was not used ("ED-off"), the monkey had to undo incorrect selections by selecting the "delete" target. When error detection was used ("ED-on"), detected errors were "auto-deleted." Thus, when incorrectly selected targets were detected as errors based on neural activity, the same target would be re-prompted (as opposed to the "delete" key), thereby circumventing manual deletion. We alternated ED-off and ED-on trial blocks. During ED-on blocks, we detected 93 ± 0.5% of incorrect selections with 3 ± 0.4% false detection, thereby addressing (2) above. Error detection increased the correct target selection rate by 16 ± 0.01%, approaching the ceiling imposed by initial selection success rate. In order to better understand the sources of neural activity that enabled us to distinguish between correct and incorrect selections, we examine the two leading PCs of the difference between the outcome-averaged selection-aligned neural activity. These two PCs capture 75% of the neural variance, with weights concentrated in PMd. The subspace of the two PCs reveals dynamical differences between the two conditions in different phases of the task: movement to target, target-holding and waiting for reward. These results show that a signal correlated with task outcomes is present in motor cortex and can be used to increase the performance of BMIs.

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Error detection

MOTOR CORTEX

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