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Closed Loop Decoding of Ipsilateral and Contralateral Proximal Movements in an Individual with Tetraplegia

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Introduction: It is widely acknowledged that the output of cortical areas involved in movement generation is mainly focused on the contralateral side of the body. Accordingly, with a few exceptions[1], most BCI research has focused on contralateral control of a single limb. However, numerous studies have shown that each hemisphere of the brain can drive movements of the ipsilateral limb independently[2]. Here, we study ipsilateral and contralateral control about a single proximal joint of a virtual anthropomorphic limb from unilaterally placed microelectrode arrays in an individual with tetraplegia.

Material, Methods and Results: We developed a virtual environment using the Unity software platform to enable control of ipsilateral and contralateral shoulder abduction of an anthropomorphic virtual avatar. Neural activity was recorded using two 96-channel microelectrode arrays placed in the left precentral gyrus of participant T11 in the BrainGate2 clinical trial (NCT00912041). T11 is a 40-year-old male with tetraplegia from a cervical spinal cord injury (C4 AIS-B). T11 completed a posture match task using shoulder abduction imagery to move the virtual arm to a discrete set of target angles presented on the screen. A 1D Kalman filter trained using rapid calibration enabled T11 to control both the ipsilateral and contralateral effector within seconds (without any previous open loop training data). T11 achieved a target accuracy of 86% within the ten second time limit for both the ipsilateral side and contralateral side. For analysis, we examined two types of features per electrode: multi-unit threshold-crossing spike rates and power in the spike band (250-5000 Hz). Using a Kruskal-Wallis test, 90 of the 384 features displayed significantly different values between upwards and downwards movements for both the ipsilateral and contralateral effector. Of those 90 features, 16 also showed significantly different activity between ipsilateral and contralateral movement, thus discriminating between both effectors and direction of movements.

Conclusion: This work demonstrates an early characterization of neural representation of ipsilateral and contralateral upper limb proximal joint kinematics.

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