 DOI: 10.3217/978-3-99161-050-2-109

Proprioceptive and Visual Feedback Effects on iBCI Decoding of Hand Grasps

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Introduction: Intracortical brain-computer interfaces (iBCIs) enable people with paralysis to control assistive devices by decoding motor signals directly from motor-related areas of the brain. Augmenting visual feedback with somatosensory feedback, such as through haptic interfaces [1] or intracortical microstimulation [2], has been shown to enhance iBCI performance for users who have also lost the ability to feel with their hands. Meanwhile, the integration of iBCI decoding with soft robotic wearables presents an opportunity to restore movement of one's own limbs while incorporating information from residual proprioceptive pathways available to some users, such as those with ALS. Although proprioceptive signals have been observed in human motor cortex recordings [3], it remains unclear how these inputs interact with concurrent motor attempt–related activity. Here, we investigated how visual and proprioceptive feedback provided by a soft robotic glove (SRG) modulate neural activity in motor cortex and affect grip decoding performance for iBCIs.

Material, Methods and Results: Experimental sessions were performed by two BrainGate participants: T17, a 34-year-old man with advanced ALS, and T11, a 40-year-old man with a spinal cord injury (C4 AIS-B). T17 had six 64-electrode arrays implanted in his left precentral gyrus (PCG), and T11 had two 96-electrode arrays implanted in his left PCG. A fabric-based, pneumatically actuated glove and control system were manufactured and programmed to provide 4 grip states: power grip, pinch grip, open hand, and relax. Using the SRG, we recorded neural responses while participants actively attempted or passively observed hand grips in the presence or absence of proprioceptive feedback (SRG on own hand vs. on mannequin) and in the presence or absence of visual feedback (SRG visible vs. behind a barrier). For T17, 59% of neurons selective for grip type during the motor intention only condition (no sensory feedback, "M") were also grip-selective during passive movement of the hand with the SRG (proprioception only, "P"). Only 5% of neurons selective during M trials were selective during the visual feedback only condition ("V"). For T11, of the neurons identified as grip-selective during M trials, none were selective during P trials, but 30% were selective during V trials. Although the presence of sensory feedback (visual or proprioceptive) did not significantly affect decoding of grip attempts in T11, sensory feedback provided moderate decode performance gains in T17 (Fig. 1).

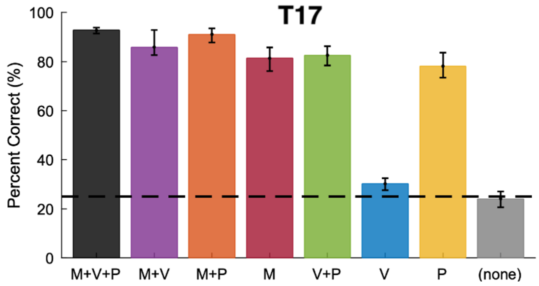

Figure 1: *Offline LDA grip classification performance on SRG grasps performed with concurrent motor attempts (M), visual feedback (V), proprioceptive feedback (P), and combinations.*

Conclusion: Our findings highlight the presence of sensory modulation in human PCG while confirming that iBCI decoding of attempted hand grasps remains robust when proprioceptive feedback is present and may further benefit from its inclusion. The results support the potential of soft robotics for the restoration of movement through iBCI decoding.

Acknowledgments and Disclosures: The authors would like to acknowledge T11, T17, and their care partners, as well as Beth Travers, Maryam Masood, and Dave Rosler. This work was supported by American Heart Association 19CSLOI34780000; NIH-NIDCD U01DC017844, NIH-NINDS U01NS123101; Department of Veterans Affairs Rehabilitation Research and Development Service A2295R, N2864C, and A4820R. The MGH Translational Research Center has a clinical research support agreement (CRSA) with Axoft, Neuralink, Neurobionics, Paradromics, Precision Neuro, Synchron, and Reach Neuro, for which LRH provides consultative input. LRH is a non-compensated member of the Board of Directors of a nonprofit assistive communication device technology foundation (Speak Your Mind Foundation). Mass General Brigham (MGB) is convening the Implantable Brain-Computer Interface Collaborative Community (iBCI-CC); charitable gift agreements to MGB, including those received to date from Paradromics, Synchron, Precision Neuro, Neuralink, and Blackrock Neurotech, support the iBCI-CC, for which LRH provides effort. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health, or the Department of Veterans Affairs or the United States Government. CAUTION: Investigational Device. Limited by Federal Law to Investigational Use.

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