Titolo: VR-BCI4PM: A virtual reality system controlled by a hybrid brain-computer interface to improve powered mobility in individuals with neuromotor disorders

Codice Progetto: 2022BCZ52A

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Abstract del Progetto: Individuals with spinal cord injuries (SCI), traumatic and acquired brain injuries (ABI), cerebral palsy (CP), multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS), spinal cord injury (SCI) may have limited mobility and often require power wheelchairs for conducting an independent life. Powered mobility is a viable option but requires strenuous training to guarantee safe driving conditions. Usually, wheelchair training is conducted with therapists at the hospital with considerable costs for the national health system. Also, 10-40% of people cannot use a power wheelchair due to sensory, motor, and neurocognitive impairments. These people are considered unable to safely drive and are forced to use manual wheelchairs or ask for caregivers' support. Driving skills and types of aid suitable for independent mobility are established based on the Powered Mobility Program (PMP). However, to date, no clinically validated tools support the user's training to fulfill the PMP. Virtual reality (VR) constitutes a portable solution to perform safe training at home. To date, no existing VR simulators have been developed to assess users' driving skills. Also, the existing VR simulators allow controlling movements with joysticks or hand trackers, but they are unusable for individuals with severe upper limb motor impairments. In this context, brain-computer interfaces (BCI) represent a potential candidate as an innovative control interface. Although previous studies have explored the development of multimodal approaches integrating joysticks, electromyography (EMG) and eye-tracking, there are no training systems based on hybrid BCI solutions that decode information from electroencephalography (EEG) and EMG and that involve a wider audience.

Herein, we will develop an innovative simulator based on a VR platform (the VR-BCI4PM) and we will longitudinally evaluate the improvement of wheelchair driving performance with 20 participants suffering from CP, ALS, MS, ABI, or SCI. A self-paced hybrid BCI will be developed for the VR joystick-free control. Through 10 driving sessions with VR-BCI4PM at home (if the participant is able to use the joystick) or in the clinic (if the BCI controller is required), we will evaluate the effectiveness of the simulator by comparing the pre-and post-training results using the PMP protocol as ground-truth. Furthermore, a calibration system for VR-BCI4PM will be developed to compare the VR metrics to real-world conditions during on-road wheelchair tests. Lastly, usability, level of satisfaction, stress due to mental workload, and motion sickness will be assessed via behavioral questionnaires and physiological signals. Not only will VR-BCI4PM improve the wheelchair driving skills of people with severe motor impairment but it will also establish objective measures to personalize the training, with the ultimate goal of improving the independence of individuals with motor disabilities and reducing the burden on the health system.

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