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Brain-Computer Interface Operation in Virtual Reality for Children with Complex Mobility Needs

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Introduction: Brain-Computer Interfaces (BCIs) are an interaction method that presents an abundance of opportunity for people with low or limited mobility which rely on power mobility devices (PMDs) such as power wheelchairs. Combining these technologies open the doors for independence of movement through BCI control of a power wheelchair. Testing such an apparatus in physical space presents many challenges and hazards, such as walls, ledges, and free standing physical obstacles. These challenges may be avoided by testing an analogous system in a virtual environment using immersive Virtual Reality (VR). By practicing in VR, skills develop that should allow for increased performance of an analogous physical system without the hazards that operating such an apparatus with no prior experience would provide [1], [2]. Additionally, the novelty and potential gamification of the system may increase the appeal to juvenile populations and resultantly improve performance on an analogous physical system. This work aims to establish a Virtual Reality Digital Twin of these systems to enable children with complex mobility needs to practice independent movement in comfortable and safe spaces.

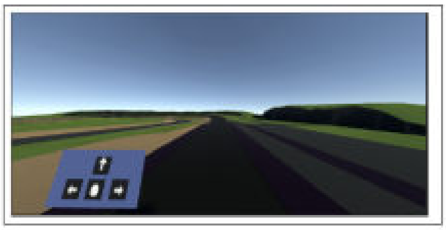

Figure 1: *Image of the preliminary setup in VR exemplifying how a user would interact with the system.*

Material, Methods and Results: An immersive simulation was designed in the Unity3D game engine in which users utilize a P300 paradigm to make selections to move throughout a simulated space (see Fig 1). This environment contains a road with multiple turns and straightaways for a user to engage with steering in more than one direction for varying durations.

Through testing of the system, it is expected that confidence in performance of both the individual and the physical system will increase, leading to increased independence of movement for juvenile populations in which this is lacking. Testing of the system involves a user donning both a DSI-7 (Wearable Sensing) dry-electrode BCI headset with 7 channels, placed underneath an immersive Meta Quest 2 VR headset. Participants are then instructed to attempt to complete one lap of the circuitous road in the simulation through P300 control. The time this takes for completion is recorded, along with the number of intended and unintended selections made by the user. After completing the single lap, participants are asked to complete a multi-question questionnaire to assess considerations about their mental workload, user experience, user interface, and overall satisfaction with the combined BCI+VR system.

Conclusion: This is ongoing work, and our early results are based on first prototypes tested with able bodied adults. This work enables operation of a power wheelchair through a BCI+VR system that can improve quality of life for many children. The potential to practice operating such a system safely in a virtual environment that mimics a real-world device, the Neuromove, is very promising; this eliminates many of the hazards present in the physical world and can make the application of relevant skills in the physical world much easier and more accessible, particularly for children.

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