Towards enhanced rehabilitation experience combining somatosensory cortex stimulation and immersive virtual reality

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***Abstract*— Despite recent technological advancements that have led to the development of dexterous artificial hands, advanced control methods, and haptic interfaces, these systems are rarely integrated into the body representation of subjects. Existing electrode systems can provide brain stimulation to achieve a more natural sensory-motor integration. However, current implanted neural devices are complex, invasive, and primarily used only for signal acquisition. The proposed work will explore how to enhance ownership of virtual artificial limbs through non-invasive stimulation of the somatosensory cortex.**

I. Introduction

Coordinated motor input combined with multisensory feedback (i.e. visual, audio, tactile) is crucial to the development of embodied artificial limbs. While several research groups investigate the use of invasive and non-invasive systems to restore feedback information at the peripheral level, less attention has been given to the central nervous system. In this regard, stimulation of the somatosensory cortex can provide a route to bypass an impaired peripheral nervous system, and generate ownership of artificial body parts [1]. In this work, we preliminarily assess the use of multi-sensory perceptual illusions using non-invasive central nervous system stimulation combined with immersive virtual reality. The long-term goal is to enhance embodiment and sensory-motor integration of artificial limbs through direct cortical stimulation with minimally invasive nanoelectrodes [2]. We hypothesize that the proposed methodology can reinforce the rehabilitation experience, yielding motor activation and plasticity between the somatosensory and motor cortices during the use of artificial limbs.

II. Methods

We designed a virtual reality environment using the games engine Unity3D (Unity Technologies Inc., USA) that combines manipulation tasks with cognitive task for training the use of a myoelectric prosthesis. Training consists of grasping a group of cubes, placed in a different shelf height, and release them on a table to form a colour predefined sequence. A Myo Armband (Thalmic Labs, USA) is used to acquire surface electromyography (sEMG) signals from the participant and train a multi-class linear discriminant analysis classifier. The user has proportional velocity control of the virtual hand closure and wrist flexion/extension We will conduct a study with at least 10 able-bodied subjects, where participants will train for 10 min. A more complex version of the training environment is developed and used for pre- and post-training assessment of the level of embodiment and function achieved. To assess the spatial selectivity and motor cortex activation during the use of myoelectric control systems, we will do a first experiment where brain activity is recorded via Electroencephalography (EEG). We will analyze brain patterns indicating ownership of the virtual artificial hand and active regions, which will be used to choose stimulation target areas later. A second experiment will be conducted by clinicians to include non-invasive transcranial magnetic stimulation (TMS) for somatosensory cortex stimulation in 6 healthy volunteers. Results from both experiments will be compared to evaluate the effect of the central nervous system stimulation in terms of embodiment and functional improvements.

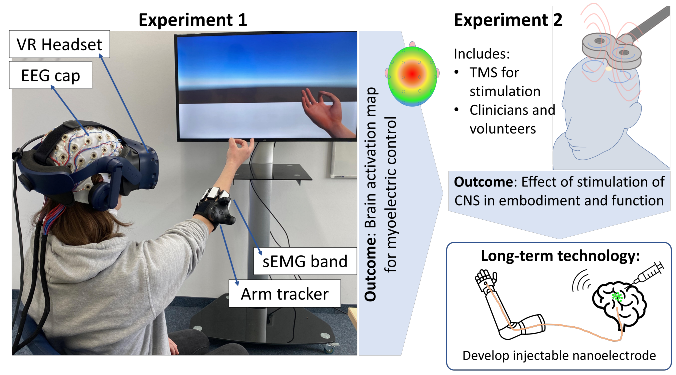

Fig. 1. Schematic overview of the planned experiments and outcomes.

III. Conclusions

This study will give important insights about somatosensory cortex stimulation for enhanced sensory-motor representation of virtual artificial limbs, and provide specific results to improve the design of injectable, wireless nanoelectrodes for future studies.

References

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