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Design and Evaluation of Vibrotactile Stimulus to Support a KMI-based Neurofeedback

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Introduction: We are developing a brain-computer interface integrating visual and vibrotactile feedback on the forearm and the hand in a gamified virtual environment to give situated and embodied information about the quality of stroke patients' kinesthetic motor imagery (KMI) of a grasping movement. Multimodal sensory stimuli are used to provide a sense of embodiment [1]. Particularly, adding vibrotactile feedback is expected to improve the performance of a motor imagery task in neurotypical [2], [3], and stroke participants [4].

Material, Methods, and Results: Three vibration motors are activated using triggers sent by an OpenViBE scenario via an Arduino Nano (Figure 1). They are synchronized with our existing BCI Grasp'it [5]. Our conception process consists of 3 stages: 1) designing the vibrotactile feedback by first establishing the minimum and maximum vibration intensities for three groups of participants based on their ages (18-39, 40-59, 60≤). Then, we compared a sequential vs. a simultaneous activation pattern using 2 vs. 3 motors. Participants seemed to accept either configuration as a support to the visual animation of a hand grasping a bottle. 2) Validating the BCI with a neurotypical population by comparing visual, vibrotactile, and bimodal (vibrotactile + visual) feedback conditions to identify the one preferred by users and that helps the most to perform KMI. Preliminary results indicate that 72% of participants preferred bimodal feedback and they considered performing better under this condition. For the last stage 3), we will evaluate the multimodal BCI in terms of performance, usability, and attractivity with post-stroke patients and therapists.

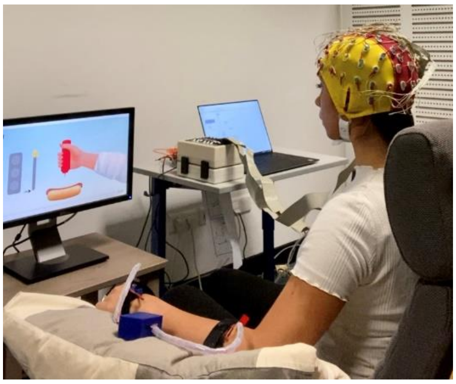

Figure 1. *Three vibrotactile motors are located on the hand and the forearm. Their activation rotation frequencies and duration are synchronized and analogous to the visual feedback corresponding to four different levels of a grasping movement.*

Discussion: The acceptance of both vibration activation patterns may be because they were congruent and synchronized with the visual stimulus. The vibration may help execute the KMI task by delivering skin stimulations above targeted muscles.

Significance: Vibrotactile feedback can help a large majority of BCI users to perform a KMI task by offering complementary information to the user and a better overall experience.

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