World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:10, No:06, 2016

The Effects of Adding Vibrotactile Feedback to Upper Limb Performance during Dual-Tasking and Response to Misleading Visual Feedback

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Abstract : Introduction: Sensory substitution is possible due to the capacity of our brain to adapt to information transmitted by a synthetic receptor via an alternative sensory system. Practical sensory substitution systems are being developed in order to increase the functionality of individuals with sensory loss, e.g. amputees. For upper limb prosthetic-users the loss of tactile feedback compels them to allocate visual attention to their prosthesis. The effect of adding vibrotactile feedback (VTF) to the applied force has been studied, however its effect on the allocation if visual attention during dual-tasking and the response during misleading visual feedback have not been studied. We hypothesized that VTF will improve the performance and reduce visual attention during dual-task assignments in healthy individuals using a robotic hand and improve the performance in a standardized functional test, despite the presence of misleading visual feedback. Methods: For the dual-task paradigm, twenty healthy subjects were instructed to toggle two keyboard arrow keys with the left hand to retain a moving virtual car on a road on a screen. During the game, instructions for various activities, e.g. mix the sugar in the glass with a spoon, appeared on the screen. The subject performed these tasks with a robotic hand, attached to the right hand. The robotic hand was controlled by the activity of the flexors and extensors of the right wrist, recorded using surface EMG electrodes. Pressure sensors were attached at the tips of the robotic hand and induced VTF using vibrotactile actuators attached to the right arm of the subject. An eye-tracking system tracked to visual attention of the subject during the trials. The trials were repeated twice, with and without the VTF. Additionally, the subjects performed the modified box and blocks, hidden from eyesight, in a motion laboratory. A virtual presentation of a misleading visual feedback was be presented on a screen so that twice during the trial, the virtual block fell while the physical block was still held by the subject. Results: This is an ongoing study, which current results are detailed below. We are continuing these trials with transradial myoelectric prosthesis-users. In the healthy group, the VTF did not reduce the visual attention or improve performance during dual-tasking for the tasks that were typed transfer-to-target, e.g. place the eraser on the shelf. An improvement was observed for other tasks. For example, the average±standard deviation of time to complete the sugar-mixing task was 13.7±17.2s and 19.3±9.1s with and without the VTF, respectively. Also, the number of gaze shifts from the screen to the hand during this task were 15.5±23.7 and 20.0±11.6, with and without the VTF, respectively. The response of the subjects to the misleading visual feedback did not differ between the two conditions, i.e. with and without VTF. Conclusions: Our interim results suggest that the performance of certain activities of daily living may be improved by VTF. The substitution of visual sensory input by tactile feedback might require a long training period so that brain plasticity can occur and allow adaptation to the new condition.

Keywords : prosthetics, rehabilitation, sensory substitution, upper limb amputation
Conference Title : ICBE 2016 : International Conference on Biomedical Engineering
Conference Location : Paris, France
Conference Dates : June 20-21, 2016