ABSTRACT

LEARNING TO USE VIBROTACTILE SENSORY AUGMENTATION TO CONTROL THE ARM; PRACTICE EFFECTS IN HEALTHY PEOPLE AND STROKE SURVIVORS

Valay A. Shah, B.S.
Marquette University, 2020

Stroke causes deficits of cognition, motor, and/or sensory functions leading to inability for survivors to perform activities of daily living (ADLs). Many research investigations have focused on mitigating the motor deficits of stroke through motor rehabilitation. However, somatosensory deficits are common and may contribute importantly to deficits in the control of functional arm movement. The research conducted in this dissertation advances the goal of promoting functional motor recovery after stroke by investigating the use of a vibrotactile feedback (VTF) body-machine interface (BMI) that is intended to improve kinesthetic feedback control of the contralesional arm by delivering augmented feedback to the ipsilesional arm where somatosensory feedback remains intact.

To develop and utilize a VTF BMI, we first investigated how vibrotactile stimuli delivered on the arm are perceived and discriminated. We determined that stimuli are better perceived sequentially than those delivered simultaneously. Such stimuli can propagate up to 8 cm from the delivery site, so future applications should consider adequate spacing between stimulation sites. We applied these findings to create a multi-channel VTF interface to guide the arm in goal-directed reaching in a 2D workspace. In healthy people, we found that short-term practice (~2.5 hrs) allows for small improvements in the accuracy and precision of reaching. Long-term practice (~10 hrs) is required to accrue motor learning and achieve improvements also in movement efficiency. During practice, participants adopted a movement strategy whereby they decomposed movements such that vibration changed first in one channel of the VTF interface and then the other. From this observation, we sought to develop a practice paradigm that might improve stroke survivors’ learning of VTF-guided reaching. We investigated the effects of short-term practice methods (whole practice vs part practice) in stroke survivors’ capability to make VTF-guided arm movements. Stroke survivors were able to improve VTF-guided reaching performance regardless of the method of practice. In conclusion, VTF BMIs can be used by stroke survivors and healthy people to improve kinematic performance of 2D reaching after practice. Future studies should investigate long-term practice in stroke survivors and their capability to use VTF BMIs to improve performance of unconstrained actions, including ADLs.