

Enriched sensorimotor feedback modalities may increase upper extremity motor recovery in stroke survivors using brain-computer interface-mediated functional electrical stimulation

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Introduction: Brain-computer interface (BCI)-mediated functional electrical stimulation (FES) of the stroke impaired upper extremity is thought to improve motor capacity through neuroplasticity. Of the various device designs, BCI interventions utilizing paired FES of the stroke impaired extremity typically result in superior increases in mobility compared to other BCI designs. However, it is not known whether BCI-FES devices are superior because they superficially link task-directed intent to move brain changes with peripheral muscle activation or, because the multimodal feedback inherent to BCI-FES designs allows a richer learning environment with more afferent sensory input to sensorimotor brain areas, which may result in better learning. The present preliminary analysis sought to determine if additional sensory feedback of BCI task performance, via electro-tactile stimulation in the form of a tongue display unit (TDU), results in greater motor recovery.

Material, Methods and Results: In order to test whether increased sensory feedback leads to greater motor recovery, we compared *post hoc* groupings from our larger study cohort where some individuals received BCI-FES and others received BCI-FES-TDU. Data were acquired from 25 stroke survivors ($n = 25$, 12 females, age = 64.0 ± 12.1 yr, mean \pm SD), who are part of a larger on-going study. A BCI-FES-TDU group ($n = 18$) and a BCI-FES group ($n = 7$) received up to 30 hours of BCI intervention. All participants were assessed at baseline and completion with behavioral measures which included the Action Research Arm Test (ARAT). Changes in group mean ARAT total score of the impaired upper extremity were calculated and compared using an independent samples t-test. The mean change in ARAT total score increased for participants who received BCI-FES-TDU intervention (difference = $+2.28 \pm 4.21$, mean \pm SD). In contrast, no such increase in total ARAT total score was observed for the BCI-FES group (difference = $+0.71 \pm 3.30$, mean \pm SD). The difference in mean change between the two groups, however, was not statistically significant ($t = 0.98$, $df = 14$, $p = 0.344$).

Discussion and Significance: For stroke survivors with upper extremity motor impairment, both BCI-FES-TDU intervention and BCI-FES intervention may be effective methods for motor recovery, and increased sensory feedback provided in the BCI-FES-TDU intervention may lead to additional recovery. However, more research into the neural mechanisms behind these measured differences is required.

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