INVESTIGATING HOW TRAINING CAN IMPROVE DEXTEROUS FINGER FORCE CONTROL

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Background

Many of our day-to-day activities require skillful use of individual fingers. However, it is naturally difficult to move just one finger (with the exception of the thumb) without moving other fingers you did not intend to move. This case is known as Finger Force Enslaving and is even worse for stroke patients with motor impairments.

This project seeks to design and evaluate the efficacy of short-term training to improve independent or dexterous finger force control.

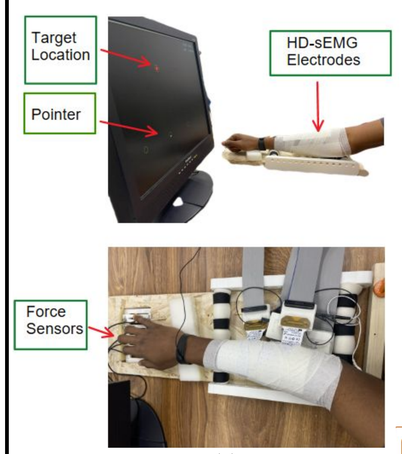
(a) (b) (c)

Figure 1: (a) & (b) Examples of dexterous finger movements (c) Impaired hand of stroke patient

Hypothesis

We hypothesize that short-term training can reduce finger force enslaving and the training effects can be retained at least a day after training.

Methods



(a)

(b)

$$\begin{bmatrix} P_z \\ P_x \end{bmatrix} = \begin{bmatrix} -0.8 & 1 & -0.8 & -0.8 \\ -g & 0 & g & 0.5g \end{bmatrix} \begin{bmatrix} F_I \\ F_M \\ F_R \\ F_L \end{bmatrix}$$

$$T_{out} < 2, g = g + 1; T_{out} < 1, g = g + 2$$
$$T_{out} > 2, g = g$$

P_z and P_x are the positions of pointer in the y- and x-directions while F_I, F_M, F_R and F_L are force contributions of the index, middle, ring and little fingers respectively. T_{out} is time spent outside the target during a trial while g is gain which signifies the level of difficulty of a trial.

(c)

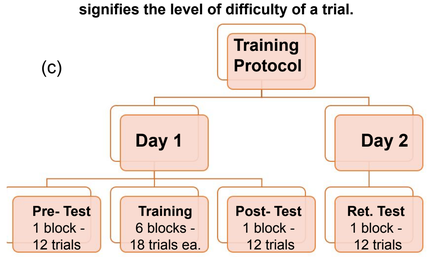


Figure 2: (a) Experiment Setup (b) Equations Used to Develop Training Protocol (c) Experiment Design

Results

Preliminary data was collected on four young healthy subjects after experimental design and pilot study. The middle finger was the training finger. Four 8x8 HD-sEMG electrodes (two on flexor muscles and two on extensor muscles) as shown in **Figure 2a** were used to collected muscle activity data during each trial.

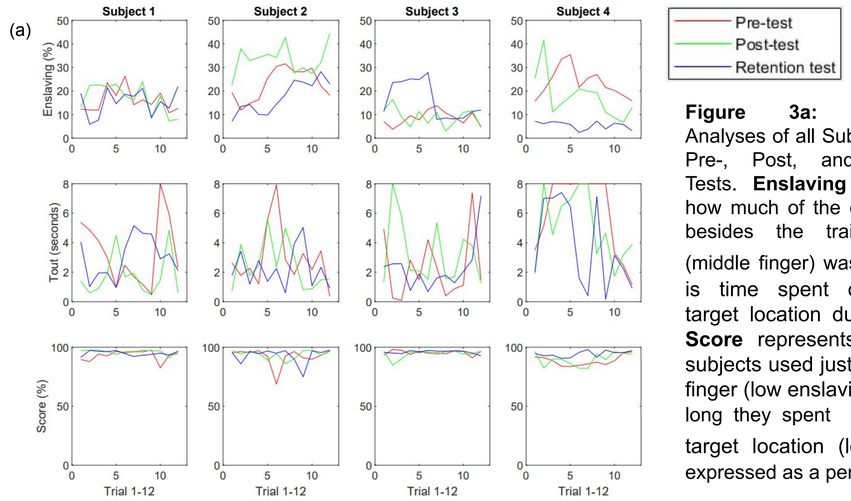


Figure 3a: Behavioral Analyses of all Subjects During Pre-, Post, and Retention Tests. **Enslaving** represents how much of the other fingers besides the training finger (middle finger) was used. **T_{out}** is time spent outside the target location during a trial. **Score** represents how well subjects used just the training finger (low enslaving) and how long they spent outside the target location (low T_{out}) expressed as a percentage.

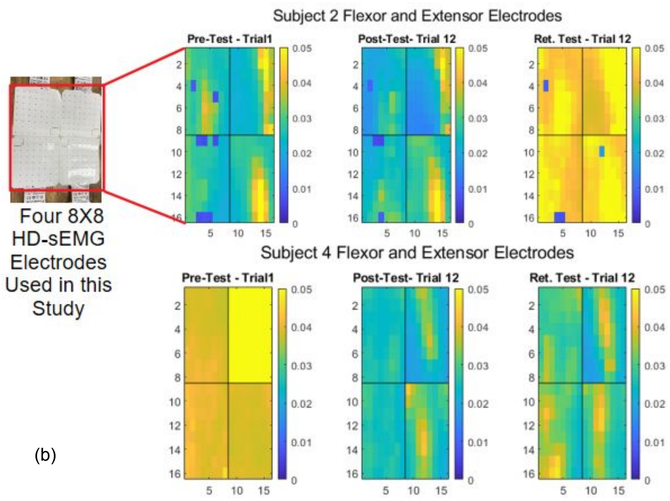


Figure 3b: Spatial Maps for Muscle Activity of Flexor Muscles and Extensor Muscles during Pre-, Post-, and Retention tests for Subject 2 and Subject 4. These maps represent how the muscles were used during each trial. The **blue** color represents less muscle activity while the **yellow** color represents more muscle activity. The **black lines** within each map divides the image into the four 8x8 electrodes used for the study.

Discussion

Results from the behavioral analyses of subjects during training shows that;

- All subjects had a different response to training
- All subjects except Subject 2 improved in independent use of trained finger by Post-Test.
- All subjects except Subject 3 retained the training effects at least a day after training.

Results from Spatial Maps for Muscle Activity of Flexor Muscles and Extensor Muscles shows that;

- Muscle activity was mostly spread across muscle during pre-tests, especially for Subject 4.
- Muscle activity areas shifts to focal points by Post-test indicating the effects of the training.

Further study is being conducted to draw main conclusions.

Future Directions

Collect data on more subjects → Perform further analysis with motor unit decomposition → Publish new results

Acknowledgement

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