Electromyography Guided Video Game Therapy for Stroke Survivors

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OBJECTIVE

- Develop an engaging, serious myoelectrical-based video game and an accessible two-channel electromyography (EMG) device for repetition-based rehabilitation to reduce abnormal coactivation post-stroke

BACKGROUND

- Stroke is a global epidemic, ranking as the third-leading cause of death and the second-leading cause of disability worldwide
  - Abnormal muscle coordination, characterized by the coactivation of muscles during movement, is a common motor impairment post-stroke
    - Such impairments can manifest as extensor carpi radialis (ECR) weakness, resulting in partial or complete loss of wrist extension

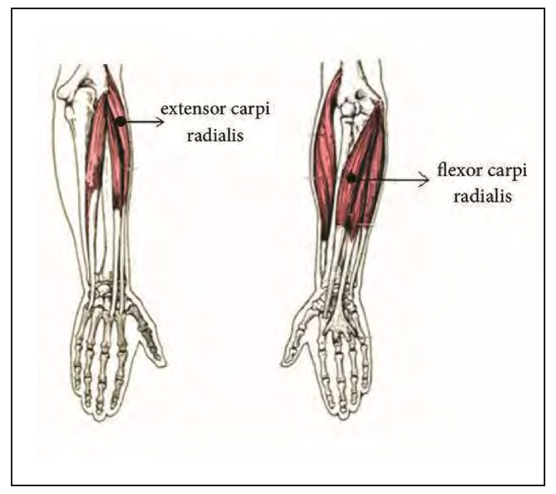

Figure 1. **ECR and flexor carpi radialis (FCR)**

- High doses of rehabilitation can lead to a greater likelihood of improvement in upper extremity function
  - Limitations to accessible and effective rehabilitation include cost, time, and the shortages of providers
    - Telerehabilitation and self-rehabilitation options have become favorable options
      - Serious gaming can improve telerehabilitation compliance through engagement
      - EMG signals can be used as a source of biofeedback to track muscle activation patterns and guide users in a telerehabilitation setting

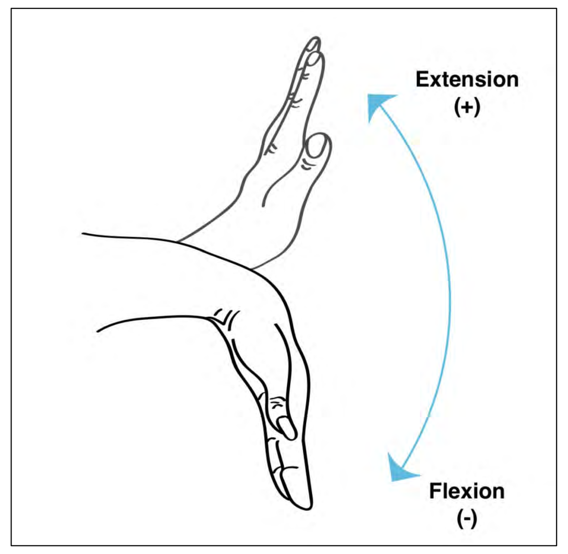

Figure 2. **Wrist flexion and extension**

ACKNOWLEDGEMENTS

Our group would like to recognize Dr. Roh for her support in the development of this project, and the guidance of Dr. Schultz and Dr. Chen.

METHODS & MATERIALS

- The EMG device was constructed using the Myoware ecosystem and a ELEGOO UNO R3 microcontroller. The Myoware muscle sensor can output the raw, rectified, or enveloped signal. The sensor has a built-in instrumentation amplifier and bandpass filter. Each muscle requires a Myoware muscle sensor and link shield, but only one Arduino shield and microcontroller is needed for both muscles. The link shield also acts as a power source for the muscle sensor; therefore, no external battery source is needed.

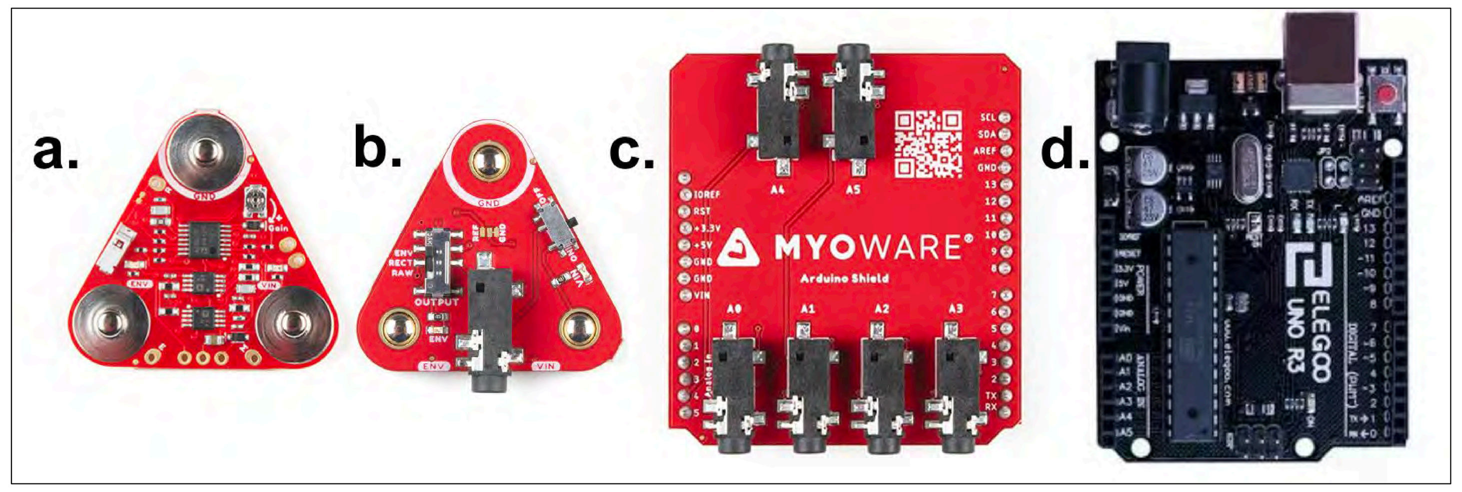

Figure 3. **Components utilized to build EMG device.** Signal is received from gel electrodes and read by the a.) Myoware muscle sensor 2.0 and then transferred to the b.) Myoware link shield. This shield enables the signal to be transferred to the c.) Myoware Arduino shield. This shield enables the signal to be transferred to the d.) ELEGOO UNO R3 which will allow for the conversion of the analog signal into a digital signal.

- An encasement for the device was modeled in Inventor and printed using an Ender-3 3D printer with black PLA.

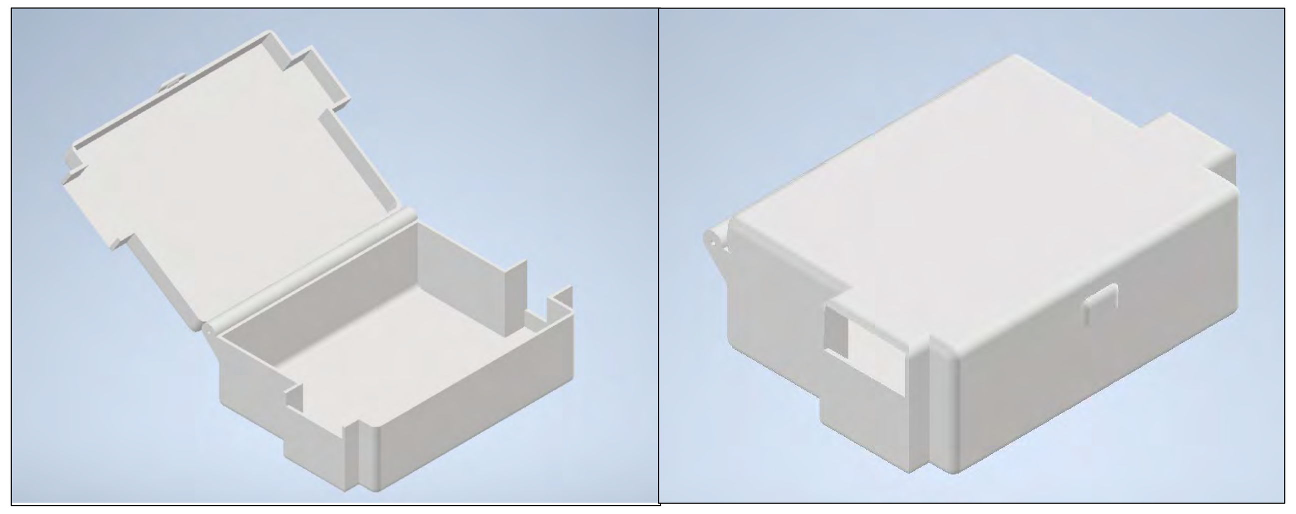

Figure 4. **Visual representation of modeled encasing in inventor.** The encasing should allow for two holes for appropriate wiring of the device and should have a hinge to allow for the opening and closing of the encasement.

- The video game was coded using Unity3D. This includes the entirety of the gameplay, objects, and software integration. Initially, the signal is received from the microcontroller and read into the system through the use of a serial port.

RESULTS

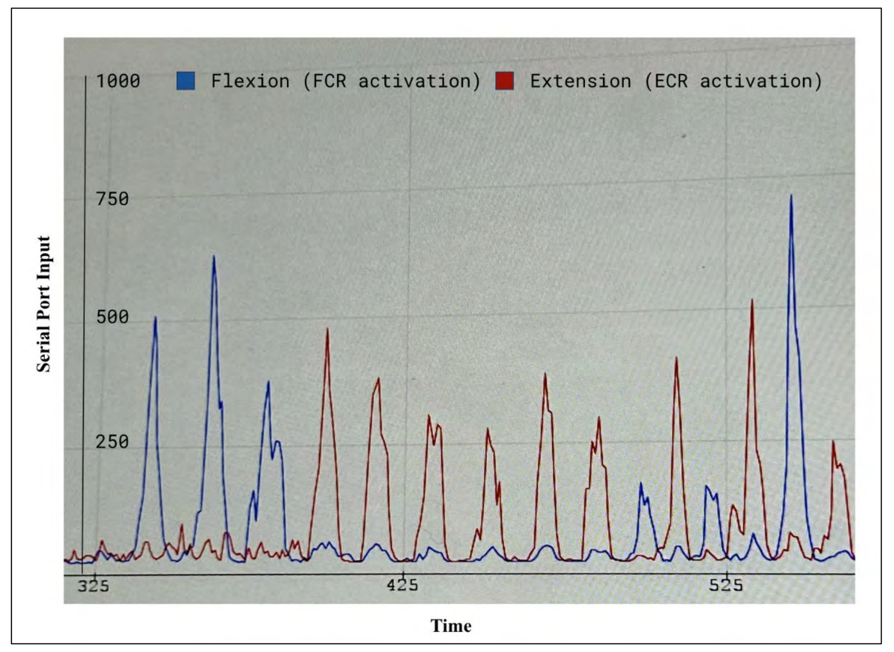

Figure 5. **Arduino Serial Plotter illustrating independent activation of ECR and FCR in healthy control.** The two-channel EMG device was able to collect myoelectric data and visually represent activation and inactivation of the muscles during wrist flexion and extension in a healthy control.

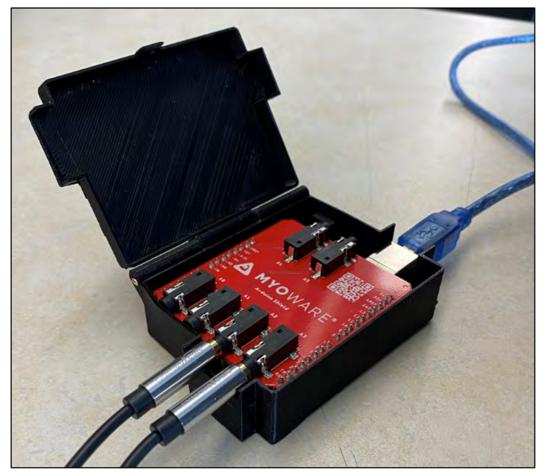

Figure 6. **Final version of the encasing.** The printed encasing is functional as it opens and closes and protects the device from physical damage. Additionally, it protects the user from potential abrasions due to sharp pins on the device.

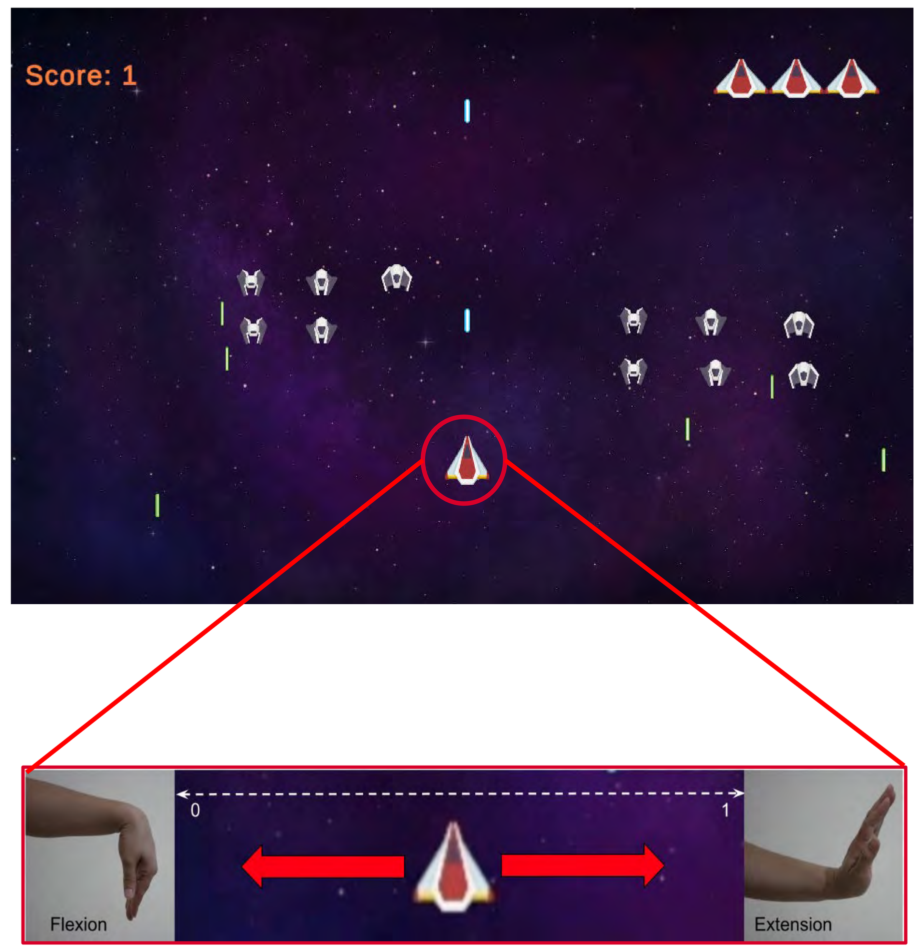

Figure 7. **Video game interface.** The game requires horizontal movement to shoot enemies. We utilized an extensor ratio (shown below), so that independent activation of the ECR through extension would move the ship to the right and independent activation of FCR would move the ship to the left.

$$ER = \frac{Extension}{Extension + Flexion}$$

CONCLUSION

- The two-channel EMG device was effectively able to convert the analog signals into digital signals which were in turn used to control horizontal motion within the video game
- The video game is fully functional and can be controlled with myoelectric input. Additionally, the game features various speeds and levels which can be utilized as the user's muscle coactivation improves.