Mental Workload and Performance Assessment During Upper Limb Prosthesis Training

UNIVERSITY OF MARYLAND HONORS COLLEGE

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Problem Statement

Our project aims to contribute to filling the gap within the research on the relationship between learning how to use prosthetics and the mental workload involved, improve the design of these types of devices, and expand the scope of this research area.

Research Questions

- How does mental workload and motor performance change over the course of motor learning?
- What are the underlying cognitive-motor mechanisms of motor learning observed during prosthesis training in able-bodied bypass body-powered vs. myoelectric users?

Hypotheses

- Performance will improve over training sessions as movements are refined through learning
- Movement quality will increase as motor coordination becomes more refined
- Alpha power will increase over training sessions, due to decrease in mental workload as the task becomes familiar participant (high-alpha (11-13 Hz) may change slower than low-alpha (8-10 Hz) since it reflects task specific processes)

Methodology

- Participants will be right-handed, able-bodied, have no injuries limiting movement, and within the ages of 18 and 60 years old
- Participants will be randomly assigned to one of two types of upper-limb bypass prosthesis
  - Body-powered bypass prosthesis (10 participants)
  - Myoelectric bypass prosthesis (10 participants)
- During each session participants will complete grasp and manipulation tasks (unilateral mAMULA tasks, Box and Blocks task, and the Southampton Hand Assessment Procedure (SHAP))
- Electroencephalography (EEG), kinematics, and performance data will be collected

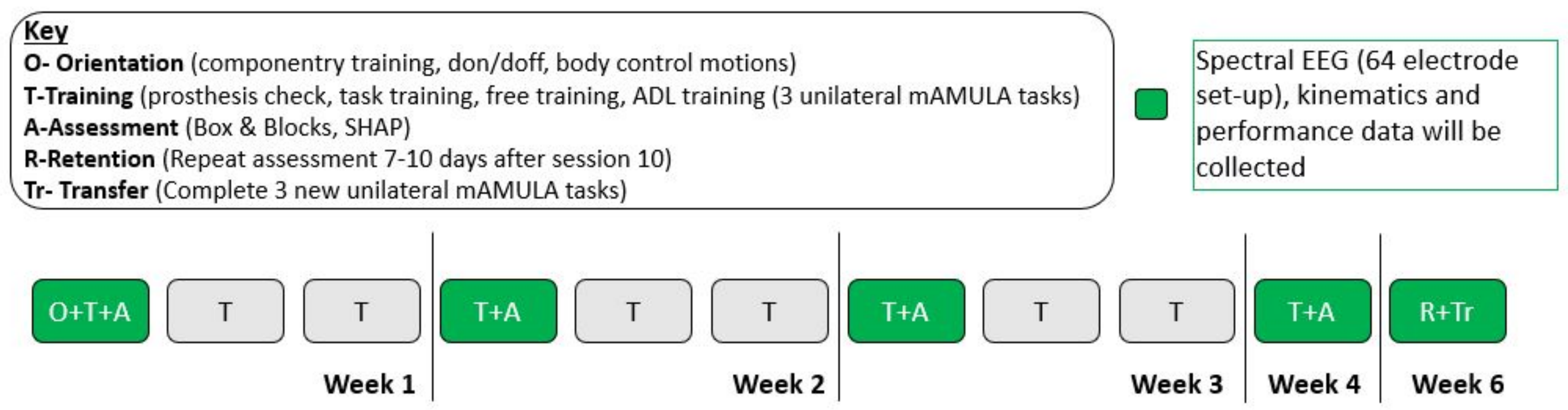

Figure 1. Training sessions. Session 1 (150 min.) will include training and orientation. Sessions 4, 7, and 10 (150 min.) will include training and assessment by the Box and Blocks Test and SHAP. Sessions 2, 3, 5, 6, 8, and 9 (45 min.) will include only training. Session 11 (110 min.) will include assessment of transfer and retention. Figure by Christopher Gaskins.

Figure 2. A) a body-powered prosthesis and B) a myoelectric bypass prosthesis. From " Application of machine learning to the identification of joint degrees of freedom involved in abnormal movement during upper limb prosthesis use," by Wang, S. L., Bloomer, C., Civillico, G., & Kontson, K., 2021

Potential Pitfalls

- Learning mechanisms studied in able-bodied individuals may not translate directly to amputee population
- Small sample size may limit statistical power
- Potential variability in protocol timeline may affect retention

Applications

- Prosthesis training for upper-limb amputees
- Assistive technology design
- Learning novel motor tasks

Goals and Future Directions

We aim to understand cognitive-motor processes underlying motor learning during bypass prosthesis training.

Areas for future research include studying the interplay of **other cognitive-psycho-motor processes** (e.g., self-efficacy) with those studied, and researching a similar protocol with **participants with upper-limb loss** to compare results.