

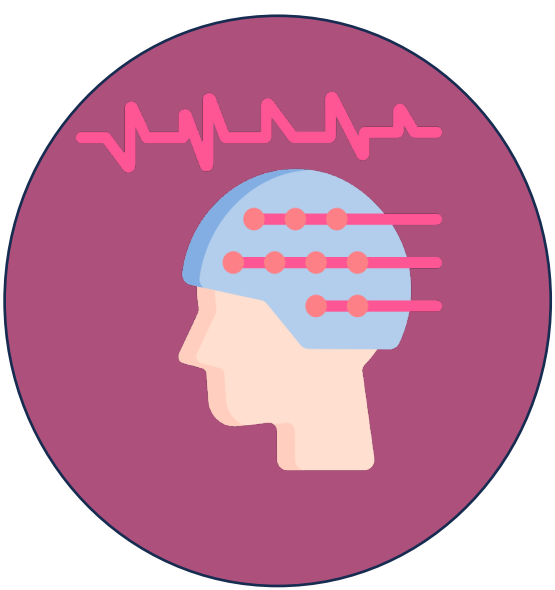
Towards Multimodal BCIs for Access: A Performance and Usability Comparison of Individual Modalities

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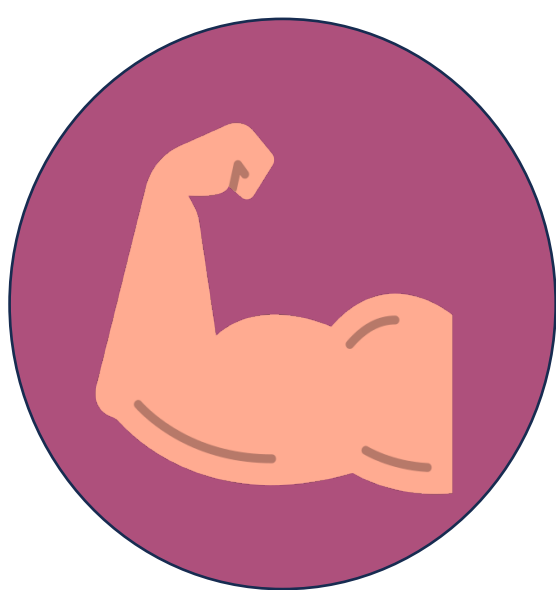
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Background

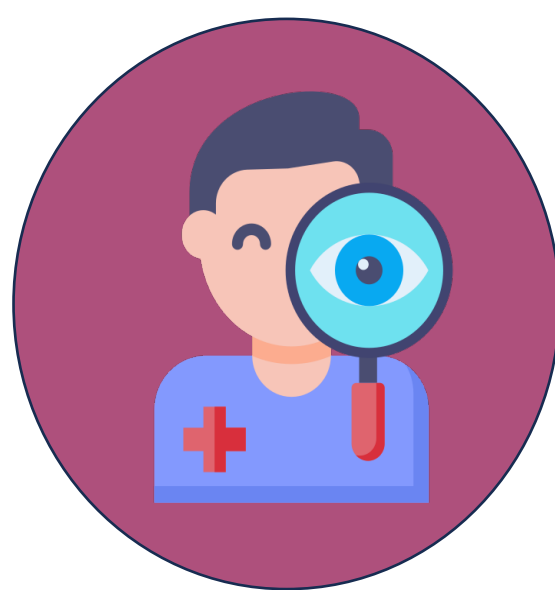
Cerebral Palsy is a group of conditions that affect movement and posture. There are varying levels of impairment, some requiring access technologies¹:



EEG



EMG



EOG

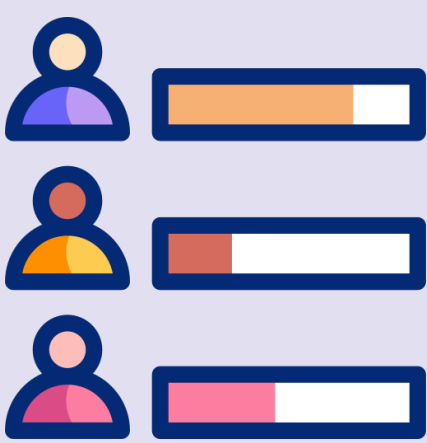
We want to develop a new hybrid brain computer interface that uses these signals from the body

Objective

To compare the usability of EOG, EMG, and EEG control modalities in adult and youth populations, measured by effectiveness, efficiency, and user satisfaction.

Methods & Analysis

1. Testing Sessions and Data Collection

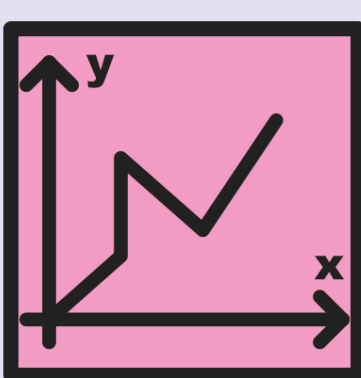


- Population:
- 16 adult (29.8 +/-5.3 years old) and 9 pediatric (10.8 +/- 3 years old) participants
- Neurotypical



- 2x video game testing sessions
- EMG, EOG, and EEG data collected from each participant.
- Usability questionnaire

2. Machine Learning and Statistical Analysis



- Usability questionnaire was compiled and compared across modalities using repeated measures ANOVA



- Machine Learning Pipeline
 - Offline Accuracy
 - Online Simulation Accuracy

Comparing the strengths and limitations of individual modalities shows the need for hybrid technologies to improve accessibility and communication for people with cerebral palsy.



Results

Questionnaire Analysis – User Satisfaction

[Peds] I would feel confident using this modality to control the system in my daily life.

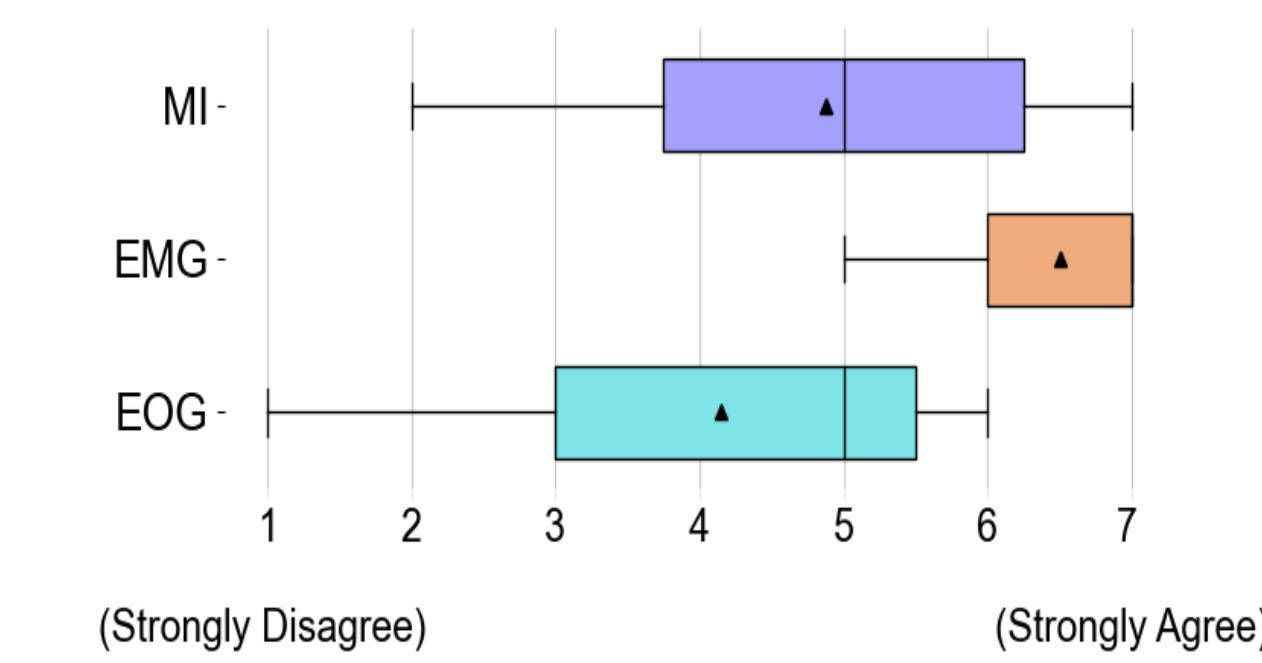


Figure 1. Confidence (Peds): Children had the most confidence with EMG, while MI and EOG resulted in the least ($F(2, 12) = 12.60, p = .001$).

[Adults] I would feel confident using this modality to control the system in my daily life.

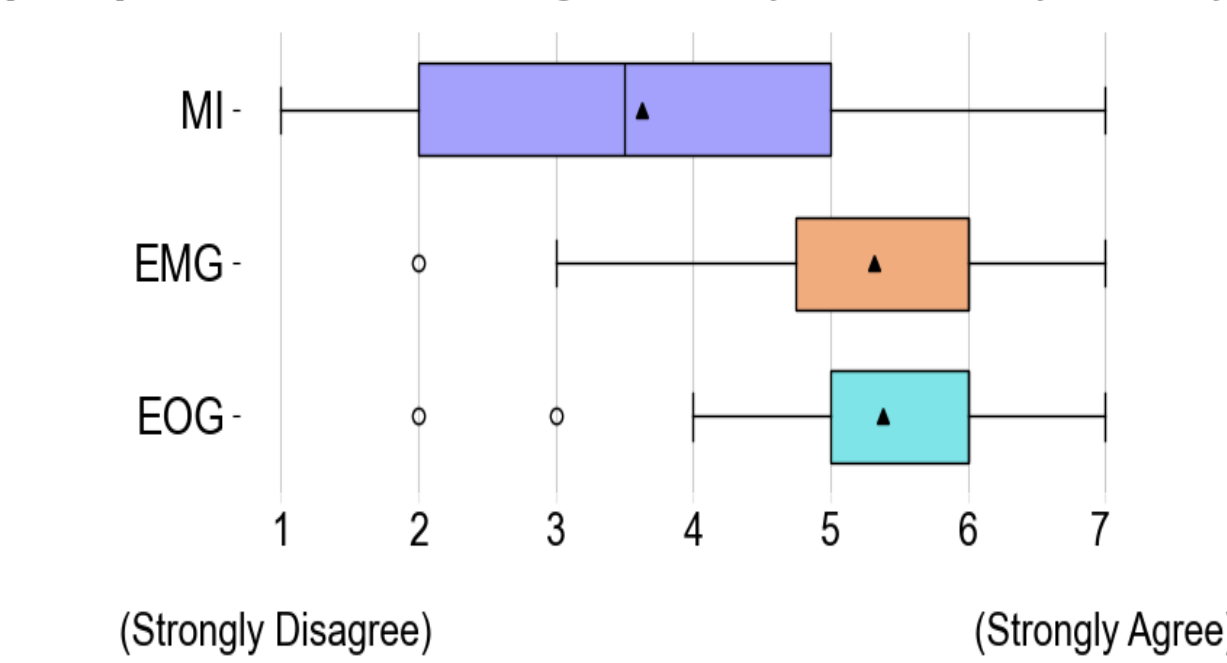


Figure 2. Confidence (Adults): Adults had high confidence with both EMG and EOG, while MI had lower confidence ($F(2, 30) = 5.16, p = .012$).

[Peds] How much effort did it take for you to control the system?

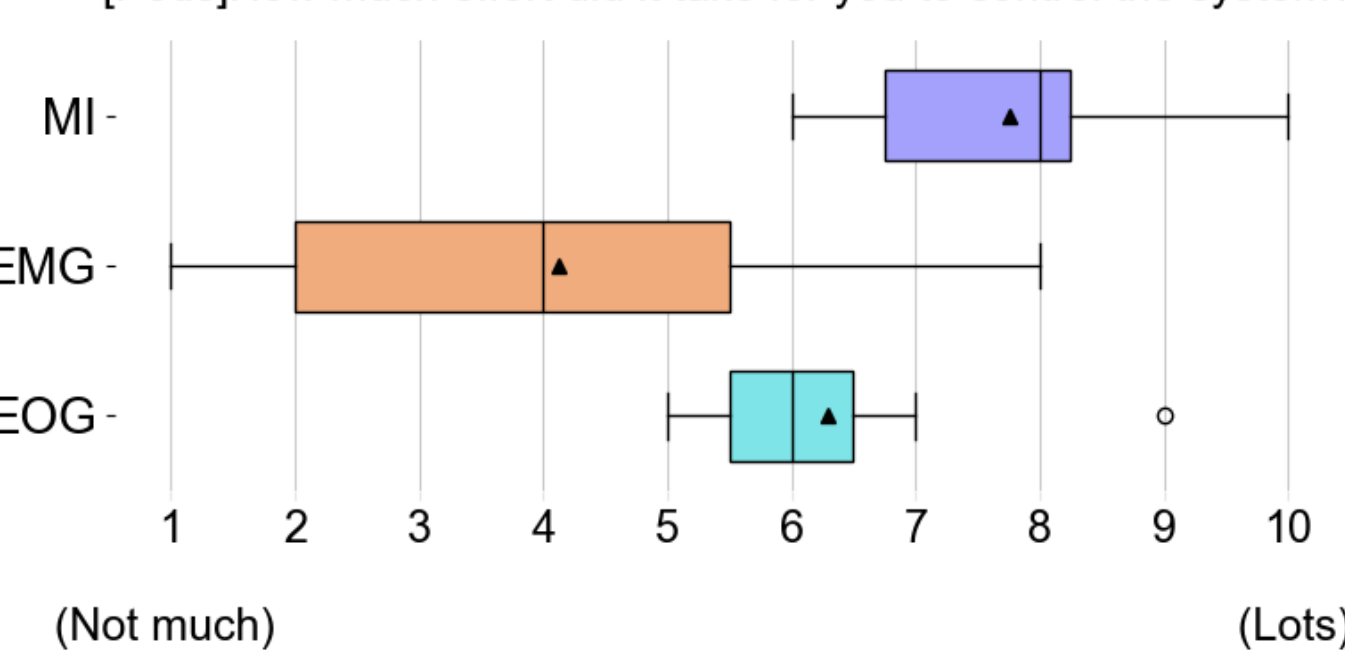


Figure 3. Effort (Peds): Children felt MI and EOG required the most effort, whereas EMG required less effort ($F(2, 12) = 5.36, p = .022$).

[Adults] How much effort did it take for you to control the system?

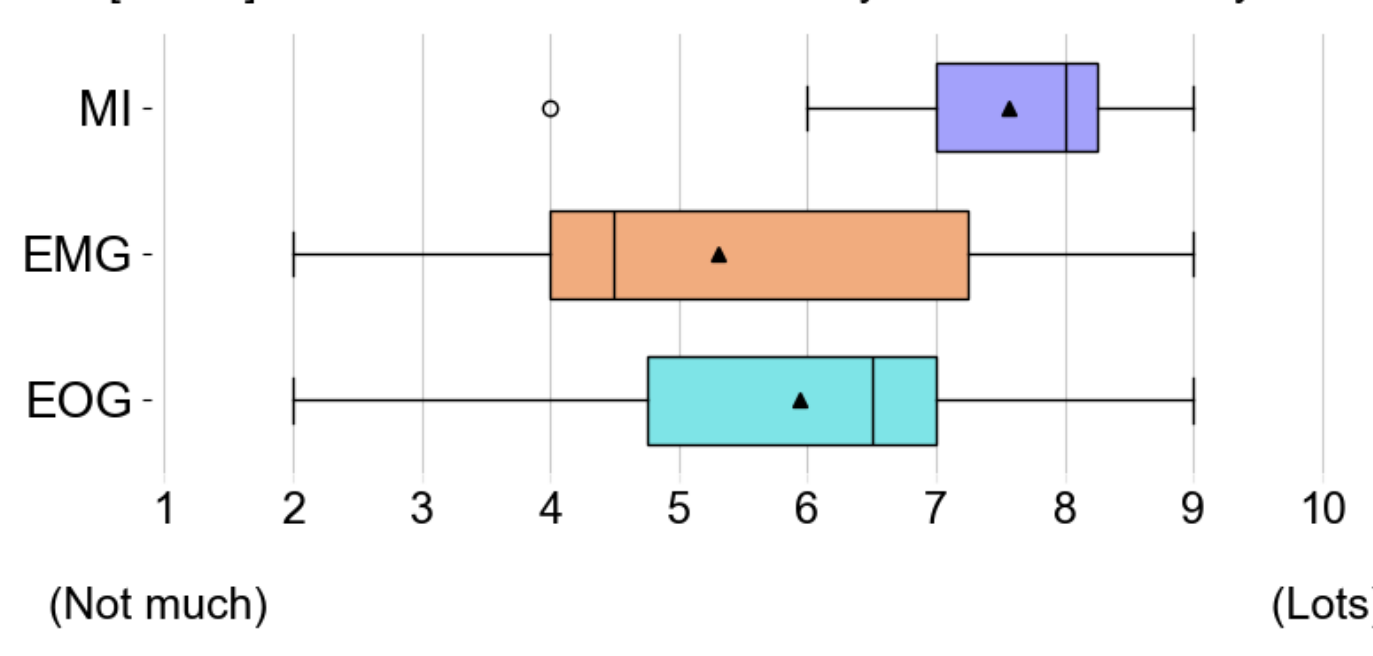


Figure 4. Effort (Adults): Adults felt MI required the most effort overall, with EMG and EOG both requiring less effort ($F(2, 30) = 6.38, p = .005$).

Online Performance Analysis

[Peds] Average Online Classification Accuracy by Modality

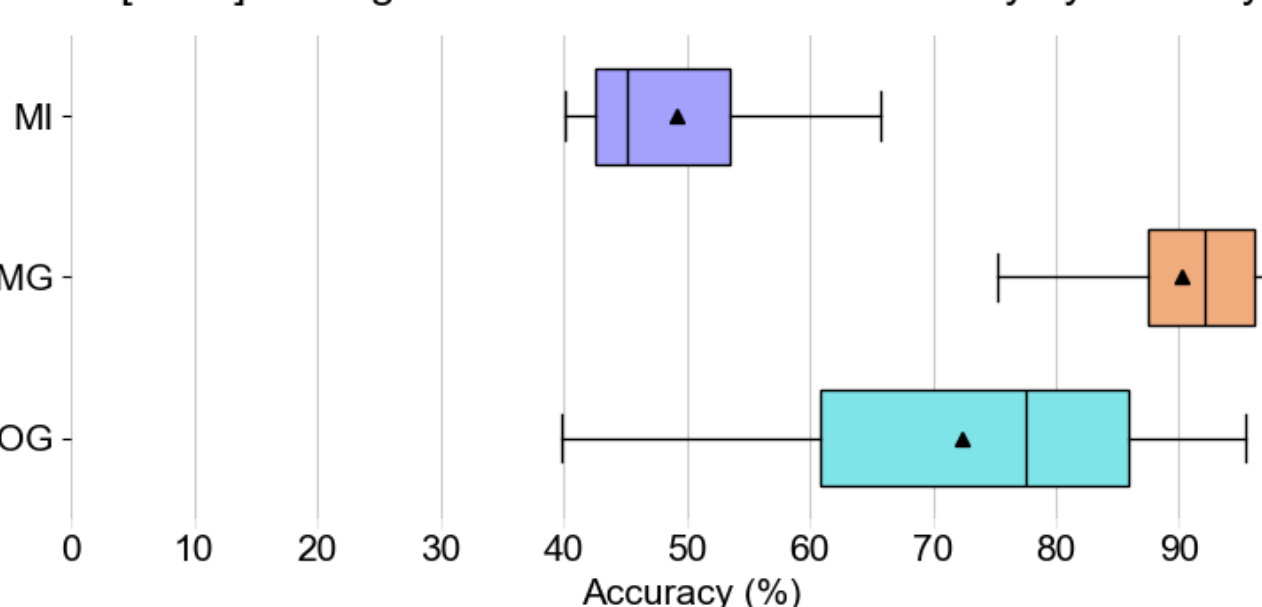


Figure 5. Online Accuracy (Peds): Children showed the highest performance with EMG $F(2, 30) = 27.31, p < .001$.

[Adult] Average Online Classification Accuracy by Modality

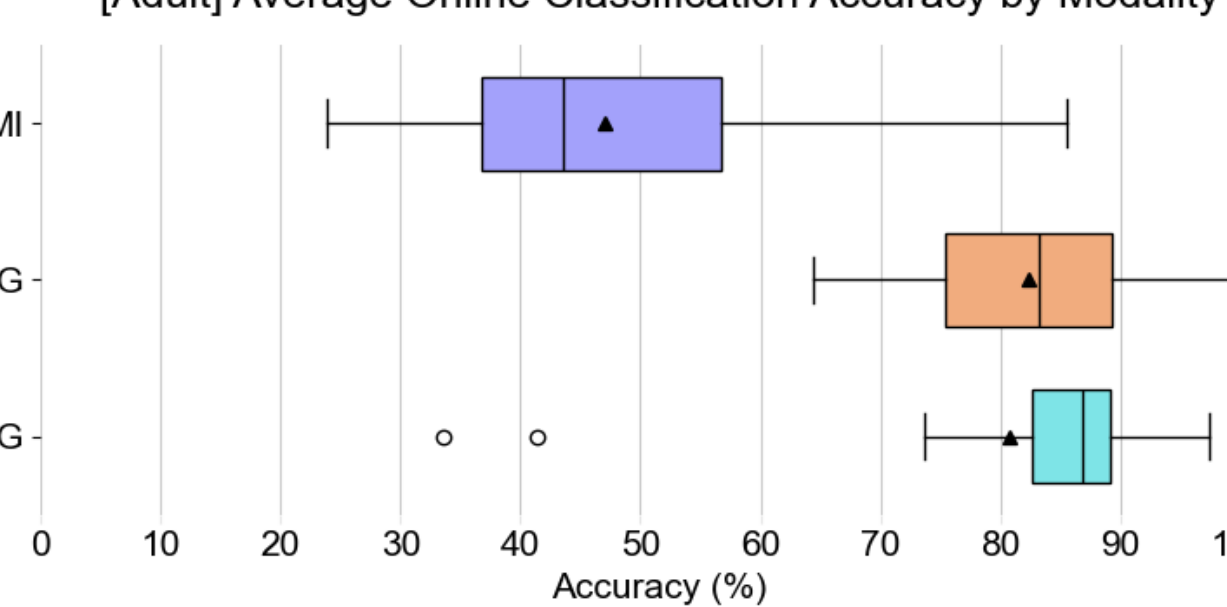


Figure 6. Online Accuracy (Adults): Adults showed almost equally high performance with EMG and EOG $F(2, 14) = 20.28, p < .001$.

[Peds] Average Online Accuracy by Block

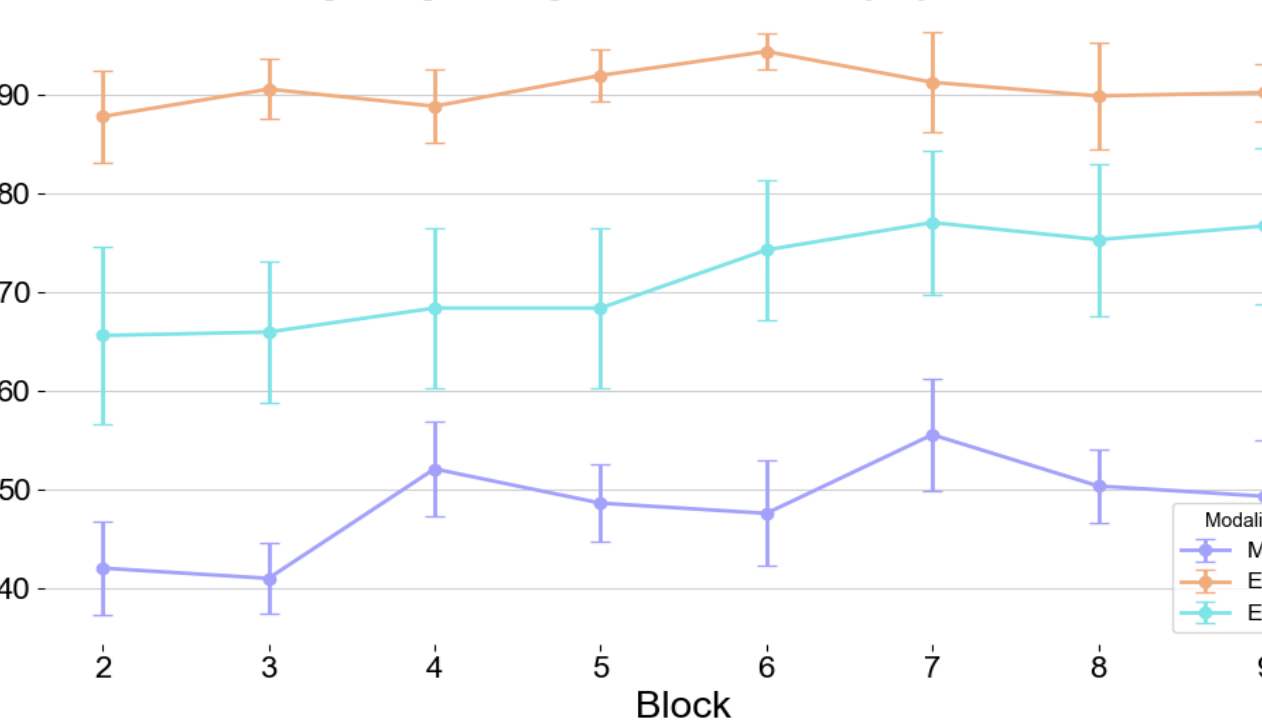


Figure 7. Online Accuracy Per Block (Peds): Shows a learning curve for EOG and indicated high EMG performance.

[Adults] Average Online Accuracy by Block

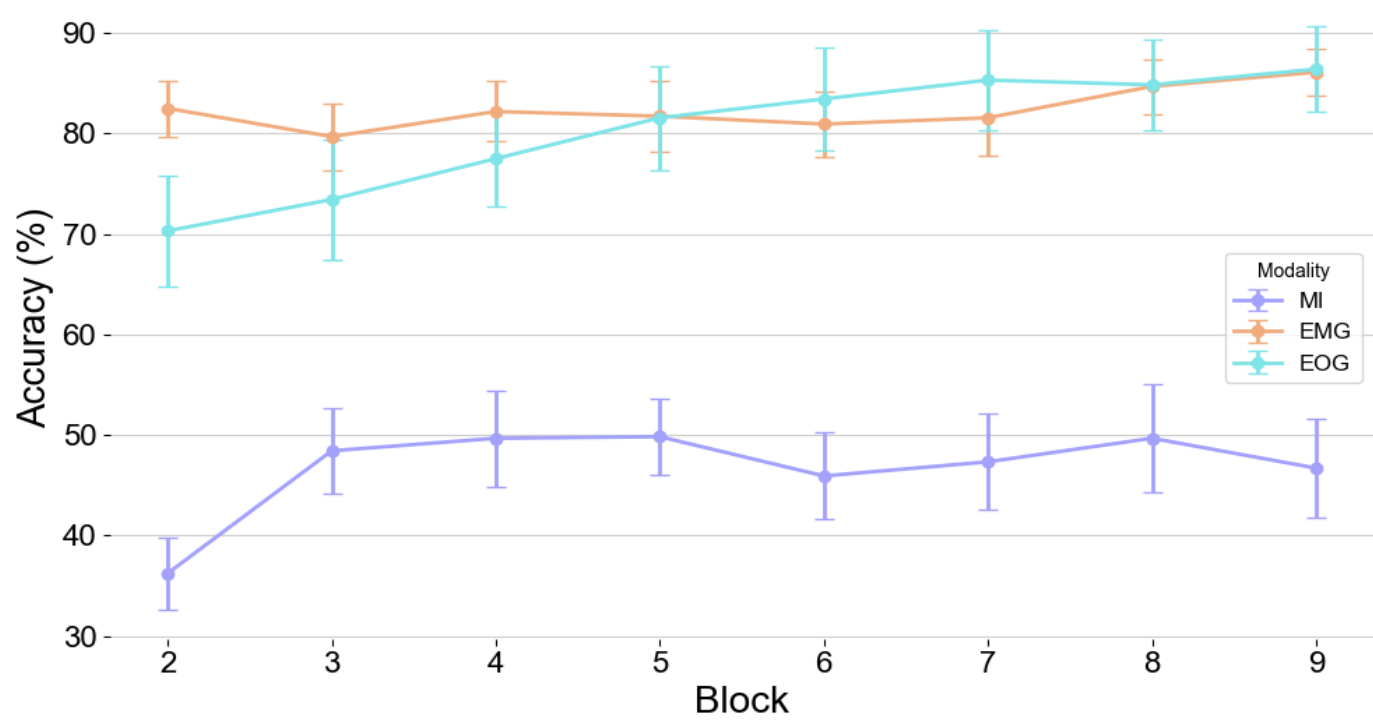
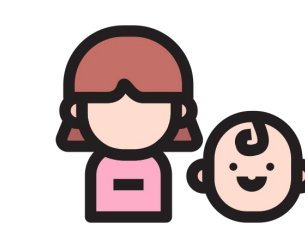


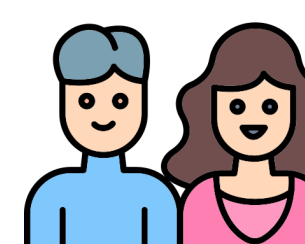
Figure 8. Online Accuracy Per Block (Adults): Shows a learning curve for EOG and low MI performance.

Conclusions & Relevance

Analysis revealed age- and modality-specific differences.



Children found both EOG and MI the most challenging to use



Adults did not struggle with EOG as children did. Highest rated modality was EMG - MI was rated the lowest.

Relevance to Holland Bloorview:

These findings show the need of personalized solutions - the need for inclusive, hybrid technologies to give children with cerebral palsy new ways to connect and communicate.



References

- Tai, K., Blain, S. & Chau, T. A Review of Emerging Access Technologies for Individuals With Severe Motor Impairments. Assistive Technology 20, 204–221 (2008).