Evaluation of a P300 BCI for functional communication in children with disabilities
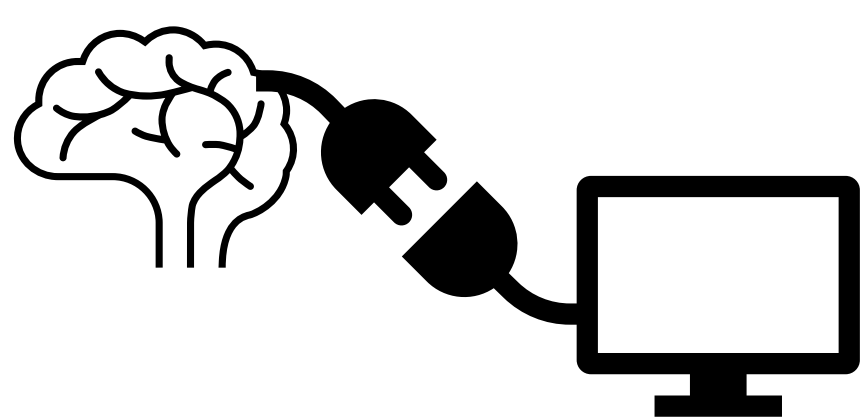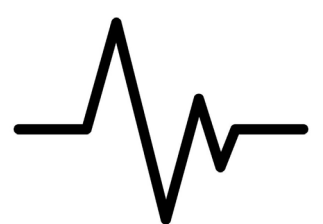
Samantha Schaus[1], Jason Leung[2], Nicolas Ivanov[2,3], Tom Chau[2,3]
McMaster University ECE and iBioMed[1], PRISM Lab Bloorview Research Institue[2], University of Toronto[3]
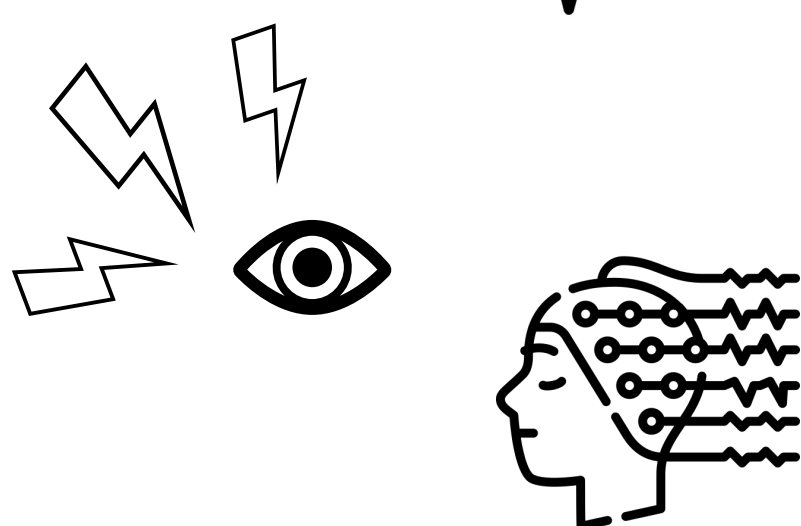
Background

Brain-computer interface (BCI) is a promising approach for alternative communication for children with disabilities

Computers record and analyze your brain activity through electroencephalograms (EEG)

P300 BCI relies on a visual stimulus to evoke an event-related potential (ERP), which is recognized in EEG activity

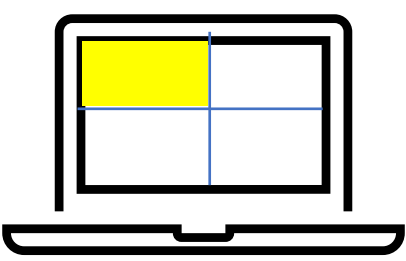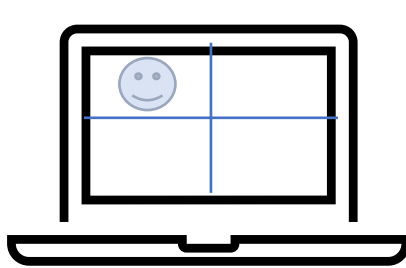The efficiency of P300 BCI for children with disabilities is under researched

Objective

Determine if P300 BCI is a feasible communication method for children with severe motor disabilities

Methods
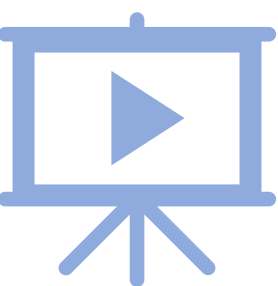
13 Participants, aged 5-19, with limited speech and motor function were recruited

Instructed to visually focus on target button with cartoon picture

Buttons flashed in random order to trigger P300 ERPs

Button was selected when cumulative probability exceeded a dynamic threshold

When target button was selected, a YouTube video was played as a reward

Eye gaze data was recorded simultaneously

Results

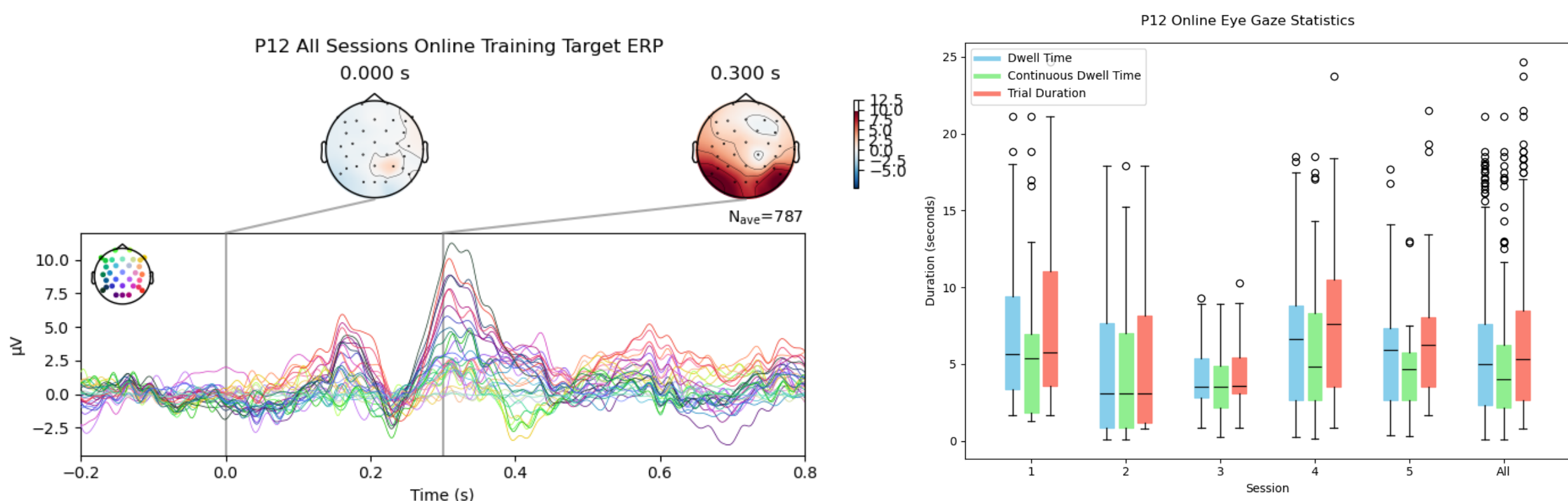**What does a strong P300 ERP response look like?**

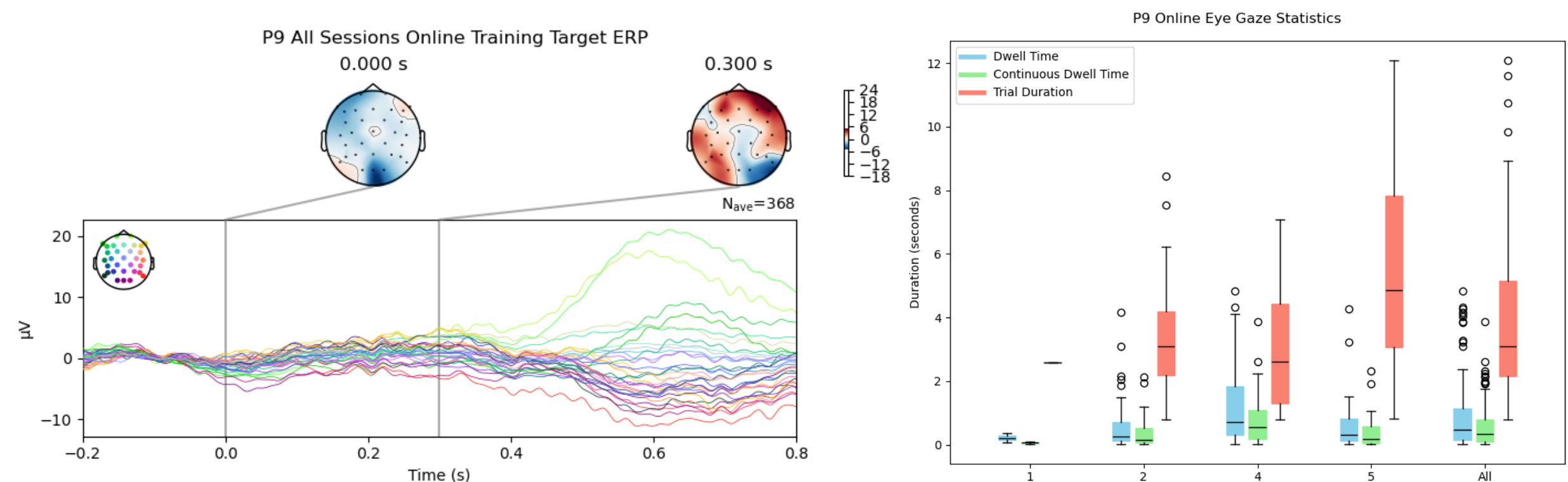Fig. 1: Strong P300 ERP and Eye Gaze Data

Fig. 2: Weak P300 ERP and Eye Gaze Data

Preliminary evidence supports the feasibility of a P300 BCI for communication in children with severe motor disabilities who retain good visual attentiveness

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Results

Some participants had inconsistent P300 ERP responses

P4, Session 1

P4, Session 5

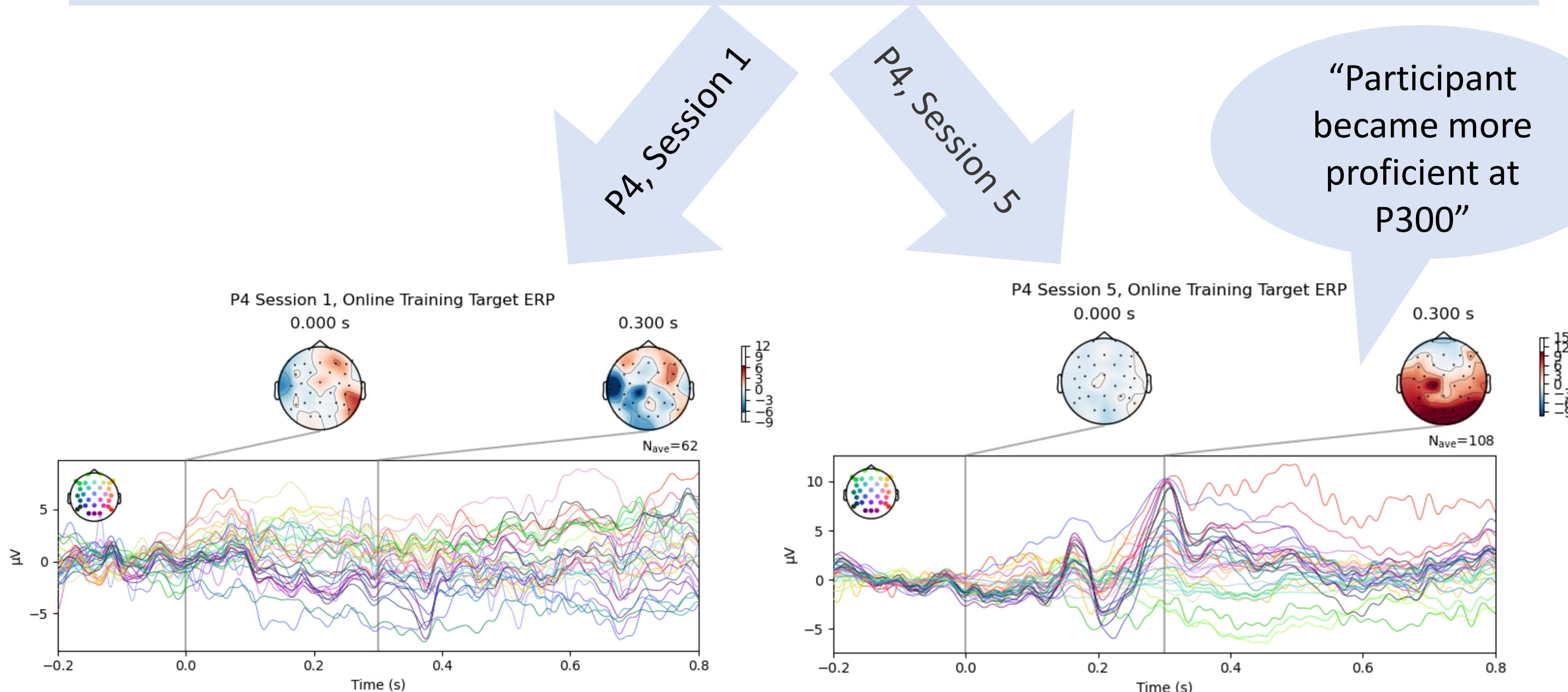"Participant became more proficient at P300"

Fig. 3: P4, Session 1 P300 ERP

Fig. 4: P4, Session 5 P300 ERP

Table 1: Mean and Maximum Accuracies per Participant

Participant	Mean	Maximum	Participant	Mean	Maximum
1	32.64	53.33	8	38	38
2	37.5	55	9	36.28	50
3	40.85	41.18	10	46.3	56.41
4	45.45	59.09	11	46.67	69.23
5	53.41	61.76	12	57.26	75
6	39.81	48.48	13	52	54.05
7	47.62	66.67			

ACCURACY STANDARD DEVIATION VS. VISUAL IMPAIRMENT
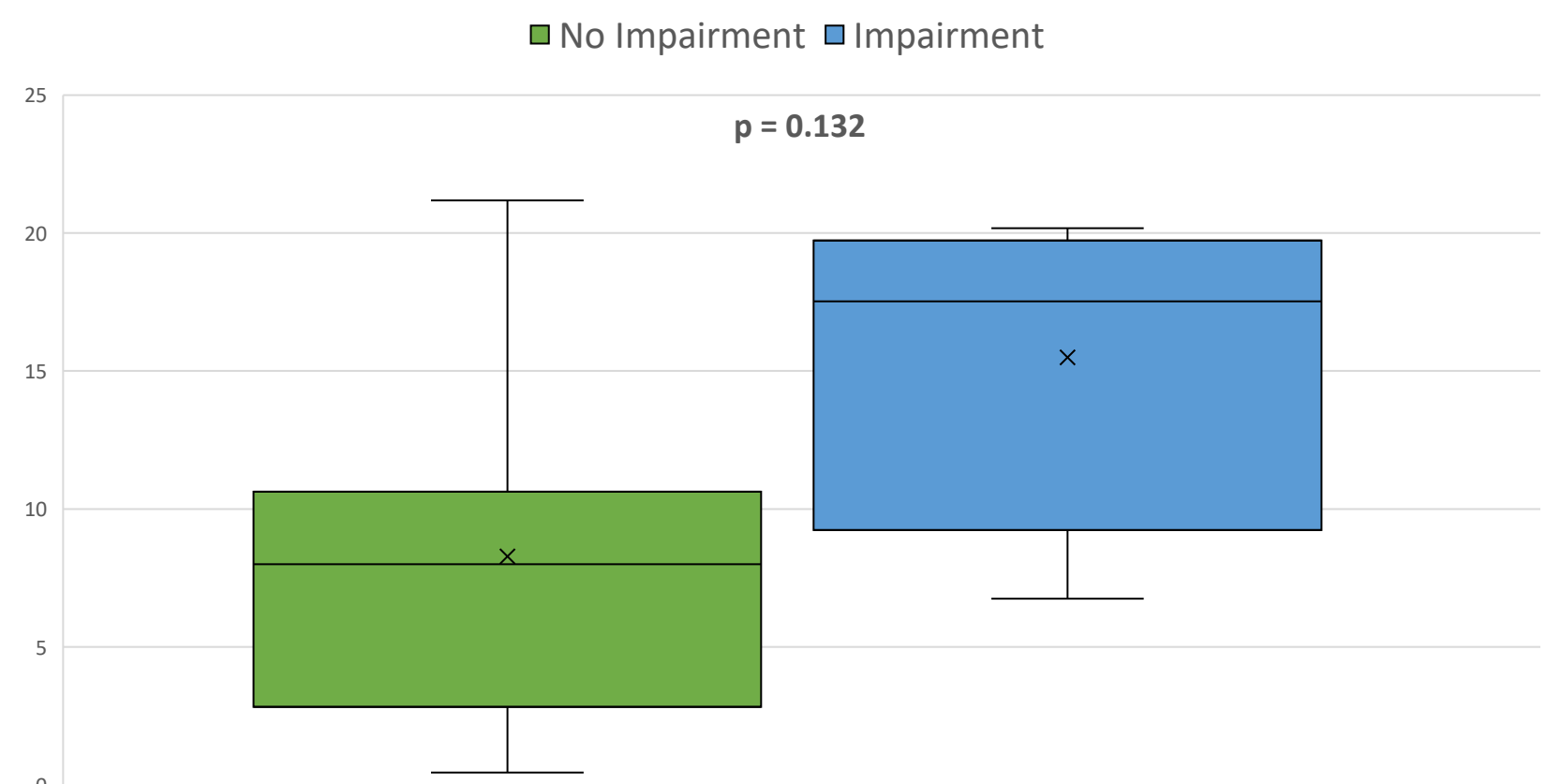

$p = 0.132$

Fig. 5: BCI Standard Deviation vs. Visual Impairment Box Plot

More variation in BCI accuracy across sessions for participants with visual impairments

BCI ACCURACY (SESSION) VS. REPORTED FATIGUE

$y = -1.5029x + 50.546$
$R^2 = 0.0274$
$p = 0.150$
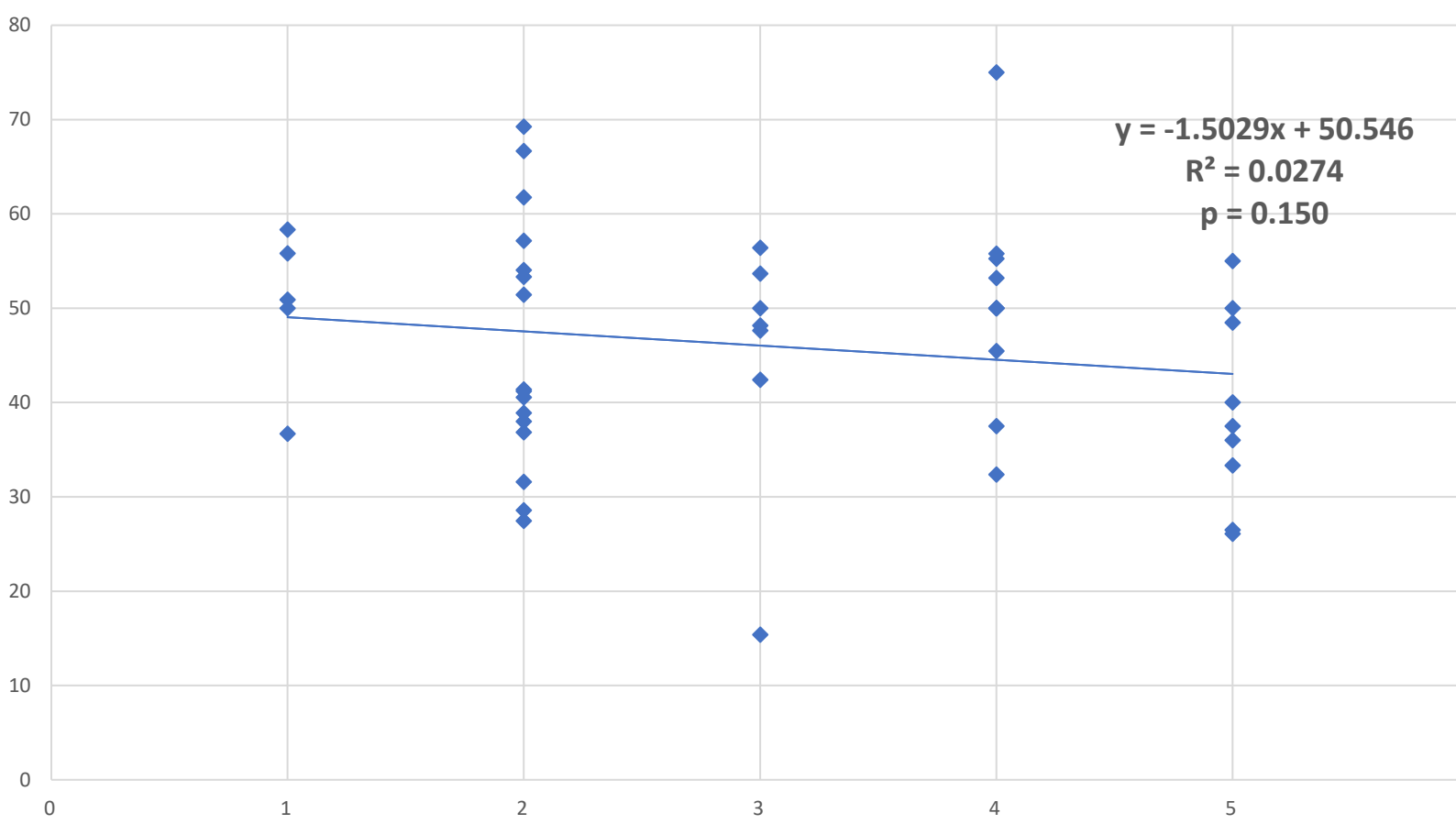
Fig. 6: BCI Accuracy vs. Reported Fatigue Regression Plot

Increased fatigue possibly associated with decreased accuracy

2 out of 13 participants demonstrated strong P300 ERP responses

Why did participants have **weak P300** responses?

- "Participant was getting tired and loosing focus towards end"
- "Difficult to make association by looking at button"
- "Lots of head movement so training might not be working too well"

Conclusion

- P300 was successful for some participants
- Weak P300 responses can be attributed to participants being **not focused** (nonunderstanding, bored, disinterested), **tired**, and having **visual impairments**

Future Step
Determine ways to improve visual attentiveness

Relevance

Visual-attention based BCIs are a promising approach for **functional communication** in children with severe motor disabilities

This research will help bring this technology into **clinical care** settings

Holland Bloorview
Kids Rehabilitation Hospital