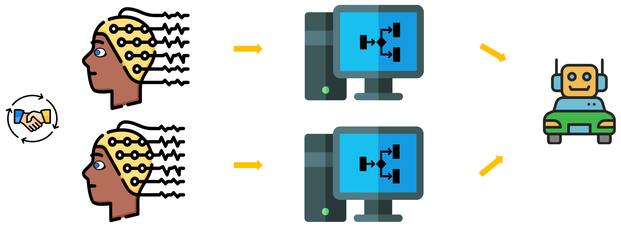
Interbrain Synchrony During Cooperative Dynamic Visual Imagery in a Multiuser Brain-Computer Interface

Authors: Kristin Figueredo[1], Natalia Molano[2], Tom Chau[2]
[1] Electrical and Biomedical Engineering, McMaster University, [2] PRISM Lab, Holland Bloorview Kids Rehabilitation Hospital

Background

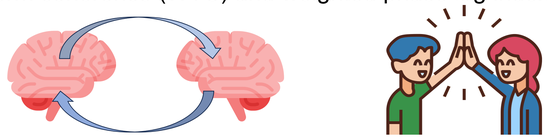
Multiuser Brain-Computer Interfaces (mBCIs)

- Systems that allow more than one individual to contribute neural information towards a common task.



Interbrain Synchrony

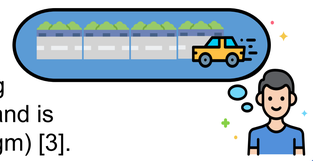
- Phenomenon that occurs when neural activity becomes coordinated in power or phase and is quantified by phase-locking value (PLV), wavelet transform coherence (WTC) and weighted phase lag index (wPLI) [1].



- Elevated WTC during joint puzzle solving, cooperative singing, verbal communication and cooperative gameplay. Elevated PLV and wPLI during speaking/listening, joint attention, musical coordination and cooperative decision-making [2].

Dynamic Visual Imagery

- The mental ability to form visual moving representations in short-term memory and is used originally to control mBCI (paradigm) [3].



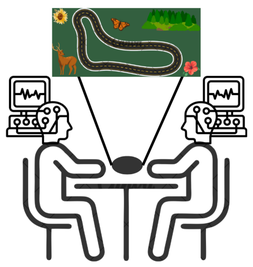
Research Question

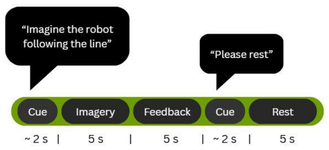
Does cooperative dynamic visual imagery during a shared recreational toy robotic-based mBCI task elicit greater interbrain synchronization compared to resting state?

Methods & Analysis

Data Collection

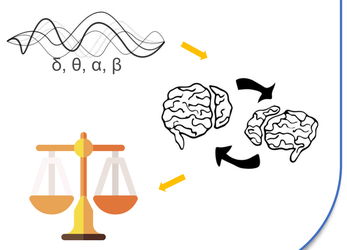
- 6 typically developed adult dyads with normal/corrected vision
- 40 offline and 40 online trials created 4 s epochs of electroencephalography (EEG) data for imagery and rest conditions.





Data Analysis

- Extracted frequency-specific synchrony, statistically compared imagery vs. rest across interbrain connections and validated them against surrogate dyads ($p < 0.05$) [4,5].



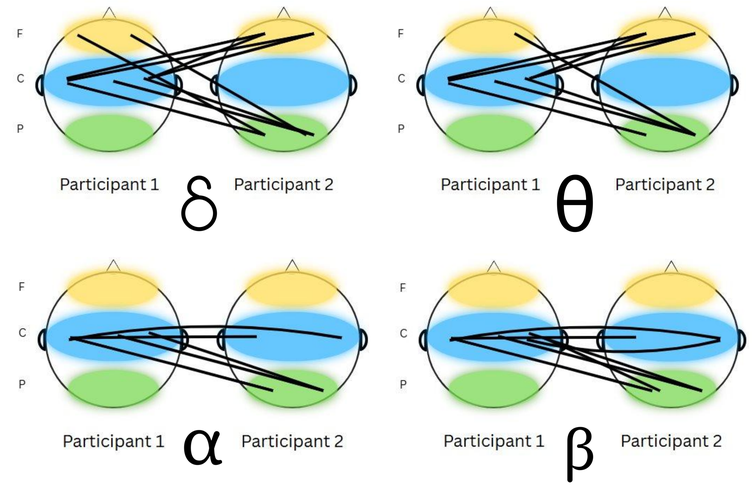
Cooperative dynamic visual imagery elicited significant interbrain synchrony measured using Wavelet Transform Coherence, suggesting that multiuser BCIs may support collaborative neural engagement.

See more here:

Results

Wavelet Transform Coherence

- Identified numerous connections amongst all frequency bands in 6 dyads in central and posterior regions



Phase Locking Value & Weighted Phase Lag Index

- Identified very few to no significant connections amongst all frequency bands in 6 dyads

Conclusion

Interpretation

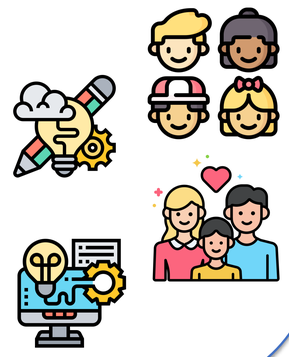
- Strong WTC findings support coordinated neural activity during shared task engagement.
- Findings are consistent with previous hyperscanning studies reporting increased synchrony during cooperative social tasks [6].

Next Steps

- Increase sample size and include additional dyads
- Incorporate NASA-TLX, VVIQ-2, and Participant Pairing Questionnaire data
- Investigate directionality using Granger causality
- Investigate various tasks like collaborative drawing and music-generation tasks

Relevance to Holland Bloorview

- Traditional BCIs focus on individual communication and device control.
- Multiuser BCIs demonstrate platform for collaboration, social participation, and engagement based on neural coordination.
- Provides opportunity for family engagement, socializing, creativity and learning.



prism lab

Holland Bloorview Kids Rehabilitation Hospital

Bloorview RESEARCH INSTITUTE