Repeat at-home sampling of gamified behavioural tasks and wearable dry-EEG can match the quality of lab-based systems

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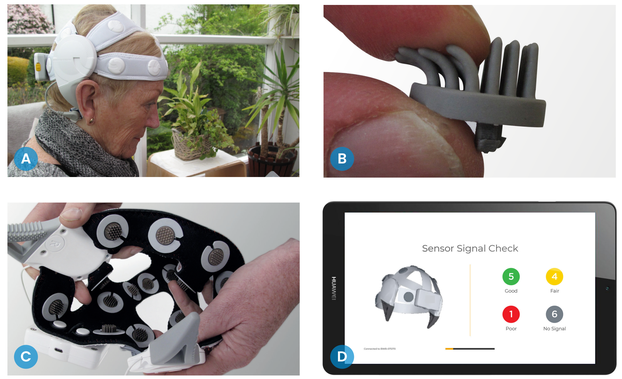
Motivation

- Recent advances in sensor development, signal processing, and cloud-based technologies have led to the creation of wireless, dry EEG recording systems (1)
- Gamification of laboratory cognitive paradigms – adding game-like features (points, graphics, levels, storyline, etc.) – reduce attrition and increase participant engagement over extended periods (2,3)
- These technologies combined allows the repeated collection of task-driven EEG data by research participants themselves over days, weeks, or months (4).
- The quality of remote self-administered gamified EEG needs to be investigated

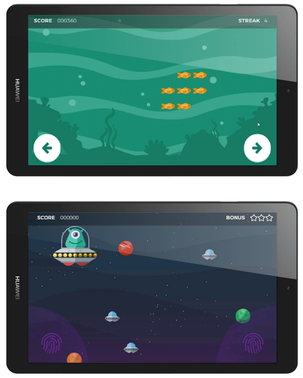
Method

- 30 healthy male adults (mean age=25.6 years) completed 4 weeks of self-administered dry EEG at-home recordings
- Gamified visual Oddball and Flanker tasks
- Usability was evaluated via participant adherence, percentage of sessions successfully completed, and quantitative feedback using the System Usability Scale.
- EEG signals were pre-processed with frequency domain filtering and automatic artefact removal methods. Low quality epochs were removed using a conservative correlational approach, discarding ~50% of trials.
- Signal variability was quantified by computing the Standardized Measurement Error (SME) (5) over repeated sessions and multiple trials. Event-related potentials (ERPs) from the Oddball task were extracted from stimulus locked Target trials at Pz. SMEs were calculated across the 400-500 ms time window. ERPs from the Flanker task were extracted from response locked Correct and Error trials at FCz. SMEs were calculated across the 0-100ms time window. The shaded areas correspond to the 95% confidence intervals.
- Wet EEG reference SME values were extracted from the open-source ERP CORE EEG database for comparison (6).

Cumulus Headset

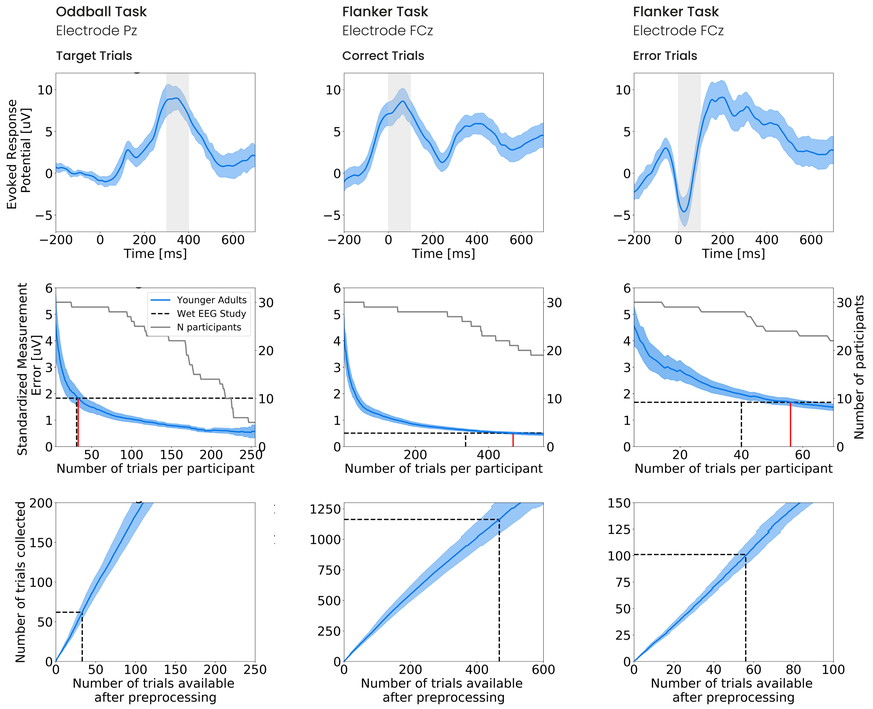


Flanker and Oddball Gamified Tasks



ERPs analyses

Top Row: Event-related potentials. **Middle row:** Standardized Measurement Errors per number of trials. The grey continuous lines correspond to the number of participants remaining in the SME calculation after trial rejection. **Bottom Row:** Mean numbers of trials available after preprocessing. The black dotted lines correspond to the mean numbers of trials extracted from the wet EEG study.



Results

- 684 EEG sessions were collected. On average, participants completed 22.87 sessions of 23 sessions requested (std=1.92).
- Participants successfully completed 96% (std=5%) of the sessions attempted and reported a mean usability score of 88.3 (std=9.90).
- In the Oddball, 33 Target trials (red line in the figure), were required to reach the same SME values obtained with 30.5 trials using a wet EEG system.
- For the Flanker task, 467 Correct trials and 56 Error trials were required to reach the same SME values obtained with 337 Correct trials and 40 Error trials using a wet EEG system.
- Allowing for differing epoch rejection rates, aggregation of ERPs across 2 to 4 sessions (depending on task) resulted in grand average signal quality comparable to single-session data collected using wet EEG.

Conclusions

Wireless EEG technology is a suitable tool for cognitive neuroscience investigations, and has the potential to provide objective, frequent and patient-centered tracking of biomarkers of functional neurophysiology. This approach has potential to facilitate large scale longitudinal studies of brain disorders that manifest on different time scales.

Bibliography

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