Cumulus

This poster was originally published under the BrainWaveBank brand name.

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Validating virtual tools for remote sampling of neurological function: comparing task-driven EEG in the lab and in the home

INTRODUCTION

- The Covid-19 pandemic has accelerated adoption of methods for "virtual" trials
- Brain imaging still requires visits to larger clinics and research centres
- The BrainWaveBank platform enables repeated recording of resting and domain-specific neurological function in small clinics and in the home
- Here we assess risks that may be associated with remote neuroscience studies:
  - Poor signal quality due to dry sensor hardware and lack of experimental control
  - Lower motivation/adherence, because of lack of direct interaction with researcher
  - Challenge in learning how to use tools without a researcher present

Suite of Tools For EEG Data Collection at Scale



Affordable, easy to use, wireless 16 channel EEG headset


EEG signals synchronised to game events.


Montage and calibration in<5 mins.


Adherence rewarded and activity tracked.


Durable soft dry sensor technology.

METHODS

1. In the lab, how does wearable dry EEG signal quality compare to wet EEG?

The BrainWaveBank headset was used to record EEG in the lab while 8 adult participants viewed simple visual stimuli across two days: a static visual-evoked-potential (VEP) and a flickering 14Hz steady-state VEP (Barbey et al. 2020, AAT-AD/PD, Vienna). The same tasks were recorded using a Biosemi ActiveTwo setup which uses state-of-the-art preamplified wet sensors. The ordering of wet/dry sessions was counterbalanced.

2. Are people prepared to do repeated sessions in the home, and is the data usable?

After an in-person familiarisation session, 89 uncompensated adults (40-80yrs) were asked to use the EEG headset and paired behavioural tasks (resting EEG, and ERP tasks in attention, memory and executive function) for 20 minutes a day, 5 days a week for 12 weeks. Tasks are gamified to encourage adherence (Buick et al. 2018, AAT-AD/PD, Turin; McWilliams et al., in review).

3. How much cleaner is lab-recorded data, compared to home-recorded data from the same users?

30 young adults took part in a benchmark study using a well-studied and safe psychoactive compound (intravenous racemic ketamine). During the pre-intervention period, 2 in-lab baseline recordings were taken, alongside 6 at-home baseline recordings, using gamified tasks. Passive and task-driven recordings were made for comparison (Murphy et al. 2020, FENS, Glasgow).

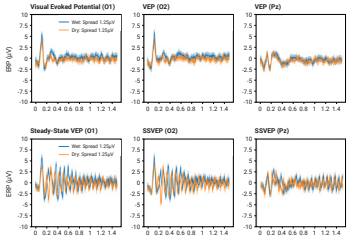
4. Is a study compromised if all system training is performed remotely, by video-conference?

10 younger adult (18-55yrs) participants were enrolled entirely remotely, without any person-to-person familiarisation session. Enrolment sessions were conducted by video conference. Separately, as part of a pre-pandemic project, 10 younger adult (18-55yrs) participants were enrolled in-person. Both groups completed recordings at home over two weeks.

RESULTS

1 Signal quality comparison to conventional wet EEG in-lab

- Similar waveform morphology and amplitude across recording conditions for static VEP
- Average signal spread at occipital electrodes marginally higher for dry sensors (1.27uV) vs. wet (1.24uV)
- For the 14Hz steady-state VEP, the corresponding dry EEG signal spread was again marginally higher (1.28uV) than the wet (1.25uV).

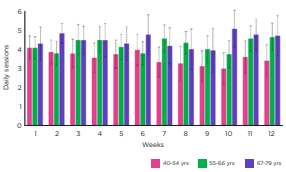


Signal quality
In-lab comparison of BWB headset immediately before or after traditional 128 channel wet EEG session. Montecarlo-based 95% confidence interval, calculated over the grand average ERP (8 participants x 2 sessions x 2 modalities).

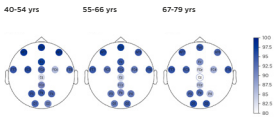
2 User acceptance and compliance, at-home

- Mean usability at home was high at 78.9 on the System Usability Scale, though lower for those aged 67+ yrs (SUS of 68.6).
- Good study adherence – highest at 90% for oldest age band.
- Average contact reliability in home-based sessions was 93% for 40-54 yrs; 93% for 55-66yrs; 90% for 67-79yrs.
- Grand average morphology and topography of home-recorded ERPs as expected based on the literature.

Average weekly adherence, at-home sessions, by age-band

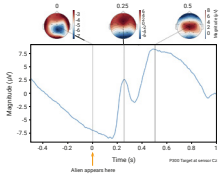


Average contact reliability in at-home sessions, by age-band and sensor locations

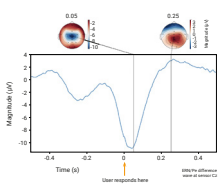


Grand average ERPs for gamified tasks, at-home sessions


AstroTap: Gamified 2-stimulus visual oddball eliciting P300



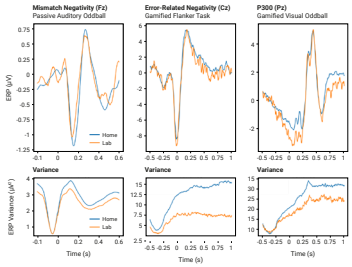

Go with the Flow: Gamified Flanker task eliciting Error-related negativity (ERN difference wave shown)



3 Signal quality comparison recording in-lab vs at-home

- Grand-average lab-based and home-based signals for three ERPs (the P300; the Error-Related Negativity – ERN; and the Mismatch Negativity - MMN) all showed similar topography and morphology.
- The variance of home-based recordings was higher, requiring 19% (P300), 46% (ERN) and 22% (MMN) more data to yield equivalent statistical power to in-lab recordings.

ERPs and their respective variances for three gamified tasks performed at home and in-lab.



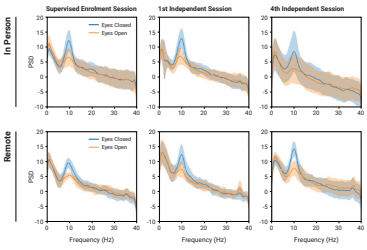
Grand averages were created from all epochs using a robust averaging method (Huber method). Variance was also calculated using this method. Power analysis equations tell us that the number of samples needed to detect a change of a given magnitude is proportional to Variance, so here we demonstrate an ERP and its corresponding pointwise variance for 3 tasks at-home (6 session) and in-lab (1 session). A single channel is plotted for display only here, while the percentages calculated represent the overall variance across all channels and time points.

4 Comparison between in-person study enrolment and remote

ENROLMENT STYLE	IN PERSON	REMOTE
System Usability Scale mean score	87.25 (95% CI: 82.5, 92)	90.25 (95% CI: 88.5, 92)
Adherence (mean % of sessions requested)	68% (Range: 40% - 140%)	86% (Range: 44% - 122%)

- For both enrolment styles, system usability was rated highly (>85 rated as 'excellent' by Bangor et al., 2009).
- Resting EEG demonstrated the characteristic alpha attenuation in eyes-open vs. eyes-closed.
- Adherence was satisfactory in both cases – providing preliminary evidence that participants can be successfully engaged by a fully remote study.

Resting state spectral power by session/setting



CONCLUSIONS

In controlled settings, grand average signal quality is very similar to that from burdensome lab-systems.

The BrainWaveBank platform was judged as very easy to use by participants, and this results in very high levels of compliance for frequent repeated sampling autonomously in the home, even with older individuals.

Resting and domain-specific event related potentials can be collected in supervised lab, and unsupervised home environments. The additional noise associated with unsupervised data collection in uncontrolled home settings adds only modestly to the amount of data required to achieve similar statistical power – as can easily be achieved by asking patients to make multiple daily recordings.

Initial data does not show evidence that remote enrollment results in noisier home recordings or lower participant motivation.