Cognitive performance in older adults using home-based EEG repeated measurements

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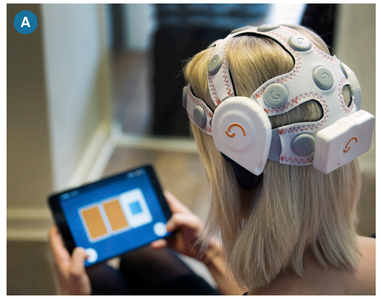
Marie Skłodowska-Curie Actions

Introduction

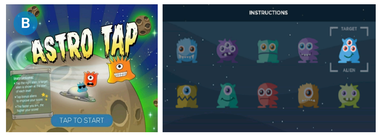
The earliest cognitive effects of neurodegeneration are subtle, and so are challenging to detect on an individual basis1. Common laboratory-based face-to-face assessments are usually snapshots of performance, hindering the detection of early cognitive changes. Remote digital assessment of cognition can address this in part by enabling repeated sampling in more naturalistic environments[2]. This is the case of home-based electro-encephalography (EEG) combined with task performance.

Aim

To identify neurotypical participants who have low performance in the Montreal Cognitive Assessment (MoCA) using home-based EEG.



A. BrainWaveBank headset*



B. Gamified visual oddball task*

*From Murphy et al. 20183

Methods

Subjects

N=94 (58 females), 57-79 years old, mean age 66.4 years pooled from two previous studies at Trinity College Dublin (TCD) and Queen's University Belfast (QUB).

Task

A resting state (RS) paradigm and a gamified visual oddball task developed by Cumulus Neuroscience. Volunteers were instructed to respond as fast as possible to an infrequent stimulus, while not responding to a frequent stimulus.

Experimental design

- Participants were asked to do sessions of ~25mins repeatedly over a number of months, while wearing a 16-channel dry-EEG headset[3,4,5].
- Data from the first 6 weeks of participation is used here.
- In average, participants did 15.3 sessions in the first 6 weeks.

Feature extraction

- Behaviour: reaction time to the infrequent stimulus.
- Task EEG: P300 peak amplitude and latency.
- Resting state EEG: normalized theta, alpha and beta bands in frontocentral, parietal and occipital areas during eyes open and eyes close; reactivity, and exponent of log-transformed spectrum during eyes close.
- Summary across sessions: average and standard deviation of above

Outcome variable

- Median split of high and low MoCA scorers (<=27).

Machine learning pipeline

- Data types used for training: i) behavioural only, ii) task EEG, iii) resting state (RS) EEG; and iv) all data types.
- Additional models included age and gender covariates to assess their effect on classification.
- Five model types were fitted: logistic regression, elastic net, random forest, adaptive boosting and bagging.
- Hyperparameter tuning with 10-fold nested cross-validation
- Model performance was assessed with 10 repetitions.
- Feature importance from the best model was assessed by dropping variables and bootstrapping the model fit per repetition and outer fold.

Home-based dry-EEG can identify high (or low) cognitive performance

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great potential for identifying **early cognitive deficits** in neurodegenerative diseases.

Demographics

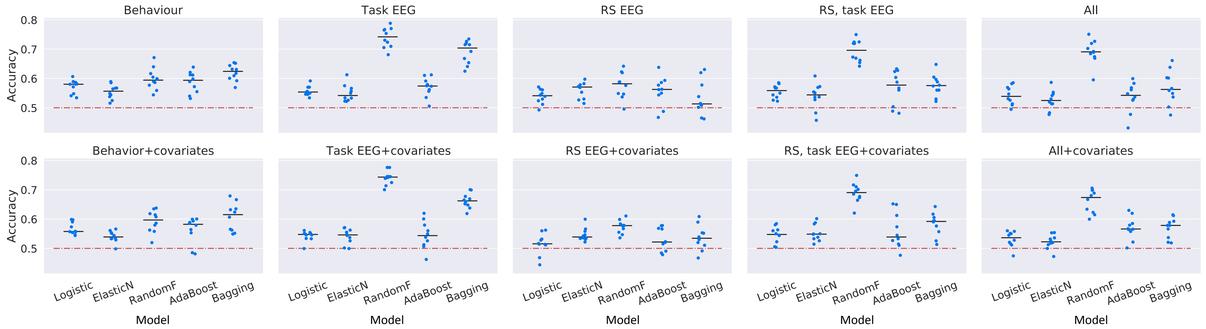
The groups defined by the median split of MoCA were similarly spread across gender groups and age.

	Study QUB		Study TCD	
	high MoCA	low MoCA	high MoCA	low MoCA
male	5	7	9	15
female	11	22	15	10
age	63.8	65.5	67.8	67.6

Results

Best median accuracies: random forest trained with the Task EEG dataset (**74.2%**) and the All dataset (**69.1%**). The random forest trained with the behavioural data only showed a median accuracy of 59.4%.

Similar accuracies were found when including the variables age and gender which provides confidence that the results are not driven by these covariates.



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Dots show the cross-validated accuracy of one repeated model run. The black line shows the median across the repeated cross-validated accuracies; the red dotted line shows the threshold of 0.5. The top row shows results without age and gender; the bottom row shows results including those variables.

RS: resting state; ElasticN: elastic net; RandomF: random forest; AdaBoost: adaptive boosting.

Feature importance in random forest and variability check

Most important feature: **standard deviation of the P300 amplitude at Pz**.

Given that the standard deviation is a measure of variability, we investigated if this was "true" individual day-to-day variability, or due to different levels of signal noise.

Following Luck et al. (2020)[6], we estimated the average level of signal noise per participant (for the P300), and substituted that into the model, in place of the P300 variability feature.

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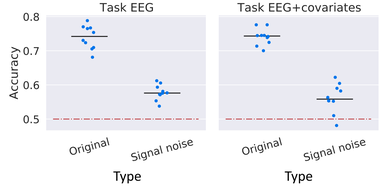
The accuracies were reduced when using a noise feature, in place of the P300 amplitude variability, suggesting that this feature reflects "true" within-subject variability.



Discussion

- Features extracted from home-based EEG recordings during the visual oddball task and resting state can be used to identify participants with high (or low) cognitive performance.
- Better accuracies were found with Task EEG data than with behavioural data suggesting that EEG carries more relevant information to high/low cognitive performance than behaviour performance in a visual oddball task.

References

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Acknowledgments

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