A Novel Machine Learning Technique using Resting-State EEG to Assess and Monitor Cognitive Impairment

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Background

Cognitive impairment is monitored with pen-and paper tests, like the mini-mental state exam (MMSE)

EEG is low-cost and widely available, but signal complexity has limited practical applications

Machine learning can predict patients' cognitive status, simplifying diagnosis and monitoring in clinics and drug trials

Data

Resting-state EEG collected from a real-world clinical sample. Eyes open and eyes closed recordings.

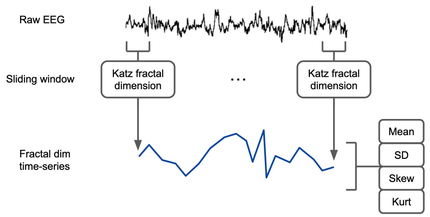
Multiple Levels of Impairment

- Subjective cognitive impairment
- Mild cognitive impairment
- Mild-to-moderate dementia

Causes and co-morbidities

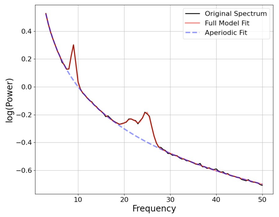
- AD, VD, PD, DLB, Diabetes, Bv-FTD, TBI, OSA, MDD, Anxiety, Aging...

Banded Fractal Variability

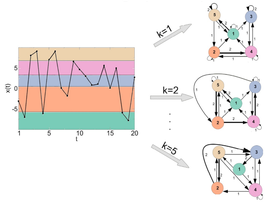


Other features

FOOOF Spectral Parameterization



Quantile graph analysis



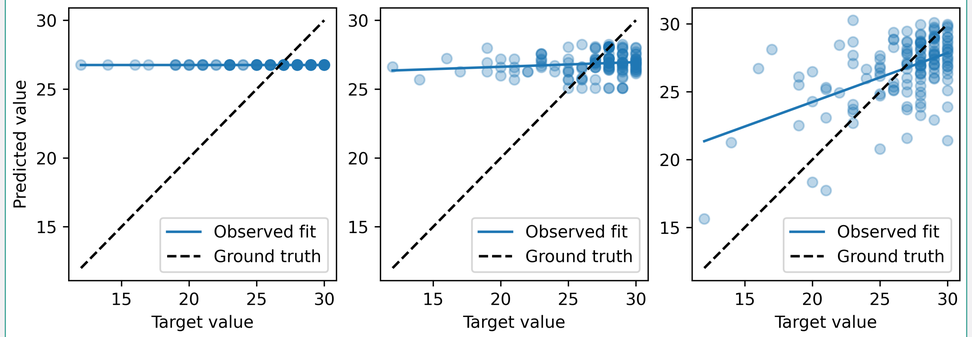
Results

3 models trained to predict a patient's MMSE score

1st panel: A null model always predicts the mean MMSE and serves as a baseline.
MAE* = 2.56, R^2 = 0.0

2nd panel: a demographics-only XGBoost model was trained on age and sex to determine how informative demographics alone are about cognitive impairment.
MAE* = 2.44, R^2 = 0.02

3rd panel: an EEG + Demographics XGBoost model was trained on EEG features along with demographics (age and sex).
MAE* = 2.22, R^2 = 0.26



The model trained with EEG provided the best mean absolute error and R^2.
The patterns of a patient's resting-state EEG reflects their level of cognitive impairment.

* **M**ean **A**bsolute **E**rror is the average prediction error for a model in MMSE points. Lower values indicate better performance.

Conclusions

Cognitive impairment may be assessed in the clinic and in clinical trials using machine-learning and resting-state EEG

EEG could help track patients' cognitive impairment regardless of disease status, facilitating better clinical care and accelerating drug-development pipelines.

References

Caselli et al. *Neurology 62.11 (2004).*

Donoghue et al.
Nature neuroscience 23.12 (2020).

Hoops et al. *Neurology*, *73* .21 (2009).