Neuropsychological outcome prediction after surgery

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Objective

Epilepsy is a disabling disease[1]. If medication fails, surgical resection of seizure foci is an option to render patients seizure free, however, it may be accompanied by neuropsychological impairment such as language related difficulties. Predicting individual neuropsychological performance and seizure outcome is therefore important for doctors advising patients. We investigate a deep learning model's ability to find predictors to traditional ones for performance or outcome.

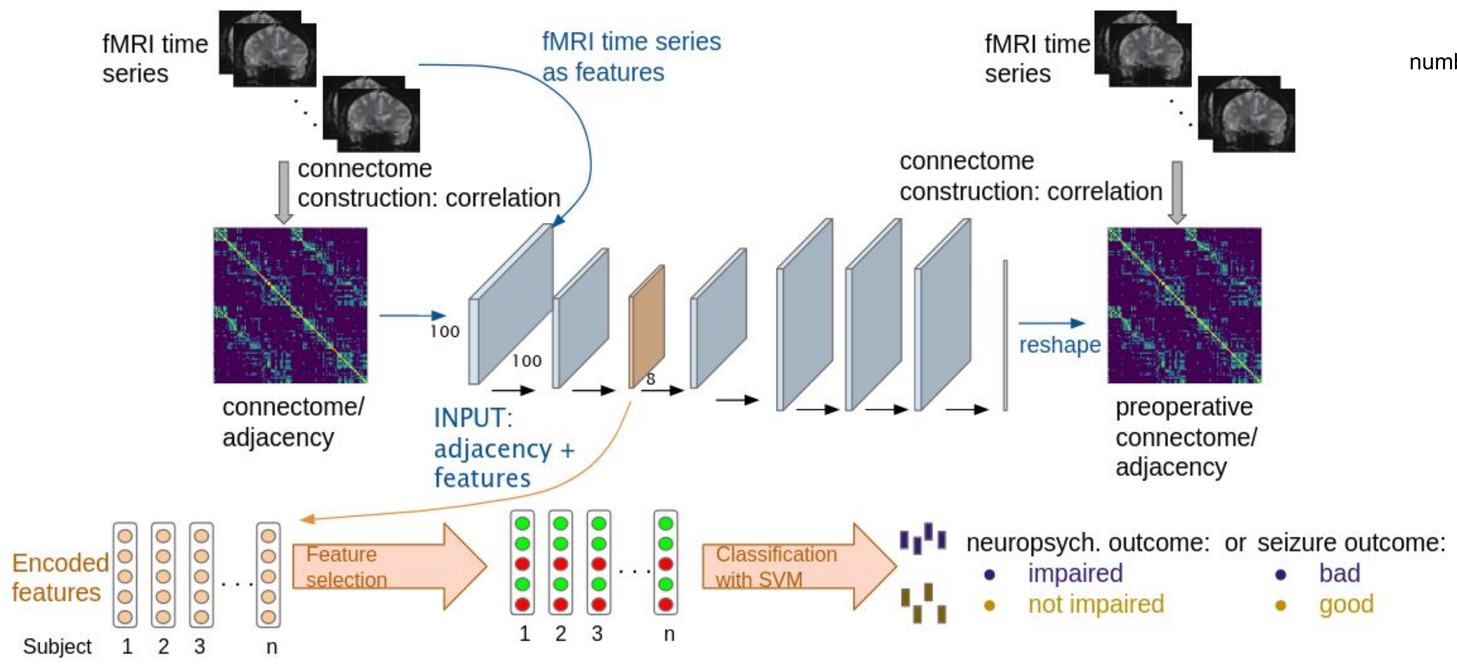
Material and Methods

Data:

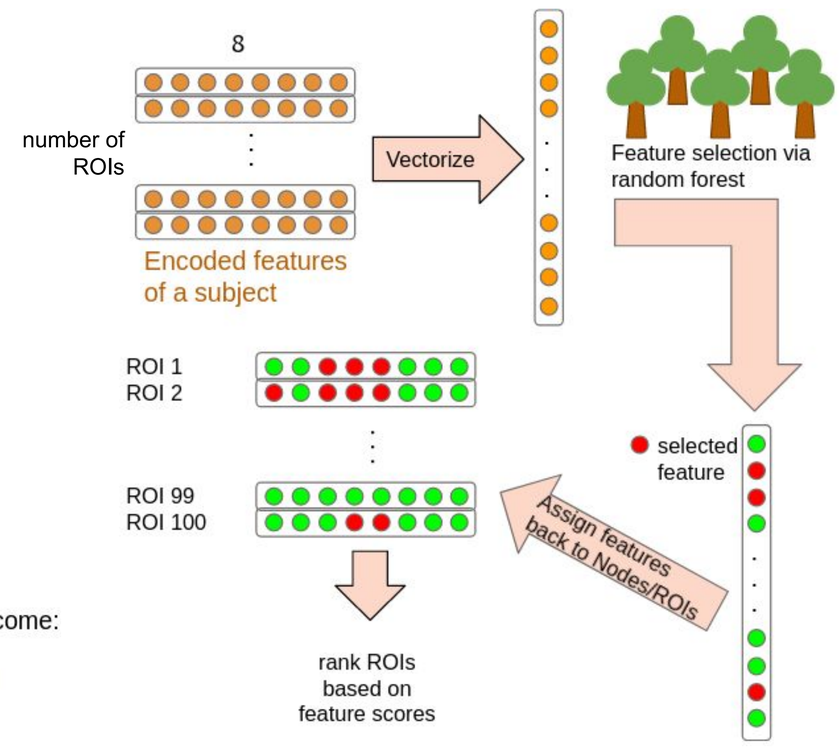
26 patients with temporal lobe epilepsy from General Hospital of Vienna
- Language related task-fMRI preoperatively: verb generation and phrases task
- Seizure outcome (excellent/moderate) + neuropsychological performance (not impared/ impaired) postoperatively

223 healthy volunteers from Human Connectome Project
- Resting state fMRI

Model:



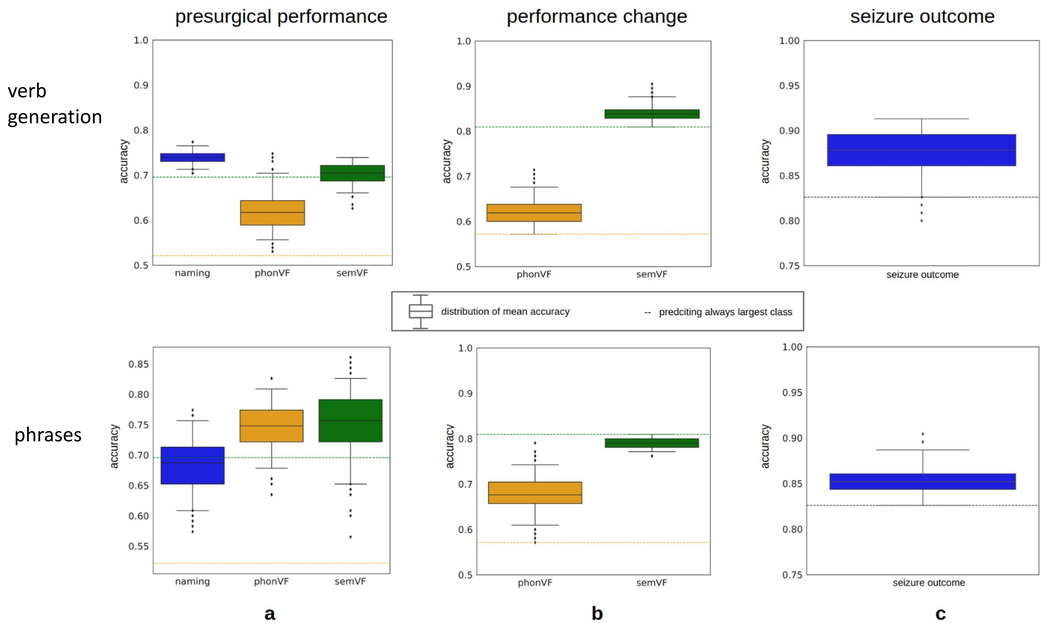
A variational graph auto-encoder[2] was used as feature extractor. It was trained on connectivity data of healthy volunteers. After completed training it was applied to an epilepsy cohort and extracted features are used to predict neuropsychological performance and seizure outcome.



A random forest classifier is used to assign feature importance scores to the extracted features. Each feature corresponds to one of 100 cortical regions. Summing over importance scores of features corresponding to the same regions gives a region-wise importance score

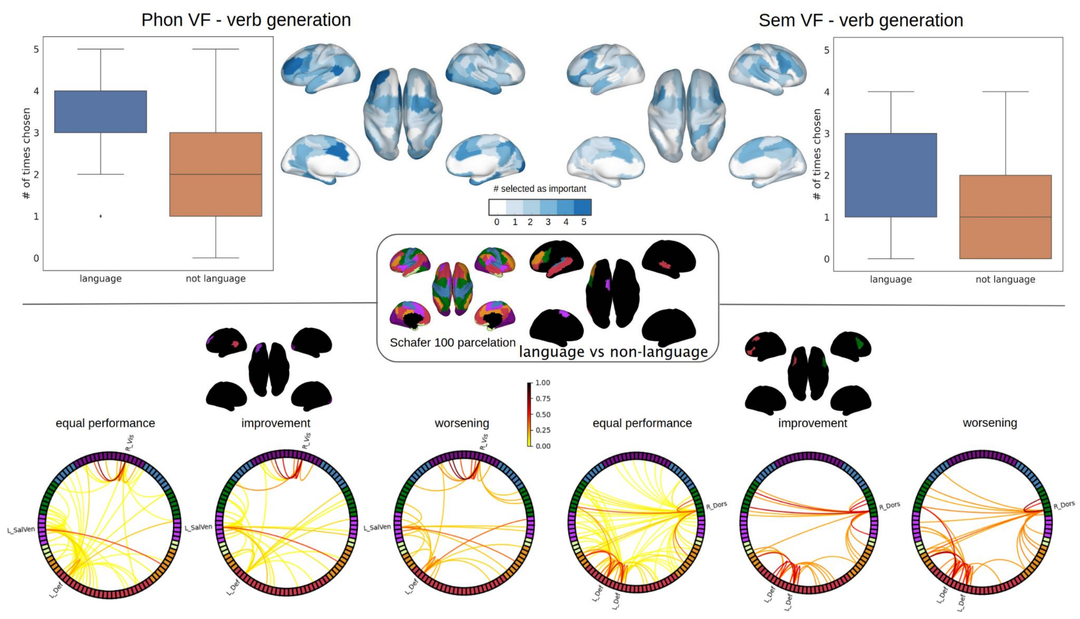
Results

Prediction accuracy:
- mean accuracy ranges from 0.42 to 0.88
- is associated with:
  - fMRI task: verb generation or phrases
  - connectome density: threshold to keep 10% of connections works best in most cases



Accuracy distribution over 5 seeds used to train the auto-encoder. Wiskers correspond to lower and upper bound of confidence intervals for mean accuracy. Dashed lines correspond to the accuracy, when always the largest class is predicted, whereby color indicates correspondance between baseline and model performance.

Regions useful to predict postsurgical language performance change:



The figure shows the ROI-wise importance for prediction of language performance change, a comparison of importance for language vs non-language related regions (top), as well as connectivity patterns for the 3 most important ROIs for prediction (bottom). The mean connectome of subjects whose perforamnce worsens after surgery tend to have stronger connections than those of subjects with equal or impoving performance.

Conclusion

The graph-autoencoder successfully extracts connectivity features useful for predicting language performance and seizure outcome in a small cohort of epilesy patients although it was trained on a dataset of healthy volunteers. The learned features therefore capture clinically relevant functional properties which makes the trained model an applicaple feature extractor to other datasets and clinical questions beyond epilepsy.

References

1. Devinsky, O., *et al.*: Epilepsy. *Nat Rev Dis Primers* **4**, 18024 (2018)
2. Grover, A., *et al.*: Graphite: Iterative generative modeling of graphs. In: Chaudhuri,K.; Salakhutdinov, R. (ed.) Proceedings of the 36th International Conference on Machine Learning. Proceedings of Machine Learning Research, vol. 97, pp. 2434–2444. PMLR (09–15 June 2019), http://proceedings.mlr.press/v97/grover19a.html, code: https://github.com/ermongroup/graphite

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