SpExNeuro – A behavioural and brain imaging data collection of speech and executive functions

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INTRODUCTION

Can Speech predict Cognitive Performance?

- Speech and executive functions (EF) are related [1, 2].
- However, the validity of speech biomarkers remains inconclusive [3].

- SpEx study collected behavioural data from healthy participants [4].
- We used ML to research if prosodic features can predict EF.

Can we acquire high-quality Neuroimaging during Productive Speech?

- SpExNeuro expands this by adding neuroimaging data.
- →Investigation of neural mechanisms linking speech and EF

- Speaking introduces noise and spatial misalignment in fMRI data.
- Identifying excessive motion is crucial to avoid false neural findings.

METHODS

PART A

SpEx: Prediction of EF by Prosody

sample: n=231

66 EF target variables

- attention
- cognitive flexibility
- working memory
- inhibition

spontaneous speech tasks

- picture description
- story retelling
- fictional story telling

DATA

openSMILE
audio feature extraction

- frequency related features
- spectral features
- temporal features
- energy related features

264 prosodic feature variables

FEATURE EXTRACTION

Prediction of EF by prosodic features

- 10-fold cross-validation
- stratification (strat.) by target performance
- confound removal (CR) with linear regression model
- metrics: coefficient of determination (R^2)

PREDICTION

PART B

SpExNeuro: Expansion of SpEx through the integration of Neuroimaging Data

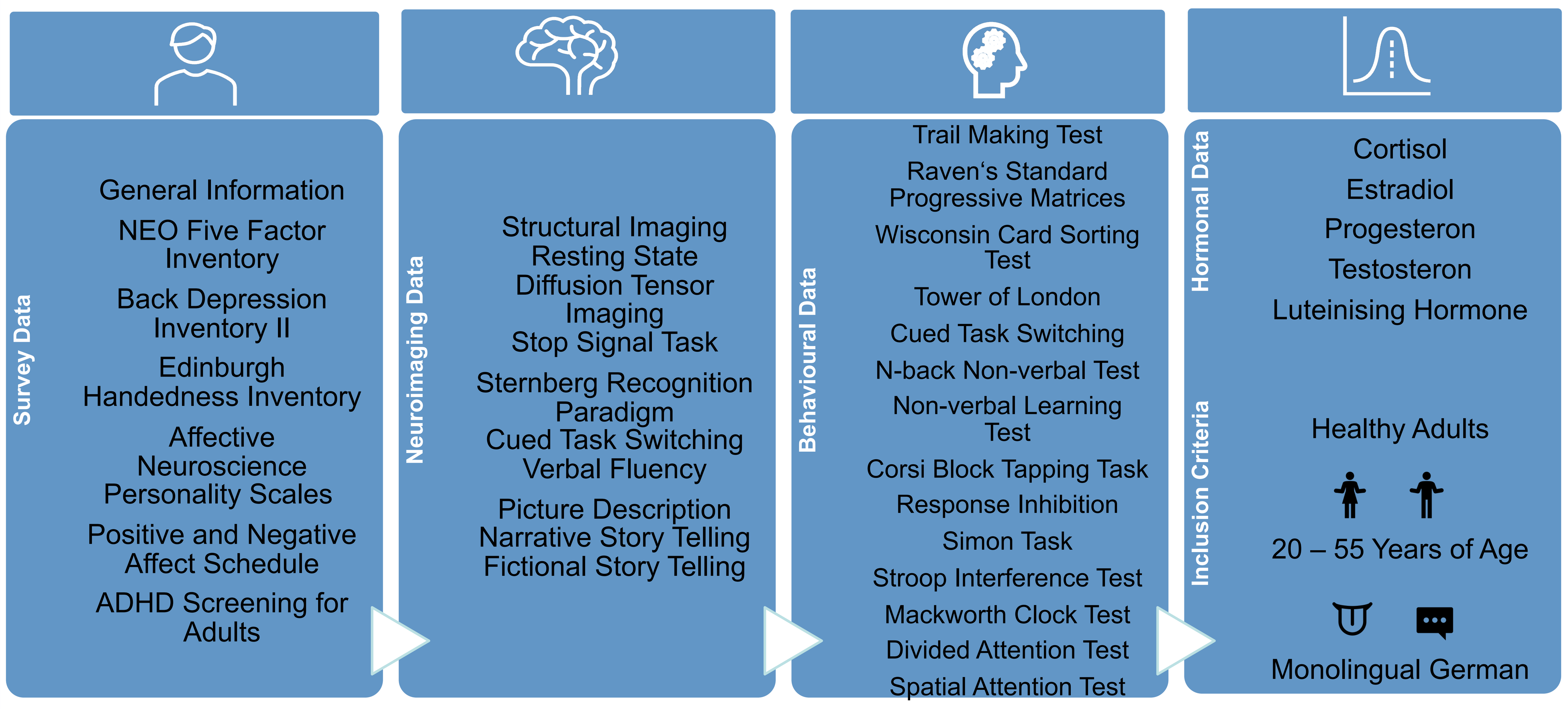

Fig. 1 Experiment Protocol SpExNeuro Study.
Scanning parameters for fMRI include 64 slices with a resolution of 2.2 mm x 2.2 mm x 2.0 mm³, TR = 980 ms, TE = 30 ms, FA = 70, a Multi Band Acceleration factor of 4, and DTI with 100 slices at a resolution of 1.6 mm x 1.6 mm x 1.6 mm³, TR = 3800.0 ms, TE = 70 ms, b-value = 2500 s/mm², and a Multi Band Acceleration factor of 4.

Neuroimaging Quality Control

- MRIQC [6] tool-box used to extract automated image quality metrics.

- Metrics used to evaluate data integrity and control for artifacts in analysis:
  - DVARS,
  - Framewise Displacement (FD),
  - Probability Score

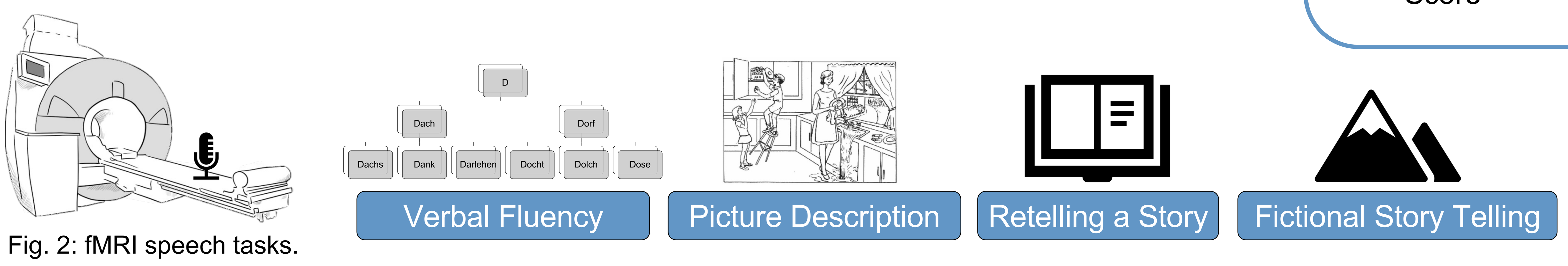

Fig. 2: fMRI speech tasks.

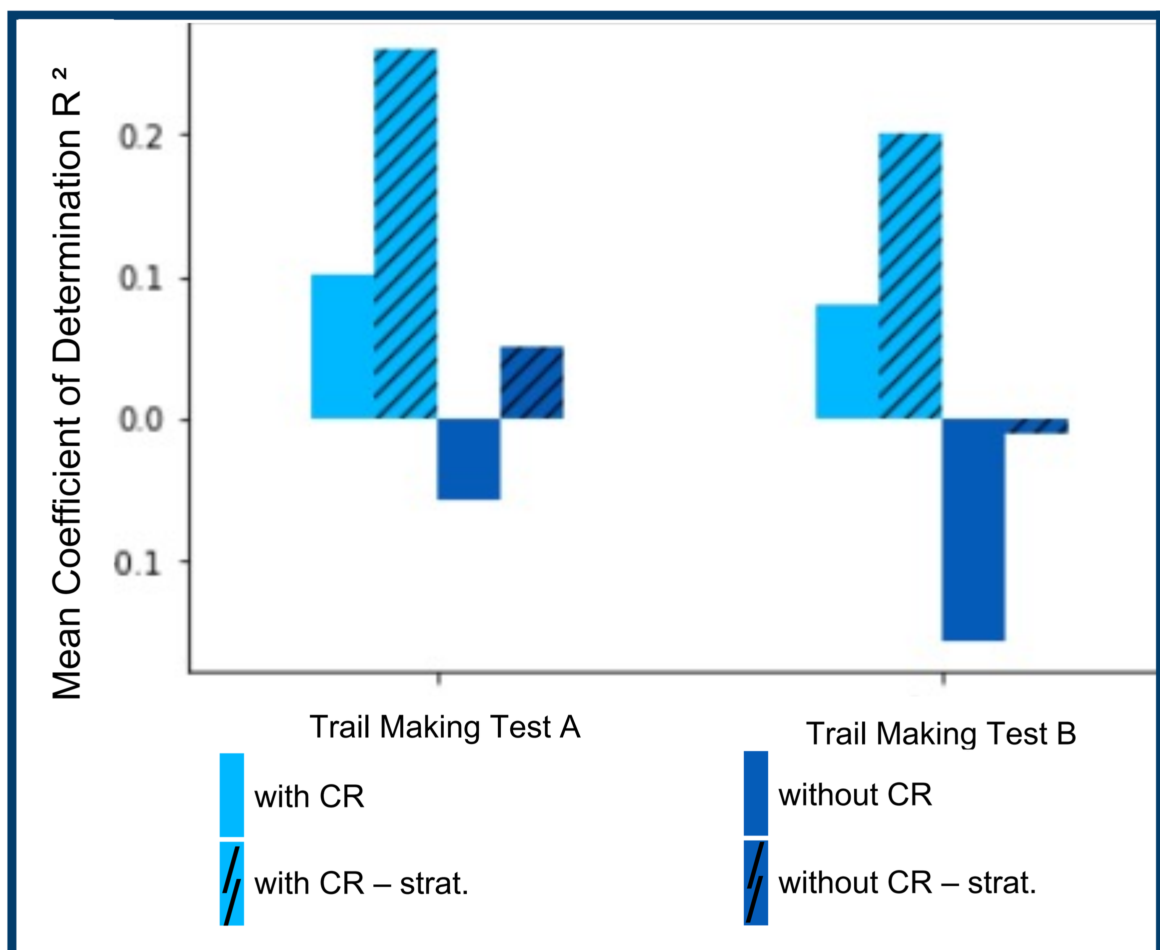

Fig. 3: Prediction of Trail Making Test targets in different conditions [5].

- Trail Making Test performance is predictable from prosodic features, despite small effects.
- Prediction power decreases when not removing the confounding variables, though.
- Careful control of confounding variables is essential.

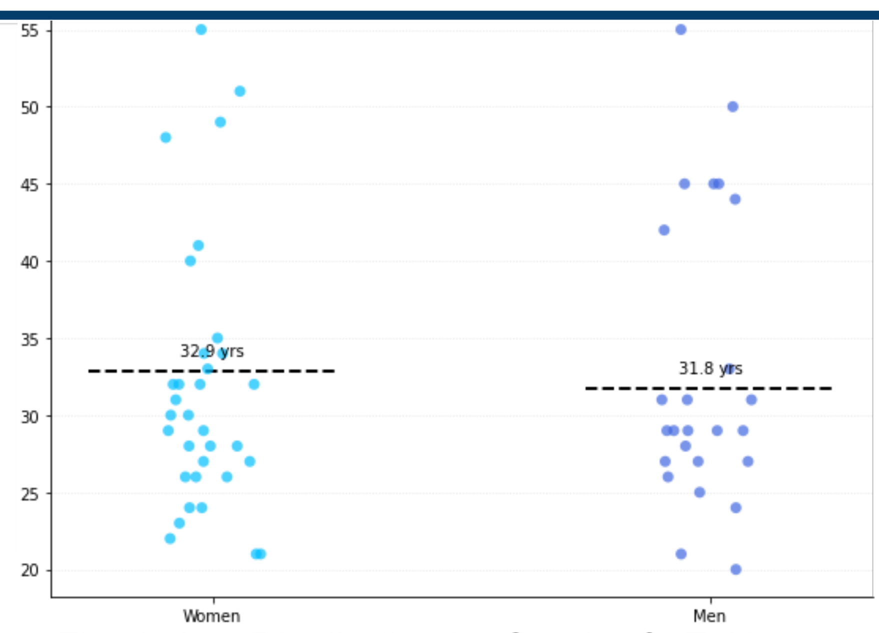

Fig. 4: Age Distribution by Gender SpExNeuro. Data acquisition is ongoing

Raw Data before Correction

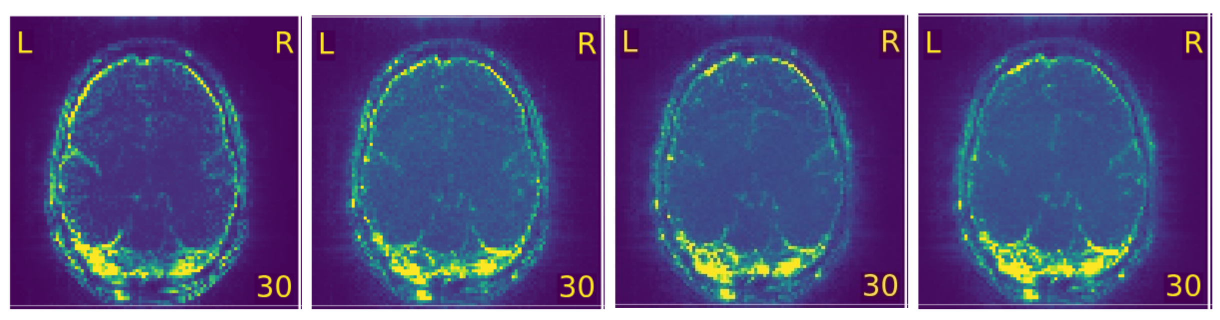

Fig. 5: Standard Deviation of signal through time of the four speech tasks. Exemplary for one subject.

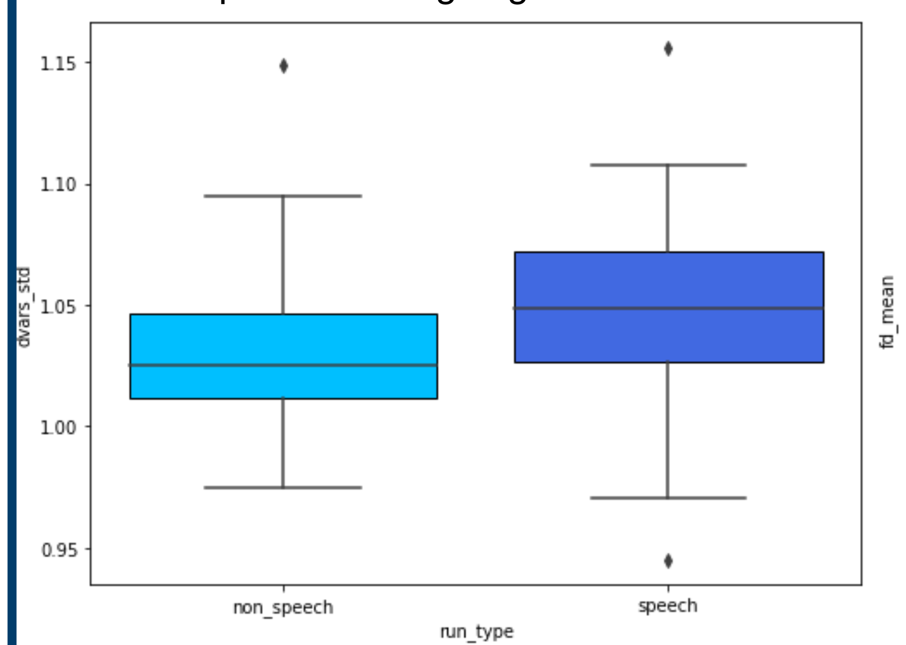

Fig. 6: DVARS: Speech vs Non-Speech. Higher signal variability observed during speech production.

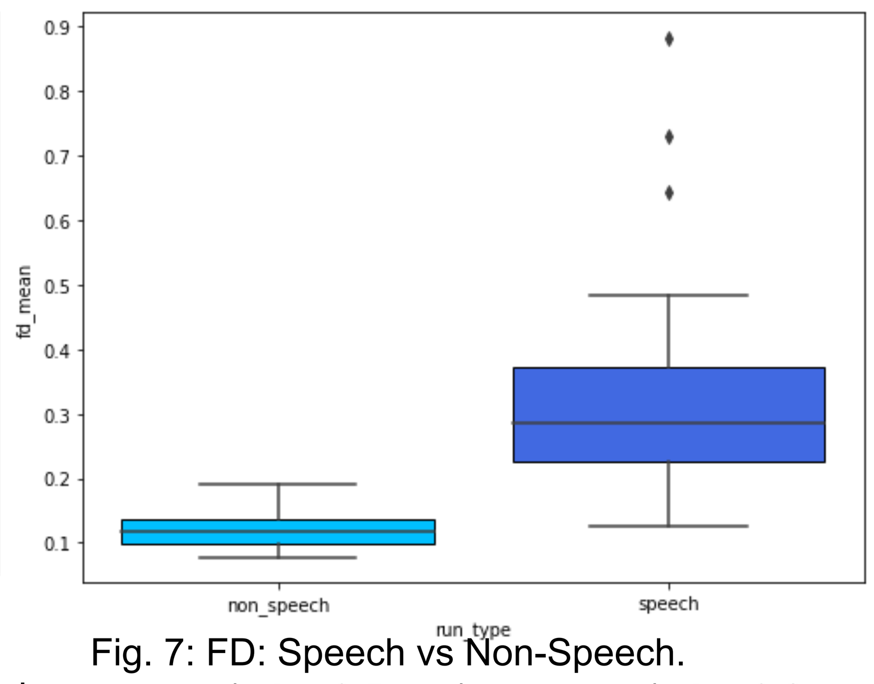

Fig. 7: FD: Speech vs Non-Speech. Lenient (FD = 0.5 mm) and strict (FD = 0.2 mm) thresholds [7].

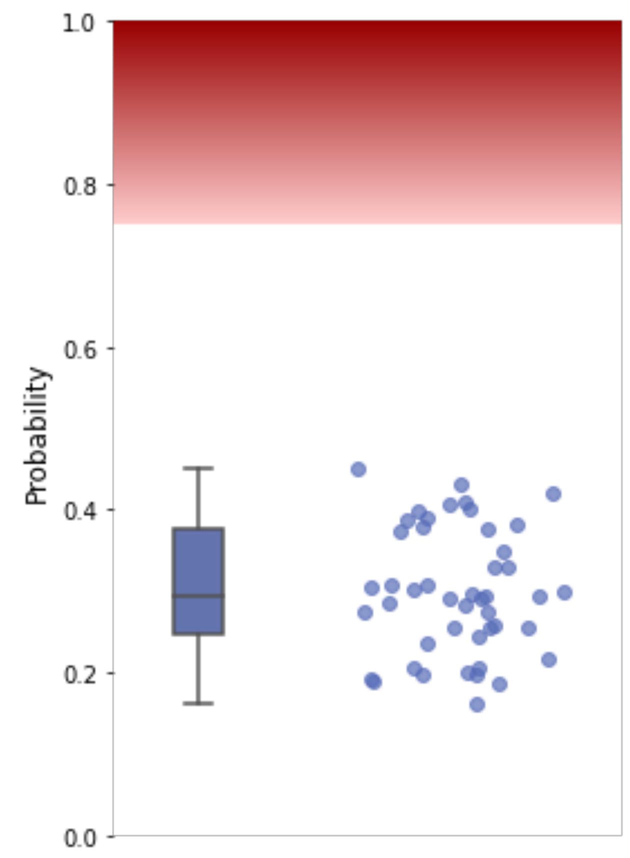

Fig. 8: Probability Score Distribution for T1. Overall quality score derived from all IQMs – all subjects < 0.75.

DISCUSSION

- SpEx(Neuro) datasets provide a comprehensive multimodal resource to investigate individual differences.
- ML analyses can uncover shared brain activation patterns of speech and EF.

- Quality control is crucial for maintaining data integrity and ensuring that observed effects reflect true neural and cognitive processes - particularly in productive speech data, which is highly sensitive to noise and motion.
- Despite expected variability, our results suggest that acquiring productive speech in the scanner is feasible without major loss in image quality.

- We encourage scientists to leverage this growing dataset for collaborative research.
- → Available data paper: Camilleri & Volkening et al., 2024 [4]

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Preprint: PART A

Scan me! → → →

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