Explainable AI for Autism Diagnosis
Identifying Critical Brain regions using fMRI data

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NEURAL INFORMATION PROCESSING SYSTEMS

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THE CHALLENGE OF EARLY AUTISM DIAGNOSIS

- Lengthy wait times, expensive and subjective assessments
- Potential bias in current diagnostic methods, affecting diverse groups
- Critical early intervention windows often missed due to delayed, uncertain diagnoses

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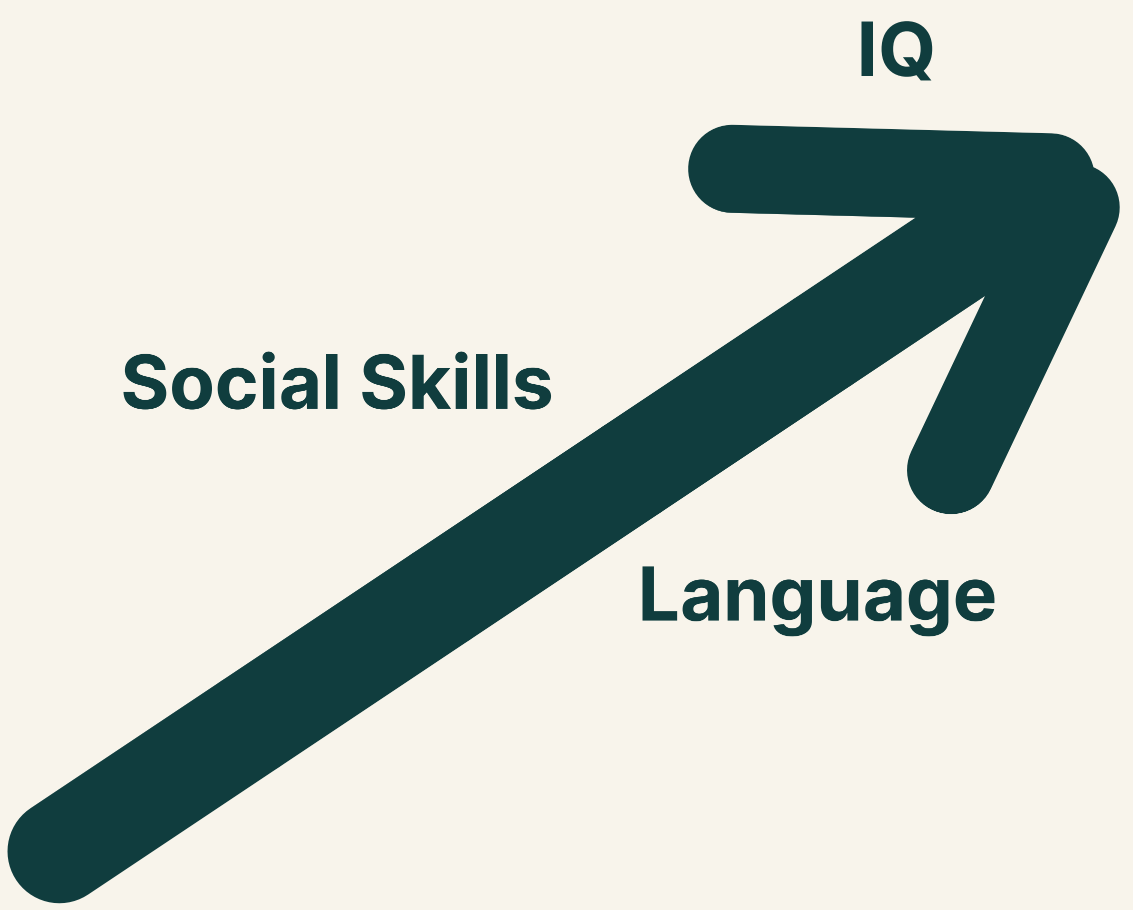
WHY EARLY DIAGNOSIS MATTERS

- Early (age 2-3) identification of Autism Spectrum Disorder (ASD) can significantly improve long-term quality of life
- Timely interventions enhance language, social skills, and cognitive development
- Reducing diagnostic delays helps harness critical windows for optimal support

(Estes et al., 2015; Okoye et al., 2023)



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THE BRAIN AND AUTISM

- Resting-state fMRI measures how different parts of the brain are active over time at rest.
- Functional connectivity looks at which areas of the brain's activity rise and fall together, indicating they are "connected."
- Differences in functional connectivity can serve as "biomarkers" for ASD.

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THE POTENTIAL OF AI

- Deep learning detects subtle fMRI patterns linked to autism.
- But most AI models are "black boxes," offering no explanation.
- We build upon previous research to improve MRI-based models and add transparency, so we know why a decision is made.

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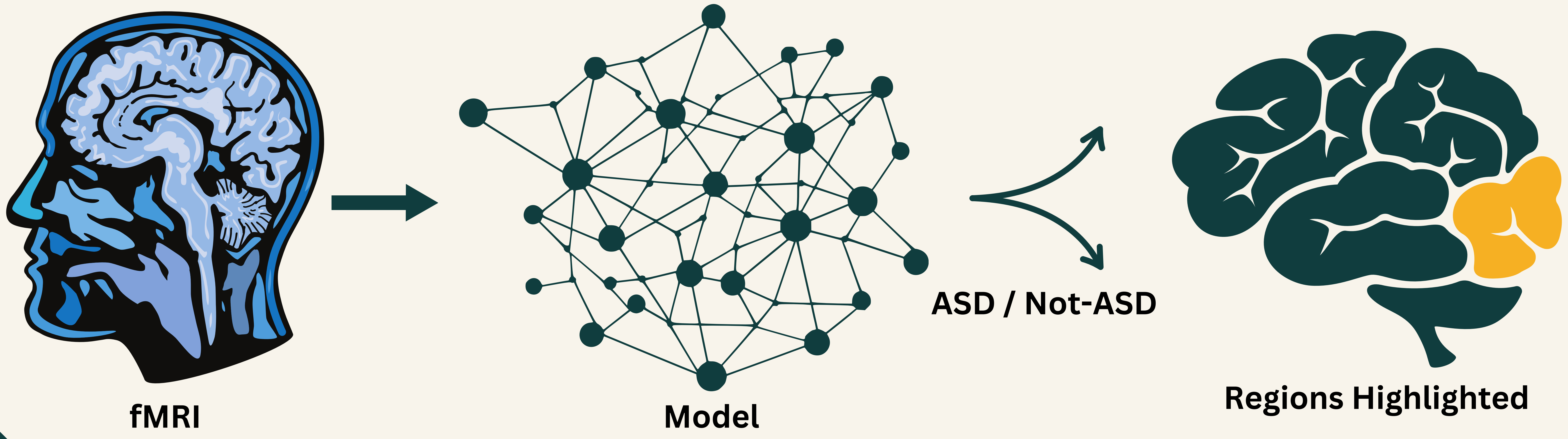
HIGH LEVEL APPROACH



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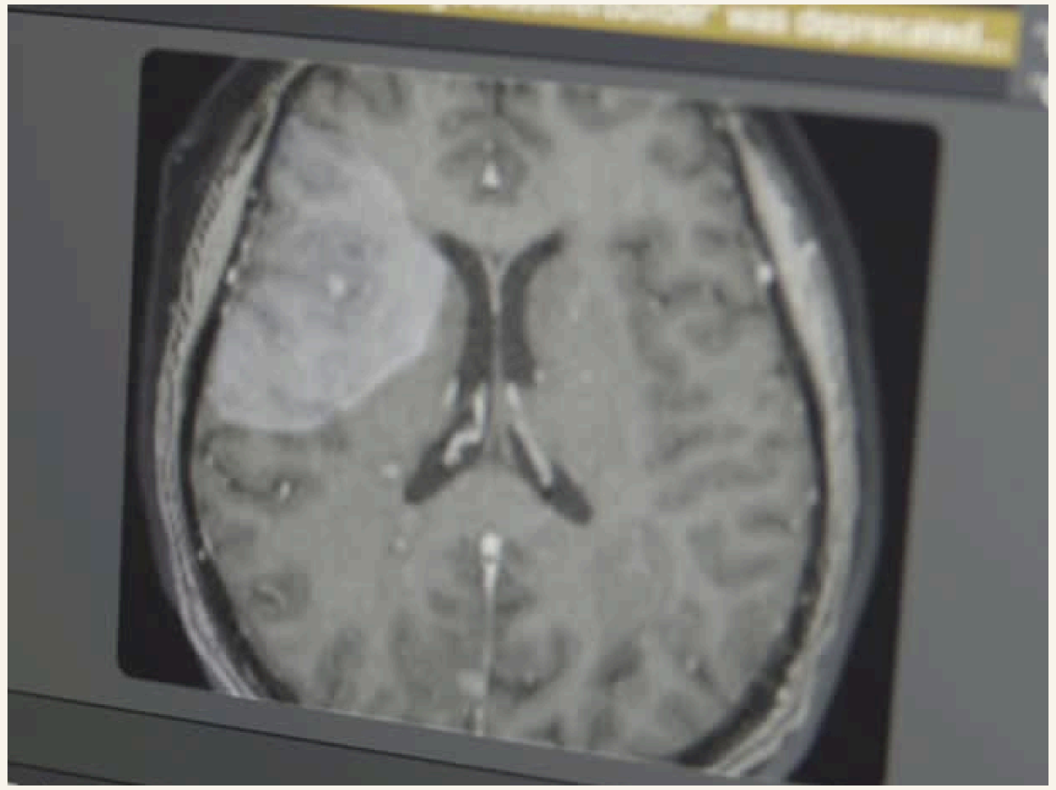
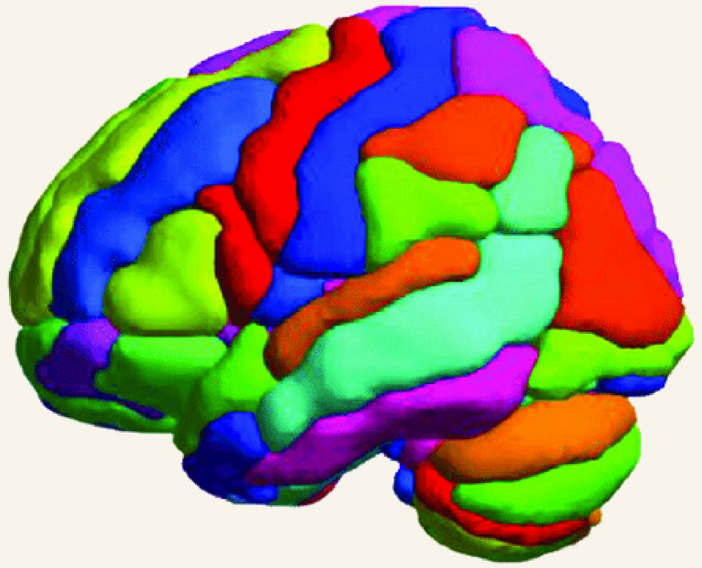
DATA AND PREPROCESSING

- Utilized the largest publicly available dataset: ABIDE (1112 samples)
- Ensured data quality by removing scans with excessive head movement, down to 884 samples.
- Applied standard preprocessing steps (e.g., motion correction, normalization)
- Parcellated the brain into 116 regions using the AAL atlas for consistent feature extraction



ABIDE I (Di Martino et al., 2013)



AAL atlas (Tzourio-Mazoyer et al., 2002)

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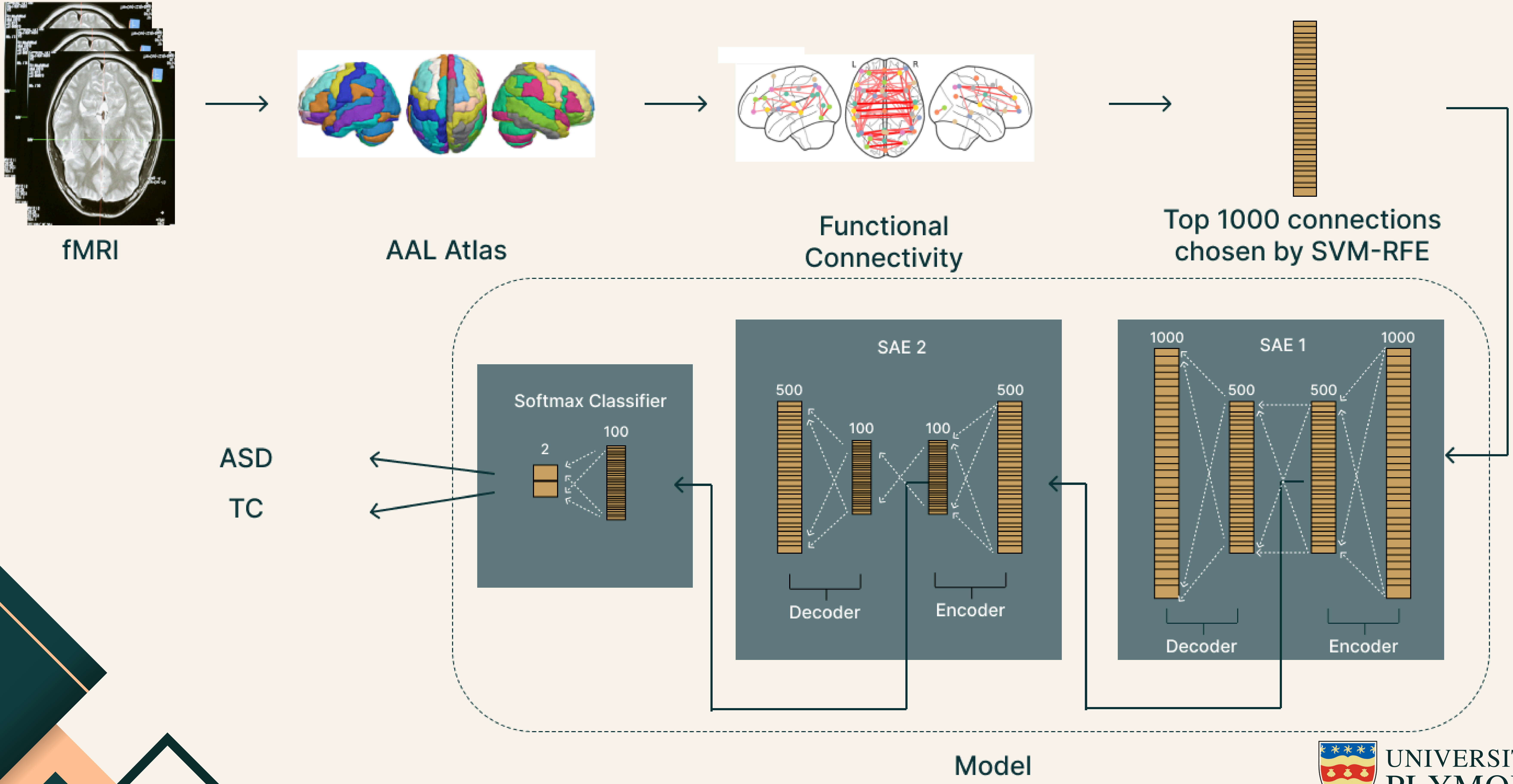
THE MODEL ARCHITECTURE



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RESULTS

Model	Accuracy
Pavithra et al. (2023)	85.0%
Bhandage et al. (2023)	92.4%
Wadhera et al. (2023)	88.1%
Wang et al. (2019)	93.5%
Our Model	**98.2%**

Sensitivity: 0.99
Specificity: 0.98
Precision: 0.98
F1 Score: 0.98

Overfitting?

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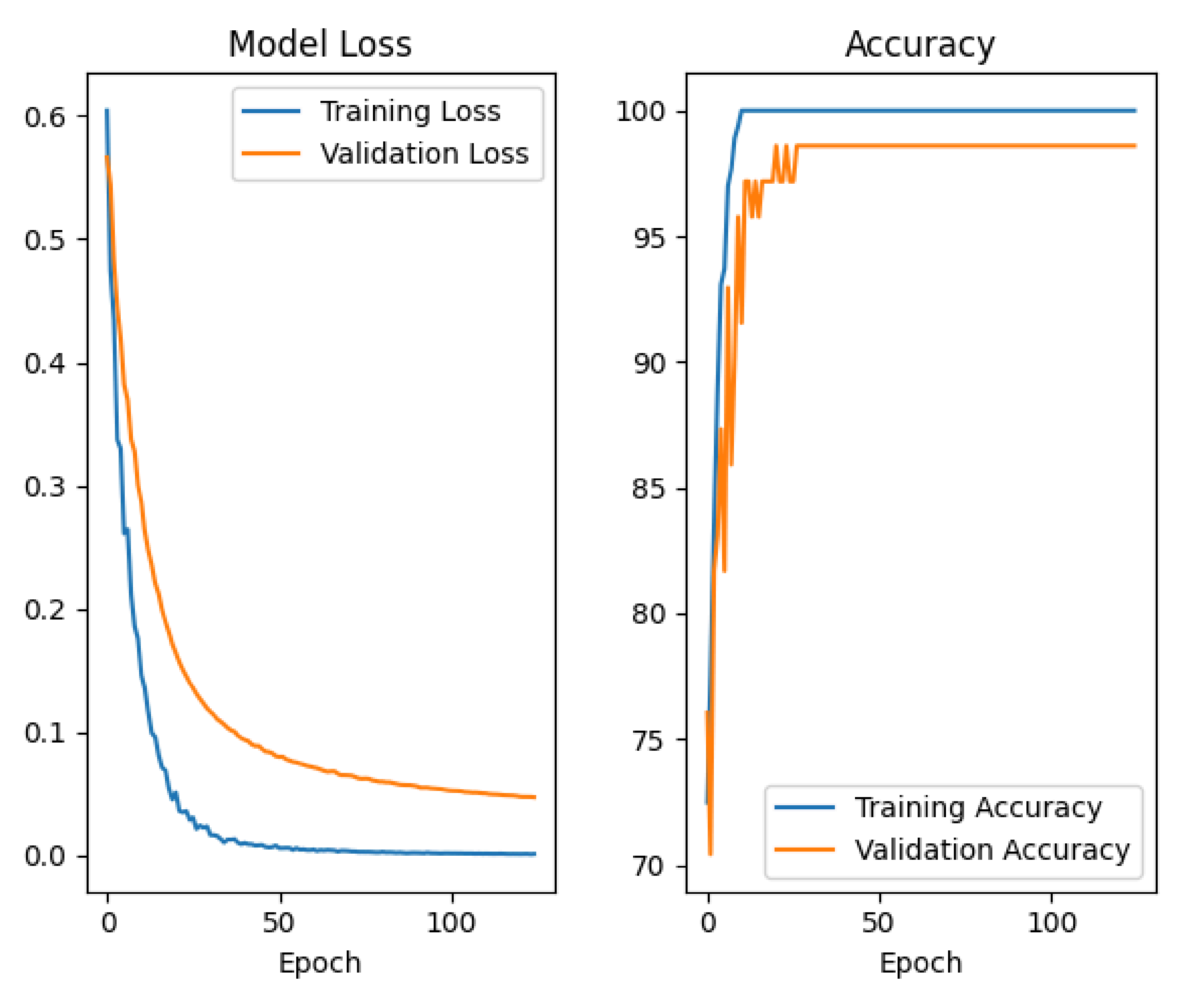
LOSS MONITORING

- Training and validation loss both decrease steadily over time
- Validation loss remains stable, not diverging from training loss
- Indicates good generalization



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WHAT METHOD TO USE?

List of recent interpretablility methods we implemented from literature:

- Integrated Gradients
- LIME
- SHAP
- DeepLift
- DeepLiftShap
- GradientShap
- GuidedBackprop

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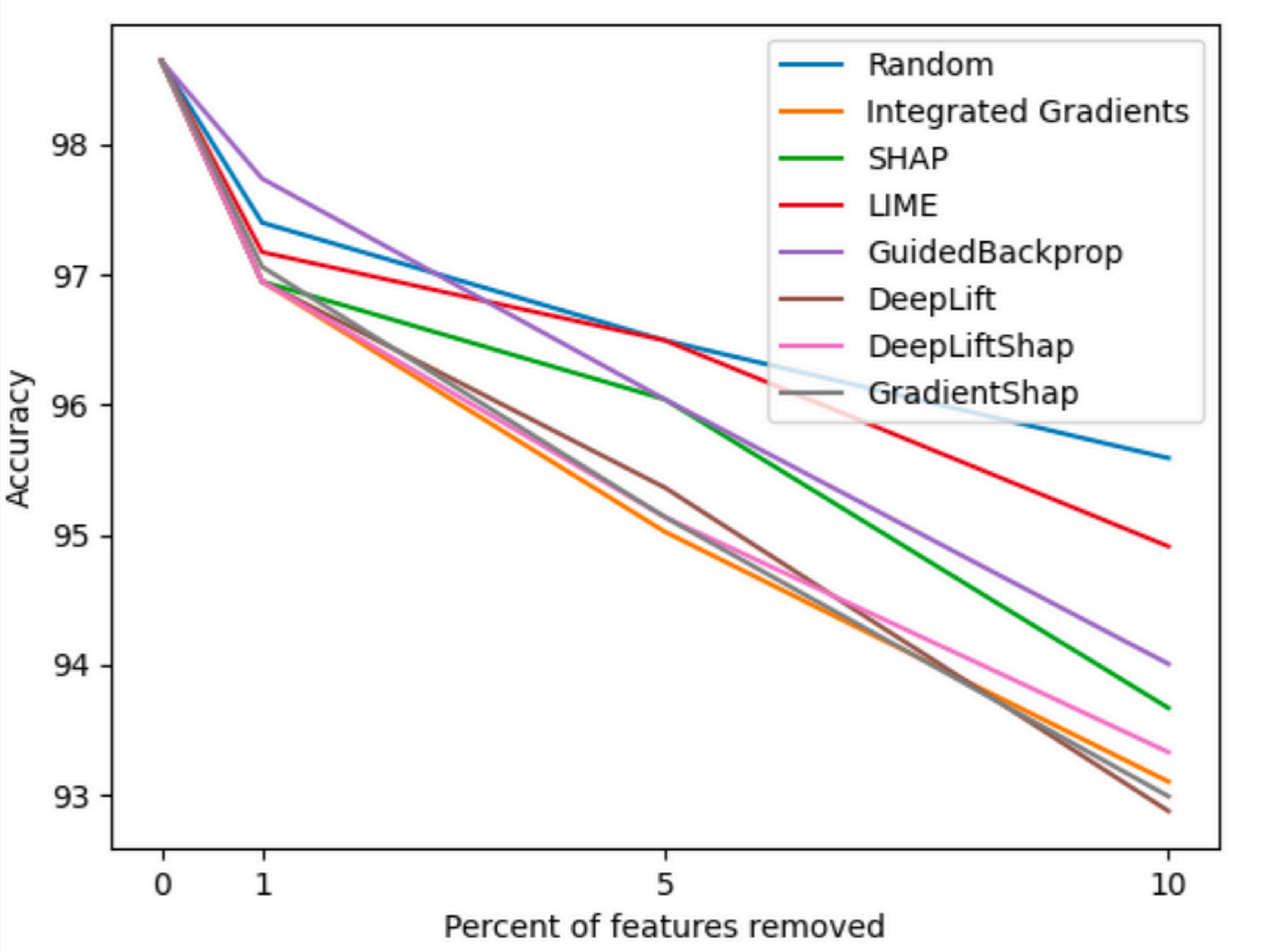
BENCHMARKING METHODS

- The RemOve And Retrain (ROAR) benchmark (Hooker et al., 2019).
- Gradient-based methods performed best
- Perturbation methods performed the same as a random baseline
- Integrated Gradients was the best performing method



ROAR Analysis

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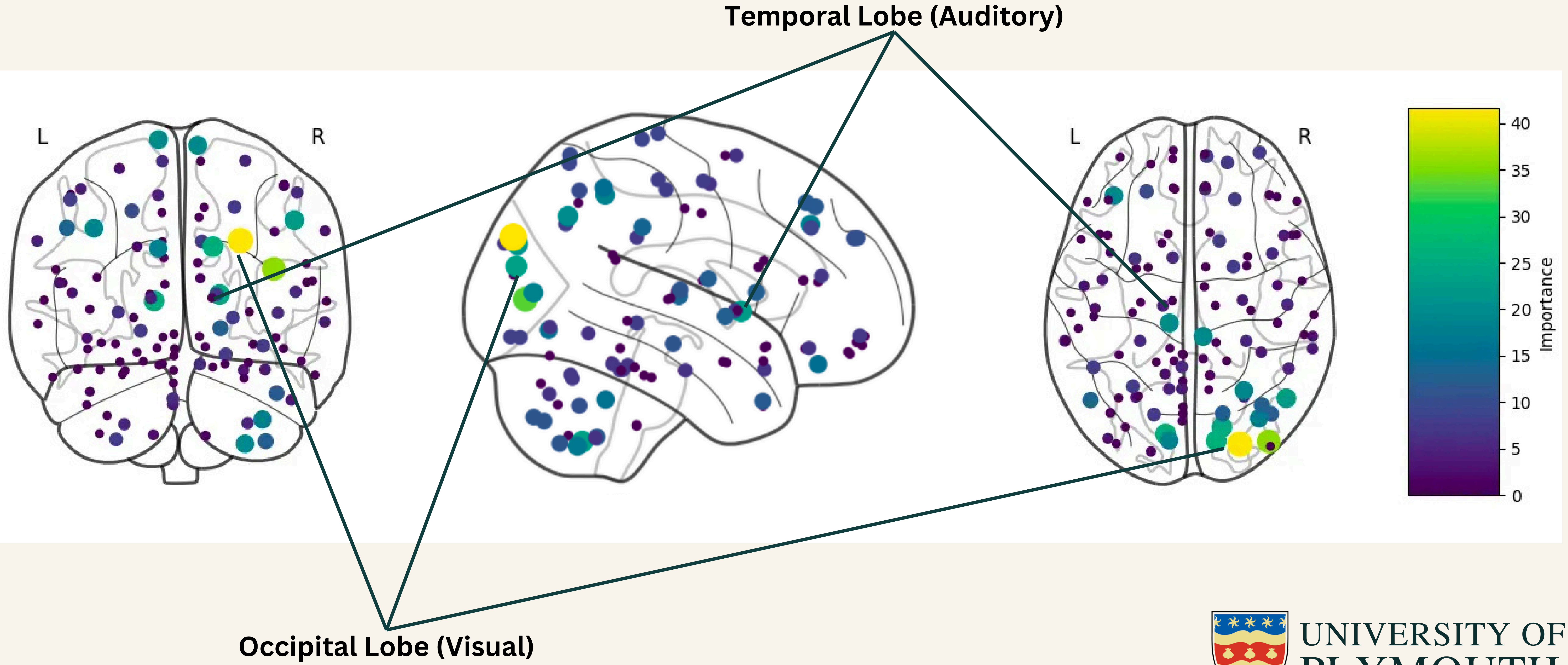
IDENTIFIED BRAIN REGIONS



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LITERATURE ANALYSIS

Consistent findings across multiple research approaches:

- Genetic studies highlighting importance of visual cortex in autism (Gandal et al., 2022)
- Other directions like global motion perception deficit research and atypical gamma oscillation studies also show links to visual and auditory cortex (Orekhova et al., 2023; Robertson et al., 2014)

Demonstrates potential biomarkers common across ASD severity levels

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LIMITATIONS AND FUTURE DIRECTIONS.

- Tested only on ABIDE so we do not know performance on OOD data. There is a need for larger datasets.
- Need a dataset with other forms of neurodivergents such as ADHD, otherwise we might just be building a neurodiverse classifier instead of an Autism one.
- Use of multi modal data. Autism symptoms show in other modalities of data as well such as eye tracking, EEG etc.
- Also need to explore alternative imaging methods like optical imaging, which offer greater accuracy and speed than fMRI

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QUESTIONS