360? Turns Out We Only Needed 8

Varying data cleaning and normalization methods to identify the crucial ROIs contributing to our MLP model's accuracy

Age of Perceptron Members

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Project Background

Background Literature

- Machine learning (ML) methods are widely used to decode cognitive processes from fMRI studies (Liang et al., 2018).
- Rastegarnia et al. (2023) trained nine ML decoder models to predict whether inter-subject BOLD activations predicted different task conditions and found that Multilayer perceptron (MLP) achieved the best accuracy.

Guiding Research Questions

- When training an MLP model, do specific data cleaning and normalization methods lead to better results?
- Could we train our MLP model to conduct whole-brain reduction to determine which regions most contributed to its accuracy?

Project Approach

Hypotheses

Phase 1: Cleaning & Normalization

- ‘Original’ cleaning method will yield the most accurate modeling predictions.
- Subject-wise normalization will be a better approach as it allows for the consideration of absolute BOLD values between subjects.

Phase 2: Whole-Brain Reduction

- Regions associated with specific visual processing (Liang et al., 2018) and emotional processing (Sylvester et al., 2017; Zheng et al., 2017) will play a significant role in discrimination accuracy.

Data Set: HCP 2021

- Emotion Processing Task
- 100 Subjects
- 2 Conditions (Fearful, Neutral)
- 6 Blocks of 18 Trials across 2 Runs*

Phase 1: Cleaning & Normalization

3 Data Cleaning Methods

'Original'

'Hard'

'Cleverer'

X

3 'How' Normalization Methods

Whole Sample

Subject -Wise

Baseline

X

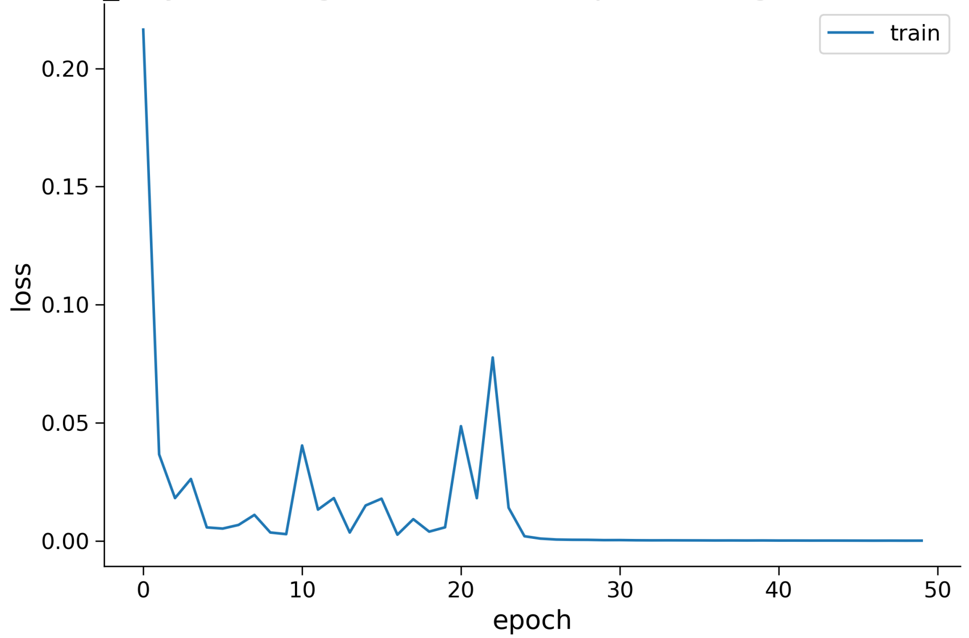
2 'When' Normalization Methods

Before

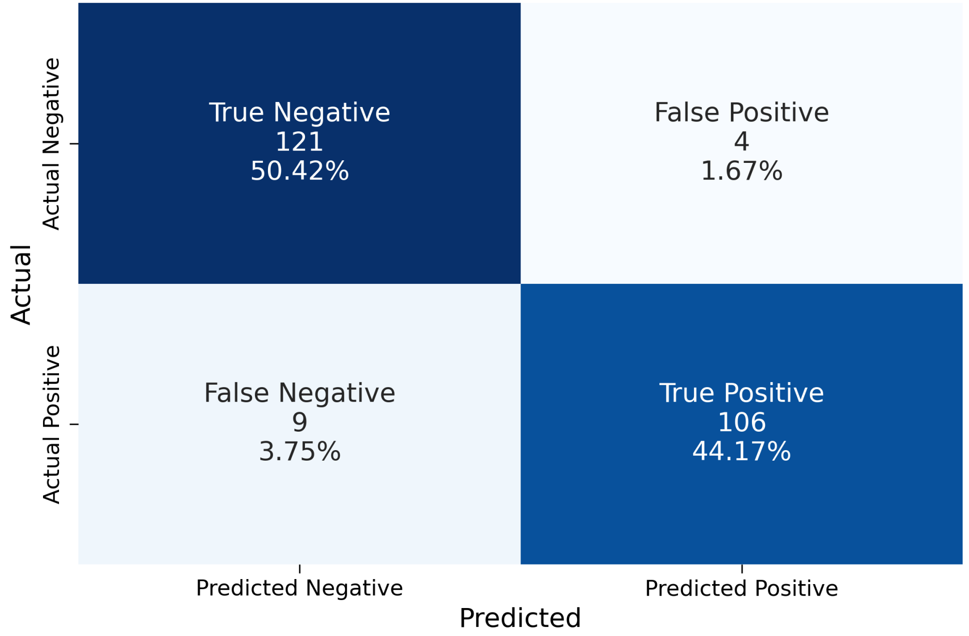
After

Phase 1: Key Findings (I)

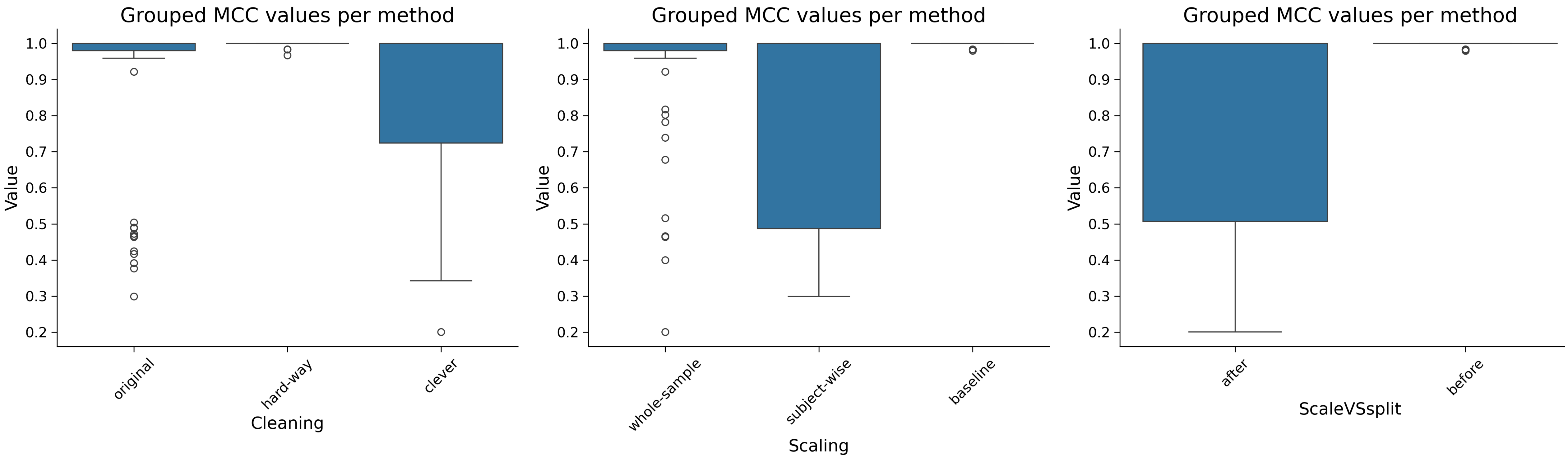
Loss per epoch for MLP metrics
with 'hard_way' cleaning and 'whole-sample' scaling, done before splitting



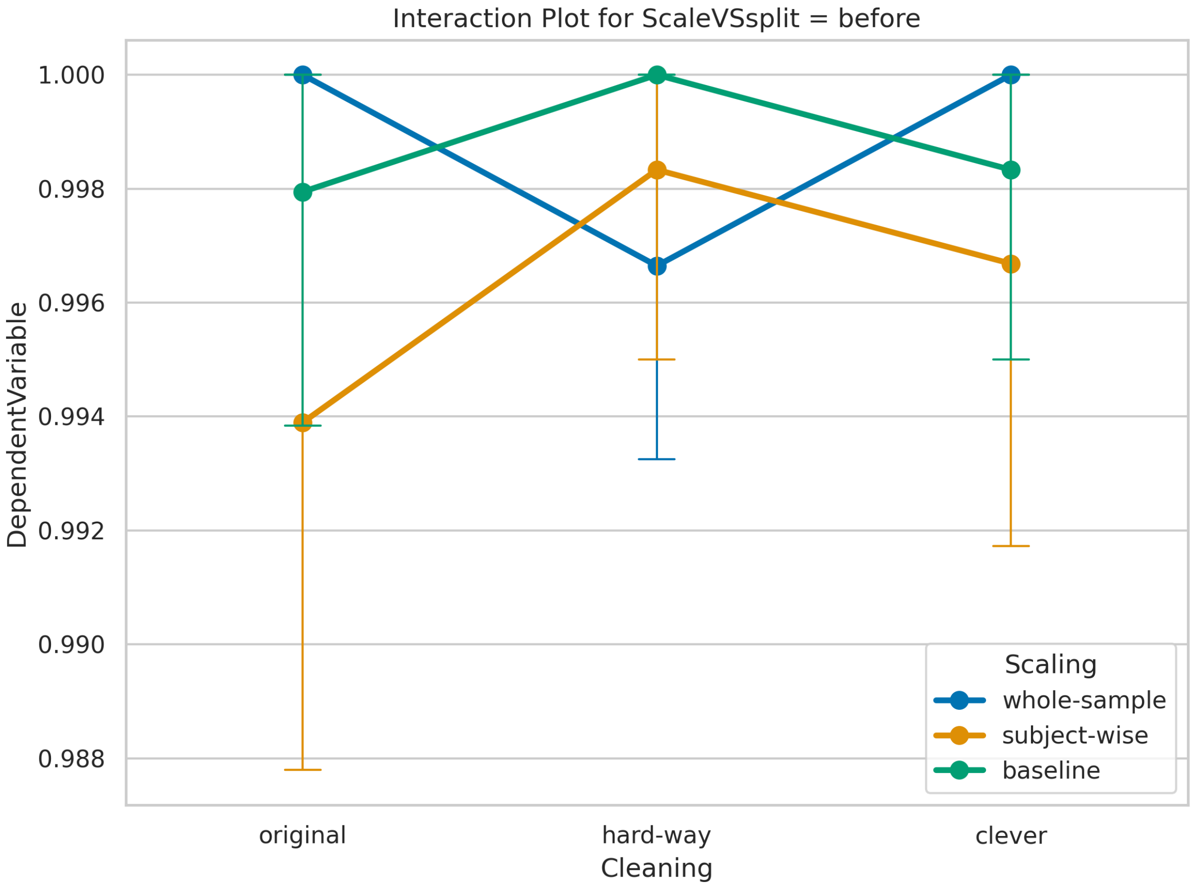
Confusion Matrix for MLP metrics
with 'hard_way' cleaning and 'whole-sample' scaling, done before splitting

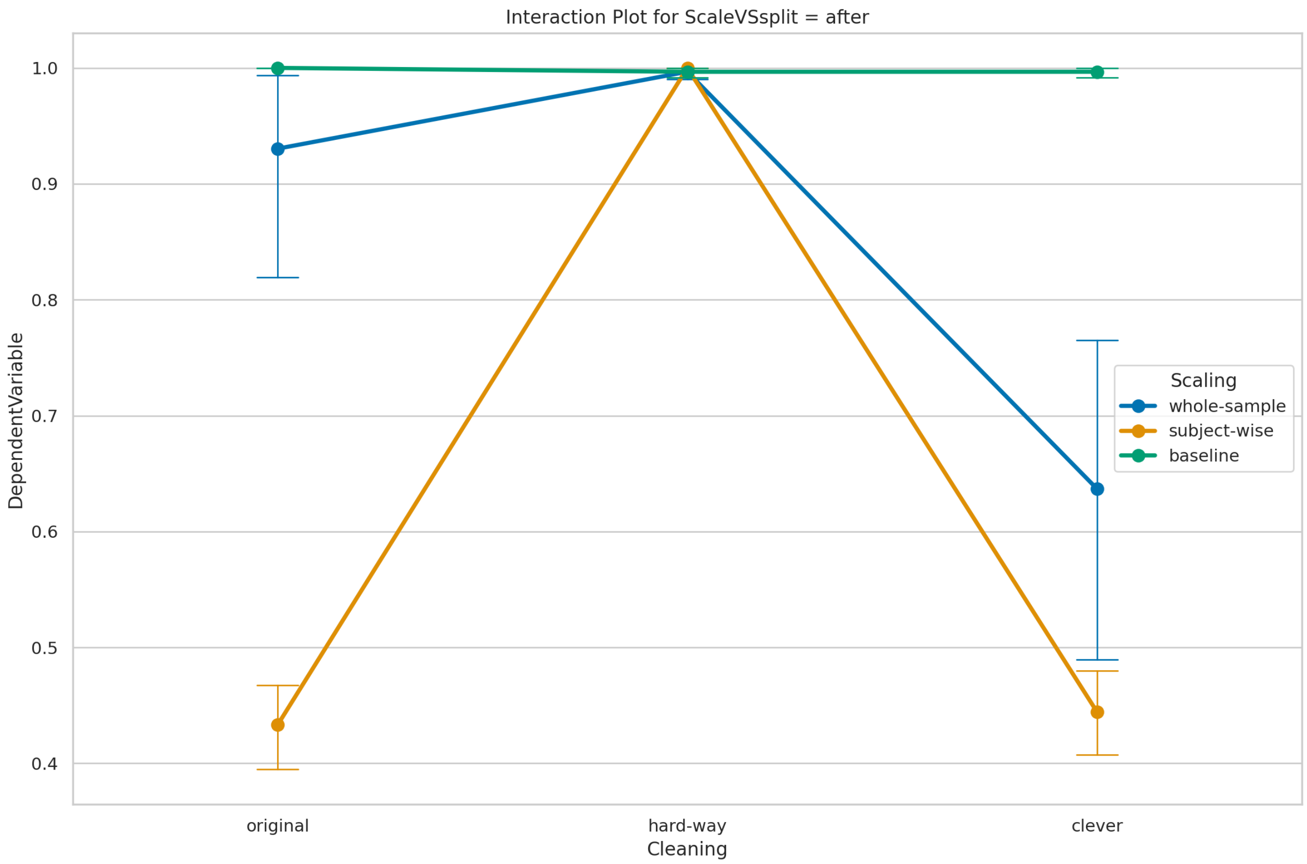


Phase 1: Key Findings (II)

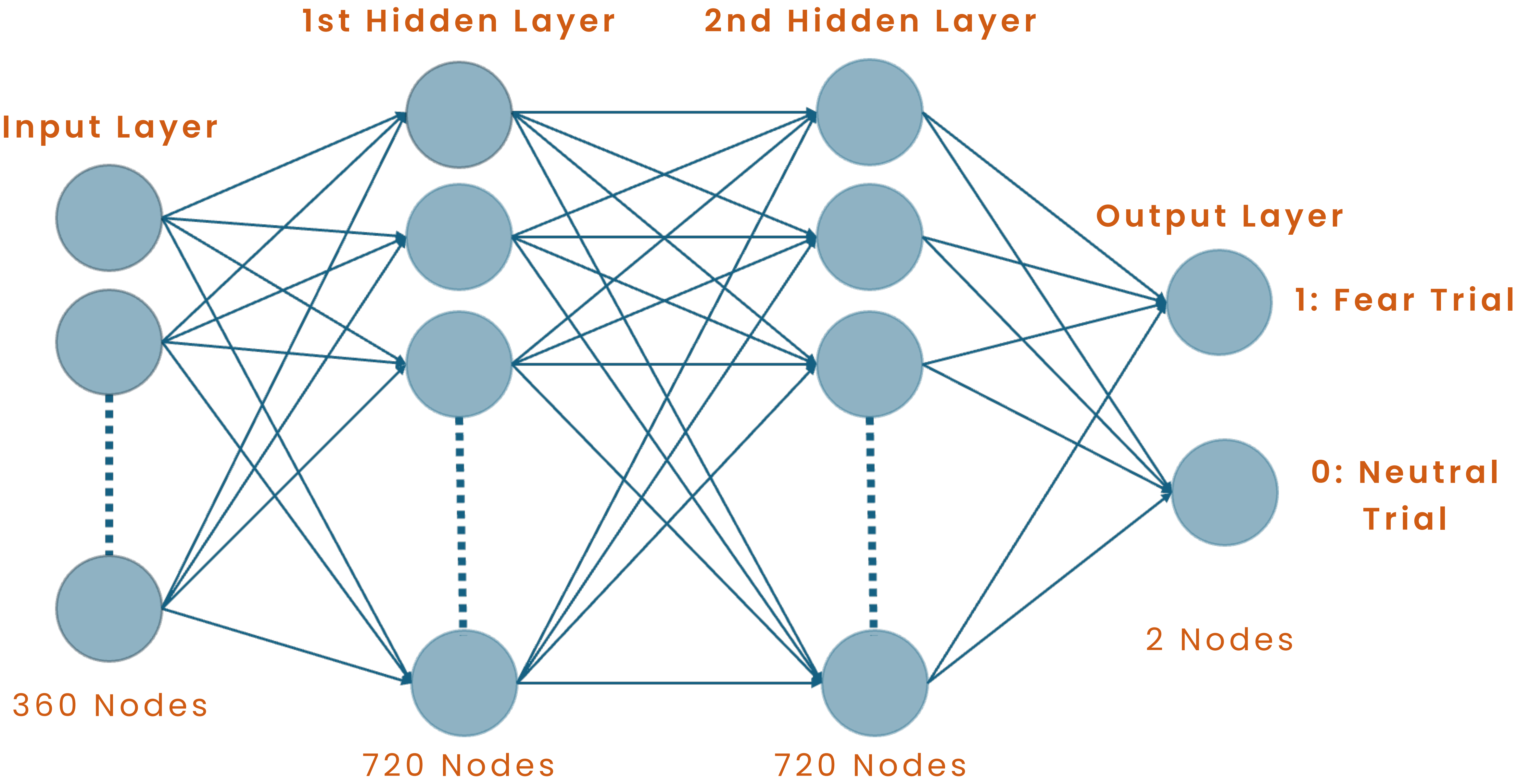


Phase 1: Key Findings (III)





Phase 2: MLP Architecture



Phase 2: Removing Non-Significant ROIs

MLP Training

- At each round and each iteration, the network was trained with 1 ROI removed.
- Significant ROIs were identified based on the model's accuracy, and these ROIs were selected for training in the next round.
- In each round, we trained the neural network with two-thirds of the ROIs from the previous round (e.g., if there were 360 regions in the previous round, there would be 240 regions in the current round).

Round 1

360 ROIs

At each iteration, the NN was trained with **359** ROIs (1 different ROI removed) – **360** models were trained

Round 2

240 ROIs

At each iteration, the NN was trained with **239** ROIs – **240** models were trained

Round 3

160 ROIs

At each iteration, the NN was trained with **159** ROIs – **160** models were trained

Round 11

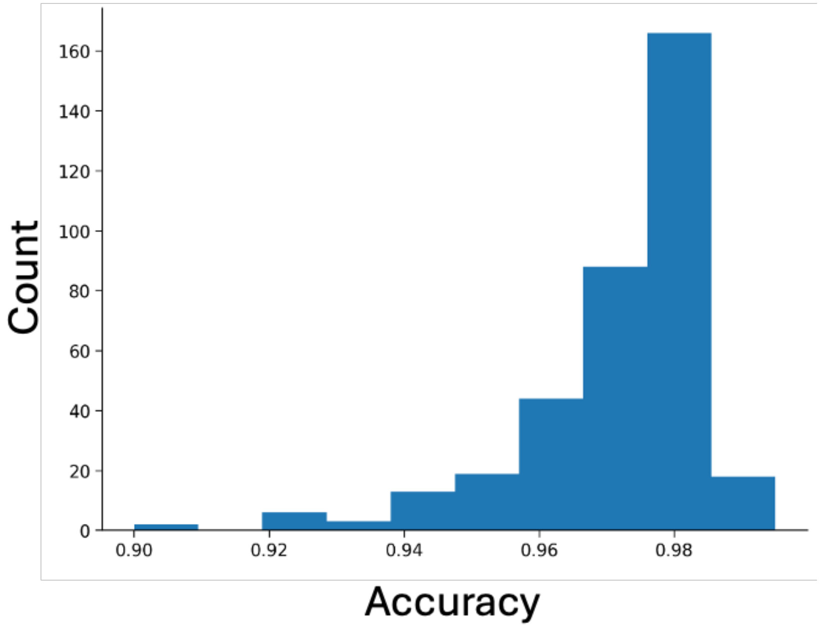
8 ROIs

At each iteration, the NN was trained with **7** ROIs – **8** models were trained

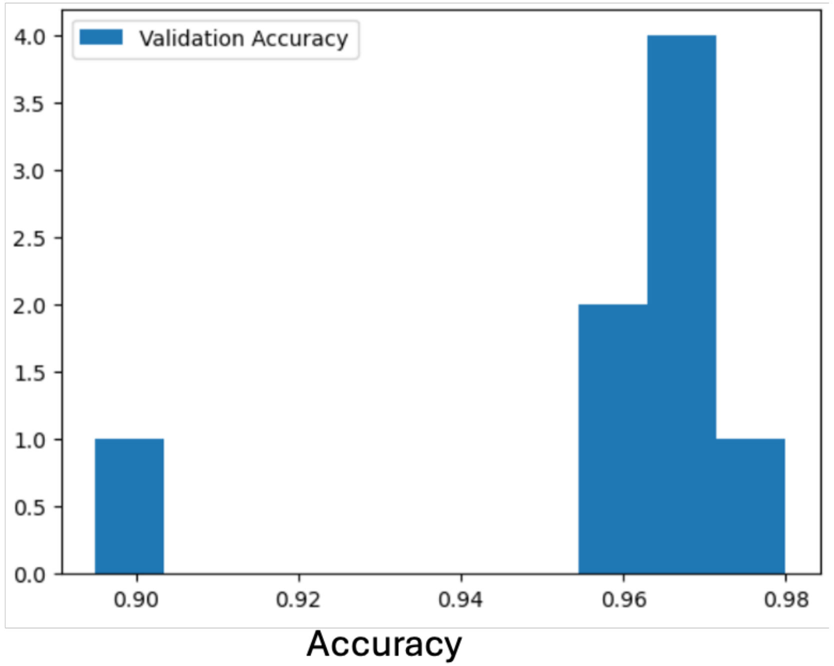
Phase 2 Results

- 8 significant brain regions in the last round
- The neural network was trained with 7 brain regions in each iteration
- Results of the neural network showed high accuracy after training the network with significant ROIs only

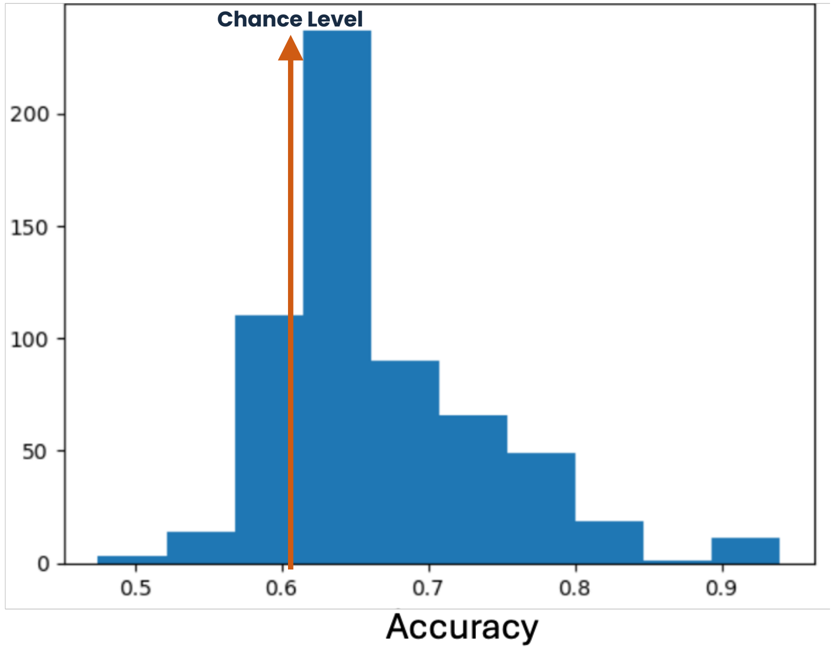
Round 1– 359 Brain Regions



Round 11 – 7 Brain Regions



Random Sampling – 600 Samples – 7 Brain Regions



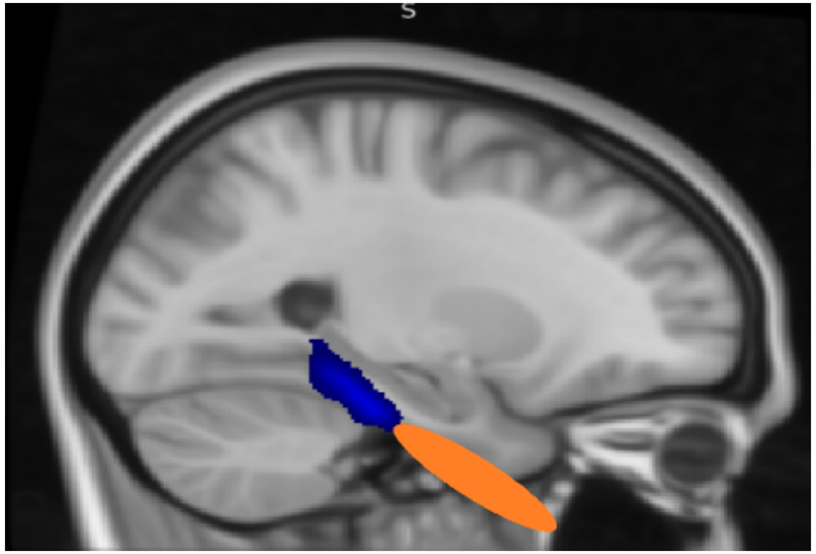
Phase 2: From 360 to 8 ROIs

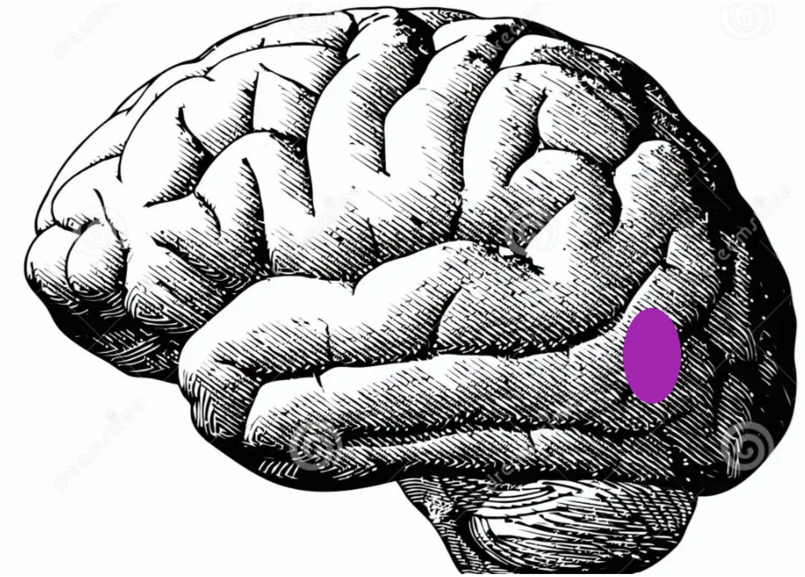
Left

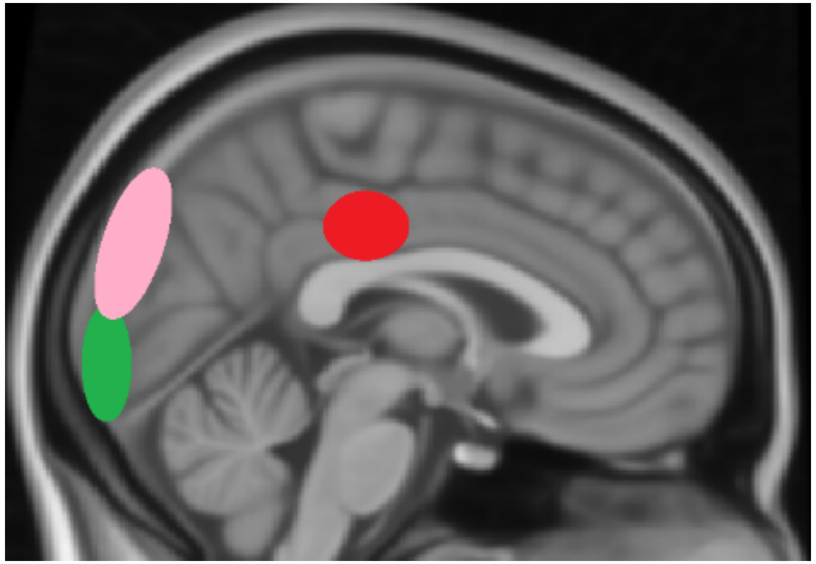
Entorhinal Cortex

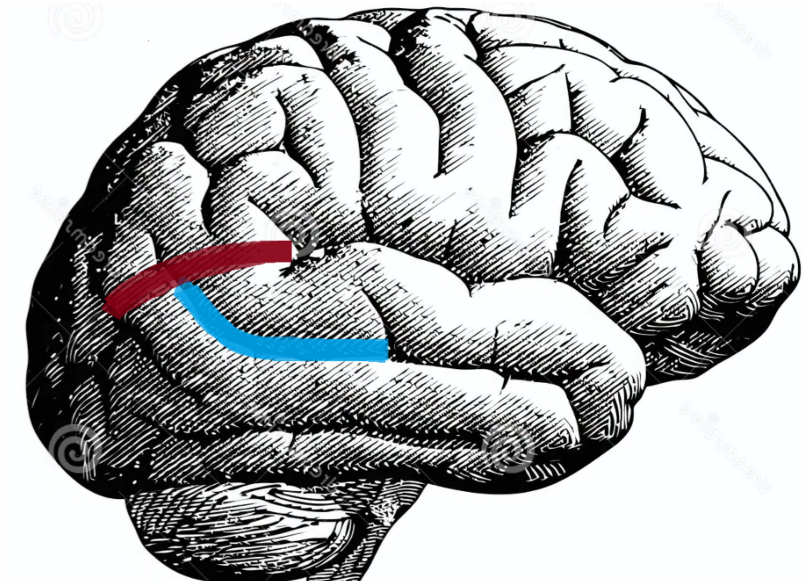
Para hippocampal gyrus

Visual Cortex (V5 Area)









Right

Posterior Midcingulate Cortex

Visual Cortex (V3 Area)

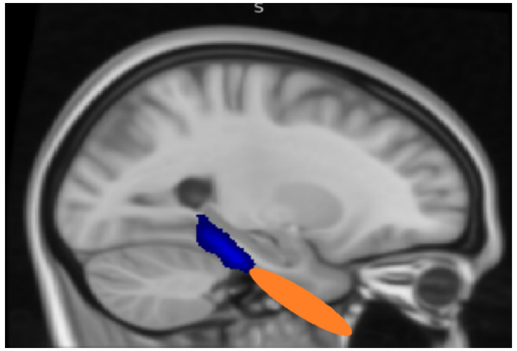
Lateral Occipital Cortex

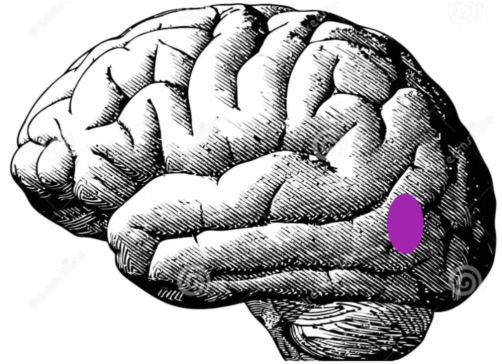
Superior Temporal Sulcus

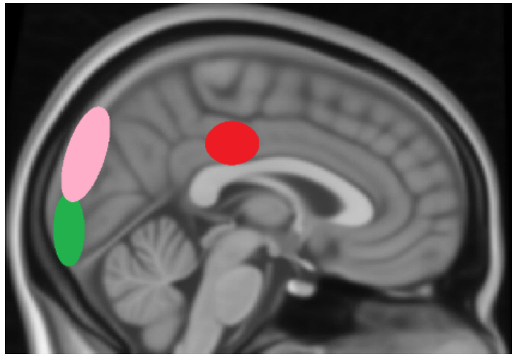
Temporo-Parieto-Occipital Junction

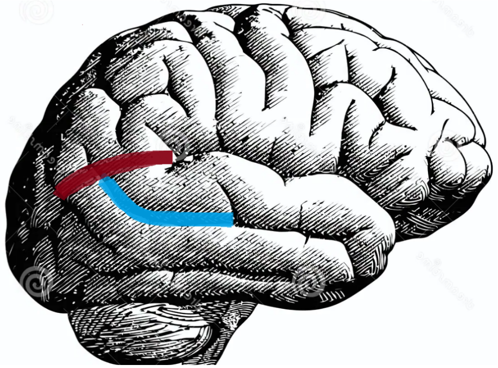
Phase 2: Why These 8 ROIs?

- **Retinotopic Cluster- V3** (Swisher et al., 2007)
  - Visual processing of shapes
- **Posterior Midcingulate Cortex** (Maddock et al., 2003)
  - Emotional salience and fear learning
- **Superior Temporal Sulcus Dorsal Posterior** (Pitcher et al., 2017)
  - Face processing and connected to the amygdala
- **Temporo-Parieto-Occipital Junction** (Beauchamp, 2005)
  - Recognizing stimuli patterns and integrating visual cues related to fear
- **Lateral Occipital Cortex** (Grill-Spector et al., 2001)
  - Intact object processing with clear shape interpretations
- **Middle Temporal- V5** (Kravitz et al., 2013)
  - Processing of depth and visual motion
- **Entorhinal Cortex** (Wilson et al., 2013)
  - Aids in recognizing novel objects based on contextual features
- **Para hippocampal gyrus** (Baker et al., 2018)
  - Encoding stimuli, with greater activation for objects than faces









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