# Medial prefrontal cortex compresses concept representations through learning


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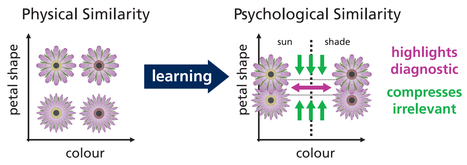
## Introduction

Prefrontal cortex (PFC) is thought to focus on goal-relevant information. Specifically, medial PFC has been shown to code for latent structures of experience in cognitive maps[1,2,3].

Category learning models formalize this process through feature-based attentional tuning and knowledge clustering[4,5].




This theoretical convergence suggests mPFC may perform data reduction, compressing task-irrelevant features and emphasizing goal-relevant information structures.

## Research Questions

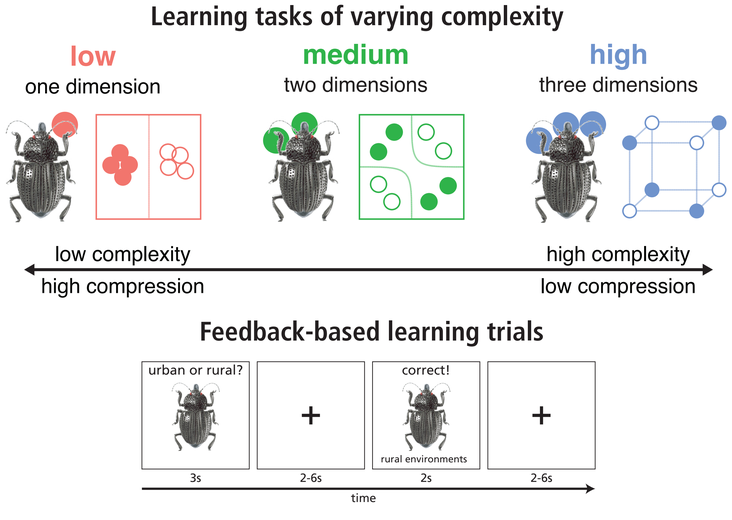
- Does mPFC perform goal-sensitive data reduction during learning?
- Are individual differences in learning ability and attentional tuning predicted by mPFC neural compression?

## Methods

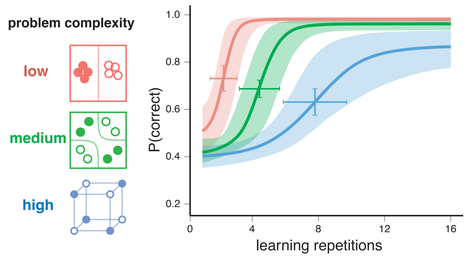
**fMRI category learning tasks** (1.7mm-iso voxels, 2s TR, whole brain)

22 participants learned three classic categorization tasks[6]

4 fMRI runs per task, 32 trials per run, 128 trials total per task

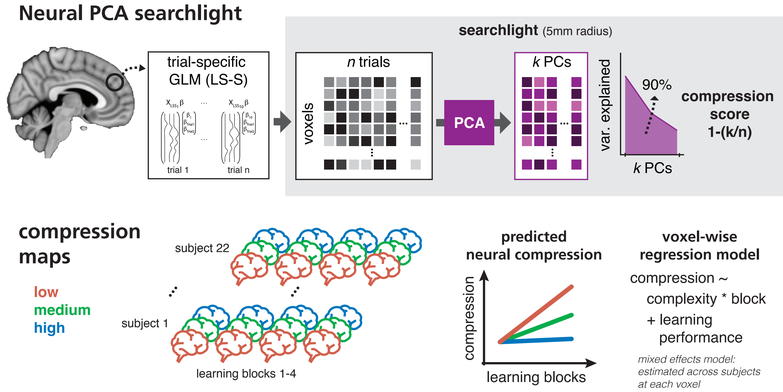



## Learning Behaviour



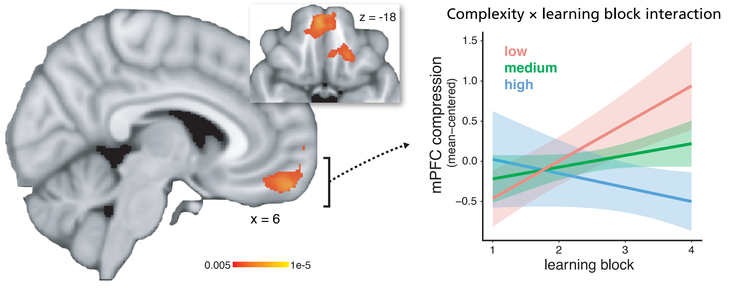

- Both low and medium complexity problems learned quickly
- Complexity related to learning difficulty
- RTs showed corresponding speed-ups with learning

## Indexing neural dimensionality reduction with principal component analysis (PCA)




## Learning-related neural compression

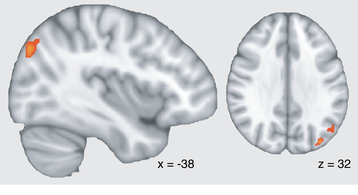
**Medial PFC representational compression during learning**




- mPFC representations show task-specific compression (low > medium > high complexity)
- Neural compression emerges over learning
- Similar pattern in left parietal, but subthreshold

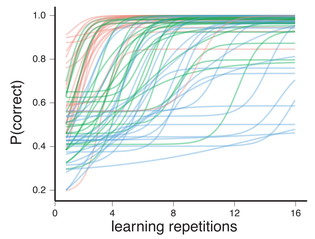
**Left Inferior Parietal**

Cluster extent 167 voxels, P = 0.05 threshold of 176 voxels

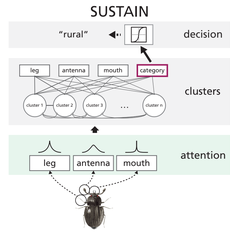


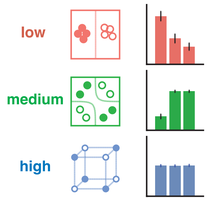

## Neural compression predicts individual differences in learning ability

**Variability in learning ability**




**Computational modeling of learning**

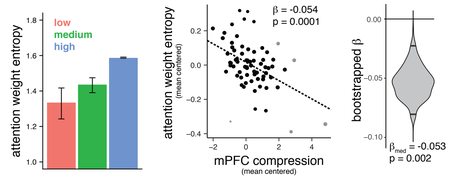



**Predicting attentional tuning with neural compression**

specificity of attentional tuning

$$entropy(w) = -\sum w_i \log(w_i)$$




Greater mPFC compression associated with more optimal task-specific feature attention

## Conclusions

- mPFC representations are shaped by experience through goal-sensitive dimensionality reduction
- mPFC compression consistent with mechanisms of SUSTAIN learning model[4,5], providing quantitative account of mPFC's role in concept *formation*[7]
- Dimensionality reduction through selective attention may underlie many mPFC functions (e.g., cognitive maps, latent causal models, schemas, value coding)


### Acknowledgements

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