The representation and retrieval of general versus specific category knowledge

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Introduction

Building useful knowledge requires learning both **general** and **specific** information (most dogs bark, but your friend's dog bites)

There is evidence that different neural systems may be dedicated towards learning this information[1-4]

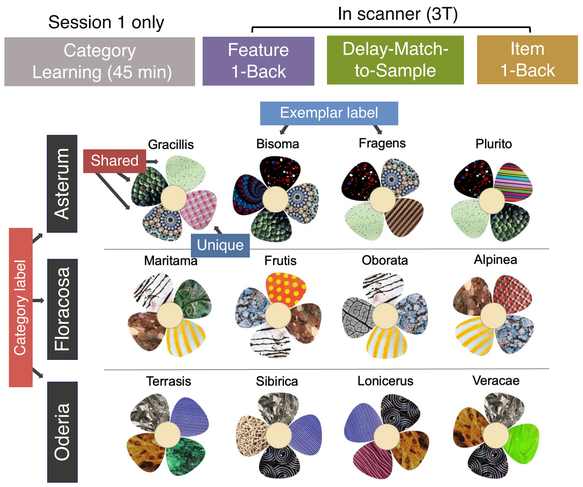
How does the brain **represent** and flexibly **retrieve** general versus specific knowledge?

How is this knowledge learned **rapidly** and how might it transform over **time**?

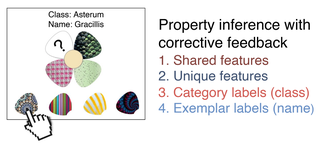
Design

n = 30, two-session fMRI (1-2 weeks apart)

Categories with **general** (shared features, category labels) and **specific** (unique features, exemplar labels) information

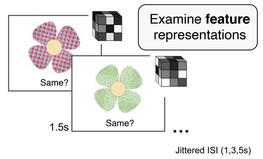


Category Learning

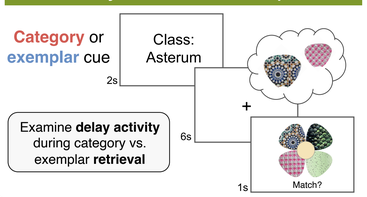


Property inference with corrective feedback
1. Shared features
2. Unique features
3. Category labels (class)
4. Exemplar labels (name)

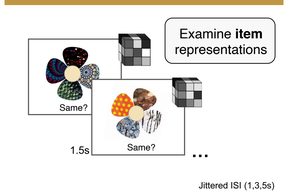
Feature 1-back



Delay-Match-to-Sample

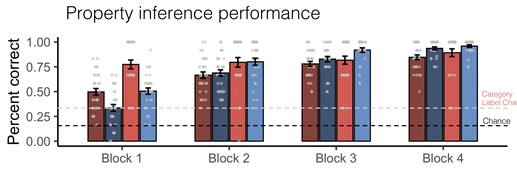


Item 1-Back

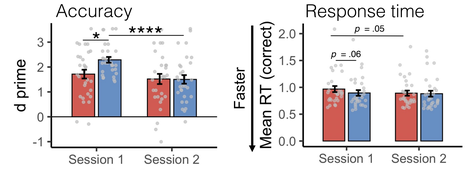


Behavioral Results

Category Learning



Delay-Match-to-Sample



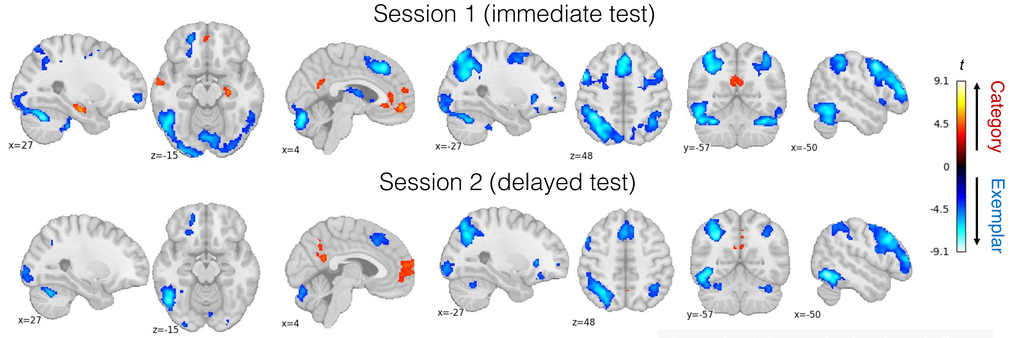
Shared Feature | Unique Feature | Category Label | Exemplar Label

Rapid learning of **general** and **specific** information. Memory for **exemplars** gets worse with time while **categories** persists

Retrieval Results

Delay-Match-to-Sample

Whole-brain univariate analysis: Category — exemplar retrieval



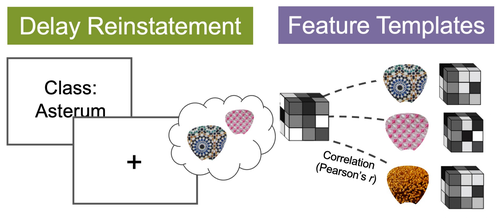
Clusters survived multiple comparisons using non-parametric permutation testing at $p < .05$
Analyses restricted to the first 3 seconds of the delay period on correct trials only

In session 2, less parietal and cerebellum for **exemplars** and less dorsal striatum for **categories**

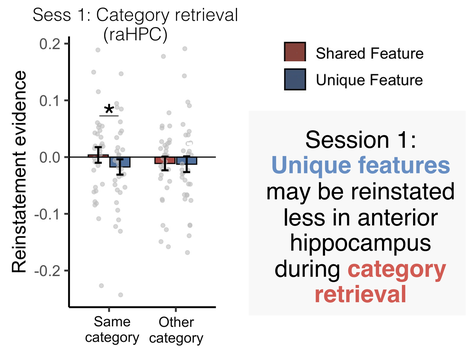
Category retrieval: Medial prefrontal cortex, anterior hippocampus, anterior temporal lobe, precuneus

Exemplar retrieval: Visual cortex, parietal cortex, dorsal and lateral prefrontal cortex, cerebellum

Preliminary hippocampal reinstatement analysis



Reinstatement Evidence
Correlation between delay period (retrieval) and feature patterns

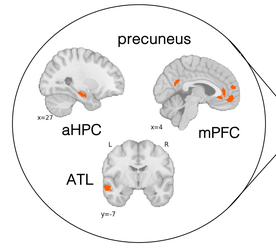


Session 1: **Unique features** may be reinstated less in anterior hippocampus during **category retrieval**

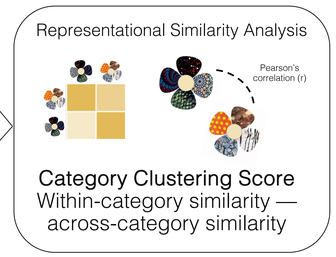
Item Representations

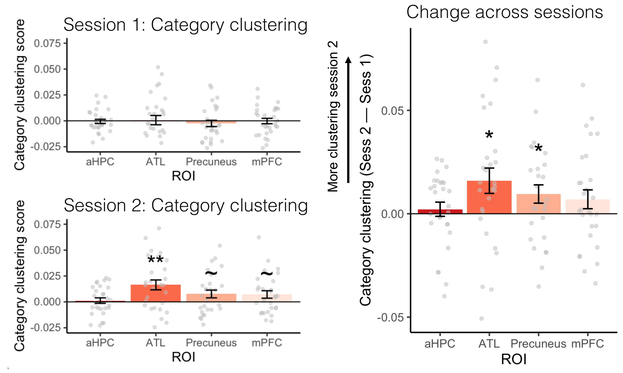
Item 1-Back

Category retrieval ROIs from delay-match-to-sample



Look for category clustering of items in these ROIs





Items show **category clustering** in category retrieval regions, but only after 1-2 weeks

Conclusions

Distinct brain regions support the retrieval of general vs. specific knowledge, consistent with work showing some of these regions employ representations at different levels of abstraction[2]

Representations of **items from the same category become more overlapping** in regions important for retrieving categories, but **only after consolidation**

Next Steps

Feature RSA, hippocampal subfield analyses, searchlight, relate neural measures to behavior, examine the content of reinstatement during category vs. exemplar retrieval

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References

1. Schapiro, A. C., Turk-Browne, N. B., Botvinick, M. M., & Norman, K. A. (2017). Complementary learning systems within the hippocampus: a neural network modelling approach to reconciling episodic memory with statistical learning. *Philosophical Transactions of the Royal Society B: Biological Sciences, 372*(1711), 20160049.
2. Bowman, C. R., Iwashita, T., & Zeithamova, D. (2020). Tracking prototype and exemplar representations in the brain across learning. *elife, 9*, e59360.
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4. McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory. *Psychological Review, 102*(3), 419.