Information Sharing Between Category Learning Systems

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Background

- Evidence supports distinct category learning systems[1,2] , which map on to distinct memory systems[3,4]
- Strong encapsulation predicts no interaction between systems[5]
- Information sharing refers to content shared between systems
- However, category learning systems can interact through:
  - Competition[6–8]
  - Parallel learning, but single-system responding[9–11]
- These types of interaction do NOT involve information sharing
- However, memory systems may share information[12,13]

→Is information sharing possible in category learning?

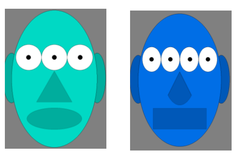
Research strategy: Category learning task with an explicit rule and simultaneous implicit pattern. If no information sharing, then no effect of implicit pattern.

Stimuli

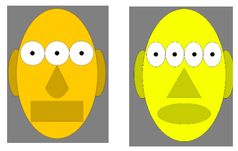
We constructed a stimulus set that simultaneously contained a rule based on shape (eyes and mouth) and a probabilistic color distribution.

Explicit rule: (exclusive OR)

Category A
Odd # eyes + round mouth OR
Even # of eyes + square mouth

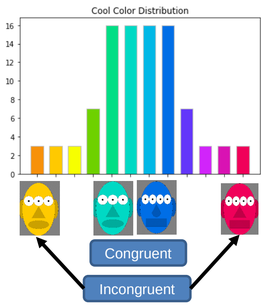


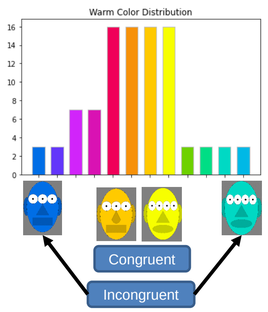
Category B
Odd # eyes + square mouth OR
Even # eyes + round mouth



Participants *WERE* told the eye-mouth rule for categorization.

Implicit color distribution:

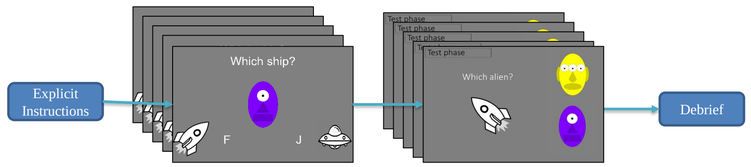




Participants *were NOT* told about the color distributions.

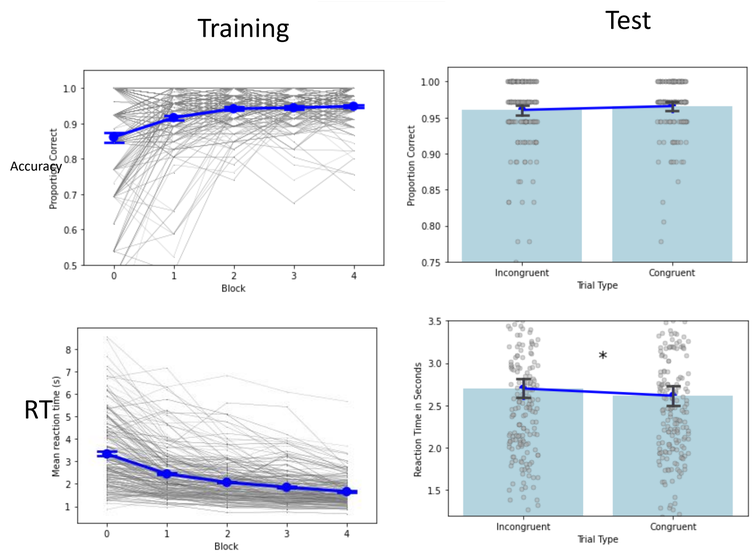
Behavioral Study

Procedure



Participants completed a training phase with feedback after each trial and biased color distributions, followed by a test phase.

Results

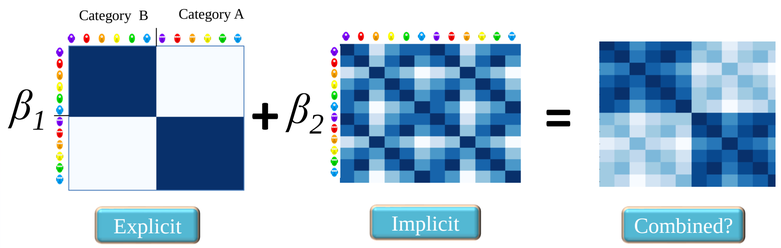


Discussion

If there were no interaction and no information sharing, then performance on congruent and incongruent trials should be the same (explicit rule use only). However, at test, participants were slower on incongruent trials than congruent trials ($t = 4.25$, $p < .001$). From these results it is not clear whether information is shared between systems during learning, or later at a response stage. We will use fMRI-RSA to answer this question.

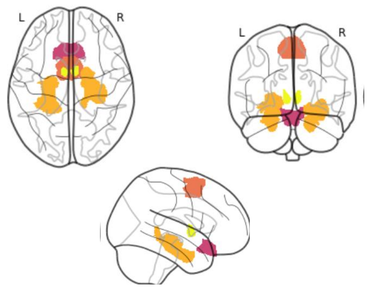
Imaging Methods

Representational Similarity Analysis



- The explicit rule and implicit color distribution create different dissimilarity matrices (RDMs).
- We will compare the relative beta weights in ROIs after training.
- Similar beta weights for implicit and explicit RDMs in striatal or temporal ROIs suggest information sharing at learning.
- Similar beta weights in frontal ROIs suggest information sharing at decision/response

Regions of Interest



- Hippocampus – explicit learning
- Striatum – implicit learning
- mPFC --decision making, rule use
- SMA – response selection

References

1.Ashby, F. G. & Maddox, W. T. Human category learning 2.0. *Ann N Y Acad Sci* **1224**, 147–61 (2011).
2.Ashby, F. G. & Maddox, W. T. Human category learning. *Annu Rev Psychol* **56**, 149–178 (2005).
3.Ashby, F. G. & Ell, S. W. The neurobiology of human category learning. *Trends Cogn Sci* **5**, 204–210 (2001).
4.Ashby, F. G. & O'Brien, J. B. Category learning and multiple memory systems. *Trends Cogn Sci* **9**, 83–89 (2005).
5. Fodor, J. A. *The Modularity of Mind*. *The Modularity of Mind* (1983). doi:10.7551/mitpress/4737.001.0001.
6.Poldrack, R. A. *et al.* Interactive memory systems in the human brain. *Nature* **414**, 546–550 (2001).
7.Brown, R. M. & Robertson, E. M. Inducing motor skill improvements with a declarative task. *Nat Neurosci* **10**, 148–9 (2007).
8.Galea, J. M., Albert, N. B., Ditye, T. & Miall, R. C. Disruption of the Dorsolateral Prefrontal Cortex Facilitates the Consolidation of Procedural Skills. *J Cogn Neurosci* **22**, 1158–1164 (2010).
9.Crossley, M. J. & Gregory Ashby, F. Procedural learning during declarative control. *J Exp Psychol Learn Mem Cogn* **41**, 1388–1403 (2015).
10.Turner, B. O., Crossley, M. J. & Ashby, F. G. Hierarchical control of procedural and declarative category-learning systems. *Neuroimage* **150**, 150–161 (2017).
11.Sanchez, D. J. & Reber, P. J. Explicit pre-training instruction does not improve implicit perceptual-motor sequence learning. *Cognition* **126**, 341–51 (2013).
12.Batterink, L. J., Oudiette, D., Reber, P. J. & Paller, K. A. Sleep facilitates learning a new linguistic rule. *Neuropsychologia* **65**, 169–179 (2014).
13.Reber, P. J. The neural basis of implicit learning and memory: A review of neuropsychological and neuroimaging research. *Neuropsychologia* **51**, 2026–2042 (2013).

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