Differentiation and Integration of Competing Memories: A Neural Network Model

Victoria J. H. Ritvo[1,2], Alex Nguyen[2], Nicholas Turk-Browne[3], Kenneth A. Norman[1,2]

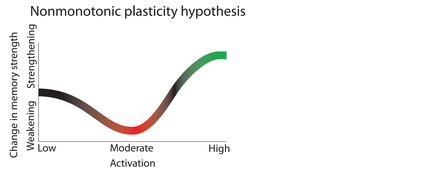
[1]Department of Psychology, [2]Princeton Neuroscience Institute, Princeton University; [3]Department of Psychology, Yale University

Introduction

What causes neural representations of memories to move together (integrate) or apart (differentiate)?

Recent studies have posed a challenge to supervised learning models, showing that linking stimuli to a shared associate can result in differentiation rather than integration.

We present an unsupervised neural network model of representational change that uses a non-monotonic learning rule to modify competitor-target connections.



Low coactivity causes **no effect**

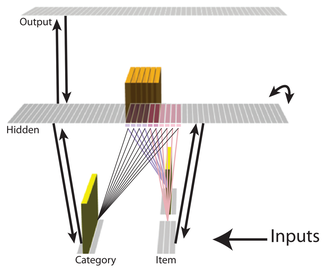
Moderate coactivity causes **differentiation**

Strong coactivity causes **integration**

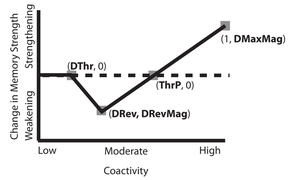
Basic Network Properties

We modeled three experiments using the same basic architecture.

Model Architecture

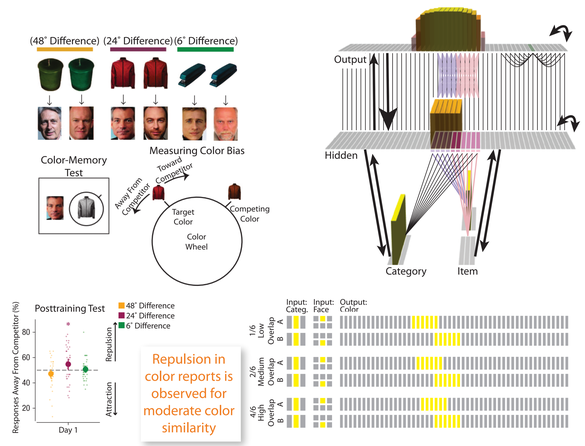


Learning Rule



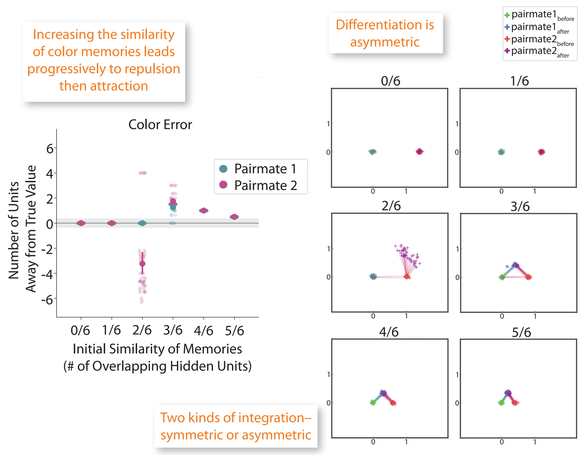
Chanales et al. (2021, Psych. Science)

Study & Model



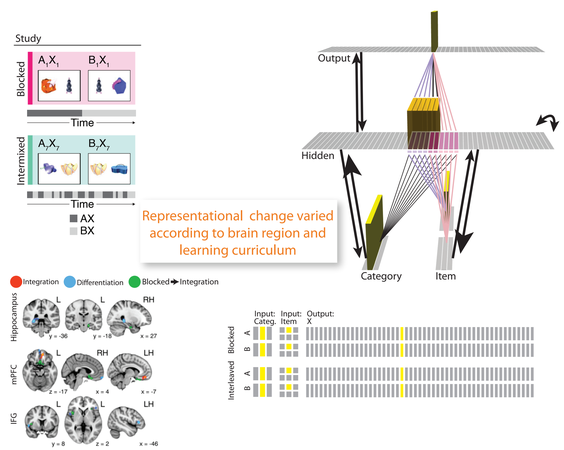
Competitor activity is modulated by color similarity (overlap between hidden and output A & B units).

Model Results



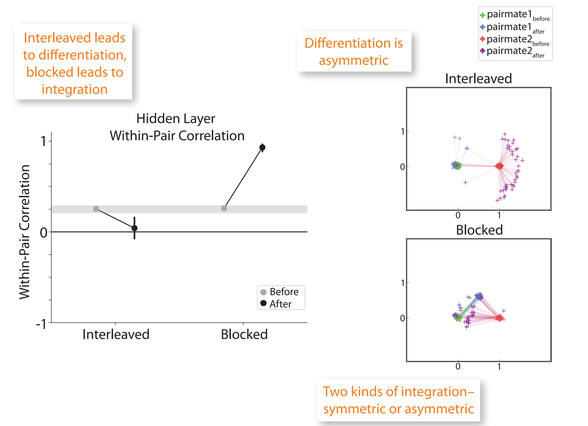
Schlichting et al. (2015, Nat. Comms.)

Study & Model



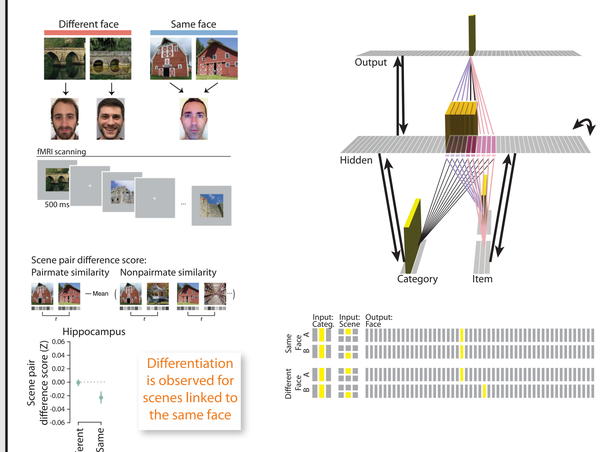
Competitor activity is modulated by learning curriculum (interleaved vs. blocked learning; here through relative strength of Output-to-Hidden connections).

Model Results



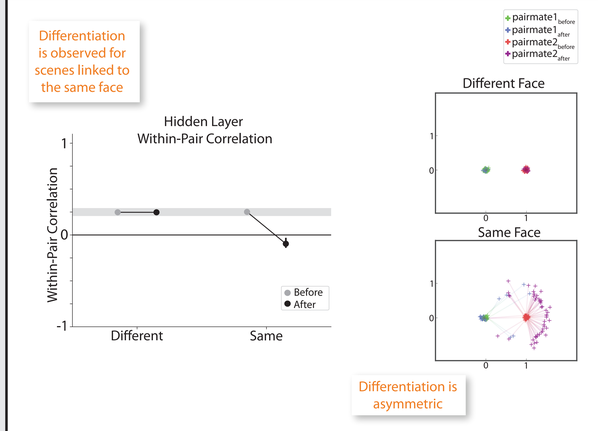
Favila et al. (2016, Nat. Comms.)

Study & Model



Competitor activity is modulated by predictive consequences (whether stimuli predict the same or different outcomes).

Model Results



Summary & Discussion

Our model provides an "existence proof" that a network imbued with nonmonotonic plasticity can explain these findings that challenge supervised learning.

In addition to replicating the results from these studies in our simulation, the model provides several novel predictions:

1) Differentiation requires a rapid learning rate but integration does not.

2) Differentiation is asymmetric (one item anchors and the other distorts).

3) Integration can be asymmetric (one item distorts) or symmetric (both items distort).

scan QR code for video explainers

This research was supported by RO1 MH069456 awarded to K.A.N and N.B.T-B