Complementary Learning Systems and Episodic Memory

Tyler McDaniel

bmcdan16@utk.edu, mcdanielbt@ornl.gov

volsec.eecs.utk.edu

University of Tennessee
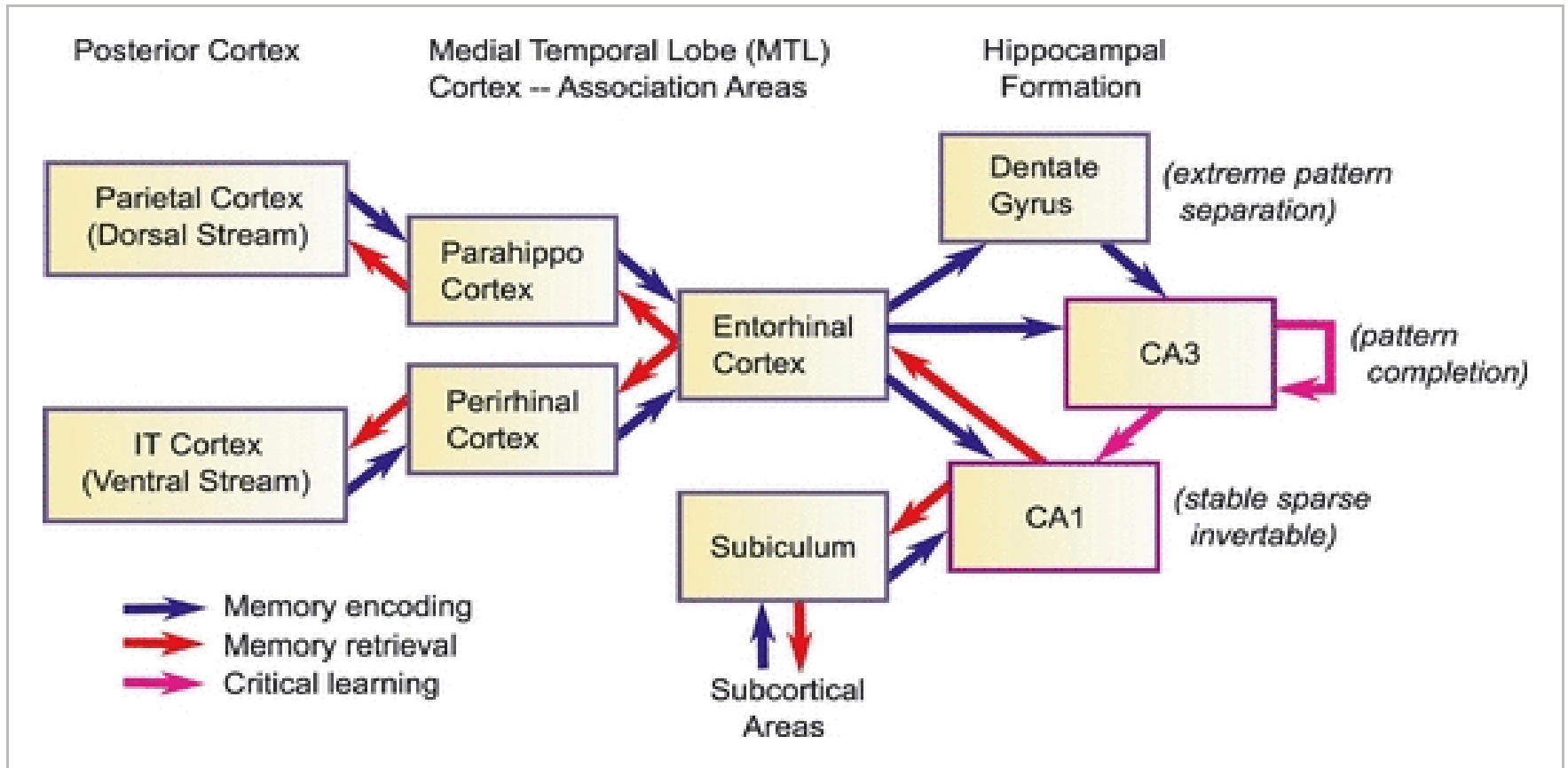
VOLSEC

— COMPUTER SECURITY LAB —

University of Tennessee

VOLSEC
— COMPUTER SECURITY LAB —

BIG ORANGE
BIG IDEAS

Background

Hippocampus structure, fiberarchitecture, and proposed function (Marr, 1971)

- Multiple memory systems

- Archicortex (hippocampal system) for rapid storage

- Pattern completion/pattern separation

Posterior Cortex
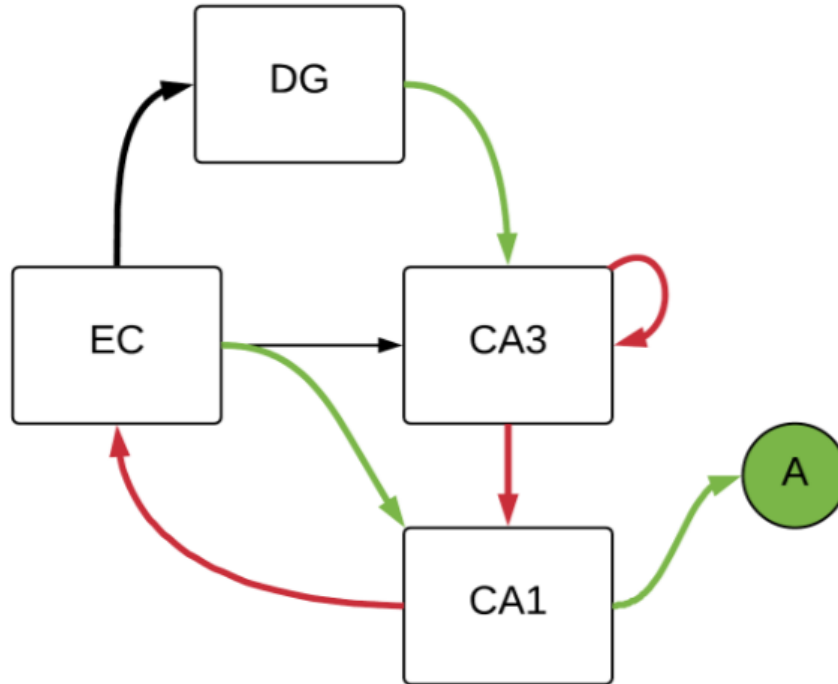
Medial Temporal Lobe (MTL)
Cortex -- Association Areas

Hippocampal Formation

Parietal Cortex (Dorsal Stream)

IT Cortex (Ventral Stream)

Parahippo Cortex

Perirhinal Cortex

Entorhinal Cortex

Subiculum

Dentate Gyrus

(extreme pattern separation)

CA3

(pattern completion)

CA1

(stable sparse invertable)

Subcortical Areas

→ Memory encoding
→ Memory retrieval
→ Critical learning

What's missing?

- Reconciling tension between pattern completion/separation?

- How to solve tasks requiring synergistic operation between systems?

- Contribution from surrounding cortical and subcortical regions?

- Detailed analysis of computational characteristics, e.g. storage capacity

Neuromodulation

- Without sufficient distinctness, encoding could trigger recall of similar memories (pattern completion)

- But, higher levels of distinctness work against pattern completion

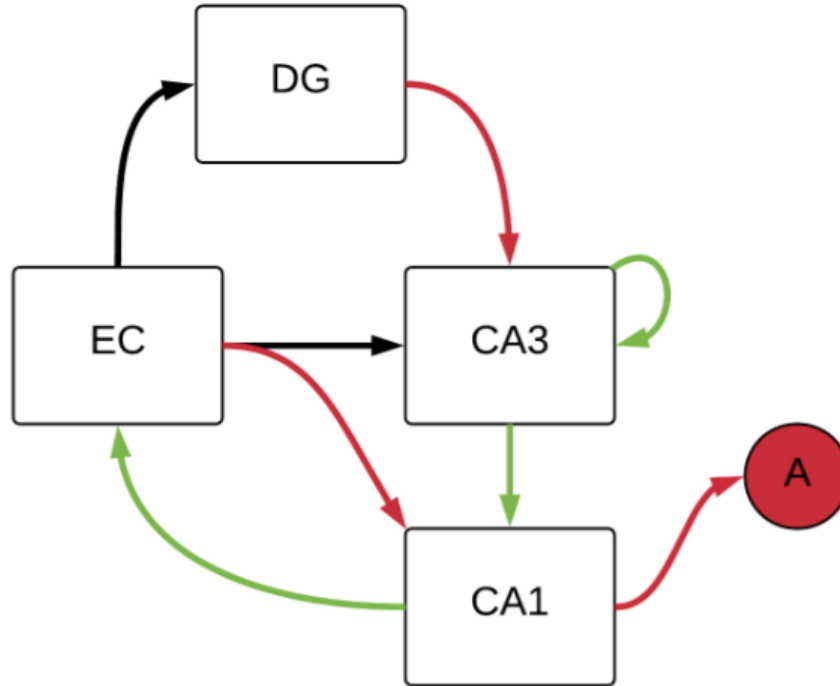- One solution: **neuromodulation** by acetylcholine (Hasselmo 1997)

Encoding Mode

- Default mode: strong cholinergic suppression

- CA3 -> CA1 connections de-emphasized

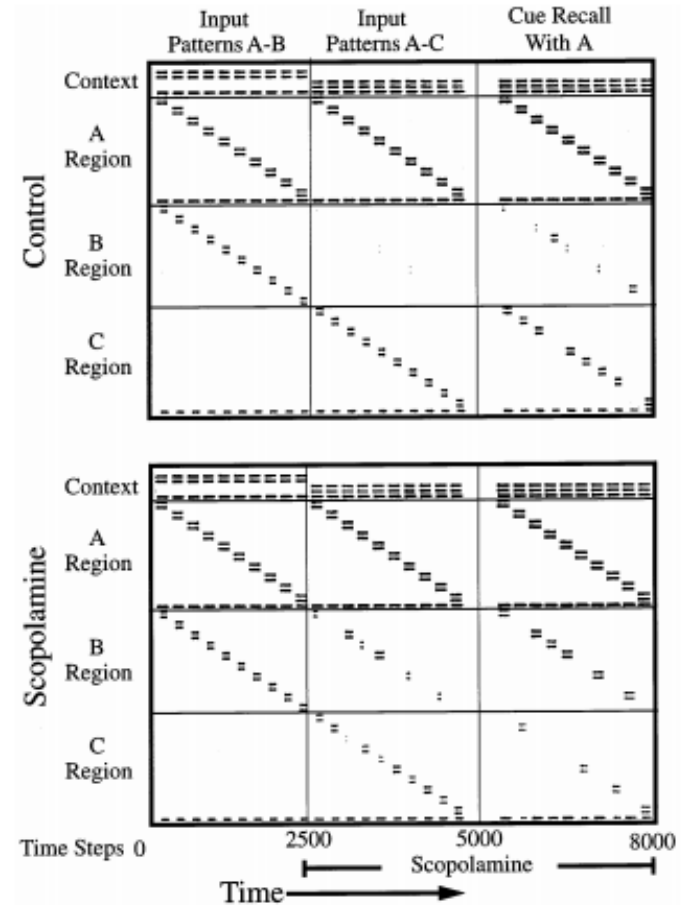- Primary input to CA1: current EC configuration

Retrieval Mode

- Triggered by CA1 -> medial septum

- Occurs when perforant path/CA3 inputs activate same CA1 units

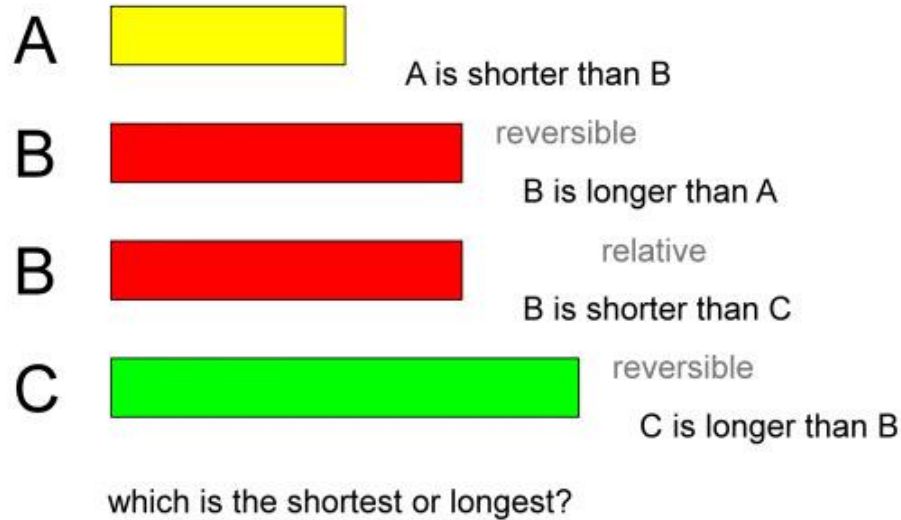- Primary input to CA1: CA3 pattern (content address)

Result: AB-AC

- Lists of 10 words represented by binary strings with high overlap

- Present A-B, present A-C, cue recall of C with A.

- Scopolamine introduced after A-B presentations

Synergistic Tasks

- Broad, functional division of neocortex and hippocampal system in CLS; what about tasks requiring both?
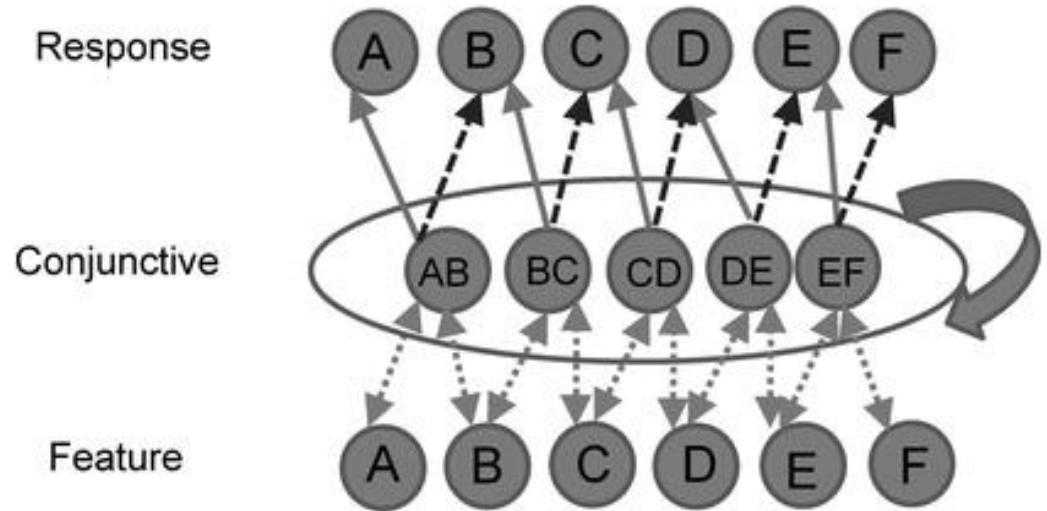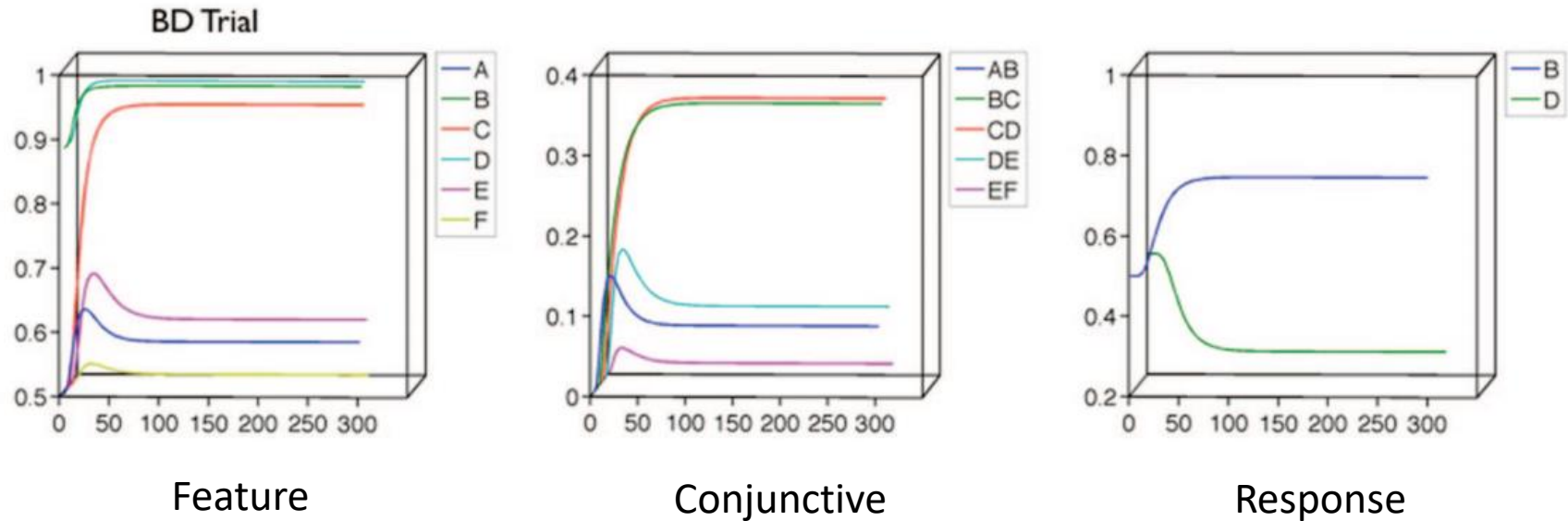
Adding recurrence

- Assume patterns are ideally separated (stored orthogonally)

- Recurrence within system is necessary to form generalizations across representations

- **REMERGE** model (Kumaran and McClelland 2012)

REMERGE Model

- Feature layer: inputs, bidirectional excitatory with conjuctive

- Conjunctive layer: associated memories, feedforward inhibitory/excitatory connection to response

BD Inference Activation

Feature | Conjunctive | Response

Open Questions

- Surrounding cortical/subcortical regions
- Full theory of modulation
- Learning mechanisms
- Coding and orthogonalization

Tyler McDaniel

bmcdan16@utk.edu,
mcdanielbt@ornl.gov

volsec.eecs.utk.edu