

Relating Properties of Human Memory to Cortico-Hippocampal Architecture

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Introduction

Episodic memory (Tulving, 1995) refers to our ability to remember events and situations in our daily lives and acquire memories of specific events by reading a newspaper or watching a newscast. There is a broad consensus that the hippocampal system (HS) consisting of the hippocampal formation and neighboring cortical areas in the medial temporal lobe plays a critical role in the encoding and retrieval of episodic memories (Squire, 1992; Cohen & Eichenbaum, 1995; Nadel & Moscovitch, 1997). But how the HS subserves this mnemonic function in concert with cortical circuits is not fully understood.

Although a number of computational models have been proposed to explain how the HS might support episodic memory function, several key representational problems have remained unsolved. In particular, most existing models view an item in episodic memory as a *feature vector* or as a *conjunctive code* that binds together the components of memory, but as argued in (Shastri, 2002; 2001), such a view is inadequate for encoding events and situations.

SMRITI

SMRITI (System for memorizing relational instances from transient impulses) is a computational model of episodic memory that demonstrates how a cortically expressed transient pattern of activity representing an episode can be transformed rapidly into a persistent and robust memory trace in the HS as a result of long-term potentiation (Shastri, 2001; 2002).

SMRITI explicates the representational requirements of encoding events and situations, proposes a detailed neural circuit that satisfies these requirements, and demonstrates that the propagation of a suitable pattern of activity encoding an event can lead to the rapid and automatic formation of the requisite neural circuit within the HS.

The neural circuit required for encoding an episodic memory trace is fairly complex and idiosyncratic, but SMRITI shows that this complexity and idiosyncrasy is well matched by the complexity and idiosyncrasy of the architecture and local circuitry of the HS.

Predictions and Explanations

SMRITI predicts (i) the functional role of each HS component and some of the cortical areas interacting with the HS, (ii) the properties of cortically expressed event schemas underlying episodic memories, (iii) the sorts of memories that must persist in the HS for the long-term, (iv) the nature of memory consolidation, and (v) memory deficits that would result from cell loss in different HS regions and cortical circuits encoding semantic knowledge.

SMRITI also offers biologically grounded explanations of behavioral findings about human memory such as the fan-effect (Anderson, 1974) and the list-strength effect (Ratcliff, Clark, & Shiffrin, 1990). It is significant that no attempt was made to model these behavioral findings; the explanations for these phenomena arise directly from the biologically grounded architecture and structure of the model.

SMRITI makes specific behavioral predictions about the time required for retrieving memorized facts. For example, it predicts that the time to retrieve a fact, wherein an entity fills a given role, is affected primarily by the total number of facts memorized in which the entity plays the same role, and not by the total number of facts memorized about that entity. Thus SMRITI suggests a modified form of the fan-effect. SMRITI also predicts that retrieval times of facts pertaining to populated event schemas are qualitatively different from those of facts pertaining to unpopulated ones. Here, an event schema is heavily (lightly) populated if many (only a few) instances of the schema have been memorized.

This talk will present an overview of SMRITI, and discuss some of its key properties and predictions.

Acknowledgments

This work is funded by NSF grants 9720398 and 9970890.

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