Summary: “A Computational Cognitive Neuroscience Approach to Understanding Event Representation and Episodic Memory” (Charan Ranganath, PI) to ONR MURI program, Topic 12 – Event Representation and Episodic Memory. Total costs are estimated at $7,500,000.00 over 5 years with 3-year base period of $4,500,000 and 2-year option period of $3,000,000.

Memory for specific events (“episodic memory”) and knowledge accrued across multiple events (“event schemas”) play powerful roles in human cognition. Neuroscience research has strongly linked these abilities to interactions between the hippocampus, ventromedial prefrontal cortex (vmPFC), and a posterior medial (PM) neocortical network. Gaining a mechanistic understanding of the neural processes that support representation of event schemas and episodic memory could be of enormous significance to basic neuroscience. Achieving this goal would have significant implications for DOD capabilities, such as the development of autonomous systems capable of rapid extraction of information about temporal and spatial relations, causality, and intentionality from complex data streams. At present, however, there is insufficient knowledge about how events are segmented, learned, and retrieved in the human brain, and the field lacks an appropriate computational framework to explain existing data. To address these challenges, we propose an integrative computational cognitive neuroscience approach to understanding event representation and episodic memory.

The centerpiece of this project is an innovative neurocomputational framework called Structured Event Memory (SEM). SEM integrates the strengths of three different, but related, approaches—Latent Cause Models, Event Segmentation Theory, and the Complementary Learning Systems Model—to explain how interactions between the hippocampus, vmPFC, and PM network support event representation and episodic memory. The architecture of SEM is scalable, it is meaningfully tied to neural mechanisms, and it provides a principled and parsimonious account of a diverse range of processes, including: schema formation, event segmentation, context in memory and language, episodic memory encoding, consolidation, retrieval, and updating, prediction, and mental simulation. SEM is especially innovative in that it is designed to learn about the structure of the world, in terms of temporal, causal, and situational relationships within an event, and in terms of the characteristic transitions between different kinds of events. Building on our initial work, we will accomplish the following Tasks: (1) Develop a computational model of event representation and episodic memory. (S. Gershman, Harvard), (2) Specify the neural mechanisms that support learning and application of semantic knowledge about events. (K. Norman, U. Hasson, Princeton), (3) Specify how cortico-hippocampal interactions support episodic memory retrieval and consolidation. (C. Ranganath, UC Davis), (4) Specify the cognitive and neural causes and consequences of event segmentation (J. Zacks, Washington University), & (5) Determine how broadband and oscillatory neural activity contributes to event segmentation and episodic memory (Orrin Devinsky, NYU, in collaboration with all team members).

By addressing fundamental questions about how event segmentation shapes the structure of semantic and episodic memory, and how the hippocampus interacts with neocortical networks, the proposed empirical studies go well beyond the current state of the art. Moreover, by utilizing novel data-driven machine learning analysis approaches and theory-driven forward modeling of neuroimaging and electrocorticography data, every study in this project will break new methodological ground. At the end of the five-year period, we will deliver an integrated computational architecture that can translate in any direction between complex narrative or video stimuli, real-time brain activity patterns, and meaningful cognitive representations of the spatial, temporal, and causal relations that characterize our world.