Dynamics of Memory Search

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Keywords: memory search; foraging; random walks; mental lexicon; semantic memory; gamification

Symposium overview

Humans engage in a wide variety of search behaviors during their lifetime. These search behaviors may be *external* such as foraging for food in the wild (O'brien et al., 1990), or searching for mates (Miller & Todd, 1998), or *internal*, such as searching for concepts in memory (Hills et al., 2012; Smith et al., 2013). Decades of work on search processes among humans has suggested that these two types of search behaviors share common characteristics and physiological mechanisms (Hills et al., 2008; Dorfman et al., 2022). Despite this progress, understanding the dynamics of internal search is an ongoing challenge in the field.

Recent computational approaches to modeling language and memory have yielded important insights into how concepts may be organized and retrieved (Kumar, 2021). These approaches leverage advances in network science and language modeling to better understand the complex interplay of cognitive (Siew, 2019; Kumar et al., 2022), neural (Ovando-Tellez et al., 2022), and pragmatic (Kumar et al., 2021; Todd & Hills, 2020) constraints that contributes to memory search. At the same time, this body of work has brought forth several new and unexplored questions about search behavior. For example, do similar cognitive mechanism underlie search and other complex cognitive behaviors such as creativity and cooperation? What do differences in search strategies and outcomes tell us about the individual or a population? How do complex language models compare to humans in search outcomes?

This symposium brings together four speakers from very different backgrounds and institutions, who have recently presented novel theoretical and computational perspectives to address these new burgeoning questions in the field of memory search.

Peter Todd is a cognitive scientist who has made important contributions to establishing common ground between the mechanisms governing adaptive internal and external search, drawing from ecology, evolutionary psychology, and animal cognition. Yoed Kenett applies network science-based approaches to investigate links between the cognitive and neural mechanisms underlying search, memory, and creativity. Cynthia Siew is a psycholinguist who uses computational modeling and network science to understand the dynamics of memory search in diverse domains. Lastly, Abhilasha Kumar uses computational and gamified approaches to understand search behavior at multiple levels of analysis, from individuals to groups. Additionally, all speakers conduct research at different types of institutions (US-based research university, liberal arts college, and international universities) and also come from very different cultural backgrounds, and therefore represent a diverse group.

Memory search at multiple scales: Insights from individuals, dyads, and groups

Abhilasha A. Kumar

Retrieving concepts from memory is ubiquitous and mental search is a core component of several cognitive abilities. It is widely acknowledged that individuals widely vary in how they search for information, and this behavior likely depends upon their internal lexicon, their search strategies, as well as resource and task constraints. However, a systematic investigation of which *factors* influence the processes by which individuals search their lexicon for concepts has been challenging from a computational standpoint. In this talk, I will discuss insights from recent work on how individuals cluster items during memory search, that suggests a complex interplay of semantic, phonological, and frequency-based information contributing to individual-level variance in memory search. I will also discuss novel gamified approaches to understanding search behavior at multiple scales, drawing from work with individuals, partners, as well as larger groups. [1]

Beyond cats and dogs: Memory search in diverse domains of knowledge

Cynthia S.Q. Siew

The verbal fluency task has been an instrumental paradigm for studying the structure of semantic memory and search

[1]This material is based upon work supported by the National Science Foundation under Award Numbers 2235362 and 2235363

In L. K. Samuelson, S. L. Frank, M. Toneva, A. Mackey, & E. Hazeltine (Eds.), *Proceedings of the 46th Annual Conference of the Cognitive Science Society.*

processes that operate on semantic memory structure. But can the verbal fluency task also be useful in studying internal memory search in other domains beyond commonly used categories of animals and furniture? In this talk I discuss how the verbal fluency task can be used to investigate how individuals search their emotional lexicon and domain specific knowledge. Participants were asked to either retrieve as many emotional concepts or as many concepts related to specific academic domains (e.g., biology, psychology). By leveraging the tools of computational network science, cognitive networks can be estimated from verbal fluency responses, enabling group-level comparisons of network structure. I present recent results showing that (i) individuals with elevated distress exhibited less overall network connectivity and greater modularity than control individuals, which suggest less accessibility to emotional concepts and increased difficulties traversing out of certain emotion categories (e.g., fear), and (ii) individuals with more years of education (i.e., university students) produced knowledge networks with more efficient connectivity and lower modularity than individuals with fewer years of education (i.e., high school students), which suggest better integration across sub-domains of a particular field of knowledge.

Testing memory foraging with large language models

Peter M. Todd

When searching semantic memory, people's behavior often appears analogous to foraging: they produce concepts clustered in local patches (i.e. regions of semantic space) and switch to new patches when old ones become less productive. Testing such memory foraging models requires determining when people make deliberate switches, often via similarity metrics that reveal jumps in semantic space. But people also often seem to make such jumps without switching between patches, instead creating an extended fluid patch that links distant concepts by some category that overlaps both (e.g., dog, cat, tiger, zebra, giraffe), where similarity metrics can erroneously indicate switching. Large language models (LLMs) have recently demonstrated a variety of impressive semantic abilities including the capacity to make categorical links between sets of words in ways similar to people. In this talk, I show how LLMs can be used to identify switches and non-switches and apply them to analyze the behavior of both humans and LLMs themselves in semantic search tasks.

Retrieving animal names predicts high-level cognition

Yoed N. Kenett

High-level cognition, such as creativity and intelligence, involves the ability to efficiently search through memory. Thus, can the way a person searches their memory be indicative of their high-level cognitive abilities? I will present a series of studies where we computationally and empirically examine how performance in a semantic fluency task operationalizes mental navigation through a multidimensional representation of their mental lexicon – a cognitive multiplex network. I will show how such analysis can be used to accurately predict individual differences in creativity, intelligence, and the personality trait Openness to Experience. Critically, this work highlights a common search behavior that emphasizes a more "peripheral" search in relation to heightened cognitive abilities. Furthermore, this work highlights the advantages of studying the mental lexicon as a multidimensional construct.

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