COMPUTATIONAL APPROACHES TO MEMORY AND DECISION MAKING

A symposium organized by the Society for Mathematical Psychology

Hosts: Clintin Davis-Stober, Pernille Hemmer

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The Society for Mathematical Psychology promotes the advancement and communication of research in mathematical psychology and related disciplines. Mathematical psychology is broadly defined to include work of a theoretical character that uses mathematical methods, formal logic, or computer simulation.

The topic of this year's symposium is "Computational Approaches to Memory and Decision Making." The invited speakers will be presenting their work on this theme from a variety of quantitative modeling perspectives. This symposium will also feature a poster session.

SYMPOSIUM SCHEDULE

8:55	*Opening remarks*	Jennifer Trueblood, President Society for Mathematical Psychology
Session I: Computational Brain & Behavior		
9:00	Springer	
9:20	Editor CB&B	Scott Brown
9:40	Associate editor CB&B	
10:00	Associate editor CB&B	
10:20	*Break until 10:35*	
Session II: Modeling episodic memory		
10:35	Mark Steyvers	Modeling missing data in memory and learning
10:55	Chris R. Sims	A computationally rational theory of perceptual memory and generalization
11:15	Gregory E. Cox	Parallel interactive retrieval of item and associative information from event memory
11:35	Candice Morey	The impact of remembering verbal and spatial information on processing speed in school-aged children
11:55	*Lunch until 13:00*	
13:00	*Poster session until 14:15*	
Session III: Modeling decision making		
14:15	Sudeep Bahtia	Preference accumulation in subjective desirability ratings
14:35	Timothy J. Pleskac	Modeling the decision to shoot, or how I came to learn a bit about social cognition
14:55	David Kellen	Measurement modeling of decision making under risk: Comparing Prospect Theory with two attention-based rival accounts
15:15	Clintin P. Davis-Stober	Tests of rationality across multiple experimental domains

ABSTRACTS

Session I:

Modeling missing data in memory and learning
Mark Steyvers, University of California Irvine

Outside the laboratory, people govern aspects of their own learning that are tightly controlled in laboratory experiments. For example, in educational settings, students do not study all of the materials for an upcoming test for the same amount of time; they make decisions about how long to study different materials and when to stop learning altogether. Similarly, on many internet platforms, people self-select which items to judge and which to skip. The ability of individuals control their own learning leads to missing data problems where the pattern of missingness needs to be explained. We propose a modeling approach that combines cognitive modeling, theories of metacognitive control, and statistical ideas for handling missing data. We present three case studies that illustrate this approach. In the first case study, we model the metacognitive processes in opt-in conditions where individuals can select subsets of general knowledge questions to answer, and compare performance to a control group for whom questions are randomly allocated to individuals. In the second case study, we model the memory performance of learners who make their own decisions on the study time allocated to each to-be-learned item, and compare performance to a control condition in which items are studied at a fixed pace. In the third study, we model the learning curves from a large sample of Lumosity users, who make their own decisions on when to practice a number of cognitive skills and when to dropout from the platform.

Parallel interactive retrieval of item and associative information from event memory
Gregory E. Cox & Amy Criss, Syracuse University

Memory contains information about individual events (items) and combinations of events (associations). Despite the fundamental importance of this distinction, it remains unclear exactly how these two kinds of information are stored and whether different processes are used to retrieve them. We use both model-independent qualitative properties of response dynamics, as measured by Systems Factorial Technology (Townsend & Nozawa, 1995), and quantitative modeling of individuals to address these issues. Item and associative information are not independent and they are retrieved concurrently via interacting processes. During retrieval, matching item and associative information mutually facilitate one another to yield an amplified holistic signal. Modeling of individuals suggests that this kind of facilitation between item and associative retrieval is a ubiquitous feature of human memory.

A computationally rational theory of perceptual memory and generalization
Chris Sims, Rensselaer Polytechnic Institute

Memory is an information channel; its goal is to communicate information across time. Naively, a perfect memory system is one that perfectly stores and faithfully reflects the structure of the world. However, all physical systems (whether biological or artificial) possess only finite information processing resources, and hence perfect memory performance is often physically unobtainable. This is particularly true in the case of perceptual working memory, which has long been studied as a strongly capacity-limited system. In this situation, what constitutes an ‘optimal’ perceptual memory system? This talk will introduce a mathematical framework known as rate–

distortion theory that answers this question. According to this framework, the goal of perceptual memory is not veridicality, but rather to minimize the expected costs of memory error, subject to constraints on information-theoretic channel capacity. In this talk, experimental evidence in support of the framework will be presented from several domains including absolute identification, visual working memory, and stimulus generalization.

The impact of remembering verbal and spatial information on processing speed in school-aged children
Candice C. Morey, Lauren Hadley, Frances Buttelmann, Tanja Koenen, Julie-Anne Meaney, Bonnie Auyeung, Julia Karbach, & Nicolas Chevalier.

Examining the impact of maintenance on processing speed enables hypothesis testing about whether storage and processing resources are shared, and if so, how. Comparing these relationships in school children of different ages allows further insight into whether one or multiple resources for these operations must be assumed and whether mnemonic strategies are spontaneously performed throughout childhood. We tested 188 4-6 and N 8-10 year-old children using adaptive complex span tasks, in which simple judgments were interleaved between memoranda. The adaptiveness of our tasks ensured that all participants frequently correctly recalled the memoranda. If storage and processing require a single resource, and if participants serially rehearse or refresh the memoranda in between processing episodes, processing response times should increase with serial position of the processing judgment within each list. We observed differing within-list dynamics for each age group. Older children displayed a more complex pattern which is partially consistent with the hypothesis that they cumulatively re-activated verbal memoranda, while younger children showed no evidence of proactive remembering during processing. Our results support models of working memory that assume that some common resource is responsible for verbal and spatial storage and processing and suggest novel constraints on working memory models.

Session II:

Preference accumulation in subjective desirability ratings
Sudeep Bahtia, University of Pennsylvania

In subjective desirability rating tasks, decision makers evaluate objects on a continuous response scale. What are the key behavioral patterns at play in these tasks, and can existing theories of preferential choice quantitatively describe these patterns? We address these questions using models of multiattribute preference accumulation, modified to generate continuous responses. These models make precise predictions regrading stochasticity, dynamism, and competition in desirability ratings, and we confirm these predictions in two experimental studies. Additionally, model fits indicate that most participants are better described by some variant of a multiattribute preference accumulator, relative to a baseline linear model. Our results show that the descriptive power of theories of preference accumulation extend beyond simple discrete choice, and that the core assumptions of these theories accurately characterize the broader cognitive processes at play in preferential deliberation.

Modeling the decision to shoot, or how I came to learn a bit about social cognition
Tim Pleskac, Max Planck Institute for Human Development

The shooting of unarmed Black males by police officers is a topic of great potential concern. In this talk, I will share some findings (and lessons learned) as I worked to take evidence accumulation models and apply them to extant and new datasets from laboratory analogs of the situation. In all cases, the studies focused on testing if the race of the suspect impacted the decision to shoot. Using these tasks a robust race bias has been reported. But, the form of the bias shifts between the errors and response times. When participants are under time pressure the race bias appears more reliably in error rates: Participants are more likely to shoot unarmed Black targets than unarmed White targets. With less time pressure and more experienced participants the race bias shifts to response times: Participants are faster to shoot armed Black targets and slower to not shoot unarmed Black targets. Modeling this data with a diffusion model brings more clarity to the effect of race: for novice participants the target's race (regardless of the time pressure conditions) is integrated over time as evidence so that drift rates for armed and unarmed targets are shifted toward shooting and thus biasing decisions. Some participants appeared to be more cautious with Black targets setting higher decision thresholds. The model also suggests that factors like the background scene have an inconsistent effect on the decision to shoot. I will conclude foreshadowing some of our current work working with police officers with more realistic shooting simulators to illustrate some of the exciting challenges we as modelers can face as we try to scale up our computational models for more complex decision making behavior.

Measurement modeling of decision making under risk: Comparing Prospect Theory with two attention-based rival accounts
David Kellen, Syracuse University

The study of preferences regarding monetary value and chance traditionally involves individuals choosing between lotteries with different probabilistic outcomes (e.g., an option A that yields $100 with probability .50, otherwise nothing, and an option B that yields $40 for sure). These decisions `under risk' are typically characterized using Cumulative Prospect Theory (CPT) and its subjective representations of value and probability. Since its introduction, several studies have shown that CPT is unable to account for specific choice patterns (commonly referred to as `choice paradoxes'). These choice patterns are predicted by the Transfer of Attention Exchange (TAX) model, which despite its reported successes has not taken over the prominent position that CPT holds. More recently, an extension of Decision Field Theory has been proposed as an alternative (and somewhat more parsimonious) account, but no direct model comparisons with either CPT or TAX have been reported so far. The present work provides a direct comparison of all three theories using a diverse set of choice trials involving potential gains and losses. Bayes factors for individual model fits show that the extended DFT model provides a superior account.

Tests of rationality across multiple experimental domains
Clintin P. Davis-Stober, University of Missouri

We present a comprehensive mathematical framework for evaluating whether decision makers utilize compensatory, rational models of choice or simple non-compensatory heuristics. Our methods are based on Bayesian formulations of random preference models. We report the results of a series of experiments spanning a wide range of domains: (1) decision making under acute alcohol intoxication, (2) risky sexual decision making, and (3) older versus younger adults in decision making under risk tasks. We find that the type of decision making process used by participants is highly domain dependent and varies systematically.