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Sequential Sampling Models Representing a Unifying Framework of Human Decision Making

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Sequential sampling models have been applied for describing the cognitive processes underlying various psychological processes such as memory, perception, or value-based decision making. They share the common assuming that people accumulate information stochastically over time and once the accumulated information passes a decision boundary a response is made. Depending on the cognitive domain the models differ in the specific nature of the accumulation process. In particular, they differ in their assumption about what type of information is processed, how the information is represented, and how the boundary is defined.

In this symposium we will illustrate how sequential sampling models successfully explain human behavior for various cognitive domains. For the decision making domain we show how people construct their preferences by accumulating options' attributes values over time once a decision threshold is reached. For the perceptual domain we show how gradual accumulation of sensory evidence over time explains people's perceptual decisions. Furthermore, we illustrate that sequential sampling models do not only predict the final outcome of a cognitive process but also present a description of the cognitive process itself. As such the symposium will illustrate how the analyses of response time distributions provide evidence for the dynamic accumulation process. Furthermore, the neurological basis of the dynamic accumulation process has recently also been explored. In sum, the symposium will illustrate the strength of sequential sampling model as a unifying framework for explain human cognition and behavior across many domains.

Accumulation of Information with Attention Shifting Across Attributes

Adele Diederich* & Jerome Busemeyer*

Most applications of sequential sampling (diffusion) models to decision making assume that information is sampled from a constant or stationary, albeit noisy, source of information during the accumulation period leading up to a decision. Formally, these models usually employ a constant mean drift rate throughout the accumulation process leading up to a decision. However, many cognitive and decision tasks provide conflicting attributes that could compete for selective attention to guide the accumulation process while making a decision. For example, when choosing a consumer product, a person needs to shift attention between quality and cost; when a security agent scans a bag, the person needs to shift attention to different objects in the bag; when making a social choice, a person can attend to either implicit attitude feelings or explicit rational arguments.

Diederich (1997) developed a multiple stage diffusion model that represents this attention shifting as a Markov process that changes the drift rate across stages of the decision. This work describes the multiple stage model and reviews five major applications which compared the multiple stage model to stationary models with respect to their ability to account for perceptual decisions involving conflicting attributes. This includes behavioral studies modeling choice and response time as well as electrophysiological studies that used the model to account for the trajectory of neural activation during evidence accumulation. Based on this body of evidence, we conclude that there is substantial empirical support for an attention shifting process during multi-attribute decision making.

A Two-Phase Theory of Choice Conflict Tasks

Andrew Heathcote* & Kirsty Hannah

We propose a theory of how decision processes are affected by response conflict. The theory is developed to account for the fine-grained time course of both response speed and accuracy as quantified by delta functions and conditional accuracy functions. The theory, Two-Phase Evidence Accumulation (TPEA), extends Brown and Heathcote's (2008) Linear Ballistic Accumulator (LBA) model to provide a unified account of three tasks that have been central to the study of cognitive interference the Stroop, Simon and Flanker tasks. The theory is explicated by demonstrating that it provides a coherent parametric account of Stroop and Simon effect delta functions shown by Pratte, Rouder, Morey and Feng (2010) to be incompatible with existing theories. We then show that, without modification, TPEA is also able to account for White, Ratcliff and Starns' (2011) flanker data.

The Attentional Drift-Diffusion-Model: Eye-tracking and Neurobiological Evidence

Antonio Rangel*

We propose a computational model of value-based binary choice in which fixations guide the comparison process. The model is an extension of the classic Drift-Diffusion-Model to an environment in which attention matters. We provide eye-tracking evidence showing that the model can quantitatively explain complex relationships between fixation patterns and choices, as well as several fixation-driven decision biases. We also provide fMRI evidence showing that key elements of the model are consistent with the operations of the decision-making circuitry at the time of choice.

Decision Making With Non-stationary Evidence, Adaptation and Decision-Confidence

Marius Usher*

The integration of evidence supporting different choice options is a fundamental process underlying all of our decisions, ranging from the simplest perceptual decisions (e.g., detect the presence of an enemy-rocket signal embedded in a noisy radar stream) to complex economic ones (e.g., which apartment to buy). A limitation of most studies that examined evidence-integration, however, is that they focussed on situations in which the evidence is stationary. I will present recent computational and experimental studies that examines decision-making under non-stationary evidence, characterized by temporal uncertainty: Observers detected visual luminance "signals" embedded within longer streams of "noise" with signals varying in duration and occurring at different onset latencies. Using a computational model, we showed that optimizing performance under such conditions, requires a leaky ("forgetful") integration process, the time-scale of which is matched to the expected signal duration. In subsequent psychophysical experiments, we tested whether human observers can indeed control their integration-time scale, such as to flexibly *adapt* it to the characteristic signal duration. The results provide strong support for this idea. Finally, I will discuss how the evidence-integration framework can account for data that requires the observers to report their decision-confidence.

Comparing Perceptual and Preferential Decision Making

Gilles Dutilh & Jörg Rieskamp*

What are the differences between perceptual and preferential decisions? In a perceptual decision the decision maker aims for a correct decision and there is an outside criterion that determines which decision is correct. In contrast, in a preferential task the decision maker's goals are subjective, so that no correct option exists. Despite these differences sequential sampling models have successfully been applied to both types of decisions. In our study we explore the overlap and the differences between perceptual and preferential decision making. To do so, we developed an experimental task that can be presented as either a perceptual or a preferential task. We show that the classic speed-accuracy trade-off and effects of stimulus difficulty are elicited in the perceptual version of this task. In the preferential version of the task, the stimulus array reflects a gamble that the participant can choose to play or not. In this gamble, the black and white dots represent potential gains or losses. We show that people behave risk and ambiguity averse in this task. The diffusion model is applied to both versions of the task for identifying the essential differences between the two types of decision making. We conclude that similar evidence accumulation processes could underlie rather different decision making processes, but that the model parameters have to be interpreted differently.

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