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The response dynamics of preferential choice

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ABSTRACT

The ubiquity of psychological process models requires an increased degree of sophistication in the methods and metrics that we use to evaluate them. We contribute to this venture by capitalizing on recent work in cognitive science analyzing response dynamics, which shows that the bearing information processing dynamics have on intended action is also revealed in the motor system. This decidedly "embodied" view suggests that researchers are missing out on potential dependent variables with which to evaluate their models—those associated with the motor response that produces a choice. The current work develops a method for collecting and analyzing such data in the domain of decision making. We first validate this method using widely normed stimuli from the International Affective Picture System (Experiment 1), and demonstrate that curvature in response trajectories provides a metric of the competition between choice options. We next extend the method to risky decision making (Experiment 2) and develop predictions for three popular classes of process model. The data provided by response dynamics demonstrate that choices contrary to the maxim of risk seeking in losses and risk aversion in gains may be the product of at least one "online" preference reversal, and can thus begin to discriminate amongst the candidate models. Finally, we incorporate attentional data collected via eye-tracking (Experiment 3) to develop a formal computational model of joint information sampling and preference accumulation. In sum, we validate response dynamics for use in preferential choice tasks and demonstrate the unique conclusions afforded by response dynamics over and above traditional methods.

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1. Introduction

A hallmark of recent theoretical work in cognitive psychology (and judgment and decision making in particular) is an increased emphasis on the underlying mental processes that result in behavior. That is, rather than simply trying to predict or describe the overt choices people make, researchers are increasingly interested in forming specific models about the latent cognitive and emotional processes that produce those decisions. Broadly, we might classify these as computational or process models, which consist specifically of production rule systems (Payne, Bettman, & Johnson, 1992, 1993), heuristic "toolboxes" (Gigerenzer, Todd, & The ABC Research Group, 1999), neural network models (Glöckner & Betsch, 2008; Simon, Krawczyk, & Holyoak, 2004; Usher & McClelland, 2001), sampling models (Busemeyer & Townsend, 1993; Diederich, 1997; Roe, Busemeyer, & Townsend, 2001; Stewart, Chater, & Brown, 2006), and more. To many, including the present authors, this is a welcome and exciting evolution of theorizing in our field.

With an increase in the explanatory scope of these process models comes the need for advancement in the methodological tools and analytic techniques by which we evaluate them (Johnson, Schulte-Mecklenbeck, & Willemsen, 2008). Traditional algebraic models, such as Savage's (1954) instantiation of expected utility, were assumed to be paramorphic representations, not necessarily describing the exact underlying mental process of *how* individuals make choices, but rather *what* choices people make. Therefore, researchers were content—and it was theoretically sufficient—to only examine choice outcomes and the maintenance (or not) of principles such as transitivity and independence (e.g., Rieskamp, Busemeyer, & Mellers, 2006). However, contemporary emphasis on process modeling requires more sophisticated means of model evaluation.

In the past few decades, process-tracing techniques such as mouse- and eye-tracking have become popular for drawing inferences about the information acquisition process in decision making (Franco-Watkins & Johnson, 2011; Payne, 1976; Payne et al., 1993; Wedel & Pieters, 2008; Wedell & Senter, 1997; and many more). This large body of work seeks to verify the patterns of information acquisition that decision makers employ, and compare these to the predictions of various process models. This represents a boon in the ability to critically assess and compare different theoretical processing accounts. Granted, there are some strong assumptions that need to be made when using this paradigm, and some limitations in the resulting inferences (Bröder & Schiffer, 2003, and the references therein; Franco-Watkins & Johnson, 2011). Still, this paradigm has proven valuable in acknowledging the importance of bringing multiple dependent variables to bear on scientific inquiry in decision research.

In the current work, we are not disparaging the contribution of process-tracing techniques to our understanding of decision processes. However, the process-tracing paradigm is focused on patterns of information acquisition, but not necessarily the *direct* impact this information has en route to making a decision. That is, even though this approach is able to monitor the dynamics of information collection, it does not dynamically assess how this information influences preferences or "online" behavioral intentions. In fact, it *cannot* do so: the only indication of preference in these tasks remains discrete, in the form of a single button press or mouse click to indicate selection of a preferred option at the conclusion of each trial. At best, then, process-tracing paradigms can only draw inferences about how aggregate measures (such as number of acquisitions or time per acquisition) relate to the ultimately chosen option, or the strategy assumed to produce that option. In response to this general shortcoming, we simply propose to dynamically monitor the response selection action as well. Just as process-tracing has been used as a proxy for dynamic attention in decision tasks, we propose that response-tracing can be used as a dynamic indicator of preference. We begin with some theoretical context and a brief survey of this paradigm's success in cognitive science before presenting a validation, extension, and application of this approach to preferential choice.

1.1. Embodied cognition

Our basic premise rests on the assumption that cognitive processes can be revealed in the motor system responsible for producing relevant actions. This proposition can be cast as an element of embodied cognition, which is already theoretically popular in behavioral research (for overviews,