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Single-process versus multiple-strategy models of decision making: Evidence from an information intrusion paradigm☆

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ABSTRACT

When decision makers are confronted with different problems and situations, do they use a uniform mechanism as assumed by single-process models (SPMs) or do they choose adaptively from a set of available decision strategies as multiple-strategy models (MSMs) imply? Both frameworks of decision making have gathered a lot of support, but only rarely have they been contrasted with each other. Employing an *information intrusion* paradigm for multi-attribute decisions from givens, SPM and MSM predictions on information search, decision outcomes, attention, and confidence judgments were derived and tested against each other in two experiments. The results consistently support the SPM view: Participants seemingly using a "take-the-best" (TTB) strategy do not ignore TTB-irrelevant information as MSMs would predict, but adapt the amount of information searched, choose alternative choice options, and show varying confidence judgments contingent on the quality of the "irrelevant" information. The uniformity of these findings underlines the adequacy of the novel *information intrusion* paradigm and comprehensively promotes the notion of a uniform decision making mechanism as assumed by single-process models.

1. Introduction

Every day, humans are confronted with a multitude of choice problems and situations that differ, for example, in complexity, information accessibility, time constraints, and so on. Most researchers in the field of multi-attribute decision making agree that decision makers are able to adapt their behavior to these task features (Bröder & Schiffer, 2003a; Gigerenzer, Todd, & ABC Research Group, 1999; Payne & Bettman, 2001; Rieskamp & Hoffrage, 1999). There is, however, no consensus about how people adapt their behavior. Instead, two frameworks of multi-attribute decision making coexist that make fundamentally different assumptions about the process underlying this adaptivity.

Although several authors have advocated for the importance of distinguishing between these two frameworks (Glöckner & Betsch, 2011; Newell, 2005; Newell & Bröder, 2008) and a few attempts have been made to do so (Bergert & Nosofsky, 2007; Glöckner, Betsch, & Schindler, 2010; Hausmann & Läge, 2008; Lee & Cummins, 2004; Newell, Collins, & Lee, 2007), there is no conclusive evidence, yet, to decide which framework fares better. The reason for this shortfall is an "empirical challenge," as Newell (2005, p. 13) puts it. Both frameworks can often account for empirical findings equally well and are therefore virtually impossible to tease apart. As one potential solution to this problem, we introduce the *information intrusion* paradigm that builds on very basic assumptions of the two frameworks. Using this paradigm, we tested basic predictions of both approaches against each other.

In the remainder of the introduction, we describe the two frameworks of multi-attribute decision making in more detail and subsequently discuss some attempts that have been made to disentangle the two approaches. After introducing the theoretical foundations and the basic idea of the novel *information intrusion* paradigm, we present two empirical implementations of the paradigm. The first experiment contrasts the two frameworks of interest by means of information search, choice outcomes, and, additionally, memory performance, whereas the second study also considers confidence judgments.

1.1. Two frameworks of decision making

Multi-attribute decision making deals with preferential choice and probabilistic inferences. The difference between these two domains is

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that in the former decisions are made in relation to a subjective criterion (e.g., "Which dessert do you like better?"), whereas in the latter the decision criterion is an objective one (e.g., "Which dessert contains more calories?"). Formally, these domains are similar: The decision maker chooses between two or more options that are characterized by a categorical set of attributes (cues). The cue values display the, often binary (positive versus negative), evaluation of the options by the respective cue. The cues differ with regard to the strength of the correlation between their evaluation and the actual decision criterion (cue validity). As empirical similarities suggest similar cognitive processes in both domains (Bröder & Newell, 2008; Payne, Bettman, & Johnson, 1993; Todd, Gigerenzer, & ABC Research Group, 2012), we will consider models that were developed for preferential choice as well as models for probabilistic inferences in the subsequent discussion of frameworks for multi-attribute decision making.

1.1.1. Multiple-strategy models

One popular framework for multi-attribute decision making can be summarized by the notation of "multiple-strategy models" (MSMs, e.g., Beach & Mitchell, 1978; Gigerenzer et al., 1999; Payne et al., 1993; Scheibehenne, Rieskamp, & Wagenmakers, 2013). MSMs propose that decision makers have several distinct decision strategies or heuristics at their disposal (for example, the "adaptive toolbox," Gigerenzer & Todd, 1999) and choose adaptively between them. The selected decision strategy determines the sequence of information search (search rule), the amount of information searched (stopping rule), and how information is integrated (decision rule).

One prominent decision strategy for multi-attribute decision making has received great attention: the "take-the-best" heuristic (TTB, Gigerenzer, Hoffrage, & Kleinbölting, 1991). It assumes a cue-wise information search along a cue validity hierarchy—from the cue with the highest validity to the cue with the lowest validity (TTB's search rule). Information search terminates as soon as a cue discriminates between the considered options and favors only one of them (TTB's stopping rule). The decision maker chooses the option favored by the discriminating cue (TTB's decision rule). Thus, TTB offers a prominent example of a decision strategy that, if the stopping rule is satisfied before all cues have been investigated, uses only a subset of available and applicable information (so-called *frugality*, Gigerenzer & Goldstein, 1999).

The question, how the decision maker selects a decision strategy from the set of alternatives, has been posed by several researchers (e.g., Payne & Bettman, 2001; Payne et al., 1993). Whereas many authors seem to suggest a top–down mechanism (Beach & Mitchell, 1978; Marewski & Schooler, 2011; Payne et al., 1993), evidence accumulated that bottom–up learning also shapes strategy selection (Bröder, Glöckner, Betsch, Link, & Ettlin, 2013; Bröder & Schiffer, 2006; Rieskamp, 2006; Rieskamp & Otto, 2006). In addition to this strategy selection problem, the MSMs need to deal with the question, how many strategies actually comprise the set of possible alternatives (cf., Marewski & Schooler, 2011; Scheibehenne et al., 2013).

1.1.2. Single-process models

The "single-process models" (SPMs, e.g., Busemeyer & Johnson, 2004; Busemeyer & Townsend, 1993; Glöckner & Betsch, 2008a; Hausmann & Läge, 2008; Lee & Cummins, 2004) comprise the second, coexisting framework for multi-attribute decision making. Here, it is assumed that instead of selecting one decision strategy from a set of different alternatives, the decision maker employs one single decision making mechanism (for example, the "adjustable spanner (or wrench)," Newell, 2005) that might be adjusted to the particular task at hand. Two prominent classes of the SPMs are connectionist models (e.g., Glöckner & Betsch, 2008a; Simon & Holyoak, 2002; Thagard & Millgram, 1995) and evidence accumulation models (e.g., Busemeyer & Johnson, 2004; Busemeyer & Townsend, 1993; Hausmann & Läge, 2008; Lee & Cummins, 2004; Newell, 2005).

Connectionist models assume that decisions are formed by parallel consideration of all available decision-relevant information in a neural network representing the decision problem (e.g., Glöckner & Betsch, 2008a; Simon & Holyoak, 2002; Thagard & Millgram, 1995). Activation spreads in the network until a stable state is reached and consistency is maximized. The option with the highest positive activation is chosen. The connectionist models focus on the process of information integration, given a set of information.

Evidence accumulation models, to name another class of SPMs, assume a sequential sampling process that terminates as soon as one option surpasses a certain threshold of preference or confidence (e.g., Busemeyer & Townsend, 1993; Hausmann & Läge, 2008; Lee & Cummins, 2004; Newell, 2005). Whenever this happens, a choice is made in favor of this option. Evidence accumulation models do not focus exclusively on information integration, but often also model the process of information search—either in a probabilistic (e.g., Busemeyer & Townsend, 1993) or a deterministic (e.g., Lee & Cummins, 2004) way.

Although the SPMs avoid the aforementioned strategy selection problem by assuming only one single mechanism that is applied to all multi-attribute decisions, one might argue that they merely replace this issue with a different problem (e.g., Marewski, 2010; Newell & Lee, 2011): How do decision makers adjust the proposed uniform mechanism? Some attempts have been made to answer this question for the SPMs in particular (e.g., Glöckner & Betsch, 2008a; Hausmann & Läge, 2008; Jekel, 2012; Newell & Lee, 2009) and some work on the strategy selection problem of the MSMs (e.g., concerning the central role of *learning*, Rieskamp & Otto, 2006) can probably be transferred to this problem. The theoretical advantage of the SPMs over the MSMs, however, lies in the fact that the MSMs often do not confine the set of decision strategies in a principled fashion. Hence, new behavioral phenomena may be captured by extending the toolbox with more sophisticated strategies (e.g., Glöckner & Betsch, 2011; Newell & Lee, 2011; Newell, 2005, but see Marewski, 2010). The downside of SPMs is, however, that they currently do not provide strict predictions for search or the selection of decision boundaries.

1.2. How to distinguish between the two frameworks?

The coexistence of the two frameworks (SPMs and MSMs) is theoretically disappointing (Glöckner & Betsch, 2011), but consequential as both frameworks can often account for empirical data equally well. For example, a well-documented finding in multi-attribute decision problems refers to the influence of information costs on decision behavior: Increasing information costs leads to a more frequent use of fast and frugal heuristics like TTB instead of compensatory[1] strategies (MSM interpretation, Bröder, 2000, 2003; Newell & Shanks, 2003). This empirical finding can, however, also be interpreted from a SPM view—for example, as a lowering of the evidence threshold in an evidence accumulation model. Hence, both frameworks invoke different metaphors that explain and capture contingent decision behavior.

The crux is that the SPMs aim at unifying the different decision strategies incorporated in the MSMs (Glöckner & Betsch, 2008a; Hausmann & Läge, 2008; Lee & Cummins, 2004; Newell, 2005). Thus, it comes as no surprise that these SPMs can equally well account for decision behavior that can be described by the decision strategies. The quest to empirically distinguish between the two frameworks poses a challenging research task that some authors have doubted is solvable at all (Newell, 2005; Newell & Bröder, 2008). Nevertheless, in the next section some recent attempts to separate the two frameworks will be discussed.

[1] The term *compensatory* (or *noncompensatory* respectively) can describe a decision strategy as well as an environment. It refers to the degree of tradeoffs among cues. Noncompensatory decision strategies (like TTB) do not allow for a good value on one cue to make up for a bad value on a different one, whereas compensatory decision strategies allow for these tradeoffs (e.g., Payne et al., 1993). If the term is used for environments, it refers to the environment's payoff structure—favoring either noncompensatory or compensatory cue integration (e.g., Bröder, 2003).