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Directions Toward a Meta-Process Model of Decision Making: Cognitive and Behavioral Models of Change

Joseph P. McFall
State University of New York at Fredonia

Hundreds of partially unique decision-making models, primarily differing by context, currently coexist in the decision-making literature. Yet we have 1 brain that makes decisions in all these contexts. The study of decision making needs integrative metatheory to advance and test the research questions of tomorrow. Existing descriptive, behavioral, information processing, dual process, fuzzy trace, and motivational and contextual models are examined to find commonalities that may inform future attempts at building a holistic, dynamic, integrative metatheoretical model of everyday decision making. Features of such a future metamodel are described and related to the study of behavioral development, such as the value of reinforcement as a mechanism of change.

Keywords: behavioral development, decision making, everyday cognition, process model

> At the high level of grand theory, we may be driven by quite general concerns: to explore development; . . . to show that man is a processor of information; to show he is solely analyzable in terms of contingencies of reinforcement responded to. . . . Indeed, psychology with its penchant for being explicit about its methodology has created special terms, such as "orienting attitudes" and "pretheoretical dispositions," to convey the large distance that separates the highest levels of theory from the immediate decisions of day to day science. (Newell, 1973, p. 287)

As a fundamental and continuous process impacting daily life outcomes, decision making has evoked multitudinous theories and models to explain it. Theorists have competing perspectives about the roles of logical reasoning, heuristic strategies, and biological processes in choosing courses of action. Theories tend to focus on probability functions (e.g., economics-based approaches such as expected utility theory) in describing how individuals should make decisions under ideal circumstances (i.e., rational approach), examining how decisions should be made under realistic conditions (i.e., prescriptive approach), assessing the role of automatic thoughts and behavior for making efficient decisions (i.e., heuristic approach), and testing the many cognitive errors and biases that heuristics can produce (i.e., normative approach).

However, of the many theories and models of decision making emerging from economics and cognitive psychology, none have integrated the contributions of behavioral psychology and its long-standing history of measuring choice behavior. Furthermore, decision-making researchers rarely identify links between cognitive decision-making processes and development. In a related article, I discussed the specific contributions of existing decision-making models and outline the utility of contextualism as an integrative framework for developing a metatheory of decision making (McFall, 2015). Future decision making research must integrate the decision-making process with behavioral development principles to generate more holistic and dynamic research on human decision making.

In the present article, I outline several features and issues that a potential integrative metatheoretical model of everyday decision making should address. For example, decision making must be examined at multiple levels of analysis. I believe that a multilevel approach in a decision-making metamodel will provide the framework for analyzing decision making both as a source of behavioral development and a

Correspondence concerning this article should be addressed to Joseph P. McFall, Department of Psychology, State University of New York at Fredonia, W357 Thompson Hall, 280 Central Avenue, Fredonia, NY 14063. E-mail: joseph.mcfall@fredonia.edu

cause of behavioral development, depending on the level of analysis. This highlights the dynamic processes that occur during decision making and decision making's role in behavioral development, especially through mechanisms of change such as reinforcement of decision outcomes. I seek to demonstrate that extant process models share core features, and that behavioral development approaches are complementary, rather than competing.

First, I will briefly describe key elements of existing decision-making models that must be integrated into a more holistic metamodel, including bounded rationality, information processing, and fuzzy trace theories of decision making. Then, I will highlight the links between these theories and behavioral approaches to choice. Next, general features of a potential integrative model will be identified, including emphasis on bounded rationality, the process model framework, perspectives about decision-making process components' transitions, the hierarchical nature of decision-making process components, and decision making as an independent, but interdependent system. My hope is that highlighting these issues may help build links among decision-making models, with the eventual goal of generating holistic, dynamic, and integrative decision metatheory.

Existing Theoretical Models

It is daunting to undergo a task of integrating multiple classes of theories, including hundreds of separate models and applications within thousands of publications. One approach is to treat each supported decision-making model as a representation of an observation of the "true" decision-making process, in a particular context. Then, presumably, the overlap of the sum of decision-making models is akin to interobserver reliability of the decision-making process. An examination of hundreds of decision-making models across various disciplines is beyond the scope of the present article; however, key highly cited models will be described in the next sections. The goal of integrative metatheory is to provide a framework that can encompass these extant models and build interconnections that link them according to higher-level features.

Procedural Rationality

Rationality models of choice, or classic theory in economics, assume that humans use logical decision rules to maximize outcomes (i.e., expected utility theory) of scare resources, such as monetary gain (Simon, 1979). Simon was critical of rationality models' lack of emphasis on the characteristics of the decision maker in a decision task. Rationality models incorporate "*substantive rationality*—the extent to which appropriate courses of action are chosen," but fail to consider "*procedural rationality*—the effectiveness, in light of human cognate powers and limitations, of the *procedures* used to choose actions" (Simon, 1978b, p. 9). Given evidence across multiple paradigms, Simon goes on to conclude that it is hard to take subjective expected utility (SEU) models as viable models for how humans make decisions when faced with uncertainty (i.e., everyday life decisions). This is not surprising considering the fact that SEU models were developed by economists to predict what outcomes occurred, not the process of getting to the outcomes.

Simon's bounded rationality approach emphasizes the role of human limits in processing information during decision making. Rather than focusing on the outcomes, Simon emphasizes the constraints of the process. Simon was influenced by John Dewey's (1910) Theory of Thinking, which consists of the following steps: (a) problem recognition, (b) problem definition, including isolating the location and features of the problem, (c) generating strategy alternatives, (d) reasoning through the strategy options to pick the best option, and (e) testing the selected solution strategy. As a theory of *thinking,* the steps of the process stop prior to action. Wallas (1926) refined the thinking steps to focus on the creative process: (a) *preparation*—collecting and creating an internal representation of problem-relevant information, (b) *incubation*—mulling over the problem, (c) *illumination*—developing an insightful conception of a solution, and (d) *verification*—considering whether the solution would actually work.

Simon (1976, pp. 92–170) identifies the typical procedural rationality model, which is based on utility maximization, as (a) identifying and listing all alternatives, (b) determining all the consequences resulting from each of the alternatives, (c) ensuring certainty in the present and future evaluation of the alternatives, and (d) comparing the accuracy and efficiency of each set of consequences in terms of utility. To integrate the bounded nature of rationality, Simon (1979) focused on two elements of this process model: search and satisficing.

By acknowledging that individuals have limited cognitive resources, such as attention, memory, and logical/reasoning abilities, Simon explained that the search for a decision alternative would follow an individual's *aspiration*, or how good an alternative is. During the search for alternatives, the decision maker would be satisfied if a satisfactory alternative was found, thereby ending the search process. He called this *satisficing*; it is evaluating alternative courses of action until one that will satisfy the demands of the environment, even if it is not the best outcome, is found (Simon, 1978b, 1979).

Recent versions of procedural rationality resemble Simon's model. According to Galotti (2002, p. 4), the individual must be as careful as possible to gather as much information as possible regarding the alternatives, evaluate the evidence that supports the best outcome, but also evaluate the evidence against it. The process of rational decision making in everyday life follows five steps according to Galotti (2002, pp. 4–6): Setting goals, Gathering information, Decision structuring, Making a final choice, and Evaluating.

Rationality process models of decision making have become standard Business Management textbook inclusions. They often include a 5-step process: (a) Formulating a goal, (b) Identifying the criteria for making the decision, (c) Identifying alternatives, (d) Analyzing the alternatives, and (e) Making a final decision (Boundless, 2014). Similarly, nursing textbooks include the steps of decision making as (a) "Establishing objective," (b) "Classifying and prioritizing objectives," (c) "Developing alternative actions," (d) "Evaluating alternatives against objectives," (e) "Tentative decision to most appropriate alternative," (f) "Evaluation of tentative decision for more consequences," and (g) "Decisive action is taken and additional actions to prevent consequences" (Decision-Making Models, 2013).

Taken together, bounded rationality process models emphasize six common steps: (a) Antecedent conditions (including Preparation, Goal formation, and Establishing objectives); (b) Recognizing the opportunity to make a decision (including Incubation, Gathering information, and Classifying and prioritizing objectives); (c) Judgment and interpretation of the problem (including Problem definition, Incubation, Decision structuring, and Establishing decision criteria); (d) Surveying alternatives (including Generating/developing alternatives, Reasoning through/analyzing alternatives, Testing/evaluating alternatives, Illumination, Determining consequences, Ensuring certainty, Comparing efficiency,); (e) Action (i.e., choosing and enacting some alternative); and (f) Reflection. A potential integrative model of decision making might begin as a rationality process model. Once a base process model of decision making in everyday life is determined, one can begin to identify the component process of each step, such as which reasoning processes lead to the selection of a strategy and how reflection leads to behavioral change. These component processes depend on how information flows through the decision-making process.

Information-Processing Theory and Decision Making

Information processing theories (e.g., Kail & Bisanz, 1992; Klahr, 1989; Palmer & Kimchi, 1986; Siegler & Shipley, 1995; Simon, 1962) explain that the human experience can be likened to the metaphor of a computer. There are three general continuous processes: inputs (afferent sensory activity), processing (interpretation, integration, generation of symbolically represented information), and outputs (efferent motor responses, verbal behavior, action). Thus, decision making is not a sole process, but a collection of processes that follow the path of information through our cognitive systems. An assumption of the information processing approach is that there are relatively few cognitive processes involved in cognition (Kail & Bisanz, 1992), they operate at a higher-order level than component subprocesses, and these higher-order processes interact to generate cognition (Palmer & Kimchi, 1986).

Classic information processing theories have been criticized for the failure to account for the interaction of cognition with affect and motivation in modeling human cognition (Simon, 1967). Early simulation models (see Simon, 1967 for a review) included limited developmental processes, single motive (i.e., goal), and no emotion-related processes. Simon suggested that information-processing theories incorporate two additional elements of the human experience: a goal-terminating mechanism, which approximates Simon's satisficing heuristic (i.e., discontinuing a strategy search upon discovery of an acceptable solution, albeit not the best solution), and an interruption mechanism to represent the impact of emotion in cognition (e.g., allowing the system to respond to more pressing needs).

Boneau (1974) characterized information processing as a system of processes in which an individual, who interacts with the environment, creates an internal model of the environment. This model contains known information about the situation, potential available outcomes of behavior, and the likelihood that those outcomes will occur after a chosen action is performed. For example, Boneau and Cole (1967) examined color discrimination in pigeons to successfully demonstrate an animal model for an expected utility decision rule. The known situational information included hue variations and presence/absence of key pecking, potential outcomes were a fixed amount of grain and a fixed effort for key pecking, and the likelihood that the outcomes would occur were determined by internalized probabilities of reward, depending on the reinforcement schedule. Boneau (1974)'s model concludes that an individual (a) "evaluates the set of possible outcomes with their various hedonic effects at that time," (b) "determines the expected hedonic value of the outcomes," and (c) "performs the action necessary to produce the highest expected hedonic values."

The contextual world view adds to the contributions of information-processing theory by necessitating that cognitive processes occur within a particular sociohistorical/cultural context. The availability of possible inputs depends on the particular environment at a particular time. The processing that is activated may also be influenced by the context, and the possible actions and outcomes of those actions will be constrained by the time and place in which they are to occur. Therefore, the collective of decision-making processes is fundamentally and necessarily contextual. As nature is bound to nurture, genes unfold within an environment, likewise decision making cannot occur outside of context. Individuals learn within specific contexts, which directly impacts decision-making outcomes. In the next section, the links between learning and decision making will be explored.

Fuzzy Trace Theory

Some cognitive theories of decision-making emphasize internal cognitive processes learning processes as sources of decision making. A popular approach is the application of dual process theories of cognition to decision making and reasoning (see Evans, 2011). Wason and Evans (1974–1975) describe the application of dual systems of thought to the psychology of reasoning. People tend to have two concurrent systems of reasoning: Type I is fast and automatic; Type II is slow and effortful. People tend to begin a decision-making encounter by selecting a fast processing strategy, or heuristic, and depending on self and environmental factors, may choose to modify that reasoning line using more controlled and thorough cognitive analysis (Evans, 2011).

Fuzzy-trace theory is a special application of dual process theories that focuses on the types of memory representations that are formed from incoming information processing streams. *Verbatim* and *gist* memory representations from the environment are encoded, providing the inputs for the cognitive system (Brainerd & Reyna, 2002; Reyna & Brainerd, 1995). People often rely heavily on gist representations, which are less precise memory representations than verbatim representations. However, these fuzzy traces often lead to efficient and successful reasoning, sometimes more adaptive than the processing that arises from careful (i.e., Type II) processing (Reyna, 2004). Reyna and Brainerd (2011) demonstrate how gist and verbatim representations can account for predictions of Kahneman and Tversky's Prospect Theory, one of the most cited models of decision making since Simon.

Sometimes, interference processes can be disruptive to the intuitive processing and lead to worse behavioral outcomes. Fuzzy trace theory has been especially applied to understanding situations involving risk, such as the everyday lives of adolescents (see Reyna & Brainerd, 2011). Reyna provides neurological evidence to support the developmental nature of risky decisions via fuzzy processing (Reyna & Huettel, 2014). Reyna and Huettel reviewed decision neuroscience research and identified neural reward circuitry and response inhibition patterns as influential in decision outcomes. They also highlighted research that links activity in emotion centers (i.e., amygdala) to that of decision-making centers (i.e., ventromedial prefrontal cortex) of the brain in adolescence. Furthermore, anterior insula activity, known to process aversive emotions such as anxiety, was consistently related to risky choice behavior.

In decision-making tasks, participants encode both verbatim, and gist representations of the probabilities and outcomes of choices, but generally rely on the simplest gist representations when choosing a response (see Reyna & Huettel, 2014). Neurological evidence can predict this gist-based responding: the posterior parietal cortex and dorsolateral prefrontal cortex predict gist-based choices. The ventromedial prefrontal cortex and anterior insula activations predict verbatim-based (analytical) choices. Given the link between adolescents' developing prefrontal cortex and anterior insula in risky decision making, the reliance on gist-based processing may actually be adaptive for adolescents to overcome reasoning that leads to tolerance of excessive risk.

Behavioral Development and Decision Making

The premise of Sedlmeier and Betsch's (2002) book is that a fundamental piece of information used throughout cognitive processing, from making sense of past events, to present decisions, to predicting the future, is frequency representation. People have mental representations about the tendency of a situation to repeat. Frequency information is often used heuristically in judgments. We make associations, often causal, among information that cooccurs frequently. Behavioral learning theory (Baer, 1970; Bijou, 1989; Skinner, 1938) provides the behavioral link to how frequency information affects behavior.

The value of a reinforcer (or punisher) is one explanation for the likelihood of a future behavior to be linked to past experience. Reinforcer value is the notion that some reinforcers, certain levels of reinforcers, or reinforcement schedules (i.e., PR; Francisco, Borrero, & Sy, 2008) are better than others to elicit a future response for a particular individual in a particular context. For example, Bonardi (2001) emphasizes the link between mental representations of a stimulus and reinforcers, in contrast to the older viewpoint that classical conditioning is a result of direct stimulus-response association. In a level of analysis which excludes the role of mental representations in effecting behavior, the stimulus–response association viewpoint predicts that a change in reinforcer value would have no effect on responding. However, experiments do find that manipulations of reinforcer value alter response rate.

During decision making, an individual's learning history, especially reinforcement value, is an individual factor that interacts with context factors throughout the decision-making process. Some cognitivists refer to the sum of learning history as a learning and memory cognitive system. This system of information about prior behavior is expected to interact with similar high-level systems, such as the decision-making process. Therefore, information processing can occur at a systems level of analysis, at which multiple systems may interact to generate complex behavior.

The model of hierarchical complexity. Commons and colleagues' provide an alternate model about the development of complex behavior. They examine the stage of behavioral development at which an individual performs during a task. Different tasks require different orders of complexity, which are represented by the *Orders of Hierarchical Complexity*. The measurement model examines the match between the demands the environment and the individual's performance in that particular task domain (Commons & Pekker, 2008; Commons, Trudeau, Stein, Richards, & Krause, 1998; Commons & Tuladhar, 2014).

Commons, Ross, and Bresette (2011) state that, besides stage of development, the value of an outcome influences behavior. There are four types of value: (a) reinforcer value, (b) discounting (e.g., temporal), (c) risk, and (d) cost (Commons & Tuladhar, 2014). Reinforcer value is based on two factors: the sensitivity to the reinforcer and the perceived value of the reinforcer. Perhaps reinforcer sensitivity (e.g., how strongly the reinforcer elicits a behavior) can interact with relevant context factors in a decision-making situation. Commons and Tuladhar (2014) considered reinforcer sensitivity to be linked to an interaction of genes and the environment, perhaps an epigenetic effect. Furthermore, they stated that the perceived value of reinforcement, a person's reported reinforce sensitivity, determines behavior frequency.

Reinforcement learning. Normative decision-making researchers, especially those in neuropsychological settings, have begun in recent years to include learning mechanisms into probability models (Eppinger, Hämmerer, & Li, 2011). Because individuals never receive all the required information to make a completely informed decision, they must learn to predict the outcomes. Reinforcement learning is now popular within decision neuroscience and neuroeconomics research as researchers attempt to model this learning in the brain (Lee, Seo, & Jung, 2012). In that context, reinforcement learning is an adaptive process by which an individual utilizes past experiences to maximize desired future outcomes.

At a cognitive level of analysis, reinforcement learning is one source of self-knowledge, among other self-factors that influence decision outcomes. Other self-factors also influence reinforcement learning, through value of reinforcers. As reinforcement learning becomes internalized into some learning and memory cognitive system or neural network, future decisions may correspondingly differ (i.e., decision-making draws on prior knowledge, especially self-knowledge). However, we also learn from our decision making and experience of decision effects. This learning can also become integrated within the broader self-knowledge base, thereby acting like a developmental mechanism. In this sense, decision-making is both influenced by behavioral development and influences behavioral development. This is reminiscent of a contextual perspective, such as dynamic systems theory that emphasizes the unfolding of developmental processes as an individual gains experience in the context.

Features of a Meta-Theoretical Model of Decision Making

Bounded Rationality

Although rationality models may not best represent everyday decision making, they have been the inspiration for viewing decision making as a process. Von Winterfeldt and Edwards (1986, p. 2) defined modern rationality models of everyday decision making as "selecting ways of thinking and acting to serve your ends or goals or moral imperatives, whatever they may be, as well as the environment permits." Simon (1978b) stated that decision making surely must follow some process. The fundamental difference between the rationality process model and Simon's conceptualization of *bounded rationality* (i.e., humans have processing limits) is that Simon does not assume that every decision-making occurrence involves logical reasoning or results in selection of the optimal outcome. Simon (1979) warned that rationality models of decision making have important limitations, specifically that humans have limited cognitive resources. For example, limits on information processing abilities (e.g., attention, memory), cognitive (e.g., intellectual) abilities, and experiential resources limit reasoning capacity and prevent people from being *ideal* decision makers.

Cognitive resources, such as attention, analysis/computational power, and memory capacity, are limited because they demand energy resources to function. As the mind gets tired and resources get depleted, decision making slows. For example, take a situation when you were exhausted but continuing to stay awake to accomplish some goal, whether it was work-related, a leisure activity, or even night-time driving. Perhaps you began to doze off in midthought. Your head dropped down and you immediately lifted it back up, only to lose control again in a few seconds. During this battle of the sleep–wake systems, you were likely thinking about one thought, trapped in a loop, and could not muster enough power to finish the thought, until something jarring occurs, such as a loud noise or realizing you are about to get injured. Cognitive resources (e.g., attention, intelligence, memory, processing speed) are important to the decision-making process because these resources interact with the decision-making process, determining the level of constraints on reasoning.

Process Model

A process model is a strong base model for integrating various perspectives about decision making and behavioral development (see McFall, 2015). McFall explains that a process model can subsume the outcome model, but the latter cannot account for the former. Simon (1978b) calls for *procedural rationality* in decision-making theory—the use of bounded rationality process models in understanding decision making in order to focus on the *how* of a decision over the *what*.

There is also a sense of ecological validity in the process model, not present in the outcome models. The experience of making a decision in everyday life *feels* like a process. To quantify this feeling, decision making in everyday life appears to have, from occasion to occasion, variability in several factors, including perceived level of mental effort, degree of susceptibility to interruption or distraction, and time lapse from decision onset to action. The assumption that multiple processes underlie decision making provides possibilities for explaining the numerous sources of variability in the perceived process.

A Process Model of Decision Making Containing Steps, Not Stages

Decision making, logically, involves certain steps; for example, the earlier description of procedural rationality resulted in a six-component process model. The first component, antecedent conditions, encompasses preexisting conditions before a decision is made. For example, the individual, the environment, and their interaction preexist any decision that is made by a person and in a given environment. Furthermore, a person logically must choose to make a decision before he can evaluate its outcome. By categorizing model components into steps, future research can begin to produce a tentative model for empirical model testing.

The general term *step* is used over more specific terms, such as level, period, phase, or stage, to acknowledge the uncertainty surrounding internal events. Among decision-making and development theories, labels such as level, period, phase, and stage are often used purposefully, but sometimes interchangeably. However, they have very precise applications. Von Glasersfeld and Kelley (1982) explain that the term *level* does not refer to a stretch of time, but a degree of some measurable characteristic. It is an inappropriate descriptor for indicating relations among cognitive processes. The terms *period* and *phase* do denote stretches of time, but these terms are also inappropriate for modeling cognitive processes in decision making. *Period* represents a limited stretch of time that is not necessarily related to any other stretches of time within the continuum. *Phase* is a term for predicable, cyclical events (e.g., the phases of the moon; von Glasersfeld & Kelley, 1982); decision making may, but need not, be cyclical. The very purpose of making a decision is to resolve a dilemma, making further action unnecessary. Upon a successful decision-making process, resulting in resolution, a person may realize upon reflection that further action is unnecessary in that situation.

Humans are not perfect decision makers, though, and often repeat the decision-making process. This does not, however, make the process a series of cyclical phases. The act of engaging in the decision-making process changes the individual. Each attempt at decision making changes the antecedent conditions (e.g., the relevant self- and/or context factors that preceded the decision-making process), even when the decision-making attempt is unsuccessful (i.e., engaging in decision making likely leads to reflective thoughts that alter self-factors). To suggest that the decision-making process occurs in phases, even though it is a dynamic process guiding self-change, would be akin to suggesting that the phases of the moon (i.e., the various patterns of visible moon luminance during its orbit around Earth) *change* the actual moon.

Finally, the term *stage* implies progression toward an end state from a known beginning state, while some components remain constant (or undergoes continuous quantitative change as in Piaget's *horizontal décalage*) throughout the stage. Each stage is generally separated by an abrupt qualitative change (von Glasersfeld & Kelley, 1982). The notion of steps, on the other hand, implies progression, but permits deviations from the process, such as *side steps* and *backward steps* or *skipping a step* or *stepping in* *place* (i.e., repeating a step). In the present model, each successive step is a general set of processes that are assumed to occur after the prior set. The notion that the decision-making steps are successive, rather than *progressive*, implies that there is a logical order to the steps, but they do not necessitate progress or improvement, as does the term progressive (Goldhaber, 2000, p. 310).

In essence, the steps of the decision-making process represent logical boundaries rather than physiological, behavioral, or cognitive boundaries. Given the unknown about the brain and its functions, there is no basis for stating with certainty that steps of the decision-making process described below cannot occur simultaneously. Logically, however, the complexity of processes involved in decision making appear to require some temporal precedence, making the step model most appropriate. This successive nature of the proposed model allows for the flexibility of thinking that the human brain provides: iterative processes are allowed and links among nonsuccessive steps are built into the model.

Hierarchical Processes

Multilevel theory in organizational research provides a framework for tying together nested levels of theoretical influences (e.g., the individual, subunits, firms, etc.), levels of measurement, and levels of analysis (Costa et al., 2013). This is reminiscent of Bronfenbrenner's (1979) ecological systems theory, a contextualist perspective. The premise of multilevel theory is that information can be processed on two or more distinct levels, leading to different outcomes (Leventhal & Scherer, 1987).

John Teasdale (1999), a proponent of the development of multilevel theories, explains that the multilevel theoretical approach's major strength is specifying the functional relationships of individual process and their interactions observed across research investigations. Although it can be a great challenge to fully test the models empirically, it is the specification of component relations and interactions that facilitates empirical analysis of the processes. Researchers who lump cognitive-emotional processes into a general term, such as *cognition*, do little to promote the empirical study of cognitive processes because the individual component processes are not operationalized. Component cognitive processes must be identified for multilevel theories to be testable, to test the relations among the levels of multilevel models, and examine predictive factors (Teasdale, 1999).

A cognitive process system may refer to functional brain activity in the realm of perception, decision making, reasoning, cost–benefit analysis, and so forth. Cognitive process systems may be different from cognitive resources, such as attention, memory capacity, intellectual abilities, and so forth. One viewpoint is that cognitive processes are situated within a casualty timeline for the emergence of behavior. This timeline includes initial *inputs* (i.e., new sensations and retrievable stored information), followed by all levels of cognitive processes (e.g., encoding, modifying, and storing information), then *outputs* (i.e., verbal behavior, motor behavior). Next, cognitive processes are the mechanisms underlying the transformation of inputs into outputs. Cognitive resources are tools that facilitate such transformation, but are not the initiating causes of it.

Simon (1978a, p. 3) described the importance of the level of analysis in describing mental representations of thought: "There is not a single problem of representation; there are several, each referring to a different level of analysis." An integrative metamodel of decision making should adopt the spirit of a multilevel approach to understanding the decision-making process and, later, testing it. At the highest hierarchical level of multilevel theory is the cognitive system: in this case, the decision-making process. This system interacts with other general systems, such as information-processing and memory/learning. Within decision making, this highest level represents the process as a whole, including the output of the decision-making process and its effect on the developing person. For example, Strough, Karns, and Schlosnagle (2011) hypothesized a conceptual model of decision-making biases and errors in which motivational processes interact with affective, experiential, and deliberative processes.

Grossberg's (1980) thought experiment on cognitive code raised important questions about the functional level at which a cognitive system impacts behavior. He posited that the functional unit of a cognition system is a state of resonant activity within the whole system. Only the resonant state enters consciousness and can serve as a cause of adaptive change. For example, learned changes are results of consonant bottom-up or top-down computations within the system, called *adaptive resonance*, which stabilize the *cognitive code* against irrelevant environmental fluctuations. Systems-level processes (e.g., negativity, low attention, prior experience, etc.), when relevant to the task at hand, influence the decision-making process. The adaptive resonance of a system is an effect of its function, which can influence other systems, like the decision-making process. Therefore, it is the effects of other cognitive systems, rather than the systems, themselves, that influence the decision-making process (assuming that decision making is a cognitive system). An integrative model of decision making should account for systems-level outcomes as well as component processes and behavioral observations.

The next, lower, hierarchical level of a decision-making process metamodel should be a general sequential set of steps comprising the decision-making process. The features of these level 2 steps are described in the earlier A Process Model of Decision Making Containing Steps, Not Stages section. The next lower, or third, level consists of individual processes that make up each step of the model. These processes are hypothesized to occur only during the particular step in which they are nested, but may interact with other processes within the step. They are the work horses of the model. The resulting outputs of these processes lead to successive or prior steps of the decision-making process and continue until the process is either aborted or the decision situation resolved. There is likely a fourth (and lowest) level of component processes that accounts for the processing involved in each level 3 process. These subprocesses are closest to the biological level of analysis. Finally, the model should include a reflection process that exists outside the steps of the model, which may account for an interaction effect of the decision-making process with other systems, such as learning and memory. Additionally, the model may incorporate nonprocess components, such as *resolution*, *status quo*, and relevant person and context factors that impact the entire model.

Integrative Processing of Independent Systems

Networks of neurons in the human brain make up each cognitive system that processes information in some unique way, such as perception processes, the attention system, memory encoding and retrieval, categorization, emotion regulation, and cognitive simulation, to name a few. The Planning, Attention-Arousal, Simultaneous and Successive (PASS) theory of intelligence counters traditional g-theory by identifying modular, interdependent, but separate, intellectual systems through a series of lesion studies (Das, 2002; Das, Kirby, & Jarman, 1979). Input systems such as the senses, according to Fodor (1983, pp. 47–101), are modular and encapsulated; they consist of vertical neural networks that connect Area A to Area B, leading to faster and efficient communication that boosts the analytic power of the brain. There must also be central systems that can integrate, or cut across domains horizontally, to facilitate the use of inputs in effecting behavior, as it is necessary in decision making (Fodor, 1983, pp. 102–103). Within a system, there may be parallel neural pathways processing elements of the information. Across systems, nonmodular processes facilitate cognition, such as thought and decision making.

In some systems, this parallel processing may occur at a nonconscious level before integration at conscious higher-order regions (e.g., dorsal vs. ventral stream visual processing). Another example of parallel processing may be the intriguing phenomenon of déjà vu. Four classes of theories have attempted to explain this feeling that a novel situation is familiar (see Brown, 2003). Although the initial causal emphasis varies from explanation to explanation (e.g., attention/distraction, dual processing, seizure activity), most of these theories center on the notion that parallel processing pathways lose synchronization. Hypothetically, a distracted individual in a novel situation may consciously attend to some other input than the novel pattern of environmental features at the same time that basic processing of those features is completed in parallel pathways; by the time the conscious awareness is reunited with the environmental features path, memory has been initiated for those features and the feeling of prior experience without source memory is formed.

Integrative processing between independent systems is the explanation for how the decision-making process is influenced by environmental features and self-factors (e.g., attention, experience, knowledge, reasoning capacity, memory capacity, etc.) in an integrated decision-making model. Integrative processing assumes that the decision-making process is a central system that interacts with other cognitive systems, but maintains a separate processing identity. It would be curious to suggest that humans have distinct patterns of decision-making processes for each of the innumerous contexts in which decision making has been studied. Rather, the parsimonious assumption is that the decision-making processes that occur are one, holistic set of cognitive processes that continuously exist and function as the context changes. When we consider an analogous brain system, such as the visual system, we would be remiss to suggest that we have different visual systems for seeing forests versus living rooms. It is one visual system, albeit incredibly sophisticated, designed to provide sight in any context.

If decision making is, in fact, distinct from other cognitive systems, then one would expect individual difference patterns to emerge in decision-making outcomes that do not align perfectly with any other person characteristics (e.g., cognitive ability). Similarly, if decision making draws on other cognitive systems, such as memory or intelligence, then individual differences among these characteristics should partially account for individual differences in decision-making outcomes. A significant body of research has examined individual differences across a variety of decision tasks, including many forms of heuristics (Kokis, Macpherson, Toplak, West, & Stanovich, 2002; Stanovich & West, 1998a, 1998b, 1998c, 1999, 2008a, 2008b; Toplak, West, & Stanovich, 2014; West & Stanovich, 2003). The researchers have obtained a myriad of data points representing the intersection of cognitive ability (mostly SAT performance test scores) and decision outcomes and/or reasoning ability. The resulting correlations have varied with decision task, averaging on the moderate-sized correlation.

Although evidence supports the perspective that decision making is an independent system, are there data to support the notion that the decision-making system interacts with other systems? Some of the research on cognitive ability and decision making highlights the interactive nature of multiple cognitive systems in influencing decision making. Stanovich, Grunewald, and West (2003) examined cost–benefit reasoning in 27 high school students who had received multiple school suspensions. The repeat offenders, despite having comparable performance on a general cognitive ability test in relation to control students, performed worse on the cost-benefit reasoning task. They failed to maximize earnings in the card game gambling task because they were not deterred by strategy options that involved higher penalties (Stanovich et al., 2003). In this case, a faulty reasoning strategy overrides the decision outcome. In another study, Stanovich, West, and Toplak (2013) found the *myside bias*, making decisions that are biased toward one's own opinions, to also be unrelated to intelligence. In this case, other, more salient self-factors likely outweigh cognitive ability factors in driving decision outcomes.

A decision-making metamodel can embrace such patterns. Intelligence and general cognitive ability measures should be moderately linked to decision-making performance in general. If decision making and cognitive ability were highly correlated, one may conclude that there is little distinction among the systems. If they were completely unrelated, one might question whether decision making is a central cognitive system that draws on and interacts with other systems. The bounded rationality approach emphasizes limitations of cognitive resources (e.g., attention, short-term and working memory, knowledge base, analytic capacity, etc.) in decision making. These limits are based on individual differences (person factors) and task demands (situational factors). Given that multiple systems are relevant to, and active during, the decision-making process, there are numerous sources of individual differences in the process outcomes.

Summary

The decision-making literature is flooded with specific model applications to every and any situation. A higher-level model is needed to organize the contributions of mainstream decision-making theories. The present article has outlined several highly cited decision-making models that can be integrated into a common framework, as long as disciplinary barriers can be viewed as opportunities for reflecting on common goals, rather than obstructions to integration. Such a common framework may function as an integrative metatheoretical account of decision making.

In particular, information processing, behavioral development and learning approaches, and fuzzy trace dual processing models aim each aim to understand the development of behavioral patterns. However, each extant approach emphasizes different levels of analysis of decision making. By integrating these models into a behavioral development framework, and allowing the strengths of each model to persist on one of several levels of analysis in a multilevel integrative metamodel, future researchers will be able to integrate research findings within a common framework and possibly ask bigger research questions that require multiple levels of measurement and analysis of the developing organism in decision-making encounters.

To create a holistic, dynamic, metamodel of decision making, several decisions must be made about the model's structure and features. The present article argues for a process model framework, which can both explain the process of how a decision is made as well as analyze the outcome of decisions and factors that predict such outcomes. The process model should be embedded within a bounded rationality perspective that highlights the limits of human reasoning capacity. Dual process theories, especially Fuzzy Trace Theory, explain how the processing of information, bounded by fuzzy memory traces, may or may not be analyzed more comprehensively with effortful reasoning processes. Reasoning occurs in hierarchical levels of the decision-making cognitive system. This system is constrained and enhanced by its interactions with other cognitive systems, such as the learning and memory that arises from behavioral learning encounters. As the steps of the decision-making process unfold, the outcome is ever tied to the person who is interacting with his or her environment.

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