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Walking with the Scarecrow: The Information-processing Approach to Decision Research

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Introduction

From the mid-twentieth century on, the "information-processing" approach has been a theoretical and methodological framework (paradigm) driving much research on human judgment and choice. Part of the so-called "cognitive revolution" in psychology, this approach builds upon the pioneering work of Herbert A. Simon. By the time this volume is published, it will be almost exactly 50 years since Simon's path-breaking 1955 article on the concept of bounded rationality. Our chapter takes its title from the classic tale of the Wizard of Oz (Baum, 1903), in which the Tin Man seeks a heart, the Lion courage, and the Scarecrow a brain. The information-processing approach to decision research has traditionally focused on understanding the cognitive (mind/brain) aspects of decision making; however, as noted later in this chapter, recent work has attempted to integrate the cognitive with more emotional and motivational aspects of decision making (Luce, Bettman, & Payne, 2001; Shiv & Fedorikhin, 1999).

Simon captures three key aspects of the information-processing approach to decision research in the following quotes:

1 A theory of human rationality "must be as concerned with procedural rationality – the ways in which decisions are made – as with substantive rationality – the content of those decisions" (Simon, 1981, p. 57).

2 In terms of models of procedural rationality, "the task is to replace the global rationality of economic man with a kind of rational behavior that is compatible with the access to information and the computational capacities that are actually possessed" by humans (Simon, 1955, p. 99).
3 "Human rational behavior is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (Simon, 1990, p. 7).

As the first quote states, focusing on the processes of judgment and choice and using various methods to trace decision processing are hallmarks of the information-processing approach, in contrast to the traditional focus in economics on *what* decisions are made rather than *how* they are made. The second quote stresses the need to replace the assumptions of classical economic theory about the rational decision maker (a person with complete knowledge, a stable system of preferences, and unlimited computational skill) with a view of the decision maker more compatible with humans' memory systems and computational capacities. Simon (1955) argued that limits on computational capacity are particularly important constraints upon the definition of rational choice, i.e., people exhibit only "bounded" rationality.

The last quote implies that understanding decision processing must reflect the intersection of cognitive limitations with the demands of different decision tasks. One consistent and striking conclusion from many studies of decision behavior is that judgments and choices are highly contingent upon a variety of task and context factors, due to the interaction between properties of both the human information-processing system and decision environments (Payne, 1982).

A related point is that decision researchers increasingly believe that preferences for and beliefs about objects or events of any complexity are often constructed – not merely revealed – in the generation of a response to a judgment or choice task, at least in part due to limitations in information-processing capacity (Bettman, 1979; Payne, Bettman, & Johnson, 1992; Slovic, 1995). That is, people are seen as constructing preferences and beliefs on the spot when needed, instead of having known, well-defined, and stable preferences. Further, preferences are not generated by some invariant algorithm such as Bayesian updating or expected utility calculations, but instead are generated by the contingent use of a variety of different decision heuristics or simplification mechanisms. Such use of *multiple* simplifying mechanisms (heuristics) for judgment and choice under various task and context contingencies yields the incompletely evoked and labile preferences and beliefs that typify a constructed response.

Next we present some of the key conceptual and methodological aspects of this information-processing approach to decision research. Later we illustrate the approach by focusing on a program of research (the Adaptive Decision Maker framework) dealing with choice among alternative courses of action. We end the chapter by considering how the information-processing framework can be extended to include noncognitive factors such as emotion and how the information-processing approach relates to current dual-process theories of thinking.

Information-processing Concepts and Methods

Attention as the scarce resource

A core idea of the information-processing approach is that conscious attention is *the* scarce resource for decision makers (Simon, 1978). Thus, people are generally highly selective about what information is attended to and how it is used. Understanding what drives selective attention in decision making is a critical task for decision research.

There are two major types of attention, voluntary and involuntary (Kahneman, 1973). Voluntary attention describes devoting attention to information that individuals perceive is relevant to current goals, e.g., prevention of harm (Higgins, 2002). Attention also can be captured involuntarily by aspects of the environment that are novel, unexpected, potentially threatening or otherwise affect-related, or simply perceptually salient, e.g., changes and losses relative to some aspiration, target, or reference level. Simon (1983) has argued that emotions focus attention and help overcome the limits of our one-at-a-time information-processing system. Importantly, people may be *unaware* that their attention has been focused on certain aspects of the task environment, and that their decisions consequently have been influenced.

Many common context and task effects in decision making, indicative of constructed values and beliefs, result from selective attention due to making different aspects of the judgment and choice environment salient. For instance, one of the most striking task effects in decision research is that the preference order between two gambles (prospects) often reverses, contingent upon whether the response requested is a direct choice between the gambles or a bidding price for each gamble. Although several factors likely contribute to such preference reversals, one of the explanations offered is the compatibility between a feature of the response mode and an aspect of the gambles, e.g., the need to express a bidding response in terms of dollars may direct increased attention towards the payoffs of the gamble being evaluated. At a more general level, selective attention may involve not only differential attention paid to the various aspects of a single alternative, such as gamble payoffs versus probabilities, but also a greater focus on the best and worst outcomes of a gamble as compared to intermediate outcomes, as in recent work on rank-dependent utility models of risky choice (see Chapter 20, this volume), or differential attention paid to features across multiple alternatives, e.g., the common versus unique dimensions of the alternatives.

A critical point is that decision processing in which attention is highly selective does not necessarily produce poor decisions. To the extent that a decision maker's selective attention maps onto the relevant aspects of the environment and ignores the irrelevant aspects, even highly simplified choice mechanisms are likely to yield good (satisfactory) decisions (Johnson & Payne, 1985). However, to the extent an individual selectively attends to irrelevant information or ignores relevant information, poor decisions can result. If attention is the scarce resource of a decision maker, then helping individuals manage attention is critical for improving decisions. Many decision aids have substantial value in simply helping to ensure that attention is spread more evenly across the features of an option and across multiple options (see Chapter 16, this volume).

The distinction between the *cost of processing* an item of information and the cost of acquiring information is related to the idea of attention as the scarce resource. Deliberation (processing information) about a decision is a costly activity (Conlisk, 1996), and we should consider processing costs as well as the costs of acquiring information in modeling decision making. An increase in the cognitive (or emotional) cost of processing an item of information, like the cost of acquiring an item of information, will lead to greater use of simplification mechanisms that minimize information processing. The cost of acquiring and processing an item of information may also affect the order in which information is processed, as well as whether or not an item is processed at all. Finally, because processing is costly, people tend to accept information in the form in which it is given rather than expending cognitive effort to transform it (Slovic, 1972).

Serial processing

Generally, the information-processing approach assumes that decision making involves the serial manipulation of symbols that reflect the internal representation of a problem. That is, one step in thought follows, *and is influenced by*, another. However, as Simon (1979) has noted, the specification that "the human information processing system is serial is a highly controversial claim" (p. 4). As we discuss in more detail below, several researchers have argued for dual-process views of thinking (e.g., Kahneman & Frederick, 2002; Sloman, 1996), with one type of processing that is parallel, relatively automatic, associative, and fast ("System 1") and another that is serial, effortful, and rule-based ("System 2"). Most decision researchers in the information-processing tradition accept the possibility of parallel processing in some judgments; however, we focus most on those aspects of decision processing that are serial and attention-demanding, i.e., System 2 thinking.

Heuristic judgment and choice strategies

The central idea of bounded rationality (Simon, 1955) is that limited cognitive capacity requires the use of mechanisms (heuristics) involving the selective and simple use of information to solve decision problems. Further, information-processing researchers argue that heuristics generally produce *satisfactory* outcomes. There are several reasons for the use of simplifying heuristics. First, individuals must sometimes use simplification mechanisms because there is no other choice; i.e., limited cognitive capacity or limited time for processing may act as constraints on feasible processing in a specific environment. Second, individuals may simplify because of the cost in time or effort of using the scarce resource of computational capacity. Finally, a person may use simplification mechanisms because they have worked satisfactorily in the past and are readily available in memory.

Simon (1955) proposed that one important simplification of decision processing was to stop search after the first satisfactory solution to the decision problem is obtained rather than exhaustively search for the best (optimal) solution to a problem. A related idea is that decision consequences are valued using simple payoff schemes, where the outcomes of a decision are seen as either being satisfactory or unsatisfactory relative to some aspiration level or reference value. Dynamic aspects of decision behavior can be captured by changes in the aspiration level or reference point. Although heuristics involving satisficing and simple payoff schemes can often lead to reasonable choices, they also can result in choice biases. Using satisficing to guide search and alternative selection, for instance, means that the order in which alternatives are considered can greatly impact the alternative selected. Using simple payoff schemes means that decisions will not consider reasoned trade-offs among conflicting objectives.

Other heuristic mechanisms may involve problem redefinition. Kahneman and Frederick (2002), for instance, argue that people may solve a difficult judgment problem by attribute substitution, i.e., substituting an easier to solve definition of the problem. For example, the more difficult question of how likely it is that a person with characteristics X is currently doing a job with characteristics Y may be answered by substitution of the easier to answer question of how similar the characteristics of X are to the characteristics of Y. The more similar the two sets of characteristics (the more representative), the higher the judged probability. Like selective attention effects, the redefinition of the problem may or may not be something of which the decision maker is aware. Note that use of attribute substitution means that potentially relevant information for probability forecasts, e.g., the base-rates of different jobs, may be neglected.

A critical assumption of the information-processing approach to judgment and choice is that an individual possesses a variety of heuristic strategies for solving decision problems, i.e., a "repertoire," "toolkit," or "toolbox" of strategies (Payne, Bettman, & Johnson, 1993; see Chapter 4, this volume), acquired through experience and more formal training. We have long argued that the use of multiple heuristics contingent upon task demands is a way for humans with limited cognitive capabilities to intelligently adapt to complex decision environments (Payne, Bettman, & Johnson, 1988).

In sum, heuristics provide methods for solving complex problems with limited information processing; heuristics also generally produce satisfactory outcomes. However, the use of heuristic (selective) processes for information processing also means that decision errors can occur; importantly, such errors in judgment and choice will tend to be systematic (predictable). Consequently, systematic human error in decision making does not *require* motivated irrationality but can be the result of a limited information processor trying to do the best that he or she can. Further, the potential biases or errors in reasoning that result should not be viewed as fragile effects that can easily be made to disappear; they are important regularities in decision behavior. These cognitive, as opposed to motivational, aspects of decision errors have important implications for evaluating and aiding decisions.

Methodological Considerations

The information-processing approach to decision research also shares some methodological features. As stressed earlier (quote 1), the information-processing approach emphasizes the study of *how* decisions are made, not just what decisions are made (Simon, 1978). As a result, decision researchers within the information-processing framework often *complement* an analysis of final judgments or choices with the results of "process-tracing" techniques such as verbal reports of processing during the task, i.e., verbal protocols; the monitoring of information search; and response times (Svenson, 1996). The use of process-tracing methods is consistent with the idea that an understanding of decision processes "must be sought through microscopic analysis rather than through indirect and remote interpretations of gross aggregative data" (Simon, 1982, p. 204).

Verbal protocols

Protocol analysis is one approach to gathering detailed data on decision-making processes (e.g., Hastie, Schkade, & Payne, 1998). The essence of a verbal protocol analysis is to ask a subject to give continuous verbal reports, i.e., "to think aloud," while performing some task of interest to the researcher. The researcher treats the verbal protocol as a record of the subject's ongoing problem-solving or decision behavior and interprets what is said as an indication of the subject's state of knowledge at a particular point in time or the use of a particular operation to transform one state of knowledge into another (Newell & Simon, 1972).

Monitoring information search

Monitoring information acquisition behavior is one of the most popular process-tracing methods used by decision researchers. To implement this method, the choice or judgment task is structured so that the subject must seek information so that what and how much information is sought, in what order it is acquired, and how long each piece of information is examined can be monitored easily.

Several methods for monitoring information acquisition behavior have been utilized in the past, ranging from simple "information boards" (e.g., Payne, 1976) to sophisticated eye-movement tracking (Russo & Dosher, 1983). However, today the most common approach is to use computerized information retrieval systems for presenting and recording information acquisition (e.g., Jacoby, Mazursky, Troutman, & Kuss 1984; Payne & Braunstein, 1978), including systems designed for use over the Internet (Edwards & Fasolo, 2001). For recent examples of monitoring information acquisition in studies of predictions and preferential choice, see Newell and Shanks (2003) and Costa-Gomes, Crawford, and Broseta (2001).

Response time

One advantage of information-processing models in decision research is that they provide a natural way of accounting for differences in the time it takes to make particular judgments or choices, due to the ideas of stages of processing, different operations within each stage, and the more general serial processing viewpoint. Thus, information-processing researchers often include response time measures as part of the information that is collected when people make a judgment or choice. For an example of the use of response times to study choice behavior, see Bettman, Johnson & Payne (1990).

An Example of the Information-processing Approach: The Adaptive Decision Maker

We illustrate the use of information-processing methods and concepts by reviewing a program of research on choice among alternative courses of action, often seen as the heart of the decision-making process. A key assumption of this program of research is that how individuals decide how to decide reflects considerations of cognitive effort as well as the accuracy of various information-processing strategies (Payne et al., 1993). The goal of minimizing cognitive effort fits well within the concept of "bounded rationality" advocated by Simon (1955). It is further assumed that how people make decisions is generally adaptive and intelligent, if not always optimal, given multiple goals for a decision.

Task analysis

Given the importance of the structure of task environments in understanding human behavior (Simon, 1990), an important first step is a task analysis. A typical multiattribute choice problem, for instance, consists of a set of m options where each option i (alternative) is described by a vector of n attribute values (x_{i1}, x_{i2}, . . ., x_{in}), with each attribute value reflecting the extent to which each option meets the objectives (goals) of the decision maker for that attribute. A key feature of almost all choice problems is the presence of value conflicts, since usually no single alternative is best (most preferred) on all attributes. Attributes generally vary with respect to their desirability to the decision maker, the uncertainty of actually receiving the attribute value, and the willingness of the decision maker to accept a loss on one attribute for a gain on another attribute. The presence of value conflict, and the fact that a rule for resolving the conflict often cannot be drawn from memory, is why preferential choice problems are generally solved using processes of information acquisition and evaluation rather than simply pattern recognition and response.

Strategies for multiattribute choice problems

How do people solve multiattribute choice problems? Research has shown that an individual uses a variety of different information-processing strategies contingent upon task demands, e.g., the number of alternatives to be considered. Different individuals also tend to use different strategies. Some of those strategies involve the processing of all relevant information about the available alternatives and explicit consideration of the tradeoffs among values (i.e., they are compensatory), whereas other heuristic strategies use information in a more limited and often very selective fashion and avoid tradeoffs (i.e., they are non-compensatory). Some decision strategies process information primarily by alternative, with multiple attributes of a single option processed before another option is considered. Other strategies are more attribute-focused, and the values of several alternatives on a single attribute are examined before information on another attribute is considered.

A classic decision-making strategy is the weighted additive strategy (WADD), which captures trade-off processing and is often considered to be a normative rule for decisions. To implement WADD, a measure of the relative importance (weight) of an attribute is multiplied by the attribute's value for a particular alternative, the products are summed over all attributes to obtain an overall value for that alternative, and the alternative with the highest overall summed evaluation is selected (i.e., WADD is a maximizing strategy). Thus, the WADD strategy uses all the relevant decision information. The weighting and summing of the resulting values potentially allows for a poor value on one attribute to be compensated for by a good value on another attribute. The WADD strategy is also an alternative-based strategy for processing information in that a summary evaluation of one alternative is reached before processing moves on to the next alternative in the choice set. Expected Value, Expected Utility, and various non-linear expectation models for risky decisions are strategies related to WADD (see Chapter 20, this volume).

People sometimes make decisions in ways consistent with WADD and related expectation models; however, these strategies can be very effortful to implement using scarce cognitive resources. Hence, years of decision research have made clear that people often make decisions using simpler decision processes (heuristics). For example, people frequently use a lexicographic strategy (LEX), where the alternative with the best value on the most important attribute is selected (assuming that there are no ties on this attribute). The LEX strategy is a clear example of a choice heuristic, in that people using the strategy are assumed to be highly selective regarding what information is used. The LEX strategy also uses attribute-based information processing. A very similar model for inferential judgments is the take the best heuristic (see Chapter 4, this volume).

In spite of its highly selective use of information, in some task conditions the very simple LEX choice heuristic can produce similar decisions as more information-intensive strategies like WADD (Johnson & Payne, 1985). In some decision environments (e.g., tasks where there is high variance in decision weights across attributes), there is relatively little cost in terms of decision quality associated with using a LEX strategy to make a choice. This is a critical point, because it implies that the use of a heuristic like the LEX strategy may be an adaptive response to some decision tasks for a decision maker who has a goal of saving cognitive effort as well as making the best possible choice. That is, although heuristics may not be optimal strategies in the narrow sense of decision accuracy alone, they may be reasonable ways to solve many decision problems.

Although the LEX heuristic performs well in some environments, it can lead to errors such as intransitive patterns of choice when combined with the idea that people have a just-noticeable-difference structure on attribute values (a lexicographic semi-order) (Tversky, 1969). As would be expected, the more the task environment is characterized by multiple important attributes, the less well the LEX strategy does in making a high quality decision (Johnson and Payne, 1985). For a similar point in terms of the take the best heuristic, see Martignon and Krauss (2003).

Simon (1955) proposed a satisficing (SAT) strategy for decisions. In SAT, each attribute's value for the option currently under consideration is compared to a predetermined cutoff level for that attribute. If any attribute fails to meet the cutoff level, the option is rejected and the next option is considered. SAT is alternative-based because multiple attributes can be considered for an alternative, although there will generally be variance in how much information is processed for each alternative. Importantly, the first option in a choice set passing the cutoffs for all attributes is selected, so people are not assumed to maximize; stopping after a satisfactory alternative has been identified can save a lot of information processing. If no option passes all the cutoffs, the levels can be relaxed and the process repeated. Busemeyer and Johnson offer a model for preference that combines elements of the LEX, SAT, and WADD strategies (see Chapter 7, this volume).

Elimination by aspects (EBA) is a commonly used decision strategy that contains elements of both the LEX and SAT strategies. EBA eliminates options that do not meet a minimum cutoff value or do not have a desired aspect for the most important attribute. This elimination process is repeated for the second most important attribute and continues with the next most important attributes, with processing continuing until a single option remains (Tversky, 1972). EBA focuses on attributes as the basis for processing information, is noncompensatory, and does not use all potentially relevant information. To the extent that the order in which the attributes are used reflects the decision maker's basic values, this heuristic may work well. However, to the extent that the attributes used reflect "irrelevant" factors of selective attention such as the salience of particular attributes in a display, the EBA strategy may not perform well in terms of decision accuracy.

Decision makers may also use combined choice strategies. A typical combined strategy has an initial phase in which some alternatives are eliminated and a second phase in which the remaining options are analyzed in more detail. One frequently observed combination is initial use of EBA to reduce the choice set to two or three options followed by a compensatory strategy such as WADD to select among those. An implication of using combined strategies is that the "properties" of the choice task may change as the result of using a particular strategy first. For example, the initial use of a process for eliminating dominated alternatives from a choice set, an often advocated procedure, will make the conflict among attribute values more extreme, perhaps then triggering the application of a new strategy on the reduced set of options.

Strategy selection

A critical question for the information-processing approach to decision research is how, and why, does a decision maker select one decision strategy instead of another for a particular task? A hypothesis that has led to a great deal of research is that strategy selection is guided by goals of both minimizing cognitive effort and achieving a satisfactory level of decision accuracy (Beach & Mitchell, 1978; Payne, 1976).

The different decision strategies described above seemingly require different amounts of computational effort; however, we need a more precise level of analysis to compare decision strategies in terms of cognitive effort. We have taken the approach of decomposing choice strategies like WADD and EBA into more basic components called elementary information processes (EIPs), with a specific decision strategy defined in terms of a specific collection and sequence of EIPs. Newell and Simon (1972) suggest that the number of EIPs needed for a strategy to complete a task provides a measure of the cognitive processing effort for that strategy for that task. The set of EIPs we have used includes such operations as reading information, comparing values, adding values, and eliminating options or attributes from consideration. We can then characterize each strategy by a sequence of such operations. A lexicographic choice strategy, for example, would involve a number of reading and comparison EIPs, but no compensatory EIPs such as adding or multiplying.

A particular set of EIPs represents a theoretical judgment regarding the appropriate level of decomposition for choice processes. For instance, one could further decompose a multiplication EIP into more detailed elementary information processes. One could also use more general processing components, e.g., a rule for selective search and a rule for stopping search. We believe that the level of decomposition represented by EIPs such as reading information or comparing values, however, is sufficiently detailed to provide useful measures of the relative cognitive effort of various decision strategies in differing task environments. Such EIPs are similar to those postulated for other cognitive tasks and have been successfully used to predict decision times and self-reports of decision effort (Bettman et al., 1990).

To measure the cognitive effort of specific decision strategies in various task environments more precisely, strategies can be modeled as production systems (Newell & Simon, 1972). A production system consists of a set of productions expressed as (condition)–(action) pairs, a task environment, and a (typically limited) working memory. The actions in a production are performed (fired) only when the condition matches the contents of working memory, which can contain both information read from the environment and information deposited by the actions of other production rules. Actions can include both changes to the task environment (e.g., eliminate option A from further consideration) and the creation of new states of knowledge (e.g., gamble one has the best chance of winning). Once decision strategies have been represented in the form of production systems, the performance of those strategies can be assessed using computer simulation, another method widely used in the information-processing approach.

Simulation of effort and accuracy in decision environments

We have used production system representations of decision strategies and computer simulation to explore the cognitive effort and accuracy of various strategies in a wide variety of decision environments (Johnson & Payne, 1985; Bettman, Johnson, Luce, & Payne, 1993; Payne, Bettman, & Luce, 1996; see also, Chapter 4, this volume). Typically, we have used the performance of normative models for the task, e.g., WADD or expected value, as the standards for accuracy. In preference tasks, as opposed to inference tasks, individual differences in values must be acknowledged to define what constitutes an accurate or high quality decision. It is also likely that individuals adjust their standard for accuracy as a function of task demands (see Chapter 7, this volume).

Several conclusions about decision heuristics are suggested by these simulation results. First, heuristic choice strategies can be highly accurate with substantial savings in cognitive effort. Thus, the use of choice heuristics can be a reasonable (adaptive) response for a decision maker concerned with both minimizing the use of scarce cognitive resources and making good decisions. Second, no single heuristic does well across all environments in terms of accuracy. The lack of generalized good performance for any given heuristic across all task environments is one of the costs of heuristic processing. This result suggests that *if a decision maker wants to achieve both a reasonably high level of accuracy and low effort (by using heuristics), he or she must use a repertoire (toolbox) of heuristic strategies, with selection contingent upon situational demands.*

Third, the cognitive effort required with heuristics increases more slowly than the effort required to use WADD as the choice task is made more complex. Fourth, the accuracy advantage of strategies like WADD is greatest in contexts with greater levels of conflict among the attribute values (i.e., more negative intercorrelation among the attributes) or lower dispersion (more nearly equal values) in the probabilities of the outcomes or the weights of the attributes of the alternatives in a choice set. More generally, one advantage of more "normative" strategies like WADD is that accuracy tends to be less sensitive to changes in task and context factors than is the case for heuristics. One exception to this general conclusion is the case of time pressure; although increased time pressure hurts the accuracy of all choice strategies, the biggest impact in terms of lowering accuracy is for WADD, because time often expires before computations can be completed. In cases of substantial time pressure, the simple LEX rule is often "best" in terms of maintaining decision accuracy (Payne et al., 1988; Payne et al., 1996). That is, it is best to examine some, albeit limited, information about each option under severe time pressure rather than to examine some options in more depth and not examine others at all.

Experiments examining adaptive strategy selection

Simulation results highlight how an idealized adaptive decision maker might shift choice strategies as task and context demands change. Do actual decision makers behave adaptively? In our experimental work, described next, participants make choices among options under various choice environment properties such as time pressure, and we observe the details of their information processing. Hypotheses regarding how observable aspects of processing may change are derived from the simulations. In the various experiments summarized below, we use process-tracing methods to measure the extent to which such aspects of processing vary with changes in the decision task. These aspects include the amount of information processed, the selectivity of information processing, the degree of alternative-based versus attribute-based processing, and the extent to which attribute-based processing involves multiple alternatives. Each of these aspects of processing can be related to prototypical decision strategies. For example, the EBA strategy uses less than complete information, is selective across alternatives, and uses relatively more attribute-based processing that can extend over multiple alternatives (n > 2); on the other hand, WADD uses complete information, is not selective, and is alternative based. The experiments also include the use of within subject designs to provide a strong test of adaptivity, the use of performance contingent payoffs, and the assessment of final choices and judgments as well as process measures of behavior.

What has been learned from such experiments? One clear result is that people increase their use of choice heuristics such as EBA and satisficing as the decision task becomes more complex. For instance, people process information quite differently if faced with many alternatives (four or more) than if faced with just two or three alternatives in a choice set. Importantly, these strategy shifts as a function of task complexity occur within subjects. That is, the same individual will use a more compensatory strategy in some situations and a more heuristic strategy in other situations. This result directly supports the critical idea that a person has a repertoire of decision strategies. In addition, there is evidence that people sometimes adapt their processing in top-down fashion. The following excerpts from verbal protocols of two decision makers illustrate this point: (1) "Well, with these many apartments (six) to choose from, I'm not going to work through all the characteristics. Start eliminating them as soon as possible" (Payne, 1976); (2) "With just two [gambles] to choose from, I'm going to go after all the information. It won't be that much trouble" (Payne and Braunstein, 1978). Thus, people sometimes plan a priori how to solve various types of problems. However, we also believe that strategy selection proceeds at other times in a much more bottom-up, constructive fashion, with little or no conscious awareness of a strategy being selected. Instead, people adjust their processing during the course of solving a decision problem in an "opportunistic" fashion as they learn more about the structure of the decision.

Another result is that processes like WADD are more likely to be used when decision accuracy is emphasized more than saving decision effort (Creyer, Bettman, & Payne, 1990), consistent with the general idea of a cost–benefit tradeoff underlying strategy selection. A less obvious prediction from the simulations, verified in the experimental results, is that the use of processes such as WADD is greater in task environments characterized by greater levels of conflict among the attribute values (i.e., more negative intercorrelation among the attributes) (Bettman et al., 1993). Simulation results show that in domains characterized by negative correlations among attributes, the relative penalty in decision quality for using a heuristic is greater. Interestingly, subjects who shifted strategies more in response to different levels of attribute correlation were better performers in terms of average payoffs.

One of the most important decision task variables is time pressure. Time pressure can result because a decision must be made by a certain point in time or because errors in judgment or choice can result from either deciding too soon (rush-to-judgment) or from delaying decisions too long (opportunity-cost). One of the major advantages of heuristic decision rules is that they can lead to quicker decisions, and, as noted above, our simulation results suggest that simple heuristics such as LEX perform better than WADD in terms of maintaining decision accuracy in the face of substantial time pressure, both for time pressure that is the result of a fixed time constraint for making a decision and for opportunity-cost time pressure. Shifting to strategies more like the LEX rule is associated with higher payoffs under such time pressure. Thus, adaptive decision behavior is characterized by more selective and more attribute-based processing under time pressure. There is also evidence of a hierarchy of responses to time pressure. People shift towards strategies like LEX as time pressure is increased, but this shift in processing tends to occur only after the decision maker first tries to respond by simply increasing the speed with which he or she tries to carry out the current decision strategy. Finally, we predict that those subjects who adapt more to time pressure by shifting strategies, and not just by working faster, will perform better, i.e., achieve greater decision accuracy. These predictions have been verified in several experiments (Payne et al., 1988; Payne et al., 1996).

Such results support the claim that decision makers often use choice heuristics in adaptive ways. However, we have also shown that contingent strategy use is not always appropriate. In one of the Payne et al. (1996) studies, for example, we found that people were not adaptive in terms of decision accuracy under competing time pressure and correlation structure demands. In particular, greater responsiveness to correlation structure under no time pressure resulted in higher payoffs, whereas greater responsiveness to correlation structure under time pressure led to lower payoffs; shifting to more alternative-based, non-selective processing strategies in response to negative correlation is not adaptive under conditions of time pressure.

To summarize, our program of research shows that an individual uses a variety of strategies to solve multiattribute choice problems, including heuristic strategies involving highly selective information processing. We can predict the conditions under which certain types of decision strategies are more or less likely to be used, based upon such factors as the number of options, time pressure, information format, response mode, attribute correlational structure, and so on. Next, we briefly review an extension of the Adaptive Decision Maker framework that includes emotion and other goals for a decision.

Emotion and Other Goals: Bringing Together the Scarecrow and the Tin Man

Cognitive effort and decision accuracy are two primary determinants of decision behavior. However, it is increasingly clear that strategy selection and other forms of decision behavior also are influenced by other goals, often developed constructively on the spot. Note that these goals can apply both to the processes of the decision and the products of the decision.

A choice goals framework for decision making

Bettman, Luce, and Payne (1998) suggest that four important meta-goals for choice are maximizing the accuracy of a decision, minimizing the cognitive effort required for the decision, minimizing the experience of negative emotion while making the decision and afterwards, and maximizing the ease of justification of a decision. This set of goals adds two goals relating to negative emotion and justification to the standard accuracy/effort approach.

Different subsets of these goals are likely to be relevant in different situations depending upon such factors as the importance and irreversibility of the decision and the timeliness and ambiguity of the feedback available on performance relative to each goal. For instance, effort feedback is generally much easier to obtain than accuracy feedback (Einhorn, 1980). This is one reason why cognitive effort considerations may play such a big role in explaining decision behavior. Obviously, however, the usefulness of a choice goals framework is compromised if too many goals are postulated, such as a different goal for each decision. Accordingly, we have focused on the limited subset of goals listed above, because we believe these four meta-goals capture many of the most important motivational aspects relevant to decision making.

Minimizing negative emotion

Although not all decisions are likely to evoke emotional responses, it is clear that people sometimes face emotion-laden choices. For instance, consumers find certain tradeoffs more emotionally difficult than others, e.g., trading off the increased safety of a larger vehicle against environmental damage due to poorer gas mileage. At the extreme, people often resist even thinking about such issues as the value in monetary terms of saving a human life or accepting a decrease in environmental quality. Tetlock (2002) has referred to such tradeoffs of sacred versus profane considerations as taboo tradeoffs. Note that the nature of emotion-laden choices is such that the ensuing negative emotion is associated with the decision itself and not with some unrelated ambient negative mood.

How might the negative emotions experienced while making a choice involving difficult tradeoffs impact strategy selection and decision making? One approach is to argue that emotion will interfere with decision processes, degrading cognitive performance (e.g., Hancock & Warm, 1989). Thus, one could modify the models of decision strategies illustrated above by assuming that any cognitive operation will both take more time and contain more error as negative emotion is increased. This suggests that decision makers adapting to negative emotion will simply shift to easier-to-implement decision strategies, analogous to the effects of increasing task complexity.

Another approach to broadening information-processing theories to account for the influence of emotions is to argue that decision makers may directly adapt to the negative emotion itself. People can respond to emotion-laden tasks in two related, but separate ways. One way is to use what Folkman and Lazarus (1988) have called problem-focused coping. That is, negative emotions associated with a task are dealt with by trying to solve the problem as well as possible, in effect treating negative emotions as a signal of decision importance. Trying to solve the decision problem effectively will increase the weight given to the goal of maximizing accuracy. As noted above, the motivation to perform accurately is often associated with more extensive processing of information. Extensive processing of information is the most readily available (to oneself) and observable (to others) indicator of one's motivation to be accurate. This suggests that instead of leading to the use of easier heuristic strategies, increased negative emotion associated with a decision should lead to more extensive processing.

A second way of coping with emotion-laden decisions is to take actions to directly minimize emotion by changing the amount or content of thought about the decision (emotion-focused coping). At one extreme, this can involve avoidant behaviors such as refusing to make any decision (Anderson, 2003), letting another make the decision for you, or showing an increased preference for the status quo option or any other option that is more easy to justify to oneself or others (Luce, 1998). A related strategy is not to avoid the decision altogether but instead to avoid whatever specific aspects of the decision problem one finds most distressing, even under high levels of tradeoff-induced negative emotion. For example, an individual undertaking an automobile purchase may refuse to consider the possibility that he or she may be involved in a life-threatening accident, yet may be quite willing to carefully assess other aspects of the purchase decision (e.g., the cost, reliability, and styling of various cars). We believe that explicitly making tradeoffs generates negative emotions, so one hypothesis is that individuals may cope with emotion-laden decisions by avoiding tradeoffs and adopting non-compensatory strategies such as LEX. Any attribute-based processing strategy is likely to minimize confronting the possibility that one attribute must be sacrificed to gain another (Hogarth, 1987).

Thus, if individuals try to directly adapt to negative emotion, the arguments above imply that people will simultaneously process more extensively (reflecting an accuracy goal) and in a more attribute-based fashion (reflecting a goal of minimizing negative emotion by avoiding difficult tradeoffs) in emotion-laden choices. In a series of studies involving either the selection of a child to support through a charity or a job choice, Luce, Bettman, & Payne (1997) found these predicted shifts in processing (i.e., a simultaneous increase in the amount of processing and more attribute-based processing). In other studies, we have also found less willingness to trade off higher values on a quality attribute for a lower price as the quality attribute under consideration increases in emotional tradeoff difficulty, regardless of which attribute is seen as more important (Luce, Payne, & Bettman, 1999, 2000).

To further demonstrate the necessity of considering an emotion-minimization goal, we examine reactions to increased decision conflict (more negative intercorrelation among the attributes). In the Bettman et al. (1993) studies of choice among gambles summarized above, increased conflict among attributes resulted in more processing, less selectivity in processing, and more alternative-based processing, consistent with increased use of strategies like WADD. In the Luce et al. (1997) studies, on the other hand, increased conflict was associated with more extensive and more attribute-based processing. In combination, these two sets of studies suggest that decision makers tend to confront between-attribute tradeoffs required by decision conflict explicitly when attributes are relatively low in emotional tradeoff difficulty, but they avoid these explicit tradeoffs when attributes are higher in emotional tradeoff difficulty. Somewhat ironically, decision makers may be more willing to use the types of conflict-confronting processes associated with normative decision rules for less emotion-laden choices than they are for more emotion-laden and sometimes more crucial decisions. See Luce et al., (2001) for more details on the work summarized above.

Maximizing ease of justification

The choice goals framework advocated by Bettman et al. (1998) also includes the goal of easily justifying a decision to others or to oneself (Tetlock, 2002). Due to space limitations, we do not review research indicating that ease of justification cannot be fully accounted for by accuracy and effort considerations. We stress, however, that maximizing ease of justification may involve the use of a different type of decision heuristic based on easily seen and communicable relationships among options, such as simply choosing the compromise option in a set. We have called such heuristics relational heuristics (Bettman et al., 1998); changes in the set of options under consideration change the relationships among the options and therefore some of the potential reasons for choosing among the options. To illustrate, consider research on the "asymmetric dominance" effect (Huber, Payne, & Puto, 1982; Simonson & Tversky, 1992). One classic assumption of rational choice theories is *regularity*, i.e., adding a new alternative to a choice set cannot increase the probability of choosing a member of the original choice set. However, people's choices do not always obey regularity. In particular, adding an option to a choice set that is dominated by one option in the original set but not by the other (an asymmetric dominance relationship) has the remarkable effect of actually increasing the choice share of the dominating alternative, violating the principle of regularity. In an important study dealing with the need to justify a decision, Simonson (1989) showed that an increased need for justification led to a greater asymmetric dominance effect.

Boxes 6.1 and 6.2 provide summaries of the major elements of the "Adaptive Decision Maker" framework and the major results from that program of research. Chapter 4, this volume, summarizes a very related program of research dealing with "fast and frugal" heuristics for predictive and probability judgments.

Dual Process Theories

Another extension of the information-processing perspective is dual process views of thinking. Recent theorizing in psychology (e.g., Hogarth, 2001; Kahneman & Frederick, 2002; Sloman, 1996) has argued for two modes of thinking characterized by different properties. One type of thinking, called System 1 thinking, is relatively unconscious, automatic, highly associative, rapid, contextualized, parallel, evolved early, is relatively independent of language, and generates feelings of certitude. System 1 thinking is related to what is commonly called intuition and also to the "affect heuristic," which reaches good–bad assessments in a rapid, automatic, and relatively effortless manner (Slovic, Finucane, Peters, & MacGregor, 2002). System 2 thinking is controllable, conscious, constrained by working memory, rule-based, serial, develops with age and is vulnerable to aging, is related to language, and is less characterized by feelings of certitude. System 2 thinking is commonly called analytic. These two systems probably represent the ends of a continuum rather than two distinct categories (Hammond, 1996).

As noted earlier, Simon (1979) argues strongly for the serial nature of the higher-level cognitive, attention-demanding, information-processing activities that characterize much

Box 6.1 Assumptions of the Adaptive Decision Maker Framework

People have a constrained repertoire (toolbox) of strategies for solving decision problems, including choice heuristics like the lexicographic choice rule and elimination-by-aspects; relational heuristics that focus on the ordinal relationships among options, such as choosing an asymmetrically dominating option or a compromise option; and more compensatory strategies like weighted additive value.

Strategies for solving decision problems are acquired through experience and training as well as potentially being "hardwired."

Constraints on the repertoire of strategies available to solve a specific problem include knowledge of strategies and cognitive limits on the implementation of a strategy in particular task environments.

Different strategies have differing advantages and disadvantages for any particular decision task, and these relative advantages and disadvantages are contingent upon task, context, social, and individual difference factors.

The advantages and disadvantages of strategies relate to the meta-goals of decision makers. Four important meta-goals for decision making are maximizing the accuracy of the decision, minimizing the cognitive effort required for the decision, minimizing the experience of negative emotion while making the decision and afterwards, and maximizing the ease of justification for the decision.

Strategies are sequences of mental operations used to transform an initial state of knowledge into an achieved goal state where the decision problem is viewed as solved. The relative cognitive effort needed to execute a particular strategy in a specific task environment reflects both the number *and* types of mental operations used. Certain mental operations, e.g., making tradeoffs, will also tend to be more emotionally difficult and less easy to justify to others as the basis for choice.

Individuals select among strategies in an adaptive fashion that can lead to reasonable performance on the meta-goals of accuracy, effort, the experience of negative emotion, and justification.

Strategy selection is sometimes a conscious top-down process reflecting learned contingencies, but it also can be a bottom-up process responding in an opportunistic fashion to information encountered during the decision process.

decision making. In terms of dual-process models of cognition, therefore, the focus of Simon's work and much of the decision research reviewed in this chapter is System 2 thinking, although relational heuristics may be more akin to System 1. However, there is growing awareness that information processing below the level of consciousness (i.e., System 1) may have a far greater impact on judgments and choices than previously realized (Bargh & Chartrand, 1999; Hogarth, 2001). To be fair, Simon (1983) also argued that any kind of serious, complex thinking employs both analytical and intuitive thought in varying proportions and in various ways.

Box 6.2 Results from the Adaptive Decision Maker Research Program

Heuristic strategies such as the lexicographic rule that involve highly selective processing of information and that use only relatively simple mental operations can provide relatively high levels of decision accuracy with substantial savings of both effort and the experience of negative emotion.

No single choice heuristic performs well in terms of accuracy, effort, negative emotion, and justification across changes in the task environment. As a result, people shift strategies as a function of task and context demands consistent with the relative emphasis placed on accuracy, effort, negative emotion, and justification.

Although not perfectly adaptive, people often change strategies appropriately given changes in features of the decision problem. Furthermore, the more adaptive the decision maker, the better the relative performance.

Effort considerations may be more salient than accuracy considerations in the selection of a strategy due to ease of assessment.

Strategies like weighted additive value that impose greater information processing demands are generally less sensitive to changes in the task environment than simplifying heuristics in terms of accuracy but are more sensitive in terms of effort. However, under some conditions (e.g., time constraints), a heuristic strategy can be more accurate than a strategy like weighted additive value.

People use a hierarchy of responses to time pressure: acceleration of processing, then increased selectivity of processing, and finally changes in strategies.

Emotion-laden choices are characterized by more extensive, more selective, and more attribute-based processing. In general, emotion-laden choices encourage avoidant behaviors.

Many context effects can be accounted for by general heuristics that focus on the ordinal relationships among options; these relationships often are viewed as reasons or justifications for choice.

People have greater difficulties in properly assessing and adapting to context factors than to task factors, which is one source of failure in adaptivity.

We believe that an important direction for broadening the information-processing framework is to examine how processes of judgment that evoke little or no attention demands (System 1 thinking) interact with "higher" level, attention-demanding, cognitive processes (System 2 thinking). One hypothesis is that an initial judgment involving little or no effort and no conscious awareness is arrived at quickly via System 1 thinking and that such an initial judgment may then either be expressed immediately or be confirmed or corrected by more effortful, conscious, System 2 processing (e.g., Cobos, Almaraz, & García-Madruga, 2003).

Correction of System 1 thinking by System 2 thinking is one way in which the two modes of thinking may interact. Another possible way the two types of thinking may interrelate is expressed in "selection" models (Gilbert & Gill, 2000). Selection models argue that the mode of processing is selected based on such factors as cognitive load or time pressure. For instance, one would expect System 1 thinking to be selected when cognitive load was high or time was short, a variant of the adaptive strategy selection ideas expressed earlier in this chapter. Correction models, on the other hand, suggest that people generally start with System 1 processes and then may or may not engage in System 2 processing. That is, System 1 is the default processing mode, always exerting an influence on judgments and choices, and the results of System 1 are sometimes corrected and sometimes not corrected by System 2 processing. Note that the results of System 1 judgments may also influence any later System 2 thinking through such effects as predecisional information distortion (Russo, Meloy, & Medvec, 1998).

An evolutionary, adaptive argument for the value of a corrective approach to judgment is that our environment has been structured so that most of the time quick, low-effort judgmental systems yield good answers, with the corrective system only needed to deal with more unusual cases. Hogarth (2001) argues that a mark of intelligence among humans is learning when intuition (System 1 thinking) may be erroneous and how to use deliberate (System 2) thought appropriately to correct such judgments. However, Wilson and Brekke (1994) suggest that correction processes may be relatively rare. Correction of an initial judgment requires awareness of the potential for bias or error *and* the ability *and* the motivation to correct the flawed judgment process. If either awareness or ability or motivation is lacking, correction will not take place. Thus, many judgments we observe may be the result of System 1 thinking rather than more analytical System 2 thought. However, modern technological society, with frequent and often large changes in the decision environment, may require more and more System 2 thinking. That is, more experientially based System 1 thinking may perform more poorly the more it is asked to deal with events to be experienced in a future that might be different from the past.

Although System 2 thinking has been the focus of much of the research within the information-processing approach to decisions, particularly preferential choice, there is still much to learn about the nature of System 1 decision making and how Systems 1 and 2 may interact. Such learning may be facilitated by adapting some of the concepts and methods of the information-processing approach. For example, it may be possible to engage in "process-tracing" for System 1 thinking by using new techniques in neuroscience to provide time-ordered data localized to particular brain areas (Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001). Developing computational models of specific System 1 judgment strategies (e.g., relational heuristics), as has been done for System 2 choice strategies, may also help in understanding how the various systems of thinking interact.

Conclusion

In the 50 years since Simon's (1955) classic article on bounded rationality, much has been learned about the processes of decision making. There is now a strong research foundation for Simon's conjectures about the nature of decision processes. People often make judgments and choices using simplifying mechanisms (heuristics) that are attuned to and constrained by people's limited computational capabilities. Many heuristics for judgment and choice have been, and continue to be, identified. Some of those heuristics reflect simple rules for System 2 thinking and some represent more perceptually based (System 1) thinking.

Importantly, the same individual has been shown to use many different heuristics contingent upon task demands. Simon's point that "human rational behavior is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (Simon, 1990, p. 7) has been verified over and over again.

Use of multiple heuristics contingent upon task demands often leads to reasonable (satisfactory) decision outcomes. It is clear, however, that using heuristics can lead to predictable and significant decision errors. The task-contingent nature of human decision processing also means that people systematically violate the principles of descriptive, procedural, and context invariance traditionally assumed by economic models. As a result, the view that preferences and beliefs are frequently constructed as needed on the spot, rather than simply retrieved from memory, is becoming increasingly accepted and has important implications for the understanding, assessment, and improvement of decisions (Payne, Bettman, & Schkade, 1999).

Taken together, the past 50 years of decision research using concepts and process-tracing methods from the information-processing approach have resulted in a more complex, yet more realistic, view of the processes of actual human decision making. Although a theory should be no more complex than necessary, a good theory of the psychology of judgment and choice behavior should be complex enough to capture the key cognitive and emotional mechanisms leading to a decision. Increasingly, there is less need to "satisfice" in our models of decision behavior. Many of the once "revolutionary" ideas of Simon have now been empirically verified and have become part of the mainstream in decision research.

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