BEHAVIORAL DECISION THEORY: PROCESSES OF JUDGMENT AND CHOICE

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INTRODUCTION

Why are normative theories so prevalent in the study of judgment and choice, yet virtually absent in other branches of science? For example, imagine that atoms and molecules failed to follow the laws supposed to describe their behavior. Few would call such behavior irrational or suboptimal. However, if people violate expected utility axioms or do not revise probabilities in accord with Bayes' theorem, such behavior is considered suboptimal and perhaps irrational. What is the difference, if any, between

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the two situations? In the latter we implicitly assume that behavior is purposive and goal-directed while this is less obvious (if at all) in the former. (It is problematic how one might treat plant and animal behavior according to a descriptive–normative dichotomy.) Therefore, if one grants that behavior is goal-directed, it seems reasonable to assume that some ways of getting to the goal are better, in the sense of taking less time, making fewer errors, and so on, than others. Indeed, much of decision research concerns evaluating and developing ways for improving behavior, thereby reflecting a strong engineering orientation (Edwards 1977; Hammond, Mumpower & Smith 1977; Keeney & Raiffa 1976). Moreover, comparison of actual behavior with normative models has been important in focusing attention on the discrepancies between them, and this in turn has raised important questions about the causes of such discrepancies.

Central to normative theories are the concepts of rationality and optimality. Recently Simon (1978) has argued for different types of rationality, distinguishing between the narrow economic meaning (i.e. maximizing behavior) and its more general dictionary definition of "being sensible, agreeable to reason, intelligent." Moreover, the broader definition itself rests on the assumption that behavior is functional. That is,

> Behaviors are functional if they contribute to certain goals, where these goals may be the pleasure or satisfaction of an individual or the guarantee of food or shelter for the members of society. . . . It is not necessary or implied that the adaptation of institutions or behavior patterns of goals be conscious or intended. . . . As in economics, evolutionary arguments are often adduced to explain the persistence and survival of functional patterns and to avoid assumptions of deliberate calculation in explaining them (pp. 3–4).

Accordingly, Simon's concept of "bounded rationality," which has provided the conceptual foundation for much behavioral decision research, is itself based on functional and evolutionary arguments. However, although one may agree that evolution is nature's way of doing cost/benefit analysis, it does not follow that all behavior is cost/benefit efficient in some way. We discuss this later with regard to misconceptions of evolution, but note that this view: (a) is unfalsifiable (see Lewontin 1979, on "imaginative reconstructions"); (b) renders the concept of an "error" vacuous; (c) obviates the distinction between normative and descriptive theories. Thus, while it has been argued that the difference between bounded and economic rationality is one of degree, not kind, we disagree.

The previous review of this field (Slovic, Fischhoff & Lichtenstein 1977) described a long list of human judgmental biases, deficiencies, and cognitive illusions. In the intervening period this list has both increased in size and influenced other areas of psychology (Bettman 1979, Mischel 1979, Nisbett

& Ross 1980). Moreover, in addition to cataloging the types of errors induced by the manner in which people make judgments and choices, concern has now centered on explaining the causes of both the existence and persistence of such errors. This is exemplified by examination of a basic assumption upon which adaptive and functional arguments rest, namely the ability to learn (Einhorn & Hogarth 1978, Hammond 1978a, Brehmer, 1980). However, if the ability to learn is seriously deficient, then dysfunctional behavior can not only exist but persist, thus violating the very notion of functionality. It is therefore essential to delimit the conditions under which this can occur. Indeed, the *general* importance of considering the effects of specific conditions on judgment and choice is emphasized by the following irony: the picture of human judgment and choice that emerges from the literature is characterized by extensive biases and violations of normative models whereas in work on lower animals much choice behavior seems consistent with optimizing principles (e.g. Killeen 1978, Rachlin & Burkhard 1978, Staddon & Motheral 1978). The danger of such pictures is that they are often painted to be interesting rather than complete. In the next section we consider the complexities involved in evaluating discrepancies between optimal models and human responses, and how persistent dysfunctional behavior is consistent with evolutionary concepts.

ARE OPTIMAL DECISIONS REASONABLE?

How are discrepancies between the outputs of optimal models and human responses to be evaluated? First, consider the latter to be generated through a cognitive model of the task and note the different possibilities: 1. Both models could inadequately represent the task, but in different ways; 2. the optimal model is a more adequate representation than that of the person. Indeed, this is the assumption upon which most decision research is predicated; and 3. the person's model is more appropriate than the optimal model —a hypothesis suggested by March (1978). Furthermore, in the absence of discrepancies, neither model could be appropriate if they misrepresent the environment in similar ways. Therefore, before one compares discrepancies between optimal models and human judgments, it is important to compare each with the environment.

Task vs Optimal Model of Task

We begin by offering a definition of optimality; namely, decisions or judgments that maximize or minimize some explicit and measurable criterion (e.g. profits, errors, time) *conditional on certain environmental assumptions and a specified time horizon.* The importance of this definition is that it stresses the conditional nature of optimality. For example, Simon (1979)

points out that because of the complexity of the environment, one has but two alternatives: either to build optimal models by making simplifying environmental assumptions, or to build heuristic models that maintain greater environmental realism (also see Wimsatt 1980). Unfortunately, the conditional nature of optimal models has not been appreciated and too few researchers have considered their limitations. For instance, it has been found that people are insufficiently regressive in their predictions (Kahneman & Tversky 1973). While this is no doubt true in stable situations, extreme predictions are not suboptimal in nonstationary processes. In fact, given a changing process, regressive predictions are suboptimal. The problem is that extreme responses can occur at random or they can signal changes in the underlying process. For example, if you think that Chrysler's recent large losses are being generated by a stable process, you should predict that profits will regress up to their mean level. However, if you take the large losses as indicating a deteriorating quality of management and worsening market conditions, you should be predicting even more extreme losses. Therefore, the optimal prediction is conditional on which hypothesis you hold.

The above is not an isolated case. For example, Lopes (1980) points out that the conclusion that people have erroneous conceptions of randomness (e.g. Slovic, Kunreuther & White 1974) rests on the assumption that well-defined criteria of randomness exist. She convincingly demonstrates that this is not the case. Or consider the work on probability revision within the Bayesian framework (e.g. Slovic & Lichtenstein 1971). Much of this work makes assumptions (conditional independence, perfectly reliable data, well-defined sample spaces) that may not characterize the natural environment. Moreover, alternative normative models for making probabilistic inferences have been developed based on assumptions different from those held by Bayesians (Shafer 1976, Cohen 1977; also see Schum 1979 for a discussion of Cohen). In fact, Cohen's model rests on a radically different system that obeys rules quite different from the standard probability calculus. Competing normative models complicate the definition of what is a "bias" in probability judgment and has already led to one debate (Cohen 1979, Kahneman & Tversky 1979b). Such debate is useful if for no other reason than it focuses attention on the conditionality of normative models. To consider human judgment as suboptimal without discussion of the limitations of optimal models is naive. On the other hand, we do not imply that inappropriate optimal models always, or even usually, account for observed discrepancies.

The definition of optimality offered above deals with a single criterion or goal. However, actual judgments and choices typically are based on multiple goals or criteria. When such goals conflict, as when they are negatively

correlated (e.g. quantity and quality of merchandise, cf Coombs & Avrunin 1977), there can be no optimal solution in the same sense as the single criterion case (Shepard 1964). That is, the most one can do is to execute the trade-offs or compromises between the goals that reflect one's values. Therefore, the imposition of (subjective) values for resolving conflicts leads to rejecting "objective" optimality and replacing it with the criterion of consistency with one's goals and values. Furthermore, even the single goal situation is transformed into a multiple goal case when judgments and choices are considered over time. For example, consider the single goal of maximizing profit. Conflicts between short-run and longer-run strategies can exist even with a single well-defined criterion. Therefore, unless a time horizon is specified, optimality can also be problematic in what might seem to be simple situations.

Environment vs Problem Space

The importance to behavior of the cognitive representation of the task, i.e. "problem space," has been emphasized by Newell & Simon (1972). It is now clear that the process of representation, and the factors that affect it, are of major importance in judgment and choice. Illustrations of the effects of problem representation on behavior are found in work on estimating probabilities via fault trees (Fischhoff, Slovic & Lichtenstein 1978); response mode effects inducing preference reversals (Grether & Plott 1979); coding processes in risky choice (Kahneman & Tversky 1979a); "problem isomorphs" in problem solving (Simon & Hayes 1976); context effects in choice (Aschenbrenner 1978, Tversky & Sattath 1979) and agenda setting (Plott & Levine 1978); purchasing behavior (Russo 1977); and causal schemas in probability judgments (Tversky & Kahneman 1980a).

It is essential to emphasize that the cognitive approach has been concerned primarily with *how* tasks are represented. The issue of *why* tasks are represented in particular ways has not yet been addressed. However, given functional arguments, this is a crucial issue in view of the way minor contextual changes can lead to the violation of the most intuitively appealing normative principles, e.g. transitivity.

The reconciliation of persistent errors and biases with functional arguments has taken two forms. First, it has been claimed that such effects can be overcome by increasing incentives (through higher payoffs and/or punishments). In one sense, this argument is irrefutable since it can always be claimed that the incentive wasn't high enough. However, direct evidence shows that increased payoffs do not necessarily decrease extreme overconfidence (Fischhoff, Slovic & Lichtenstein 1977) nor prevent preference reversals (Grether & Plott 1979). Furthermore, the indirect evidence from clinical judgment studies in naturally occurring settings, where payoffs are

presumably high enough to be motivating, continues to indicate low validity and inferiority to statistical models (Dawes 1979). In addition, claims that people will seek aids and/or experts when the stakes are high (Edwards 1975) are predicated on the assumptions that: (*a*) people know that they don't know; and (*b*) they know (or believe) that others do. On the other hand, it is foolish to deny that payoffs, and thus motivation, have no effect on processes of judgment and choice. Indeed, one only needs to recall the fundamental insight of signal detection theory (Green & Swets 1966), which is that both cognitive and motivational components affect judgment (also see Killeen 1978).

A second way of reconciling biases with functional arguments involves enlarging the context in which performance is evaluated. This has taken four forms: 1. One view of evolutionary theory (as espoused by the sociobiologists; for example, Wilson 1978) could lead to the belief that the human system represents the optimal design for a complex environment. Heuristics exist because they serve useful functions and their benefits outweigh their costs. While this view is often espoused, there is surprisingly little evidence to support it. An important exception is the simulation study by Thorngate (1980), where it was shown how heuristics can often pick the best of several alternatives across a range of tasks. However, neither this study nor any other that we are aware of has considered the distribution of tasks in the natural environment in which heuristics would work well or poorly. 2. Hogarth (1980a) has argued that most judgments and choices occur sequentially and that many biases reflect

in dynamic environments. Furthermore, the static tasks typically investigated reflect

which optimal models can be constructed. 3. Toda (1962) has claimed that it is the coordination of behavior that reflects

individual and thus isolated actions. Furthermore, coordination between functions requires trade-offs and these can be facilitated by limitations (e.g. a limited memory facilitates efficient forgetting of needless detail). 4. Cost/benefit analyses can be expanded to include "the cost of thinking" (Shugan 1980), which seems compatible with notions of bounded rationality.

While there is much merit in the above arguments, care must be taken since they can easily become tautological; i.e. costs and benefits can be defined post hoc in accord with a presumption of optimality. However, can there be actual dysfunctional behavior (rather than seeming dysfunctional behavior) that persists, and if so, by what mechanism(s)?

Since functional arguments rest on evolutionary theory, it is easy to overlook the fact that nonadaptive behavior can also be compatible with principles of natural selection: 1. Biological evolution is directly related to the amount of variance in the genotype (Lewontin 1979). For example, the

development of wings could be functional for humans on many occasions. However, without an appropriate mutation (the chance of which is miniscule), such evolution cannot take place. While it is evident that physical limitations preclude certain types of behavior regardless of incentives to the contrary, biological limitations can also preclude certain cognitive operations (Russo 1978). For example, the study of memory indicates limitations on short-term storage and retrieval. Furthermore, Seligman (1970) has explicated biological limitations in the learning process itself. Cognitive limitations can therefore persist and be dysfunctional (relative to given goals) for the same reasons that account for physical limitations. 2. The time-frame of human biological evolution is such that it can be considered constant over many generations. It is thus difficult to determine whether any current trait or mechanism is becoming more or less adaptive, or is a vestige without apparent function (e.g. the human appendix: see also Skinner 1966). Therefore, without denying general cost/benefit considerations over the very long run, dysfunctional behaviors may persist for extremely long periods by human standards. The demise of the dinosaur, for example, is popularly cited as an example of the effectiveness of natural selection. However, it is easy to forget that dinosaurs existed for about 160 million years. So far, humans are a mere 2.5 million years old (Sagan 1977). 3. Humans adapt the environment to their own needs as well as adapting to the environment. For example, poor eyesight is certainly dysfunctional, yet a major judgment aid, eye glasses, has been invented to deal with this problem. Furthermore, note that this aid actually works against natural selection, i.e. those with poor vision will not be selected against since their survival chances are now equal to those without the need for glasses. In fact, if poor eyesight were correlated with higher reproductive rates, there would be an increase in the aggregate level of this deficiency. 4. The analogy has been drawn between learning and evolution (e.g. Campbell 1960). However, the attempt to link individual learning with species level survival is problematic (Lewontin 1979). For example, consider whether response competition within an organism can be viewed as identical to competition between organisms. While the latter can and has been analyzed via game theoretic ideas of zero-sum payoffs and conflicting interests, such an approach seems foreign to intraindividual response competition.

Intuitive Responses and Optimal Models

The above arguments leave us on the horns of a dilemma. Given the complexity of the environment, it is uncertain whether human responses or optimal models are more appropriate. Furthermore, we know of no theory or set of principles that would resolve this issue. Indeed, the optimal-intuitive comparison presents the following paradox: Optimal models have

been suggested to overcome intuitive shortcomings. However, in the final analysis the outputs of optimal models are evaluated by judgment, i.e. do we like the outcomes, do we believe the axioms to be reasonable, and should we be coherent?

If the assessment of rationality ultimately rests on judgment, what are its components? To discuss this, imagine being a juror in a trial and having to decide whether someone who has committed a heinous crime acted "rationally." The prosecution argues that the crime was meticulously planned and carried out, thus demonstrating that the person was in complete control of what he/she was doing. Note that this argument defines rationality by the efficiency with which means are used to attain ends. Moreover, this manner of defining rationality is exactly what decision theorists have stressed, that is, given one's goals, what is the best way of attaining them. However, the defense argues that the goal of committing such a crime is itself evidence of irrationality. That is, rationality is to be judged by the goals themselves. Moreover, the argument is made that the deliberative way such despicable goals were reached is itself an indication of irrationality. Finally, the defense argues that when one understands the background of the defendant (the poverty, lack of parental love, etc), the irrational goals are, in fact, reasonable. This last point emphasizes that goals can only be understood within the person's task representation. Moreover, this argument highlights a crucial problem; namely, to what extent *should* one be responsible for one's task representation (cf Brown 1978)?

What are the implications of the above for behavioral decision theory? First, judgments of rationality can be conceptualized as forming a continuum which can be dichotomized by imposing a cutoff when actions must be taken. This idea has been advanced by Lopes (1980) with respect to judging randomness. Moreover, she suggests that the placement of the cutoff can be viewed within a signal-detection framework; i.e. payoffs and costs are reflected by the cutoff point. Second, judged rationality is a mixture of the efficiency of means to ends (called "instrumental rationality," Tribe 1973) and the "goodness" of the goals themselves (cf Brown 1978). While the former is familiar to decision theorists, the latter is the concern of moral philosophers, theologians, and the like. However, at a practical level it is of concern to all. In fact, it may well be that the efficacy of decision aids comes from structuring tasks so that the nature of one's goals is clarified (Humphreys & McFadden 1980). Third, the importance of *behavioral* decision theory lies in the fact that even if one were willing to accept instrumental rationality as the sole criterion for evaluating decisions, knowledge of how tasks are represented is crucial since people's goals form part of their models of the world. Moreover, their task representation may be of more importance in defining errors than the rules they use within that representation. For example, imagine a paranoid who processes information

and acts with remarkable coherence and consistency. Such coherence of beliefs and actions is likely to be far greater than in so-called "normal" people (when does coherence become rigidity?) Thus, the representation of the world as a place where others persecute one is the source of difficulty, and not necessarily the incorrect or inconsistent use of inferential rules or decision strategies.

STRATEGIES AND MECHANISMS OF JUDGMENT AND CHOICE

The inescapable role of intuitive judgment in decision making underscores the importance of descriptive research concerned with how and why processes operate as they do. Moreover, the most important empirical results in the period under review have shown the sensitivity of judgment and choice to seemingly minor changes in tasks. Such results illustrate the importance of context in understanding behavior in the same way that the context of a passage affects the meaning of individual words and phrases. We consider context to refer to *both* the formal structure and the content of a task. On the other hand, normative models gain their generality and power by ignoring content in favor of structure and thus treat problems out of context (cf Shweder 1979). However, content gives meaning to tasks and this should not be ignored in trying to predict and evaluate behavior. For example, consider the logical error of denying the antecedent; i.e. "if A, then B", does not imply "if not-A, then not-B." However, as discussed by Harris & Monaco (1978), the statement: "If you mow the lawn (A), I'll give you $5 (B)", does imply that if you don't mow the lawn (not-A) you won't get the $5 (not-B). Or consider a choice between a sure loss of $25 and a gamble with 3 : 1 odds in favor of losing $100 vs $0. Compare this with the decision to buy or not buy an insurance policy for a $25 premium to protect you against a .75 chance of losing $100. Although the two situations are structurally identical, it is possible for the same person to prefer the gamble in the first case yet prefer the insurance policy in the second (for experimental results, see Hershey & Schoemaker 1980a). Such behavior can be explained in several ways: (*a*) the person may not perceive the tasks as identical since content can hide structure (Einhorn 1980); and (*b*) even if the two situations are seen as having identical structure, their differing content could make their meaning quite different. For example, buying insurance may be seen as the purchase of protection (which is good) against the uncertainties of nature, while being forced to choose between two painful alternatives is viewed as a no-win situation.

While context has typically been defined in terms of task variables, it is clear from the above examples that it is also a function of what the person brings to the task in the way of prior experience via learning, and biological

limitations on attention, memory, and the like, that affect learning. There-fore, the elements of a psychological theory of decision making must include a concern for task structure, the representation of the task, and the informa-tion processing capabilities of the organism.

In order to discuss specific findings in the literature, we artificially decom-pose processes of judgment and choice into several subprocesses, namely, information acquisition, evaluation, action, and feedback/learning. We are well aware that these subprocesses interact and that their interaction is of great importance in the organization and coordination of decision making. Accordingly, we consider these issues within subsections where appropri-ate.

The Role of Acquisition in Evaluation

Much work in judgment and choice involves the development and testing of algebraic models that represent strategies for evaluating and combining information (see Slovic & Lichtenstein 1971). Although work in this tradi-tion continues (e.g. Anderson 1979), it has been accompanied by increasing dissatisfaction in that processes are treated in a static manner; i.e. judgments and choices are considered to be formed on the basis of information that is given. In contrast, the process of information search and acquisition should also be considered (cf Elstein, Shulman & Sprafka 1978) since evaluation and search strategies are interdependent. In fact, the evaluation strategies proposed in the literature imply various search processes either explicitly (e.g. Tversky & Sattath 1979) or implicitly (Payne 1976). Of great importance is the fact that the concern for how information is acquired raises questions about the role of attention and memory in decision making that have received relatively little concern (however, see Hogarth 1980b, Rothbart 1980). Furthermore, concern for the dynamics of information search has necessitated the use of different methodologies; e.g. process-tracing approaches such as verbal protocols and eye movements, as well as information display boards (Payne 1976). However, these methods need not replace more general modeling efforts and may in fact be complementary to them (Payne, Braunstein & Carroll 1978; Einhorn, Kleinmuntz & Klein-muntz 1979).

The importance of considering the interdependence of evaluation and acquisition can be seen in considering the issue of whether people lack insight into the relative importance they attach to cues in their judgment policies. The literature contains conflicting evidence and interpretations (Nisbett & Wilson 1977, Schmitt & Levine 1977). However, the use of weights in models as reflecting differential cue importance ignores the im-portance of attention in subjective weight estimates and illustrates our emphasis on understanding persons and tasks. Correspondence between subjective and statistical weights requires that people attend to and evaluate

cues and that such cues contain both variance and low intercorrelations. Disagreement between subjective and statistical weights can thus occur for three reasons: 1. people indeed lack insight; 2. people attend to, but cannot use, cues that lack variance (Einhorn et al 1979); 3. cues to which attention is not paid are correlated with others such that the nonattended cues receive inappropriate statistical weights. Both process-tracing methods and statistical modeling are necessary to untangle these competing interpretations.

Acquisition

Acquisition concerns the processes of information search and storage—both in memory and the external environment. Central to acquisition is the role of attention since this necessarily precedes the use and storage of information. We discuss attention by using an analogy with the perceptual concept of figure-ground noting that, as in perception, the cognitive decomposition of stimuli can be achieved in many ways. Accordingly, different decompositions may lead to different task representations (cf Kahneman & Tversky 1979a). Indeed, context can be thought of as the meaning of figure in relation to ground.

In an insightful article, Tversky (1977) analyzed the psychological basis of similarity judgments, and in so doing emphasized the importance of context and selective attention in judgmental processes. He first noted that our knowledge of any particular object "is generally rich in content and complex in form. It includes appearance, function, relation to other objects, and any other property of the object that can be deduced from our general knowledge of the world" (p. 329). Thus, the process of representing an object or alternative by a number of attributes or features depends on prior processes of selective attention and cue achievement. Once features are achieved, the similarity between objects a and b, $s(a,b)$, is defined in terms of feature sets denoted by A and B, respectively. Thus,

$$s(a,b) = \theta \, f(\text{A} \cap \text{B}) - \alpha \, f(\text{A-B}) - \beta \, f(\text{B-A}) \quad 1.$$

where A $\cap$ B = features that a and b have in common; A-B, B-A = distinctive features of a and b, respectively; f = salience of features; and θ, α, and β are parameters. Note that Equation 1 expresses $s(a,b)$ as a weighted linear function of three variables thereby implying a compensatory combining rule. The importance of Equation 1 lies in the concept of salience (f) and the role of the parameters. Tversky first defines salience as the intensity, frequency, familiarity, or more generally the signal-to-noise ratio of the features. Thereafter, the way in which the f scale and the parameters depend on context are discussed. We consider three important effects: asymmetry and focus, similarity vs difference, diagnosticity and extension.

Asymmetry in similarity judgments refers to the fact that the judged similarity of a to b may not be equal to the similarity of b to a. This can occur when attention is focused on one object as subject and the other as referent. For example, consider the statements, "a man is like a tree" and "a tree is like a man." It is possible to judge that a man is more like a tree than vice versa, thus violating symmetry (and metric representations of similarity). The explanation is that in evaluating $s(a,b)$ vs $s(b,a)$, $\alpha > \beta$ in 1; i.e. the distinct features of the subject are weighted more heavily than those of the referent. Hence, the focusing of attention results in differential weighting of features such that symmetry is violated.

The similarity/difference effect occurs when $\alpha = \beta$ and $s(a,b) = s(b,a)$. In judging similarity, people attend more to common features, while in judging difference, they attend more to distinctive features. This leads to the effect in which "a pair of objects with many common and many distinctive features may be perceived as both more similar and more different than another pair of objects with fewer common and fewer distinctive features" (Tversky 1977, p. 340).

The first effect results from a shift in attention due to focusing on an anchoring point (the subject). The second is caused by a shift in attention induced by different response modes. The third effect, diagnosticity and extension, involves changes in the salience of the features in an object due to the specific object set being considered. For example, consider the feature "four wheels" in American cars. Such a feature is not salient since all American cars have four wheels. However, a European car with three wheels on an American road would be highly salient. Therefore, salience is a joint function of intensity and what Tversky calls diagnosticity, which is related to the variability of a feature in a particular set (cf Einhorn & McCoach 1977). An important implication of diagnosticity is that the similarity between objects can be changed by adding to (or subtracting from) the set. For example, consider the similarity between Coca-Cola and Pepsi-Cola. Now add 7-Up to the set and note the increased similarity of the colas.

Although Tversky's paper is of great importance for judgment and choice, it has not been linked to earlier concepts such as representativeness, anchoring and adjusting, or availability. However, the question of context and the figure-ground issues which underlie similarity would seem to be of great importance in understanding these heuristics and their concomitant biases as well as a wide range of phenomena in the literature. To illustrate, we first discuss work on base rates.

Earlier work (reviewed in Slovic et al 1977) indicated that subjects ignore base rates, and it was postulated that this resulted from use of the representativeness heuristic and/or the apparent salience of concrete or vivid infor-

mation (Nisbett et al 1976). However, a base rate can only be defined conditional on some population (or sample space). Whereas many might agree that the base rates defined by experimenters in laboratory tasks make the sample space clear, the definition of the population against which judgments should be normalized in the natural ecology is unclear. Consider an inference concerning whether someone has a particular propensity to heart disease. What is the relevant population to which this person should be compared? The population of people in the same age group? The population of the United States? Of Mexico? There is no generally accepted normative way of defining the appropriate population. Thus, for naturally occurring phenomena it is neither clear whether people do or do not ignore base rates, nor whether they should (see also Goldsmith 1980, Russell 1948).

Even in the laboratory, base rates are not always ignored. Indeed, Tversky & Kahneman (1980a) have argued that base rates will be used to the extent that they can be causally linked to target events. Their data supported this hypothesis, and Ajzen (1977) independently reached similar results and conclusions. A further implication of causal thinking concerns asymmetries in the use of information; i.e. information that receives a causal interpretation is weighted more heavily in judgment than information that is diagnostic (although probability theory accords equal weight to both). Whether such judgments are biased or not depends on whether one believes that causality should be ignored in a normative theory of inference (as is the case in standard probability theory; see Cohen 1977, 1979 for a different view).

Bar-Hillel (1980) further explicated the conditions under which base rates are used. She argued that people order information by its perceived degree of relevance to the target event (with high relevant dominating low relevant information). Causality, Bar-Hillel argued, is but one way of inducing relevance (it is sufficient but not necessary). Relevance can also be induced by making target information more specific, which is tantamount to changing the figure-ground relationship between targets and populations. We believe that further elucidation of the role of causality in judgment is needed (Mowrey, Doherty & Keeley 1979) and note that the notion of causality, like probability, is conditional on the definition of a background or "causal field" (Mackie 1965).

Central to the distinction between figure and ground is the concept of cue redundancy. As Garner (1970) has stated, "good patterns have few alternatives," i.e. cue redundancy helps achievement of the object and thus sharpens figure from ground. Tversky (1977) makes the point that for familiar, integral objects there is little contextual ambiguity; however, this is not the case for artificial, separable stimuli. For example, consider the differential effects of acquiring information from intact or decomposed stimuli (the

former being more representative of the natural ecology, the latter of experimental tasks). Phelps & Shanteau (1978) have shown that when expert livestock judges are presented with information in the form of 11 decomposed, orthogonal attributes of sows, they are capable of using all the information in forming their judgment; however, when presented with intact stimuli (photographs), their judgments can be modeled by a few cues. These results illustrate that people can handle more information than previously thought; moreover, they can be interpreted as indicating that cue redundancy in the natural ecology reduces the need for attending to and evaluating large numbers of cues. Redundancy in the natural ecology also implies that cues can indicate the presence of other cues and can thus lead one to expect cue co-occurrences. For example, in a study of dating choice, Shanteau & Nagy (1979) showed that subjects used cues not presented by the experimenters. That is, when choosing between potential dates from photographs, subjects' choices were influenced by the probability that their requests for dates would be accepted even though this cue was not explicitly given.

The importance of redundancy in acquisition has been discussed by Einhorn et al (1979), who note the following benefits: "(a) Information search is limited without large losses in predictive accuracy; (b) attention is highly selective; (c) dimensionality of the information space is reduced, thereby preventing information overload; (d) intersubstitutability of cues is facilitated; and (e) unreliability of cues is alleviated by having multiple measures of the same cue variable" (p. 466). Studies and models that fail to consider cue redundancy in search processes are thus incomplete. For example, consider risky choice in the natural ecology vs the laboratory (for reviews of risk see Libby & Fishburn 1977, Vlek & Stallen 1980). In the former, probabilities are typically not explicit and must be judged by whatever environmental cues are available. A particularly salient cue is likely to be the size of the payoff itself, especially if people have beliefs about the co-occurrence of uncertainty and reward (e.g. large payoffs occur with small probabilities). Thus, payoff size can be used as a cue to probability (cf Shanteau & Nagy 1979). Moreover, the degree of perceived redundancy may also be important in understanding issues of ambiguity in decision making (cf Yates & Zukowski 1976). That is, one's uncertainty about a probability estimate (so-called second order probability) may be related to a variety of cues, including payoff size. In fact, Pearson (1897) noted that although means and variances of distributions are usually treated as independent, in the natural ecology they tend to be correlated and can thus be used as cues to each other. The analogy to means and variances of payoff distributions from gambles seems useful.

The temporal order of information acquisition can also affect salience, both by creating shifts in figure-ground relations and differential demands on attention and memory. Consider, for example, the effects of simultaneous vs sequential information display. In a study of supermarket shopping, Russo (1977) found that when unit prices were presented to shoppers in organized lists (ordered by relative size of unit prices, hence simultaneous presentation), purchasing behavior was changed relative to the situation where shoppers either did not have unit price information or such information was simply indicated next to products on the shelves (the latter implying sequential acquisition). An interesting aspect of this study is that it represents a form of decision aiding quite different from those proposed in earlier work. That is, instead of helping people to evaluate information that has already been acquired (e.g. through bootstrapping or multiattribute models), one eases strain on memory and attention by aiding the acquisition process itself. However, that greater understanding of attention and memory processes is necessary for this approach to be successful was underscored in a study by Fischhoff et al (1978) on the use of "fault trees." Fault trees are diagnostic check lists represented in tree-like form. The task studied by Fischhoff et al (1978) involved automobile malfunction and had both experts (i.e. automobile mechanics) and novices as subjects. The results indicated that the apparently comprehensive format of the fault tree blinded both expert and novice subjects to the possibility of missing causes of malfunction.

Since information is normally acquired in both intact form and across time (i.e. sequentially), determining the manner and amount of information to be presented in acquisition aids is a subject of great importance. It raises issues of both how external stimuli cue memory and the organization of memory itself (Broadbent, Cooper & Broadbent 1978; Estes 1980). Different ways of organizing information, for example by attributes or by alternatives in a choice situation, could have implications for task representation. In addition, several recent studies of the "availability" heuristic (Tversky & Kahneman 1973) have further emphasized how ease of recall from memory has important effects on judgment (Kubovy 1977). Moreover, experimenters should be aware that subjects interpret stimuli rather than respond to them. For example, Tversky & Kahneman (1980a) show that when information is presented in a manner involving an ambiguous time sequence, intuitive interpretations may reflect a reordering of that information to conform to the time dependence of naturally occurring phenomena.

That the figure-ground relation at a particular point in time affects judgment and choice has been demonstrated in a number of studies. A particularly compelling example is given by Tversky & Kahneman (1980b): It is

expected that a certain flu will kill 600 people this year and you are faced with two options: option 1 will save about 200 people; option 2 will save about 600 people with probability of ⅓ and no people with probability of ⅔. Now consider a re-wording of the alternatives: option 1 will result in about 400 people dying; option 2 gives a ⅓ probability that none will die and a ⅔ chance that about 600 people will die. By a simple change in the reference point induced by formulating the same problem in terms of lives lost or saved, cognitive figure and ground are reversed, as were the choices of a majority of subjects. Similar preference reversals can be obtained through the isolation effect where sequential presentation of information can isolate and hence highlight the common components of choice alternatives. Aspects seen to be common to alternatives are cancelled out and the choice process determined by comparing the distinctive features of the alternatives.

Payne, Laughhunn & Crum (1979) have linked reference effects to the dynamic concept of aspiration level and further illustrated how this affects the encoding of outcomes as losses or gains relative to a standard (rather than considering the overall wealth position implied by different end states). Sequential effects in choice have also been demonstrated by Levine & Plott (1977) and Plott & Levine (1978) in both field and laboratory studies. The structure of an agenda was shown to affect the outcomes of group choice by sequencing the comparisons of particular subsets of alternatives. Tversky & Sattath (1979) have further considered implications of these effects within individuals when sequential elimination strategies of choice are used. That judgment should be affected in a relative manner by momentary reference points should, however, come as no surprise (cf Slovic & Fischhoff 1977). Weber's law predicts just this, and the prevalence of "adjustment and anchoring" strategies in dynamic judgmental tasks is congruent with these findings (Hogarth 1980a).

Cognitive figure-ground relations vary considerably on the ease with which they can be reversed. On the one hand, the tendency not to seek information that could disconfirm one's hypotheses (Mynatt, Doherty & Tweney 1977, 1978) illustrates strong figure-ground relations where confirming evidence is attracted to the figure and possible disconfirming evidence remains in the ground. Consider also the difficulty of reformulating problem spaces in creative efforts where inversion of figure and ground is precisely what is required. On the other hand, situations also arise where figure and ground can invert themselves with minor fluctuations in attention, as in the case of "reversible figures" in perception. Whereas the analogy one could draw between "preference reversals" and "reversible figures" is possibly tenuous, both do emphasize the role of attention. In particular, its fluctuating nature implies that for certain types of stimulus configura-

tions, task representations can be unstable. Both choice and the application of judgmental rules have often been stated to be inherently inconsistent and hence probabilistic (Brehmer 1978, Tversky & Sattath 1979). However, the effects of fluctuating attention in producing such inconsistencies has not been explored.

Lest it be thought that the importance of attention in acquisition is limited to descriptive research, Suppes (1966) has stated: "What I would like to emphasize . . . is the difficulty of expressing in systematic form the mechanisms of attention a rationally operating organism should use" (p. 64). Furthermore, Schneider & Shiffrin (1977) have raised the possibility that attention is not completely under conscious control. Thus the normative problem posed by Suppes takes on added difficulty.

Evaluation/Action

Imagine that you are faced with a set of alternatives and have at your disposal the following evaluation strategies: conjunctive, disjunctive, lexicographic, elimination by aspects, additive, additive difference, multiplicative, majority of confirming instances, or random. Furthermore, you could also use combinations of any number of the above. How do you choose? The wide range of strategies one can use in any given situation poses important questions about how one decides to choose (Beach & Mitchell 1978, Svenson 1979, Wallsten 1980). For example, what environmental cues "trigger" particular strategies? What affects the switching of rules? Are strategies organized in some way (e.g. hierarchically), and if so, according to what principles? Although there has been concern for meta-strategies, most notably in Abelson's "script" theory (1976), the need for general principles is acute. This can be illustrated in the following way: each evaluation strategy can be conceptualized as a multidimensional object containing such attributes as speed of execution, demands on memory (e.g. storage and retrieval), computational effort, chance of making errors, and the like. However, each strategy could also be considered as a metastrategy for evaluating itself and others. For example, an elimination by aspects metastrategy would work by eliminating strategies sequentially by distinctive attributes. However, the choice of a metastrategy would imply a still higher level choice process thereby leading to an infinite regress.

The above emphasizes the need for finding principles underlying choice processes at all levels. One appealing possibility suggested by Christensen-Szalanski (1978, 1980) is that of an over-riding cost/benefit analysis, which can induce suboptimal behavior in particular circumstances. However, this raises several issues: 1. The meaning of costs and benefits is necessarily dependent on task representation, and thus context. For example, a tax cut can be viewed as a gain or a reduced loss (Kahneman & Tversky 1979a; also

see Thaler 1980 for an illuminating discussion of how this affects economic behavior). 2. Cost/benefit "explanations" can always be applied after the fact and thus become tautological (see earlier discussion). 3. The very notion of balancing costs and benefits indicates that conflict is inherent in judgment and choice. For instance, consider our earlier example of the options of insuring against a possible loss versus facing a no-win situation. The former can be conceptualized as an approach-avoidance conflict, the latter as an avoidance-avoidance conflict. In fact, Payne et al (1979) have demonstrated the importance of considering the perceived conflict in choice in the following way: Subjects first made choices between pairs of gambles. A constant amount of money was then added or subtracted from the payoffs such that, for example, an approach-avoidance gamble was changed to an approach-approach situation. With gambles altered in this manner, systematic preference reversals were found. Hence, while the structure of the gambles remained unchanged, the nature of the conflict and the choices did not.

The importance of conflict in choice has been emphasized by Coombs & Avrunin (1977), who considered the joint effects of task structure and the nature of pleasure and pain. They begin by noting the prevalence of single-peaked preference functions (i.e. nonmonotonic functions relating stimulus magnitude to preference) in a wide variety of situations. For example, consider the usual belief that more money is always preferred to less. While this violates single-peakedness, note that great wealth increases the risk of being kidnapped, of social responsibility to spend wisely, of lack of privacy, and so on. Thus, if one also considered these factors, it may be that there is some optimal level beyond which more money is not worth the increased trouble. Hence, there is an approach-avoidance conflict between the "utility for the good" and the "utility for the bad." The nature of this conflict eventuates in a single-peaked function, given the behavioral assumption that "Good things satiate and bad things escalate" (p. 224). Therefore, at some point, the bad becomes greater than the good and overall utility decreases. (In the single object case, it is not central that the bad escalate, only that it satiate at a slower rate than the good.)

The theory becomes more complex when objects are characterized on multiple dimensions. For example, consider a number of alternatives that vary on price and quality and suppose that some are both higher in price and lower in quality than others. Such dominated alternatives would seem to be eliminated quickly from further consideration. Indeed, the second principle in the theory is just this; dominated options are ignored. Hence, the alternatives that remain form a Pareto optimal set. While single-peakedness requires stronger conditions than this, from our perspective the important point is that the remaining set of alternatives highlights the basic conflict; that is, higher quality can only be obtained at a higher cost.

While the role of conflict in choice has received earlier attention (Miller 1959), its usefulness for elucidating psychological issues in decision making has not been fully exploited (however, see Janis & Mann 1977). We consider some of these issues by examining the role of conflict in, respectively, judgments of worth or value, deterministic predictions, and probabilistic judgments. Subsequently, conflict in taking action is discussed.

Conflict in Judgment

Consider the conflict between subgoals or attributes when one is judging overall value or worth. If dominated alternatives are eliminated, this will result in negative correlations between the attributes of objects in the non-dominated set, thereby insuring that one has to give up something to obtain something else. The resolution of the conflict can take several forms, the most familiar being the use of compensatory strategies (usually of additive form, although multiplicative models have also been used, cf Anderson 1979). Psychologically, this approach can be thought of as conflict "confronting" since conflict is faced and resolution achieved through compromise. Of crucial concern in executing one's compromise strategy is the issue of judgmental inconsistency (Hammond & Summers 1972). While the origin of such inconsistency is not well understood (cf Brehmer 1978), it has often been considered as reflecting environmental uncertainty (Brehmer 1976). However, inconsistency may exist in the absence of environmental uncertainty. For example, price and quality can each be perfectly correlated with overall worth, yet one could argue that this highlights the conflict and thus contributes to inconsistency. Although the theoretical status of conflict and inconsistency needs further development, it should be noted that methods for aiding people to both recognize and reduce conflict through compensatory compromise have been developed, and several applications are particularly noteworthy (Hammond & Adelman 1976; Hammond, Mumpower & Smith 1977).

Alternatively, conflict in judging overall worth can be resolved by avoiding direct confrontation and compromise. Specifically, noncompensatory strategies allow evaluation to proceed without facing the difficulties (computational and emotional) of making trade-offs. As indicated above, the conditions in both task and person that control strategy selection remain relatively unchartered. However, in addition to the error/effort trade-offs thought to influence such decisions (Russo 1978), the existence of conflict per se and the need to take it into account makes this issue problematic.

The evaluation of information in making predictions from multiple cues raises further questions concerning conflict in judgment. In particular, when a criterion is available for comparison one can consider conflict and uncertainty to arise from several sources: uncertainty in the environment

due to equivocal cue-criterion relations; inconsistency in applying one's information combination strategy; and uncertainty regarding the weighting of cues appropriate to their predictiveness. These three aspects and their effects on judgmental accuracy have been considered in great detail within the lens model framework (Hammond et al 1975). Moreover, the integration of uncertain and contradictory evidence, which is at the heart of prediction, can be seen as an attempt to establish "compensatory balance in the face of comparative chaos in the physical environment" (Brunswik 1943, p. 257). Brunswik called this process "vicarious functioning," and Einhorn et al (1979) have expanded on this to show that the compensatory process captured in linear models can also be seen in the fine detail of process-tracing models developed from verbal protocols. Furthermore, they argued that linear models represent cognitively complex and sophisticated strategies for information integration. However, the continued predictive superiority of bootstrapping, and even equal-weight linear models over clinical judgment (Dawes 1979), attests to the difficulty of establishing the correct compensatory balance (also see Armstrong 1978a, 1978b and Dawes 1977 for further work on the statistical vs clinical prediction controversy).

The basic issues involved in studying deterministic predictive judgment also underlie interest in probability judgment. That is, both are concerned with the making of inferences from uncertain and conflicting data/evidence. However, the different terminologies used in each approach reflect different historical antecedents; the psychology of inference on the one hand, and a formal theory of evidence (de Finetti, Savage) on the other. Formal approaches are concerned with developing general structures for inferential tasks independent of specific content. However, as noted previously, the psychology of inference is intimately concerned with both content and structure. This distinction is central for understanding the discrepancies between the outputs of formal models and intuitive processes found in recent research. To illustrate, whereas causality has no role in probability theory, it is important in human inference (Tversky & Kahneman 1980a). Moreover, the existence of causal schemas can lead to the reinforcement of a person's cognitive model after receiving contradictory evidence, rather than its revision. Schum (1980) has demonstrated the enormous statistical intricacies involved in the Bayesian modeling of inferences made from unreliable data. Indeed, one interpretation of this work is that a purely formal approach cannot handle the evaluation of evidence in any relatively complex task (such as a trial). The role of content, however, in simplifying these tasks has not been explored. For example, the use of a heuristic such as representativeness, which depends on content via similarity, takes on added importance in a normative sense (cf Cohen 1979). That is, in the face

of great complexity, the use of heuristics and content may be necessary to induce structure.

The importance of heuristics in making inferences has long been recognized (Polya 1941, 1954), and current interest in them seems well justified. However, their present psychological status requires more specification (cf Olson 1976). For example, the use of the same heuristic can lead to opposite predictions (for an example concerning "availability," see Einhorn 1980). In addition, the ease with which heuristics can be brought to mind to explain phenomena can lead to their nonfalsifiability. For example, if representativeness accounts for the nonregressiveness of extreme predictions, can adjustment and anchoring explain predictions that are too regressive?

As in deterministic predictions, there has been much concern with the accuracy of probabilistic judgment. However, measurement of accuracy raises issues of defining criteria and the adequacy of samples. Moreover, in the Bayesian framework subjective probabilities represent statements of personal belief and therefore have no objective referent. Nonetheless, Bayesian researchers have borrowed relative frequency concepts to measure how well probabilistic judgment is calibrated, i.e. the degree to which probability judgments match empirical relative frequencies (Lichtenstein, Fischhoff & Phillips 1977) and what variables affect calibration (Lichtenstein & Fischhoff 1977). Calibration has therefore become the accuracy criterion for probabilistic judgment similar to the achievement index in the lens model. Moreover, the research findings in the two paradigms are also similar; that is, most people are poorly calibrated and even the effectiveness of training is limited for generalizing to other tasks (Lichtenstein & Fischhoff 1980).

Judgment = Choice?

Is judgment synonymous with choice? The normative model treats them as equivalent in that alternative x will be chosen over y if and only if $u(x) > u(y)$; i.e evaluation is necessary and sufficient for choice. However, from a psychological viewpoint, it may be more accurate to say that while judgment is generally an aid to choice, it is neither necessary nor sufficient for choice. That is, judgments serve to reduce the uncertainty and conflict in choice by processes of deliberative reasoning and evaluation of evidence. Moreoever, taking action engenders its own sources of conflict (see below) so that judgment may only take one so far; indeed, at the choice point, judgment can be ignored. The distinction between judgment and choice, which is blurred in the normative model, is exemplified in common language. For example, one can choose in spite of one's better judgment whereas the reverse makes little sense.

The distinction made above should not be construed to mean that judgment and choice are unrelated. In many situations they are inseparable. For

example, consider diagnostic and prognostic judgments and the choice of treatment in clinical situations. It seems unthinkable that the choice of treatment could proceed without prior diagnosis and prognosis. More generally, this example illustrates several further points: 1. since judgment is deliberative, there must be sufficient time for its formation; 2. deliberation can itself be affected by the size of payoffs—e.g. people may invest in judgment to insure against accusations of irresponsibility from others and from oneself in the event of poor outcomes (cf Hogarth 1980b); 3. when alternatives are ordered on some continuum, a quantitative judgment may be necessary to aid choice, as when choosing a therapy that varies in intensity. These examples point to the importance of considering the conditions under which judgment and choice are similar or different, a crucial question that has barely been posed.

Conflict in Action

The conflict inherent in taking action, as distinct from conflict in judgment, occurs because action implies greater commitment (cf Beach & Mitchell 1978, Janis & Mann 1977). Such commitment induces conflict in several ways: 1. Whereas the existence of alternatives implies freedom to choose, the act of choice restricts that very freedom. Hence, keeping "one's options open" is in direct conflict with the need to take action. 2. Given a set of nondominated alternatives, Shepard (1964) has stated, " . . . at the moment when a decision is required the fact that each alternative has both advantages and disadvantages poses an impediment to the attainment of the most immediate sub-goal; namely, escape from the unpleasant state of conflict induced by the decision problem itself" (p. 277). Thus, conflict is inherent in choice as an attribute of the choice situation. 3. Unlike judgments, actions are intimately tied to notions of regret and responsibility. For example, consider the decision to have children faced by married career women. An important component in this choice may involve imagining the regret associated with both alternatives later in life. Or imagine the conflict involved in choosing a place to live and work where the responsibility to oneself and one's family do not coincide.

As with the resolution of conflict in judgment, conflict resolution in action can involve either avoidance or confrontation. One important form of avoidance is to not choose. Corbin (1980) has recognized the importance of the "no choice" option noting that it can take three forms: refusal, delay, and inattention. Moreover, she notes that attraction to the status quo has two advantages: it involves less uncertainty, and there may be "less responsibility associated with the effects of 'doing nothing' than with some conscious choice" (Corbin 1980). Toda (1980a) points out that people often make "meta-decisions" (e.g. to smoke), to avoid the conflict of having to

continually decide on each of many future occasions. Thaler & Shiffrin (1980) further point out the importance of developing and enforcing self-imposed rules (rather than allowing oneself discretion) in avoiding conflicts in self-control problems.

Although choice involves considerable conflict, the mode of resolution typically considered in the literature is a confronting, compensatory strategy embodied in the expected utility model. This model is based on the following tenets: 1. The expected utility, E(U), of a gamble whose payoffs are x and y with probabilities p and q ($p + q = 1.0$), is given by E(U) = $p\ u(x) + q\ u(y)$. Note from the formulation that: (a) the rule says that the evaluation of a gamble is a weighted average of future pleasures and pains, where the weights are probabilities of attaining these outcomes; (b) the evaluation is solely a function of utility and probability, there being no utility or disutility for gambling per se; (c) the rule assumes that payoffs are independent of probabilities, i.e. wishful thinking (optimism) or pessimism are not admissible; (d) there is no inconsistency or error in executing the rule. Thus, although the rule specifically deals with the uncertainty of future events, it does not consider the evaluation process itself to be probabilistic (however, see Luce 1977). Moreover, choice is assumed to follow evaluation by picking the alternative with the highest E(U). 2. The theory assumes that the utility of payoffs is integrated into one's current asset position. Hence, final asset positions determine choice, not gains and/or losses. 3. Although not central to E(U), it is generally assumed that people are risk averse, i.e. utility is marginally decreasing with payoff size.

Whereas the E(U) model has been proposed as a prescriptive theory, much confusion exists in that it has been used extensively to both explain and predict behavior. However, while the descriptive adequacy of E(U) has been challenged repeatedly (Anderson & Shanteau 1970, Slovic et al 1977), Kahneman & Tversky's "prospect theory" (1979a) represents a major attempt at an alternative formulation. Since elements of this theory are discussed throughout this review, we only consider the proposed evaluation model. Prospect theory superficially resembles the E(U) model in that the components involve a value function, v; decision weights, $\pi(p)$; and a compensatory combining rule. However, the value function differs from utility in that: 1. It is defined on deviations from a reference point [where $v(0) = 0$] rather than being defined over total assets. Furthermore, the reference point may be either identical to or different from the asset position depending on a number of factors (somewhat akin to Helson's adaptation level). 2. It is concave for gains but convex for losses inducing "reflection effects" via risk aversion for gains and risk seeking for losses. For example, consider the choice between $3000 and a .50 chance at $6000 or 0. While many would prefer the sure gain of $3000 to the gamble (thus exhibiting

risk aversion), if the sign of the payoff is changed, e.g. −$3000 or a .50 chance at −$6000 or 0, they might prefer the gamble to the sure loss. Note that the reflection effect contradicts the widely held belief that people generally abhor and seek to avoid uncertainty (Hogarth 1975, Langer 1977). 3. It is steeper for losses than gains, i.e. the pain of losing is greater than the pleasure of winning an equal amount.

Although decision weights are not subjective probabilities as such, they reflect the impact of uncertainty on the evaluation of prospects (gambles) and are transformations of probabilities. They have several interesting properties; for example, the sum of complementary decision weights does not sum to one (subcertainty), and small probabilities are overweighted. These properties, when combined with those of the value function in bilinear form induce overweighting of certainty (thus resolving Allais' paradox), violations of the substitution axiom, and avoidance of probabilistic insurance. Karmarkar (1978, 1979) was also able to explain many similar violations of the E(U) model by transforming probabilities into weights (using a single parameter) and then incorporating them in what he called a subjectively weighted utility model.

Although the above models are an important step in analyzing choice behavior, March (1978) has made a penetrating analysis of the deficiencies in conceptualizing tastes/preferences in such models. He points out that people are often unsure about their preferences (see also Fischhoff, Slovic & Lichtenstein 1980) and that uncertainty concerning future preferences complicates the modeling of choice. For example, how does one model the knowledge that one's tastes will change over time but in unpredictable ways? Moreover, although instability and ambiguity of preferences are treated as deficiencies to be corrected in normative approaches and as random error in descriptive models, March (1978) points out that ". . . goal ambiguity like limited rationality, is not necessarily a fault in human choice to be corrected but often a form of intelligence to be refined by the technology of choice rather than ignored by it" (p. 598).

The management of conflict induced by unstable preferences over time is also central to self-control (Thaler 1980). The recognition that one's tastes can change, and that such changes are undesirable, leads to precommitment strategies to prevent the harm that follows such changes. For example, consider saving money in Christmas clubs which pay no interest but which restrict the freedom to withdraw money before Christmas in order to protect one against one's self. Such behavior is difficult to explain without resort to a multiple-self model (Freud 1923, Sagan 1977, Toda 1980b). Conceptualizing decision conflict as the clash between multiple selves is a potentially rich area of investigation and could provide useful conceptual links between phenomena of individual and group behavior. For example, individual

irrationality might be seen as similar to the various voting paradoxes found in group decision making (Plott 1976).

LEARNING/FEEDBACK

The beginning of this review indicated a questioning of the basic assumption upon which functional and adaptive arguments rest, namely, the ability to learn. We now consider this in light of our discussion of heuristic and other rule-based behavior. For example, how are rules tested and maintained (or not) in the face of experience? Under what conditions do we fail to learn about their quality? Are we aware of our own rules?

Hammond (1978a) and Brehmer (1980) have discussed a number of important issues bearing on the ability to learn from experience. The former paper considers six "modes of thought" for learning relations between variables which include: true experiments, quasi-experiments, aided judgment, and unaided intuitive judgment. Moreover, these modes vary on six factors, including the degree to which variables can be manipulated and controlled, feasiblity of use, and covertness of the cognitive activity involved in each. Hammond points out that the most powerful modes (involving experimentation) are least feasible and thus not likely to be implemented. Unfortunately, the least powerful modes are most feasible and hence most common. Thus, correct learning will be exceptionally difficult since it will be prey to a wide variety of judgmental biases (Campbell 1959). The seriousness of this is further emphasized by the seeming lack of awareness of the inadequacy of unaided judgment. Brehmer (1980) has further considered the difficulties inherent in learning from experience by contrasting such learning with laboratory studies (and formal learning through teaching). The former is far more difficult in that: 1. we don't necessarily know that there *is* something to be learned; 2. or if we do, it is not clear *what* is to be learned; and 3. there is often much ambiguity in judging *whether* we have learned (e.g. what, if anything, did the U.S. learn from the Viet Nam war?).

The general difficulties of learning from experience have also been demonstrated in specific areas. For example, Shweder (1977) has analyzed the ability of adults to learn environmental contingencies and points out that: 1. Whereas adults are capable of correlational reasoning, they frequently use cognitive strategies that can result in the genesis and perpetuation of myths, magic, and superstitious behavior. 2. Judgments of contingency are frequently based on likeness and similarity. For example, the treatment of ringworm by fowl excrement in primitive societies is based on the similarity of symptoms to "cure." 3. Contingencies provide the links in structuring experience by implying meaning through context. For example, "the trip

was not delayed because the bottle shattered" can be understood when speaking of "launching a ship."

The learning of contingencies between actions and outcomes is obviously central for survival. Moreover, contiguity of actions and outcomes is an important cue for inferring causality (Michotte 1963) and thus for organizing events into "causal schemas" (Tversky & Kahneman 1980a). A particularly important type of contingent learning that has received little attention involves the learning and changing of tastes and preferences. For example, consider the unpleasant affect felt by a child after eating a particular vegetable, and the ensuing negative utility so learned; or imagine the changes in the same child's taste for members of the opposite sex as he or she grows older. Concern with the normative model, in which tastes are fixed, has obscured important psychological questions about the nature of tastes/preferences (cf March 1978).

The learning of action-outcome connections illustrates an obvious but essential point, that is, learning occurs through outcome feedback (cf Powers 1973). Moreover, since multiple actions must be taken over time, judgment is often required to predict which actions will lead to specified outcomes. Thus, feedback from outcomes is used to evaluate both judgments and actions. This assumes that the quality of decisions can be assessed by observing outcomes. Nonetheless, decision theorists have pointed out that outcomes also depend on factors that people cannot control; hence, decisions should be evaluated by the process of deciding. While there is much merit in this argument, the distinction between good/bad decisions and good/bad outcomes is strongly counterintuitive and may reflect several factors: (a) people have a lifetime of experience in learning from outcomes; (b) whereas process evaluation is complex, outcomes are visible, available, and often unambiguous; and (c) evaluation of process is conditional upon an appropriate representation of the task (see above). People cannot ignore outcomes in evaluating decisions.

The role of outcome feedback has been studied extensively within a number of probability learning paradigms. However, Estes (1976a,b) has emphasized the importance of considering what is learned in such tasks. In a series of experiments using simulated public opinion polls, he found that subjects coded outcomes as frequencies rather than probabilities. Indeed, as the history of probability indicates, the notion of probability was late in developing, a key difficulty being the specification of the sample space (such problems persist, see Bar-Hillel & Falk 1980). Einhorn & Hogarth (1978) note that the transformation of frequency into probability requires paying attention to nonoccurrences of the event of interest as well as the event itself. This added burden on attention and memory may thus favor the coding of outcomes as frequencies rather than probabilities. Moreover, the

tendency to ignore nonoccurrences is intimately related to the lack of search for disconfirming evidence (Wason & Johnson-Laird 1972, Mynatt et al 1977, 1978). Furthermore, attempts to alter this tendency have been generally unsuccessful, although Tweney et al (1980) have reported some success. Whether or not this tendency can be modified, we note that it is not limited to scientific inference; e.g. how many people seek disconfirming evidence to test their political, religious, and other beliefs by reading newspapers and books opposed to their own views?

The implications of the above for learning from experience were explored by Einhorn & Hogarth (1978). They specifically considered how confidence in judgment is learned and maintained despite low (and or even no) judgmental validity. The tasks analyzed are those in which actions are based on an overall evaluative judgment and outcome feedback is subsequently used to assess judgmental accuracy. However, the structure of this task makes learning difficult in that: 1. When judgment is assumed to be valid, outcomes that follow action based on negative judgment, cannot typically be observed. For example, how is one to assess the performance of rejected job applicants? 2. Given limited feedback (which can also result from a lack of search for disconfirming evidence), various task variables such as base rates, selection ratios, and the self-fulfilling treatment effects of taking action per se can combine to produce reinforcement through positive outcome feedback. Thus, one can receive positive feedback in spite of, rather than because of, one's judgmental ability. A formal model of this process was developed in which outcomes were generated by combining various task variables with the validity of judgment. The results indicated a wide range of conditions where overconfidence in poor judgment can be learned and maintained.

Of great importance to the issue of learning from experience is the role of awareness of the task factors that can influence outcomes. This includes the probabilistic nature of the task itself (cf Brehmer 1980), as well as other task variables discussed in multiple-cue probability learning studies (Hammond et al 1975). Einhorn (1980) has discussed this issue within the concept of outcome-irrelevant-learning-structures (OILS). This refers to the fact that in certain tasks positive outcome feedback can be irrelevant or even harmful for correcting poor judgment when knowledge of task structure is missing or seriously in error. This concept is obviously similar to the notion of "superstitious" behavior (Skinner 1948, Staddon & Simmelhag 1971). However, the concept of OILS raises the issue of what is reinforced (Wickelgren 1979). For example, consider a consumer who uses a conjunctive rule when purchasing a wide range of products. It could be argued that positive outcomes following purchases reinforce the use of the rule, the specific behaviors, or both. This is a complex issue that would seem to depend on

the extent to which people are aware of their own judgmental rules (Hayek 1962, Nisbett & Wilson 1977, Smith & Miller 1978). That is, to what extent are judgmental rules reinforced without awareness, and can inappropriate rules be *un*learned? The importance of this question is that it raises the issue of whether, or to what extent, procedures for correcting judgmental deficiencies can be developed.

It is important to stress that awareness of task structure does not necessarily lead to learning (see Castellan 1977). Furthermore, it is possible to choose not to learn. For example, consider a waiter in a busy restaurant who believes he can predict those customers most likely to leave generous tips, and the quality of his service reflects this prediction. If the quality of service has a treatment effect on the size of the tip, the outcomes confirm the prediction. With awareness of the task structure, the waiter could perform an experiment to disentangle the treatment effects of quality of service from his predictions; i.e. he could give poor service to some of those judged to leave good tips and good service to some of those judged to leave poor tips. Note that the waiter must be willing to risk the possible loss of income if his judgment is accurate, against learning that his judgment is poor. Therefore, there is conflict between short-run strategies for action that result in reasonably good outcomes vs long-run strategies for learning that have potential short-run costs. That is, would you be willing to risk the loss of income by doing a real experiment in order to learn? This dilemma is quite frequent, yet it is not clear that awareness of it would lead to the choice to learn.

METHODOLOGICAL CONCERNS

The substantive matters discussed in this review raise various issues regarding the methodology of decision research. We consider some of these by posing the following questions: 1. How can we know whether applications of decision aids improve the quality of decisions? 2. How prevalent are judgmental biases in the natural environment? 3. What methods are most likely to provide insight into decision processes?

The review by Slovic et al (1977) reported a growing number of applications of decision aids in a wide variety of fields and this growth continues (see e.g. Jungermann 1980 and references). However, it is appropriate to ask whether such applications work and how one can know this. While care in applying basic principles of experimental design involving consideration of threats to internal and external validity are recognized in some applications (cf Russo 1977), many more can be characterized as one-shot case studies where the experimental treatment is the decision aid or procedure. Although painful, it might be remembered that such a design is scientifically useless for assessing treatment efficacy. Moreover, the fact that clients are

likely to seek aid from decision analysts (broadly defined) when things are not going well renders evaluation of pretest-posttest designs lacking control groups particularly susceptible to regression effects.

The difficulties in evaluating decision aids have been noted by Fischhoff (1980), who draws an analogy between decision analysis and psychotherapy. He writes that, "like psychotherapy, decision analysis is advocated because the theory is persuasive, because many clients say that it helps them, because many practitioners are extremely talented and because the alternative seems to be to sink back into an abyss (seat-of-the-pants decision making)." Indeed, we note that decision analysis might be called "rational therapy" if that term were not similar to one already in use (see Ellis 1977 on "rational-emotive therapy"). The importance of Fischhoff's analogy is twofold: it raises basic questions regarding the evaluation of decision aids, and it provides some necessary (if not sufficient) motivation to do something about it.

The issue concerning the prevalence of judgmental biases in the natural environment raises familiar questions of external validity (Brunswik 1956). Ebbesen & Konečni (1980) have studied several judgment tasks within laboratory and natural settings (e.g. setting of bail, driving a car) and have found major differences in results. In reviewing these and other studies they conclude:

> There is considerable evidence to suggest that the external validity of decision making research that relies on laboratory simulations of real-world decision problems is low. Seemingly insignificant features of the decision task and measures cause people to alter their decision strategies. The context in which the decision problem is presented, the salience of alternatives, the number of cues, the concreteness of the information, the order of presentation, the similarity of cue to alternative, the nature of the decomposition, the form of the measures, and so on, seem to affect the decisions that subjects make.

Given the above, the issue of external validity is not liable to be resolved without recourse to theory that attempts to answer how tasks vary between the laboratory and the natural environment and what kinds of effects can be expected from such differences. Howell & Burnett (1978) have taken a first step in this direction by proposing a cognitive taxonomy based on task variables and response demands that affect judgments of uncertainty. However, greater concern with how people's experience influences their judgment is needed. For example, Bar-Hillel (1979) has pointed out that although people ignore sample size in certain laboratory studies, they seem to judge sample accuracy by the ratio of sample size to population. Furthermore, she emphasizes that such a rule can be justified in the natural environment since one typically samples without replacement. For example, "When dining out, one samples, without replacement, some dishes from a menu and generalizes about the restaurant's quality. When shopping in a

new store, one samples, without replacement, the price of several items and judges how expensive the store is" (p. 250).

Lacking theoretical guidance, one has no recourse but to judge the prevalence of judgmental biases. There are two extreme views. The most optimistic asserts that biases are limited to laboratory situations which are unrepresentative of the natural ecology. However, Slovic et al (1977) point out that in a rapidly changing world it is unclear what the relevant natural ecology will be. Thus, although the laboratory may be an unfamiliar environment, lack of ability to perform well in unfamiliar situations takes on added importance. The pessimistic viewpoint is that people suffer from "cognitive conceit" (Dawes 1976); i.e. our limited cognitive capacity is such that it prevents us from being aware of its limited nature. Even in a less pessimistic form, this view is highly disturbing and emphasizes the importance of further research on the factors which foster or impede awareness of the quality of one's judgmental rules.

Both of the above positions presuppose the internal validity of the experimental evidence concerning judgmental biases. However, Hammond (1978b) has criticized much of this research by pointing out the inadequacy of exclusive reliance on between-subjects-designs for studying cognition. For example, he notes that many experimental demonstrations of "illusory correlation" rest on the incorrect specification of the sampling unit; i.e. the sampling unit should be defined by the stimuli judged (within each person), not the people doing the judging. Thus, while group data may indicate large effects unless sufficient stimuli are sampled, no single individual can be shown to exhibit the bias (see also Hershey & Schoemaker 1980b). However, within-subjects designs can also be problematic in that effects due to memory when responding to stimuli across time (e.g. anchoring and carry-over) may distort the phenomenon being studied (Greenwald 1976). This is particularly important when considering possible biases in judgment made in unique circumstances. Hence, the temporal spacing between administration of stimuli is a crucial variable in within-subjects designs and its effects also need to be studied.

While there is controversy regarding the appropriateness of different experimental designs for studying decision processes, there is more agreement on the need for multimethod approaches (Payne et al 1978). Such approaches, which can use methods as diverse as statistical modeling and verbal protocols or eye movements, not only provide much needed evidence on convergent validity, but may also be necessary to discriminate between strategies that can result in identical outcomes (Einhorn et al 1979, Tversky & Sattath 1979). Furthermore, in addition to positive scientific effects, multimethod approaches may have the salutary effect of convincing researchers that "truth" can be shared.

CONCLUSION

Decision making is a province claimed by many disciplines, e.g. economics, statistics, management science, philosophy, and so on. What then should be the role of psychology? We believe this can be best illustrated by the economic concept of "comparative advantage." For example, how much typing should the only lawyer in a small town perform (Samuelson 1948)? Even if the lawyer is an excellent typist, it is to both his/her and the town's advantage to concentrate on law, provided that typing is not a rare skill. Similarly, we believe that psychologists can best contribute to decision research by elucidating the basic psychological processes underlying judgment and choice. Indeed, this review has tried to place behavioral decision theory within a broad psychological context, and in doing so we have emphasized the importance of attention, memory, cognitive representation, conflict, learning, and feedback. Moreover, the interdependence and coordination of these processes suggest important challenges for understanding complex decision making. In order to meet these, future research must adopt a broader perspective (cf Carroll 1980) by not only investigating the topics discussed here, but also those not usually treated in the decision literature (e.g. creativity, problem solving, concept formation, etc). Indeed, given the ubiquity and importance of judgment and choice, no less a perspective will do.

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